



Water Research Laboratory

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School of Civil and Environmental Engineering

UAV Surveying of Wyong Coastline – November 2015

WRL Technical Report 2016/04
March 2016

By C D Drummond and J G Cullen

Water Research Laboratory
University of New South Wales
School of Civil and Environmental Engineering

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1. Introduction

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Australia was engaged by Wyong Shire Council to undertake Unmanned Aerial Vehicle (UAV or drone) surveying of the Wyong Coastline and to provide coastal engineering analysis of the data.

The survey campaign included the vast majority of the Wyong Shire Council coastline with total coverage of beach areas from Bateau Bay to Ghosties Beach. The survey excluded a 2 km section of remote cliff areas between Birdie Beach and Frazier Park that was inaccessible due to site restrictions.

In this report, drone surveying data and analysis is provided separately for each of the following locations:

- Location 1: Bateau Bay Beach;
- Location 2: Shelly Beach;
- Location 3: Toowoan Bay to Blue Bay;
- Location 4: The Entrance North at Curtis Pde to The Entrance at Richard Rd;
- Location 5: Pelicans Beach- North Entrance Beach at Curtis Pde;
- Location 6: Soldiers Beach;
- Location 7: Pebbly Beach;
- Location 8: Lighthouse Beach;
- Location 9: Cabbage Tree Harbour;
- Location 10: Jenny Dixon Beach to Lakes Beach Surf Lifesaving Club (SLSC);
- Location 11: Lakes Beach SLSC to Budgewoi;
- Location 12: Budgewoi Beach to Birdie Beach;
- Location 13: Frazer Park Beach; and
- Location 14: Ghosties Beach- Flat Island.

An outline of the surveying methodology and post processing is provided in Section 2, background information regarding the coastal engineering analysis is outlined in Section 3, discussion and analysis of each location is presented in Section 4. Appendix A includes beach profiles for each location and Appendix B includes site photos from each site visit.

2. Survey Methodology and Post-Processing

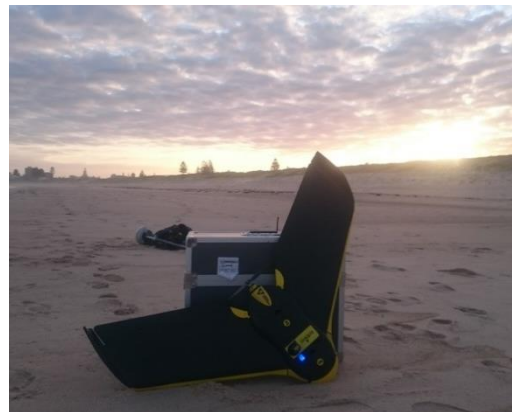
The use of UAVs as a mapping and measurement tool has grown significantly in recent years and has been pioneered by WRL coastal engineers to provide high quality coastal survey data sets in numerous locations on the NSW coastline. While traditional land-based (e.g. RTK-GPS) or airborne (e.g. LiDAR) methods of collecting topographic data over large areas can be labour-intensive and/or costly, UAV surveying provides cost-effective, rapid airborne sampling of the coastal zone at high-accuracy and very high spatial resolution.

WRL completed UAV surveys of the vast majority of the Wyong Shire Council coastline with total coverage of beach area from Bateau Bay to Ghosties Beach. The survey excluded a 2 km section of remote cliff areas between Birdie Beach and Frazier Park that was inaccessible due to site restrictions (Figure 1).

The surveys were undertaken utilising a Sensefly eBee RTK UAV equipped with a Canon Ixus RGB camera with key features summarised in Table 1. This platform is a fully autonomous survey-grade mapping UAV which carries on-board its own RTK-GNSS receiver. During flights, the eBee RTK maintains radio connection to a ground-based GNSS base station, providing in-flight processing of RTK corrections via the CORSnet-NSW network of permanent satellite base stations. This results in high precision navigation and individual image geo-tagging. Surveying was carried out by CASA approved pilot Chris Drummond over the course of a month (November 2015) and covered a total area of approximately 1000 hectares. The data collected was georeferenced into the GDA94/MGA Zone 56 datum. A number of ground control points and 2D profiles were also surveyed at each site to verify the accuracy of the UAV derived data.

Table 1: Specifications of the UAV system

Feature	Description
Type	Fixed wing UAV
Wingspan & weight	96 cm, 700 g
Endurance	Up to 40 minute flight time
Cruise speed	40-90 km/hr
Wind resistance	Gusts up to 45 km/hr
Coverage per flight	Up to 2km ²
Onboard Sensors	RGB/NIR camera RTK receiver inertial measurement unit pitot probe optical ground sensor



Post processing was completed using Postflight Terra 3D commercial software to produce a geo-rectified orthomosaic image and 3D digital elevation model for each location. This software uses advanced photogrammetry techniques to produce elevation data through the automatic detection of common features between many overlapping images to produce a dense point cloud dataset. The data output differs from that acquired using laser returns (i.e. LiDAR) in that a UAV-derived point cloud may represent the upper surface of dense vegetation or building roof rather than a ground return. The algorithm relies on the assumption that ground features remain stationary while the survey platform is in motion. For this reason, the algorithm generally has limitations mapping moving objects such as water surfaces or the wave run-up zone. Surveys were measured at low tide where possible to maximise coverage of the beach profile. This resulted in data that generally extends to a minimum level of 1.5 to 2 m AHD.

The data products produced include a densified point cloud as well as an ortho-rectified mosaic of each survey area. The point cloud data has RGB pixel colours assigned to it which provides a powerful visualisation tool. Typical ground resolutions of the imagery produced by the UAV in this study vary from 2 to 3 cm/pixel and an average density of 50 points per m³.



Figure 1: Site Location and UAV survey coverage highlighted in yellow

3. Background

Background concepts that are referenced in the analysis of each beach location are provided in this section. This includes discussion on the incident wave climate at Wyong and the wave conditions surrounding the surveys, the beach type classification method that has been applied to each beach as well as discussion on storm demand values that are referenced at each location.

3.1 Wyong Wave Climate

The Wyong coastline experiences average significant wave heights of 1.5 m from the south-south-east superimposed on a highly variable wind wave climate (Shand et al., 2010). Due to this prevailing wave direction, the southern extents of beaches in this region usually have some degree of protection from storm erosion with exposure increasing to the north of each embayment. There were three notable wave events surrounding the survey campaign with a significant wave height exceeding 3 m. These occurred on 27th October from a south direction immediately prior to the commencement of surveys, 4th November from the east and 27th November from the south-south-east (Figure 2) both of which were during the survey period.

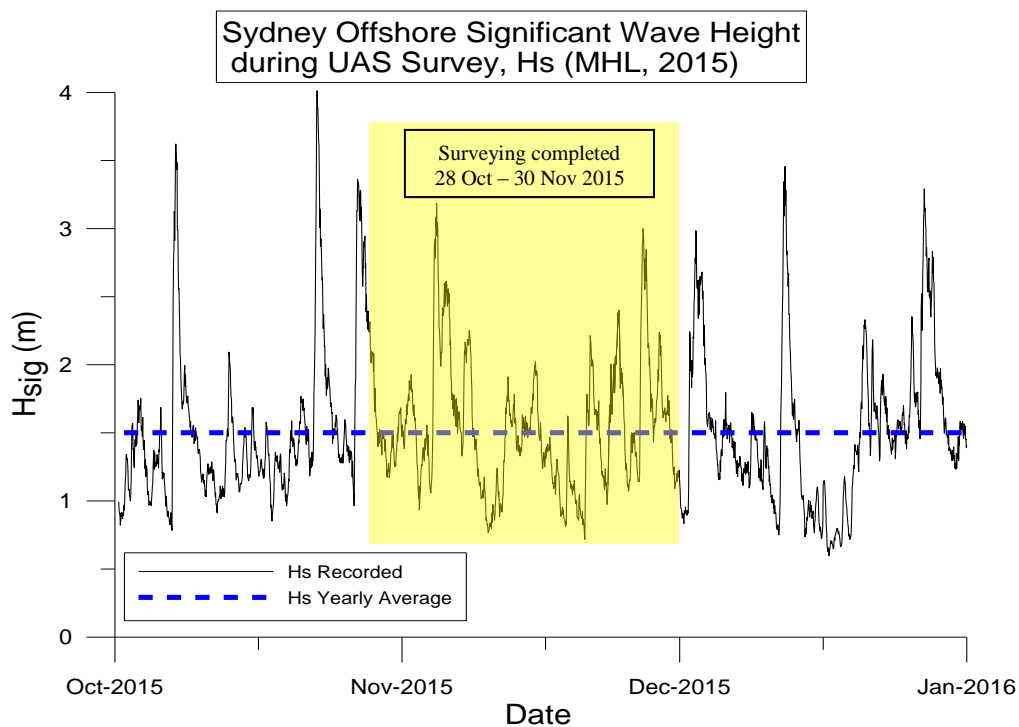
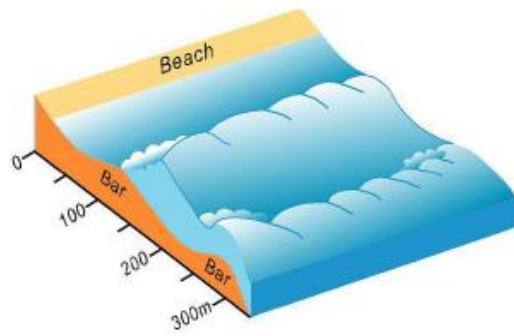


Figure 2: Sydney offshore significant wave height over the survey period (source: MHL, 2015)

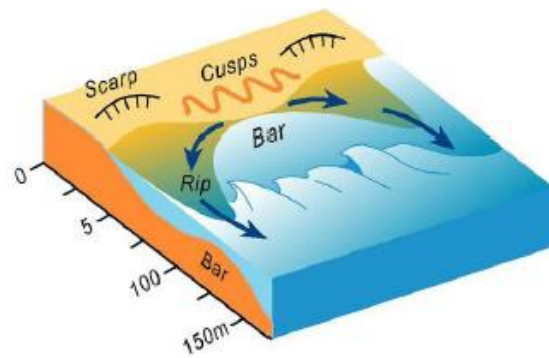
3.2 Beach Type Model

Classification of wave dominated coastlines are provided by Short (2007) which includes six beach types that are defined based on wave energy and sediment conditions (Figure 3). The coastal analysis provided in Section 4 includes classification of each beach into these beach states at the time of surveying. Beach type or 'state' refers to the prevailing nature of beach, including waves and currents, and the width and shape of the surf zone, including bars and troughs (Short 2007). At one end of the continuum are *Reflective Beaches*, where wave energy is largely reflected at the shoreline. These beaches are characterised by low wave energy and a steep, reflective shoreline. At the other

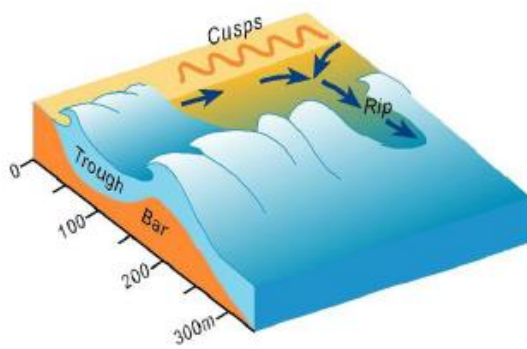
end of the continuum are *Dissipative Beaches* where wave energy is dissipated over a large surf zone. These beaches lie at the higher end of the beach energy spectrum and are found on open coasts with long wave periods and large waves. There are four *Intermediate* beach states that lie between reflective and dissipative beaches, with the majority of beaches in the Wyong Shire region falling into one of these categories. These are *longshore bar – trough* (LBT), *rhythmic bar and beach* (RBB), *transverse bar and rip* (TBR), and *low tide terrace* (LTT), and are detailed in Figure 3. Beaches naturally change between beach states in response to changes in the incident wave energy.



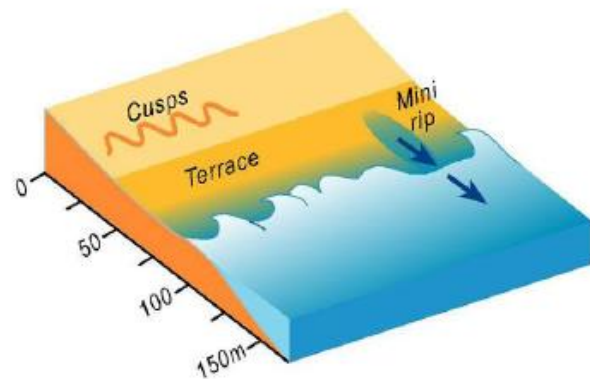
Type 1 Dissipative (D)



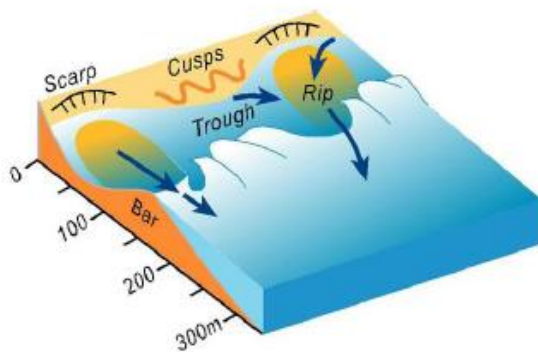
Type 4 Transverse Bar and Rip (TBR)



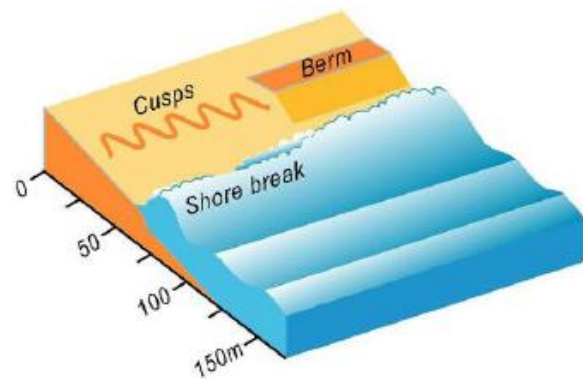
Type 2 Longshore Bar and Trough (LBT)



Type 5 Low Tide Terrace (LTT)



Type 3 Rhythmic Bar and Beach (RBB)



Type 6 Reflective (R)

Figure 3: Wave Dominated Beach Types (after Short, 2007)

3.3 Storm Demand Volumes

This report also includes analysis of the volume of available sand buffer above 0 m AHD in the beach profile in front of key public and private assets. This sand buffer is defined in Figure 4 after Nielsen et al. (1992) and can be used to provide information about the level of natural protection that assets would have in an erosive event. A value of 34° was adopted in volume calculations as the safe angle of repose of wet sand for a slumped dune profile. It should be noted that if the volumes of available sand buffer quantified in this report were removed by a storm event then the subject property would be located in a zone of reduced foundation capacity and would require piled foundations to maintain structural stability.

In cases where the UAV derived data did not extend to 0 m AHD due to interference from wave run-up, the slope from 2 m to 3 m AHD was used as a basis for extrapolation to the 0 m AHD contour.

The potential storm demand for a 100 year Average Recurrence Interval (ARI) design event for beaches within the Wyong Shire are presented in BMT WBM (2015) based on analysis of photogrammetric data and some LiDAR data from the June 2007 storm event or adopted from geomorphological comparable beaches (Table 2).

