D.2 Sediment Transport and Bed Material Testing to Support Darwin Harbour Sediment Transport Model

This page is intentionally blank

Proposed Marine Industry Park Modelling Report

Sediment transport and bed material testing to support the Darwin Harbour sediment transport model

Ruth Patterson and David K Williams

PRODUCED FOR

Land Development Corporation, Darwin

Australian Government | Australian Institute of Marine Science

Darwin
2014

Australian Institute of Marine Science

Townsville address: PMB No 3,
Townsville MC, Qld 4810
Tel: (07) 4753 4444
Fax: (07) 4772 5852

Darwin address: PO Box No 41775,
Casuarina NT 0811
Tel: (08) 8920 9240
Fax: (08) 8920 9222

Perth address: The UWA Oceans Institute (M096)
35 Stirling Highway, Crawley WA 6009
Tel: (08) 6369 4000
Fax: (08) 6488 4585

www.aims.gov.au

This report should be cited as:
Patterson, R.G., Williams, D.K. (2014), Sediment transport and bed material testing to support the Darwin Harbour sediment transport model. Report for Land Development Corporation. Australian Institute of Marine Science, Darwin.

Report reviewed and edited by Edward Butler and David K Williams, Australian Institute of Marine Science

DISCLAIMER

Contents

List of Figures

List of Tables

1 Executive Summary

The Australian Institute of Marine Science (AIMS), Darwin and the Land Development Corporation (LDC) have co-invested to provide better data for sediment transport modelling at East Arm in Darwin Harbour. East Arm and its surrounding environment will undergo major environmental changes with the development of the proposed marine industry park, a marine supply base, and other developments relating to the maintenance and improvement of the international East Arm wharf. Many of these project proposals have relied on AIMS' hydrodynamic and sediment transport modelling for use in a range of areas such as estimating the extent of dredge plumes, likely areas for sediment erosion and deposition, and design for rock walls and vessel landing areas. Previously the model outputs have been based on assumptions for key parameters in which various literature and 'default' values have been used. Best modelling practices make use of data that have been measured *in situ*. This report describes the six separate field studies (carried out in late January and mid February to mid March 2014), four laboratory experiments and five desktop analyses undertaken to achieve these data for the East Arm environment. The data collected have quantified the sediment fall velocity, bulk density of the bed surface, bed material type, thickness and distribution, and the variation and concentration of suspended sediment in the water column. AIMS also used the data to verify that of the wind waves generated by storms during the study period there was no effect of the waves on the sediment transport. AIMS highlighted the need for these data to be collected and the model coefficients to be calibrated in the Task 1 Proposed Marine Park Development Modelling report (Patterson and Williams, 2013). This report also includes further modelling to test the changes made. Reasonable results were achieved in the cohesive sediment model, which was the model that benefited most from the collection and analysis of these data. The deposition/erosion rates and locations have been predicted with confidence and could be used for estimating dredge intervals. Dredge plumes have also been modelled with confidence. The non-cohesive (sand) model could be improved further with the use of better laboratory equipment such as a flume. Although these models are calibrated and values documented to a high standard, further verification should always be sought should the opportunity arise. This report describes the field, laboratory and desktop analyses carried out and how the results have been used in the modelling. Modelling of erosion and deposition in the East Arm area have been carried out in addition to requested dredge plume modelling.

2 Introduction

AIMS Darwin has undertaken targeted sediment transport research in order to improve the AIMS sediment transport models in support of industry works at East Arm. AIMS has carried out several different sediment transport measurement techniques to target knowledge gaps. Vibrocores were taken at strategic locations to explore subsurface bed material and thickness. Sub-bottom profile transects were undertaken for the extent of the study area. Bed surface grab samples were taken to understand the connectivity between different vibrocore measurments and to explain some anomalies in the sub-bottom profiling results. Two Acoustic Doppler Current Profilers (ADCP), a Conductivity, Temperature and Depth (CTD) and turbidity nephelometer were attached to a tripod frame and deployed for a month from mid-February to mid-March 2014, capturing a full tidal cycle of 3-dimensional currents, wave data, sediment migration and suspended sediment (backscatter) data. The vibrocore and grab samples were analysed and processed in the laboratory to measure bulk density, and bed material thickness. Sediment fall velocity and compaction was also measured using sediment collected during the field studies. Modelling has been greatly improved by using parameters calculated from the above sediment surveys as direct input. These parameters are: bulk

density (wet and dry), sediment fall velocity, bed material distribution and thickness, soil compaction rates, net sediment flux direction, total suspended sediment conditions and other incidental factors such as the comparison of acoustic and optical backscatter. The study also confirmed other observations which have contributed to the overall management of the harbour, such as a vertically well mixed water column with the absence of thermoclines. This information has been collected in the strategic location of East Arm for the future development of Darwin Harbour. This report describes the conditions at East Arm as they are now, and will be a baseline reference for subsequent physical environmental studies.

3 Field surveys

3.1 Vibrocores

Vibrocores were taken in areas of high and low shear stress as indicated by the Darwin Harbour sediment transport modelling results. The vibrocore sample locations are shown below in Figure 1. Two main purposes for these tests are:

1. To indicate the quality and thickness of subaqueous material
2. To obtain a core sample for bulk density testing. The vibrocore sampling was taken on two subsequent days from 24th – 25th of January, 2014.

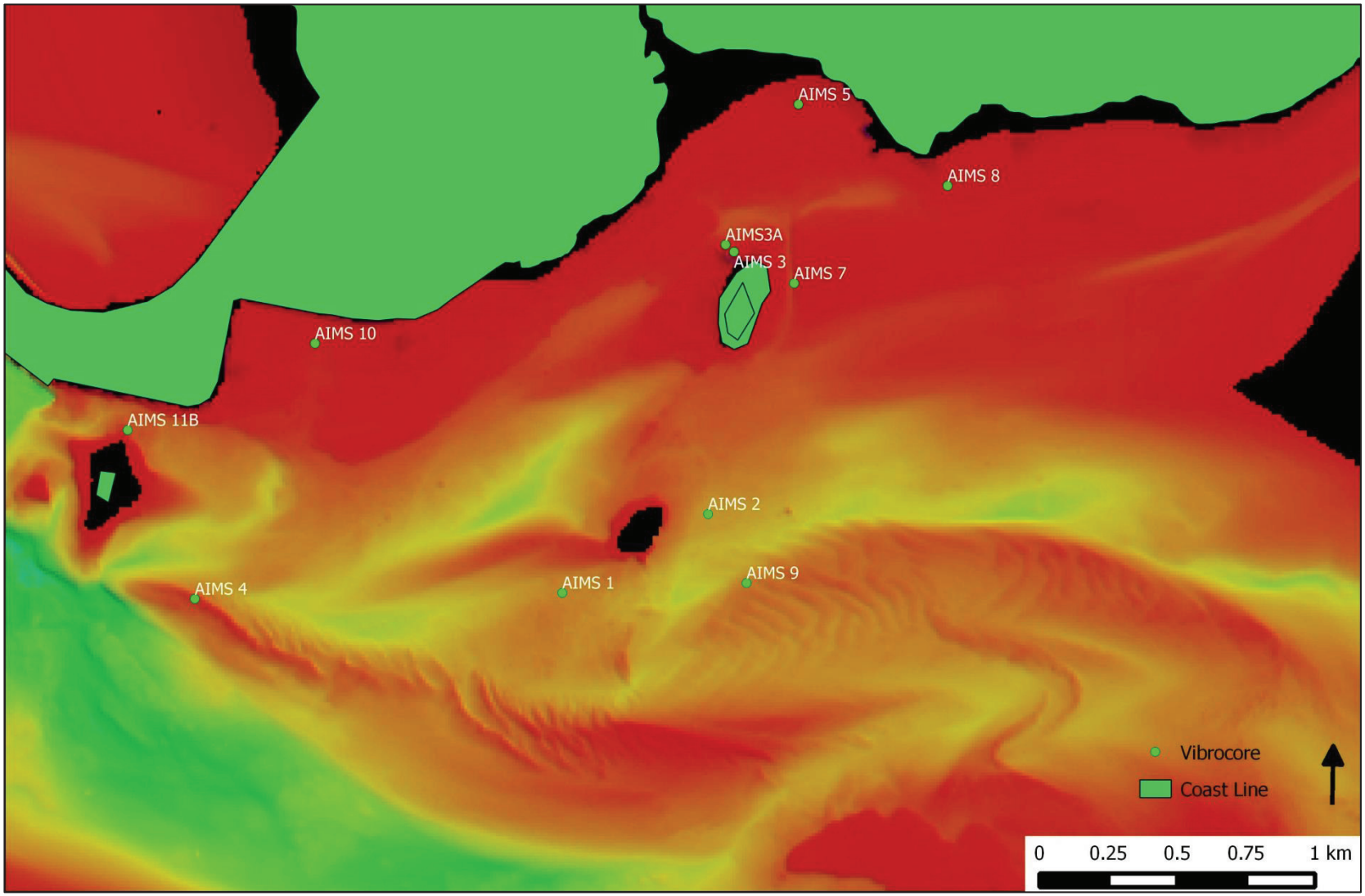


Figure 1: Vibrocore sample locations

Vibrocores were carried out at the locations specified above in conjunction with the sediment testing team at URS. The vibrocore penetrates until hard clay material causes refusal. It was observed that this usually occurred when the drill touched on hard, red and ochre coloured clay. The water was drained from the head of the first core using a sponge to hold back the sediment. However, it was observed that the water being drained was very turbid (see Figure 2) and may be important to the hydrodynamics and sediment transport if the local lutocline were better understood. After this instance, both the material and the water was retained in the tubes and allowed to settle.

Figure 2: A core taken showing no distinction between the turbid water and the mud sample.

The vibrocores were left to sit for the duration of the field work. Settling of fine material from the water column occurred, leaving visible sediment layers in some cores (Figure 3). Slight movements such as bumping or knocking the core caused the fine sediment layer to mix with the water column.

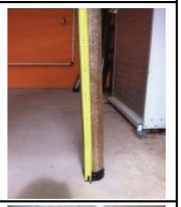
The only method of separating the different layers of sediment and collect the measurements required for bulk density analysis was to freeze the cores and manually separate the layers. This was carried out using a pipe saw and hot blade. Where visible, the fine sediment layer was also separated. The core was recapped to be airtight and allowed to thaw standing upright. Three different syringe sizes of known volume were used to carefully collect vertical core sediment samples. Each sample was placed in a beaker of known weight. They were weighed and left to dry in an oven for 55 hours at 105°C before being re-weighed.

Figure 3: Settling of fine material from the water column on top of bed sediment

Figure 4: Taking core samples of known volume for bulk density testing

Freezing and thawing the sediment may have caused the structure to change slightly. This was seen in the larger samples, where a layer of water was observed post thawing. These samples were excluded from bulk density sampling. The smaller cores appeared to be intact as before with little surface water. Cores largely made up of sand were excluded from bulk density sampling as the non-cohesive model does not require the input of a bulk density parameter. Table 1 shows the vibrocore results with each sample's detail, description and photographs.

Table 1: Vibrocore results

Sample ID	Water depth (m)	Core penetration (m)	Sample length* (mm)	Water column (mm)	Field Notes	Sample description	Photos	
AIMS 1	9.6	0.87	814	140	Core ended in refusal.	Yellow clay at bottom of sample. Otherwise fine, grey sediment. 400-600 mm some visible organic material. Fine sediment settled on surface, although boundary layer not clearly defined		
AIMS 2	9.2	1.08	417	8	flat surrounds. Core ended in refusal	0 - 125 mm hard yellow and white clay. 125 - 165 mm organic material. 165 - 398 mm fine, grey sediment. 398 - 417 mm fine silt settled out of water column.		
AIMS 3	4.3	1.3	130	244	graduated sand (fine at top, pebbles at bottom). Core ended in refusal.	0 - 115 mm large shells and gravel graduating up to 115 mm. 115 - 131 mm fine sediment settled from water column. Some organic material.		
AIMS3A	5.2	1.07	560	379	slightly off the ridge at 3 - muddy. Core ended in refusal	0 - ~300 mm coarse sand, graduating upward to fine grey sediment on top.		
AIMS 4	6.2	2.7	1184	595	calcarious coarse material to 2.7m. Bottom of sample disposed of. No refusal	continuous calcareous coarse homoeneous sediment with little visible clay. Fine sediment layer on top (5-10mm).		
AIMS 5	4.2	2.77	2119	2	vibrocore pushed to 2.77m. No refusal. Inspection of core head piece showed hard, red clay at bottom	Firm, red/yellow clay at bottom, graduating to firm, grey clay/mud with some yellow patches. Organic fragments from 1200 mm from the bottom and upwards in sections. Possible acid sulfate soils.		

AIMS 6	4	0.25	272	82	core ended in refusal. Close to catalena island. Rocky. Sand and mud.	0 - 233 mm coarse material consisting of gravel and sand, and graduates to coarse sand. 233 - 272 mm fine sediment from the water column.		
AIMS 7	4.8	2.81	1667	3	core ended in refusal. Red gravel/rock observed at base of core	0 upwards grey clay with some organic material visible from ~ 1500 mm. 1100 - 1667 mm fine grey/yellow mud/clay. ~2mm of fine material settled on top from the water column.		
AIMS 8	5.1	1.38	1088	105	core ended in refusal. Red gravel/rock observed at base of core	Yellow clay at bottom, graduating to fine, grey sediment at top. Organic fragments. No visible fine sediment layer settled out of water column.		
AIMS 9	8.4	2.82	1422	440	fine mud in lower portion of core. Coase calcareous sed on bed surface.	0 - 900 mm fine grey sediment and organic material, 900 mm coarse sand becomes visible, 1170 mm coarse sand becomes more dominant than fine grey sediment. 1420 - 1422 mm fine sediment settled from water column		
AIMS 10	5.7	0.23	350	174	fine material. Grey mud. Core ended in refusal	0 - 280 mm coarse sand. 280 - 350 mm coarse sand graduates to fine, grey material on top. Layer settled from the water column is not distinguishable.		
AIMS 11	5.4	0.25	263	79	coarse sand and fine sediment layer on top. Refusal. Rock at bottom.	Coarse sand on bottom, graduating to grey fine sediment on top. Many organic fragments. Sample fermenting. Water column dark and murky. Some pieces of hard rock/coral found in the bottom piece of the core was placed on the top of the core in the water column by one of the deck hands.		

*Length datum taken as bottom of sample = 0

3.2 Frame Setup, Deployment and Retrieval

The frame shown in Figure 5 was deployed on the 14th of February 2014 and retrieved on the 17th of March 2014. The frame was equipped with several instruments:

1. An uplooking Nortek ADCP to capture data through the water column between the frame and the water surface. It collected data on velocity and acoustic backscatter (a measure of suspended particles) at one metre intervals at 20 minute time periods and was also configured to measure waves.
2. A downlooking Teledyne RDI ADCP to collect data from the frame to the bed. The downlooking ADCP was set to measure velocities at 0.1 m intervals every 2 minutes. It was also enabled with a bottom tracking function so that bed load movement could be detected.
3. A Teledyne citadel CTD and Wetlabs nephelometer which measures optical backscatter (turbidity), salinity (conductivity), temperature and depth. This was configured to take burst samples every 10 minutes.
4. A Pinger which can be activated to send a location signal in case of problems with locating the frame.

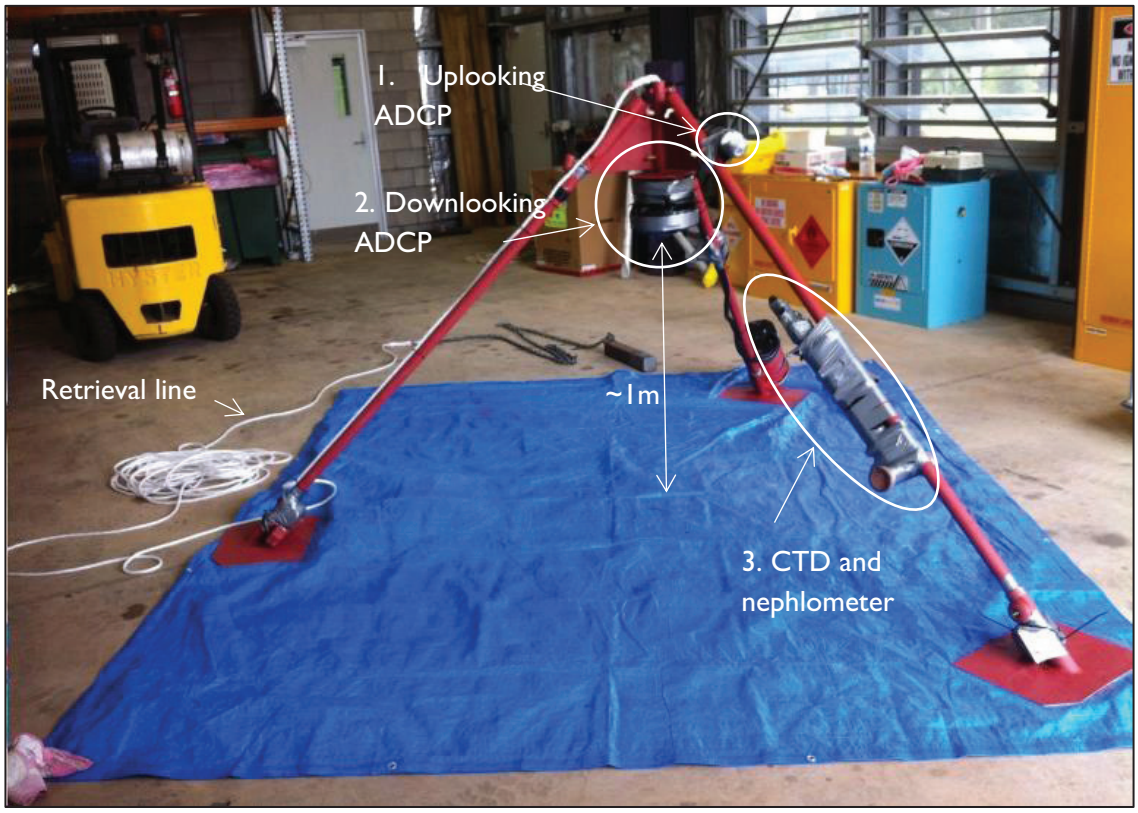


Figure 5: ADCP frame with instruments attached before deployment

The frame was retrieved successfully after 32 days of deployment. There were no signs of disturbance and little fouling was observed on the instruments. Figure 6 shows the retrieval of the large and heavy frame using the AIMS research vessel. A davit on the left holds the frame in place on the side of the slowly moving boat.

