Department for Environment and Water

Port Stanvac Multibeam and Sub-Bottom Profiler Survey
June 2020

SURVEY REPORT

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Contractor

Precision Hydrographic Services

10 Ragless Street

St Marys, SA

Australia 5042

Tel: +61 (0)8 7120 2211

info@precisionhydrographic.com.au

Client

Government of South Australia

Department for Environment and Water

81-95 Waymouth Street

Adelaide, SA

Australia 5000

Tel: +61 (0)8 8204 1910

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COMPANY DESCRIPTION

PHS is a specialist hydrographic survey company with offices located in South Australia and the Pilbara. We specialise in conducting high accuracy hydrographic survey services supervised and approved by certified AHSCP Level 1 hydrographic surveyors. PHS has experience in all facets of producing high resolution multibeam surveys for safety of navigation, dredging and maintenance operations. PHS surveys are conducted to meet local, national and international standards.

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ABBREVIATIONS

The following abbreviations may be used in this document:

AHD	Australian Height Datum
AHS	Australian Hydrographic Service
BM	Benchmark
CD	Chart Datum
C-O	Calculated minus Observed
COG	Centre of Gravity
CRP	Central Reference Point (Origin of Vessel Coordinate System)
DEW	Department for Environment and Water
DUKC	Dynamic Under Keel Clearance
GDA94	Geocentric Datum of Australia 1994
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
HDOP	Horizontal Dilution of Precision
IHO	International Hydrographic Organisation
IMU	Inertial Measurement Unit
ITRF	International Terrestrial Reference Frame
kHz	Kilohertz
LAT	Lowest Astronomical Tide
MBES	Multibeam Echo Sounder
MGA94	Map Grid of Australia 1994
MRU	Motion Reference Unit
MSL	Mean Sea Level
PDOP	Position Dilution of Precision
PHS	Precision Hydrographic Services
POS MV	Position and Orientation System Marine Vessel
Qinsy	Quality Integrated Navigation System
RTK	Real Time Kinematic
SSM	State Survey Mark (Also called PSM – Permanent Survey Mark)
SVP	Sound Velocity Profiler
SVS	Sound Velocity Sensor
TBM	Tidal Benchmark / Temporary Benchmark
THU	Total Horizontal Uncertainty
TPU	Total Propagated Uncertainty
TVU	Total Vertical Uncertainty
UTM	Universal Transverse Mercator
VDOP	Vertical Dilution of Precision
WGS84	World Geodetic System of 1984

REFERENCES

1. Geocentric Datum of Australia Technical Manual, Intergovernmental Committee on Surveying and Mapping, Version 2.4, December 2014.
2. Principles for Gathering and Processing Hydrographic Information in Australian Ports, Ports Australia, Version 1.5, November 2012.
3. IHO Standards for Hydrographic Surveys, International Hydrographic Organisation, 5th Edition, 2008.
4. Bureau of Meteorology Metadata for Tidal Data Exchange, Port Stanvac, 9 December 2010.
5. Survey Mark Details for 6527/1071, Land Services SA, dated 24/06/2020.
6. Survey Mark Details for 6527/7678, Land Services SA, dated 24/06/2020.
7. Survey Mark Details for 6527/8223, Land Services SA, dated 24/06/2020.

A. INTRODUCTION

Precision Hydrographic Services (PHS) was contracted in June 2020 by the Department for Environment and Water (DEW) to conduct a multibeam bathymetry, multibeam backscatter, and sub-bottom profiling survey in Port Stanvac to define the water depths, subtidal habitats and sand depth.

The DEW conducted video drops and seabed sampling, and Acoustic Imaging were subcontracted to conduct the analysis of the sub-bottom profiler data. The DEW and Acoustic Imaging results are covered under this report.

This report (PHS-20-033-DEW-R001) covers the methodology, findings, checks and calibrations that were carried out to ensure the survey met the required standards[3].

A.1 Summary of Operations

PHS mobilised a high-resolution wideband multibeam echo sounder survey system onto the DEW vessel *Marine Science* and a Sub-Bottom Profiler to complete this project. Management of survey operations together with data processing and quality assurance tasks were carried out from the PHS Adelaide office.

During this project, operations ran for 12 hours each day, with one online surveyor onboard *Marine Science* and one CPHS1 certified Hydrographic Surveyor ashore overseeing the operations. A summary of the survey operations is provided in Table 1.

Date	Event
24/05/2020 -25/05/2020	Survey checks and multibeam bathymetry and backscatter data acquisition
03/06/2020 – 04/06/2020	Sub-Bottom Profiler data acquisition
05/06/2020	Sub-Bottom Profiler data acquisition completed. ROV survey

Table 1: Key Events

B. EQUIPMENT

B.1 Vessel Specifications

The DEW vessel *Marine Science* was used throughout the survey.

- Length 8.12 m
- Beam 2.84 m
- Draft 0.71 m
- MBES Mounting: Side mounted pole
- IMU Mounting: Side mounted pole, with MBES

Figure 1: Marine Science Vessel

B.2 *Marine Science* Equipment

The following is a list of equipment installed on the DEW vessel *Marine Science:*

- 1 x R2Sonic 2024 Multibeam Echo Sounder
- 1 x Applanix POS MV WaveMaster II
- 1 x Acquisition laptop with Qinsy
- 1 x Comset 4G Modem (receiving RTK corrections over 4G)
- 1 x Valeport SWiFT SVP
- 1 x Valeport miniSVS
- 1 x Innomar SES-2000 compact Sub-Bottom Profiler
- 1 x Blue ROV 2

B.3 RTK Base Station

The Trimble VRS Now RTK service and SA_Port Stanvac Base Station was used with:

- 1 x Leica GR30 GNSS Reference Server

B.4 Office Equipment

The following equipment was used in the onshore processing office:

- 1 x Processing Laptop with AutoClean / Qimera
- 1 x Trimble SPS585 RTK rover (used for survey checks)

B.5 Software

Details of the software and version number in use during the survey are:

- QPS Qinsy — Version 9.2.0
- QPS FMGT — Version 7.9.3
- BeamworX AutoClean — 2020.1.1.0
- Valeport DataLog X2 SVP — Software Version (1.0.4.1259)
- R2Sonic — Build April 2017
- Applanix POSView — Version 10.20
- Trimble Terramodel — Version 10.61M
- SESWIN SBP acquisition software

C. SURVEY AREA

The area of operations was west of Port Stanvac covering approximately 5km^2. The survey area is illustrated in Figure 2.