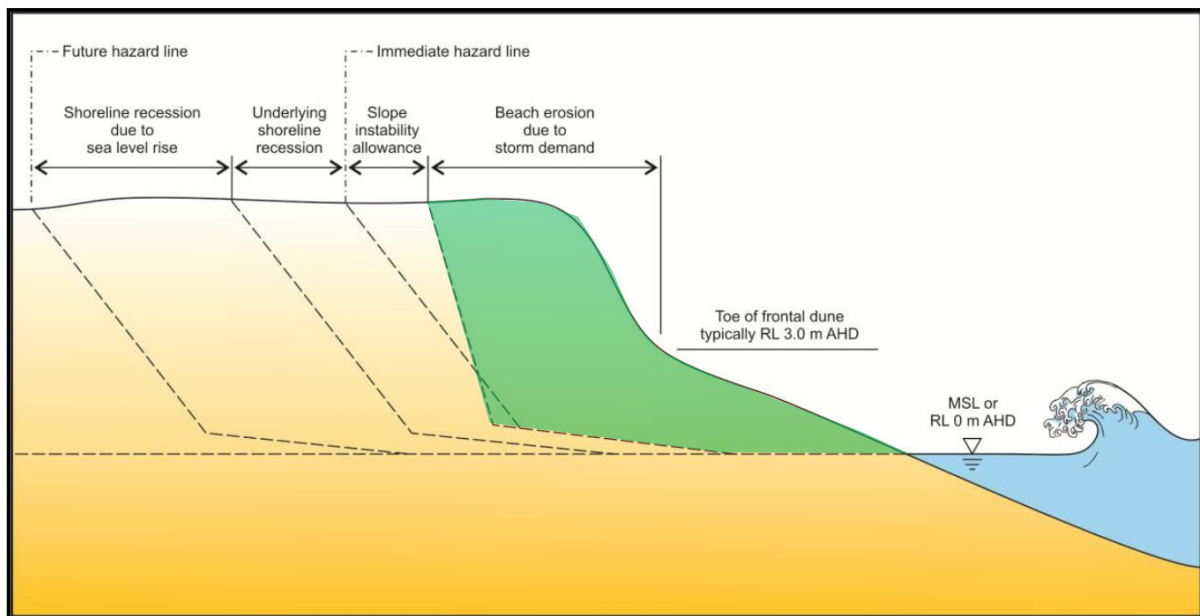


Figure 4: Definition of storm demand (zone of wave impact) highlighted in green (adapted from Nielsen et al., 1992)

3.4 Analysis Overview

A summary of the beach analysis and survey information outlined in the following section is presented in Table 2. Information on the available sand buffer has only been produced for key developed locations that include public and private assets that are potentially at risk from coastal processes. Further discussion of each location is provided in the following section.

Table 2: Summary of Beach Analysis

Survey Date	Survey/Profile Location	Dune/Bluff height (m AHD)	Representative beach slope (1 in)	Beach State¹	Available sand buffer volume (m³/m)	BMT WBM (2015) design storm erosion (m³/m) relative to ~2007 conditions
28/10/2015	Bateau Bay	2.5 to 3.6	50	R		
10/11/2015	Shelly Beach	3 to 16	11	RBB	174	290
10/11/2015	Toowoan Bay	5 to 15	9	R	162	75
11/11/2015	Blue Bay	7 to 12	12	R	103	115
28/10/2011	The Entrance - Hargraves St	2 to 12	4	TBR	410	170
28/10/2011	The Entrance North - Curtis Parade	3 to 12	21	TBR	106	170
30/11/2015	Magenta	12 to 18	11	RRB		
11/11/2015	Soldiers Beach	8 to 25	9	TBR	515	150
11/11/2015	Pebbly Beach	8 to 13	16	LTT		
11/11/2015	Lighthouse Beach	8	9	R		
19/11/2015	Cabbage Tree Harbour	20	6	R		
19/11/2015	Jenny Dixon Beach	20	62	R		Backing Cliff
24/11/2015	Hargraves Beach	4 to 15	17	LTT	298	180
24/11/2015	Lakes Beach South	6	9	TBR	291	150
24/11/2015	Budgewoi	9	6	RBB	463	250*
23/11/2015	Birdie Beach	8 to 23	51	RBB		
20/11/2015	Frazer Park	6	77	TBR		
30/11/2015	Ghosties Beach	55	19	LTT		

1. Beach state types are summarised in Section 3.4 and Figure 4.

*. Design storm erosion values adopted from geomorphological comparable beaches.

4. Survey Analysis

This section provides coastal engineering analysis for each location including quantification of dune height, volume of sand buffer above 0 m AHD, representative beach slopes and classification of the beach state at the date of surveying. Cross sectional profiles of each location are available in Appendix A with photos of each site collated in Appendix B.

4.1 Crackneck to Bateau Bay

Bateau Bay is a south-east facing embayed beach, protected by a headland at the north end, an extensive rock platform to the south and offshore reefs in the centre of the bay (Figure 5). At the time of surveying, the beach was in a reflective state with a low gradient representative beach slope of 1 in 50. The rock platform at the base of Crackneck Point had an average height of 1.5 m AHD and an average width of 150 m. The beach was backed by a well vegetated bluff with heights ranging from 3.6 m AHD at the south of the beach to 2.5 m AHD at the north. The bluff was fronted by a stable incipient foredune, moderately vegetated with grass. The closest residential development was located 170 m behind the foredune (measured from the 3 m AHD contour line). Geotechnical stability and erosion from coastal events appeared to be a low risk to public and private infrastructure at this location.

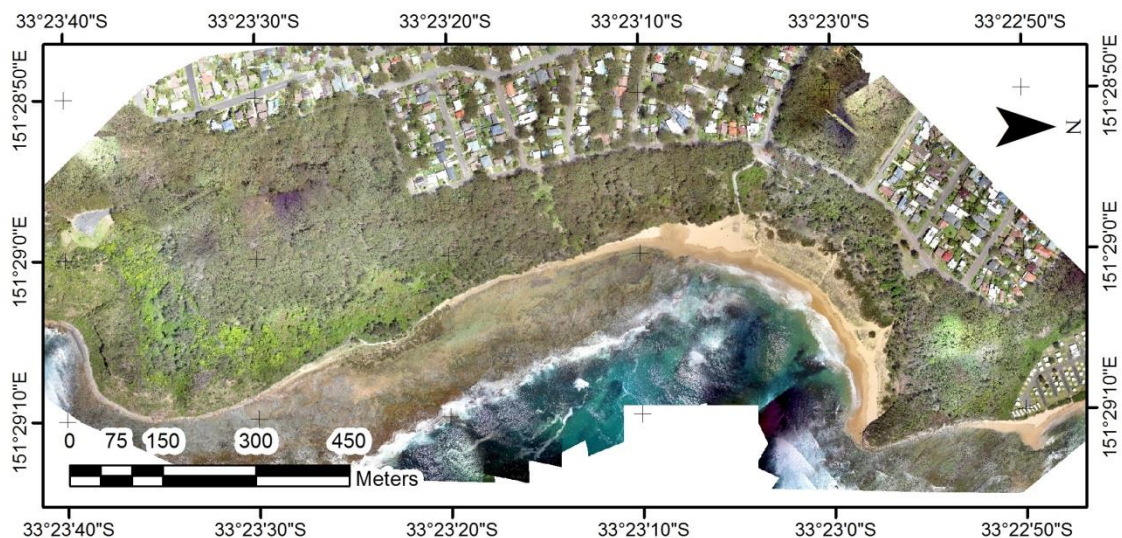


Figure 5: Bateau Bay overview

4.2 Shelly Beach

Shelly Beach is south-east facing beach that has a narrow southern extent that is protected by rock reefs and shelves (Figure 6). The centre and northern end of the beach is wider, with a well vegetated frontal dune present to the north of the Shelly Beach SLSC building and a lightly vegetated incipient foredune. The height of the frontal dune ranges from 3 m AHD to the south, 11 m AHD in the centre of the beach and 16 m AHD to the north. There are rock outcrops at the northern beach, with rock shelves and reefs bounding the far northern extent. At the time of surveying the beach had a representative slope of 1 in 11 and the beach state was rhythmic bar and beach (RBB), with irregular cusps. Blue Lagoon Beach Resort is partially protected by offshore reefs at the southern end of the beach and was 30 m from the 2 m AHD contour at the

time of surveying. The next closest development was located at the northern end of the beach at a distance of 90 m from the 2 m AHD contour. The volume of available sand buffer within the beach profile fronting Shelly Beach SLSC building was equal to 174 m³/m (Figure 7), however after removal of this sediment the SLSC building would be in the zone of reduced foundation capacity. This volume is less than the storm demand of 290 m³/m presented in BMT WBM (2015) as the design storm.

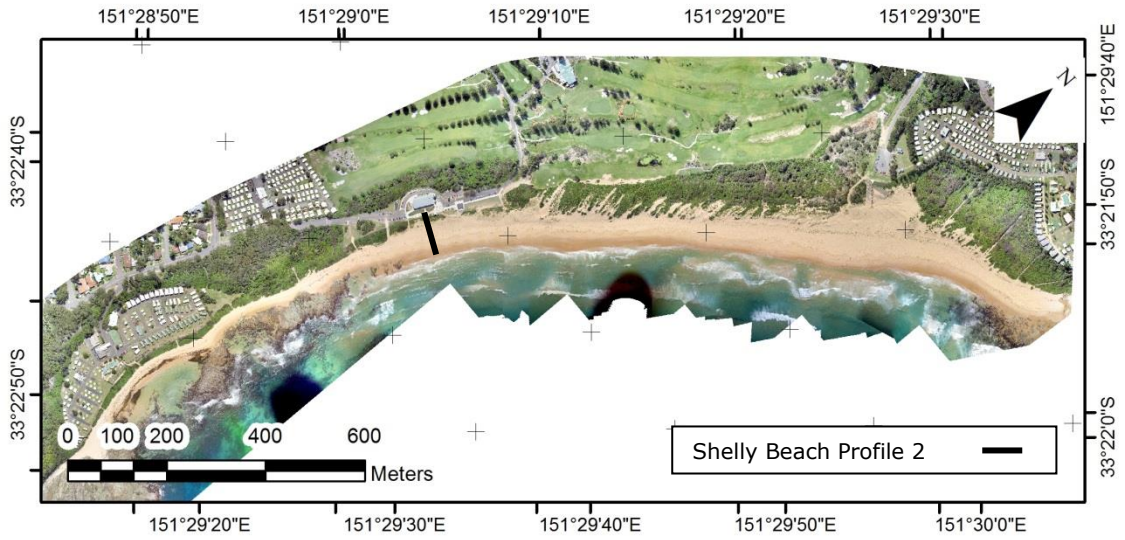


Figure 6: Shelly Beach overview

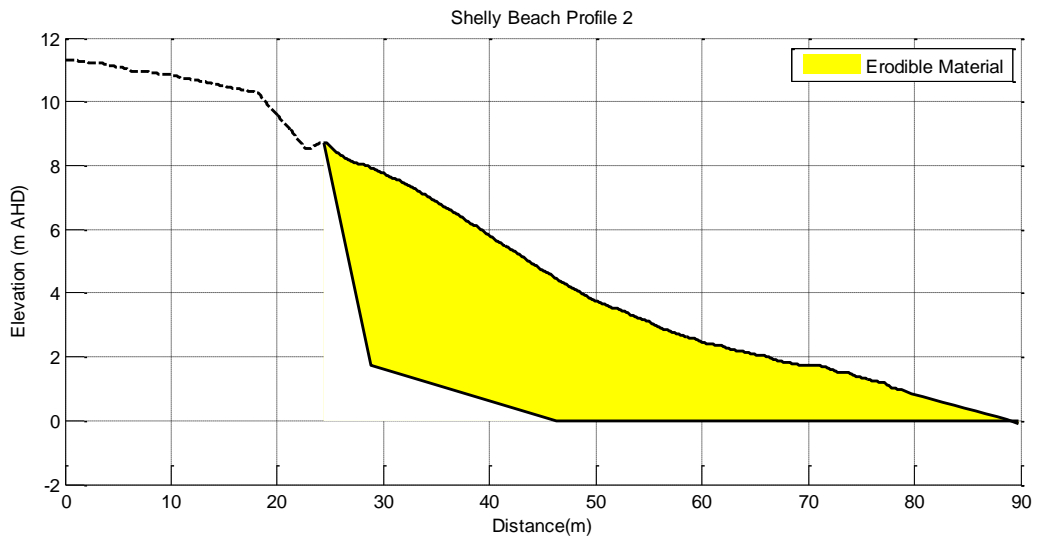


Figure 7: Profile fronting Shelly Beach SLSC (Profile 2) showing volume of available sand buffer in the beach profile above 0 m AHD

4.3 Toowoon Bay

Toowoon Bay is a predominately east facing reflective beach bounded at both extents by tombolos and protected by intertidal rock platforms and rock reefs (Figure 8). The beach is backed by residential development fronted by a narrow and well-vegetated frontal dune. At the time of surveying this dune had heights ranging between 7 m AHD to the south and 5 m AHD in the centre of the beach and a well-vegetated 15 m AHD high bluff at the northern end. The closest development was 33 m from the 2 m AHD contour and is located to the north of the SLSC. There are three small stormwater outlets or creeks and a larger stormwater outlet at the northern end of the beach. Only the larger outlet was observed to have evidence of scour when the site was surveyed. During the survey deployment the beach had a representative slope of 1 in 9.

The tombolo between Blue Bay and Toowoon Bay has an incipient foredune that was moderately vegetated with grass behind a 1 m high scarp. The frontal dune has been developed and has very little vegetation outside of the property bounds.

The volume of available sand buffer within the beach profile fronting property in the centre of the beach was equal to 162 m³/m (Figure 9), which is in excess of the design storm of 75 m³/m presented in BMT WBM (2015).

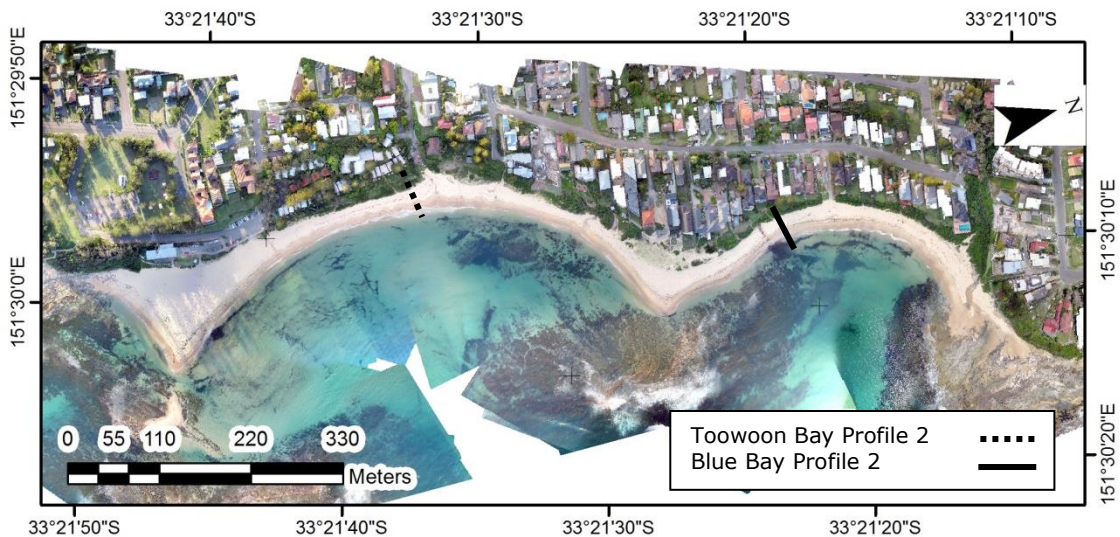


Figure 8: Toowoon Bay and Blue Bay overview

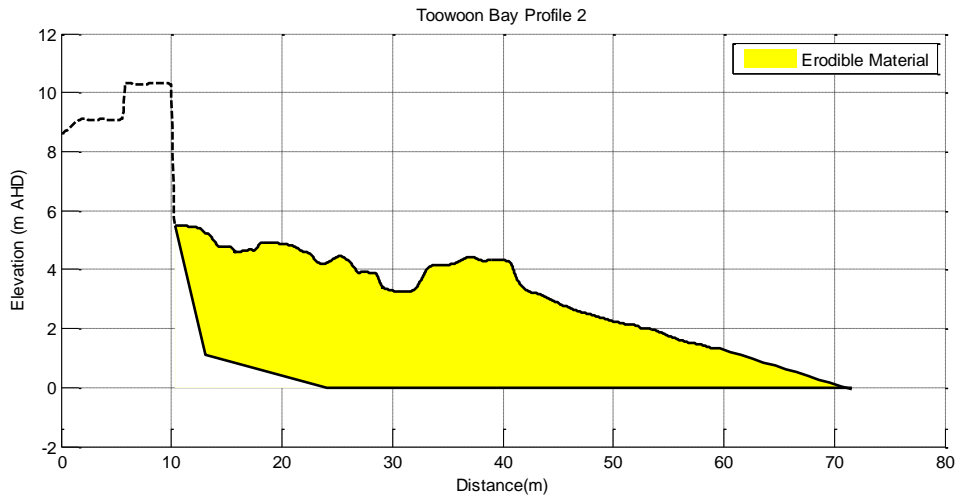


Figure 9: Profile fronting property in the centre of Toowoon Bay (Profile 2) showing the volume of available sand buffer in the beach profile above 0 m AHD

4.4 Blue Bay

Blue Bay faces east-southeast and is enclosed by intertidal rock platforms (Figure 8). It is backed by residential development, the closest of which was located 22 m from the 2 m AHD contour during the site survey. Properties were fronted by a number of ad-hoc seawalls constructed out of sandstone blocks or timber retaining walls. During the site visit, there was a narrow and well vegetated dune with heights between 7 m AHD and 12 m AHD, with a lightly vegetated incipient foredune present at the northern end of the beach. Two flowing stormwater outlets were present at the site, located at the northern and southern ends of the beach. The representative beach slope was 1 in 12 and the beach state was in a reflective state in response to low wave energy. The volume of available sand buffer within the beach profile fronting property in the centre of the beach was equal to 103 m³/m (Figure 10). This volume is comparable to the storm demand of 115 m³/m presented in BMT WBM (2015) as the design storm.