Figure 6: Frame retrieval on the AIMS research vessel

3.3 CTD profiles and total suspended sediment samples

During the frame deployment, four CTD profiles were carried out through the water column using a Seabird SBE-19 Plus. This was carried out at the location of the frame at the times marked in Figure 7. During the water column profiles, 1L total suspended sediment (TSS) water samples were taken approximately 1m from the bed surface at the location of the deployed frame. Rubber tubing leading to a peristaltic pump was attached to the SBE-19 CTD, which was lowered through the water column to measure a vertical profile of salinity, temperature and turbidity. The peristaltic pump was switched on when the end of the tube reached the depth of the deployed frame.

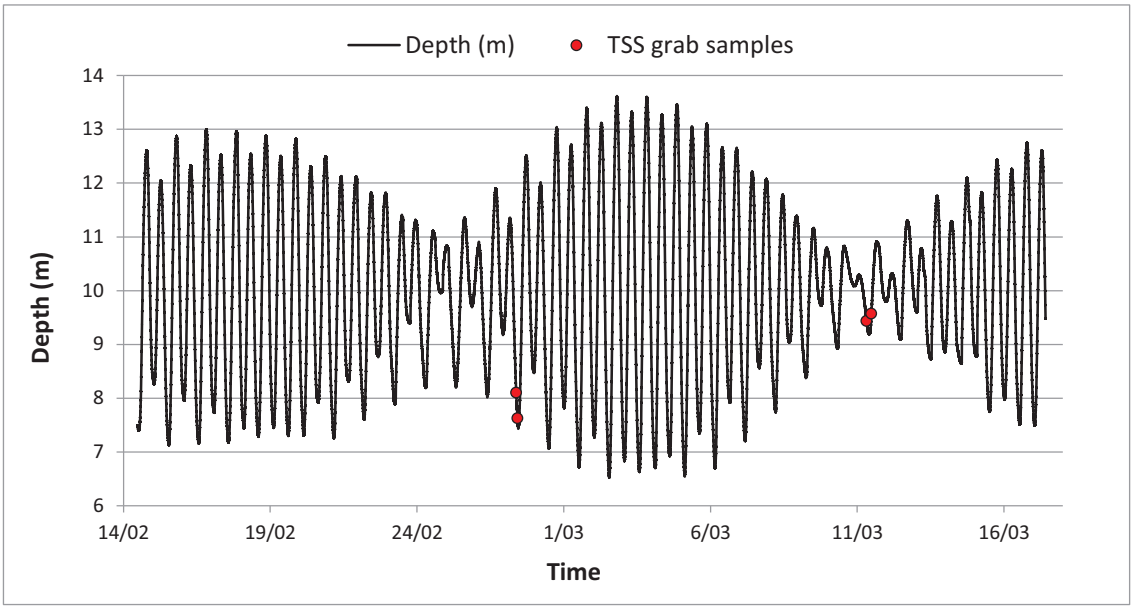


Figure 7: Frame depth record and TSS water sample times

3.4 Bed surface grab samples

Bed surface sediment samples were taken at intervals between vibrocores to map the bed surface material at East Arm Wharf in more detail. Fourteen grab samples were taken using a square pipe section designed to grab bed surface material. The results were consistent with vibrocore results where applicable. Results were also consistent with bed topography and locations of known bed material. Table 2 describes the bed surface grab samples.

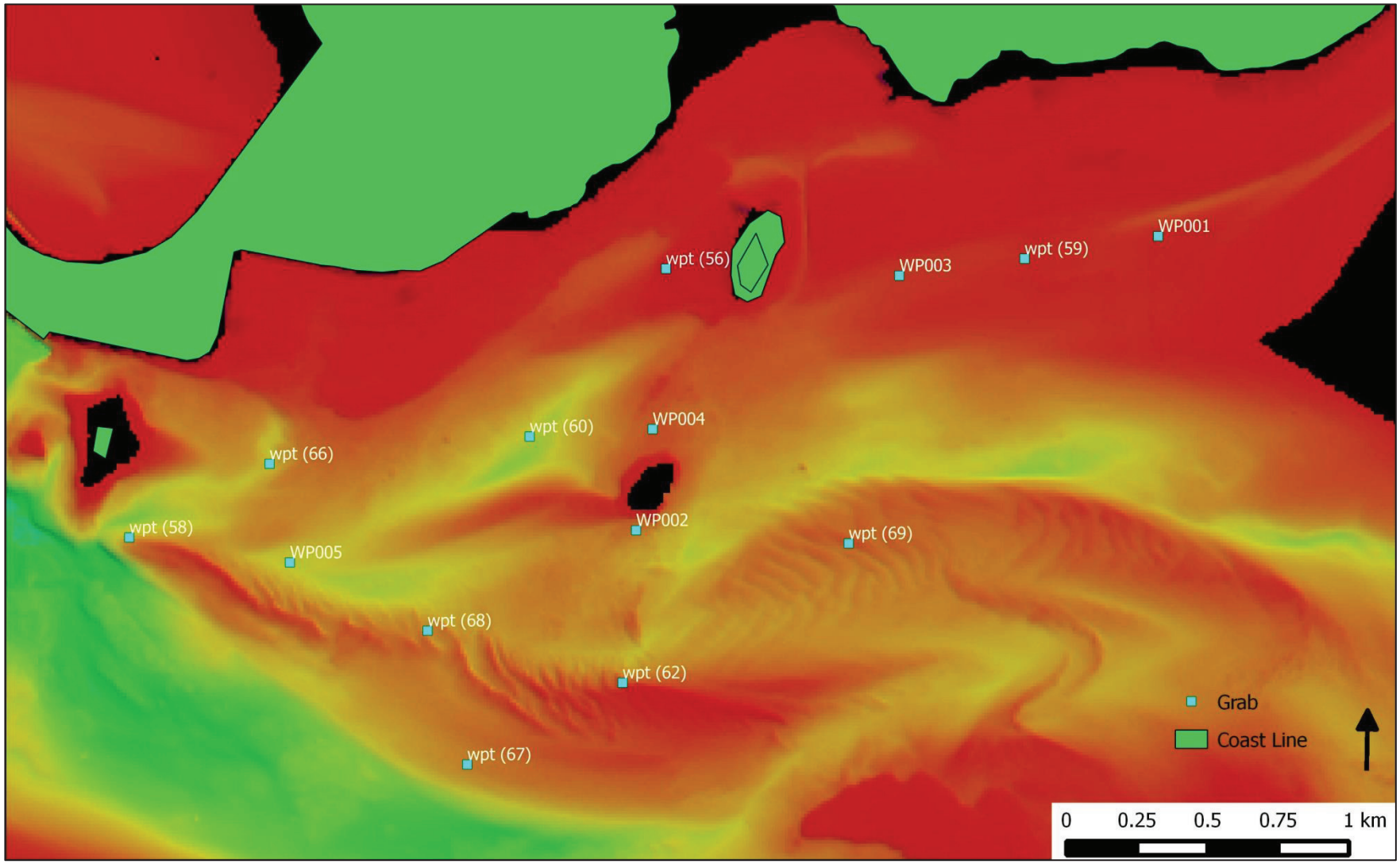
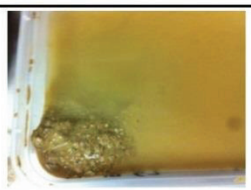


Figure 8: Grab sample location

Table 2: Bed surface grab samples

SiteName	Description	Image	SiteName	Description	Image
wpt (60)	soft mud and clay. Shell fragments/gravel (20%). soft sea plant (2%). Lutocline visible.		wpt (68)	sand and shell fragments. Mud (3%). Whole shells (2cm) (1%). Gravel (1%). Lutocline visible.	
wpt (59)	Soft fine sed. Soft sea plant throughout (25%) Gravel (5%) large shells (2cm) (<1%). Lutocline visible. similar to WP001.		wpt (67)	hard clay. Coral pieces (0.1-6cm) (20%). Gravel (5%). Broken shell (2%)	
wpt (58)	Sand and shell fragments (100%)		wpt (66)	soft mud. Sand (15%). Broken shells and hard organics (10%). Gravel (3%). Soft sea plant (2%). Lutocline.	
wpt (62)	sand. Some fine sediment (20%). Gravel (<2%). Whole shells (1cm)(3%) and shell fragments		WP003	similar to WP001 and WP59. Soft mud. Gravel (less than WP59). Soft sea plant. Whole shells (2%) crushed shells and hard	
wpt (56)	soft mud. Sand (25%) gravel (2%). Grab sank quickly and was difficult to retrieve. Lutocline visible.		WP002	mud, sand (40%) , large gravel pieces (3.5cm), coarse shells, crushed shells and gravel (20%)	
WP005	soft mud. Sand (20%). Gravel (<1%). Lutocline. Mud easily resuspended into water column.		WP001	soft mud. Soft sea plant (5%). Shells (2%) much like WP001. Appears to suspend more easily than WP69 and WP67. Lutocline	
WP004	gravel (45%). Sand (35%). Mud/clay (15%). Whole shells (1cm) (5%). 1 large (8cm) sponge like organism.		wpt (69)	hard mud/clay (yellow and grey). Sand(<10%)	

3.5 Sub-Bottom Profiler

A Tritech SeaKing Parametric sub-bottom profiler was used to undertake transects of the East Arm area to gain an understanding of the underlying sediment structure of the area. Vibrocore results were used to match acoustic return signals with structural bed composition. The profiler emits two frequencies; 20k Hz and 200 kHz. Figure 9 shows the transect path where sub-bottom profiling was carried out. Possible infill sites were observed where compacted and non-compacted bed material met. These sites are described and their locations referenced in both Table 3 and Figure 16. Details of known location and structure

are included in the table such as the railway sleepers and boat ramp near the proposed marine supply base (T9_3 and T9_4) and the recent dredge channel near East Arm Wharf (T9_7 and T9_8). Figure 17 shows the likely location of some recent infill observed with the sub-bottom profiler.

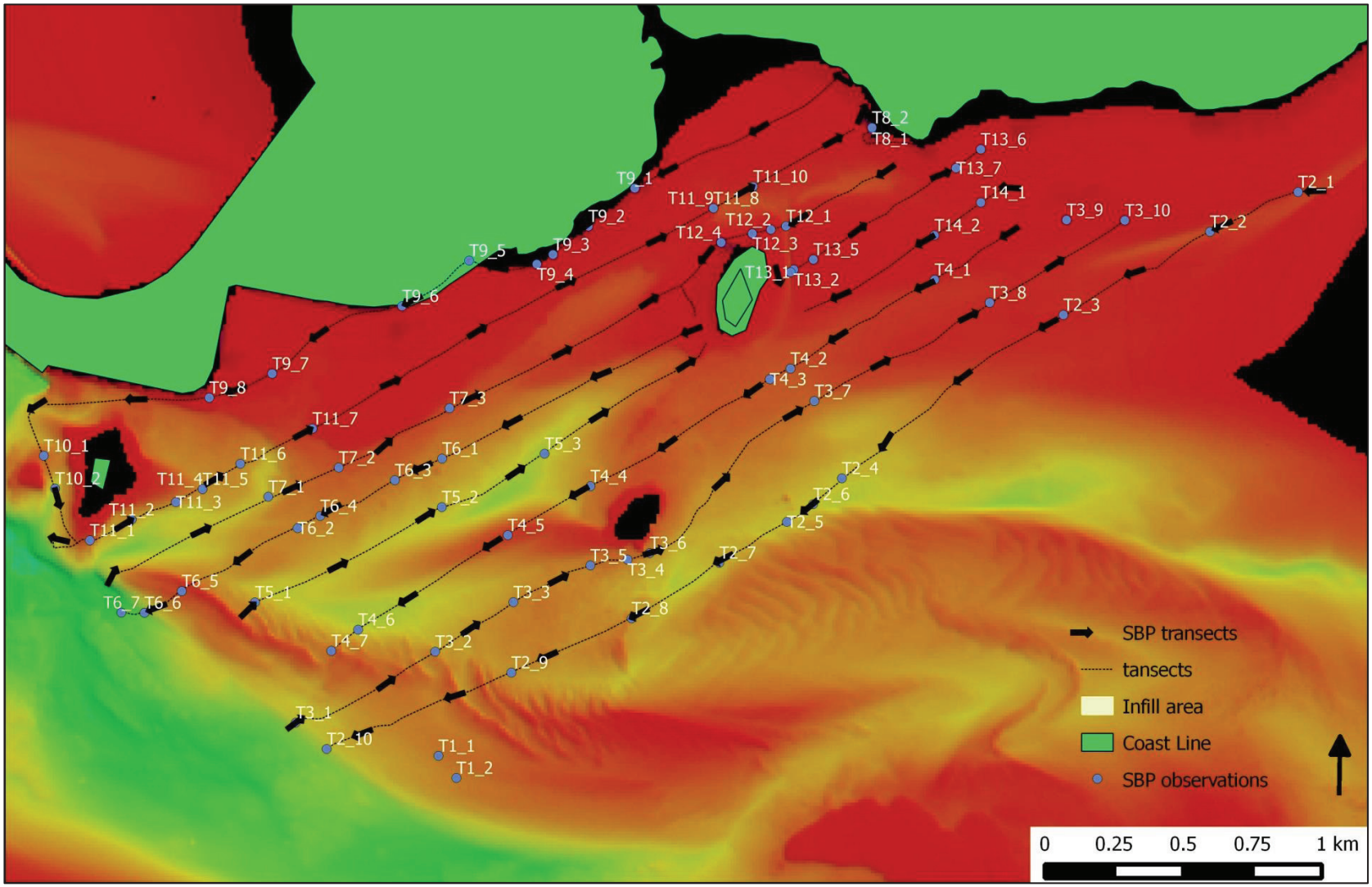
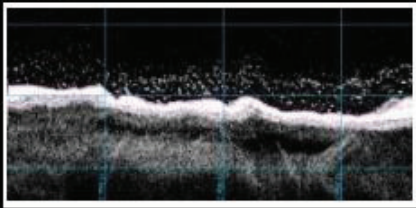
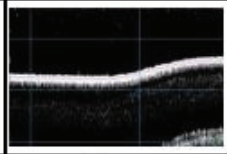
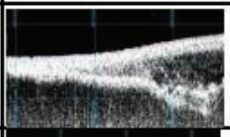
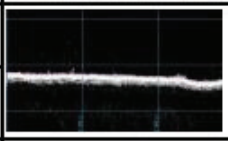
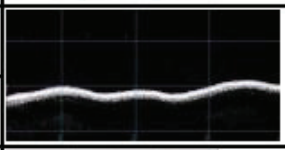
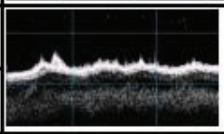
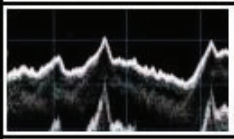
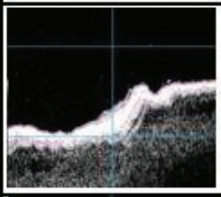
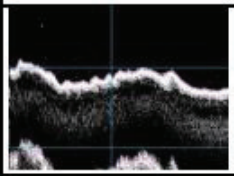
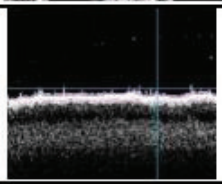
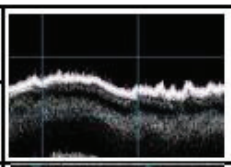
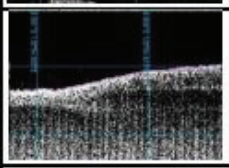
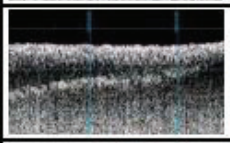
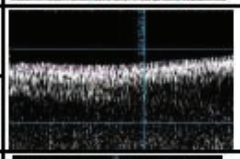
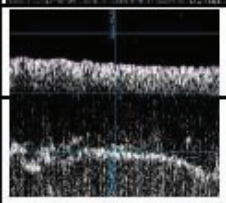
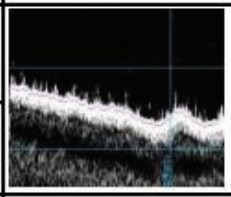
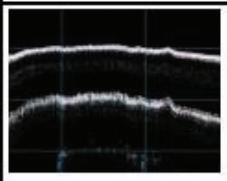
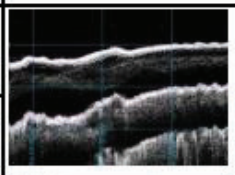
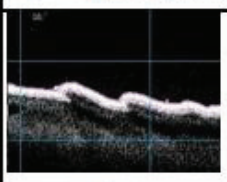
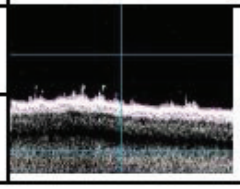
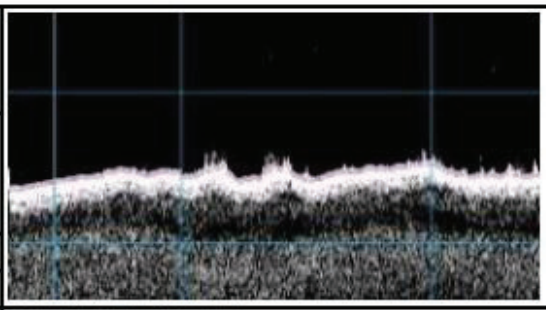
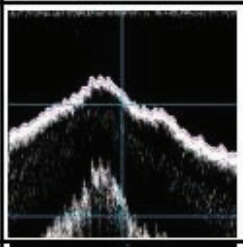
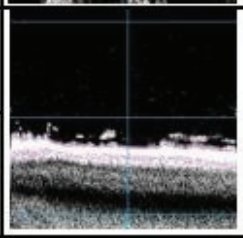
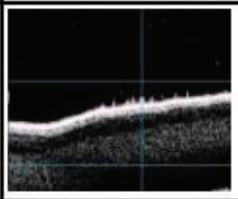
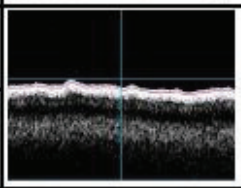
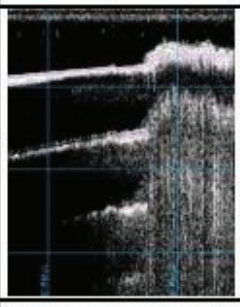
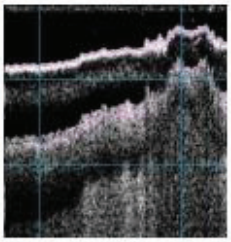


