



Shoreline Movement Study, Point Peron Rockingham

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1 Introduction

Point Peron, also known as Cape Peron is located on the southern boundary of Cockburn Sound, approximately 55 kilometres south of Perth in Western Australia (Figure 1). The Department of Environment and Conservation (DEC) are concerned with the protection of local infrastructure to the west of the Garden Island Causeway. This infrastructure includes the Point Peron camp school, a dual-use path and an oval. Erosion of this section of coast has been occurring in recent years. The DEC have requested for the Department of Transport (DoT), DoT previously being part of the Department for Planning and Infrastructure (DPI), to investigate the history and nature of the shoreline as well as provide some possible solutions and recommendations that will provide protection to the dual-use path and camp school facilities (Figure 2).

The geology of Point Peron contains an understorey of Tamala limestone consisting mainly of calcium carbonate, skeletal material and quartz which is overlayed by Rockingham sand (Dept. of Transport, 1994). The study area at Point Peron consists of a rocky cape, east of which a sandy beach extends approximately one kilometre towards a sand trap which is designed to protect the Point Peron Boat Launching Facility from sedimentation (Figure 2).

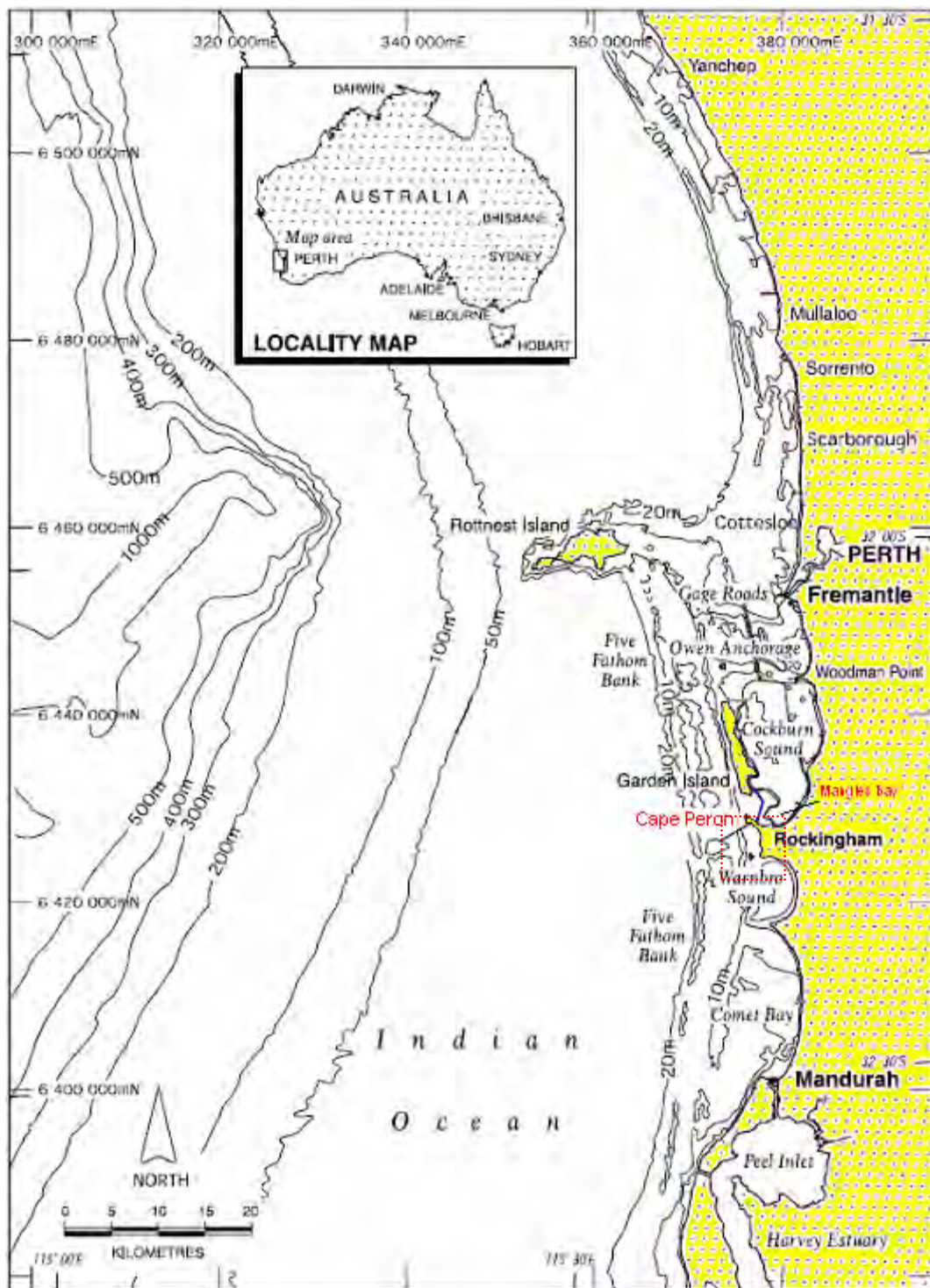


Figure 1: Location of Point Peron (Lemm, 1996)



Figure 2: Features of Point Peron including construction dates (2009 image)

2 History of the Study Area

The Garden Island Causeway was built between 1971 and 1973 by the Commonwealth Government to provide road access to the naval base on Garden Island. The design of the Causeway only allows for water flow between two trestle bridges, one located just north of the boat ramp and the other situated immediately south of Garden Island. These openings account for approximately 25 percent (0.9 km) of the total length of the Causeway. The remaining 75 percent (3.3 km) is an impermeable rock-fill wall (Cockburn Sound Management Council, 2003).

Shortly after completion of the Causeway, a 200 metre groyne was built approximately 100 metres west of the Causeway by the Commonwealth Government (see Appendix 1). The Point Peron Boat Launching Facility was then built between the groyne and the Causeway as the groyne provided a sheltered area for the boat ramp. Shelter was further improved when a near 90 degree angled 65 metre long groyne extension (pointing east) was added in 1986. Additional sand was trapped with the aid of a 50 metre spur groyne which was extended onto the groyne in 1990 (City of Rockingham). Construction dates are summarised in Table 1.

Due to the increasing build up of sand within the trap, sand has been extracted since the early 1990's in order to prevent sedimentation at the mouth of the boat launching facility. The removed sand has been used for beach renourishment at various locations including Kwinana, Penguin Island and Warnbro Sound.

Natural sediment transport has been interrupted since the construction of the Garden Island Causeway (Woods & Associates, 1988). Sand that has been accreting to the west of the groyne and sand trap. However, prior to the Causeway's existence, sand was naturally transported east towards the beaches along Mangles Bay by the natural wave action (Public Works Department WA, 1979).

The influence of the Causeway has also been reported on by the Cockburn Sound Management Council (2003). Within this report, the Council states that the Causeway's presence has impacted upon the strength and direction of natural currents that pass through the Causeway's two trestle bridges. This has caused local currents to strengthen which has increased sediment movement and scouring of the seabed. Distinct scouring of the seabed around the northern and southern trestle bridges can be seen on recent aerial photographs (Figure 2).

A seawall was constructed in the late 1980's along the coast adjacent to the dual-use path (Figure 2). Its purpose was to provide protection to the path from wave action. It is likely that the seawall was not formally designed and limestone rocks were simply deposited along the path's edge. The seawall is

currently in poor condition with large gaps and there are cracks and breakages along the path's edge (Figure 3).



Figure 3: The seawall alongside the dual-use path (27/2/2009)

Table 1: Timeline of construction dates and measurements of major coastal structures

Construction Dates	Infrastructure	Length
1971 - 1973	Garden Island Causeway	4.2 km
1973	Original sand trap groyne (west of causeway)	~200 m
1973 (approx.)	Boat Launching Facility	-
1986	90 degree extension sand trap groyne	~65 m
1990	Spur added to sand trap groyne	~50 m
Late 1980's	DEC Seawall (near path)	~170 m

According to Roger Lewis, manager of the Point Peron Camp School, strong storms in 2006 eroded away approximately 15 metres of coast in front of the oval. Water reached within metres of the oval's grass. Due to the severity of these storms, sand excavated from the sand trap was trucked to the west and deposited in and around the seawall alongside the dual-use path. Wayne Radonich (M Radonich & Sons Contractors) stated that several thousand cubic metres of sand was used to patch up this section around the seawall. According to Mr. Radonich, this sand remained in place for approximately 6 months.

3 Sand Trap Excavation

Sand has been excavated from the sand trap since the early 1990's (Figure 4). Removal of sand did not originally occur on an annual basis. Over the last 8 years, however the sand trap has been excavated annually. This has normally been conducted in two separate extractions typically during April to May and September to October. Between 2006 and 2008, approximately 10,000 cubic metres (m³) have been removed each year. The removed sand is stockpiled near the site and then trucked to Rockingham, Kwinana and Warnbro Sound beaches, depending on renourishment requirements. Actual volumes of sand have not been recorded, however Table 2 shows the approximate sand volumes removed since 2000.

Table 2: Volumes excavated from the Point Peron sand trap

Year	Excavated Volumes (m ³)
2000 - 04	~ 44,000
2004	~ 7,000 - 10,000
2005	Unknown
2006	~ 10,000
2007	~ 10,000
2008	~ 10,000
2009	~ 5,000 (at time of writing)

These volumes were estimated from documents as well as discussions held with the City of Rockingham, the DEC and M Radonich and Sons Contractors. Annual sand removal is typically conducted before the trap becomes full as this prevents sediments spilling around into the boat launching facility. Excavation works do not extend seaward beyond the spur groyne due to the close proximity of seagrass habitats. The DoT recommends that sand continue to be removed before the sand trap reaches full capacity.



Figure 4: Sand trap at Point Peron during excavation works in November, 2007

4 Metocean Conditions

A brief desktop analysis of the wind, wave and water level conditions has been carried out for the study area.

4.1 Wind Information

Point Peron is situated within the Perth metropolitan coastline which experiences large seasonal wind variations. During winter, this region is exposed to strong westerly and north-westerly winds. In summer, the wind regime switches to more south and south-westerly winds (Masselink, 1996; Pattiaratchi *et al*, 1997). The typical sea breeze for this region consists of offshore winds from an easterly direction in the morning, then in the afternoon changes to south-south westerly winds that are near parallel with the Perth Metropolitan coast (Masselink & Pattiaratchi, 1998).

Wind data was obtained from the Bureau of Meteorology from a weather station located at the southern point of Garden Island. Wind data between 2001 and 2008 was used to create a summer (November - April) and winter (May - October) wind rose to display seasonal wind variations (Figure 5 & 6). The wind roses indicate the joint occurrence (%) of wind speed (m/s) and direction (degrees). During the summer months, winds are predominantly from the south and south-south west with a significant contribution from the east. This is because the sea breeze is stronger and more persistent than in winter (Masselink & Pattiaratchi, 1998). In winter, westerly and north westerly winds are dominant although the occurrence of low wind speeds tends to be evenly spread through all directions. Westerly and north westerly winds are dominant during winter because of storm systems arriving from the north west.

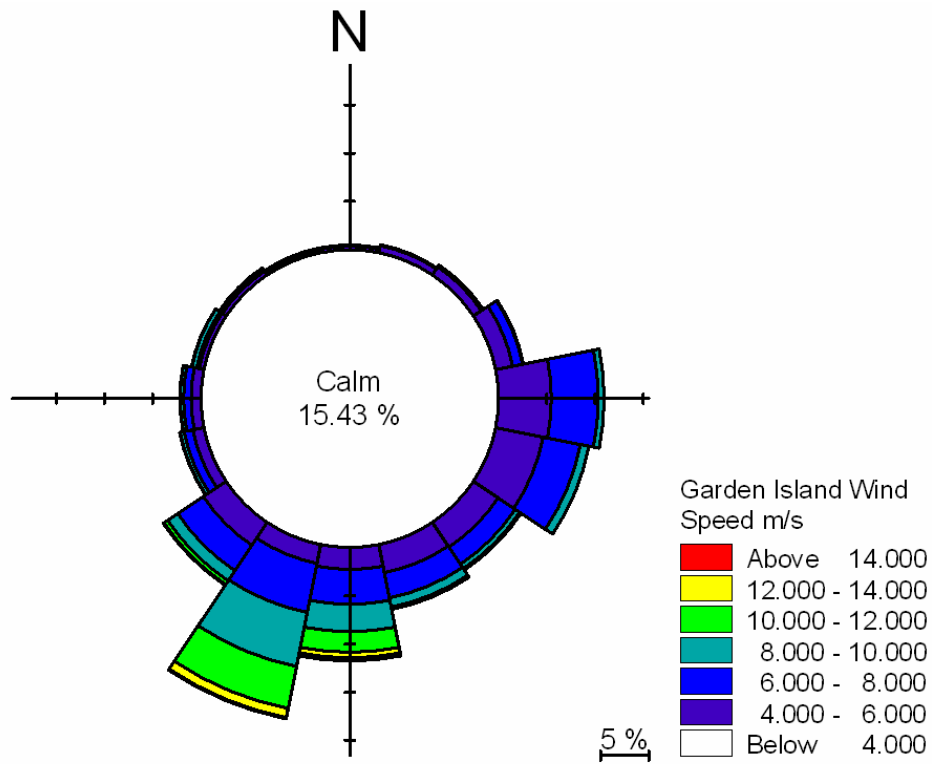


Figure 5: 2001 - 2008 wind data during summer months (November - April)

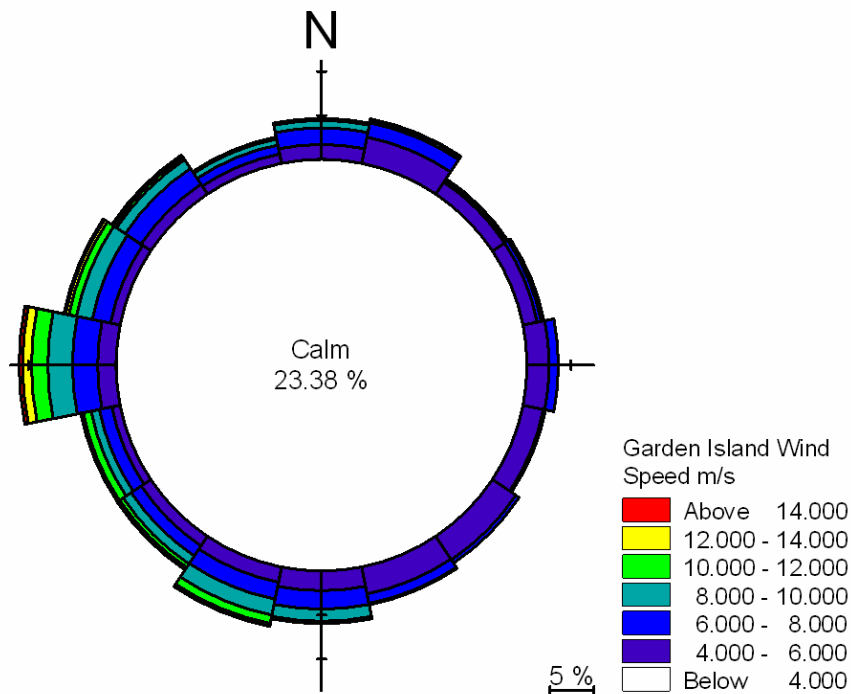


Figure 6: 2001 - 2008 wind data during winter months (May - October)

4.2 Wave Climate

Offshore wave climate:

The DPI deployed a Datawell Non-Directional wave buoy south west of Rottnest Island in 1991. This type of wave buoy measures the wave height and period. It was replaced in 2004 by a Datawell Directional wave buoy that also measures the wave direction.

Swell waves are long period waves (greater than 8 seconds) that are generated far offshore. A wave rose was created for the swell wave heights and direction (Figure 7) from data collected between 2005 and 2008 (DPI, unpublished a). Over this 4 year period, the swell waves were primarily of west-south westerly origin.