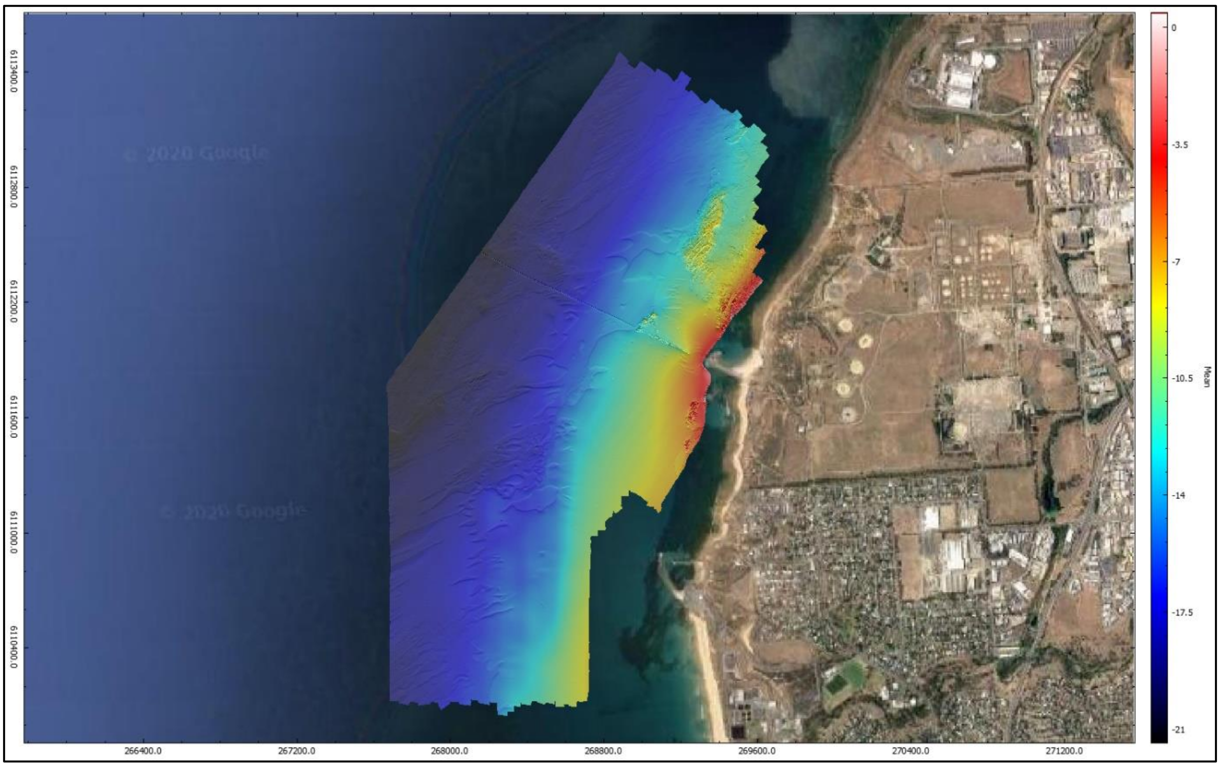


Figure 2: Survey Area June 2020 – Port Stanvac

D. HORIZONTAL DATUM AND CONTROL

The horizontal datum used for this survey is Map Grid of Australia 1994 Zone 54 (MGA94 Zone 54), based on the Geocentric Datum of Australia 1994 (GDA94)[1]. See Table 2 for the details of the MGA94 Zone 54 grid coordinate system.

Parameter	Value
Coordinate System	MGA94 Zone 54
Datum	GDA94
Spheroid	GRS 1980
Projection	Universal Transverse Mercator Zone 54 South
Latitude of Origin	0° N
Longitude of Origin	141° E
False Easting	50,000.000 m
False Northing	10,000,000.000 m
Scale Factor	0.9996

Table 2: MGA94 Zone 54 Parameters

D.1 GNSS Base Station

The Trimble VRS Now service was used to supply Real Time Kinematic (RTK) corrections via the internet using the NTRIP protocol. See Table 3 for a summary of the RTK base station coordinates.

SA_Port Stanvac RTK Base Station	
Latitude (GDA94)	30° 05' 40.95686'S
Longitude (GDA94)	138° 29' 08.56198'E
Easting (MGA94 Z50)	270806.566
Northing (MGA94 Z50)	6113561.541
Height (AHD)	58.506 m
Height (GDA94)	57.812 m

Table 3: RTK Base Station Coordinates

A base station report, certificate of verification of the base reference station, and a leaflet describing the Trimble VRS Now is provided in **Appendix A.**

D.2 Survey Control

Three standard survey marks located near the survey area were used for static position checks; the coordinates of these marks are presented in Table 4, as extracted from Land Services SA.

	6527/1071[5]	6527/7678[6]	6527/8223[7]
Latitude (GDA94)	35.12345247° S	35.12309599° S	35.12435399° S
Longitude (GDA94)	138.47767957° E	138.46951641° E	138.47919703° E
Easting (MGA94 Z54)	270154.936	269409.979	270295.853
Northing (MGA94 Z54)	6110357.506	6110375.169	6110258.005
Height (AHD)	23.407 m	17.091 m	23.208 m

Table 4: Survey Benchmarks Summary

E. VERTICAL DATUM AND CONTROL

Vertical control for the survey was Port Stanvac Lowest Astronomical Tide (LAT) which lies 1.28 m below the Australian Height Datum (AHD) at the 6527/8394 tidal benchmark, as extracted from the Bureau of Meterology[4].

Survey data was reduced to LAT with accurate GNSS heights using the Australian Geoid Model AUSGeoid09 to approximate AHD, combined with the AHD – LAT separation value of -1.28 m throughout the survey area.

F. MOBILISATION

The DEW vessel *Marine Science* was mobilised on 22-23 May 2020 while the vessel was stored in the PHS Adelaide office. The R2Sonic 2024 MBES system, Applanix POS MV motion sensor, and Valeport miniSVS were mounted on a pole over the port side of the vessel. Following the completion of the MBES survey, the R2Sonic 2024 was demobilised and the Innomar SES-2000 SBP was installed onto the same pole.

The lever arms were measured using a tape measure. Table 5 summarises the measured lever arms. For further details, refer to the Mobilisation Report in **Appendix B**.

Vessel Node	X (+ Starboard)	Y (+ Bow)	Z (+ Up)
CRP (IMU Target)	0.000 m	0.000 m	0.000 m
POS MV Primary GPS Antenna phase centre	0.930 m	2.226 m	2.899 m
MBES (Sensor 1)	0.000 m	-0.020 m	-0.430 m
SBP (Sensor 1)	0.000 m	-0.020 m	-0.430 m
RTK Tide Node (updated prior to any checks)	0.000 m	0.000 m	0.340 m

Table 5: Lever Arm Offsets for Marine Science– Standard MBES Bracket

Figure 3: Side Mounted Pole for MBES//IMU/SVS and Survey Desk

G. SURVEY CHECKS AND CALIBRATION

Numerous checks and calibrations were performed to ensure the mobilised equipment was working within specification and that the data acquired would be of an acceptable standard. Below is a summary of each check performed. Full details of the survey checks can be found in the relevant Appendix.

G.1 RTK Benchmark Position Check

Position and height checks were conducted with an independent Trimble GNSS unit on three benchmarks (outlined in Table 4). This check was conducted to confirm the reliability of the GNSS base station RTK corrections and to confirm the correct operation of the Trimble GNSS rover. Each measurement is an average of one-second observations over a minimum of three minutes. See Table 6 below for a summary of the benchmark position checks.

SSM	Date	Eastings Difference (m)	Northing Difference (m)	AHD Elevation Difference (m)
6527/7678	25/05/2020	-0.036	0.003	-0.041
6527/7678	18/06/2020	-0.043	-0.041	-0.035
6527/1071		-0.031	0.008	-0.019
6527/8223		-0.071	-0.010	-0.005

Table 6: Static RTK Position Check on Survey Mark Summary

The RTK benchmark checks above show a good comparison to the established coordinates of the survey marks which confirms the accuracy of the GNSS base station corrections as well as the correct operation of the GNSS rover. Refer to **Appendix C** for the full benchmark check reports.

G.2 GAMS Calibration

A GNSS Azimuth Measurement Subsystem (GAMS) calibration involves a series of figure eight and turning manoeuvres which calculates the baseline between the two POS MV GNSS antennas. Once the baseline between the two antennas is known, the POS MV can then use carrier phase observations to provide an accurate vessel heading rather than a traditional gyro-compass method. This calibration was carried out prior to the start of survey.

Date	X (+ Bow)	Y (+ Starboard)	Z (+ Down)
24/05/20	0.006 m	1.307 m	**-0.005 m**

Table 7: GAMS Parameter Setup

G.3 Heading Check

Prior to survey, a vessel heading check is conducted to assess the alignment of the heading sensor and the vessel reference frame, and to check for gross heading observation errors. This is done by measuring a bow and stern position multiple times using the independent GNSS rover, computing the true bearing between these positions, and then comparing this true bearing against the POS MV observed true heading. The results are summarised in Table 8 below.

Date	RTK derived True Bearing	POS MV True Heading	Difference
24/05/20	128.20°	128.89°	**-0.69°**
25/05/20	89.04°	88.86°	**0.18°**

Table 8: Heading Check Summary

The heading check on 24 May was conducted while the vessel was alongside, so there was some movement which has affected the resulting heading difference. The heading check was repeated on 25 May while the vessel was on the trailer, with a more precise result. The independent GNSS rover derived heading compared well against the POS MV derived heading, therefore no correction was entered into the POS MV system. For further details refer to the heading check report in **Appendix D.**

G.4 Vessel Position Check

Once the correct operation of the independent GNSS rover had been verified and the reliability of the base station confirmed (Section G.1), the unit was then transferred to the vessel and used to perform a comparison against the on-board POS MV positioning system. This was conducted by logging the position of a common node directly over the transducer head on the vessel simultaneously between the rover and the vessel positioning system through the acquisition software. Both systems were logging observations for a period of five minutes and the positions throughout this logging period were then compared.

See Table 9 for a summary of the results.

Date	Eastings Difference (m)	Northing Difference (m)	AHD Elevation Difference (m)
25/05/20	-0.008	-0.009	-0.002

Table 9: Vessel Position Check – Top of Pole

The above results indicate that the independent GNSS compared well with the POS MV derived position. For further details, refer to the vessel position check reports within **Appendix E**.