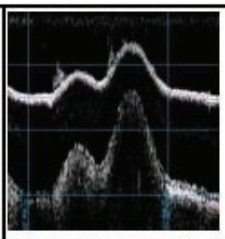
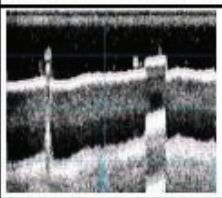
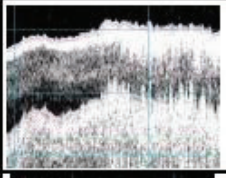
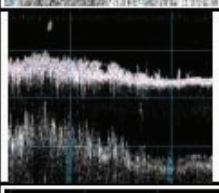
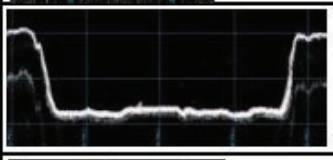
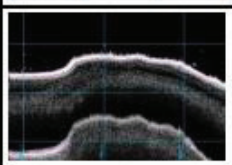
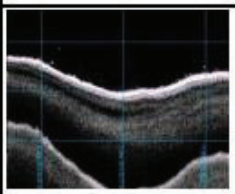
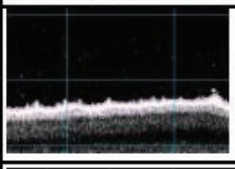
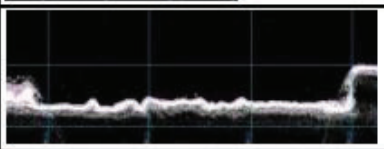
Figure 9: Sub-bottom Profile transect

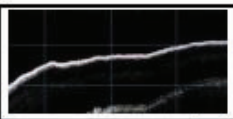
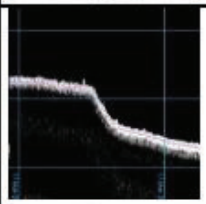
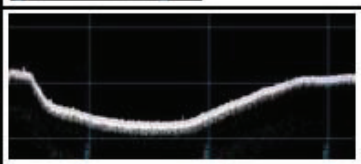
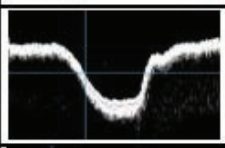
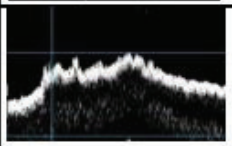
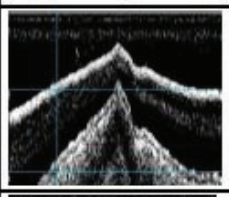
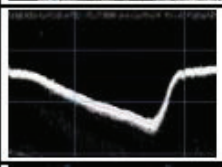
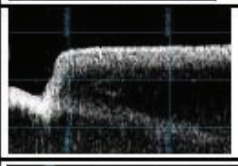
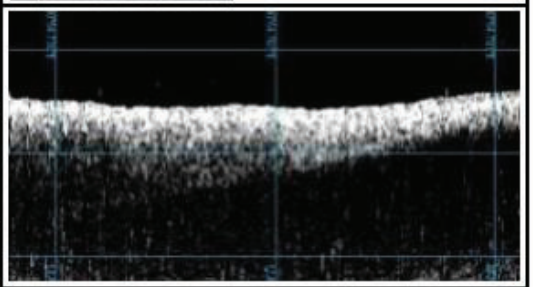
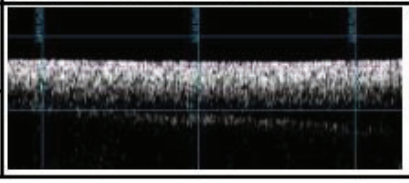
Table 3: Sub-bottom profiling bed observations

Transect	Description	Image
T1_1	undulation/sand waves. Fragments in wc	
T1_2	undulation/sand waves. Fragments in wc end	
T2_1	slight trough	
T2_2	infill	
T2_3	infill end	
T2_4	plant material	
T2_5	plant material end	
T2_6	undulation (low freq)	
T2_7	undulation (low freq) end	
T2_8	undulation	
	roughness between	
T2_9	undulation	
T2_10	undulation end	
T3_1	undulation	
T3_2	undulation end	
T3_3	plant material	
T3_4	plant material end	

T3_5	undulation	
T3_6	undulation end	
T3_7	infill	
T3_8	infill end	
T3_9	possible infill	
T3_10	possible infill end	
T4_1	infill	
T4_2	infill end	
T4_3	plant material and undulation	
T4_4	plant material and undulation end	
T4_5	peak	
T4_6	undulation and infill	
T4_7	undulation and infill end	
T5_1	unidentifiable bed waves	
T5_2	plant material	
T5_3	plant material end	

T6_1	undulation	
T6_2	undulation end	
T6_3	plant material	
T6_4	plant material end	
T6_5	sand bank peak	
T6_6	plant material	
T6_7	plant material end	
T7_1	trough and small patch of plant material	
T7_2	undulating and plant material	
T7_3	undulating and plant material end	
T8_1	soft matter hit with low return	
T8_2	soft matter hit with low return end	
T9_1	sand bank peak	

T9_2	plant material and undulation	
T9_3	railway tracks	
T9_4	boat ramp	
T9_5	soft bottom/plant material?	
T9_6	soft bottom/plant material? End	
T9_7	dredge channel	
T9_8	dredge channel end	
T10_1	peak	
T10_2	trough	
T11_1	plant material	
T11_2	plant material end	
T11_3	anomaly	
T11_4	anomaly end	
T11_5	undulation/sand waves	
T11_6	undulation/sand waves end	

T11_7	start of high plateau	
T11_8	end of high plateau	
T11_9	channel	
T11_10	channel end	
T12_1	channel	
T12_2	undulation/sand waves	
T12_3	undulation/sand waves end	
T12_4	sand bank peak	
T13_1	trough	
T13_2	peak	
T13_3	possible infill	
T13_4	possible infill end	
T13_5	relatively flat plane with slight channel	
T13_6	relatively flat plane with slight channel end	
T13_7	slight channel and possible infill	
T14_1	possible infill	
T14_2	possible infill end	

3.6 Sidescan and Structure

Sidescan and structure were both recorded during the survey. Two examples are shown in Figure 10 from transect 9 which show the structure of the foot of a rock wall (Figure 10 (a)), and the submerged railway tracks and boat ramp (Figure 10 (b)). Images such as these helped determine the bed composition.

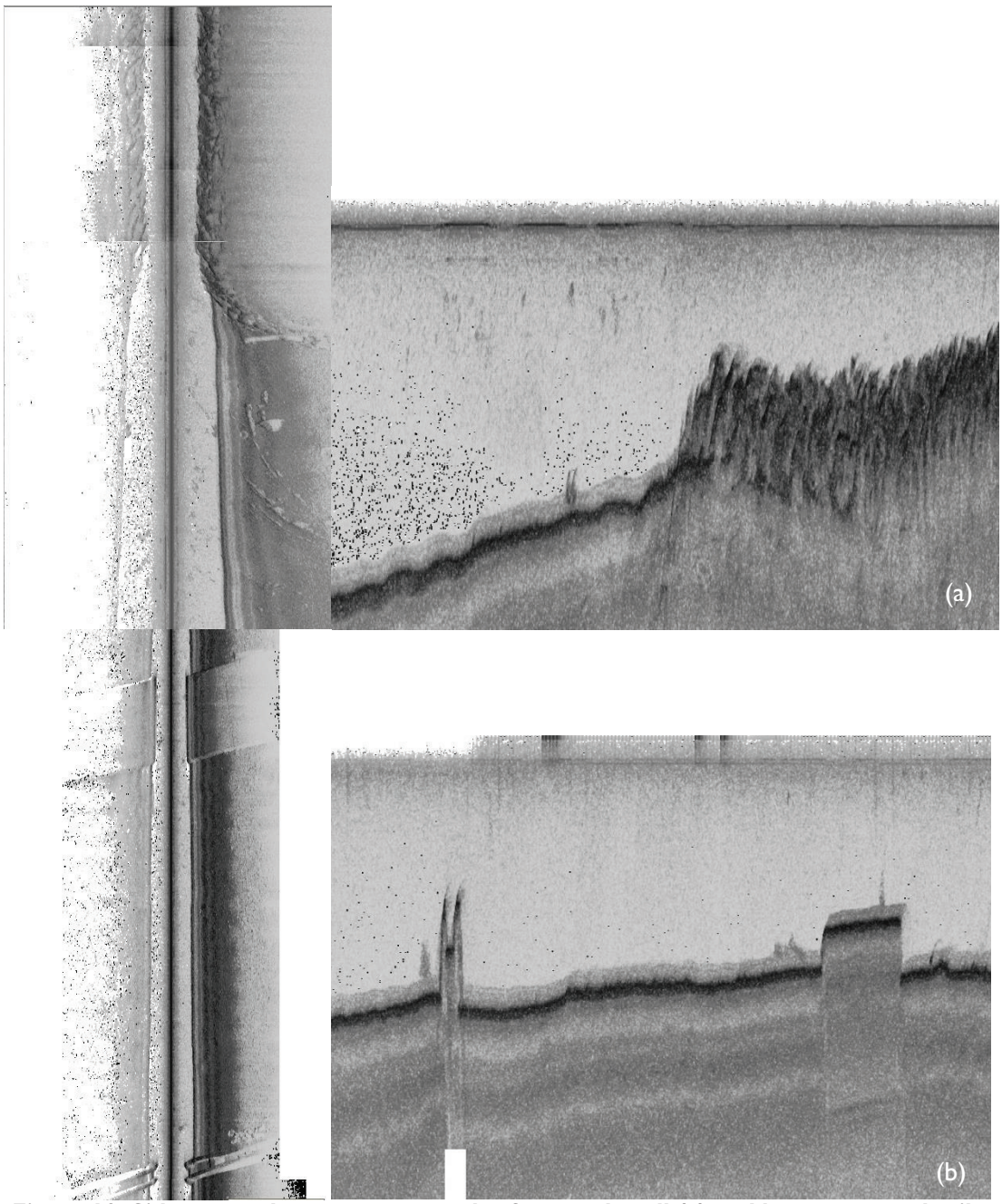


Figure 10: Sidescan and structure examples for a rock wall (a) and boat ramp and railway line (b)

4 Laboratory Analysis

4.1 Bulk Density

Not all samples were appropriate for bulk density testing due to disturbance as described in the methodology section. A total of six samples were analysed for bulk density. Their locations are shown in Figure 11.

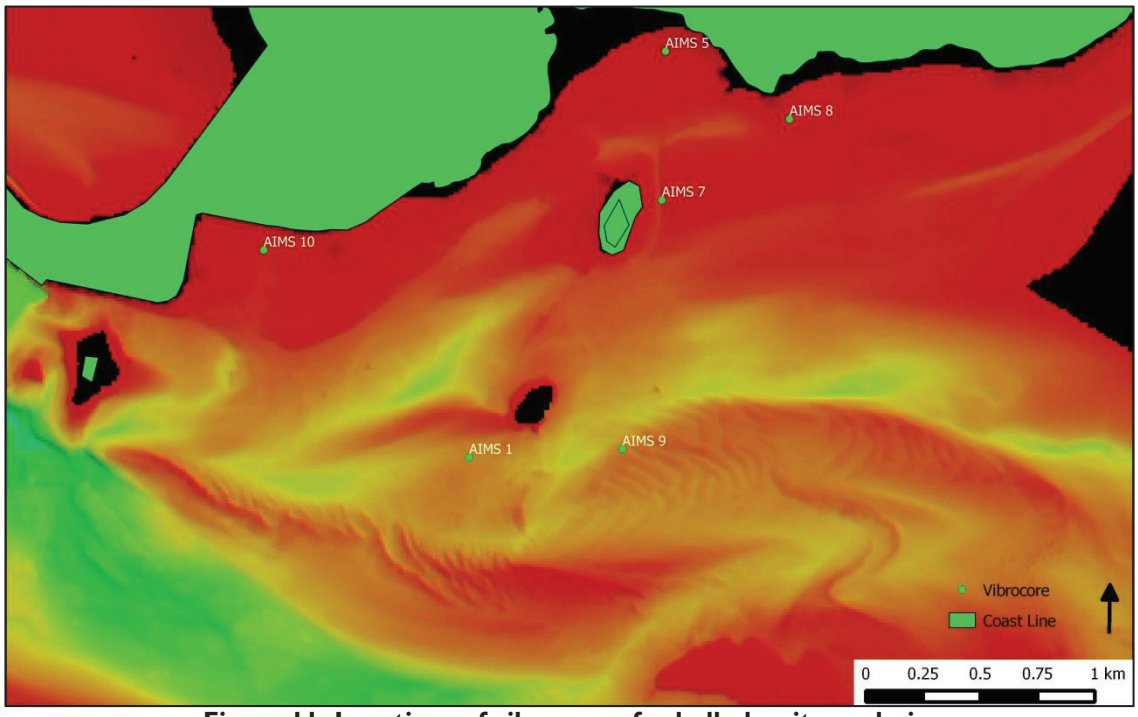


Figure 11: Locations of vibrocores for bulk density analysis

Figure 12 shows that the bulk density samples are evenly spread across the three different sized samples. Bulk density differs slightly between each site, with AIMS 7 being the lowest bulk density, and AIMS 8 having the highest. There is no spatial pattern pertaining to the different bulk density values, except that perhaps the most visually obvious infill example is very close to the vibrocore location AIMS7. The low bulk density indicates that this surface has had less compaction, indicating perhaps a more recent infill. The median value of 1493 kg/m^3 will be used in the model.