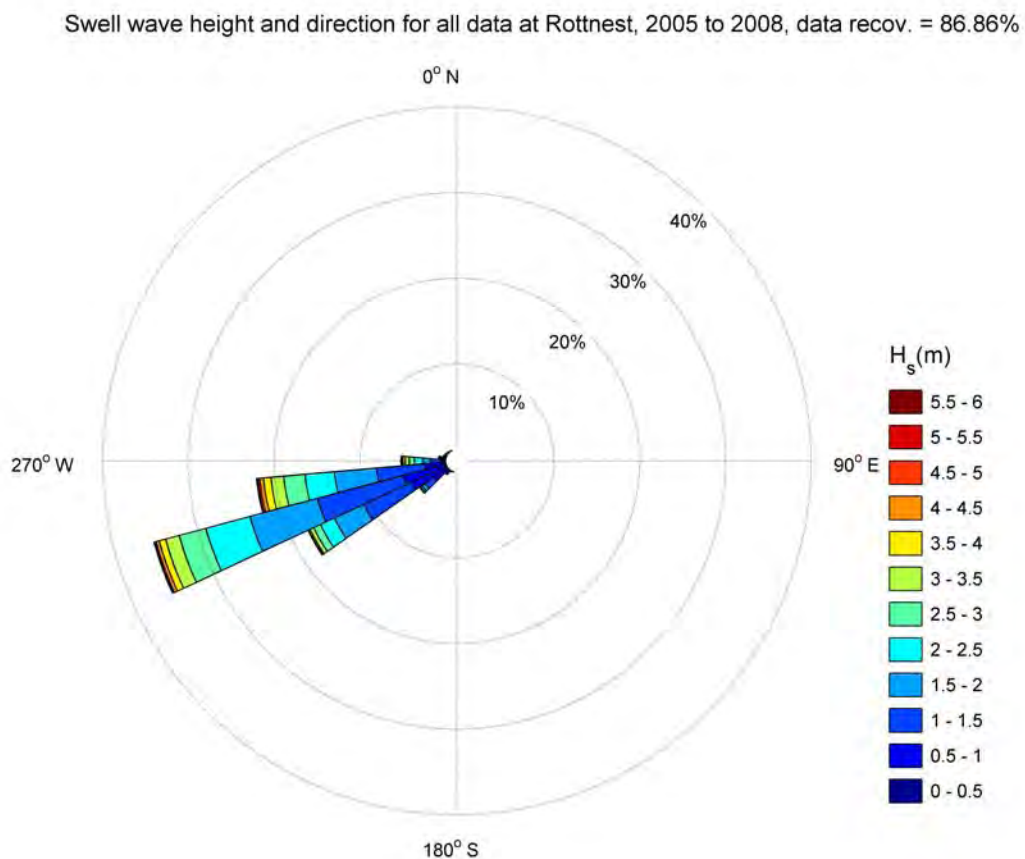


Figure 7: Swell wave height and direction at Rottnest, 2005 - 2008

Study area wave climate:

Wind data collected from the south of Garden Island is considered to be representative of locally generated sea (wind) waves near Point Peron. Sea waves during the summer are driven by the sea breeze. On a typical day, the sea breeze consists of easterly winds in the morning switching to a south-south westerly in the afternoon. In winter, the sea waves are generated from winter storms often arrive from the north west (refer to Figure 8).

Swell waves arriving at Point Peron have originated far offshore from the south west.

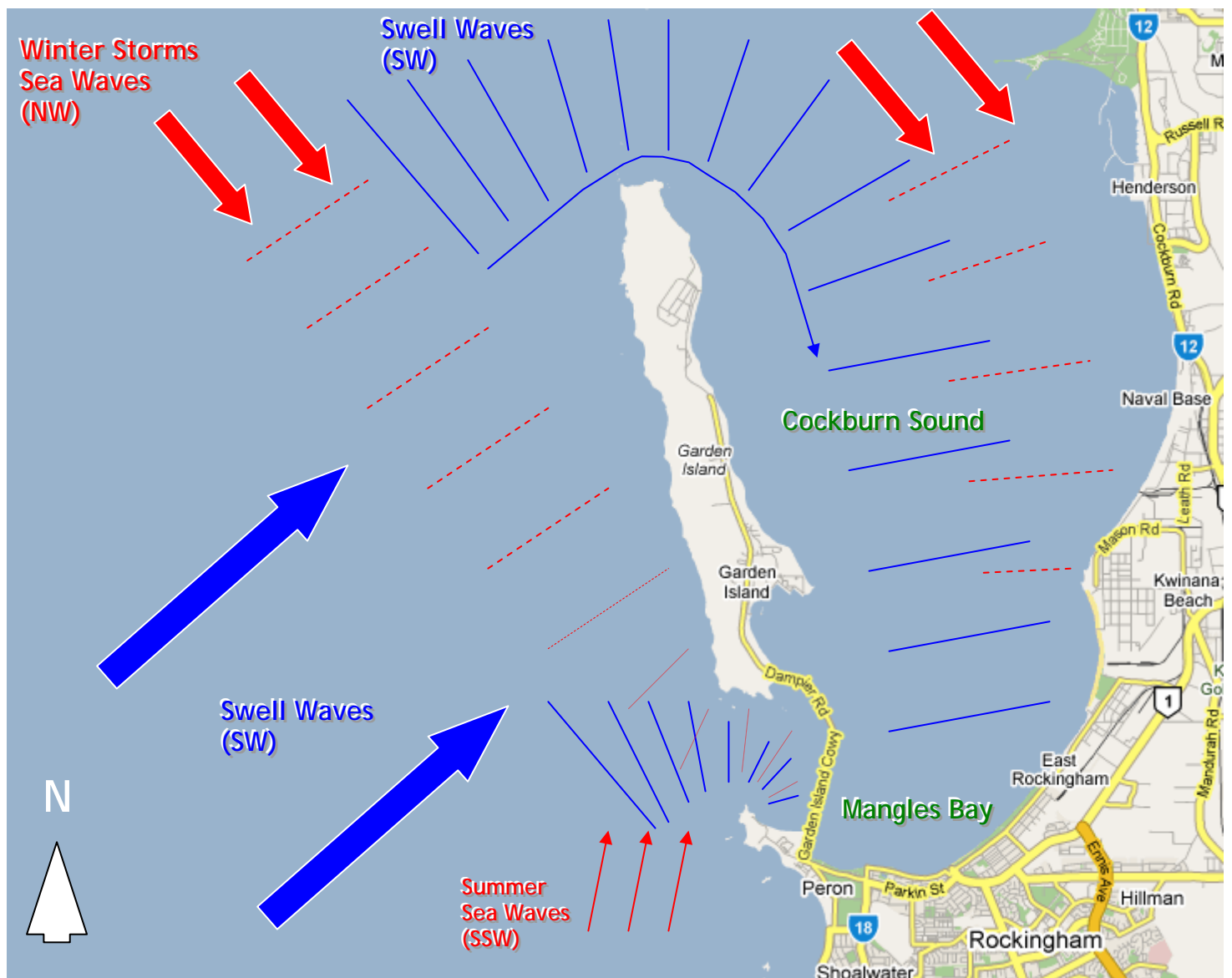


Figure 8: Swell and sea (wind) wave directions at Point Peron and Cockburn Sound (source: Google maps)

Figure 9 (below) is a numerical wave model output of total wave activity (sea and swell waves) during a storm at 12:00am in July 2008. This wave model image was created using data collected from the directional wave buoy that was deployed south of Rottneest Island. DHI Mike 21 SW Spectral Wave Model software was used to model the waves (DPI, unpublished b). Two wave roses (Figure 10 & 11) were created from this data at separate locations near the study area (labelled A and B on Figure 9). For simplicity, the southern trestle bridge of the Causeway was not included when modelling the waves. This will reduce the accuracy of the model results seen on the second wave rose (Figure 11).

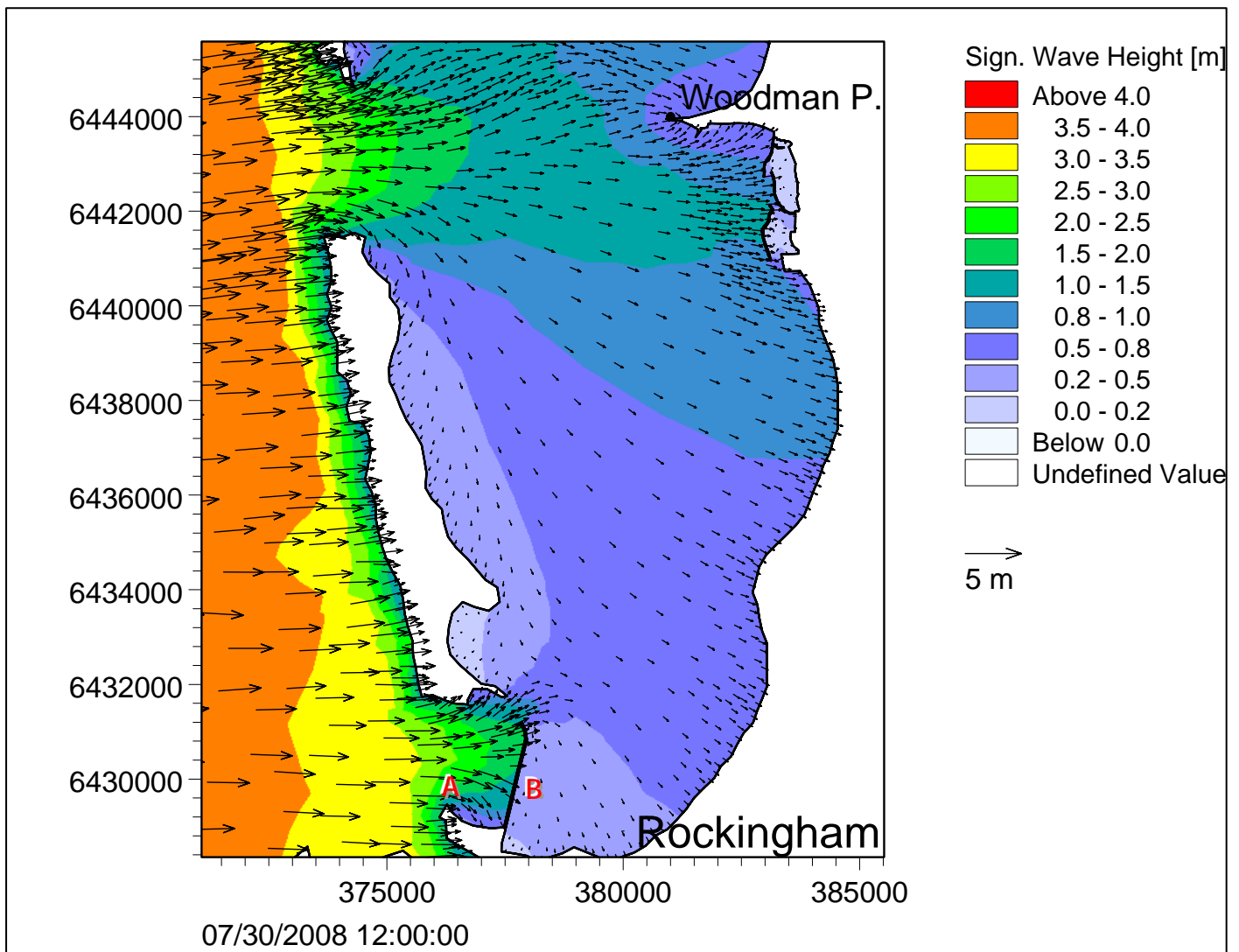


Figure 9: Wave model displaying wave direction, height and strength during a storm at 12:00am on the 30th of July, 2008 (A: 376400E, 6429500N; B: 377900E, 6429500N)

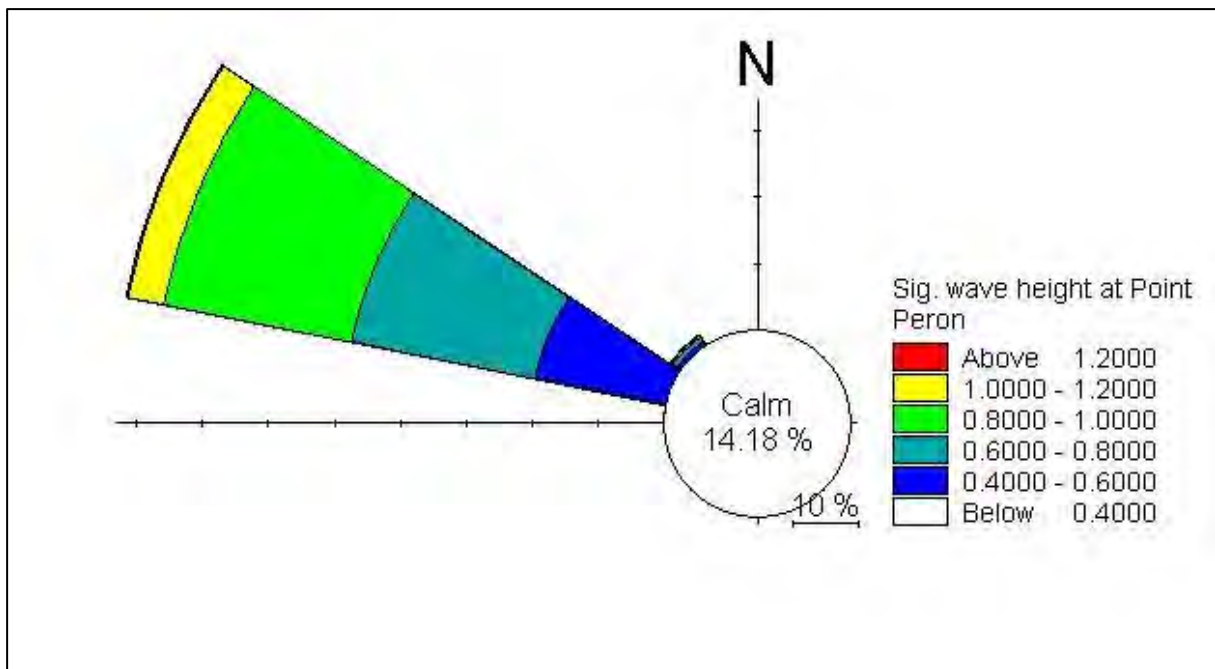


Figure 10: Wave rose displaying modelled wave height and direction at point A

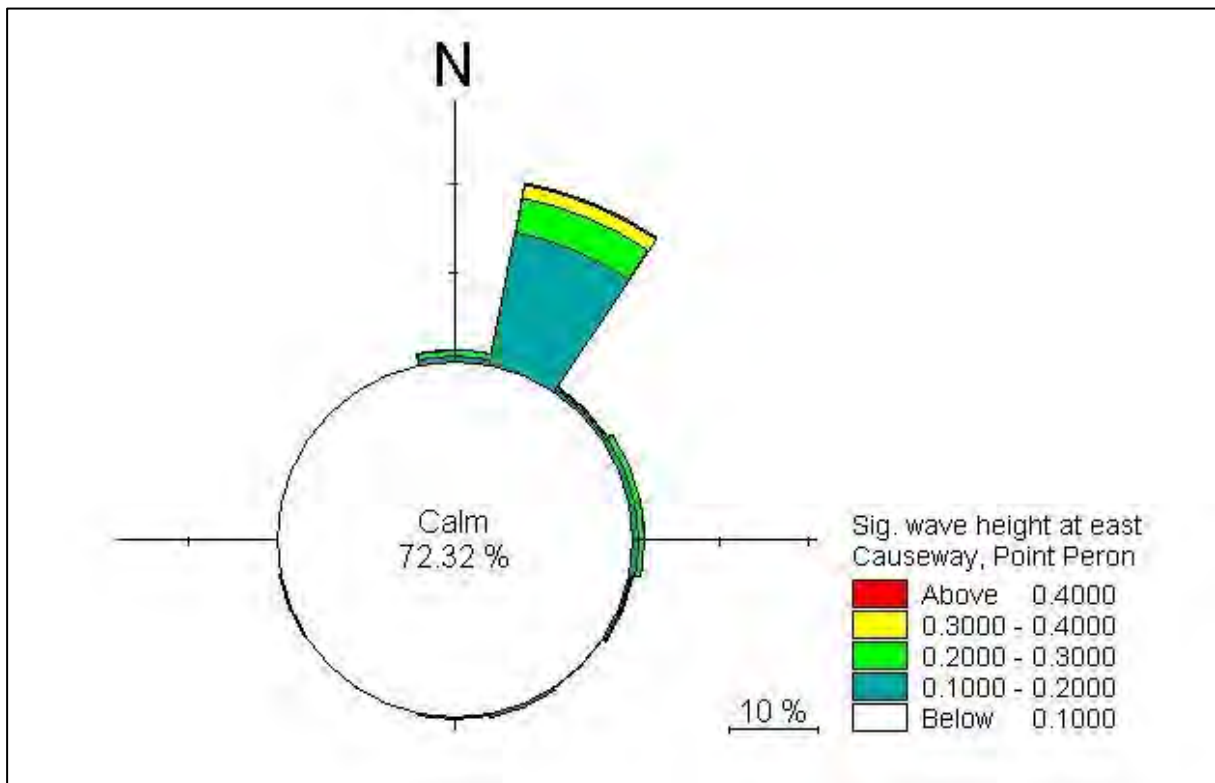


Figure 11: Wave rose displaying modelled wave height and direction at Point B

4.3 Water Levels

It is important to investigate water levels likely to occur at Point Peron, to understand the likelihood of coastal inundation of the camp school. Fremantle water levels are considered representative of water levels at Point Peron. Water levels are influenced by astronomical tides and non-tidal sea level fluctuations. Table 3 summarises the tidal planes for Fremantle. See Appendix 2 for a submergence curve summarising historic observed water levels and tidal planes at Fremantle.