G.5 RTK Tide Checks

Throughout the survey, the vertical separation between the draft reference mark and the water line was measured in order to generate a virtual RTK Tide node in Qinsy (water line elevation). When the sea conditions were suitable, the value of the RTK derived tide value (RTK Tide node elevation with reference to LAT) was compared to the tide gauge located at Outer Harbor. A summary of the RTK tide check results are presented in Table 10.

Tide Gauge Used	Number of Comparisons	Average Difference (m)	*Standard Deviation (m)*
Outer Harbor Tug Pen	11	0.011	*0.036*

Table 10: RTK Tide Check Summary

G.6 Multibeam Patch Test

A multibeam patch test is conducted to determine the angular offsets between the alignment of the MBES transducer with the POS MV coordinate frame. The test consists of surveying a series of parallel lines over a clear seabed feature or slope and uses Qinsy to calculate the angular offsets. A patch test can also be used to calculate any latency in the positioning system on the vessel, however on occasions where a pulse-per-second (PPS) time pulse is used such as this, it is deemed unnecessary as the remaining latency is negligible.

The results of these patch tests are presented in Table 11.

Offset	24/05/20
Roll	-1.44°
Pitch	2.100°
Yaw/Heading	2.800°

Table 11: Patch Test Results

See **Appendix F** for the full patch test report.

G.7 Bar Check

A bar check is conducted to ensure the correct operation of the echo sounder, as well as a check on the vertical lever arms measured during mobilisation. By using RTK positioning to reduce soundings to datum in real-time, a bar check also provides an opportunity to check that known depths are being reduced to LAT correctly.
Each value in the below tables validate the following aspects of the acquisition system:

- Difference in raw depth measurement – validates the correct range measurement of the echo sounder and the draft of the echo sounder.
- Difference in sounding reduction – validates the GNSS data reduction to the sounding datum using nearby tide gauge data as the source of datum.
- Difference in water level reduction – validates the draft measurement against the tide gauge data, plus the height reduction of the vessel.

A bar check was conducted at the start of the survey. The results of the bar check are presented in the table below.

Bar Depth	3.23 m
Difference in Raw Depth Measurement	0.080 m
Difference in Sounding Reduction	-0.050 m
Difference in RTK Tide	-0.010 m

Table 12: Bar Check Summary 25/05/2020

The weather conditions at the survey location did not permit a standard bar check to be conducted due to excessive vessel movement, and as there was no tide gauge in close proximity to this location so predicted tides were used. The bar check was conducted while the vessel was alongside as this was the most stable location, however the water depth did not exceed 3.3 m. A tape measure was used to measure the depth to the sea floor, and this was compared against the MBES.

The results above compared well and are within the survey project tolerances. The results indicate the correct operation of the echo sounder as well as validating the sounding reduction methodology. For the full bar check report, refer to **Appendix G.**

H. ACQUISITION

H.1 Multibeam Bathymetry

Multibeam bathymetry data acquisition commenced on 24 May 2020 and was completed the next day using an R2Sonic 2024.

The MBES lines were planned to achieve 100% coverage. Cross lines were also conducted as a check, as were additional lines where further information was required (i.e. over a particular seabed feature).

During the survey, the quality of the data was continually monitored through Qinsy to ensure the acquired data met the survey specifications:

- The POS MV positioning accuracy was monitored, and where RTK dropouts occurred the survey line was re-run with RTK.
- The 95% confidence level grid function (2 x standard deviations) was continually monitored to ensure all logged data met the required specifications (at 95% confidence not to exceed 0.1 m vertical).
- Sound velocity profiles were collected for every change of location or when the SVS / SVP comparison was greater than 2 m/s to correct the data from the ray bending effect caused by salinity and temperature stratification/changes across the water column.
- The MBES data was monitored online to ensure 100% coverage, and where any gaps occurred additional lines were run.

The following multibeam settings were used throughout the project:

- Frequency 400 kHz
- Pulse length 15 µs
- Maximum angular coverage 100°
- Bottom Sampling Equidistant norm (256 beams per ping)

H.2 Multibeam Backscatter

During the MBES survey, the intensity of acoustic energy was observed. As different seabed types scatter the acoustic energy differently, this information can be used to determine the seafloor's physical properties, namely acoustic impedance, roughness (grain-size and small-scale topography) and volume inhomogeneity (variability in the thin layer of sediment penetrated by the acoustic signal). For example, a softer seabed such as mud will return a weaker signal than a harder seabed such as rock.

For this project, multibeam backscatter data was collected using an R2Sonic 2024 MBES system in Beam Time Series (BTS) also called ‘Snippets’ format. Snippets provides the amplitude of the signals that reflect off the seafloor, centred around the bottom detect point, to create a footprint time series.

H.3 Sediment Sampling

Eight sediment sampling sites were determined using the backscatter data. The samples were taken using a sample grab and analysed in situ by a Marine Geologist. Each sample site was paired with a video drop.

H.4 Video Drops

Seventeen video drops were collected, eight centred on the sediment sampling sites, and nine to observe various features on the site, and to help ground truth the backscatter data. Two cameras were used, one providing an image stamped with location coordinates, and another providing a high-resolution image. The positioning provided for the video drops was from the side pole mounted IMU. The camera was lowered into the water and once close to the sea floor, dragged along as the vessel was drifting.

H.5 Sub-Bottom Profiling

Acoustic Imaging assisted with the online setup of the sub-bottom profiler data. The following information is extracted from their report, attached within Appendix I.

The SBP data was acquired with an Innomar SES-2000 compact parametric sub-bottom profiler system pole-mounted on the Department for Environment and Water survey vessel. A set of 26 primary lines were run parallel to the coast and approximately 77 cross lines were surveyed perpendicular to the coast. All lines were spaced at 50 m.

All data were acquired using an 8 kHz secondary frequency with 2 pulse cycles resulting in a pulse length of ~250 µsec. Reflector resolution in this case is around 35 cm. These settings were selected based on trial lines run parallel and perpendicular to the coast before the commencement of main survey activities.

Data supplied for this report consisted of full waveform .RAW files.

Parameter	Settings for bedload thickness survey
Primary source level	> 236 dB re 1µPa @ 1 m
Secondary source level	> 200 dB re 1µPa @ 1 m
Primary centre frequency	100 kHz
Secondary frequency	8 kHz @ 2 pulse cycles
Beam angle	2.0° @ -3 dB
Transmitter pulse length	250 µsec
Recording range	20-22 m
Sampling interval	126 µs
Ping rate approx.	20 Hz

Table 13: Acquisition Parameters for SES-2000 Compact System

I. PROCESSING

I.1 Multibeam Processing

Processing of multibeam bathymetry data was conducted using BeamworX AutoClean data processing software. Four separate processes were conducted on the data to obtain a high degree of data quality and to ensure that objects were not missed or deleted.

I.1.1 95% Confidence Assessment

The 95% confidence from the data was analysed as an overall check on the quality of the data and particularly the quality of the GNSS heighting. Any areas that fell outside the 0.1m threshold for the 95% standard deviation were analysed, corrected or removed if necessary.

I.1.2 Data filtering

Experienced surveyors analysed the data in detail and removed erroneous data manually using the BeamworX AutoClean processing software.

I.1.3 Spot Soundings

Spot soundings were used to ensure the exact shallowest depth of any small object was retained and not affected by the statistical surface creation process detailed below in Section I.1.4. These spot soundings were manually selected by the CPHS1 Hydrographic Surveyor and carried through to the final products.

I.1.4 Surface Generation

The final ASCII XYZ data sets were created as per the below processes:

1. **Spot soundings**
   Manually selected as per Section I.1.3.
2. **Processed gridded files 1m mean depth**
   All soundings within a 1m bin size are averaged to create one sounding per 1m bin.
3. **Processed 1.0m shallowest depth binned (Final deliverable)**
   The 1m mean surfaces were imported into a 1x1m "grid". The spot soundings created in Section I.1.3 were then combined with this file. Finally, the shallowest depth within each 1m bin was then exported in its exact horizontal position for charting and ASCII delivery purposes.

I.1.5 Quality Control

The data was checked by an AHSCP Level 1 certified Hydrographic Surveyor to ensure all processes had been carried out correctly and the seabed had been properly and accurately represented.

I.2 Multibeam Backscatter Processing

Multibeam backscatter (intensity of seafloor return) was processed in QPS Fledermaus Geocoder Toolbox (FMGT). This initially required all bathymetric datasets to be converted to QPD format in Qimera and then processed with the logged backscatter (Qinsy db) in FMGT.