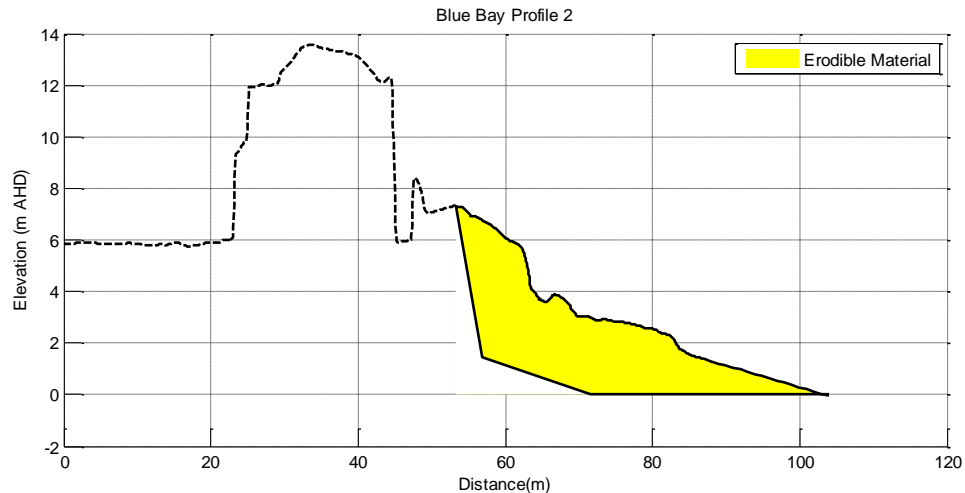


Figure 10: Profile fronting property in the centre of Blue Bay (Profile 2) showing volume of available sand buffer in the beach profile above 0 m AHD

4.5 The Entrance to The Entrance North

The estuary entrance is bounded by rocks to the south and dredging was occurring at the time of surveying (Figure 11). An overwash berm with a height of 2.8 m AHD (Profile 4) was present on the sand spit. To the north of the sand spit and south of properties was a well vegetated dune, 8.5 m high (Profile 6). Property setback from the 2 m AHD contour was 55 m at the southern end of Hutton Rd, 173 m at Bondi Rd and 65 m at the northern end of Curtis Parade.

The volume of available storm demand fronting property at Hutton Rd near Hargraves St (Profile 7) was equal to 410 m³/m (Figure 13), with a beach slope of 1 in 4. This volume is in excess of the storm demand of 170 m³/m presented in BMT WBM (2015).

The volume of available storm demand fronting property in the centre of Curtis Parade (Profile 15) was equal to 106 m³/m (Figure 14), with a beach slope of 1 in 21. This volume is less than the storm demand of 170 m³/m presented in BMT WBM (2015).

Any ad hoc seawalls fronting properties along Curtis Parade are unlikely to be structurally sound nor certified by a coastal engineer. The volume of available sand buffer at this location has been calculated up to property footprints as it has been assumed that ad-hoc seawalls at the site would be insufficient to provide satisfactory protection from a large storm event.

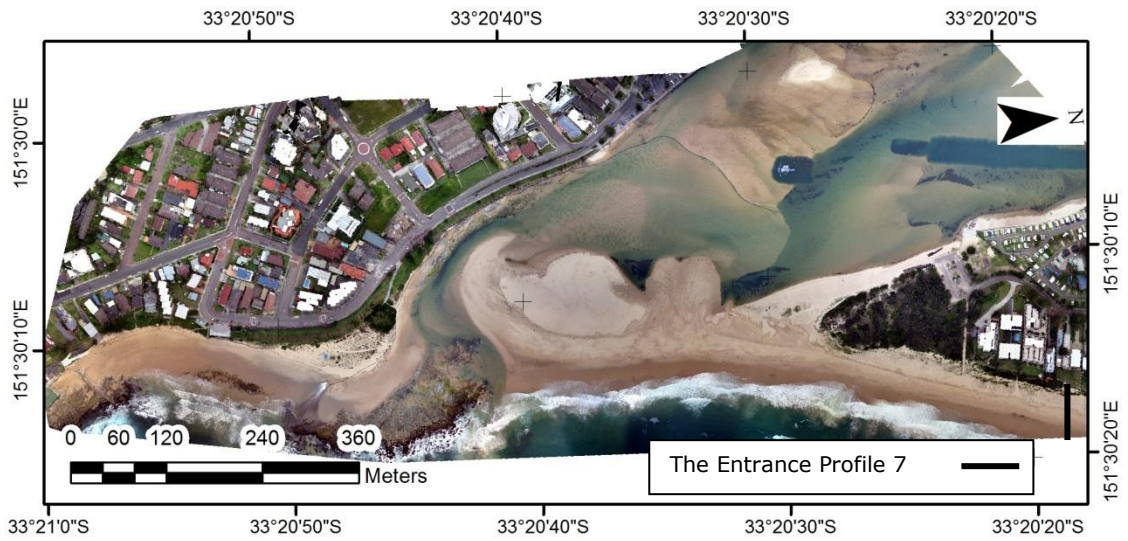


Figure 11: The Entrance overview

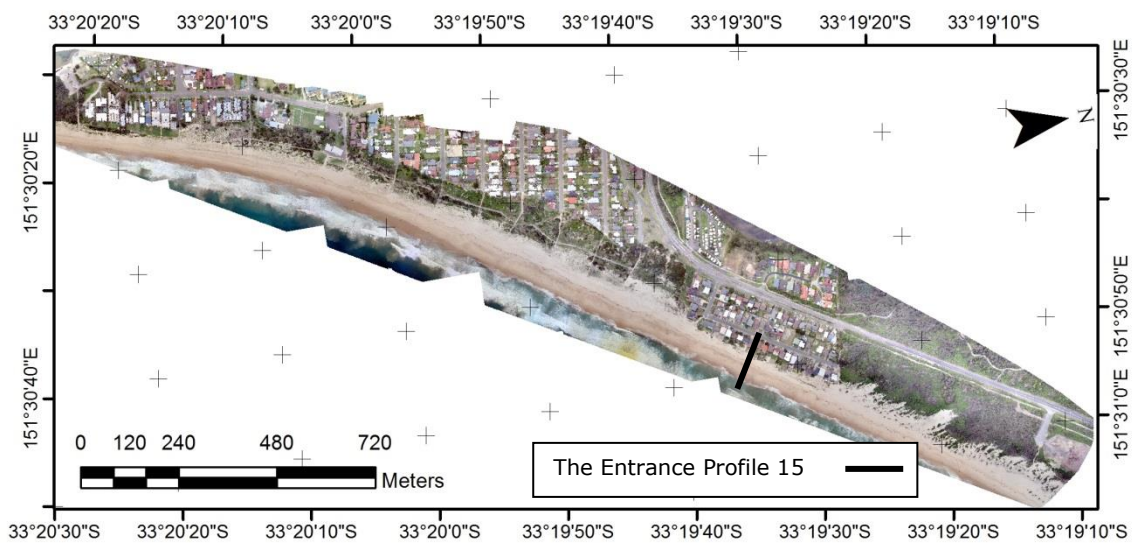


Figure 12: The Entrance North overview

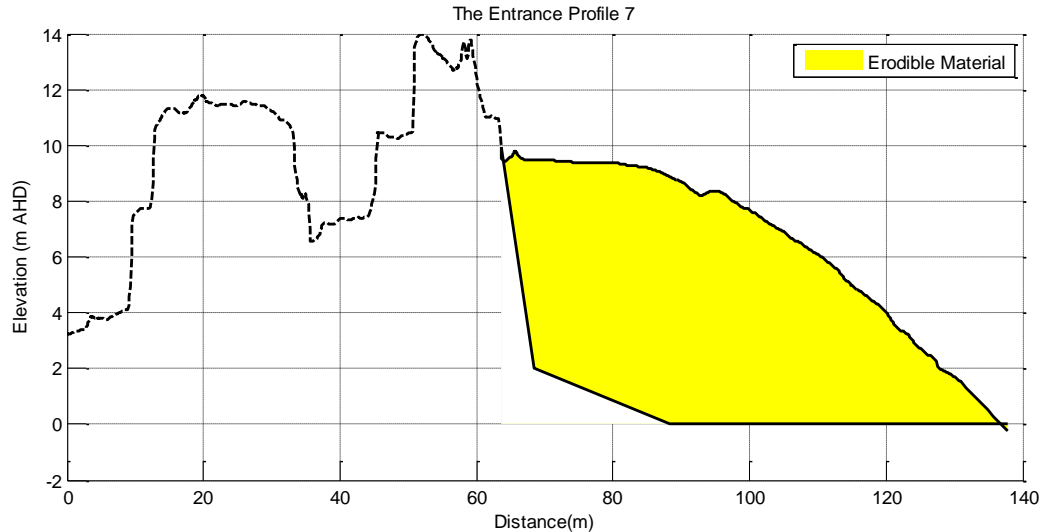


Figure 13: The Entrance profile fronting property at Hargraves St (Profile 7) showing the volume of available sand buffer in the beach profile above 0 m AHD



Figure 14: The Entrance North profile fronting property in the centre of Curtis Parade (Profile 15) showing volume of available sand buffer in the beach profile above 0 m AHD

4.6 Magenta to Pelicans Beach

Magenta Beach is an unprotected south-east facing barrier beach (Figure 15). At the time of surveying the beach had a representative slope of 1 in 11 and the beach state was rhythmic bar and beach (RBB). There was a well vegetated frontal dune with heights ranging from 18 m AHD to the south, 12 m AHD in the centre and 14 m AHD to the north. A lightly vegetated incipient foredune was present in front of the frontal dune. Magenta Shores Resort and Golf Course is located in centre of the beach and was 210 m from the 2 m AHD contour at the time of surveying.

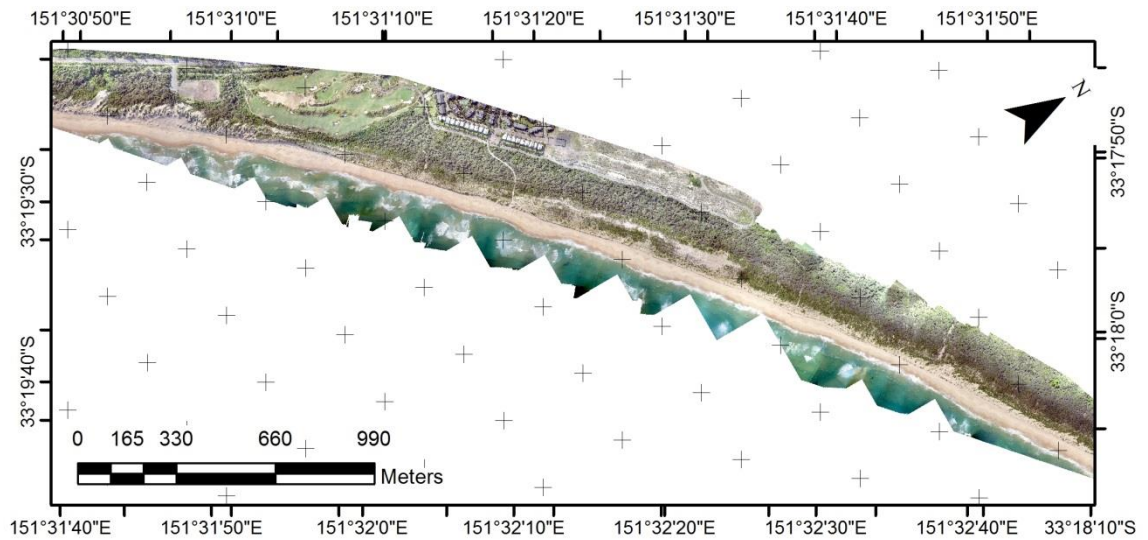


Figure 15: Magenta overview

4.7 Soldiers Beach

Soldiers Beach is south-east facing and is bounded by a headland to the north and a tombolo to the south (Figure 16). At the time of surveying, the beach had a representative slope of 1 in 9 and the beach state was transverse bar and rip (TBR), with cusps. There was a high frontal dune with heights ranging from 25 m AHD to the south, 17 m AHD in the centre of the beach and 8 m AHD at the north. The dunes at the south and north of the beach were well vegetated, with vegetation becoming more sparse at the centre of the beach where a 4WD access track runs south from Soldiers Beach SLSC. Outcrops of rock were present at the north of the beach and in the dunes 150 m south of the SLSC. The volume of available sand buffer in the beach profile located in front of Soldiers Beach SLSC was equal to 429 m³/m (Figure 17), which exceeds the design storm erosion volume of 150m³/m presented in BMT WBM (2015).

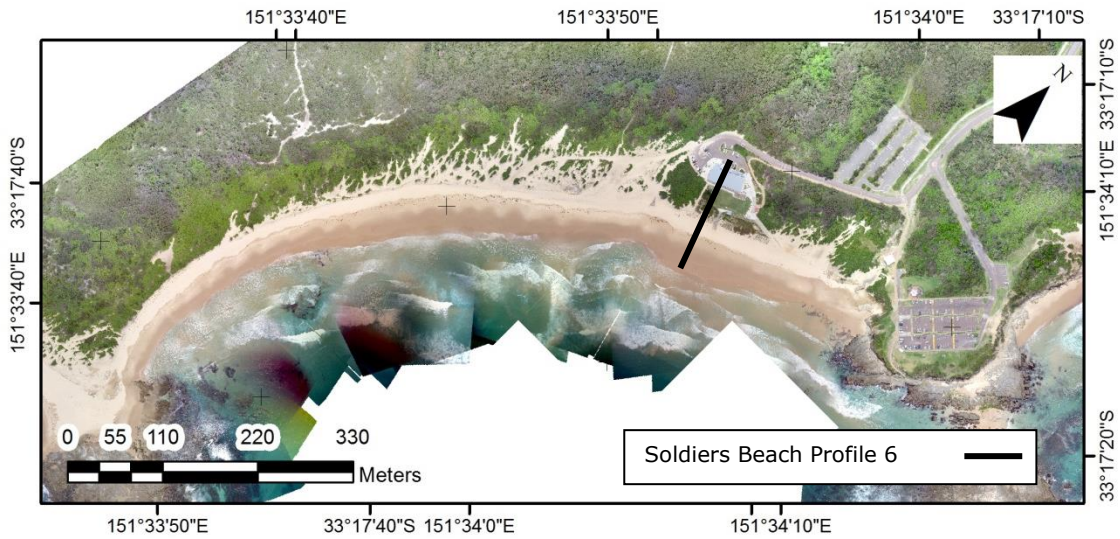


Figure 16: Soldiers Beach overview

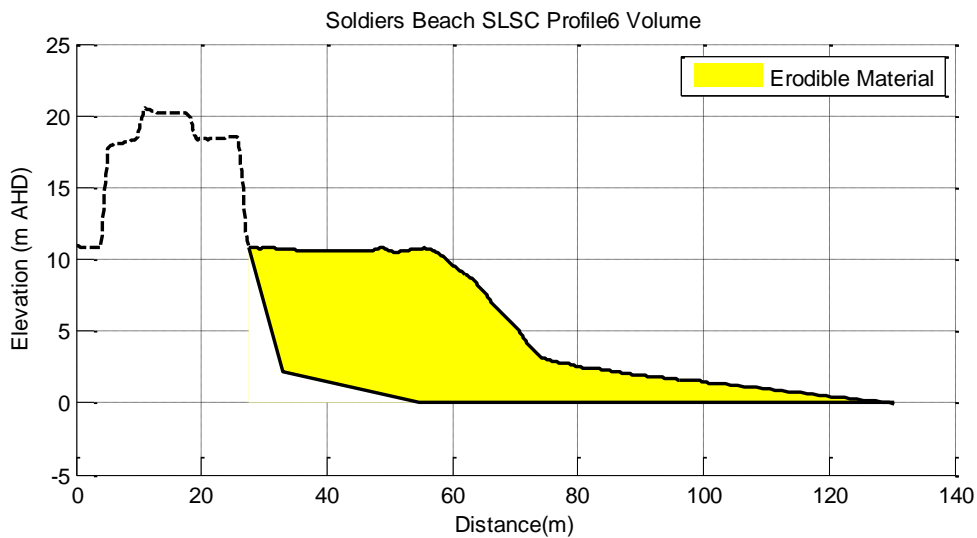


Figure 17: Profile fronting Soldiers Beach SLSC (Profile 6) showing the volume of available sand buffer in the beach profile above 0 m AHD

4.8 Norah Head (Pebble Beach to Lighthouse Beach)

4.8.1 Pebbly Beach

Pebbly Beach faces south-east and is undeveloped with the exception of the carpark on Soldiers Point (Figure 18). At the time of the survey the foredune height ranged from 8 m AHD to the south to 13 m AHD to the north and was sparsely vegetated. The hind-dune was predominantly well vegetated with heights ranging between 20 m AHD to the south and 16 m AHD to the north. Cliffs were present to the north over an intertidal rock platform. Rock outcrops were present at the southern end of the beach and in the dune at the centre of the beach. Two channels existed in the centre of the beach on either side of the outcrop, both showing evidence of scour. At the

time of surveying, the representative beach slope was 1 in 16 and the beach state was low tide terrace, with irregular cusps.