Table 3: Tidal planes for Fremantle. These are considered representative of water levels at Point Peron.

Tidal Plane	Level Relative to Fremantle Chart Datum (m)
Highest Astronomical Tide (HAT)	1.34
Mean Higher High Water (MHHW)	0.96
Mean Lower High Water (MLHW)	0.78
Australian Height Datum (AHD)	0.76
Mean Sea Level (MSL)	0.75
Mean Higher Low Water (MHLW)	0.65
Mean Lower Low Water (MLLW)	0.53
Lowest Astronomical Tide (LAT)	0.20

During storm events, non-tidal sea level fluctuations raise local water levels above predicted astronomical tides. These sea level fluctuations include:

- 1) The inverse barometric pressure effect;
- 2) Wind set-up;
- 3) Large-scale sea level fluctuations such as El Nino;
- 4) Wave set-up, and;
- 5) Wave runup

When the predicted tide is subtracted from the observed water level the result is referred to as the water level "residual". Fluctuations 1, 2 and 3 occur over large spatial scales and are incorporated in the residual. Thus, the combined magnitude of these can be determined from water level residuals (Appendix 2).

Wave setup and wave run-up, however, occur locally at individual beaches and are governed by the characteristics of the incident storm waves and the local beach characteristics. Wave setup occurs due to incident waves "piling

up" water at the beach face. It contributes with sea level fluctuations 1, 2, and 3 to create a "mean water level" during the storm. Wave runup, however, is the result of individual waves literally running up the beach face for very short periods of time (seconds) and fluctuates greatly during a storm event.

Water level estimates for a storm event that is likely to occur approximately once a year during the spring tidal cycle have been calculated. Table 4 summarises the values used to estimate the water level components during a storm event. The storm mean water level is estimated as 0.9 mAHD. The height which wave runup is expected to reach during a storm event is 2.9 mAHD.

Table 4: Input data and water level components.

Input Data:	Value:	Comment:
Offshore wave height (H_o)	5 m	Review of Rottnest wave buoy data set.
Offshore wave period (T_o)	13 sec	Review of Rottnest wave buoy data set.
Nearshore breaking wave height (H_b)	0.75 m	Estimate taken from Figure 9
Beach slope	0.016	Average of beach profile survey data (DPI 690-13-1)
Factors:	Value:	Reference:
Fremantle MHHW	0.96 mCD	Appendix 2
Water level residual	0.5 m	Reviewed Fremantle tide gauge data set.

Wave set-up	0.2 m	Equation 3.4 (CIRIA, 1996)
Storm mean water level	1.66 mCD = 0.9 mAHD	AHD is 0.76 m above Chart Datum
Wave runup	2.0 m	Equations II-4-29 and II-4-1 (USACE, 2003).
Storm maximum water level	3.66 mCD = 2.9 mAHD	Wave runup is included. AHD is 0.76 m above Chart Datum.

The entire camp school is below 5 mAHD (Figure 12). A brief field survey was conducted of the oval in May 2009, indicating that the approximate average height of the oval is 1.3 mAHD. The implication of these results is that during a reasonably energetic storm (likely to occur approximately once per year) water levels will reach 0.9 mAHD (estimated storm mean water level) which are likely to erode the dune buffer, but unlikely to inundate the oval. The runup height of individual waves during a storm event (2.9 mAHD), however, is likely to cause inundation of the seaward edge of the oval and further accelerate erosion.



Figure 12: Contours around Point Peron camp school and oval (elevation in metres above AHD) Source: DoT (Spatial Information section)

5 Coastal Processes

5.1 Sediment Transport

A brief desktop analysis has been conducted for sediment transport along the study area, Cockburn Sound and Mangles Bay (refer to Figure 8 & 13). Sediment transport was based upon expected predictions of wave patterns and estimated sediment transport volumes.

Study Area:

Sediment is transported east along the coast in the study area. This is likely due to swell waves from the south west which arrive throughout the year and wrap around the cape (Figures 8 & 10). South-south westerly summer sea waves and winter storm waves are also likely to wrap around the cape. The Causeway blocks any waves from the east and therefore inhibits sediment moving to the west.

Based on estimated excavation volumes at the sand trap (Table 2), the annual net sediment transport is in the order of 10,000m³ to the east (Figure 13).

Mangles Bay:

Sediment is transported southwards along the eastern edge of Cockburn Sound into Mangles Bay (Figure 13). South-westerly swell waves may wrap around the north of Garden Island and travel south into Mangles Bay. Winter sea (wind) waves from the north west also travel around the north of Garden Island and move into Mangles Bay. During summer there is unlikely to be sufficient fetch to generate sea waves from south-south westerly winds which are capable of moving significant amounts of sediment northwards. The annual net sediment transport is approximately 4,000m³ to the south (DPI, 2004).

Historical Sediment Movement:

Before the Garden Island Causeway was constructed, sediment transport along the study area would have been predominantly to the east, but with a possible reversal during summer from easterly wind conditions produced by morning sea breezes. Within Mangles Bay, sediment would have also been travelling eastwards and this movement would have been generated from swell waves and afternoon south-south westerly summer sea breezes travelling to the east between Garden Island and the mainland.

A section of beach slightly to the east of the oval's path has undergone some dramatic changes between 1951 and 1993 (Appendix 3). In 1951, there is a clear accumulation of sand that has formed onshore and extends

offshore. Comparisons between the 1942 and 1951 vegetation lines show that approximately 65 metres of coastline had accreted in that particular section. By 1954, this section of coast had eroded and this process continued until 1967 when it began to accrete again. This is evident from the formation of two small sand islands near the shoreline. In 1971, a significant sand bank had formed and this was moving to the west (1975 photograph). In this 4 year period, the Garden Island Causeway was constructed. By 1983 the sand bank had disappeared and a salient had formed on the beach near the camp school.



Figure 13: Sediment transport in the study area and Cockburn Sound. NB: Rates are approximate (source: Google maps)

5.2 Sediment Sources

A geological survey of Rockingham in 1985 (Appendix 6) revealed sediment in the Point Peron area is primarily sand formed from shell debris from marine animals, Tamala limestone and quartz transported from the land.

On the 27th of February 2009, six sand samples were collected from along the study site (Figure 14). Sand was collected 15 cm below the beach surface within the intertidal zone. These samples were then analysed under a microscope and the contents were examined. Table 5 summarises the contents of each sand sample, location collected and the approximate percentages of biogenic (e.g. mollusc shells, sponge spicules) and non-biogenic (e.g. quartz). The majority of each sand sample contained non-biogenic material such as quartz, feldspar and limestone. Appendix 4 displays a photograph of each sand sample taken under a microscope at 10 X magnification.



Figure 14: Location of sand samples collected

The contents of the sand samples suggest that the sources of sediments are from the offshore submarine limestone reef that extends from the south of Point Peron northwards. The sediments are pale yellow and brown quartz with traces of feldspar. There is a small amount of calcium carbonate from shell debris (Appendix 4).

Table 5: Percentage of Biogenic and Non-Biogenic material for each sand sample

Sample	Location	Biogenic %	Non- Biogenic %
1	Near dual-use path	<5%	>95%
2	Dune east of path	~30%	~70%
3	In front of oval path	~10%	~90%
4	West of sand trap	~10%	~90%
5	Sand trap (before excavation)	~5%	~95%
6	Hymus Street (east of Causeway)	~25%	~75%



Figure 15: The contents of sand sample 4

6 Shoreline Movement History

Aerial photographs have been analysed from 18 years between 1942 and 2008 (66 years) for shoreline movement along the Point Peron coast. 1942 was the earliest available aerial photograph and this was captured by the Australian Army. Using 1942 as a baseline data source, the vegetation lines for the remaining 17 aerial photos were plotted and contrasted against the 1942 vegetation line (Appendix 5) by gaining measurements from twenty cross-section lines that were 50 metres apart (Figure 16). These changes were then illustrated onto several graphs to gain a visual representation of historical shoreline movement (Figure 17 & 19). The study section of coastline extended from the rocky cape to the sand trap which is approximately 950 metres (Figure 16). A smaller section of coast was studied in further detail as this included the dual-use path and the oval which are areas of particular concern (Figure 18). This 300 metre segment (chainage 200 - 500 m) was divided into 13 cross-sections that were 25 metres apart.

The study area was divided into two sections, a western (chainage 0 - 400m) and an eastern side (chainage 450 - 950m) due to the different changes that have occurred in each over the 66 year period. Figure 20 displays a graph of the average changes for both sides. Average changes for each year were calculated by averaging the distance between the 1942 vegetation line and the year of interest for each of the 50 m cross-section lines. The Garden Island Causeway (1971-1973) appears to have had an impact on both the western (0-400 m) and eastern (450-950 m) sections of the shoreline. Prior to the Causeway, 4 years recorded between 1963 and 1971 showed signs of a dynamically stable shoreline on both sides (eastern and western). Both sides began to accrete after the causeway was built. The 4 year period between 1971 and 1975 saw an accumulation of approximately 31 and 14 metres for the western and eastern locations respectively. From 1975 onwards, the western side has been generally eroding whilst the eastern side has been steadily accumulating, with 45 m accretion from 1993 to 1998. Between 1998 and 2008, the beach in the western section (0 - 400 m) has retreated approximately 25 metres.

The shoreline along the study section is likely to still be adjusting to the presence of the Garden Island Causeway. Before the Causeway, there was wave action from the west and the east. Since the Causeway's construction, waves from the east have been limited. Waves from the west are now the sole driver of longshore sediment transport. The original sand trap groyne that was constructed during the same period as the Causeway, provided shelter for the boat launching facility from sedimentation. Sand accumulated on its western side until the groyne was "saturated". Between 1986 and 1990, 2 extensions were constructed. The structure was again saturated with sediment, hence annual excavation works at the sand trap.

However, the western side is still adjusting and this involves realigning with the shoreline on the eastern side. This process of realignment is likely to be a significant driver of the erosion in the western half of the study area.

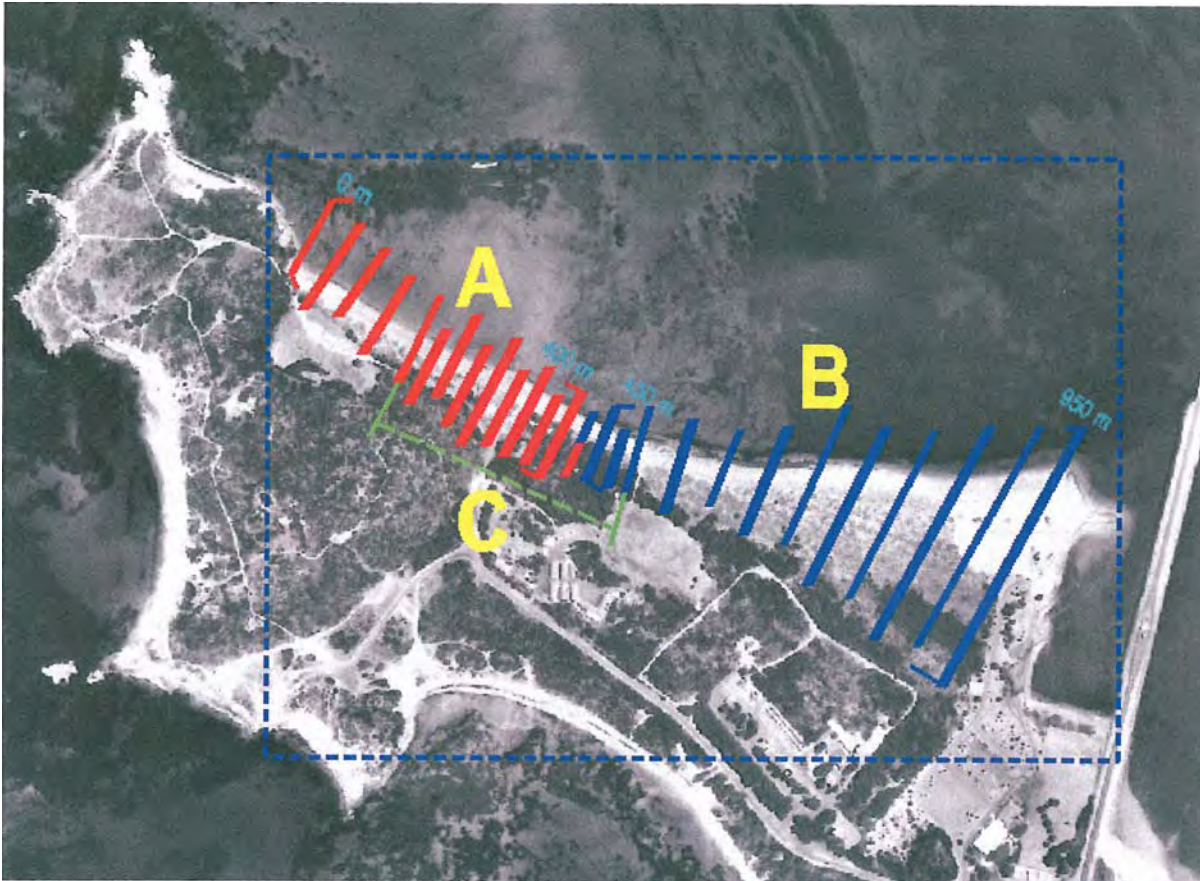


Figure 16: The study area at Point Peron (A: Western side; B: Eastern side; C: Dual-use path to oval) - 1998 photograph

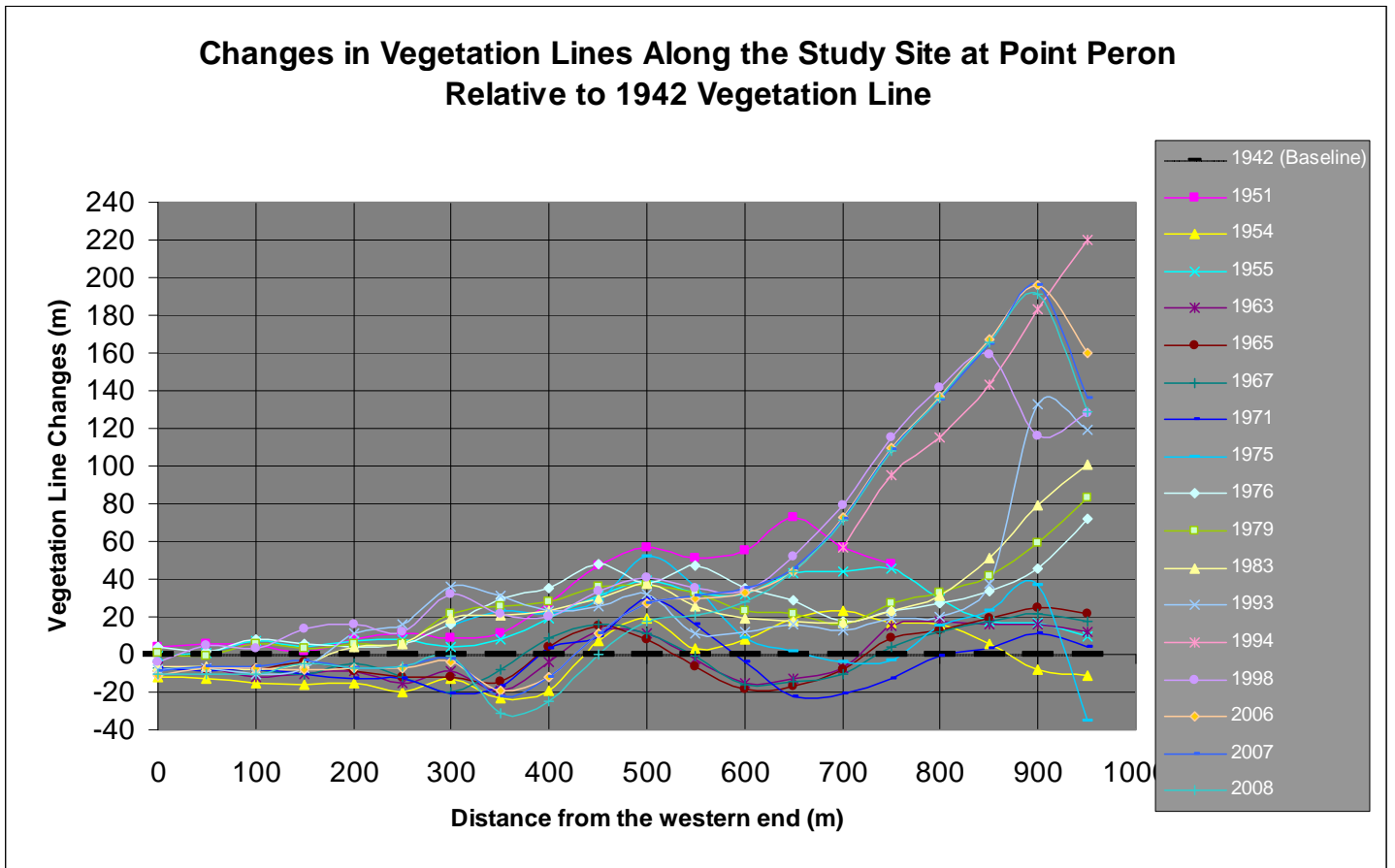


Figure 17: Changes in vegetation lines along the study area (from west to east) over a 66 year period for profiles 50 m apart