Table 4: Bulk density laboratory results

	Sample size (cm^3)	Beaker weight (g)	Beaker + sample weight (g)	wet sample weight (g)	Bulk Density (wet) (kg/m^3)	dry weight of beaker + sample (after 55 hrs in 105°C)	dry weight of sample (g)	Bulk Density (dry) (kg/m^3)
AIMS 1	5	48.953	56.145	7.192	1438	52.821	3.867	773
	12	48.607	66.444	17.837	1486	58.484	9.877	823
	24	48.349	82.141	33.793	1408	66.500	18.152	756
AIMS 5	5.8	49.297	58.279	8.982	1549	54.724	5.427	936
	9.8	48.233	62.935	14.702	1500	56.963	8.730	891
	22	47.164	80.666	33.502	1523	67.359	20.195	918
AIMS 7	5.8	46.744	54.398	7.654	1320	49.939	3.195	551
	12	47.469	62.983	15.515	1293	53.953	6.485	540
	20.5	47.832	74.341	26.509	1293	59.226	11.394	556
AIMS 8	2.7	49.464	53.935	4.471	1656	52.603	3.139	1162
	9	49.312	64.814	15.502	1722	60.320	11.009	1223
	18.5	47.057	75.937	28.880	1561	65.419	18.361	992
AIMS 9	3.8	47.544	53.368	5.824	1533	51.488	3.944	1038
	9.2	50.178	64.600	14.422	1568	59.792	9.614	1045
	21	50.499	86.580	36.081	1718	75.896	25.397	1209
AIMS 10	5.8	50.602	58.689	8.086	1394	54.879	4.277	737
	10.2	46.853	61.744	14.891	1460	54.688	7.835	768
	14.5	49.858	70.726	20.868	1439	61.108	11.250	776

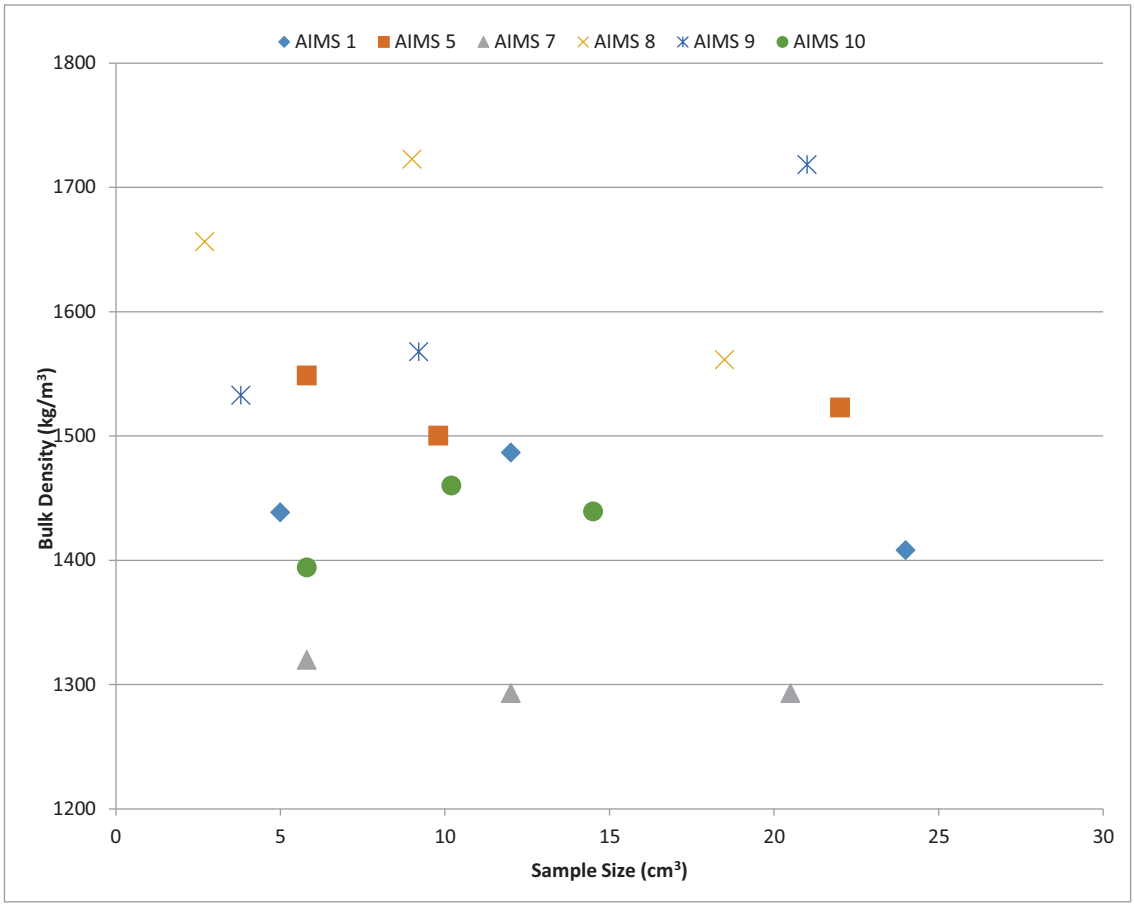


Figure 12: Variation of bulk density with sample size and location

4.2 Sediment Fall Velocity

One litre of filtered sea water and approximately 30g of mixed sediment from the vibrocore samples were combined in a 2L volumetric flask and mixed thoroughly. A measuring tape was attached to the outside of a 1L cylindrical flask to measure the sediment thickness as it settled over time (Figure 13). The mixed sediment was poured into the cylindrical flask and the accumulated sediment thickness was recorded and timed using a stopwatch. The sediment thickness was measured at intervals for a total of 14 minutes. The water was left to settle further and after 45 minutes the water was transparent but not clear. The results have been graphed (Figure 14) and show a well fitted linear settling rate. The sediment fall velocity was calculated as 1.362×10^{-5} m/s. This rate will be used as direct input into the model. The sediment was left for a further five days. The sediment was left in the cylinder and was observed to have compacted, therefore another study was carried out to understand compaction rates. A further 60g of sediment was mixed in the 1L cylinder, and the experiment carried out for a longer time interval. The results are shown in Figure 15.

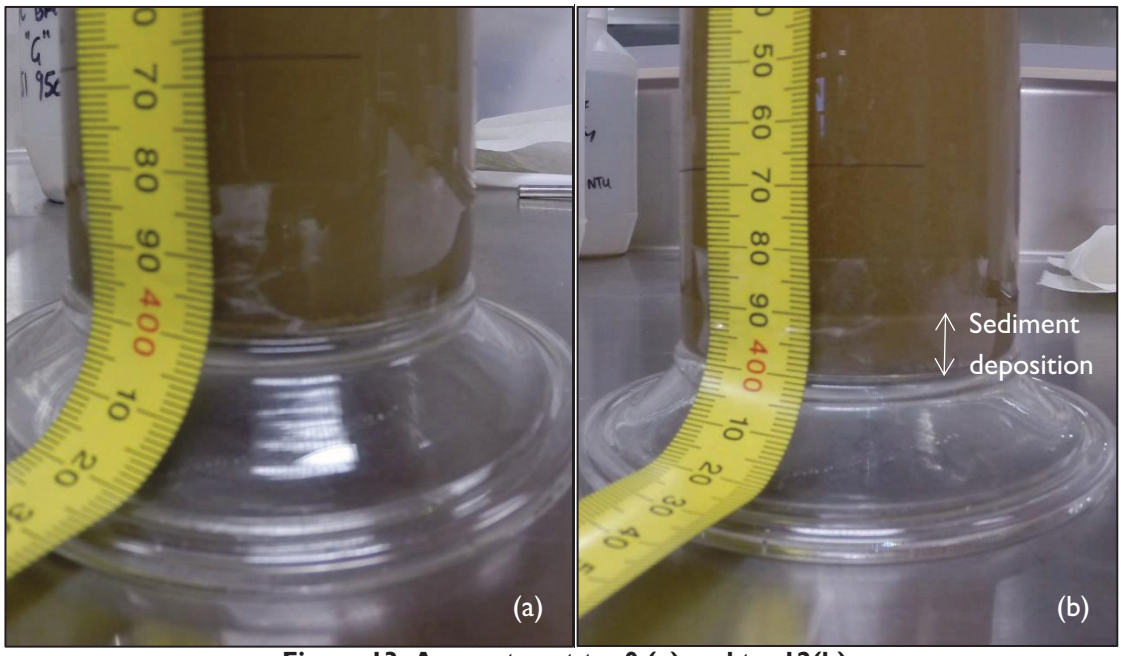


Figure 13: Apparatus at t = 0 (a) and t = 12(b)

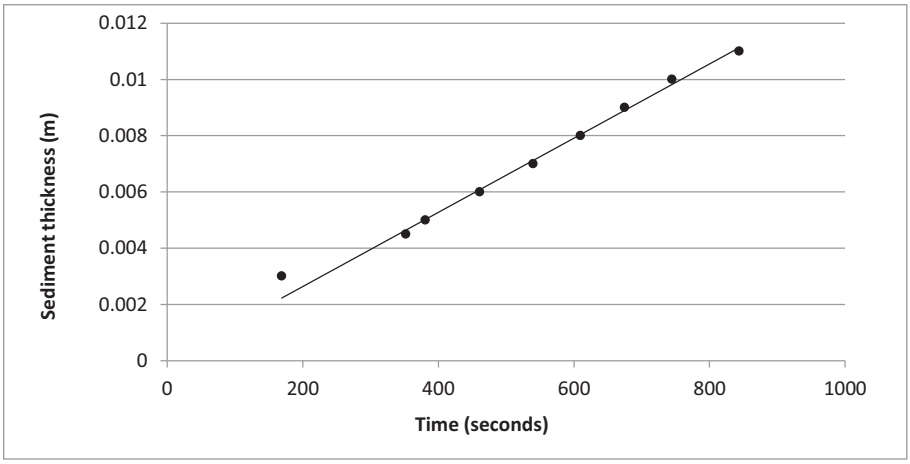


Figure 14: Sediment settlement

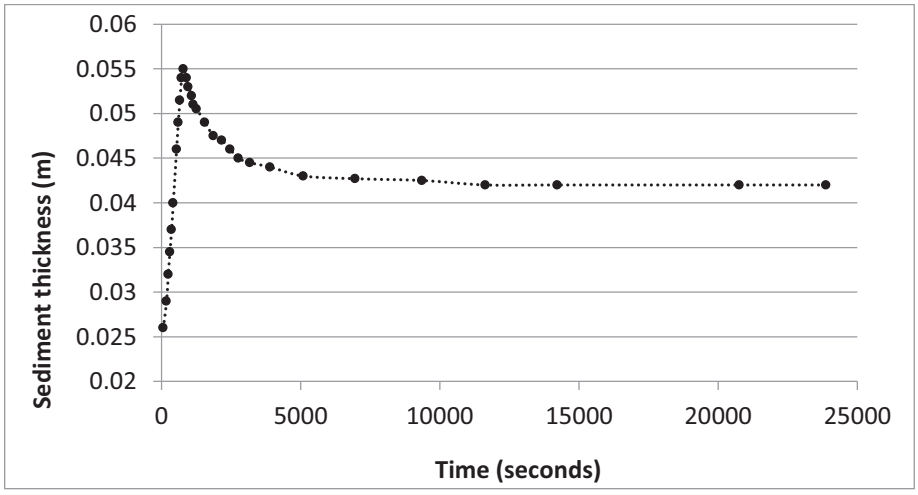


Figure 15: Sediment compaction

4.3 Total Suspended Solids

The four 1L water samples taken at the depth of the frame were analysed for TSS. 0.1L of each sample were filtered through a microfibre glass filter, dried at 105°C for one hour or until reaching a consistent weight (within 15% error) and total suspended solids calculated. Figure 7 shows the time these samples were taken in relation to the tide. Further testing for volatile suspended sediments was carried out which involved ashing the samples in a muffle furnace at 500°C for a further 15 minutes to remove any organic solids. This showed an average of 13% of sample weights were due to organic matter rather than sediment.

Table 5: Total suspended solids sample results

Sample ID	Sample time	TSS mg/L
LDC1	9:15 27/2	9.75
LDC2	10:21 27/2	8.3875
LDC3	7:42 11/3	7.3
LDC4	11:42 11/3	8

5 Desktop Analysis

5.1 Bed material distribution

The results from the various field exercises described above provides a basis by which to map bed material distribution. Figure 16 shows a concept of possible bed material pattern using a combination of the data collected in the vibrocore, grabs, sub- bottom profiling. This has been used directly as model input for initial bed material conditions. Figure 17 shows a likely case of recent bed infill. These observations have only been carried out once, therefore the rate of infill is unknown. As mentioned in section 3.5, the bulk density was also lower at vibrocore location AIMS7, indicating less compaction and therefore potentially a relatively recent infill period.

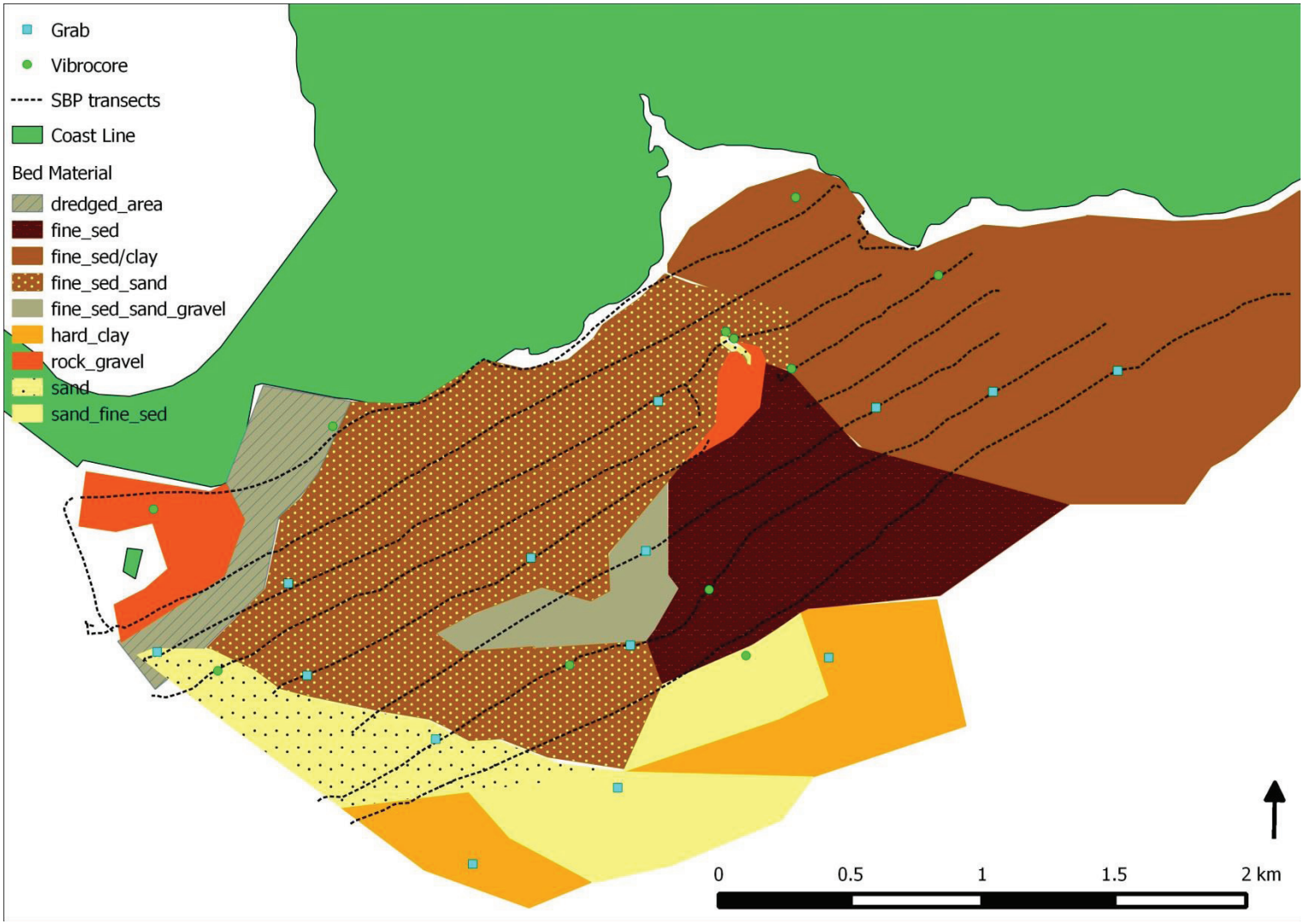


Figure 16: Bed material interpretation using grabs, vibrocores and sub-bottom profile transects

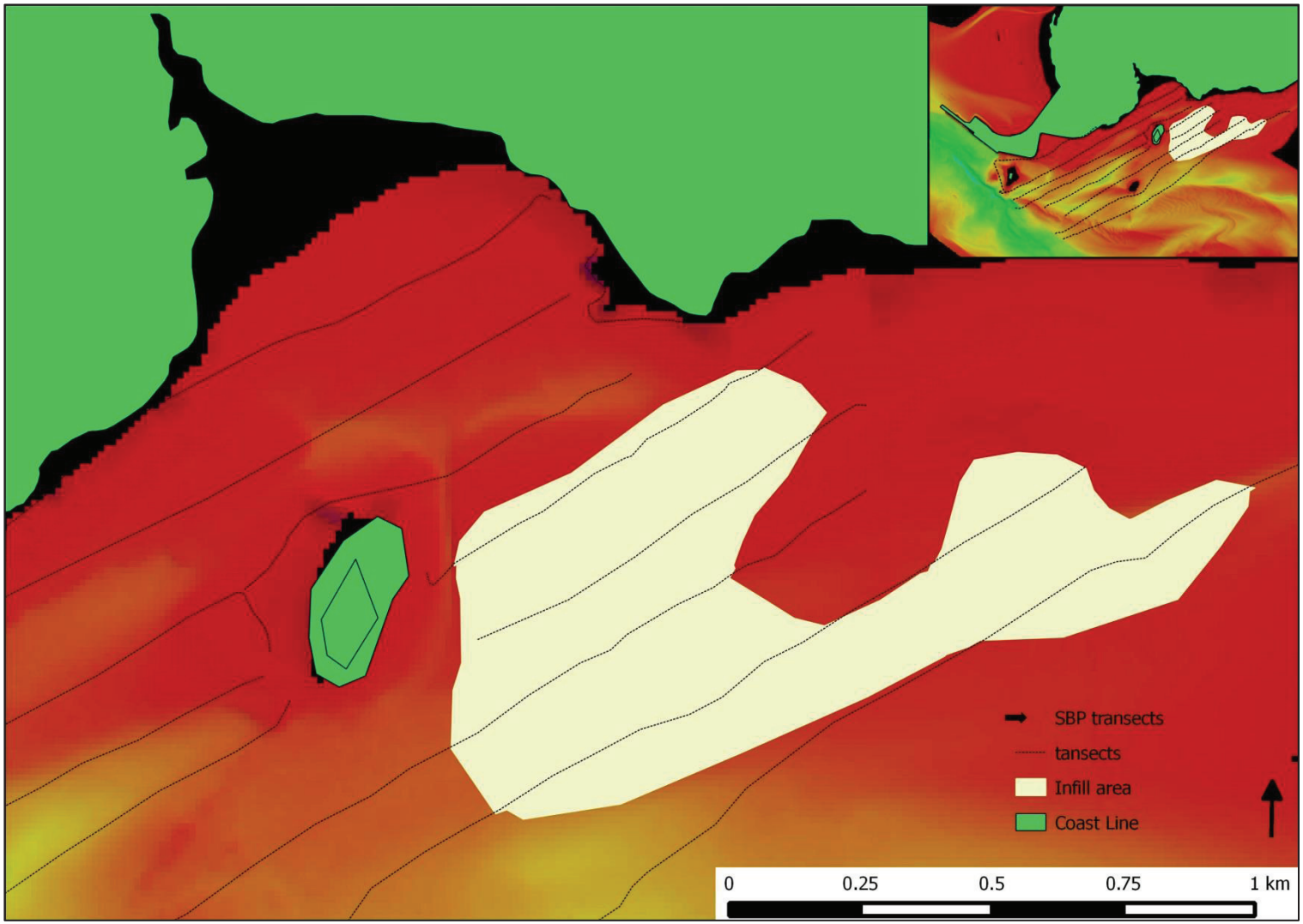


Figure 17: Possible area of infill according to sub-bottom profile results

5.2 Uplooking Nortek ADCP results

The uplooking ADCP data was loaded into a Nortek program Storm which analyses the velocity and pressure data for the occurrence of waves. No waves with a significant wave height of greater than 0.2 metres were detected in the observation period. Waves of this magnitude have no effect on sediment transport in the water depths where the frame was located. Therefore no additional processing on wave based processes was done at this time..