4.8.2 Lighthouse Beach

Lighthouse beach faces north-east and protected by extensive rock platforms to the east and west (Figure 18). At the time of surveying, there was a narrow, vegetated foredune 8 m AHD in height. The beach representative beach slope was 1 in 9 and the beach state was reflective.

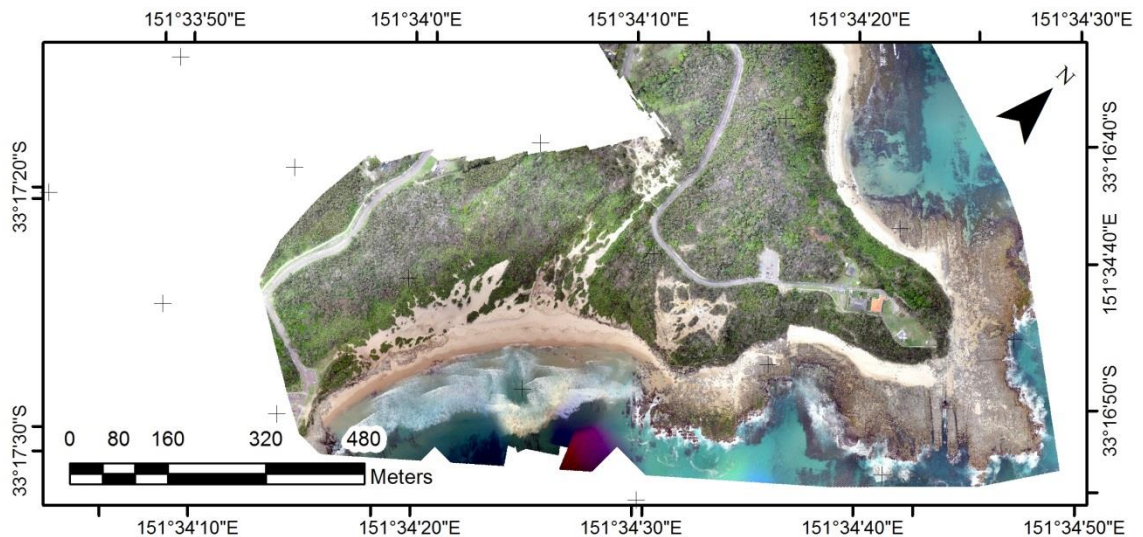


Figure 18: Norah Head overview

4.9 Cabbage Tree Harbour

Cabbage Tree Harbour faces north-east and is protected by rock platforms to the north and south (Figure 19). The beach was backed by bluffs at the centre and north with a height of 20 m AHD. At the time of surveying, the beach was narrow with a representative slope of 1 in 6 and the beach state was reflective, with cusps.

The south end of the beach and the top of the bluffs in the centre and north of the beach have been developed with properties located in close proximity to an unstable slope. A predominantly buried seawall fronts property to the south between the rock pool and the boat ramp, with a rock armour and concrete seawall surrounding the boat ramp and in front of the carpark. Rock toe protection is present at the base of the bluff in the centre and north of the beach. The volume of available storm demand is unknown due to the rocky nature of the beach. In the middle of the beach at the southern end of the rock toe protection there was observed to be recent erosion of the clayey bluff caused by a combination of uncontrolled water runoff and human activity.

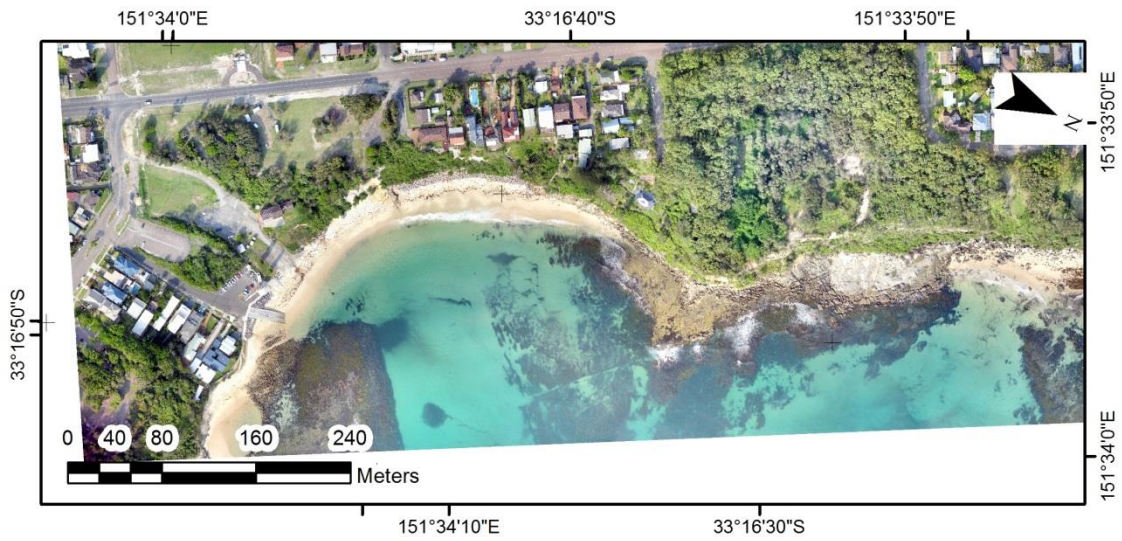


Figure 19: Cabbage Tree Harbour overview

4.10 Jenny Dixon Beach

Jenny Dixon Beach is a low gradient, east facing beach protected by rock reefs to the north and south (Figure 20). At the time of surveying, the representative beach profile was 1 in 62 and the beach state was reflective. Rock outcropping occurred in the centre and to the north of the beach and the beach was backed by a well vegetated bluff with a height of 20 m AHD. Development was present 40 m from the top of the bluff at the south end of the beach and 4 m from the top of the bluff at the north end.

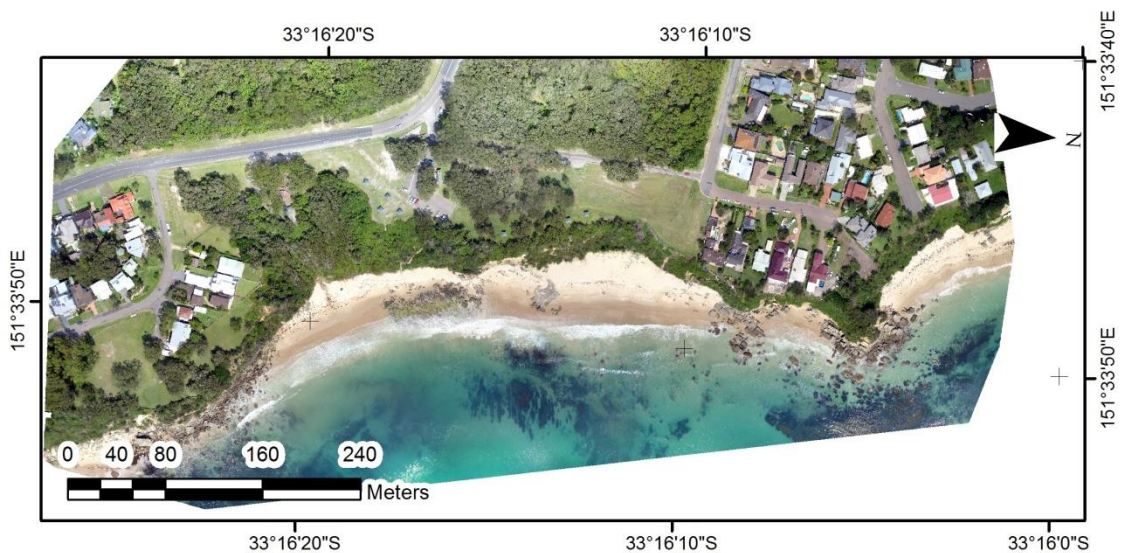


Figure 20: Jenny Dixon Beach overview

4.11 Hargraves Beach

Hargraves Beach is an east facing beach that had a representative slope of 1 in 17 at the time of surveying (Figure 21). The frontal dune has been developed along the length of the beach and was fronted by an incipient foredune that varied in width. The minimum distance between residential structures and the 2 m AHD contour line was 47 m. The foredune was moderately vegetated, and had a number of access paths directly from properties. When surveyed the beach state was low tide terrace (LTT) and cusps were present on the southern part of the beach. The volume of available sand buffer in the beach profile above 0 m AHD fronting properties in the centre of the beach is equal to 298 m³/m (Figure 22). This volume is in excess of the design storm erosion volume of 180 m³/m presented in BMT WBM (2015).

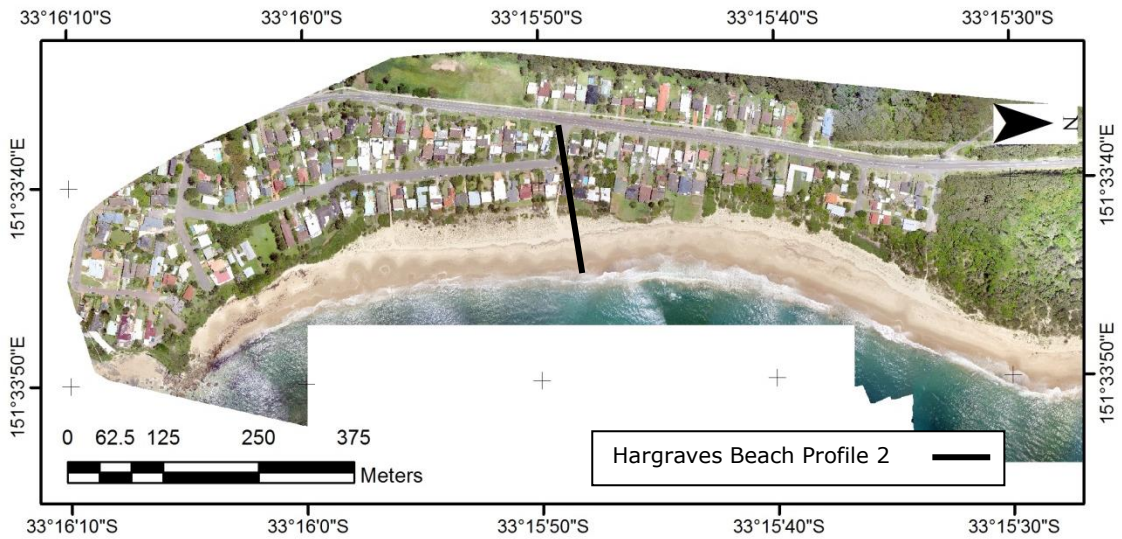


Figure 21: Hargraves Beach overview



Figure 22: Profile fronting property in the centre of Hargraves Beach (Profile 2) showing the volume of available sand buffer in the beach profile above 0 m AHD

4.11.1 Lakes Beach

Lakes Beach is a south-east facing barrier beach with a representative slope of 1 in 9 at the time of surveying (Figure 23). It is undeveloped except for the SLSC and three car parks. The dunes were well vegetated at the southern end of the beach, with less vegetation north of the Lakes Beach SLSC. A lightly vegetated incipient foredune was present along most of the beach. At a distance of 290 m to the north of the Lakes Beach SLSC, the road comes to within 95 m of the 2 m AHD contour behind sparsely vegetated dune with a height of 6 m AHD. When surveyed the beach state was transverse bar and rip (TBR). The volume of available sand buffer in the beach profile above 0 m AHD fronting Lakes Beach SLSC is equal to 291 m³/m (Figure 24). This volume is in excess of the 100 year ARI design storm erosion volume of 150 m³/m presented in BMT WBM (2015).

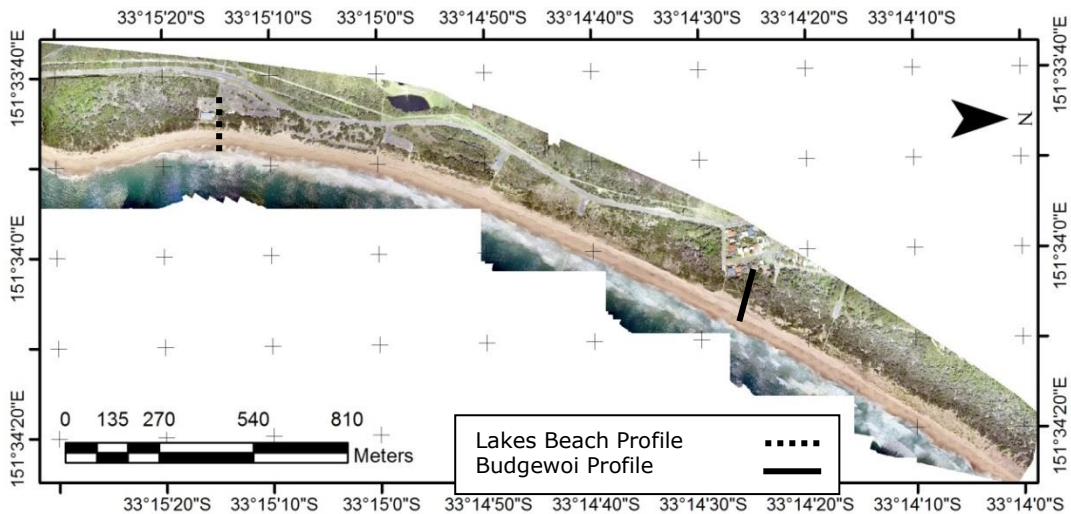


Figure 23: Lakes Beach to Budgewoi Beach overview

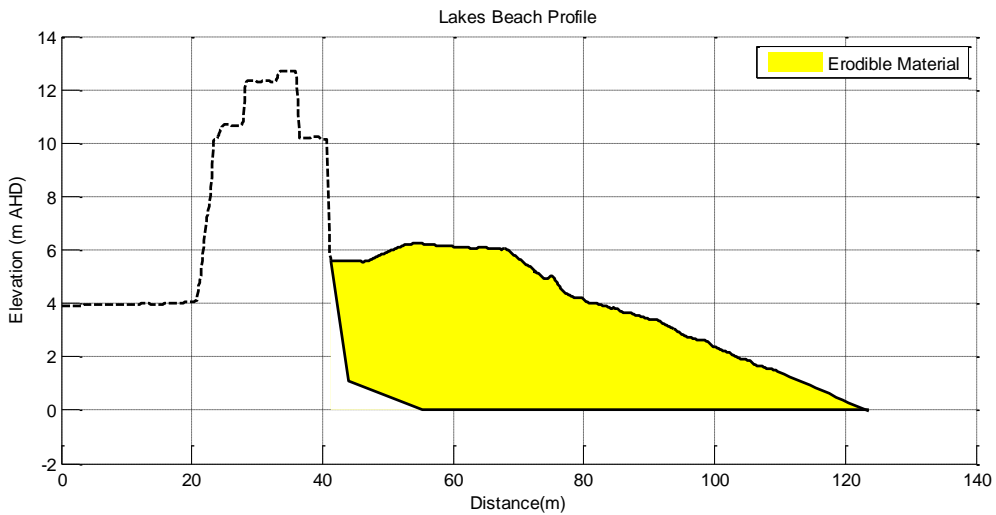


Figure 24: Profile fronting Lakes Beach SLSC (Lakes Beach Profile 1) showing the volume of available sand buffer in the beach profile above 0 m AHD

4.11.2 Budgewoi Beach

Budgewoi Beach had a representative beach slope of 1 in 6 at the time of surveying and the beach state was transverse bar and rip (TBR). Development is minimal along this beach and was located 110 m from the 2 m AHD contour. The dunes were well vegetated in front of and to the north of the development.