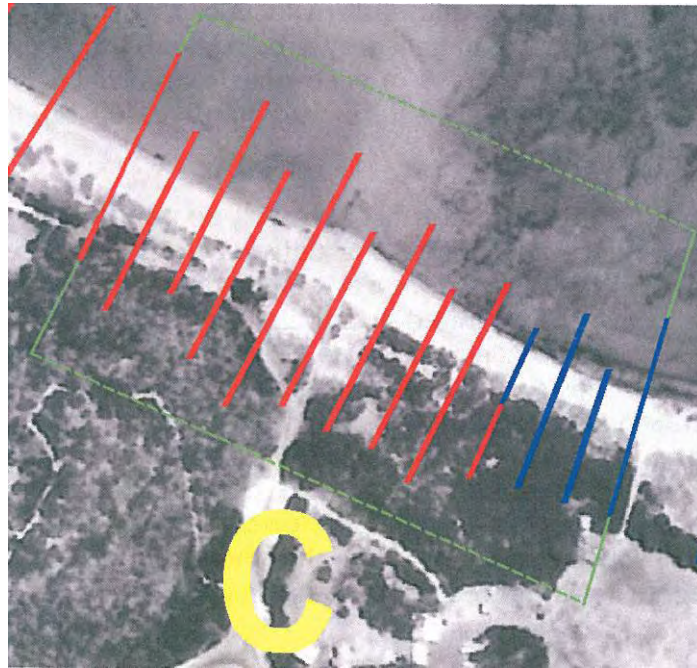


Figure 18: 25 m profiles of the coast between the dual-use path and oval

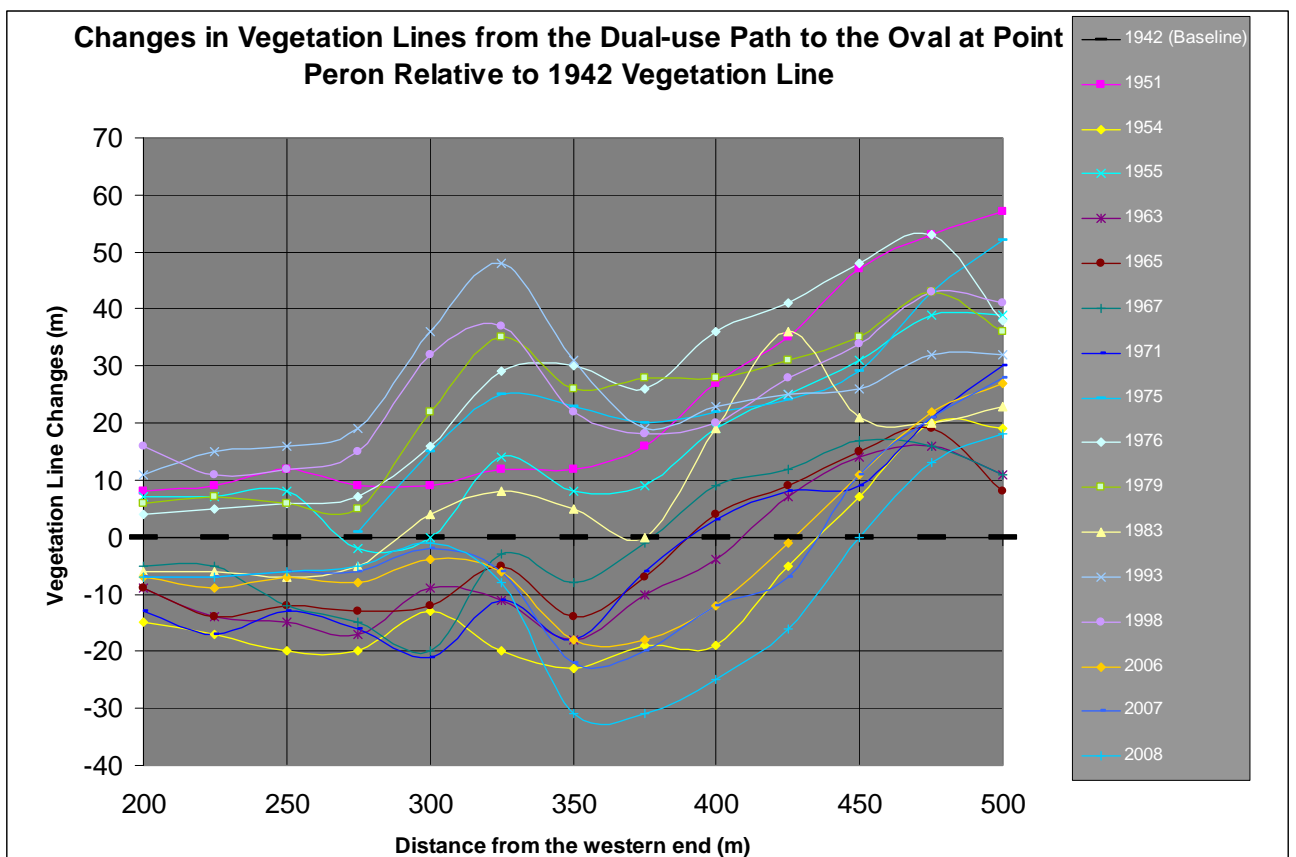


Figure 19: Changes in vegetation lines between the dual-use path and the oval over a 66 year period for profiles 25 m apart

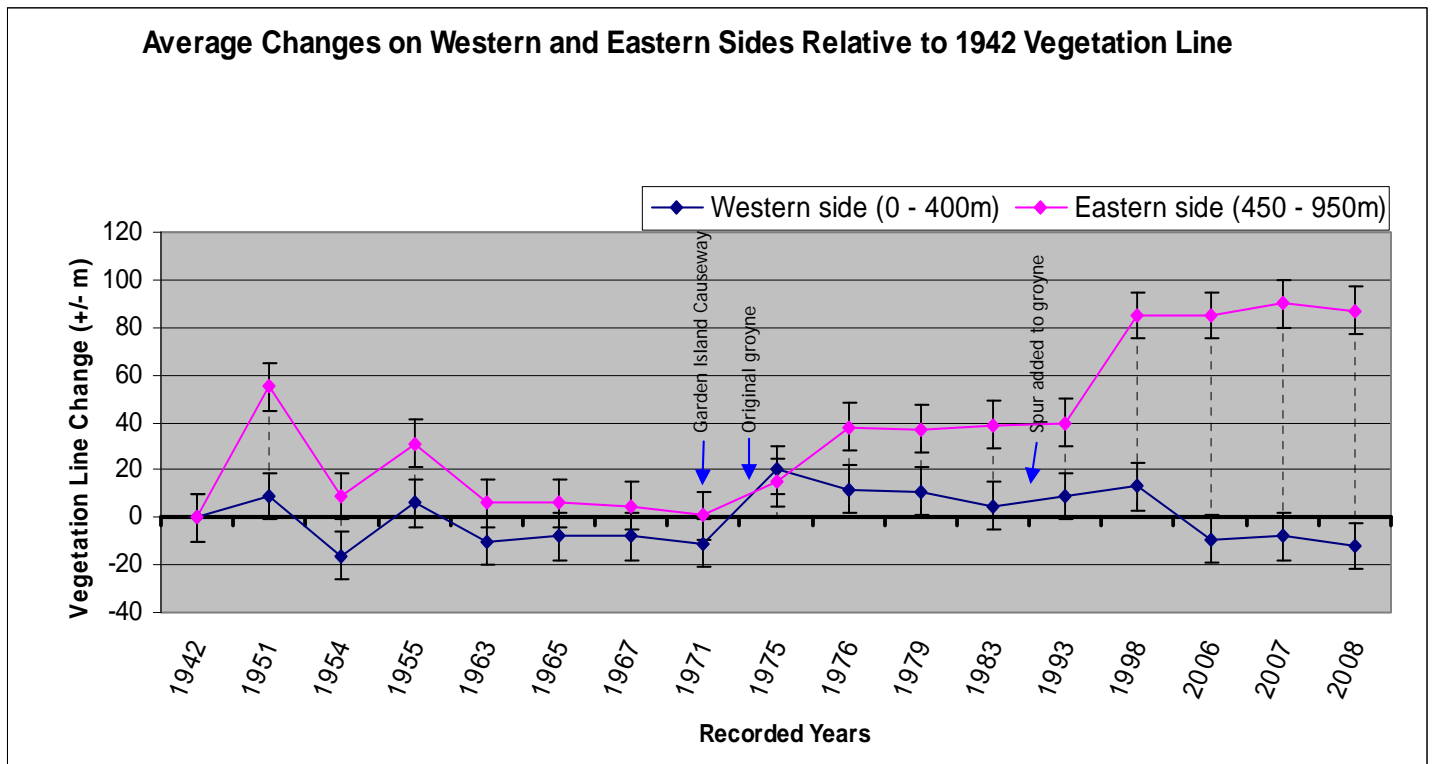


Figure 20: Average changes on each side of the study area (western and eastern) during the 66 year period (Estimated error is ± 10 m)

7 Discussion

Over the last decade, mass accretion of the beach towards the eastern half of the study area has been occurring while the western half of the beach has been eroding. In recent years, there has been some concern over erosion issues that have developed in the study area. In particular, the coast between the dual-use path and oval has experienced erosion.

The Causeway has impacted greatly on the sediment transport throughout Cockburn Sound. The impacts of the Causeway can be clearly seen in Figure 20 (average changes). The Causeway was constructed between 1971 and 1973 and during this time the shoreline in the western half of the study area began to change.

Vegetation lines for the 17 recorded years were plotted against the 1942 vegetation line. From this information, years of accretion and erosion can be tracked. Between 1971 and 1975, there was found to be an accretion of 31 metres on the western side and 14 metres on the eastern side of the study area. The recorded years from 1975 onwards show that the eastern section has been steadily accreting, especially between 1993 and 1998 (45 m). The western side has generally been eroding since 1975 onwards with the most erosion occurring between 1998 and 2008 (25 m).

Over the last decade the study area has experienced on average, 2.5 metres of erosion per year. The oval is currently approximately 25 metres away from the vegetation line and is less than five metres above AHD (Figure 12). If the recent erosion rate continues, then the oval could be subject to erosion in 10 years. During energetic storm events elevated water levels may cause the oval to inundate sooner. The mean storm water level is estimated to be approximately 0.9 mAHD. Under these conditions, significant erosion of the dune buffer is expected. The runup height of individual waves during a storm event (2.9 mAHD) is likely to cause inundation of the seaward edge of the oval and further accelerate erosion.

The seawall that protects the dual-use path is currently in poor condition and if it is not maintained or upgraded, then it will eventually collapse due to erosion of the beach surrounding its structure.

Sand trap excavation works that began during the early 1990's involved removal of sand from the sand trap which was built in 1990. These works are essential in preventing sedimentation of the boat launching facility. It is unlikely these works have been the cause of erosion to the west.

If the current situation were to continue, then the western side of the beach will continue to erode, while the eastern side will remain stable, unless excavation works are increased above the natural sediment rate over the coming years. Eventually the shore will reach a stable alignment.

However, this could be after a significant amount of erosion on the western side of the study area, between the dual-use path and the section of beach in front of the camp school and oval.

Further expensive numerical modelling, could assist in predicting how much further erosion of the western side of the study area is likely.

8 Possible Solutions

Following analysis of the problem and investigation into the likely causes, a list of options to improve the situation is provided below.

Option 1 - Continue current management plan (including controlled retreat):

Currently, approximately 10,000m³ of sand is removed from the sand trap on an annual basis. The timing and extraction volumes during the year depend on how full the sand trap is. Typically sand is removed twice a year in two 5,000m³ extractions. Excavated sand is stockpiled on site and then trucked to nearby beaches that require annual renourishing. This course of action will minimise sedimentation at the mouth of the boat launching facility.

Erosion along the western side of the study area is likely to continue as the shoreline is still adjusting to the Causeway. A controlled retreat along the western side would allow erosion to continue until the shoreline reaches a stable form. This process of shoreline stability will most likely involve the partial loss of the dual-use path and dune in front of the camp school. Therefore the dual-use path would need to be relocated, however due to the nature of the terrain, large earthworks and vegetation removal will be required. Closure of the dual-use path will prevent access to a popular tourist and fire access area. Due to recent years of seawater inundation, the oval's size may need to be reduced to increase its distance from the beach.

Option 2 - Beach renourishment in front of camp school:

The sand dune that extends along the coast in front of the camp school facilities could be artificially nourished with sand to help protect infrastructure and vegetation behind it. Excavated sand from the sand trap could be used to nourish the dune. This sand would be used as sacrificial sand. Reduced erosion of the original dune would be expected and therefore oval facilities and dune vegetation would be protected for a period of time. However, there will be no benefit to the seawall and the dual-use path. This may increase the frequency and volume of excavation works required at the sand trap. If this option is implemented, it is recommended that the dune be nourished in autumn to provide protection from winter storms.

Option 3 - Renourishment of seawall:

Some of the excavated sand from the trap could be used to renourish the eroding area around the seawall. This should be carried out on an as-required basis. It is unlikely that this will provide sufficient protection to the beach in front of the camp school and oval. It may also increase the frequency and volume of excavation works required at the sand trap.

Option 4 - Reconstruct seawall:

It is likely the seawall was not a formally designed structure, instead rocks were simply deposited along the edge of the path to help protect it. The seawall's current condition is poor and therefore an engineered seawall would have a greater influence in protecting the dual-use path from further erosion. Reconstruction of the seawall will require new rock and use of existing rock to provide sufficient protection along the path. It is likely that a small section of beach on the eastern side of the seawall will experience accelerated erosion caused by waves reflecting off the seawall. Depending on the width of the seawall, sand might initially accumulate on the western side of the seawall and may exaggerate erosion on the other side. Ongoing maintenance of the structure will be required. The seawall will need to be redesigned by a suitably qualified coastal engineer.

Option 5 - Construction of a small groyne or offshore breakwater:

A groyne constructed to the east of the oval path would allow for the build up of sand to the west of it. The beach in front of the oval and camp school will gain protection from erosion due to the sand accumulated from the groyne. An offshore breakwater will have a similar effect with sand building up behind its structure but is a more expensive option. Construction of a groyne or breakwater will also require ongoing maintenance. It is unlikely that sand would accumulate as far west as the dual-use path as this area protrudes out. Therefore it is likely that the seawall and dual-use path will not be protected by either structure.

Option 6 - Alter current sand trap:

An extension towards the north-west would allow for a slightly greater sand trap capacity. It could also reduce the frequency of sand trap excavation works as it would take longer to reach full capacity, however, volumes removed would not be reduced. Accumulation of sand in the trap would be unlikely to extend west to the eroding beaches. Therefore this option will not resolve erosion to the west. It is likely that the sand trap extension would provide slightly more protection to the boat launching facility from sedimentation. By lengthening the sand trap, it would be encroaching on the near-by protected seagrass habitat.