The Nortek ADCP provides data on the east and north components of the velocity field for each of the specified depth intervals. The ADCP also provides an acoustic backscatter value for each of the 3 beams of the instrument through the water column. This provides information on the relative level of suspended matter in the water.

The ADCP's provide valuable information on:

- The distribution of currents over time through the water column
- The level of suspended matter through the water column
- The difference in water velocity over spring and neap and flood and ebb tides
- Information where bed shear stress can be computed
- The net sediment load over a time period

Figure 18 shows the depth averaged velocity magnitude where flood tides are positive and ebb tides are negative. The plot shows that the ebb tide currents are stronger than flood tides at this location. This is shown further in Figure 20 where the coefficient of determination for the east vs north velocity is low ($R^2 = 0.6$). This indicates that the current in this location is not bi-directional, but is affected by turbulence or larger rotational currents. This could be associated with the ADCPs position in proximity to the shoal directly to the west. Figure 20 shows the rotated velocity components which are projected around the principle direction of flow. The negative flow indicates that the current is moving with the ebb tide, and positive with the flood. Again, the net current associated with outgoing tides are dominant. These results show that there may be a shadow created by the shoal to the west during flood tides. It is also likely that the currents in this location are affected by the flow exiting Hudson Creek.

Acoustic intensity data is corrected for beam spreading and absorption resulting in acoustic backscatter. This is an indication of the concentration of particles in the water column. When multiplied by the flow magnitude, a sediment load can be calculated. This assumes all backscatter data is attributed to sediment. Although limited to four samples, the TSS results showed approximately 13% of the TSS as organic.

Bed shear stress has also been calculated using the ADCP results and a number of key coefficients. Bed shear stress and backscatter are plotted together in Figure 21. Both indicate fluctuations that are relative to neap and spring tide patterns.

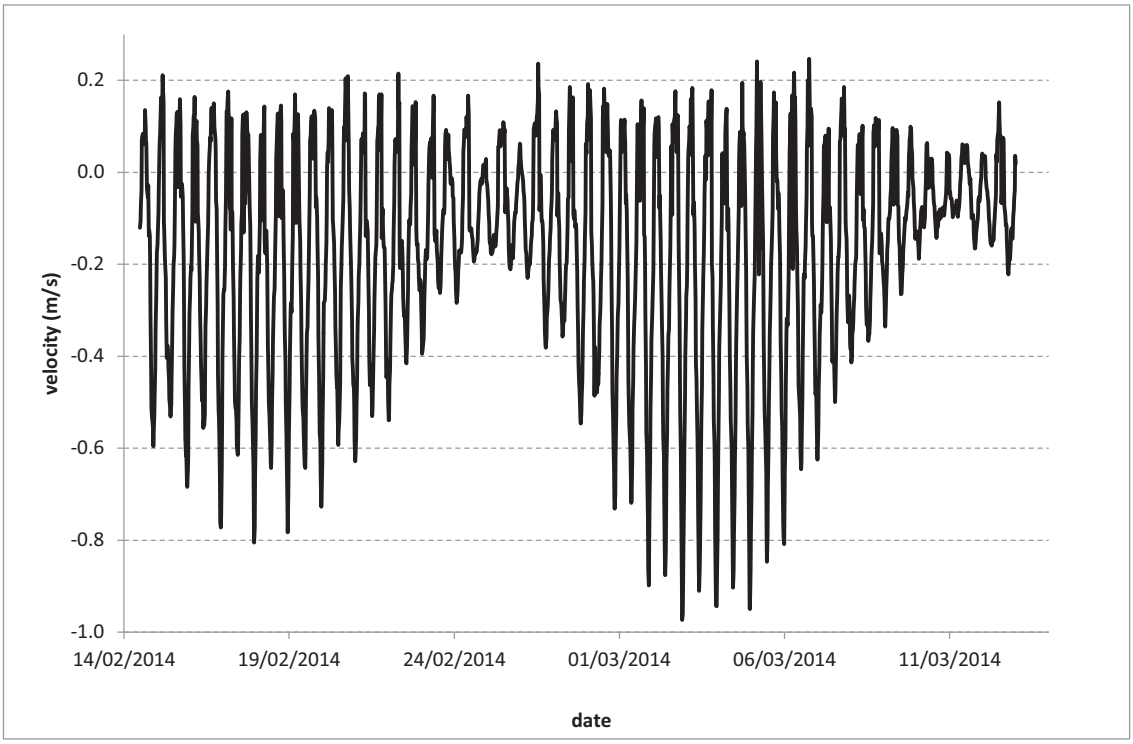


Figure 18: Velocity variation during thirty day deployment period

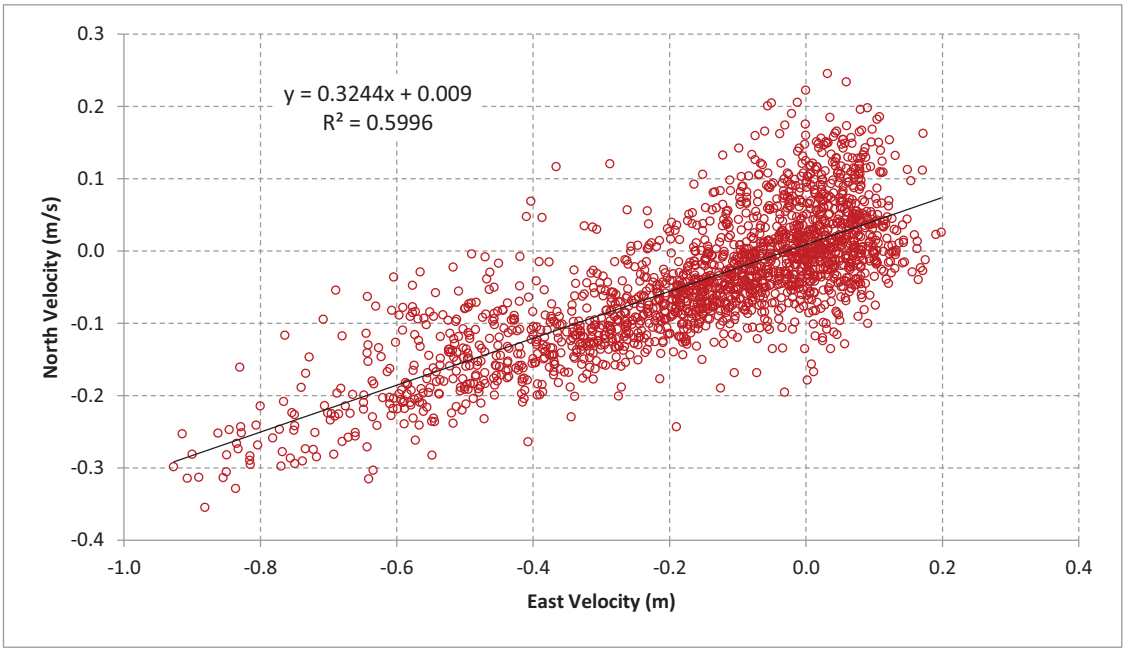


Figure 19: Variation of velocity in the east and north directions

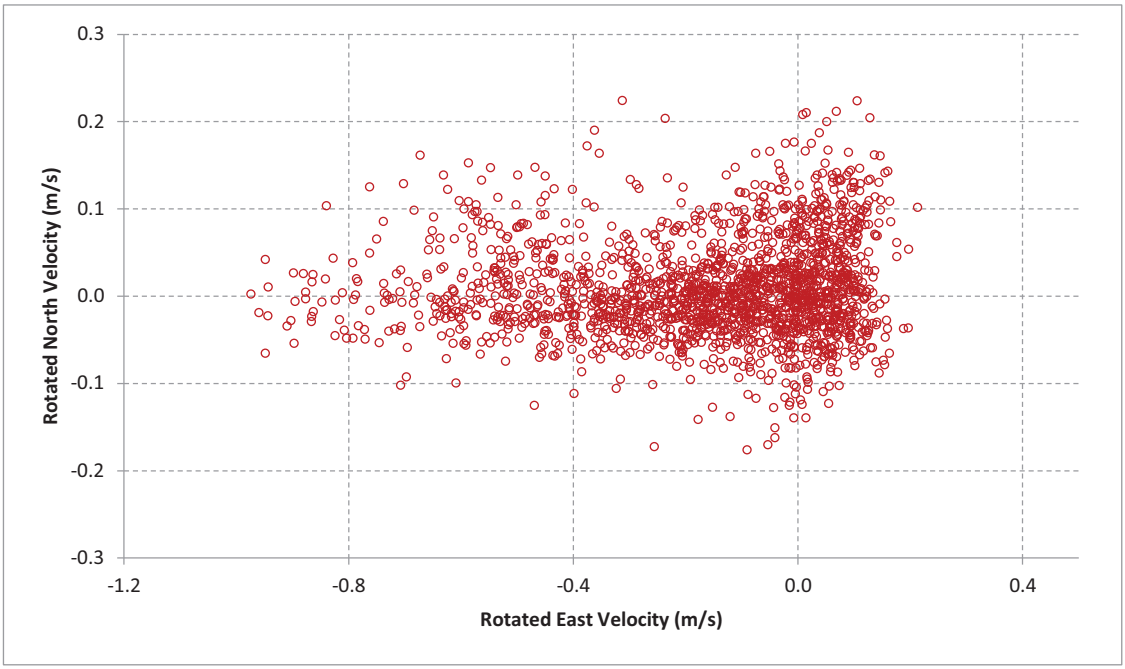


Figure 20: Rotated velocity variations

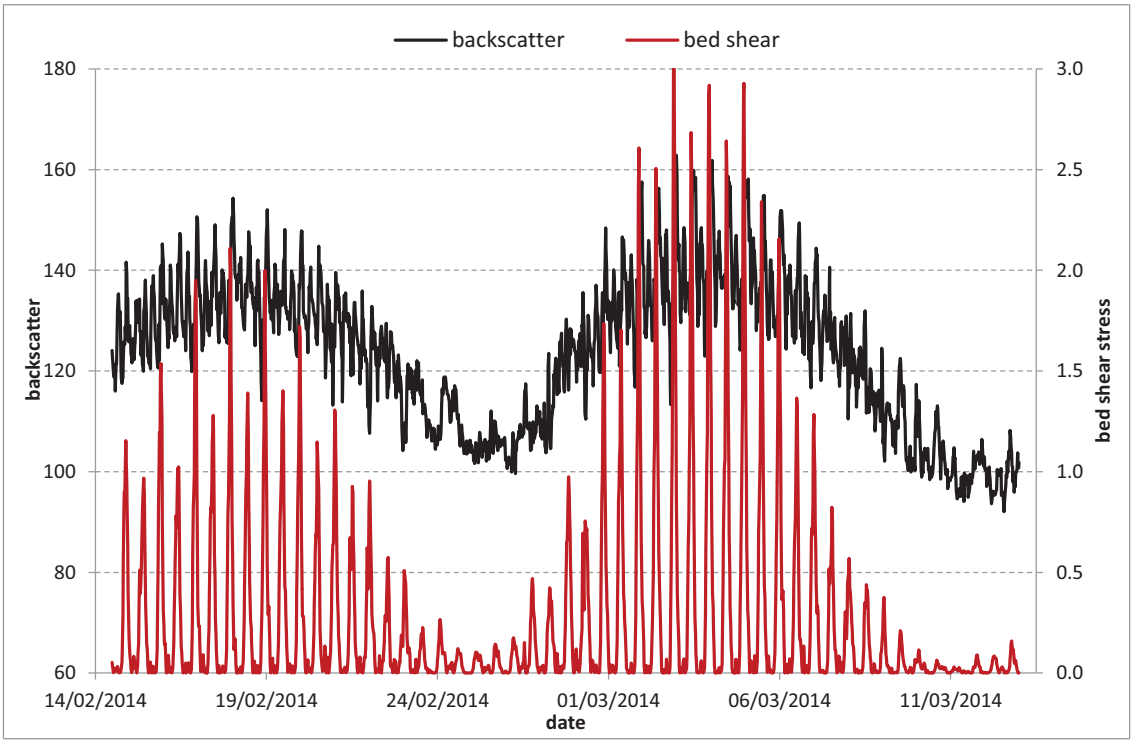


Figure 21: Bed shear stress and acoustic backscatter

5.3 Downlooking RDI ADCP

Results from the downlooking ADCP (Figure 22) show (a) the pressure reading indicating depth, (b) water speed averaged over the 0.8 m distance from the bed surface to the first instrument reading, (c) contour of acoustic backscatter, showing consistent backscatter through the 0.8 m above bed surface level, and (d) the bottom tracker (labelled boat speed), which indicates bed movement at around 40mm/s on average. This is higher during periods of

higher velocity (spring tides). It also shows constant movement of fine sand grains even when velocities are slow. There is no change in backscatter with depth, indicating that turbidity is homogeneous through the water column below the sensor (approx. 1 m from the bed).

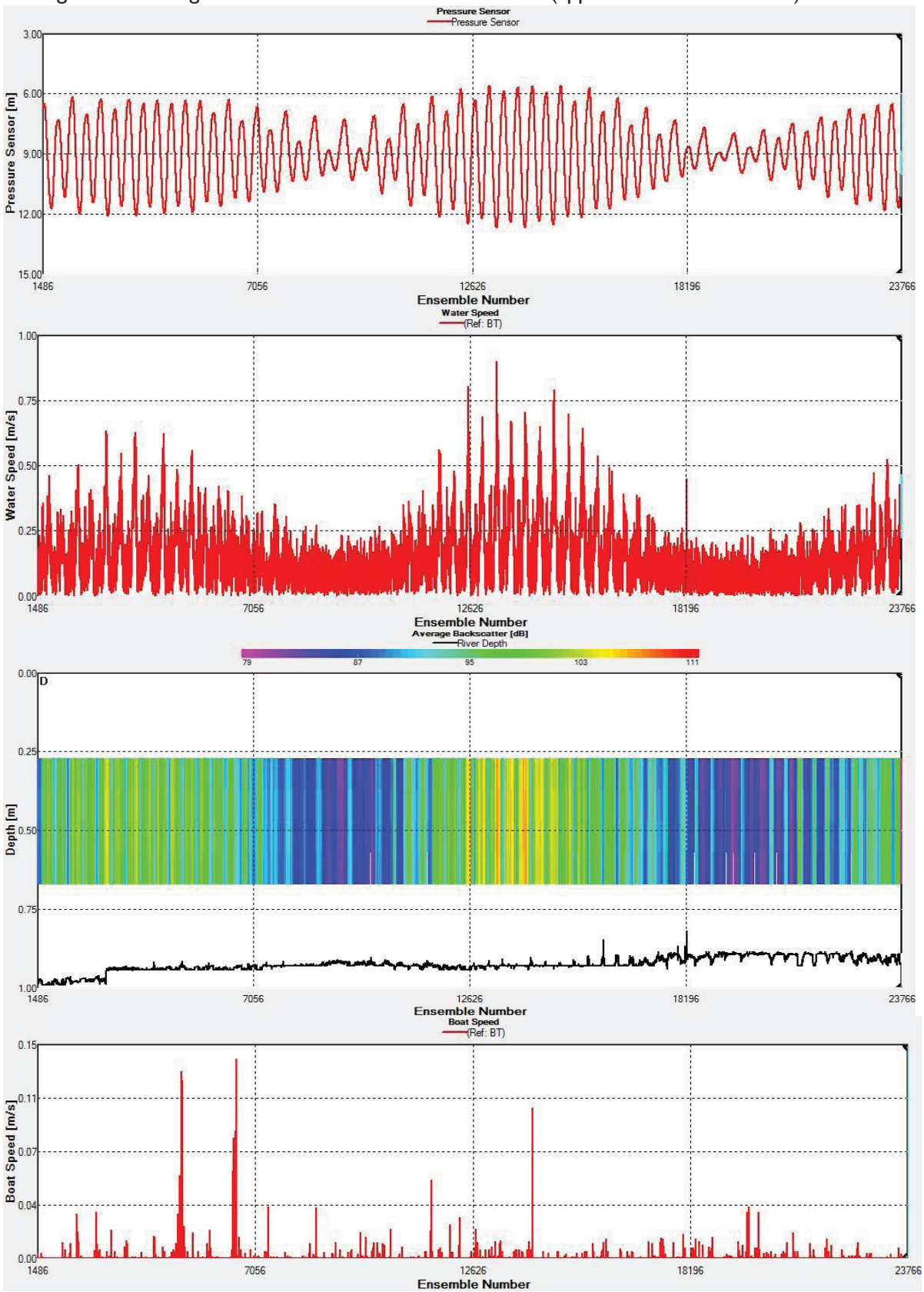


Figure 22: Results from downlooking RDI ADCP

5.4 Teledyne Citadel CTD results

The salinity, temperature, turbidity and depth results from the citadel Teledyne CTD are shown below in Figure 23 and Figure 24.