The volume of available sand buffer in the beach profile above 0 m AHD and landward of Boomerang Street is equal to 463 m³/m (Figure 25). This volume is in excess of the design storm erosion volume of 250 m³/m presented in BMT WBM (2015).

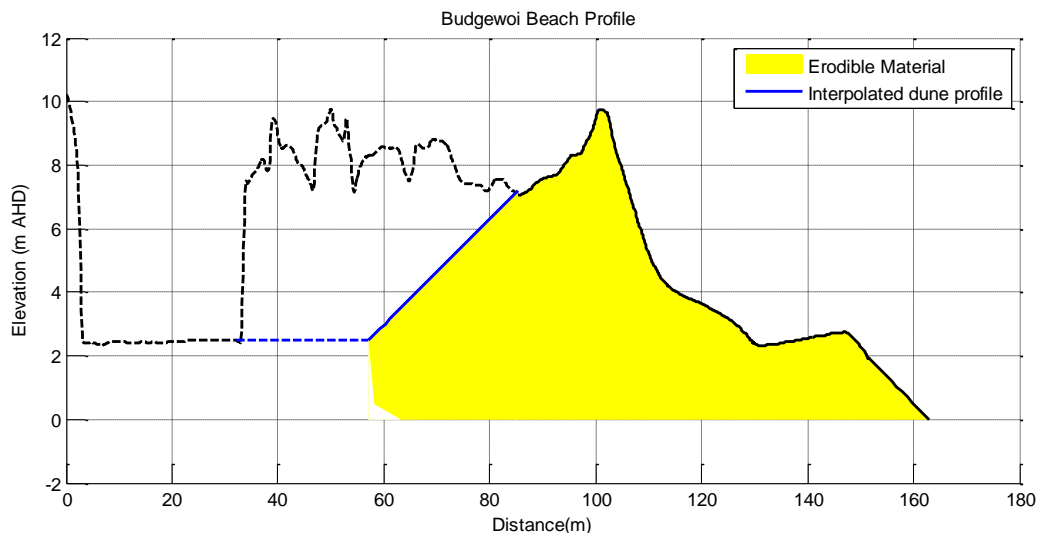


Figure 25: Profile fronting Boomerang St Budgewoi (Lakes Beach Profile 2) showing the volume of available sand buffer in the beach profile above 0 m AHD

4.12 Birdie Beach

Birdie beach is a south-east facing barrier beach, undeveloped, with access points at the northern and southern extents (Figure 26). At the time of surveying there was a steep frontal dune along the length of the beach that was well vegetated in most areas. A flowing creek outlet existed at the northern end. When surveyed, the beach state was intermediate and varied from transverse bar and rip (TBR) at the northern end to rhythmic bar and beach (RBB) in the centre and to the south, with well-defined cusps. A salient was present in the wave shadow zone behind Bird Island measuring 1 km in length and a width of 60 m compared to the adjacent average beach width. The representative beach slope was 1 in 51.

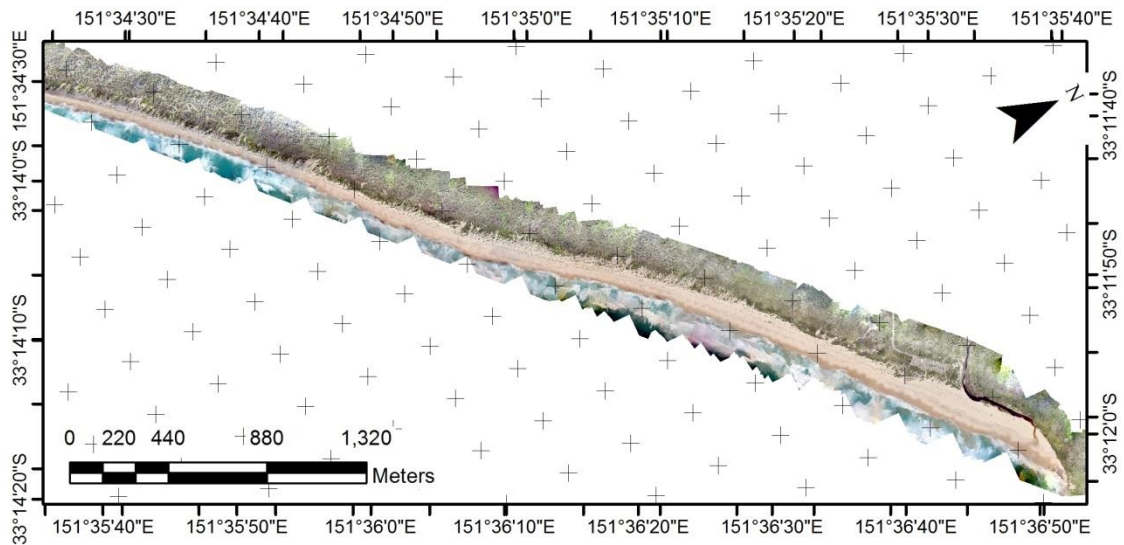


Figure 26: Birdie Beach overview

4.13 Frazer Park

Frazer Park Beach is south-east facing and had a representative slope of 1 in 77 at the time of surveying (Figure 27). The beach is undeveloped aside from three car park areas. There was a flowing creek outlet to the south of the carparks, and another smaller waterway to the north. Rock outcropping occurred at the centre and south end of the beach. When visited, the beach state was transverse bar and rip (TBR).

4.14 Ghosties Beach

The beach is backed by high, steep cliffs and is undeveloped, with the only access via Catherine Hill Bay to the north (Figure 28). The tombolo to Flat Island is lightly vegetated with grass and the island is heavily vegetated. High water level is at the base of the cliff along the majority of the beach. When visited, the beach state was low tide terrace (LTT).

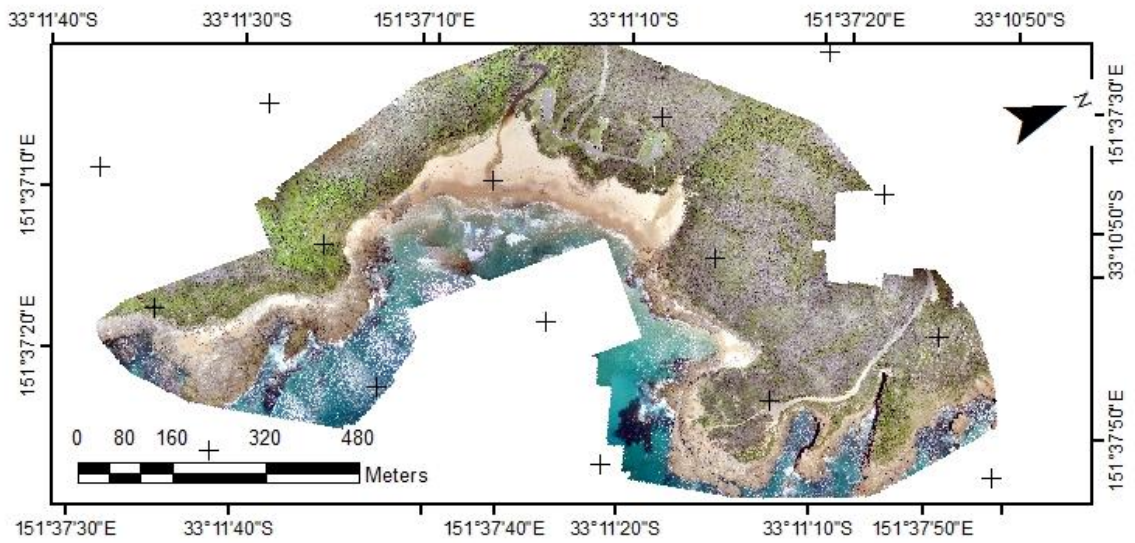


Figure 27: Frazer Park overview

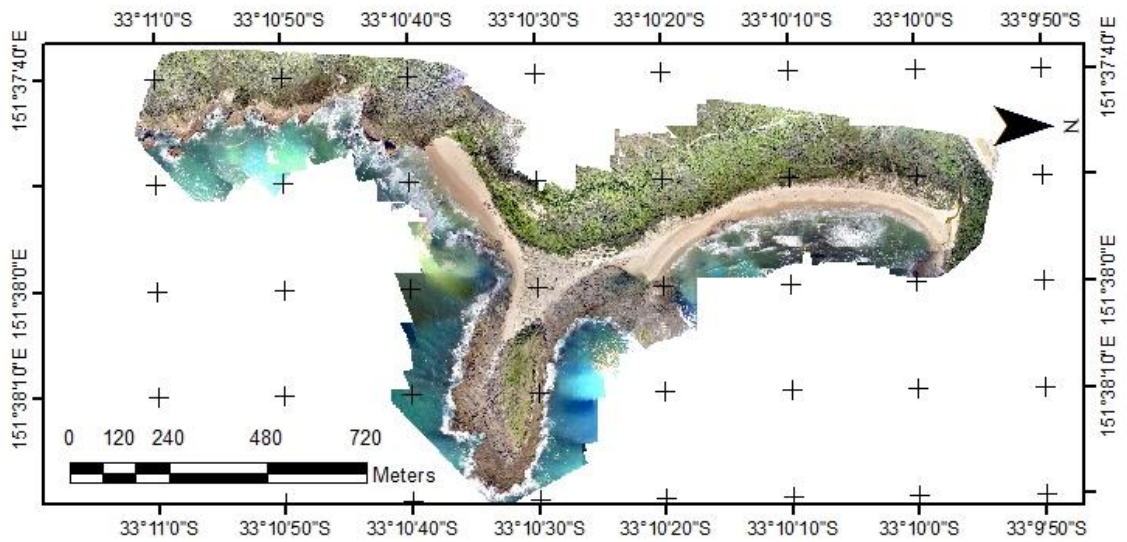


Figure 28: Ghosties Beach overview

5. Summary

The use of UAV as a mapping and measurement tool has grown significantly in recent years, such that the potential for coastal engineering applications is being realised. UAV surveying provides a cost-effective solution for rapid airborne sampling of the coastal zone at high-accuracy and very high spatial resolution.

This report outlines the first round of UAV surveying completed for the coastline of the Wyong Shire by WRL in November 2015 using a fixed wing UAV. The survey included all beaches on the coastline extending from Bateau Bay in the south to Ghosties Beach in the north. Coastal engineering analysis has been provided for all beaches including quantification of dune height, volume of sand buffer above 0 m AHD, representative beach slopes and classification of the beach state at the date of surveying. This survey deployment provides a valuable baseline dataset that will allow for further analysis of coastal process when compared against future survey deployments.

6. References

BMT WBM (2015), "Wyong Coastal Zone Management Plan draft report", pp 5, 16, 17, extract received via email from Wyong Council on 17/02/2016.

Manly Hydraulics Laboratory (2015), "Sydney Offshore Wave Buoy data", Collected under the NSW Coastal Data Network Program managed by Office of Environment and Heritage (OEH), data received 28 January 2016.

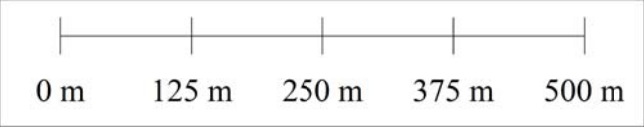
Nielsen, A F, Lord, D B and Poulos, H G (1992), "Dune Stability Considerations for Building Foundations", Australian Civil Engineering Transactions, The Institution of Engineers, Australia, Volume CE34, Number 2, p. 167 – 174.

Shand, T D, Goodwin, I D, Mole, M A, Carley, J T, Browning, S, Coghlan, I R, Harley, M D and Peirson, W L (2010), "NSW Coastal Storms and Extreme Waves", The 19th Coastal Conference, Batemans Bay, NSW, Australia.

Short, A D (2007), "Beaches of the New South Wales coast: a guide to their nature, characteristics, surf and safety (2rd ed.)", Sydney NSW, Sydney University Press, p. 23 – 36.