Table 6: Options summary table

Option	Description of Works	Advantages	Disadvantages
1	Annual excavation of 10,000m ³ from sand trap when full (inc. controlled retreat)	<ul style="list-style-type: none"> Minimises sedimentation of boat launching facility. Excavated sand renourishes beaches elsewhere. 	<ul style="list-style-type: none"> Erosion of the western side of the study area is likely to continue. Controlled retreat will involve the potential loss of the dual-use path/seawall, foredune and part of the oval.
2	Beach renourishment in front of camp school	<ul style="list-style-type: none"> Provides short term protection to foredune/vegetation, camp school/oval from erosion. 	<ul style="list-style-type: none"> Will not provide protection from erosion to seawall/dual-use path.
3	Renourishment of seawall	<ul style="list-style-type: none"> Provides short term protection to the seawall/dual-use path. 	<ul style="list-style-type: none"> Unlikely to protect the beach in front of the camp school/oval.
4	Reconstruction of seawall	<ul style="list-style-type: none"> Provides adequate protection to the dual-use path. Could initially accumulate sand to the west of the structure. 	<ul style="list-style-type: none"> Accelerated erosion immediately east of the seawall could be experienced. Unlikely to reduce erosion at the beach in front of the camp school/oval. Ongoing maintenance required.
5	Construction of a small groyne or offshore breakwater	<ul style="list-style-type: none"> Beach in front of camp school/oval will gain protection due to sand build up (west of groyne; behind breakwater). 	<ul style="list-style-type: none"> Unlikely to protect seawall/dual-use path. Ongoing maintenance required.
6	Alter current sand trap	<ul style="list-style-type: none"> Slightly greater sand trap capacity, therefore further reduction of sedimentation to boat launching facility. Could reduce frequency of excavation works at sand trap. 	<ul style="list-style-type: none"> Unlikely to benefit eroding beach to the west and seawall/dual-use path.

Table 6 indicates that many of the options provide protection to either the dual-use path and seawall or the oval and camp school, however, there is no single option that protects all assets. Therefore, a combination of options may be more suitable and effective in addressing protection of the camp school facilities, dual-use path, seawall and the boat launching facility.

9 Recommendations

Excavation of approximately 10,000 m³ per year (dependant on the sediment transport rate each year) from the sand trap will be an ongoing process. Sand is removed once the sand trap is near full capacity to prevent sedimentation of the boat launching facility. Removed sand should continue to be used to renourish eroding beaches in the region.

Undertaking regular monitoring of the site will help to gain better knowledge and understanding of sediment transport along this section of coast. By implementing the following recommendations, this information can be obtained.

1. The City of Rockingham (CoR) should record excavation volumes (cubic metres) and dates and provide a copy of these to the DoT within two months of excavation works.
2. Monthly field photographs at set locations along the Point Peron coast should be taken by either the CoR, DEC or the camp school. A copy of photographs should be provided to the DoT. A review of the period between photographs should be conducted after six months to ensure that it is appropriate. Example photographs are attached (Appendix 7).
3. A baseline survey of the area be conducted immediately and then after a two year period, a review of the situation should be carried out to determine whether it has improved or deteriorated. This will involve a hydrographic and beach survey of Point Peron. DoT will conduct the surveys subject to the availability of personnel and resources. The DoT will provide a copy of surveys to the CoR and will keep a copy on record.
4. The DEC should continue to seek coastal engineering advice from the DoT. DoT could also provide up to 50% grant funding for coastal protection works under the Western Australian Coastal Protection Policy.

10 References

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11 Appendix One - Aerial photographs of coastal infrastructure

Before the Garden Island Causeway (1971)



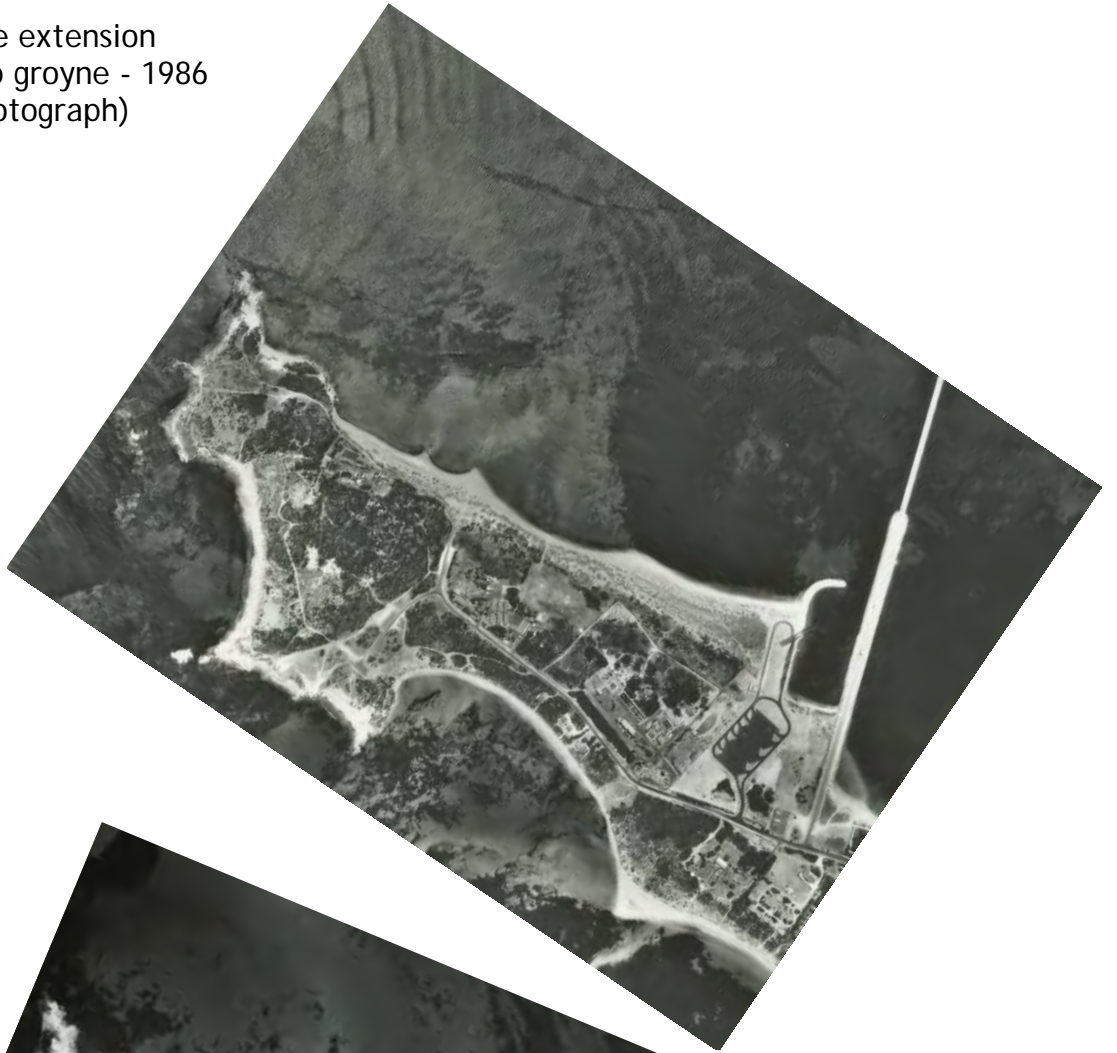
Right: Original sand trap groyne west of the Causeway - 1973 (1975 photograph)



Below: Original sand trap groyne (1983 photograph)

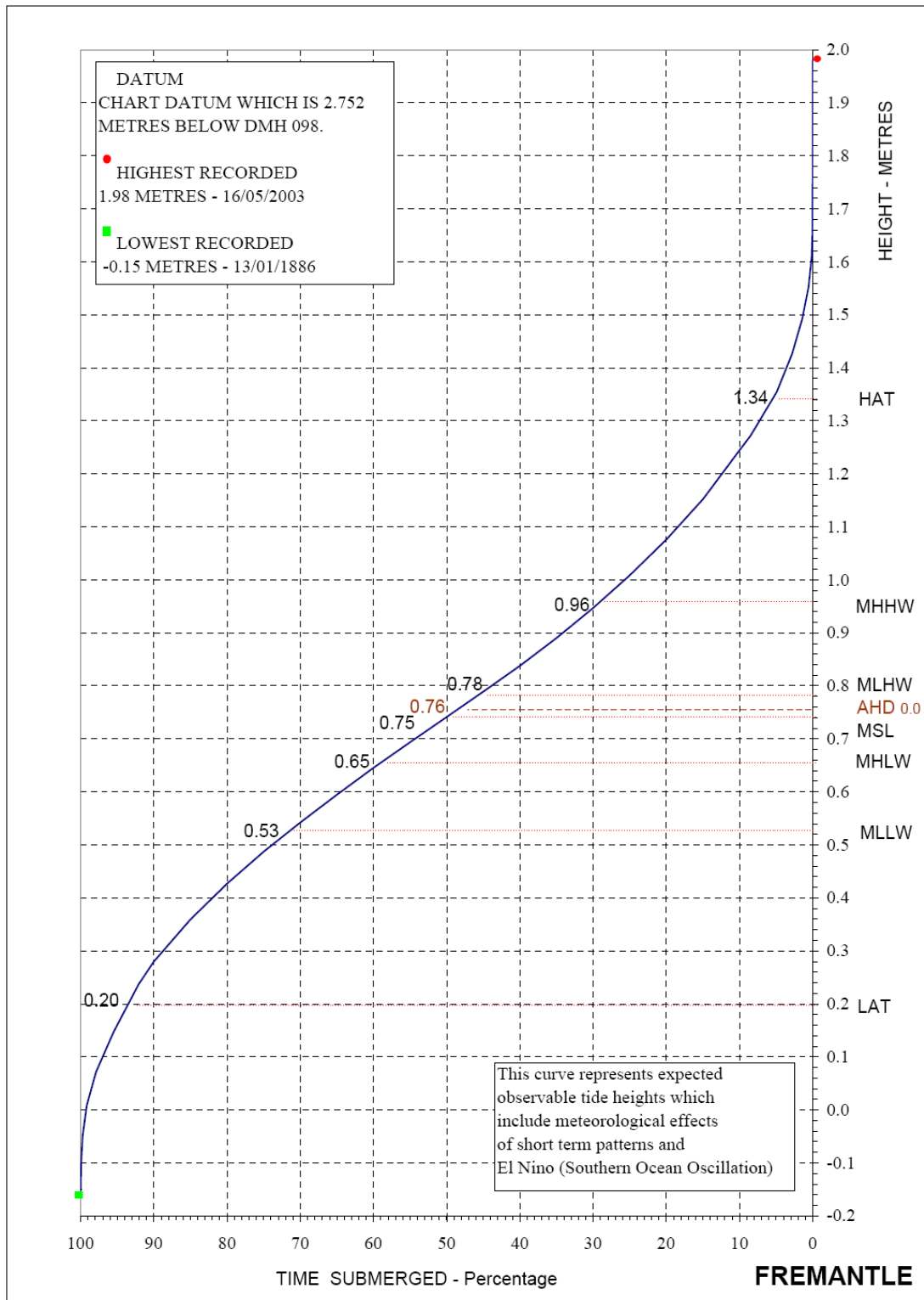


90 degree extension
Sand trap groyne - 1986
(1987 photograph)



Spur added to sand
trap groyne - 1990
(1996 photograph)

12 Appendix Two - Fremantle submergence curve



DEPARTMENT FOR PLANNING AND INFRASTRUCTURE - WA
 Tides and Waves Section
 DOT 696-33-01 B 22 March 2004