The production of the backscatter mosaic is a largely automated process that applies the following corrections:

- Angle Varying Gain (AVG)
- Line blending
- Nadir weighting
- Backscatter dB offset for individual lines (if required)

Once the backscatter data was processed a 2D representation of the ocean floor was created, called a backscatter mosaic. The resulting dataset is an Easting, Northing, Intensity (in dB relative to the source power) in both GeoTIFF and ASCII format.

I.3 Sub-Bottom Profiling

Acoustic Imaging was subcontracted to conduct the processing of the sub-bottom profiler data. The below information is extracted from their report, attached within Appendix I.

Data was analysed with both the Innomar ISE software and Chesapeake SonarWiz software. The RAW files were first converted to SEG-Y format and then imported to SonarWiz. The SBP data was enhanced through application of an Automatic Gain Control (AGC) algorithm and noise-reduction filters.

Interpretation techniques included automated picking of the seabed reflector and manual picking of the reflector marking the base of the primary Sand unit lying above a Calcarenite unit observed in the 2008 core data.

Core data results as shown in the document "ADP SV300 321 logs 2008.doc" were extrapolated from their listed GDA94 location to the nearest SBP line within SonarWiz (unfortunately these core locations were not incorporated into the line plan and hence no lines were run directly over them). The table below shows all the cores that are located within the 2020 survey area and their associated SEG-Y files.

SA Water Core Id	SBP Profile	Offset (m)	Core Direction
VC12	05062020_150042	16	SW
VC16	03062020_130151	9	NW
VC19	03062020_095602	3	NW
VC20	03062020_151947	12	NW
VC21	05062020_134451	8	NE

Table 14: Desalination Plant Cores and Associated 2020 SBP Lines

The consistency/brightness of the Sand/Calcarenite reflector varied across the survey area, largely due to the amount of overburden at any given location and other reflector horizons within the sediment column. Examples are shown in the Interpretation Section J.3

A 1500 m/sec sound velocity was used for initial display of profiles in SonarWiz (conversion of the two-way time associated with the SBP trace data to a metric measurement) and calculation of Sand unit thickness. These values were then scaled up using the velocity assigned to the 2008 seismic survey conducted for the SA Water Desalination Plant project (1750 m/sec) for consistency.

J. RESULTS

J.1 Multibeam Bathymetry Results

An extract of the MBES bathymetry data is presented below in Figure 4. This data is also presented on the accompanying bathymetry chart; details listed in Section L.1.

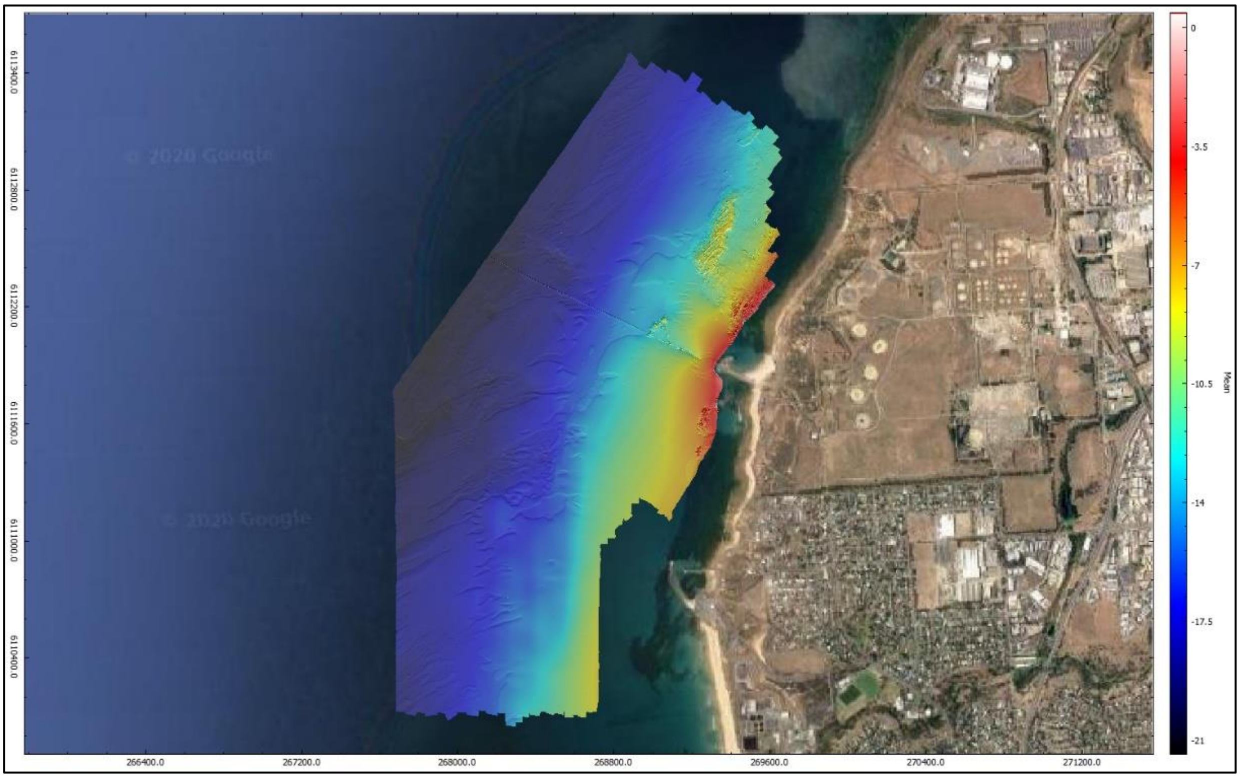


Figure 4: MBES Survey Coverage June 2020 – Port Stanvac

The following images show some point cloud data of areas of interest that were captured during the MBES survey.