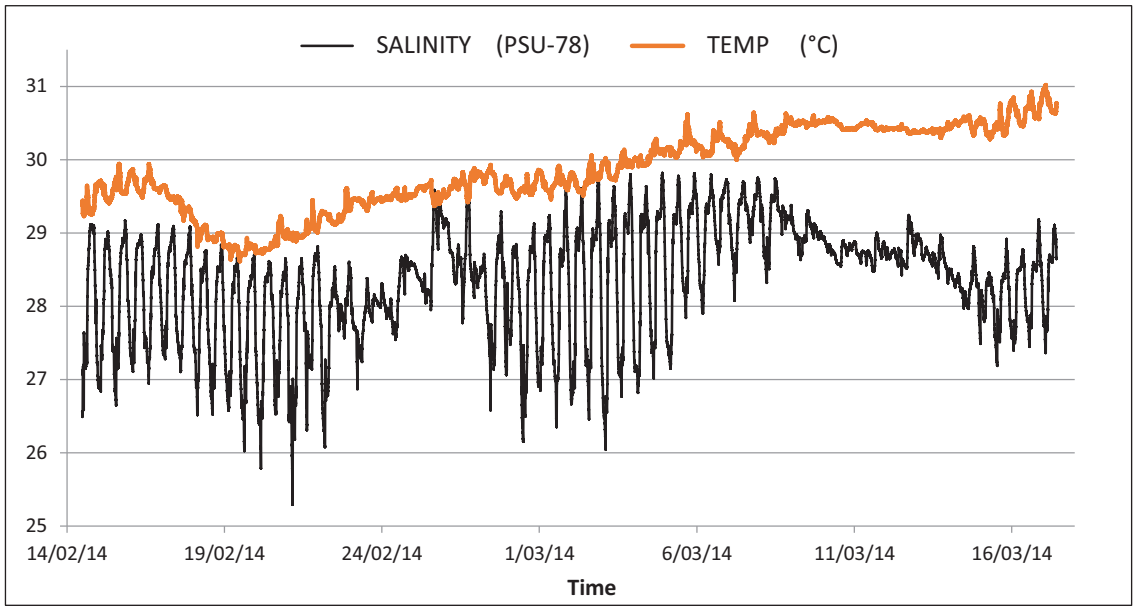


Figure 23: The variation of salinity and temperature over a 30 day period

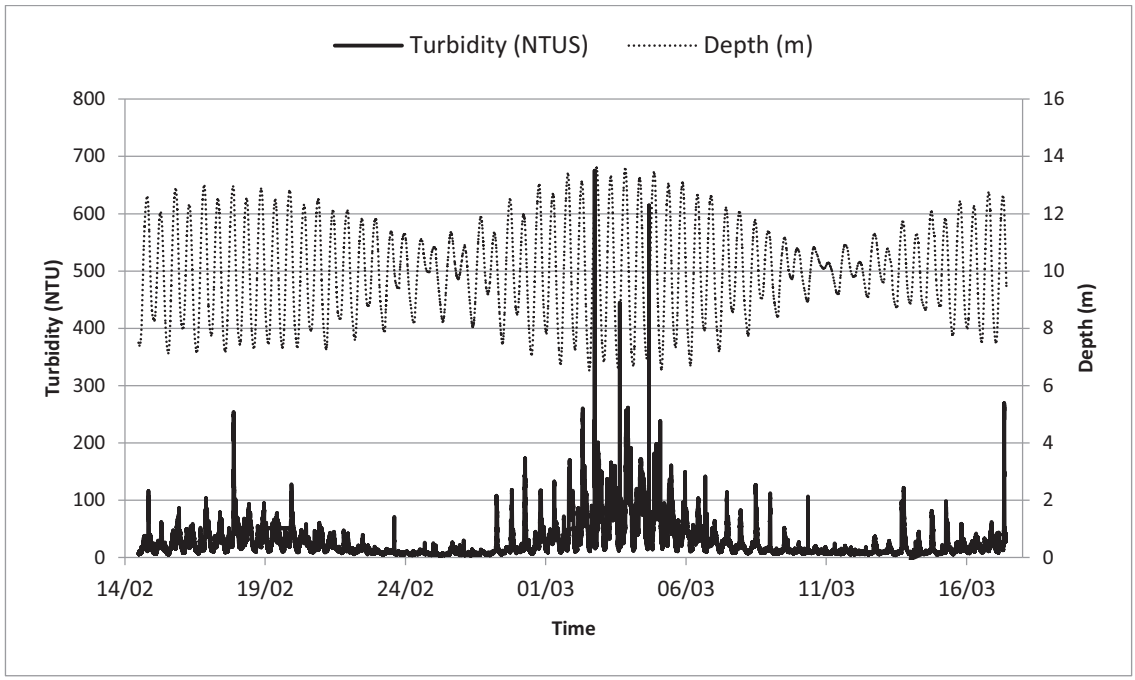


Figure 24: The variation of turbidity with tidal movement

6 Modelling

6.1 Hydrodynamic

The model from task 1 of the proposed LDC shoreline development was re-run using the data collected above. The hydrodynamic model was first run using the existing geometry. Plotting the modelled residual currents shows a large scale eddy consistent with the velocity results in section 5.2.

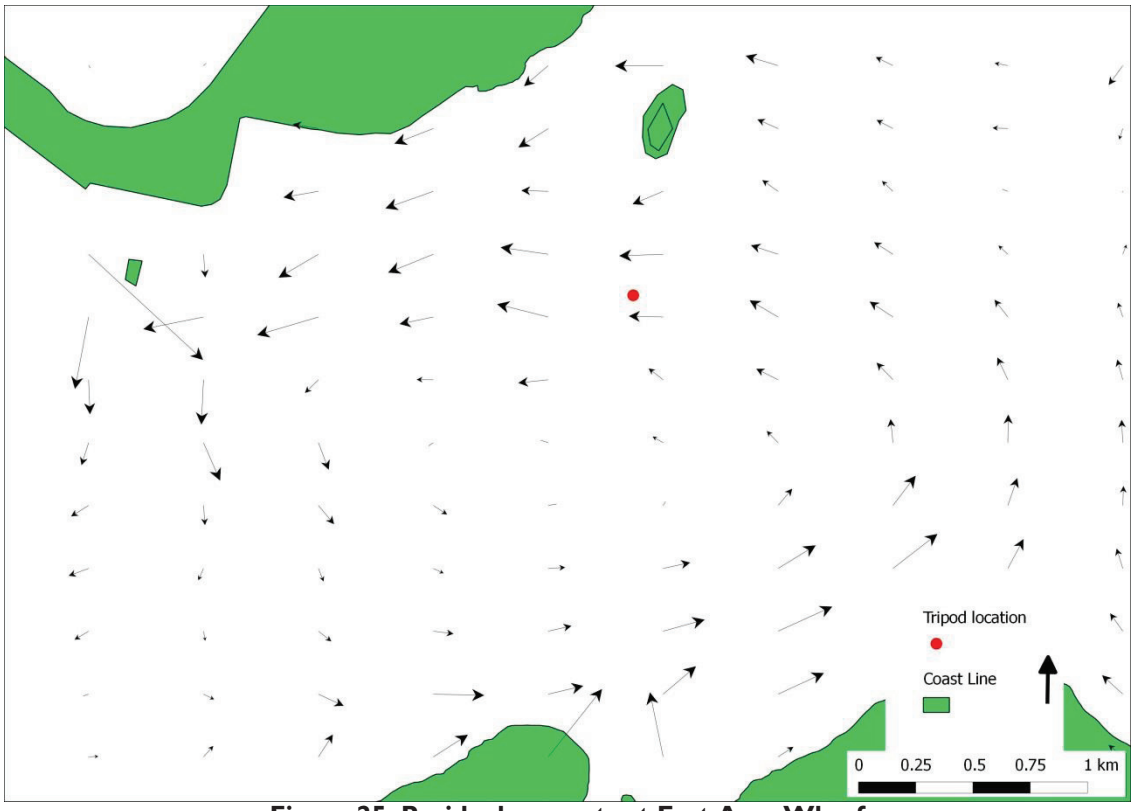


Figure 25: Residual currents at East Arm Wharf

6.2 Cohesive sediment

The cohesive sediment model was run for ninety days using bathymetry from task 1 – dredge channel and shoreline development of the proposed marine park development report (2013). The bed material distribution according to Figure 16 was integrated into the model. The modelling results for erosion and deposition of cohesive sediments are shown in Figure 26. The most recent bathymetric multibeam survey carried out in early 2014 is also incorporated into the model.

The model predicts a low rate of cohesive bed erosion. Deposition occurs mainly in the dredged areas close to the shore. The model indicates that the maximum deposition rate is approximately 0.035m per annum in the area shown in Figure 26. The model indicates that the deposition rate in the proposed ship turn area is approximately 0.008m per year.

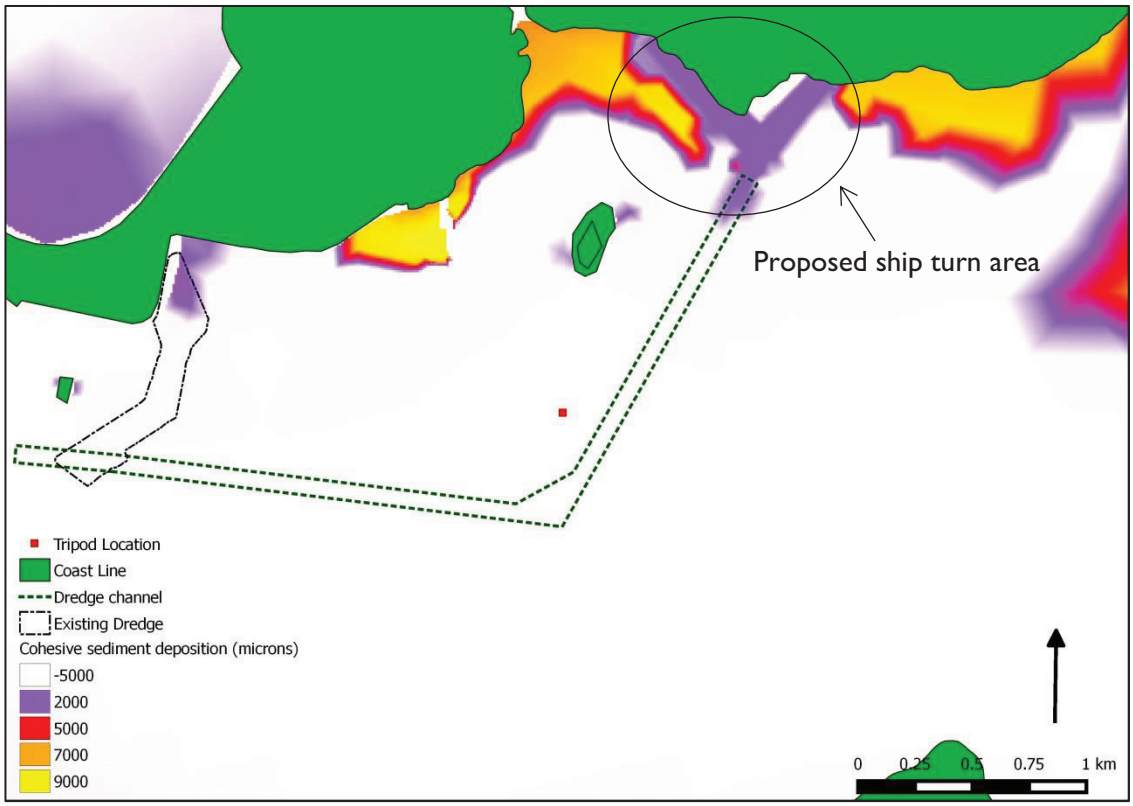


Figure 26: Model results for erosion (negative) and deposition (positive) for cohesive sediment at East Arm after 90 days.

6.3 Non-cohesive (sand)

The model shows that for sand deposition under the conditions described above in the Task 1 channel and shoreline development report, the maximum deposition rate is around 1m per year while the maximum potential erosion rate is approximately 5.5m per year in isolated areas. The sand model indicates a large amount of sand erosion and deposition at the East Arm sand bar shown in Figure 27.

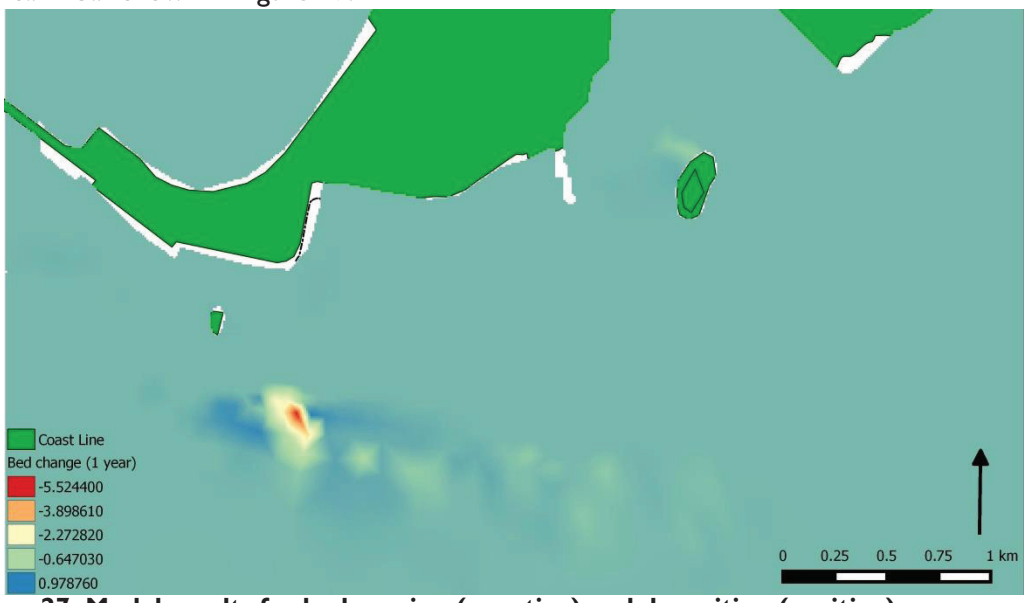


Figure 27: Model results for bed erosion (negative) and deposition (positive) over one year for non-cohesive sediment (sand) in metres