Appendix A: Beach Profiles

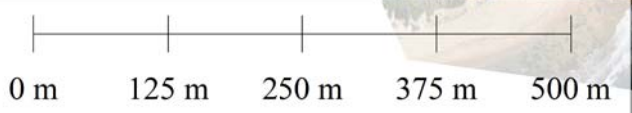
Bateau Bay



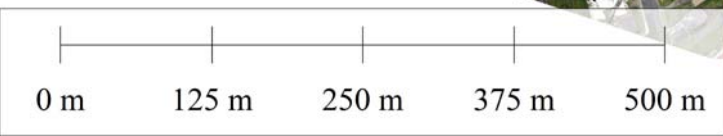
Shelly Beach



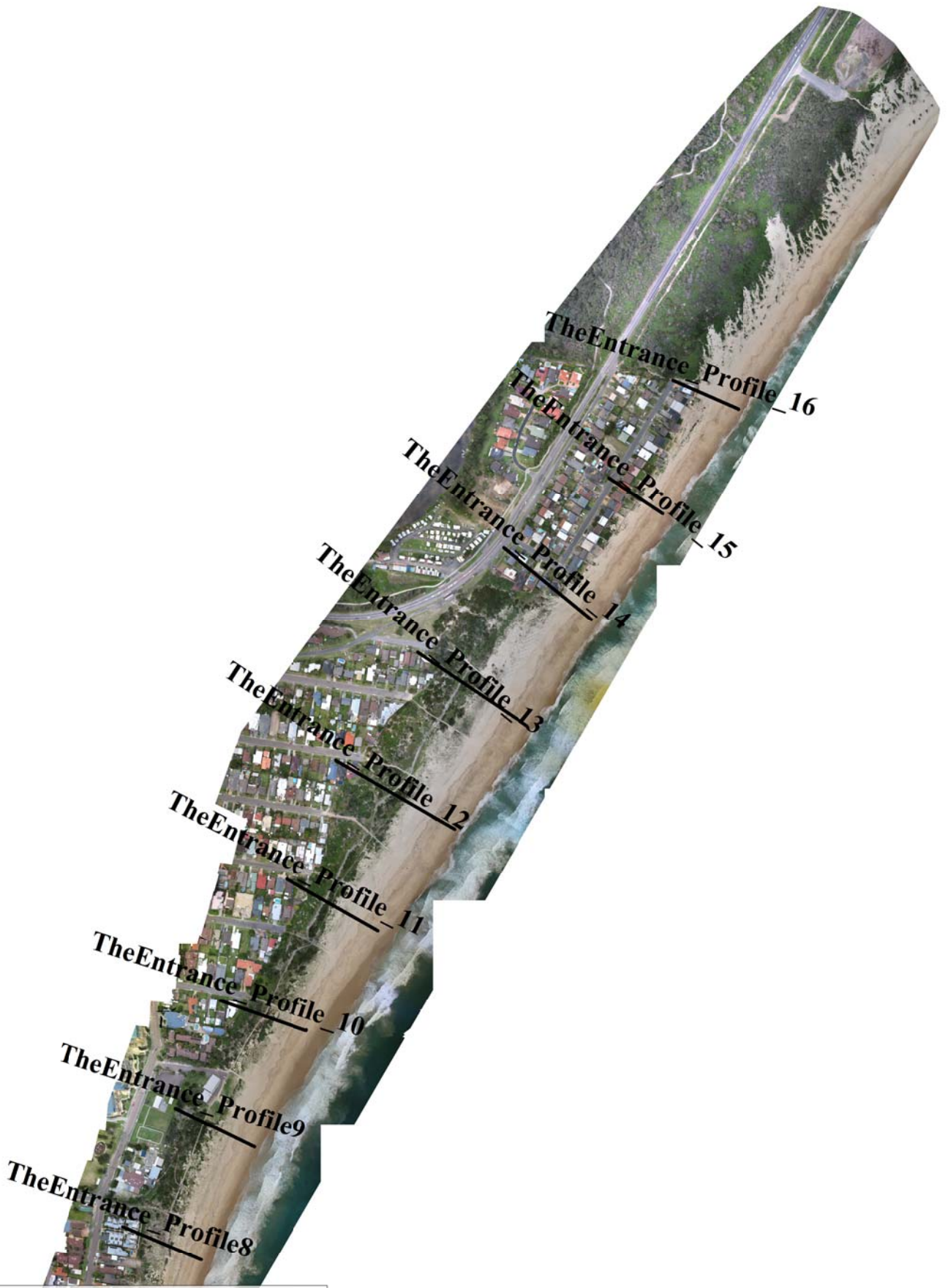
Toowoan Bay - Blue Bay



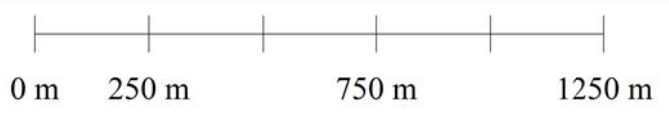
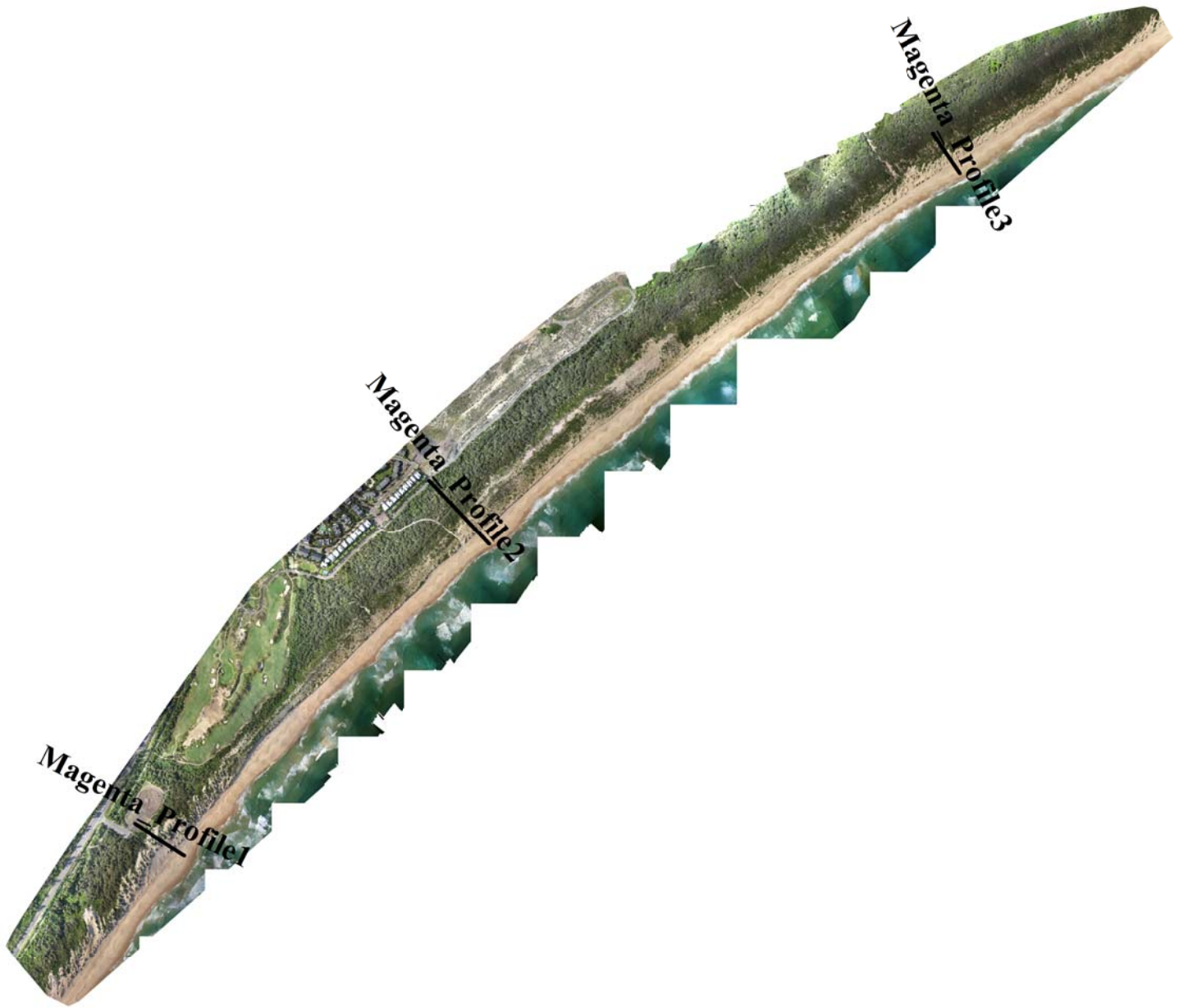
The Entrance



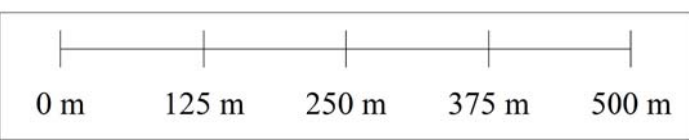
The Entrance



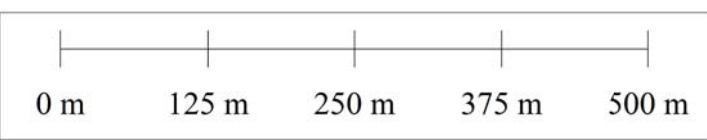
Magenta



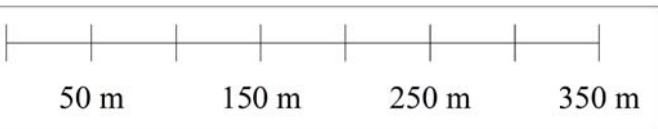
Soldiers Beach



Norrah Head (Pebbly Beach and Lighthouse Beach)



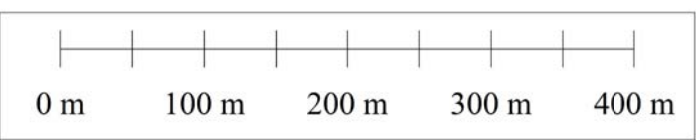
Cabbage Tree Harbour



Jenny Dixon Beach



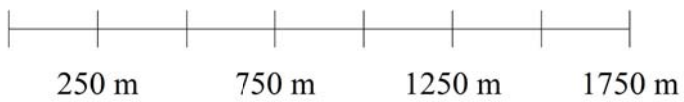
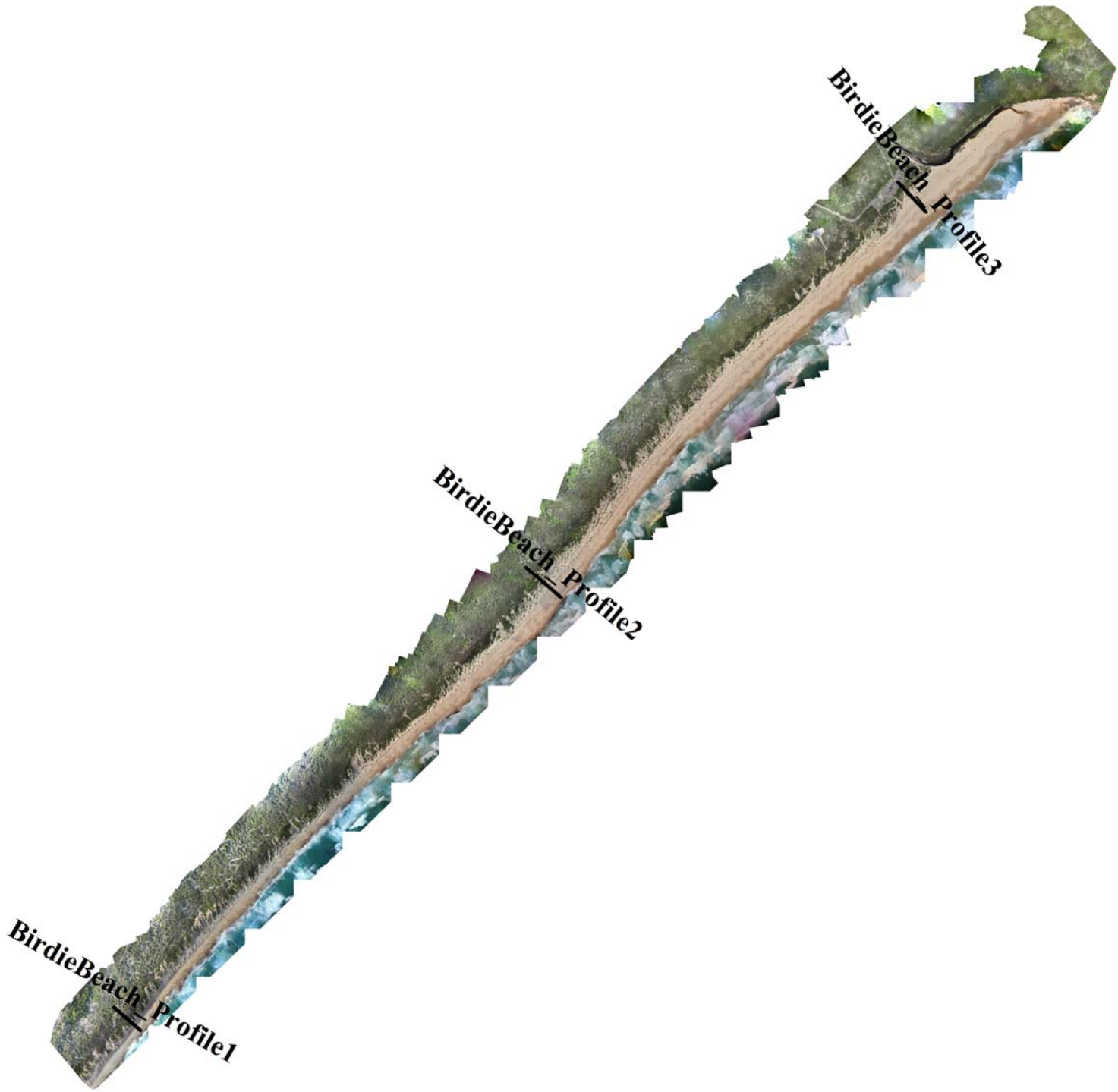
Hargraves Beach