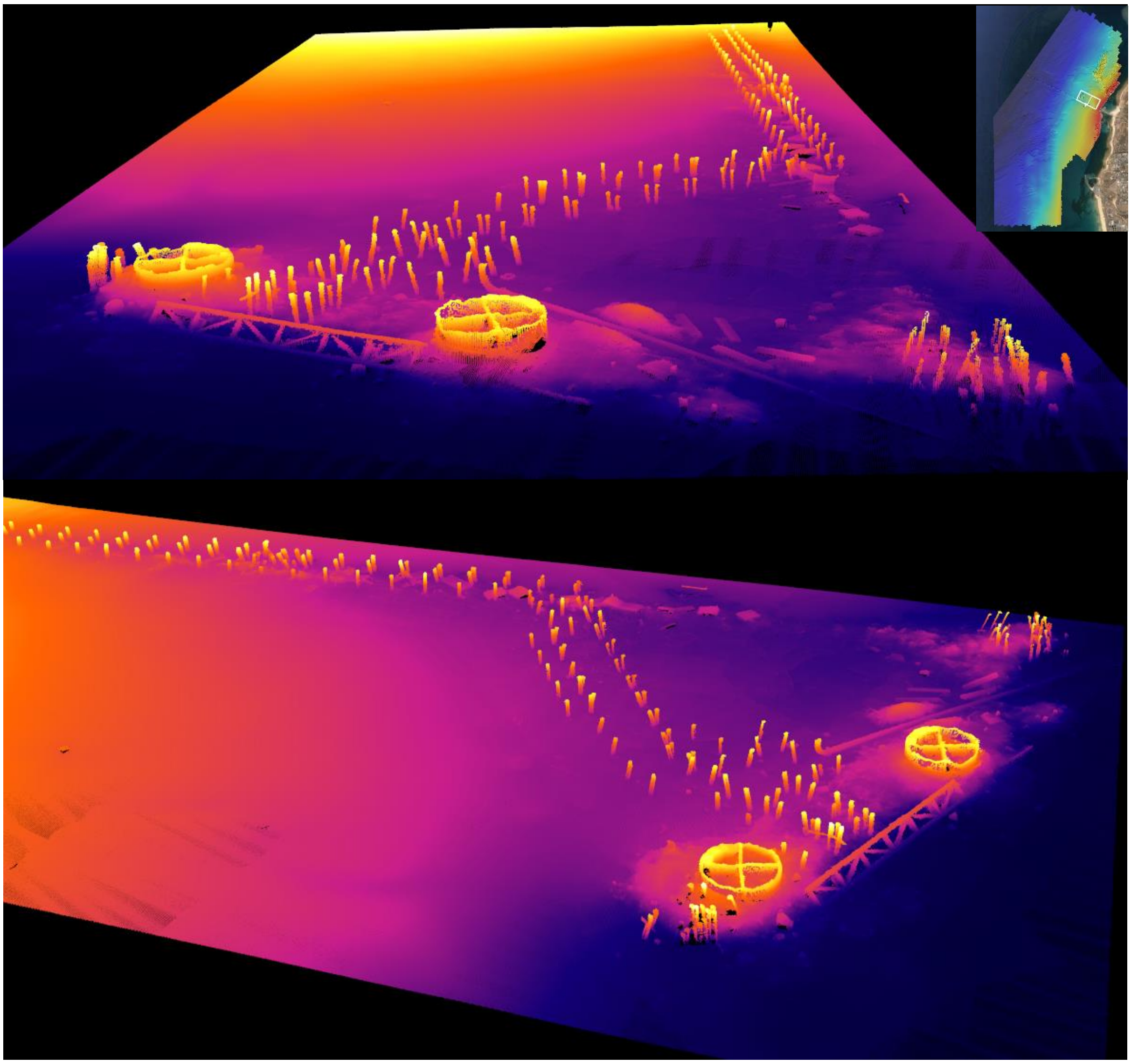


Figure 5: Defunct Jetty with Cut-Off Piles and Debris

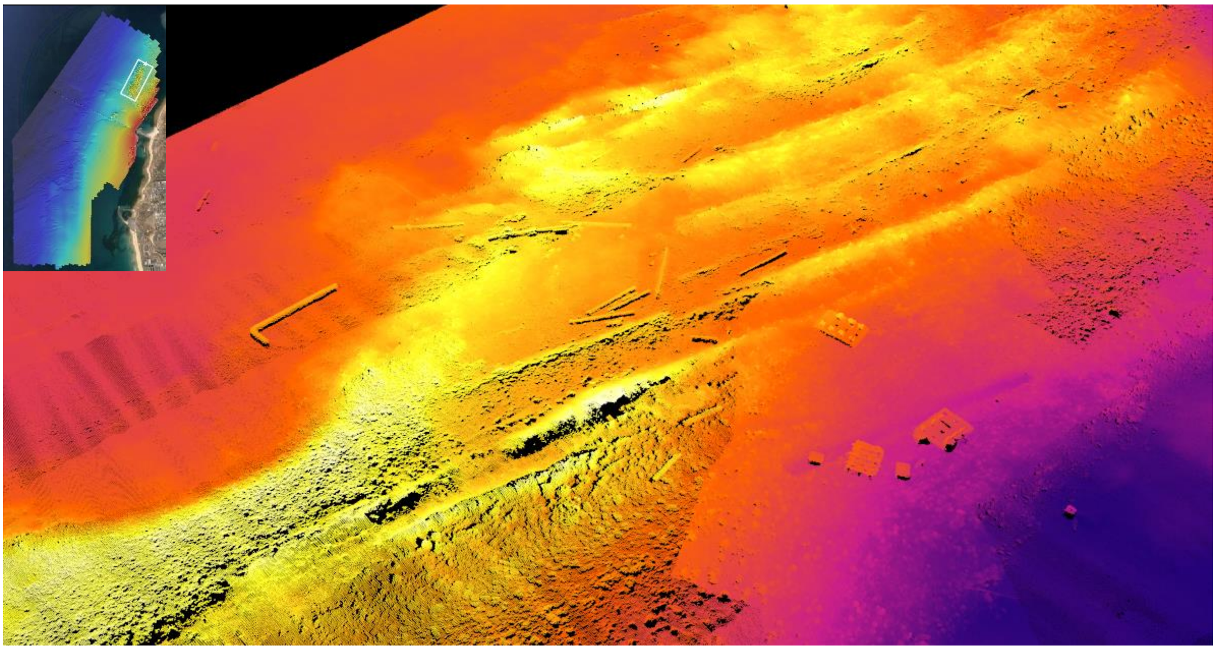


Figure 6: Reef and Various Debris

J.2 Multibeam Backscatter Results

An extract of the MBES backscatter data is presented below in Figure 7 This data is also presented on the accompanying backscatter chart; details listed in Section L.1.

Figure 7: MBES Backscatter Mosaic - June 2020 - Port Stanvac

The dark areas represent a strong backscatter / low signal absorption. The light areas represent a low backscatter / high signal absorption. For the backscatter data, observations include:

- Pronounced regions of high and low backscatter intensities (whereby lower backscatter areas are denoted by whiter pixels and higher backscatter regions are marked by dark grey or black pixels).
- Darker regions mostly confined to seabed depressions or regions of local erosion across the bulk of the survey area.
- Reef/rock areas adopt a dark grey tone with additional finer scale structure apparent in the imagery.

J.3 Sub-Bottom Profiler Results

Acoustic Imaging was subcontracted to conduct the processing of the sub-bottom profiler data. The below results are extracted from their report; attached within Appendix I.

J.3.1 Overview

Gridded bathymetry and backscatter data were provided to assist with the SBP interpretation. General observations from the bathymetry data include:

- Clear outcrops of rock/reef material existing in the north east corner of the survey area.
- The Desalination Plant outfall pipe and Transfer Station appear across the central
- section of the area.
- Isolated patches of higher rugosity seabed exist north of the outfall pipe and across the southern half of the survey area suggesting coarser, more cemented sediments in these regions.

The SBP interpretation proceeded by first loading in the 2008 SA Water Desalination Plant Project core results on to the closest associated SBP survey line as listed in Table 14. Cores VC19, VC20, and VC21 proved to be the most useful for identifying the reflector associated with the primary Sand unit overlying a Calcarenite “base” unit

(Figure 9). The other available cores located across the 2020 survey area highlighted the complexity of stratigraphic units existing across this area (e.g. the Clay and mixed Clay/Silt/Sand units in VC16 representing Holocene coastal lagoon and estuarine sediments). The interpretation in this report limited the scope to identifying the primary sand unit thickness. Much more work can be done on mapping the internal reflectors to the Sand unit once additional core data is available.

Next, the reflector marking the Sand/Calcarenite boundary at the key core locations was traced as far as possible along each of the nominated SBP lines shown in Table 14. The reflector was then traced along the nearest cross lines before finally extending the interpretation across the entire surveyed region.

Cross ties between lines were computed in SonarWiz and used to display where the interpreted reflector appeared on any new lines. Modifications were made as the interpretation/analysis proceeded because the Sand/Calcarenite reflector appeared and disappeared across different parts of the survey area.

Data examples comparing the location of the 2008 SA Water Desalination Plant relative to backscatter mosaic are presented in Figure 8 and Figure 9.

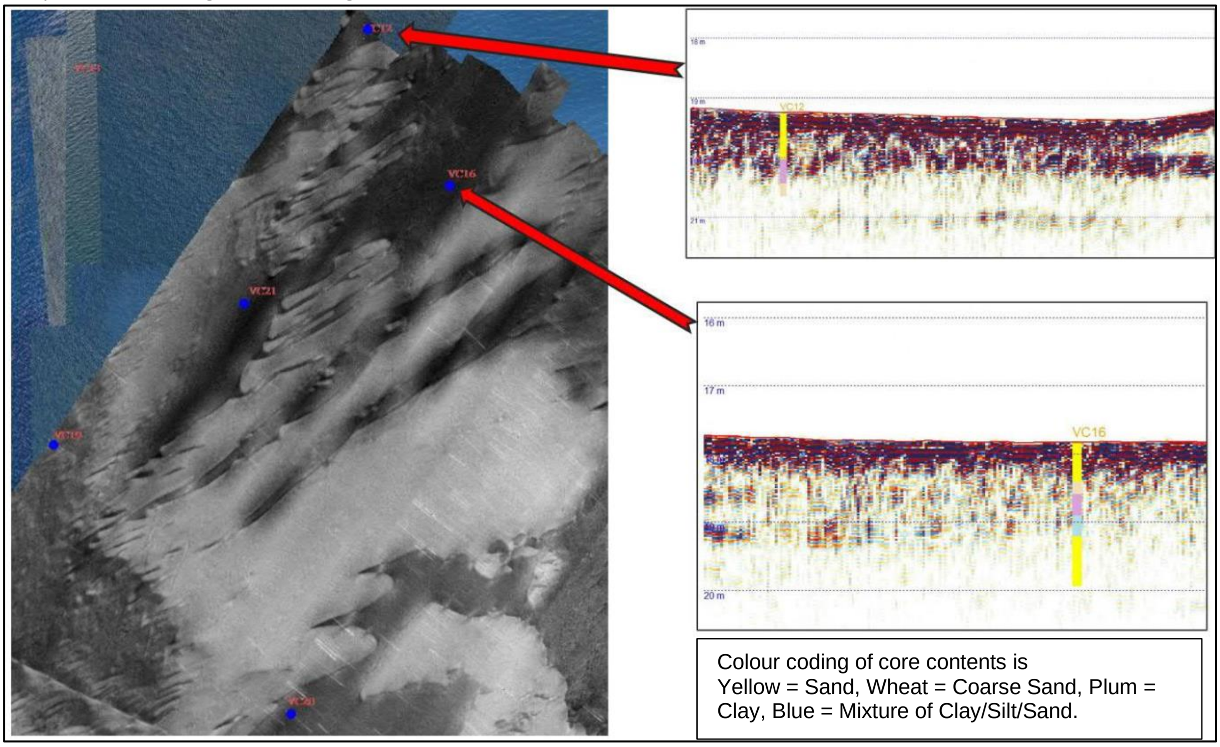


Figure 8: Cores VC12 (top) and VC16 (bottom) relative to backscatter mosaic.