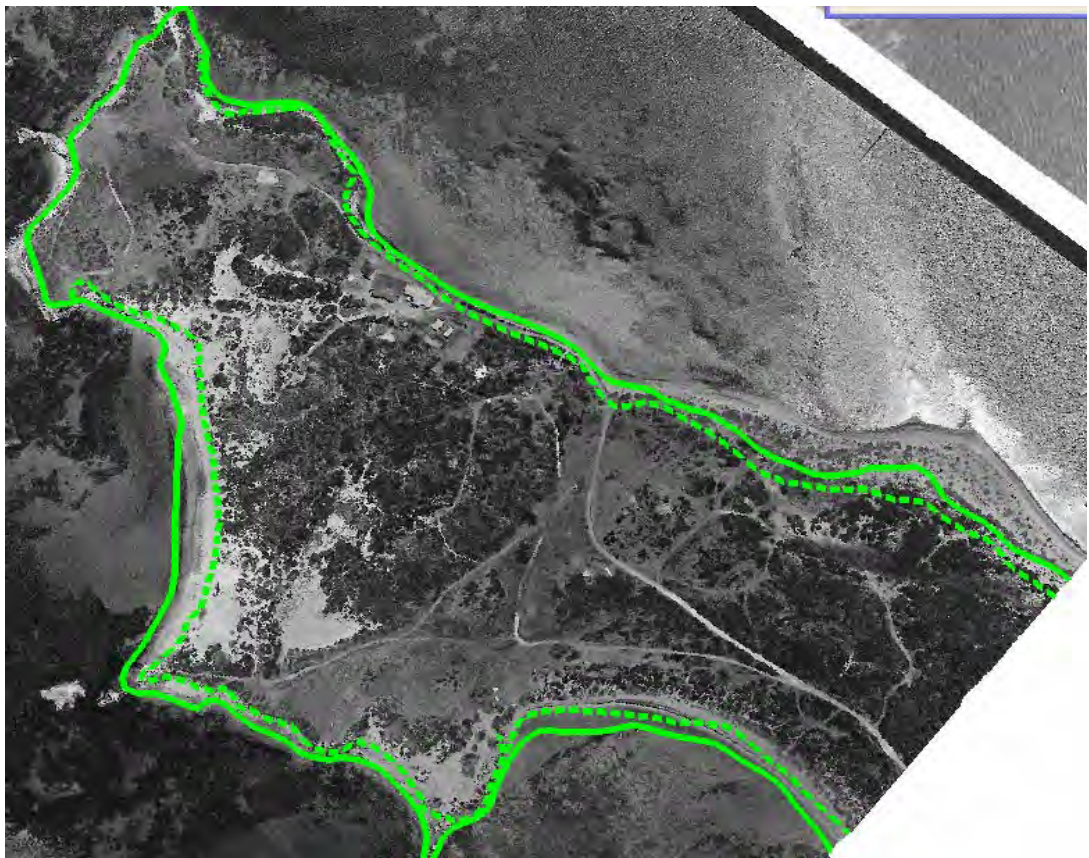
COPYRIGHT
 SUBMERGENCE CURVE

13 Appendix Three - Shoreline movement

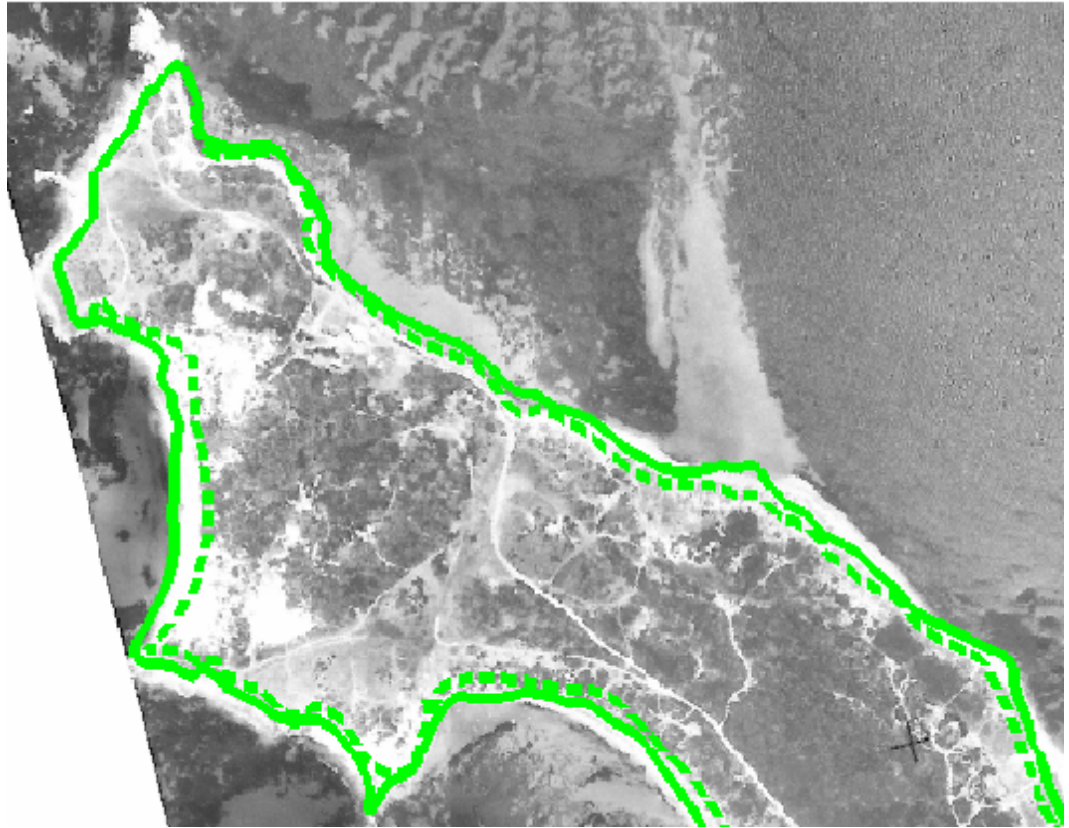
—— 1942 Waterline

- - - - 1942 Vegetation line

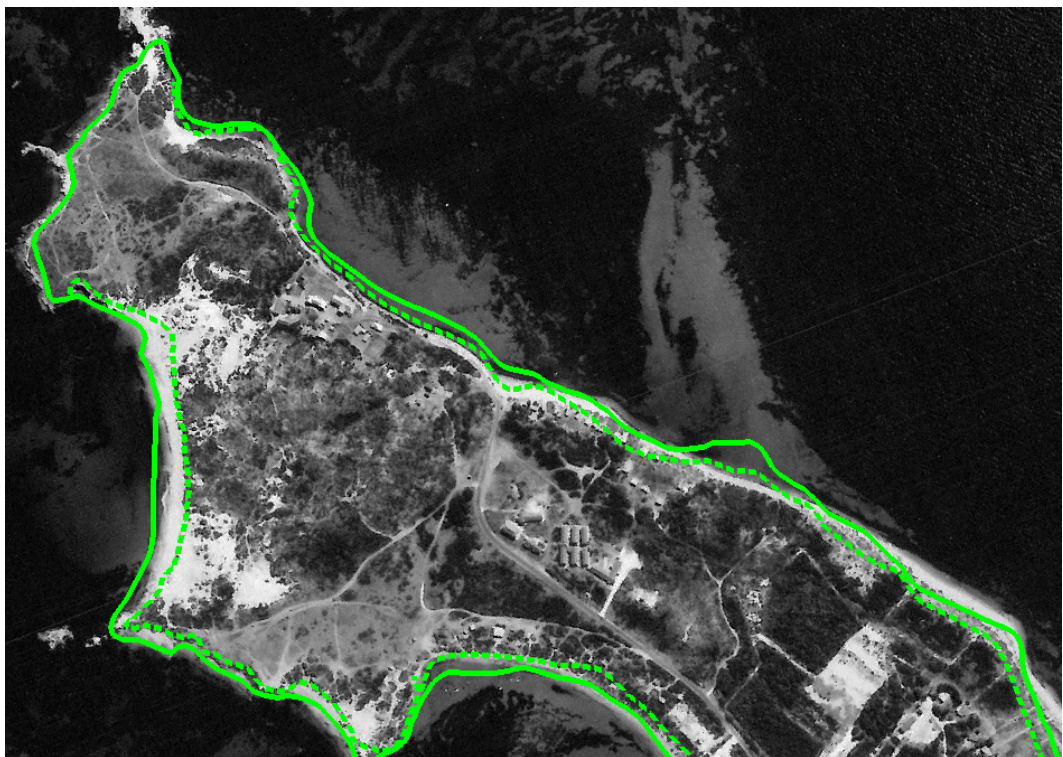
1951



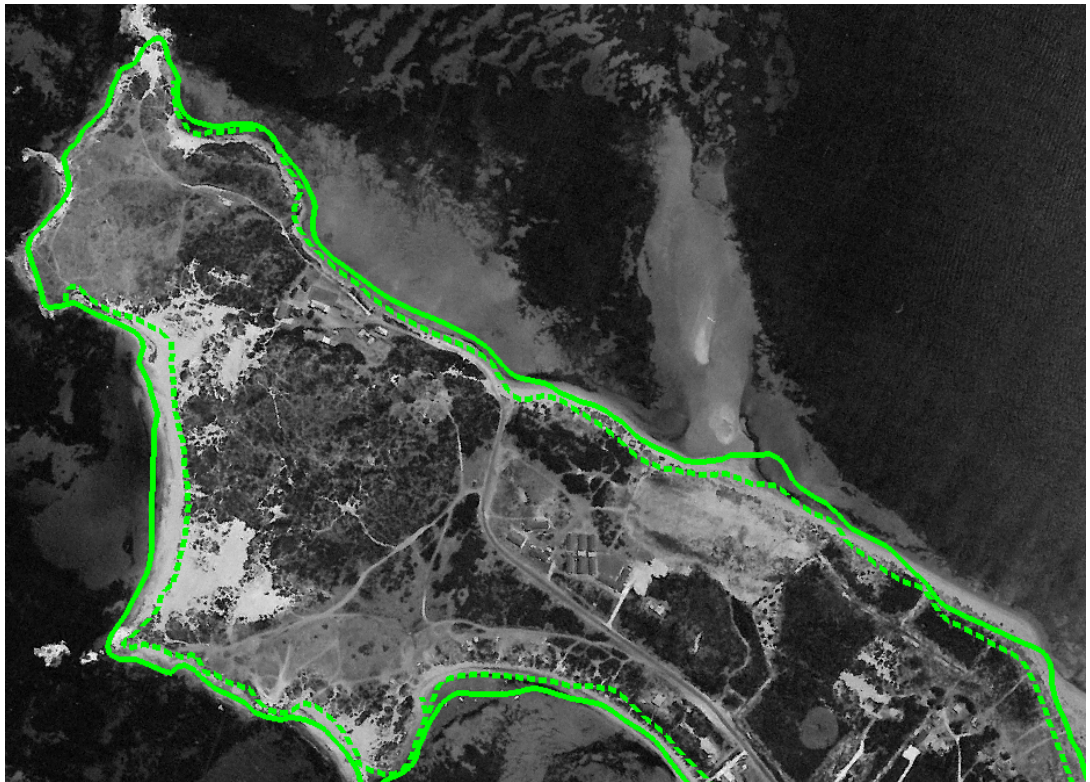
1954



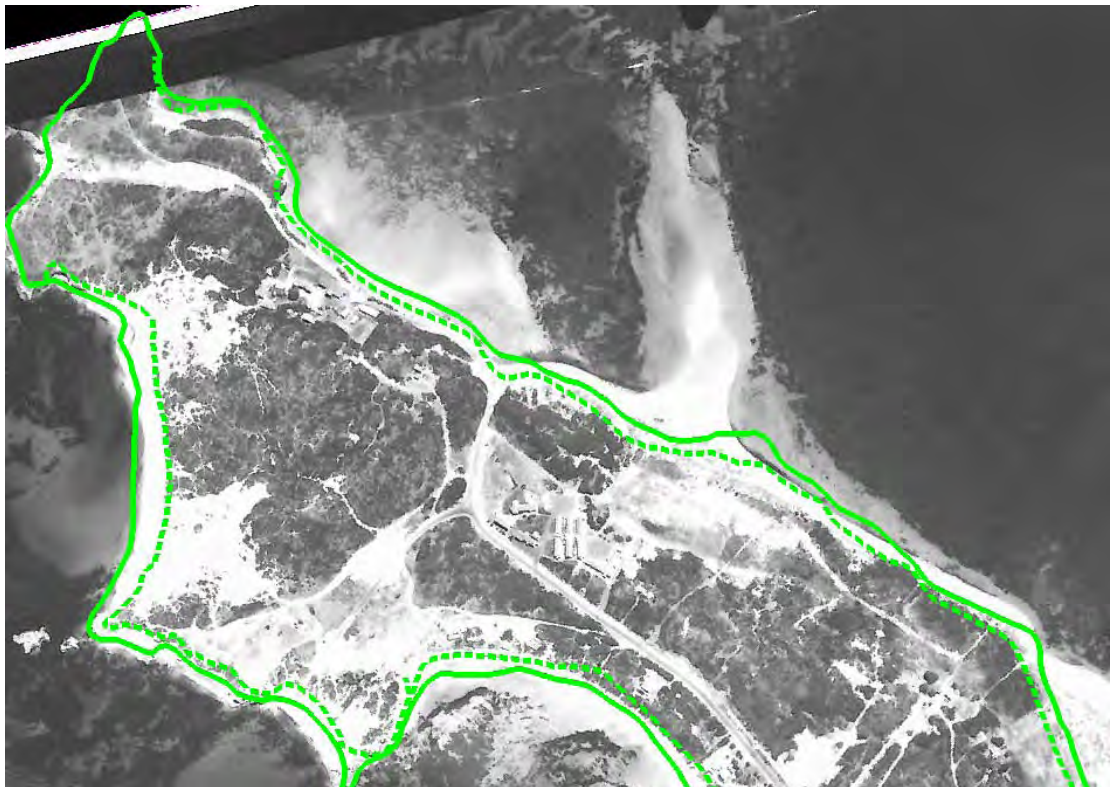
1963



1967



1971



1975



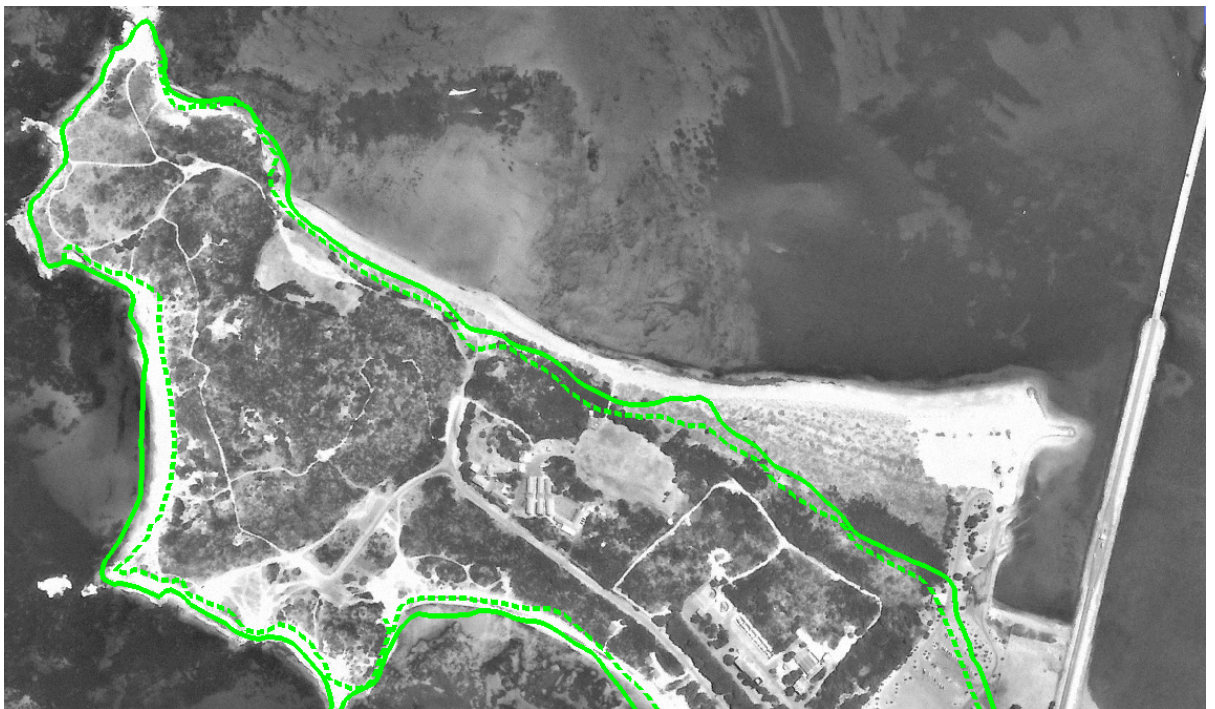
1983



1993



1998



14 Appendix Four - Collected sand samples



Sample 1



Sample 2



Sample 3



Sample 4

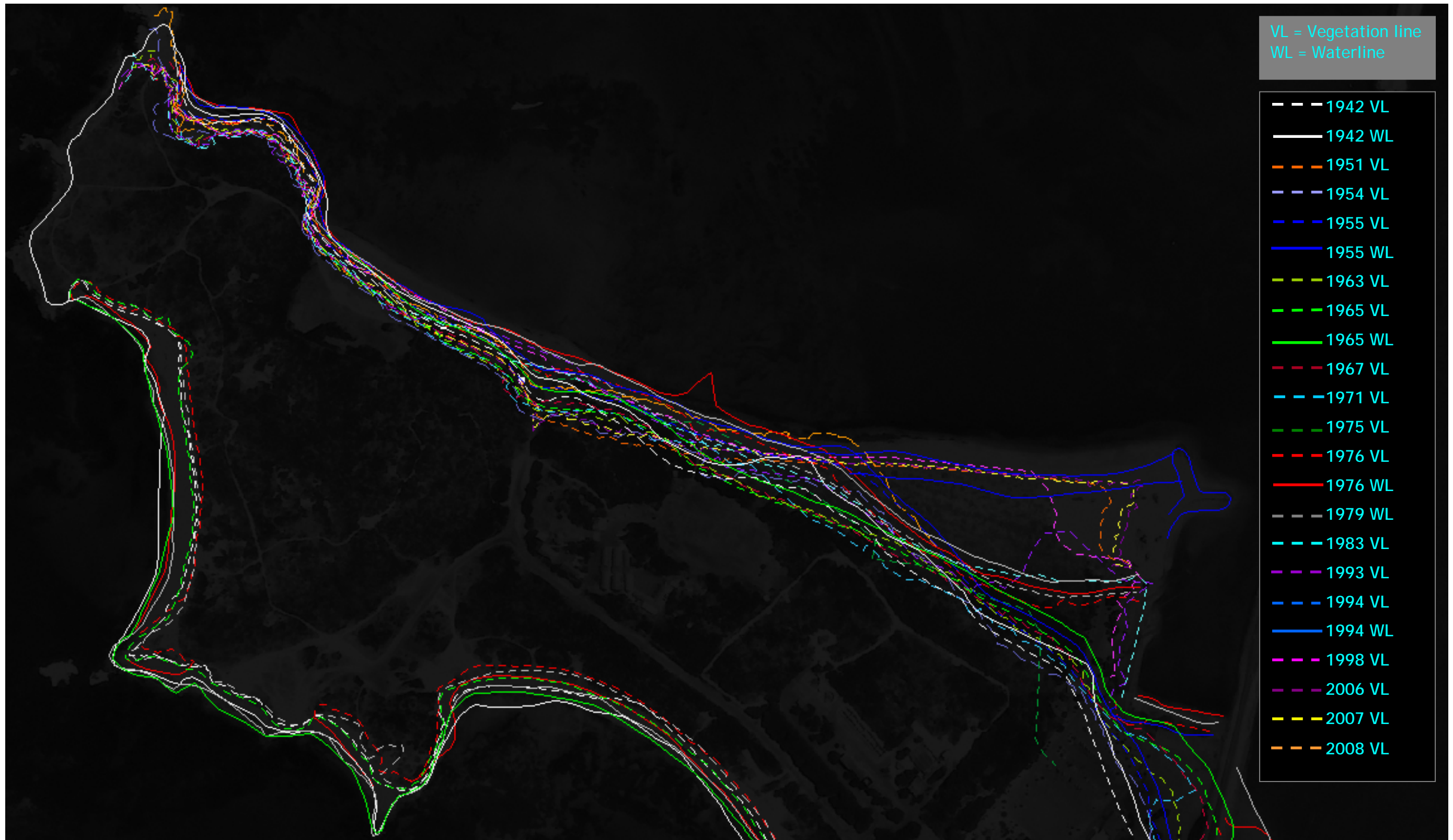


Sample 5



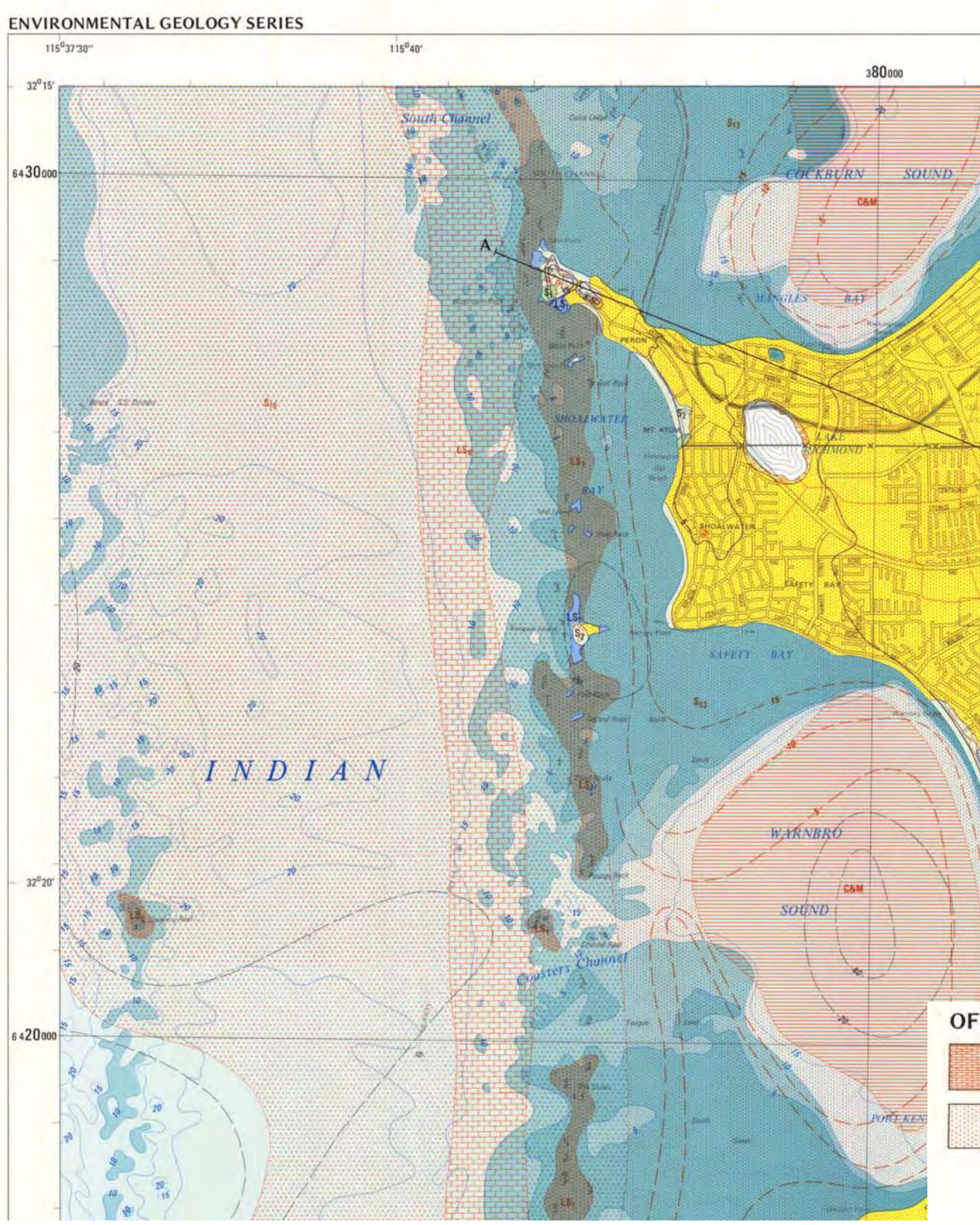
Sample 6

15 Appendix Five - Vegetation lines for each recorded year



16 Appendix Six - Geological survey of Rockingham (1985)

PART OF SHEETS 2033 II AND 2033 III



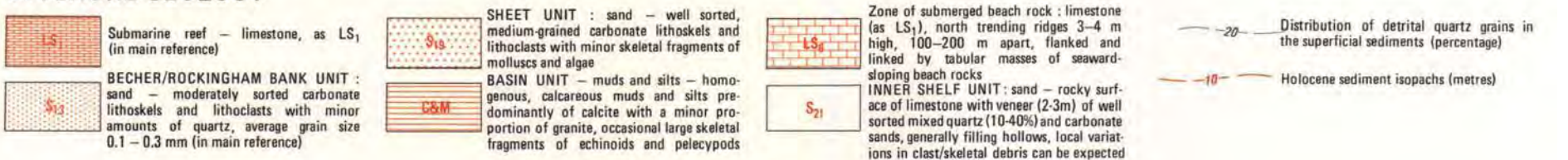
GENERAL FEATURES		PHYSICAL PROPERTIES							CURRENT PROCESSES	SUITABILITY FOR SPECIFIED LAND USES					NOTES			
Map Unit	Description	Equivalent unit on geological maps	Relief; slope	Rock-mineral resources	Permeability	Corrosion potential	Slope stability	Ease of excavation		Shrink-swell potential	Bearing capacity	SMC ⁷	Solid waste disposal	Liquid waste disposal		Septic tanks	Construction of roads	Urbanisation (mining and quarrying)
U ₁	SANDY CLAY - dark grey to black, firm, variable quartz sand content, occasionally some silt in matrix, of lacustrine origin	Swamp deposits	5 m; F	Diatomite, sand	L	M	L	H	M-H	L	CI-CH	Flooding	✗	✗	✗	✗	✗	High water table, prone to flooding, clayey soils of low bearing capacity
C ₁	PEATY CLAY - dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin	(Qhw)	5-15 m; F	Peat, diatomite	L	M-H	L	H	M-H	L	OH-CH	Flooding	✗	✗	✗	✗	✗	High water table, prone to flooding, low bearing capacity, differential settlement may occur, most materials are compressible
M ₁	SANDY SILT - dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin		6 m; F	Sand, diatomite	L	L-M	L	H	L	L-M	ML	Flooding	✗	✗	✗	✗	✗	High water table, prone to flooding, differential settlement may occur
S ₁	CLAYEY SAND - black, fine to medium-grained sand with clay matrix, variable organic matter, of lacustrine origin	Safety Bay Sand (mobile dunes) (Qhm)	3 m; F	Sand	M	L-M	L	H	L	L-M	SW	Flooding	✗	✗	✗	✗	✗	High water table, prone to flooding, differential settlement of foundations may occur
S ₂	CALCAREOUS SAND - white, fine to medium-grained, sub-rounded quartz and shell debris, of eolian origin		0-15 m; M	Limesand	H	L-M	L	H	N/A	L	SP-SW	Wind transportation	✗	✗	✗	✗	✗	Active blowouts and sand sheets, unvegetated, high lime content gives it considerable potential for fixing certain kinds of waste, like dissolved heavy metals, and neutralising acids, low bearing capacity, settlement is common and can be uneven
S ₃	CALCAREOUS SAND - as S ₂		5-40 m; M-S	Limesand	H	L-M	L	H	N/A	L	SP-SW	Wind transportation	✗	✗	✗	✗	✗	Moderate to steep slopes, very susceptible to remobilisation where the sparse vegetation is removed, high lime content gives it considerable potential for fixing certain kinds of waste, like dissolved heavy metals, and neutralising acids, low bearing capacity, settlement is common and can be uneven
LS ₁	LIMESTONE - pale yellowish brown, weakly cemented, friable, medium-grained, sub-rounded quartz and shell debris, of eolian origin	Safety Bay Sand (Qhs)	5-20 m; M-S	Limesand	H	L-M	M	H	N/A	L-M	SP-SW	Wind transportation	✗	✗	✗	✗	✗	Generally linear features with moderate to steep slopes, susceptible to remobilisation, low bearing capacity generally
S ₁₂	CALCAREOUS SAND - white, medium-grained, rounded quartz and shell debris, well sorted, of eolian origin	Alluvium (Qha)	0-10 m; F	Limesand	H	L-M	M	H	N/A	L-M	SP	Marine erosion	✗	✗	✗	✗	✗	Low undulating relic foredune topography, variably thick sands overlying LS ₁ type limestone at relatively shallow depth, generally high water table, variable bearing capacity dependent on degree of consolidation of sands
C _p	PEATY CLAY - mid to dark grey, soft, water saturated clay with variable organic content, of alluvial origin		0-2 m; F	Clay for brick, pipe and tile manufacture	L	L-M	L	H	L-M	L	CI	Flooding, stream flow, sediment transport	✗	✗	✗	✗	✗	Confined to the lower reaches of the Serpentine River and a small valley in the southeast of the area, high water table, prone to flooding, low bearing capacity
M ₁	CALCAREOUS SILT - dark greyish brown silts and minor clays, shells and shell fragments and limestone are locally common, a recent limestone is common on some low ridges	Lagoonal deposits (Qhg)	5 m; F	Marl, limestone	L	M	L	H	L	L	ML	Flooding	✗	✗	✗	✗	✗	High water table, prone to flooding, differential settlement may occur
S ₇	SAND - pale yellowish brown, medium to coarse-grained, sub-angular quartz, trace of feldspar, moderately sorted, of residual origin	Sand derived from Tamala Limestone (Qts)	10-60 m; G	Specification sand	M	L	L-M	H	N/A	L-M	SP-SW	Groundwater recharge	✗	✗	✗	✗	✗	Few limitations, some settlement under foundations can be expected, some ability to attenuate pollutants due to small clay content, usually considerable depth to water table due to topography