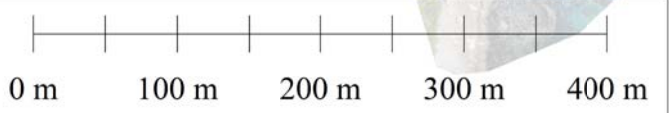
Lakes Beach - Budgewoi



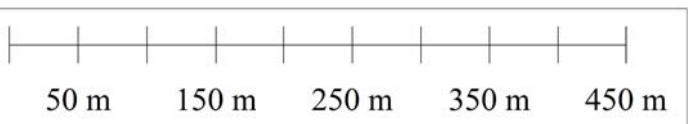
Birdie Beach



Frazer Park



Ghosties Beach



Appendix A - Beach Profiles

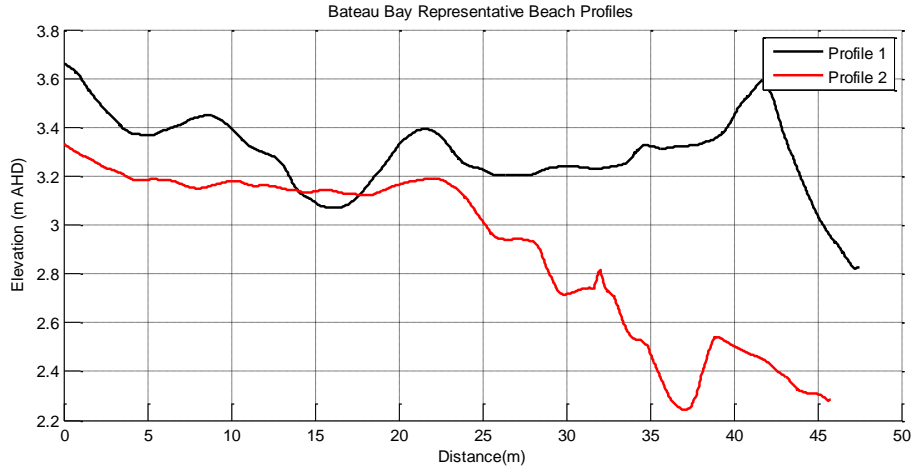


Figure 1: Bateau Bay Beach Profiles 1 and 2

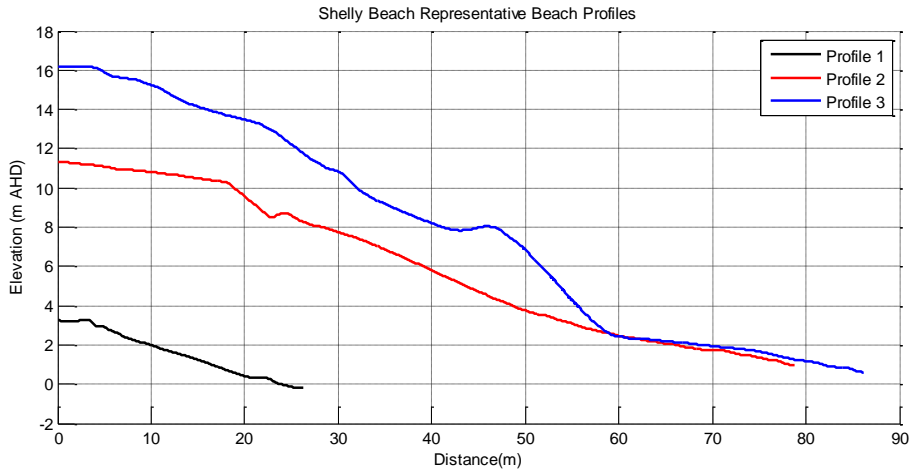


Figure 2: Shelly Beach Profiles 1, 2 and 3

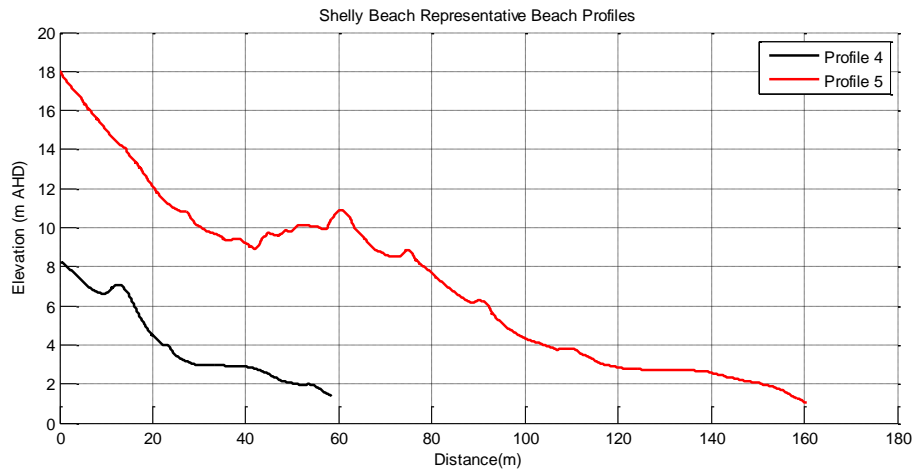


Figure 3: Shelly Beach Profiles 4 and 5

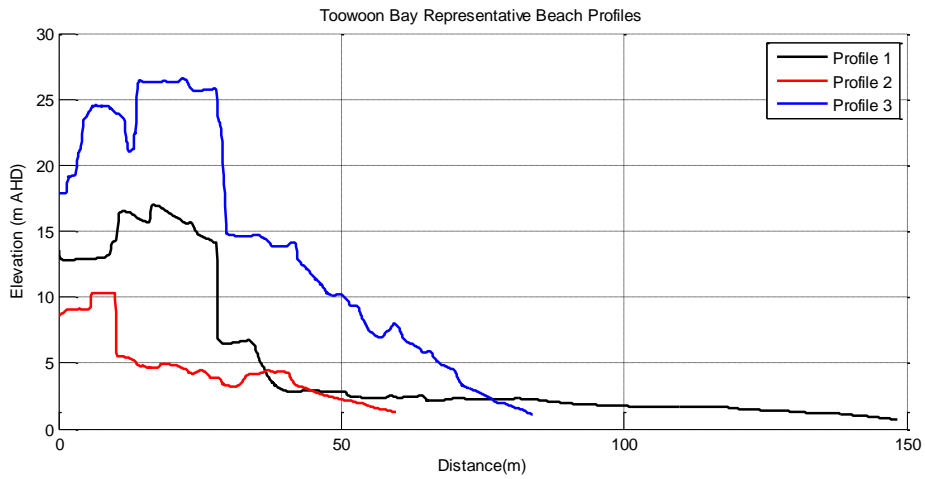


Figure 4: Toowoon Bay Beach Profiles 1, 2 and 3

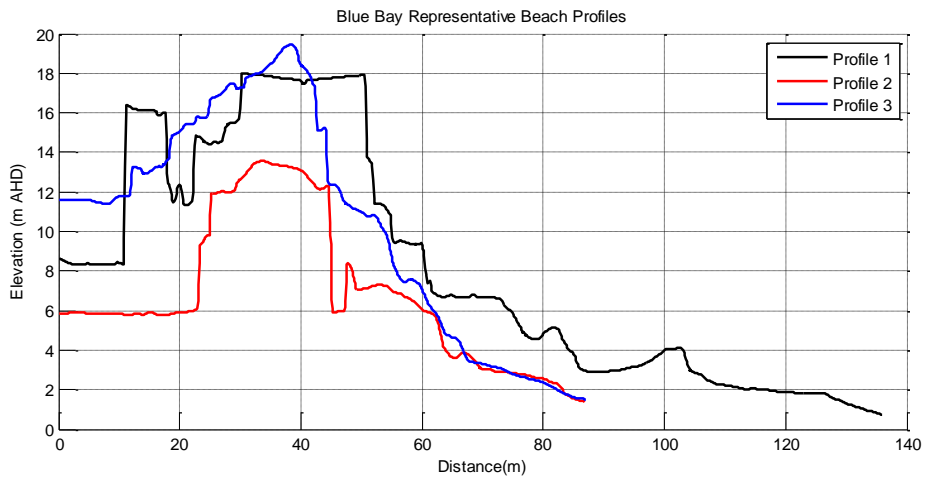


Figure 5: Blue : Toowoon Bay Beach Profiles 1, 2 and 3

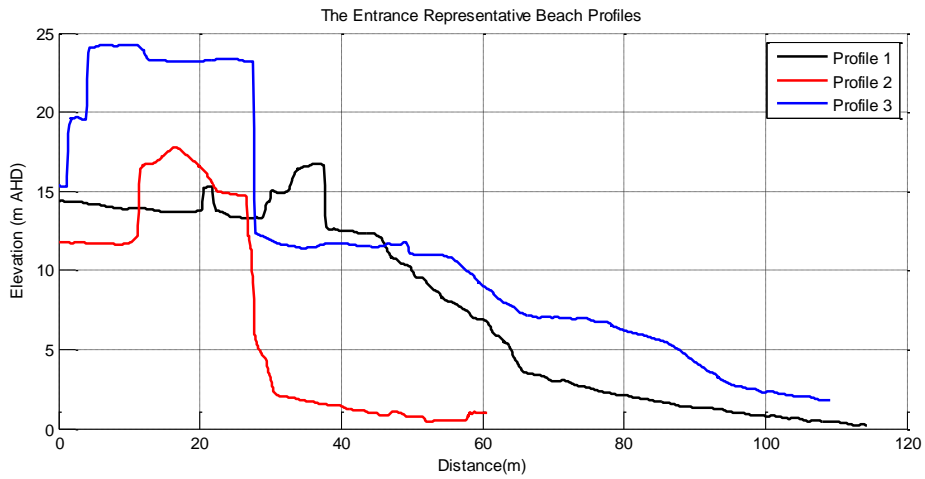


Figure 6: The Entrance Beach Profiles 1, 2 and 3

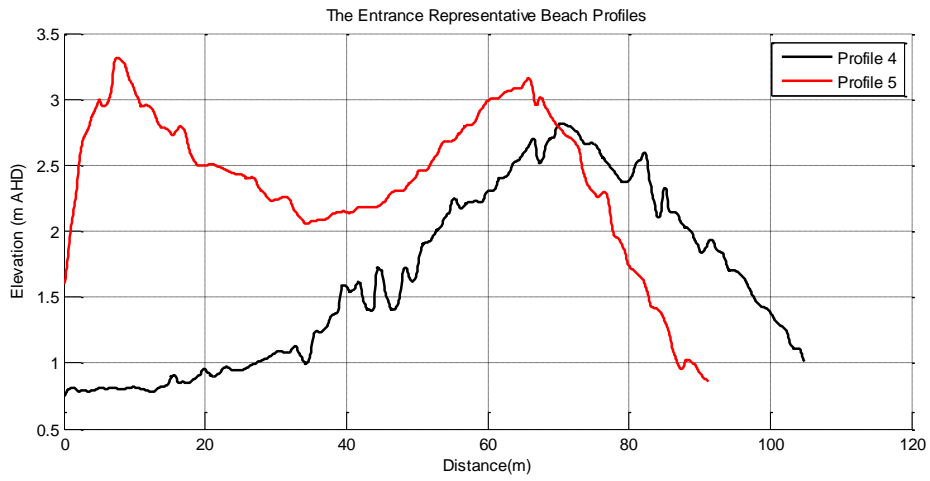


Figure 7: The Entrance Beach Profiles 4 and 5

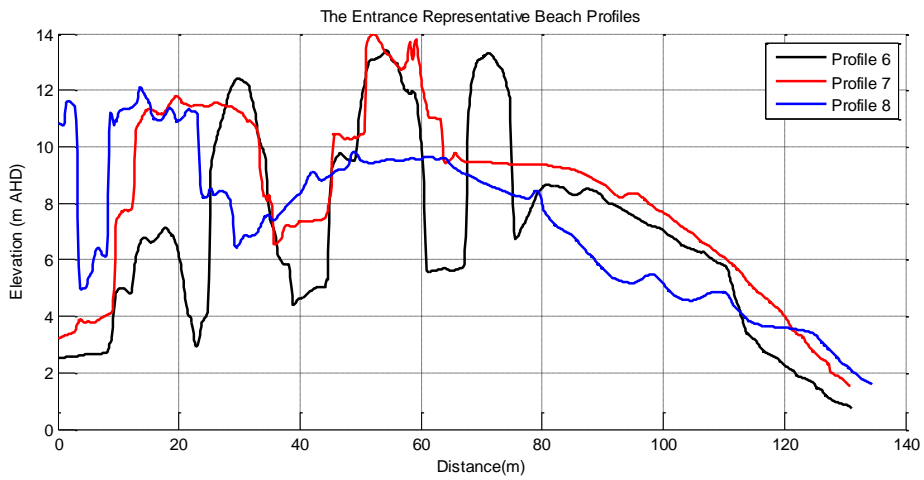


Figure 8: The Entrance Beach Profiles 6, 7 and 8

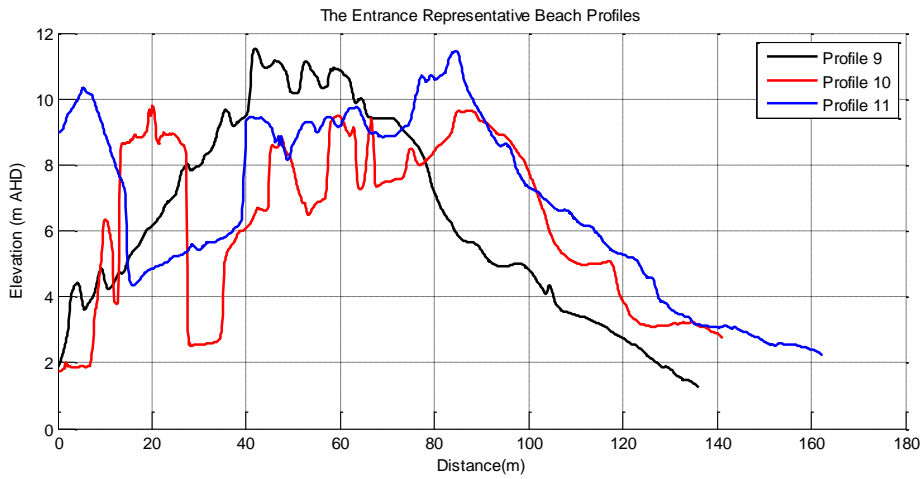


Figure 9: The Entrance Beach Profiles 9, 10 and 11

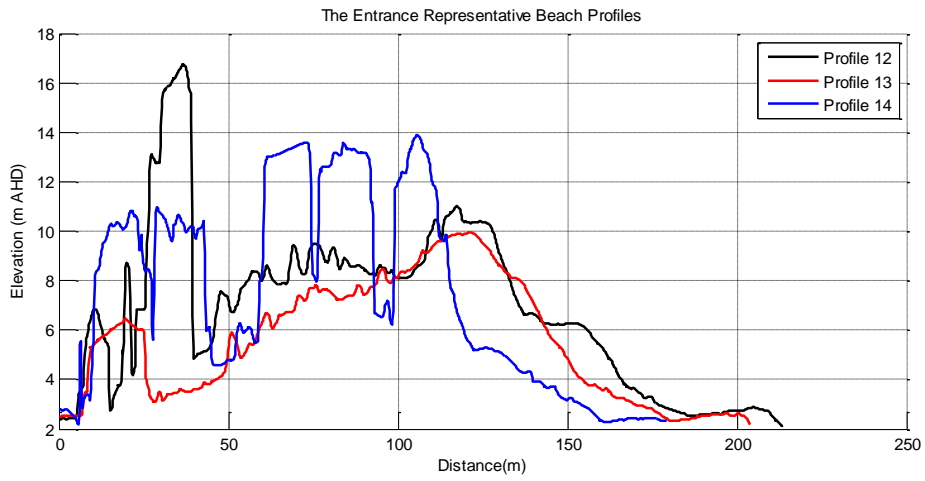


Figure 10: The Entrance Beach Profiles 12, 13 and 14

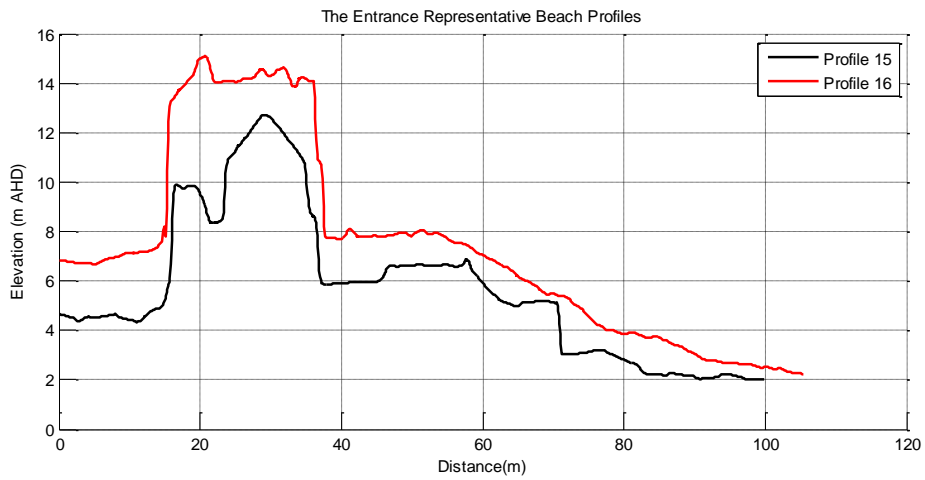


Figure 11: The Entrance Beach Profiles 15 and 16

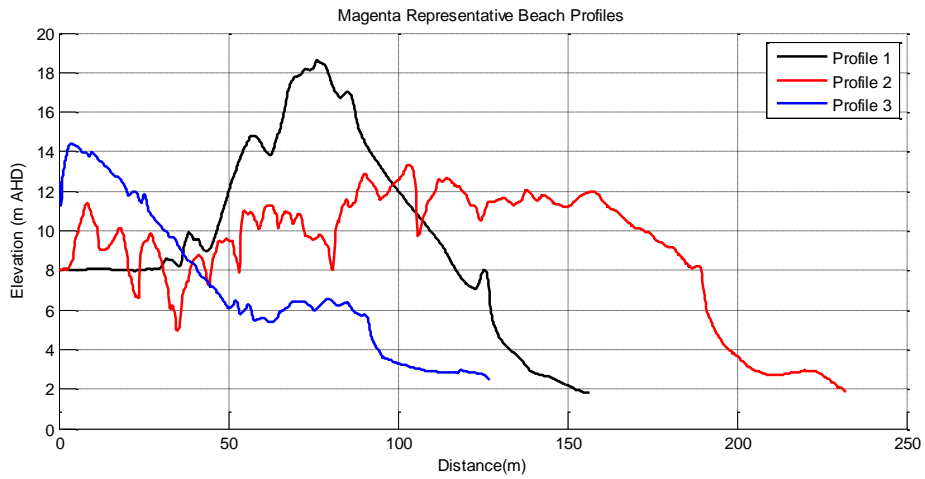


Figure 12: Magenta Beach Profiles 1, 2 and 3

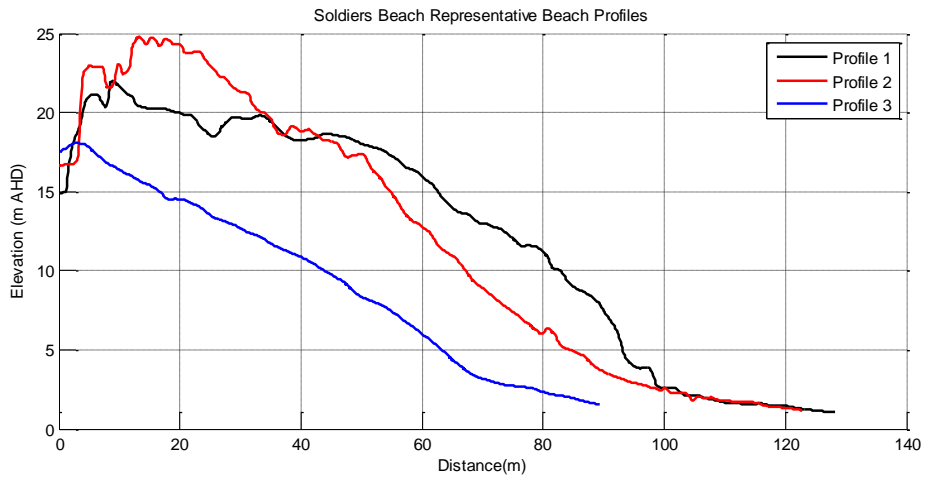


Figure 13: Soldiers Beach Profiles 1, 2 and 3

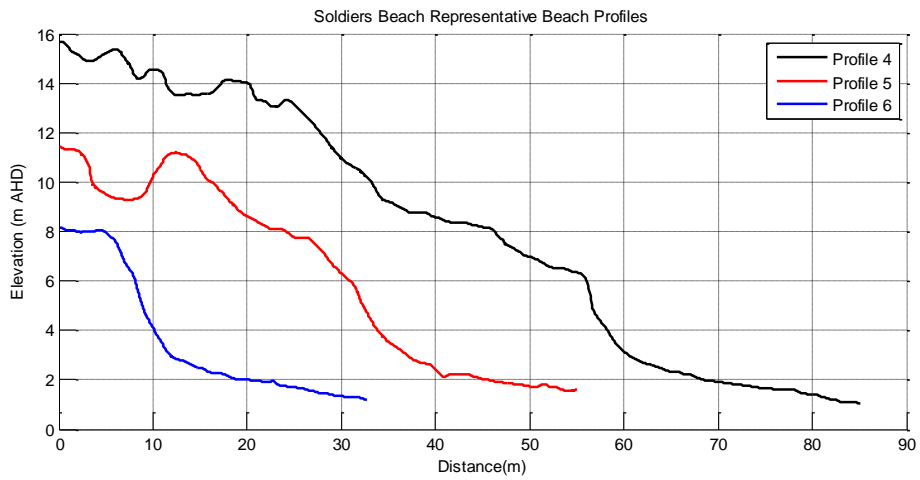


Figure 14: Soldiers Beach Profiles 4, 5 and 6

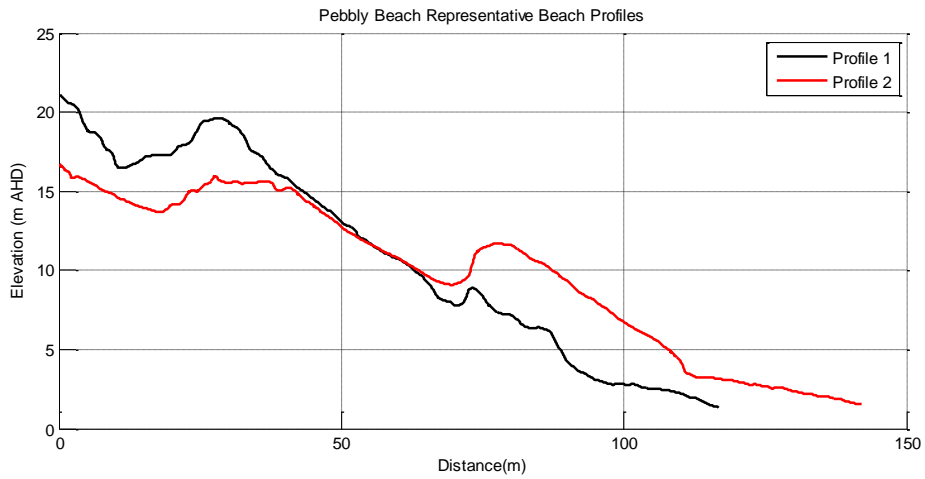


Figure 15: Pebble Beach Profiles 1 and 2

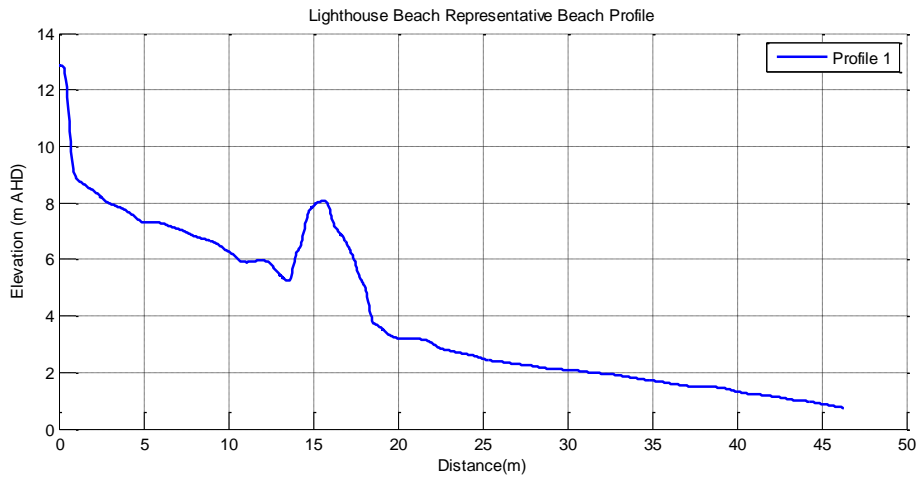


Figure 16: Lighthouse Beach Profile

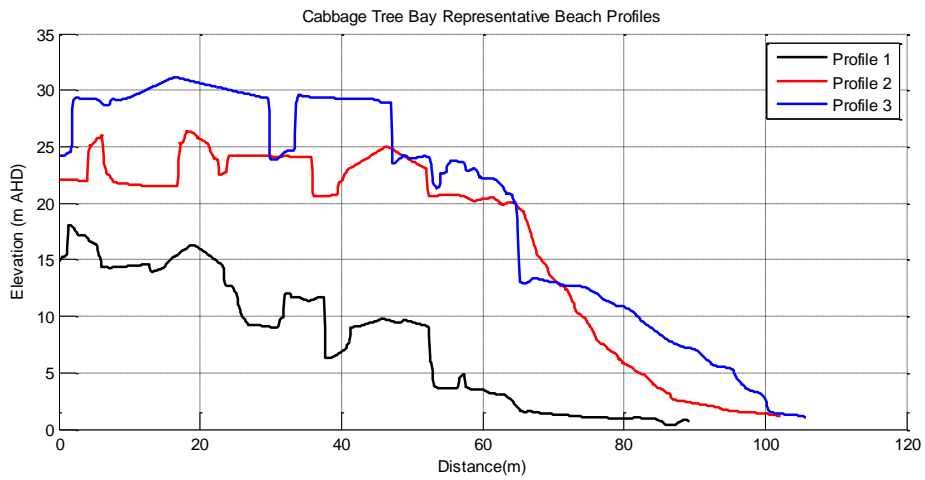


Figure 17: Cabbage Tree Harbour Beach Profiles 1, 2 and 3

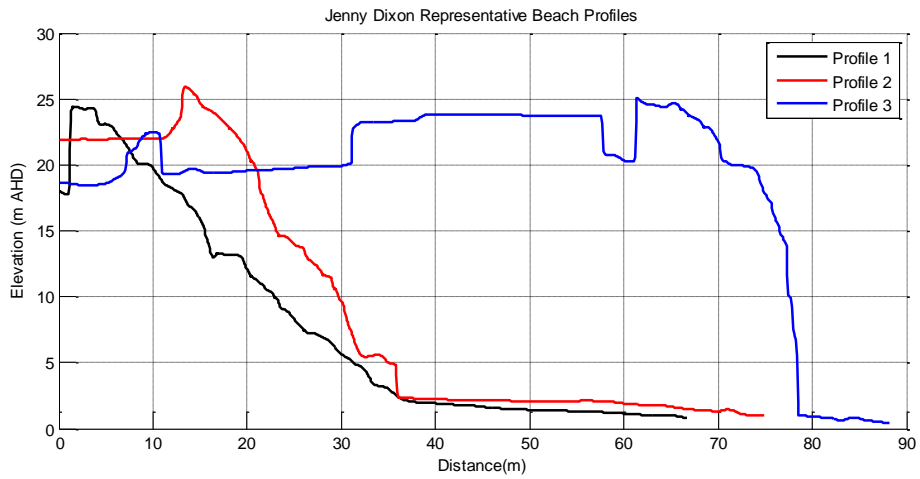