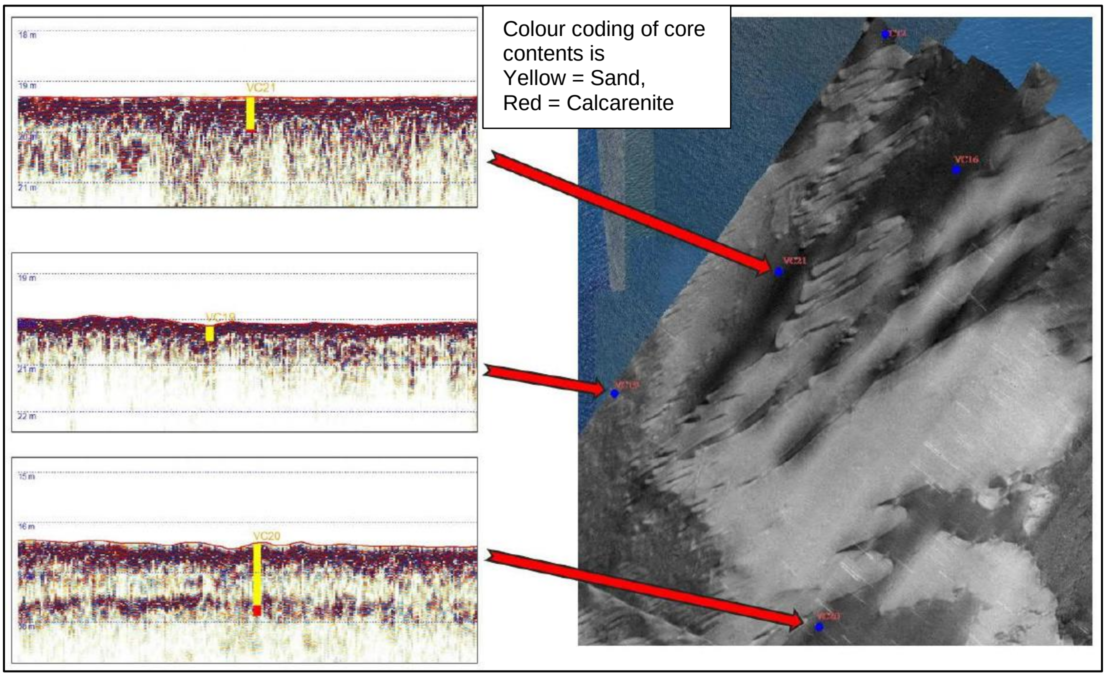


Figure 9: Cores VC21 (top), VC19 (middle), and VC20 (bottom) relative to backscatter mosaic

A perspective view of two SBP lines crossing near the location of core VC20 is presented in Figure 10, the Sand/Calcarenite boundary reflector is highlighted by yellow arrows.

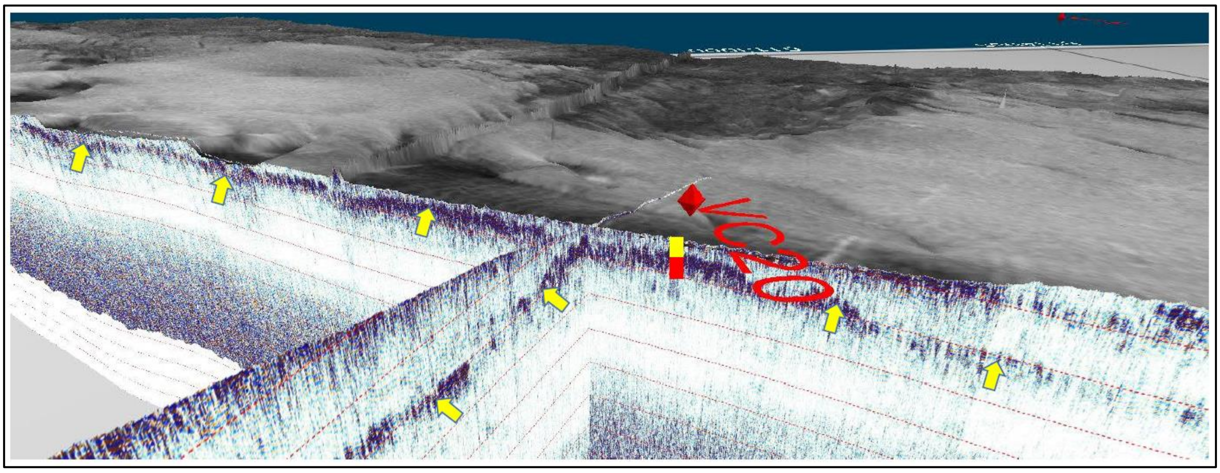


Figure 10: Perspective view of two SBP lines crossing near the location of core VC20.

J.3.2 Primary Sand Unit

Figure 11 provides an overview of the primary Sand unit thickness across the survey area. The colour palette applied was somewhat arbitrary because no critical thicknesses were defined in advance of this analysis. In essence, thinner Sand areas are denoted by red/yellow colours and thicker Sand sections are shown as green/blue. Thinner Sand sections exist across the north east corner of the survey area where reef/rock outcrops occur, across a section in the centre where a rough topography and a seabed lineation suggest fault may lie, and in the south where localised cementation may occur.