LS ₁	LIMESTONE - pale yellowish brown, fine to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin	Tamala Limestone (Qtl) and Safety Bay Sand (Qhs) in part	5-75 m; G-M	Dimension stone, metallurgical, agricultural and construction grade limestone	H	L	M-H	M-H	N/A	V	SP-SW	Groundwater recharge	✗	✗	✗	✗	✗	Variable bearing capacity depending on degree of cementation, common solution cavities and fissures could lead to severe settlement under load and also offer an easy path for pollutants down to the water table. High water table on beach ridge plain
S ₈	SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin	Bessendeen Sand (Qpb)	5-45 m; G	Construction and glass sand	H	L	L	H	N/A	M-H	SP-SW	Groundwater recharge, some wind transportation	✗	✗	✗	✗	✗	Well drained, when dry and vegetation free it could be remobilised, drainage disposal is only a problem in areas of high water table
S ₁₀	SAND - as S ₈ as relatively thin veneer over C ₂ , M ₄ and M ₂	Thin Bessendeen Sand over Guildford Formation (Qpb/Qpa)	5-20 m; F	Construction and glass sand	H	L	L	H	N/A	M-H	SP-SW	Groundwater recharge, some wind transportation	✗	✗	✗	✗	✗	Of variable thickness, the sand's physical properties are modified by the underlying material, generally high water table, prone to flooding in part
C ₂	CLAY - strong brown and dark grey clay, plastic in places, soft when wet, variable silt content in matrix, of alluvial origin	Guildford Formation (Qpa)	2-10 m; F	Clays for brick, pipe and tile manufacture	L	L	L-M	H	L-M	L-M	CI	Flooding, stream flow, sediment transport	✗	✗	✗	✗	✗	High water table, prone to flooding in part, cohesion and shrinkage vary, alternate wetting and drying may cause swelling and shrinkage, dispersive in places
M ₄	SILT - very pale brown silt, soft when dry, low clay content, of alluvial origin		5-8 m; F	Clays for brick, pipe and tile manufacture	L	L	L-M	H	L-M	L-M	ML-MI	Some flooding	✗	✗	✗	✗	✗	High water table, prone to flooding in part, potential in part for swelling and shrinkage
M ₂	CLAYEY SILT - dark greyish brown, mottled in part, soft when wet, plastic in part, blocky, variable clay content, of alluvial origin		2-5 m; F	Clays for brick, pipe and tile manufacture	L	L	L	H	L	L-M	ML	Some flooding	✗	✗	✗	✗	✗	High water table, prone to flooding in part, some settlement of foundations may occur

REFERENCES

- See Lithological Classification
- The terms unconsolidated material and rock are used in the sense of the engineering terms "soil" and "rock"
- Colours were derived from Standard Soil Colour Charts, notation omitted
- Maximum and minimum elevation of the unit with respect to Australian Height Datum
- Slopes expressed qualitatively
 F-flat < 5°
 G-gentle 5°-10°
 M-moderate 10°-20°
 S-steep > 20°
 The dominant slope of each unit is given
- H high
 M moderate
 L low
 V variable
 N/A not applicable
 Properties vary with degree of weathering
- Soavey Mountains Engineering Corporation Soil Classification which describes soils in terms of grain size, grading characteristics and compressibility. For rocks the symbols refer to the weathered products
- ✗ activity undesirable for the environment
 ✗ possible problems for the environment
 ✗ possible problems for the activity
 ✗ activity compatible with unit

The data contained on this sheet are provided for preliminary studies and are not intended as a substitute for detailed on-site investigation
 This map should not be used for navigation purposes

OFFSHORE GEOLOGY



Searle J.D., 1984. Quantitative modelling, sediment transport system, Perth Sector, Rottneet Shelf. Final report for Project 80/2039, Marine Science and Technologies Grant Scheme, Department of Geology, University of Western Australia.

17 Appendix Seven - Monitoring photograph examples



* Record the date and time when capturing monitoring photographs

Example photographs - Site 1

These photographs are captured from the western end of the study area near the stair access to the beach. Photograph 1 compares the beach height and water level with the end of the stairs (facing towards the seawall). Photograph 2 is taken from the bottom post of the stairs (facing towards the seawall).



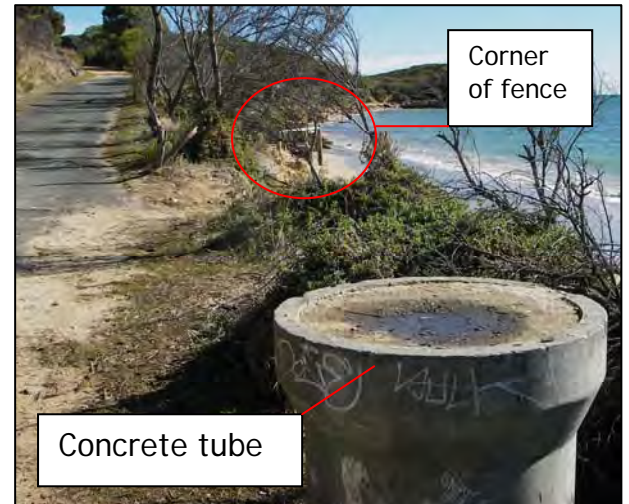
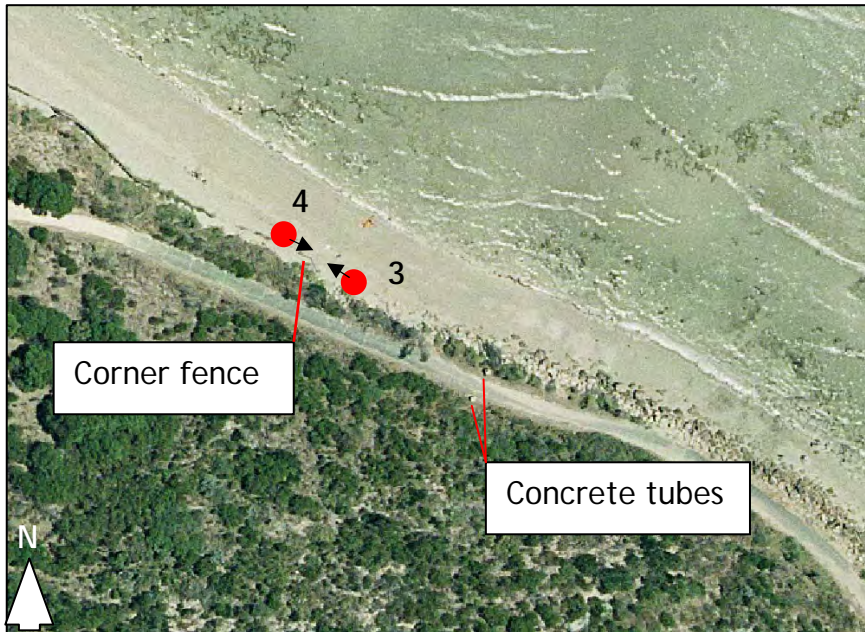
Photograph 1



Photograph 2

Example photographs - Site 2

The following photographs are captured from the corner of a fence that runs along the edge of the vegetation line. The corner of the fence is about 25 m from two concrete tubes that are on either side of the path. Photograph 3 is taken facing back towards the stairs. Photograph 4 is taken facing towards the seawall.



Photograph 3



Photograph 4

Example photographs - Site 3

These photographs were captured near the bend in the dual-use path and seawall. Photograph 5 is taken facing back towards the west. Photograph 6 is taken facing towards the dune in front of the camp school. These photographs display the seawall and path's condition.