Figure 18: Jenny Dixon Beach Profiles 1, 2 and 3

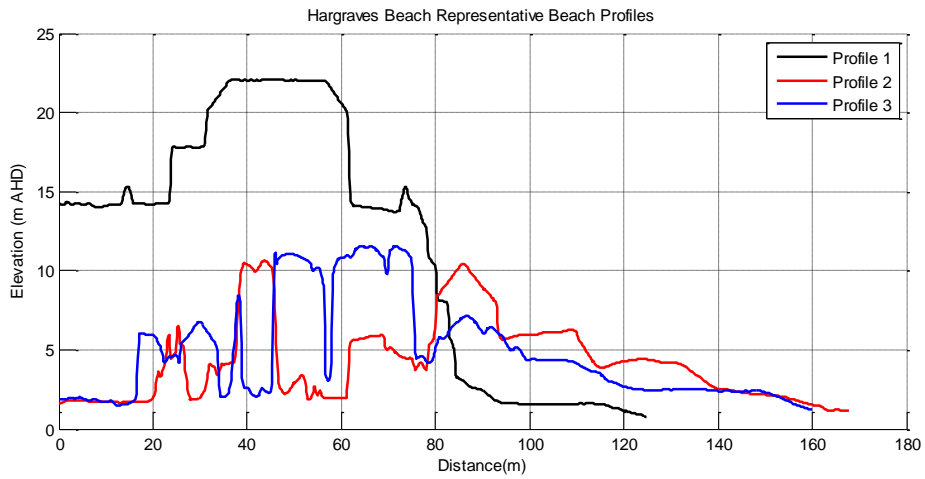


Figure 19: Hargraves Beach Profiles 1, 2 and 3

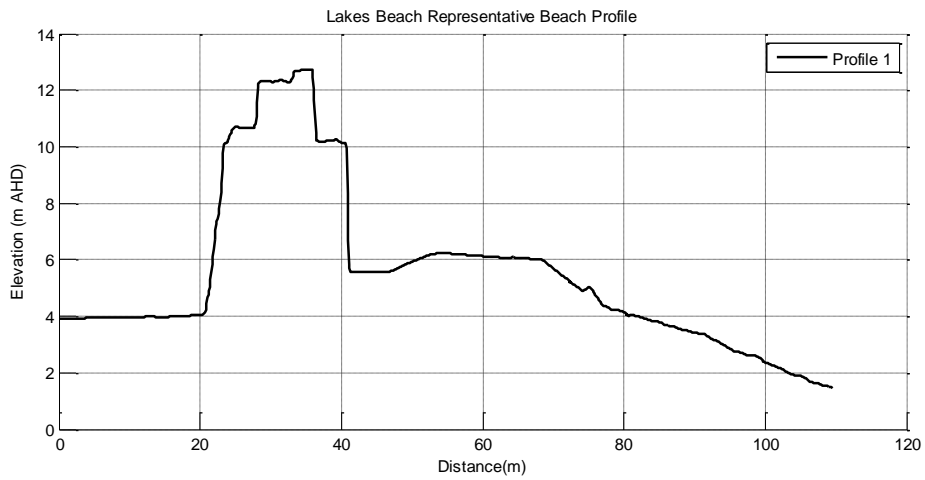


Figure 20: Lakes Beach Profile

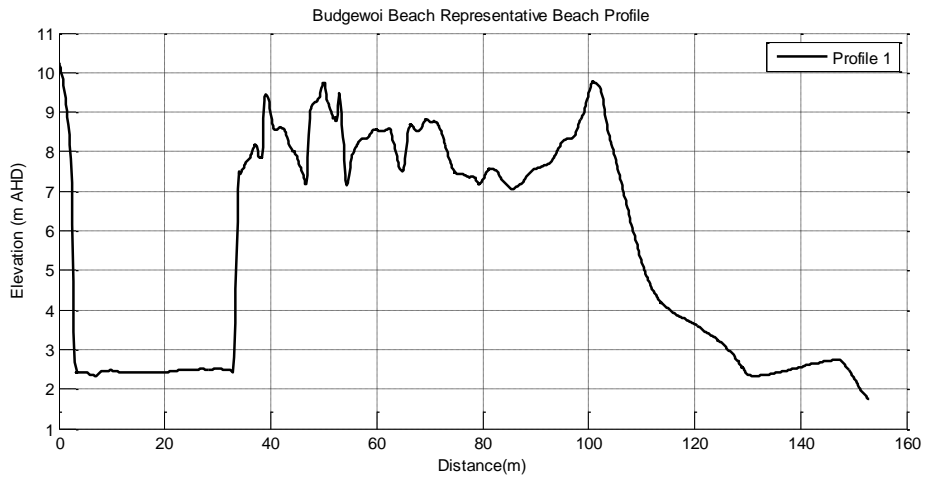


Figure 21: Budgewoi Beach Profile

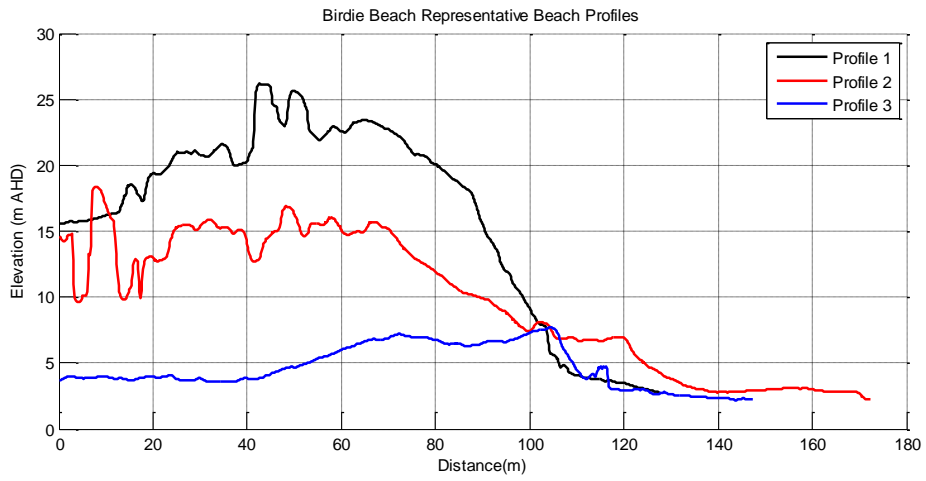


Figure 22: Birdie Beach Profiles 1, 2 and 3

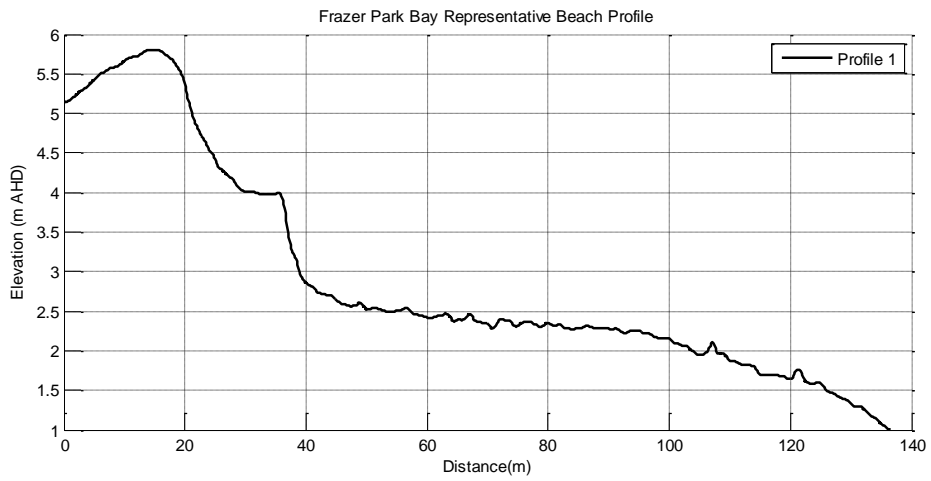


Figure 23: Frazer Park Beach Profile

Appendix B: Site Visit Photos

Appendix B - Site photos



Figure 1: Bateau Bay embayment



Figure 2: Shelly Beach SLSC



Figure 3: Toowoan Bay facing south



Figure 4: Toowoon Bay facing south from the tombolo at the northern extent



Figure 5: Blue Bay facing north



Figure 6: Incipient foredune at the southern extent of Blue Bay (facing north)



Figure 7: The Entrance facing south from the sand spit



Figure 8: The Entrance facing north from the sand spit



Figure 9: Magenta Beach facing north



Figure 10: Pelicans Beach



Figure 11: Soldiers Beach SLSC



Figure 12: Soldiers Beach facing south. Rock outcropping is visible to the right



Figure 13: Pebbly beach



Figure 14: Norah Head



Figure 15: Cabbage Tree Harbour facing South



Figure 16: Cabbage Tree Harbour facing North



Figure 17: Jenny Dixon Beach facing south



Figure 18: Hargraves Beach facing south



Figure 19: Hargraves Beach incipient foredune fronting residential property



Figure 20: Hargraves Beach facing north



Figure 21: Lakes Beach facing south with Lakes Beach SLSC on the right



Figure 22: Lakes beach facing north



Figure 23: Birdie Beach (North)



Figure 24: Budgewoi Beach facing north



Figure 25: Birdie Beach facing south



Figure 26: Birdie Beach facing north



Figure 27: Frazer Beach



Figure 28: Ghosties Beach