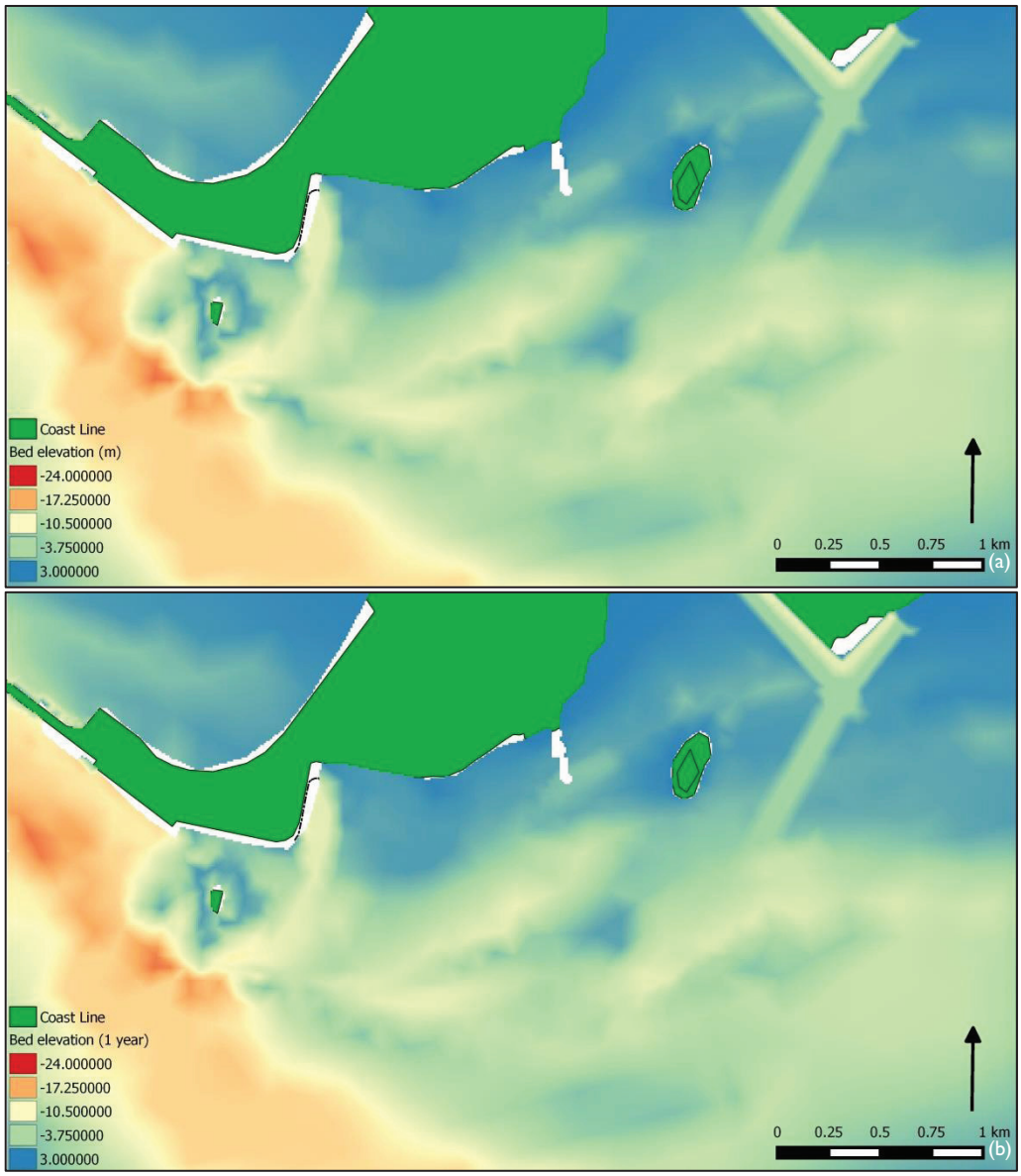


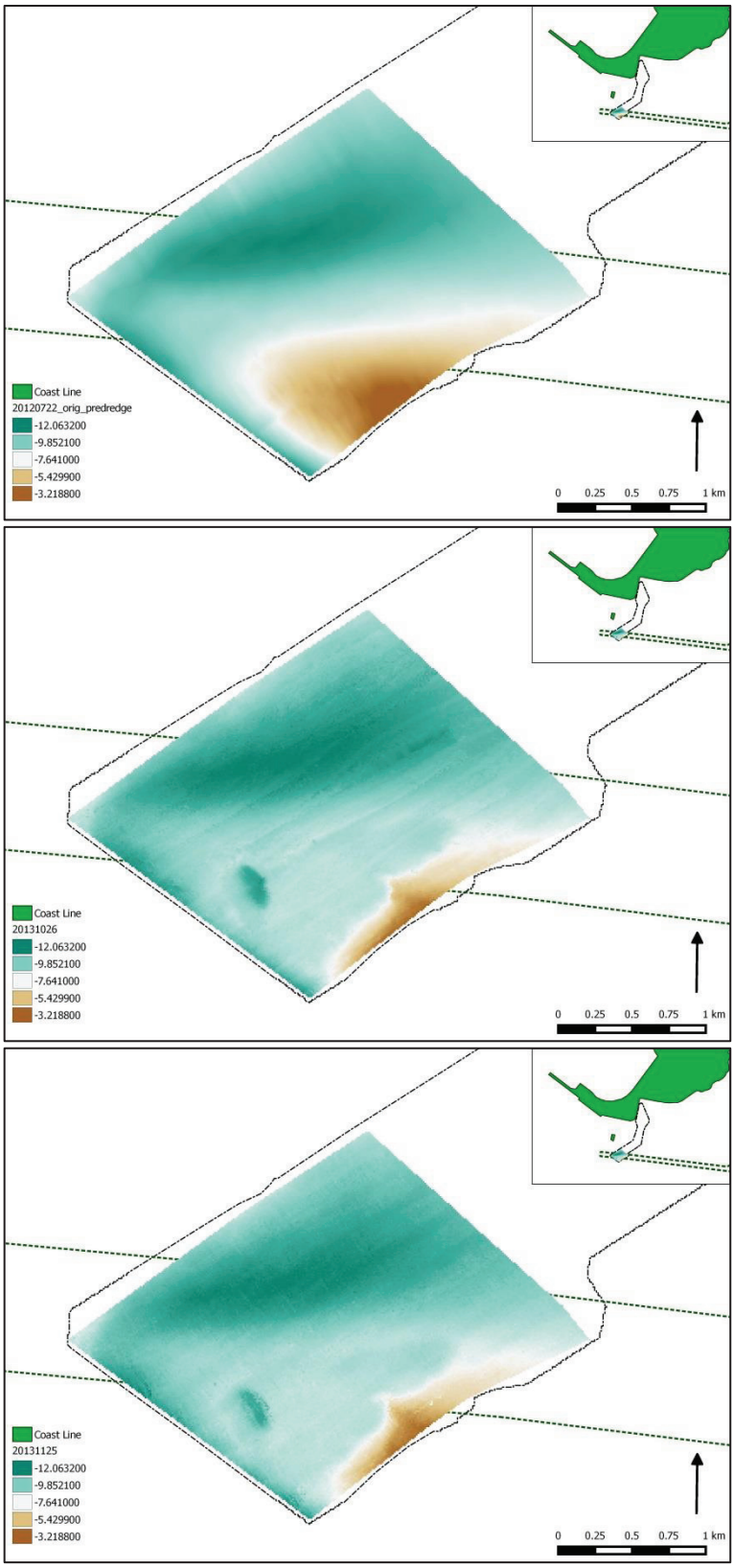
Figure 28: Bed elevation before (a) and after (b) 1 year of sand modelling

Figure 28 (a) shows the bed elevation at the start of the model run showing both the shoreline development dredge channel and the most recent dredge channel bathymetry. The model results have been added to the existing bed elevation in Figure 28 (b) so that the cumulative erosion and deposition can be shown relative to the proposed development.

6.3.1 Multibeam echosounder results analysis

Multibeam echosounder surveys were carried out before, during and after the dredging that occurred in the East Arm Wharf area for the proposed Marine Supply Base (MSB) in late 2013 and early 2014. These data were supplied to AIMS for sediment deposition and erosion rates analysis. The volume analysis was carried out using two different programs in order to check the results. These were Surfer 12 and ArcGIS in which the results agree. It was observed that sand deposition occurred at the toe of the survey area (see Figure 29 inset) during the dredge operation. In some instances there was sediment removal (or scouring). It is difficult to know whether the processes observed have been natural or anthropogenic without knowing the exact dredge schedule. However, the images in Figure 29 and the data in Table 6 show that with the removal of material in this location the sediment movement is dynamic in one month

intervals. Between October and November of 2013, an erosion rate (or sediment removal rate) of on average 0.03m of sediment in the mapped area is recorded. This equates to about 0.36m per year. Between November and December the net result is deposition at about 0.56m per year. It is possible that the model cannot predict these exact infill and deposition rates, although it is clear that the environment is dynamic in this location.



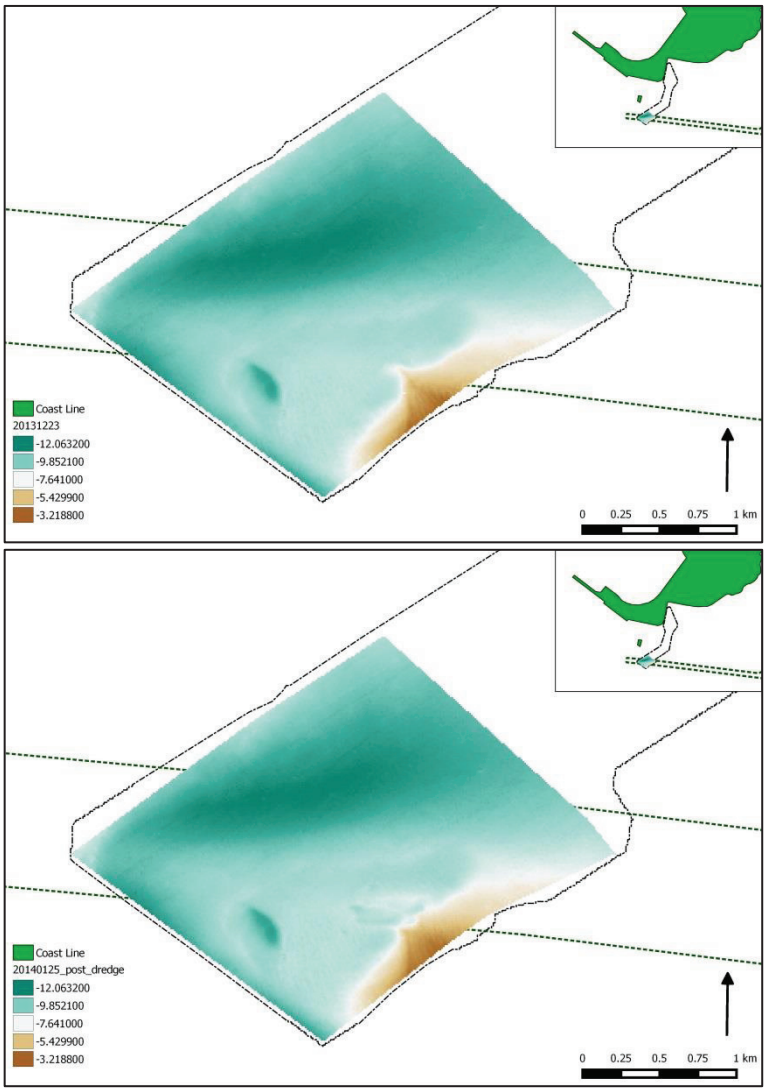


Figure 29: Multibeam survey results of the marine supply base dredge channel at various dates (shown in the map legend)

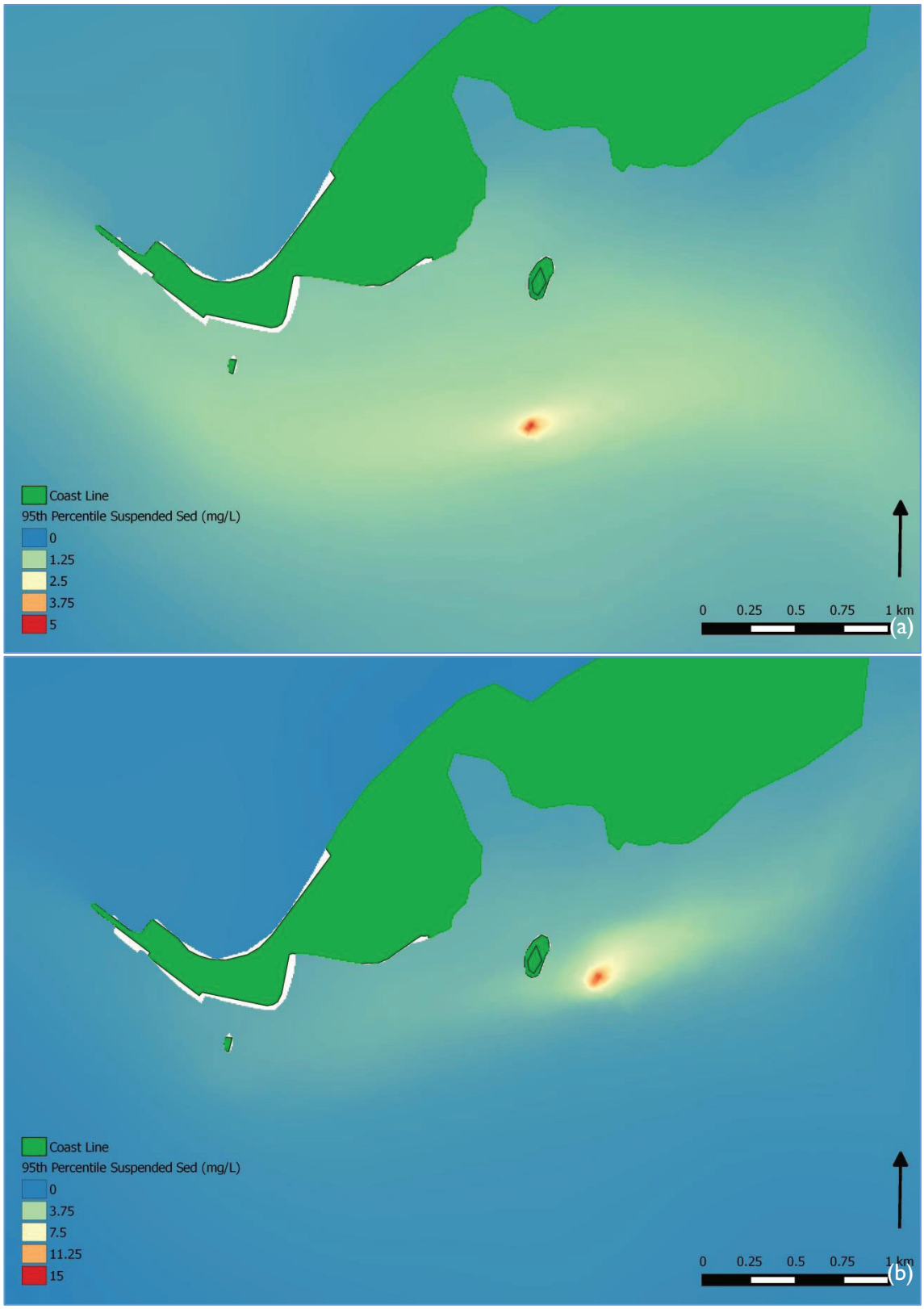
Table 6: Volume analysis of multibeam survey results

	Surfer 12			ArcGIS		
	Volume above -7.7m (m^3)	Volume difference (m^3)	Volume (m^3)/Average Area (m^2)	Volume above -7.7m (m^3)	Volume difference (m^3)	Volume (m^3)/Average Area (m^2)
20120722	13102			12832		
20131026	3434	9668		3186	9646	
20131125	3498	-64	-0.028327985	3276	-90	-0.03968138
20131223	3393	105	0.0464756	3179	97	0.042736212
20140125	3359	34	0.015049242	3146	33	0.014519535

6.4 Dredge plume

A preliminary modelling exercise was carried out to give indicative information on the extent of the sediment plume should the task 1 channel be dredged (shown in Figure 26). The following assumptions were made. The dredge rate is based on 1% leakage of a 2000m³/hr at

three locations in the dredge channel, (east, middle and west section) each one being dredged continuously for 14 days. A 9:1 water to sediment ratio was used. The dry bulk density observed in the bulk density tests in this study of 857 kg/m^3 was used. Figure 30 shows the likely extent of the dredge plume at three different locations within the dredged area under this scenario.


Coast Line
95th Percentile Suspended Sed (mg/L)
0
1.25
2.5
3.75
5
0 0.25 0.5 0.75 1 km
(a)
Coast Line
95th Percentile Suspended Sed (mg/L)
0
3.75
7.5
11.25
15
0 0.25 0.5 0.75 1 km
(b)

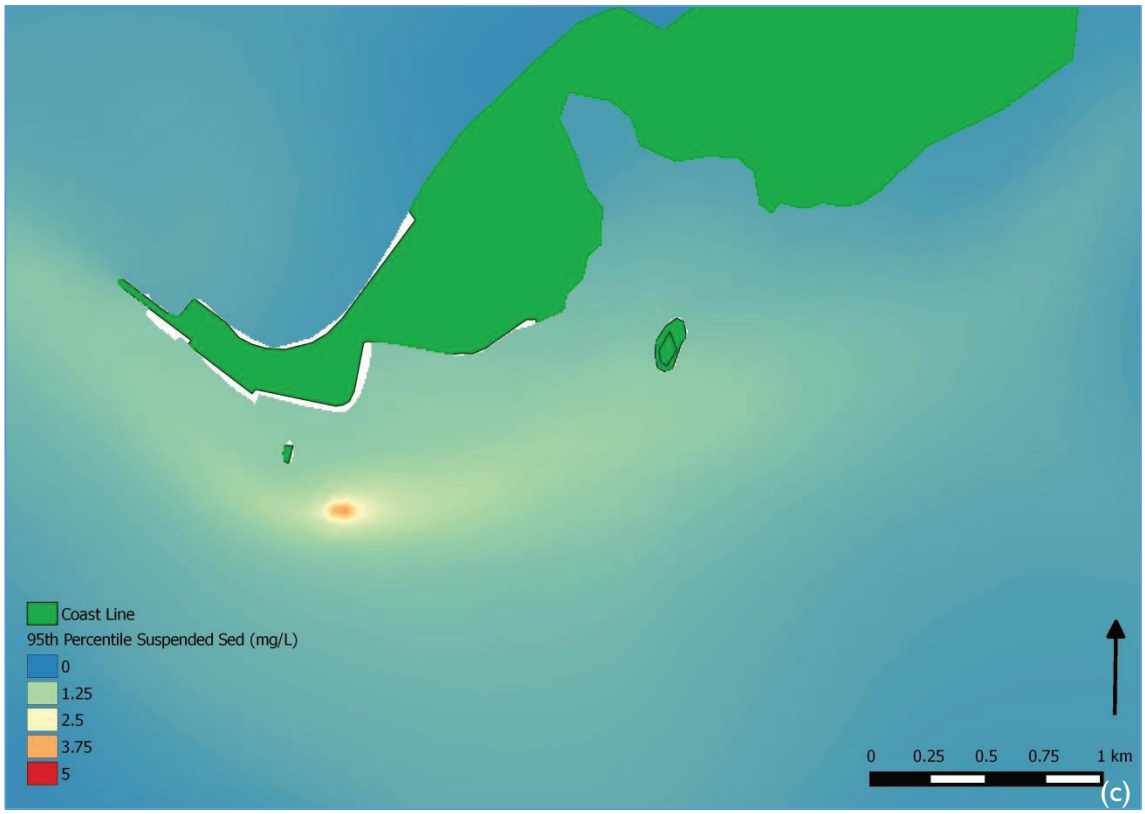


Figure 30: Likely extent from dredging at three points, east (a), middle (b), and west (c) of the dredge channel

7 Conclusion

The model has been significantly improved with the collection and integration of the field work carried out in early 2014. The bulk density of the sediment has been determined and entered directly into the model. Sediment fall velocity was also confirmed and directly used as input in the model. The bed material distribution mapping using the sub-bottom profiling, vibrocore and bed sample has given a sound indication initial conditions for both cohesive sediment and non-cohesive sediment modelling. The cohesive sediment modelling has shown reasonable estimations for deposition and erosion rates. These can be used to plan dredge intervals and confidently predict the likely dredge plumes. Model limitations still exist within the non-cohesive sediment modelling with erosion and deposition rates estimated to be higher than probable. The model underestimates bed shear stress at the location of the ADCP, which could be improved by running more model trials. However it is important to be aware that the bed shear stress calculation itself is also based on non-empirical coefficients. This report provides 2014 baseline data for bed material and water column conditions at East Arm, and provides valuable empirical coefficients for East Arm that have been used to significantly improve the cohesive sediment transport model. AIMS is confident with the modelling results given that the parameters entered into the model have been measured *in situ*. As always AIMS recommends further verification of the model to test the changes made against real data. These can be carried out as further opportunities arise to collect time and space variable data.