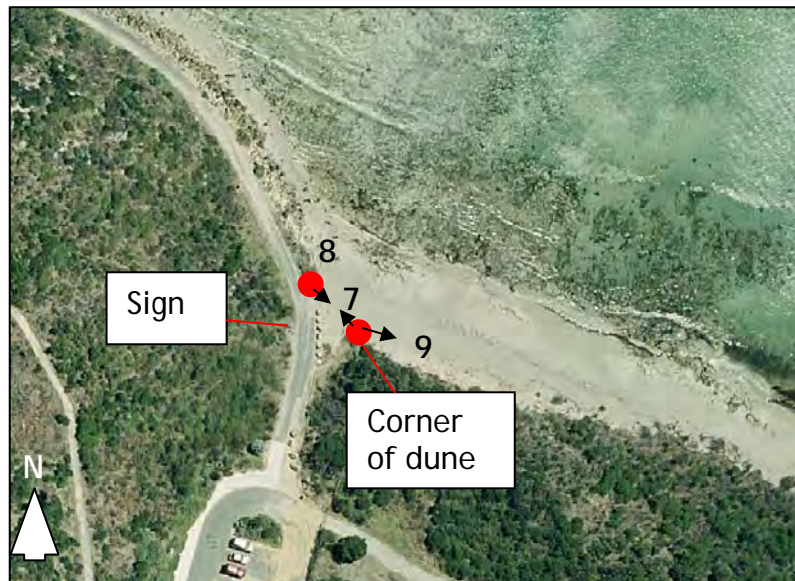
Photograph 5



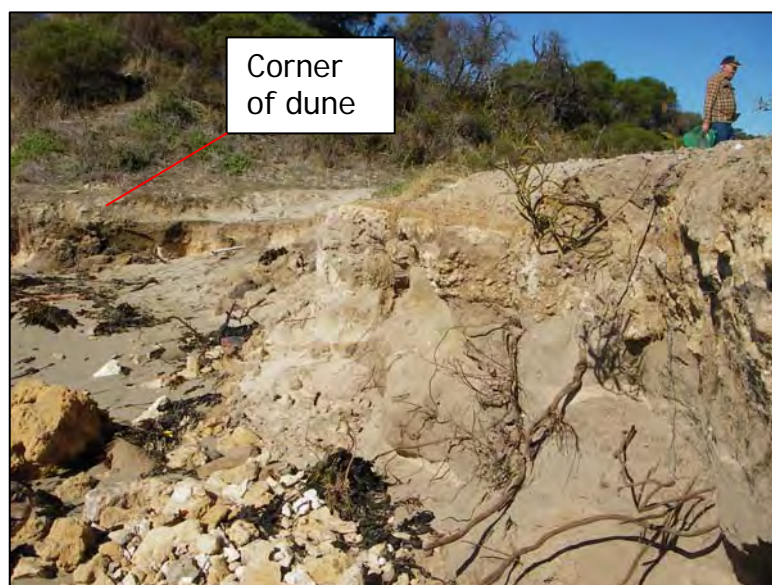
Photograph 6

Example photographs - Site 4

The following photographs are taken from a small eroded section alongside the path and in between the start of the seawall and the dune. Photograph 7 is taken in line with the 'Mangles Bay/Shoalwater Bay' sign, and facing towards the seawall. Photograph 8 is taken from near the start of the seawall towards the corner of the dune. Photograph 9 is taken from the corner of the dune and faces eastwards.



Photograph 7



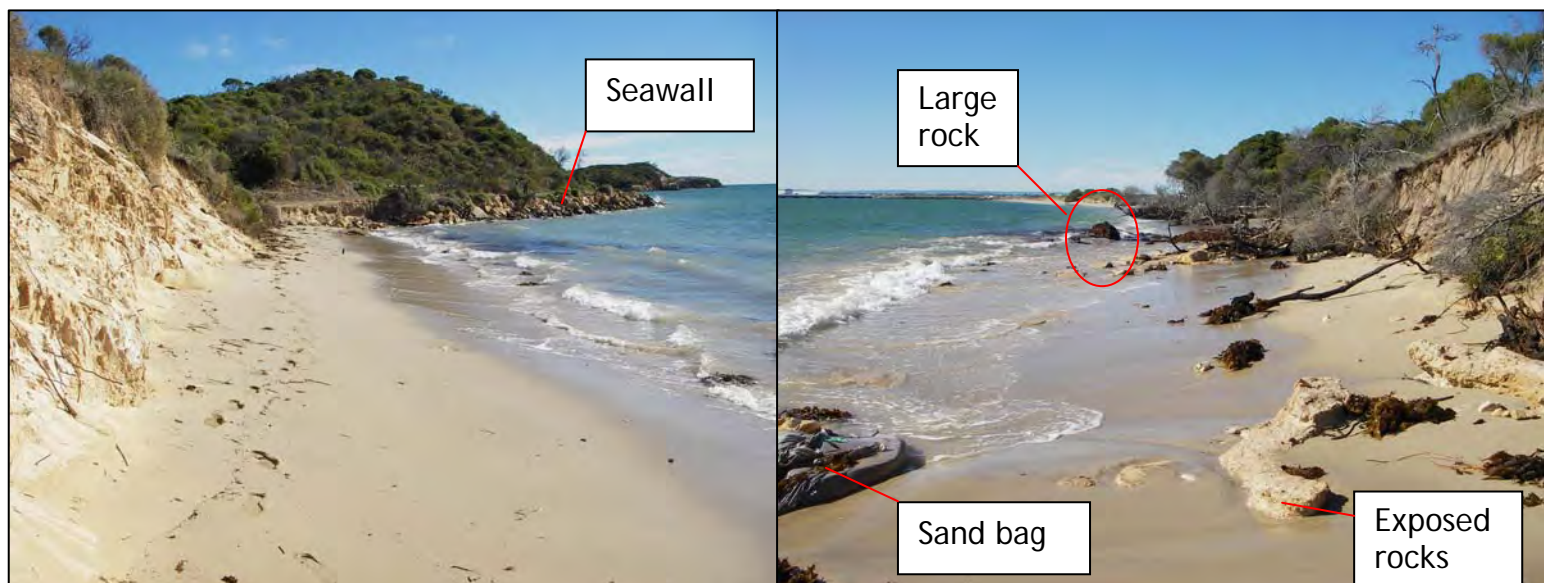
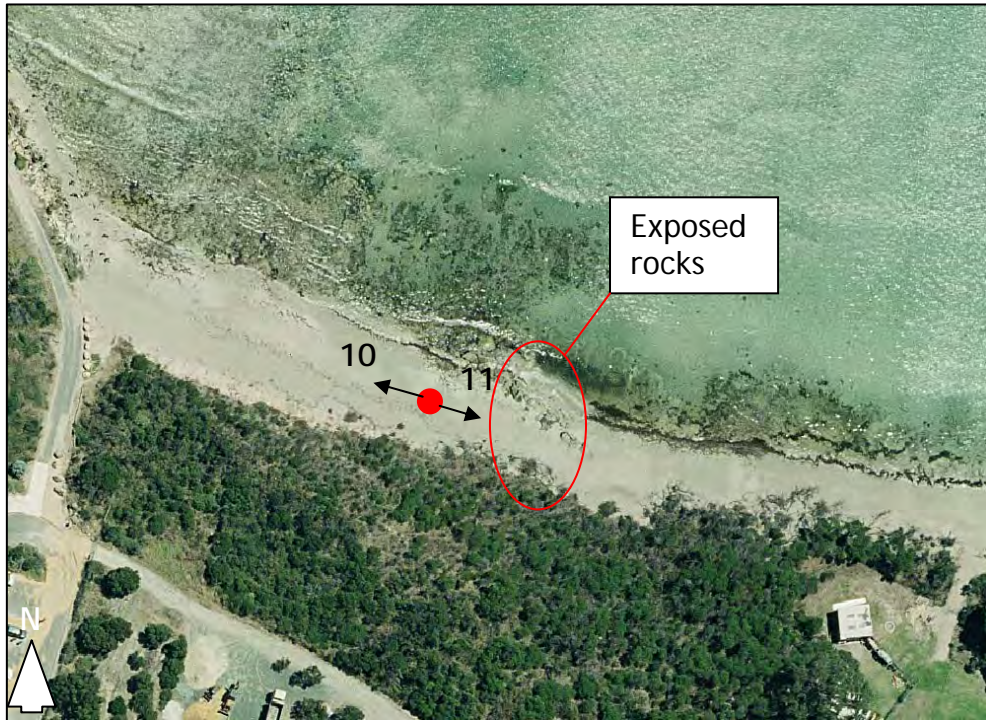
Photograph 8



Photograph 9

Example photographs - Site 5

These photographs are taken from where there are exposed rocks along the beach. Photograph 10 is taken from the rocks and faces back towards the seawall. Photograph 11 faces east and taken just before the rocks and a large sand bag.



Photograph 10

Photograph 11

Example photographs - Site 6

The following photographs are taken from the fence posts at the end of the oval's path to the beach. Photograph 12 is taken standing beside the right post (when facing the oval) and captures the beach towards the exposed rocks. Photograph 13 is taken standing beside the left post and faces eastwards along the beach.



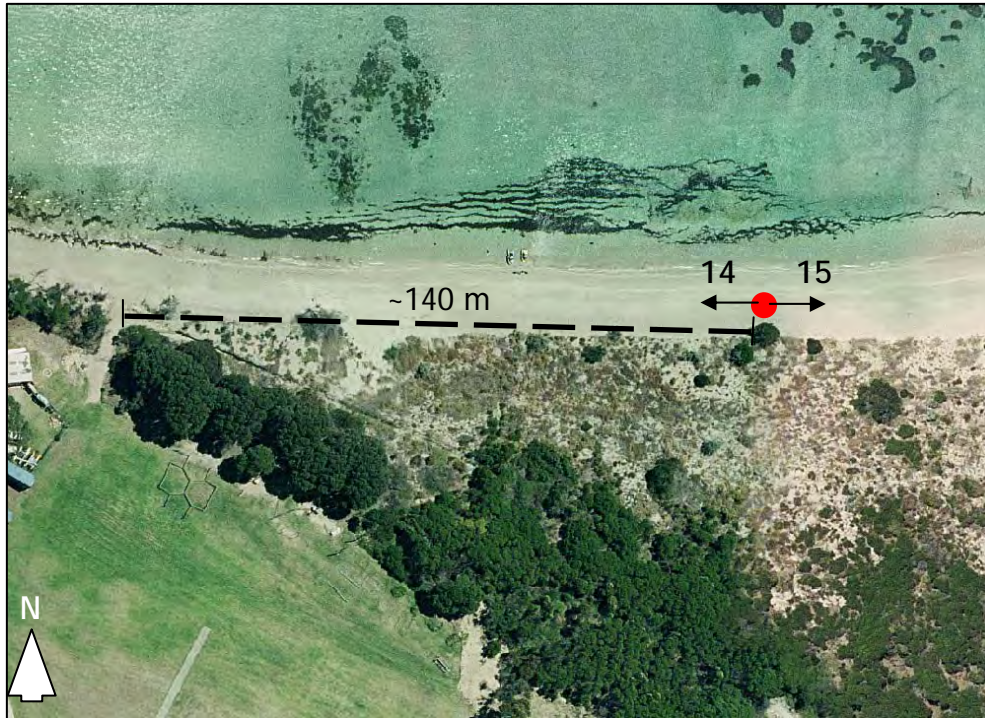
Photograph 12



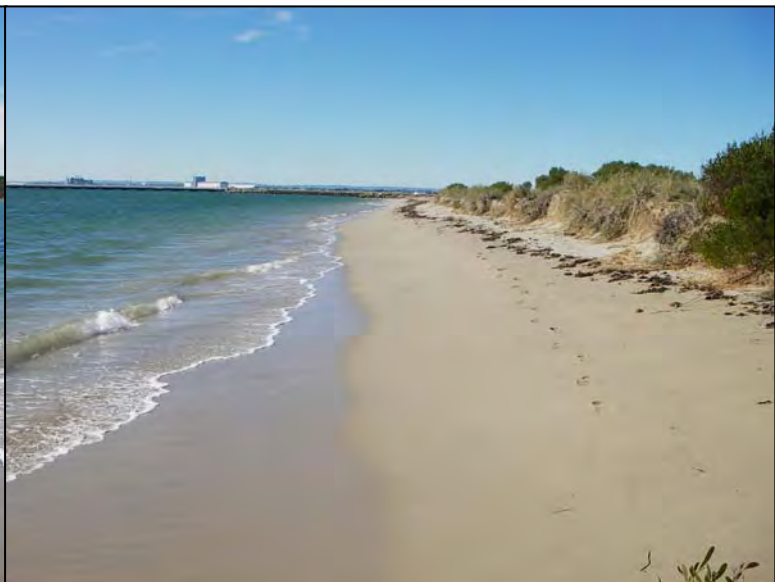
Photograph 13

Example photographs - Site 7

These photographs are taken in front of a large bush that protrudes from the vegetation line. It is approximately 140 m from the end of the oval's path. Photograph 14 shows the beach towards the oval and photograph 15 shows the beach towards the sand trap.



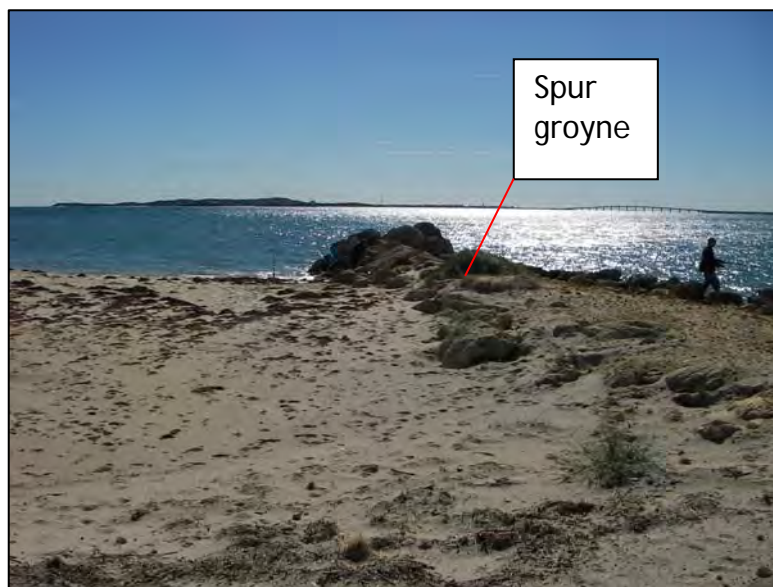
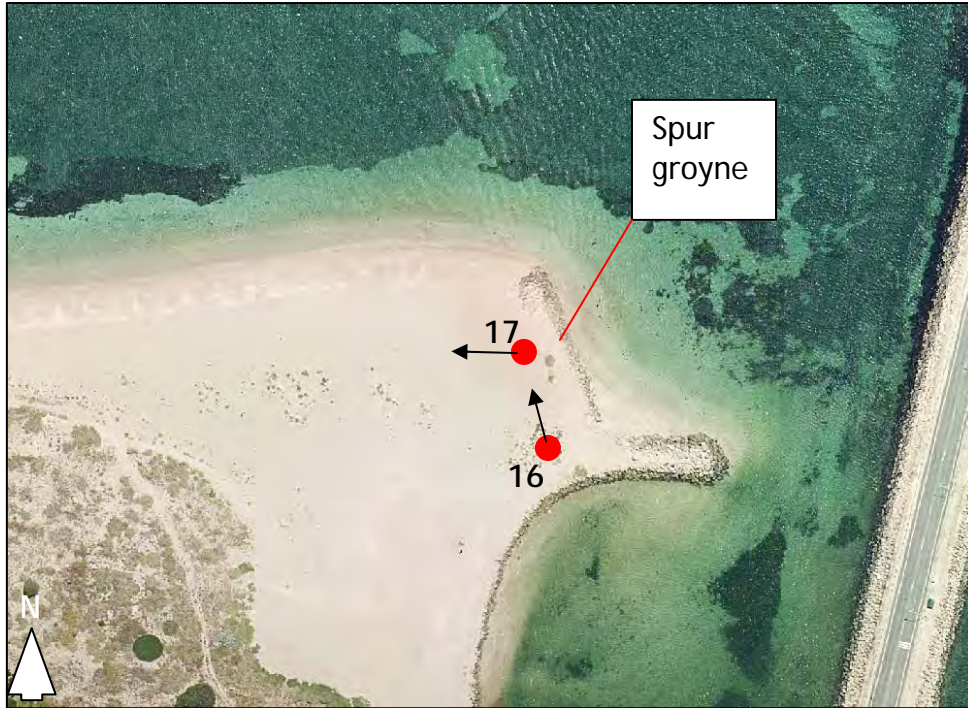
Photograph 14



Photograph 15

Example photographs - Sites 8 & 9

Photograph 16 is taken from the fence post at the start of the spur groyne and faces towards the spur. Photograph 17 is taken near the middle of the spur groyne and faces to the west.



Photograph 16



Photograph 17