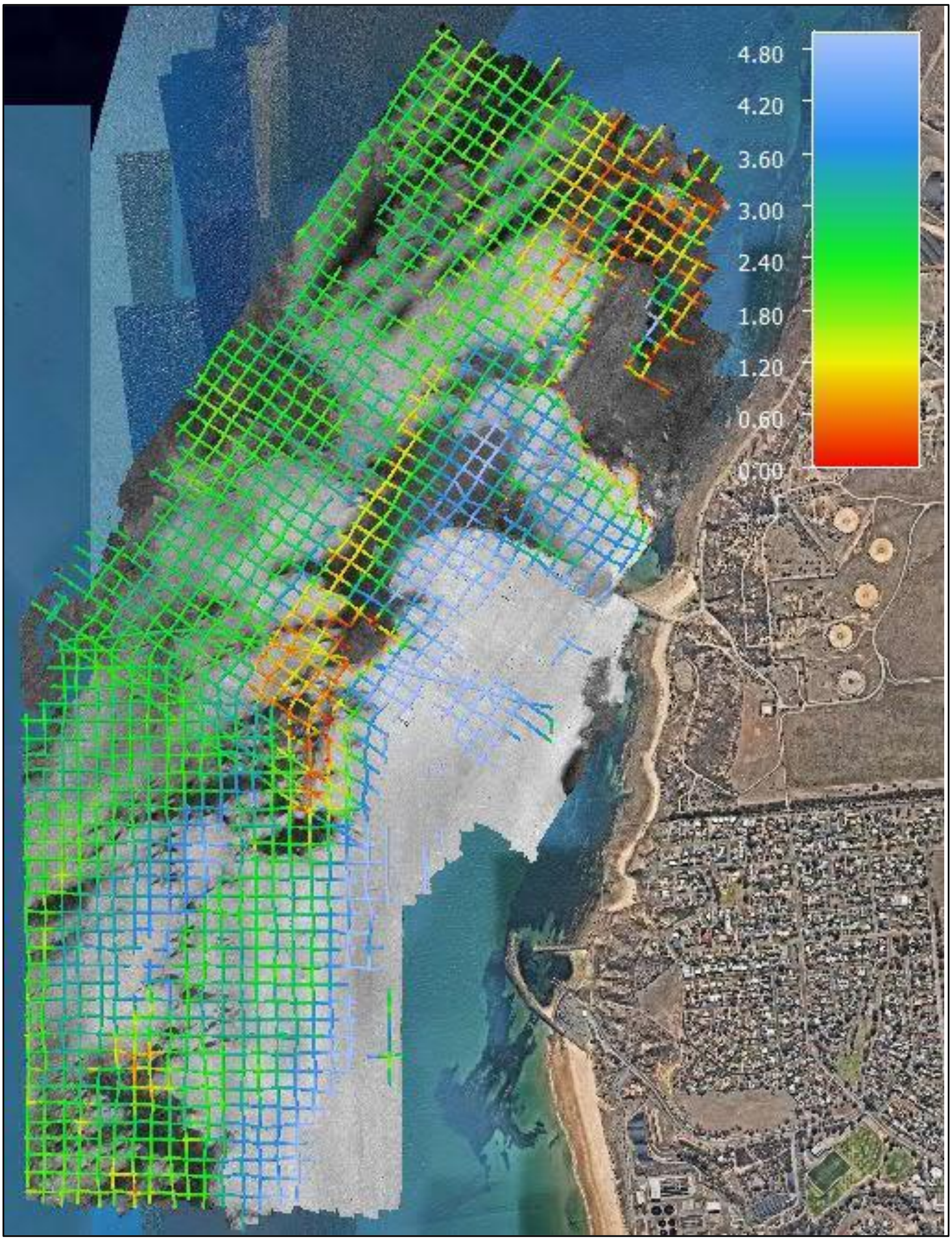


Figure 11: Overview of Primary Sand unit thickness

In the north east corner the tilted basement reflectors are clearly visible in the SBP data. A thin secondary sediment unit overlies the primary Sand unit in Figure 12. A similar unit appears along the entire coastal section but was not mapped in detail as part of this report as its importance for Sand assessment was unknown (and beyond the scope of contracted work). In this case the Sand-Calcarenite reflector represents the exposed basement section. Farther south along the coast the reflector dips beneath the overlying sediments and can only be traced a certain distance landward along the SBP transect.
Biogenic growth on top of the reef/rock outcrop was apparent in the SBP but was not mapped in detail as part of this report.

Figure 12 presents a SBP transect across an exposed reef/rock outcrop, along with sand thickness around this region. Green arrows mark a thin sediment unit overlying the primary Sand unit.

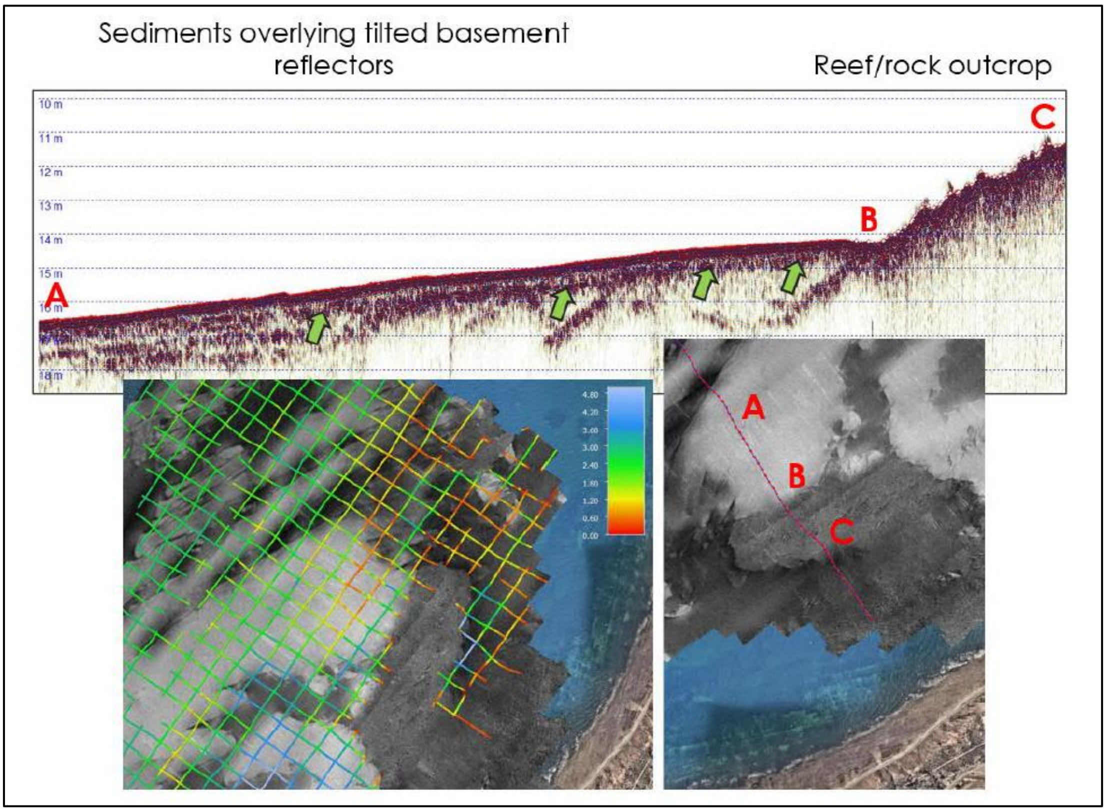


Figure 12: SBP Transects across exposed reef/rock outcrop

Another area where the Calcarenite unit appears to be exposed lies in the central section of the survey area, approximately 400m to the south west of the outfall pipe. Figure 13 presents the local exposure of Calcarenite unit. Yellow arrows mark the Sand/Calcarenite boundary reflector whereas green arrows mark the base of a surface unit lying on top of the primary sand unit. Red arrows in lower left figure show possible fault scars visible in the bathymetry data.

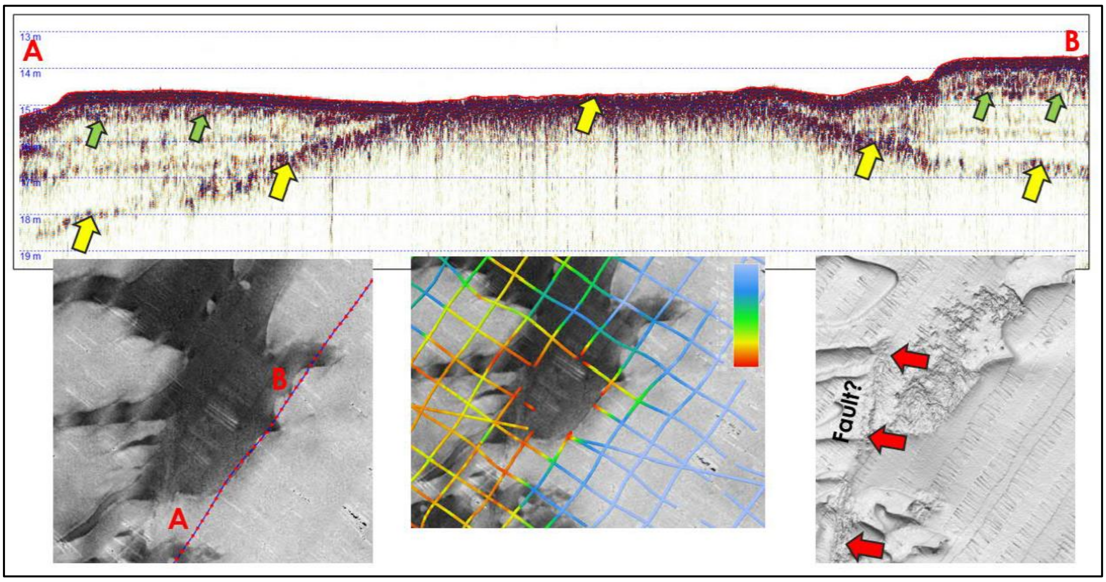


Figure 13: Local exposure of Calcarenite Unit

Areas which exhibit low and high backscatter seabed generally show good acoustic penetration within the low backscatter sections with some degree of internal bedding. The high backscatter sections are more acoustically homogenous and provide less penetration (and hence more difficult to trace the primary Sand/Calcarenite reflector). Figure 14 below is a representative example.

Figure 14 presents a typical seismic stratigraphic structure of areas transitioning from low backscatter seafloor to high backscatter seafloor. Yellow arrows mark the Sand/Calcarenite boundary reflector whereas green arrows mark the base of a surface unit lying on top of the primary sand unit.