8 References

Patterson, R.G., Williams, D.K. (2013), Proposed Marine Industry Park Modelling Report. Task 1 – Dredge channel and shoreline development. Report for Land Development Corporation. Australian Institute of Marine Science Darwin.

This page is intentionally blank

APPENDIX E *EPBC ACT* PROTECTED MATTERS REPORT

This page is intentionally blank

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 24/07/14 13:32:17

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	3
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	24
Listed Migratory Species:	47

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	90
Whales and Other Cetaceans:	11
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	1
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	32
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Historic		
Catalina 4	NT	Nominated place
Catalina 5	NT	Nominated place
Catalina 6	NT	Nominated place

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Geophaps smithii smithii Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Phascogale pirata		
Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat likely to occur within area
Saccolaimus saccolaimus nudicluniatus		
Bare-rumped Sheathtail Bat [66889]	Critically Endangered	Species or species habitat likely to occur within area
Xeromys myoides		
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Acanthophis hawkei		
Plains Death Adder [83821]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki		
Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat likely to occur within area
Pristis pristis		
Largetooth Sawfish, Freshwater Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Sterna albifrons		
Little Tern [813]		Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Dugong dugon		
Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta birostris		
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area

Name	Threatened	Type of Presence
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Foraging, feeding or related behaviour known to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat likely to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Foraging, feeding or related behaviour known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Foraging, feeding or related behaviour known to occur within area
Calidris alba		
Sanderling [875]		Foraging, feeding or related behaviour known to occur within area
Calidris canutus		
Red Knot, Knot [855]		Foraging, feeding or related behaviour known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]		Foraging, feeding or related behaviour known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Foraging, feeding or related behaviour known to occur within area
Calidris tenuirostris		
Great Knot [862]		Foraging, feeding or related behaviour likely to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]		Foraging, feeding or related behaviour known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]		Foraging, feeding or related behaviour known to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Foraging, feeding or related behaviour may

Name	Threatened	Type of Presence
		occur within area
Glareola maldivarum Oriental Pratincole [840]		Foraging, feeding or related behaviour may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Foraging, feeding or related behaviour known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Foraging, feeding or related behaviour known to occur within area
Limosa limosa Black-tailed Godwit [845]		Foraging, feeding or related behaviour likely to occur within area
Numenius madagascariensis Eastern Curlew [847]		Foraging, feeding or related behaviour known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Foraging, feeding or related behaviour likely to occur within area
Numenius phaeopus Whimbrel [849]		Foraging, feeding or related behaviour known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Foraging, feeding or related behaviour known to occur within area
Pluvialis squatarola Grey Plover [865]		Foraging, feeding or related behaviour known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Xenus cinereus Terek Sandpiper [59300]		Foraging, feeding or related behaviour known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Foraging, feeding or related behaviour known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Arenaria interpres Ruddy Turnstone [872]		Foraging, feeding or related behaviour known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Foraging, feeding or related behaviour known to occur within area
Calidris alba Sanderling [875]		Foraging, feeding or related behaviour known to occur within area
Calidris canutus Red Knot, Knot [855]		Foraging, feeding or related behaviour known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Foraging, feeding or related behaviour known to occur within area
Calidris ruficollis Red-necked Stint [860]		Foraging, feeding or related behaviour known to occur within area
Calidris tenuirostris Great Knot [862]		Foraging, feeding or related behaviour likely to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]		Foraging, feeding or related behaviour known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]		Foraging, feeding or related behaviour known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Foraging, feeding or related behaviour may occur within area
Gallinago megala Swinhoe's Snipe [864]		Foraging, feeding or related behaviour likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Foraging, feeding or related behaviour likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Foraging, feeding or related behaviour may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Foraging, feeding or related behaviour known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Limosa limosa Black-tailed Godwit [845]		Foraging, feeding or related behaviour likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew [847]		Foraging, feeding or related behaviour known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Foraging, feeding or related behaviour likely to occur within area
Numenius phaeopus Whimbrel [849]		Foraging, feeding or related behaviour known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Foraging, feeding or related behaviour known to occur within area
Pluvialis squatarola Grey Plover [865]		Foraging, feeding or related behaviour known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Xenus cinereus Terek Sandpiper [59300]		Foraging, feeding or related behaviour known to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solenostomus paegnius		
Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Syngnathoides biaculeatus		
Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus		
Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris		
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon		
Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii		
Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii		
Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii		
Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis		
Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii		
Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Crocodylus johnstoni		
Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Disteira kingii		
Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major		
Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa		
Beaked Seasnake [1126]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Name	Status	Type of Presence
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata		
Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus		
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Darwin Harbour Wetlands	NT	Indicative Place

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Annona glabra Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat may occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw		Species or species

Name	Status	Type of Presence
Creeper, Funnel Creeper [85119]		habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra		
Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pennisetum polystachyon		
Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lepidodactylus lugubris		
Mourning Gecko [1712]		Species or species habitat likely to occur within area
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Port Darwin	NT

Coordinates

-12.48037 130.91349,-12.48034 130.91623,-12.4809 130.91808,-12.48093 130.91897,
-12.48059 130.91974,-12.48042 130.92022,-12.48074 130.92105,-12.48071 130.92196,
-12.48097 130.9227,-12.48068 130.92311,-12.4803 130.92328,-12.48027 130.9245,-12.48107
130.92408,-12.48325 130.92293,-12.4849 130.9243,-12.49655 130.91689,-12.50535 130.9113,
-12.50024 130.87952,-12.4963 130.87998,-12.49877 130.90121,-12.49873 130.90627,
-12.49099 130.9082, 12.49035 130.90947, 12.48583 130.90944, 12.48527 130.90773,
-12.48529 130.90492,-12.48436 130.90378,-12.48151 130.90164,-12.48046 130.9013,
-12.47871 130.90289,-12.47723 130.90517,-12.47723 130.90536,-12.47895 130.90537,
-12.47893 130.90955,-12.47838 130.90955,-12.47836 130.91257,-12.47954 130.91261,
-12.47955 130.91247,-12.48043 130.91248,-12.48044 130.91349,-12.48037 130.91349

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. It combines a number of Matters of National Environmental Significance (NES) datasets, mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

This page is intentionally blank

APPENDIX F AAPA CERTIFICATES FOR EAST ARM

F1 Aboriginal Areas Protection Authority (AAPA) Certificate for Land Development at the Multi User Barge Ramp and Common User Area

F2 Aboriginal Areas Protection Authority (AAPA) Certificate for Land Development at East Arm, south of Berrimah Road

This page is intentionally blank

ABORIGINAL AREAS PROTECTION AUTHORITY
GPO BOX 1890
DARWIN NT 0801
TELEPHONE: 08 8981 4700
FACSIMILE: 08 8981 4169
EMAIL: enquiries.aapa@nt.gov.au

File: *D89/199; 89/343* ***In Reply Please Quote: 65432***

Land Development Corporation
PMB 588
Berrimah NT 0828

Attention: MARK NOLEN

RE: ISSUE OF AUTHORITY CERTIFICATE FOR SECTION 5421 AND PART SECTION 5633 EAST ARM.

I refer to your application for Authority Certificate received on the 11th November 2008 for the above location.

Accordingly, under the powers delegated to me under Section 19 of the *Northern Territory Aboriginal Sacred Sites Act 1989* I am pleased to issue the attached Authority Certificate.

Please read carefully the conditions outlined in the Certificate. In particular, you should note that it has been issued for an indefinite period of time, providing that the works covered by the Certificate start within the period stipulated in condition 3.

You should also note that the Authority has issued you with two identical copies of digitised maps attached. One copy should be retained with your original Certificate. The second is supplied for use by contractors to avoid unnecessary photocopying of a colour coded document.

Custodians of sacred site 5073/66 are concerned about the impacts of development on this site. In particular they are keen to ensure that dredging in the area does not adversely impact on the sand bar formation which is a feature of this sacred site. In addition custodians have noted that the area has historically been used for a variety of marine and mangrove based resource use activities, and have requested that clearing of mangroves outside the defined restricted work area be kept to a minimum.

Please note that the cost of this Authority Certificate will be **$1040** and an invoice will be issued to you by the Department of Business and Employment (DBE). The terms and conditions of the invoice will require you to make payment within 30 days of receipt.

If you have any further queries regarding this Authority Certificate please contact Gareth Lewis on 89824227.

Yours faithfully,

DR BEN SCAMBARY
Chief Executive Officer
30 July 2009

ABORIGINAL AREAS PROTECTION AUTHORITY

AUTHORITY CERTIFICATE

Issued in accordance with Section 22 of the Northern Territory Aboriginal Sacred Sites Act 1989

REFERENCE: D89/199; 89/343 (Doc: 65432) C2009/169

APPLICANT: Land Development Corporation
PMB 588
Berrimah NT 0828

SUBJECT LAND: Section 5421 and Part Section 5633 East Arm, as shown on the map which is annexure 'A' hereto.

PROPOSED WORK OR USE: Site levelling to planned RL, cut and fill, land reclamation, marine base industry, construction, sea-bed dredging, plant construction, marine structures

CONDITIONS:

1. The applicant shall ensure that the conditions of this Certificate are included in any subsequent contract or tender documents for the works or use described herein.

2. The applicant shall ensure any agent, contractor or employee is aware of the conditions of this Certificate and the obligations of all persons (who enter on, or carry out works or use land on which there is a sacred site) under Part IV of the *Northern Territory Aboriginal Sacred Sites Act 1989*.

3. This Certificate shall lapse and be null and void if the works in question or the proposed use is not commenced within 24 months of this Certificate.

4. The applicant shall ensure any agent, contractor or employee is aware of the content of section 40(1) of the *Northern Territory Aboriginal Sacred Sites Act 1989* which provides that this Certificate does not negate the need for consent, approval or permission for the subject works or use of the land which may be required under another statute.

5. No works are permitted within Restricted Work Area One (RWA1) which is associated with Sacred sites 5073-66 and 5073-90, as depicted on the attached plan.

The COMMON SEAL of the
ABORIGINAL AREAS PROTECTION AUTHORITY
was hereto affixed on the 30 day
of July 2009

DR BEN SCAMBARY
Chief Executive Officer

ABORIGINAL AREAS PROTECTION AUTHORITY
THE
COMMON SEAL
OF

706000mE
706500mE
707000mE
707500mE
708000mE
BERRIMAH ROAD
8620000mN
8619500mN
8619000mN
8618500mN
8618000mN
8617500mN
Sec 5720
Sec 5719
Sec 5633
Sec 5421
Sec 5772
5073-66
5073-90
Image credits:

Prepared and produced by Aboriginal Areas Protection Authority (AAPA), Darwin, Northern Territory of Australia 30/07/2009
© Northern Territory of Australia

Base Aerial Imagery Copyright © Digital Globe, Australia All rights reserved.

This map forms part of a Certificate issued by the Authority under section 22 of the *Northern Territory Aboriginal Sacred Sites Act 1989*. No reliance should be put on the accuracy of the information on the map except as it relates to the land the subject of the Certificate and the fact that sites are not shown in other areas shall not be taken as a definitive indication of the existence or lack of existence of sites.

Darwin East Arm
Section 5421 And Part Section 5633

ANNEXURE "A" MAP FORMING PART OF

AUTHORITY CERTIFICATE C2009/169

ISSUED TO: Land Development Corporation

AUTHORISED COPY: NUMBER....1....OF 5

CHECKED BY:.....DD.....DATE 30/07/2009

D DWYER - MANAGER TECHNICAL SECTION

J2009/0430

SCALE 1 : 10000

0 200 400

metres

Projection: MGA Zone 52
Horizontal Datum: GDA94

KEY

Subject Land

Restricted Work Area

Registered Site Centroid

Recorded Site Centroid

ABORIGINAL AREAS PROTECTION AUTHORITY
GPO BOX 1890
DARWIN NT 0801
TELEPHONE: 08 8981 4700
FACSIMILE: 08 8981 4169
EMAIL: enquiries.aapa@nt.gov.au

File: *D89/199; 89/343* ***In Reply Please Quote: 64994***

Land Development Corporation
PMB 588
BERRIMAH NT 0828

Attention: NICOLE PAAS

RE: ISSUE OF AUTHORITY CERTIFICATE FOR LAND DEVELOPMENT AT EAST ARM, SOUTH OF BERRIMAH ROAD: PART SEC. 5633, SEC. 5558, 5709, 4731, 4978, 4337 AND 5530.

I refer to your application for Authority Certificate received on the 2nd October 2008 for the above location.

Accordingly, under the powers delegated to me under Section 19 of the *Northern Territory Aboriginal Sacred Sites Act 1989* I am pleased to issue the attached Authority Certificate.

Please read carefully the conditions outlined in the Certificate. In particular, you should note that it has been issued for an indefinite period of time, providing that the works covered by the Certificate start within the period stipulated in condition 3.

You should also note that the Authority has issued you with two identical copies of digitised maps attached. One copy should be retained with your original Certificate. The second is supplied for use by contractors to avoid unnecessary photocopying of a colour coded document.

Larrakia custodians have requested that I convey their concerns regarding the significant environmental and cultural impacts of works associated with the proposed development at East Arm, in particular the destruction of mangroves and bushland

I also advise that custodians are concerned about the protection of archaeological sites which may be located within the application area. Archaeological sites are protected under the *NT Heritage Conservation Act 1991*. I recommend that you contact Heritage Conservation Services on (08) 8999 5036 regarding these sites. Custodians have requested they are given the opportunity to participate in any archaeological or environmental assessments of the area.

Please note that the cost of this Authority Certificate will be **$1040.00** and an invoice will be issued to you by the Department of Business and Employment (DBE). The terms and conditions of the invoice will require you to make payment within 30 days of receipt.

If you have any further queries regarding this Authority Certificate please contact
Gareth Lewis on 89824227.

Yours faithfully,

DR BEN SCAMBARY
Chief Executive Officer

24 March 2009

ABORIGINAL AREAS PROTECTION AUTHORITY

AUTHORITY CERTIFICATE

Issued in accordance with Section 22 of the Northern Territory Aboriginal Sacred Sites Act 1989

REFERENCE: D89/199; 89/343 (Doc: 64994) C2009/051

APPLICANT: Land Development Corporation
PMB 588
BERRIMAH NT 0828

SUBJECT LAND: Part Section 5633, Section 5558, 5709, 4731, 4978, 4337 and 5530, East Arm, south of Berrimah Road, as shown on the map which is Annexure 'A' hereto.

PROPOSED WORK OR USE: All works associated with land clearing and land reclamation; the construction and maintenance of all infrastructure associated with the development of marine based industries (boat and ship building and repair); manufacturing industries; and with the construction and maintenance of a commercial centre (shops, banks, offices and restaurants).

CONDITIONS:

1. The applicant shall ensure that the conditions of this Certificate are included in any subsequent contract or tender documents for the works or use described herein.

2. The applicant shall ensure any agent, contractor or employee is aware of the conditions of this Certificate and the obligations of all persons (who enter on, or carry out works or use land on which there is a sacred site) under Part IV of the *Northern Territory Aboriginal Sacred Sites Act 1989*.

3. This Certificate shall lapse and be null and void if the works in question or the proposed use is not commenced within 24 months of this Certificate.

4. The applicant shall ensure any agent, contractor or employee is aware of the content of section 40(1) of the *Northern Territory Aboriginal Sacred Sites Act 1989* which provides that this Certificate does not negate the need for consent, approval or permission for the subject works or use of the land which may be required under another statute.

5. No works of any kind are to occur within Restricted Work Area (RWA) 1 associated with Registered Sacred Site 5073/66, as marked on Annexure 'A'.

6. No works of any kind are to occur within Restricted Work Area (RWA) 2 associated with Recorded Sacred Site 5073/90, as marked on Annexure 'A'.

The COMMON SEAL of the
ABORIGINAL AREAS PROTECTION AUTHORITY
was hereto affixed on the 24 day
of March 2009

ABORIGINAL AREAS PROTECTION AUTHORITY
THE
COMMON SEAL
OF

DR BEN SCAMBARY
Chief Executive Officer

East Arm Development

ANNEXURE "A" MAP FORMING PART OF

AUTHORITY CERTIFICATE C2009/051

ISSUED TO: Land Development Corporation

AUTHORISED COPY: NUMBER 1 OF 5.

CHECKED BY: ..... DATE 23/03/2009

T BYFIELD - SENIOR LAND INFORMATION OFFICER

SCALE 1 : 15000

0 300 600

metres

Projection: MGA Zone 52
Horizontal Datum: GDA94

KEY

- Subject Land
- Extent of Registered Sacred Site
- Restricted Works Area
- Recorded Site Centroid
- Registered Site Centroid

Prepared and produced by
Aboriginal Areas Protection Authority,
Darwin, Northern Territory of Australia
23/03/2009

Base Aerial Imagery

This map forms part of a Certificate issued by the Authority under section 22 of the *Northern Territory Aboriginal Sacred Sites Act 1989*. No reliance should be put on the accuracy of the information on the map except as it relates to the land the subject of the Certificate and the fact that sites are not shown in other areas shall not be taken as a definitive indication of the existence or lack of existence of sites in these areas.

J2008/0771

This page is intentionally blank

GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

URS is a leading provider of engineering, construction, technical and environmental services for public agencies and private sector companies around the world. We offer a full range of program management; planning, design and engineering; systems engineering and technical assistance; construction and construction management; operations and maintenance; and decommissioning and closure services for power, infrastructure, industrial and commercial, and government projects and programs.

URS Australia Pty Ltd
Level 3, 93 Mitchell Street
Darwin, NT 0800
GPO Box 2005, Darwin NT 0801
Australia

T: +61 8 8980 2900
F: +61 8 8941 3920

www.urs.com.au