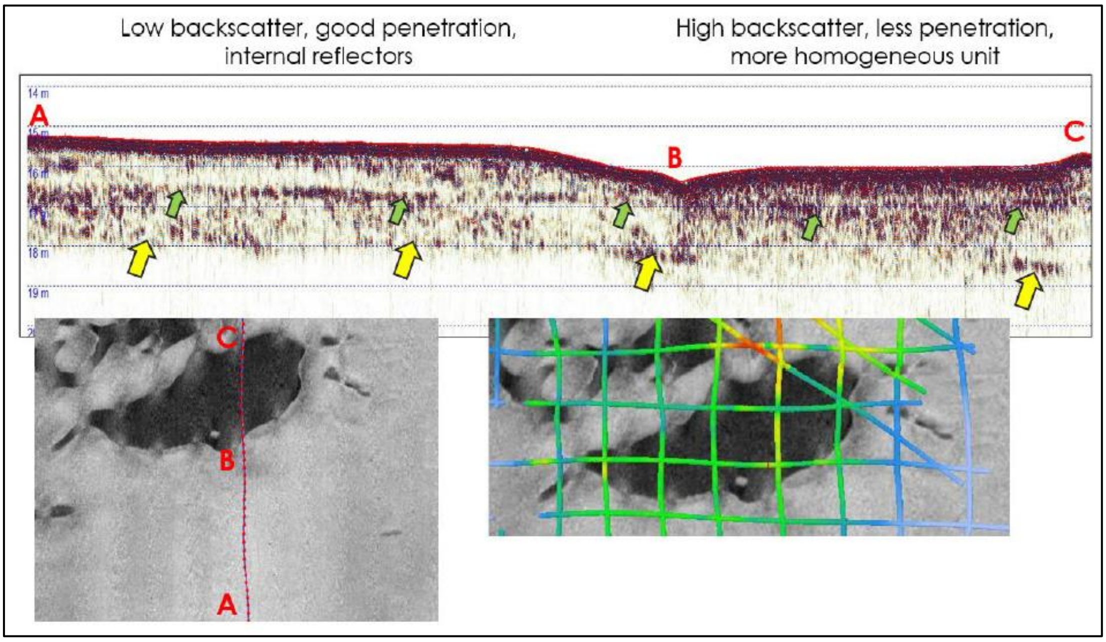


Figure 14: Typical seismic stratigraphic structure transitioning from low to high backscatter seafloor

This pattern holds for the southern section of the survey as well; see Figure 15 for a transitional area in the southern half of 2020 survey block. Yellow arrows mark the Sand/Calcarenite boundary reflector.

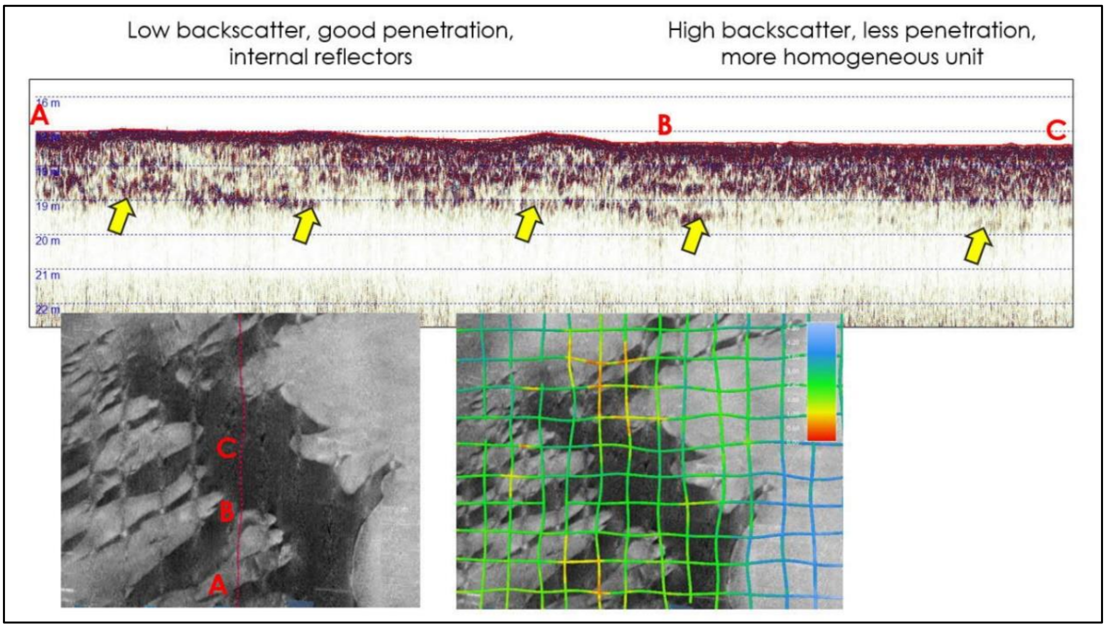


Figure 15: Transitional area in Southern Half of Survey Area

As noted previously the analysis for this report was limited to the interpreted primary Sand unit lying above a presumed Calcarenite unit. However, a number of subunits exist within the primary Sand unit as shown in Figure 16. Yellow arrows mark the Sand/Calcarenite boundary reflector, blue and green arrows mark horizons and subunits within the primary Sand unit. The reflectors defining these units are generally not continuous across the entire site and may represent local Clay horizons or areas of cementation or deposits of coarser material.

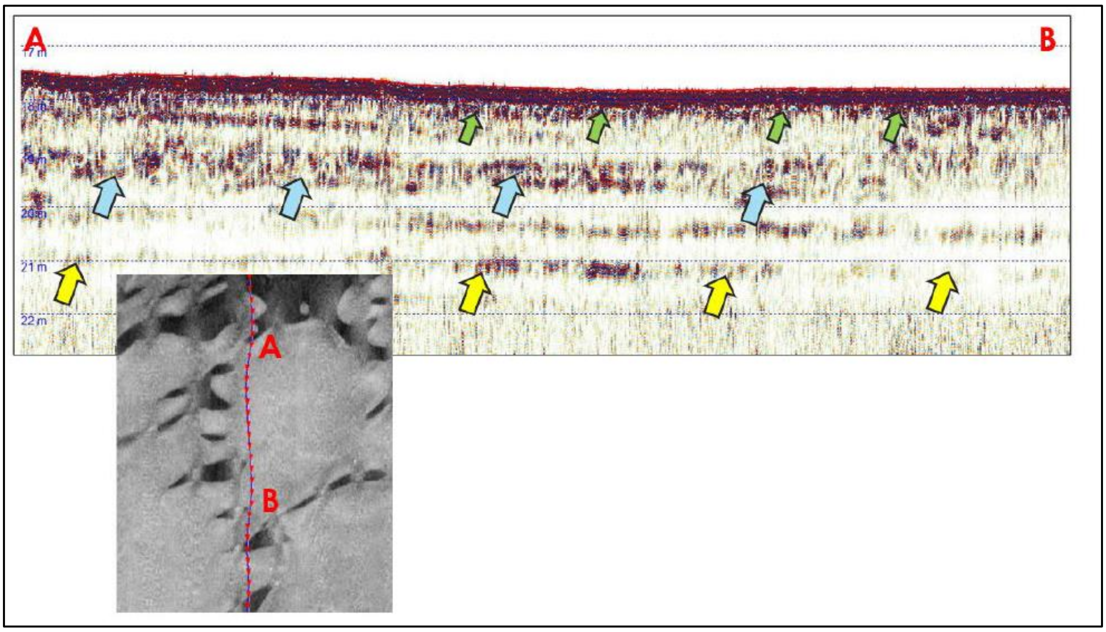


Figure 16: Examples of stratification within a section of low backscatter seabed

The current interpretation will no doubt undergo modification once more core data becomes available, especially across the southern half of the survey block. The table below provides recommendations for core locations to assist in understanding the stratigraphy shown in the SBP data. These may or may not be best suited for sand dredging objectives and hence are only suggestions.

Easting (MGA94 Z50)	Northing. (MGA94 Z50)	Objective
268182.59	6112130.08	Multiple reflectors, seaward extent
268560.58	6111618.11	Fault Zone
268489.78	6111149.65	High Backscatter area
268142.15	6111055.12	Subunit definition
267991.74	6110452.21	Transition zone; southern extent of

Table 15: Recommended Core Locations

J.3.3 Sand Volume Calculation

The following image shows sand thickness derived from SBP data. It should be noted that there are “gaps” in the SBP data where reliable reflectors were unable to be extracted from the data due to density of sediment and or depth of sand layer. A certain amount of extrapolation has been used across these areas where it was considered appropriate to calculate volumes of sand. Acoustic Imaging have suggested these areas would benefit from core samples to better understand the sediment in the area.

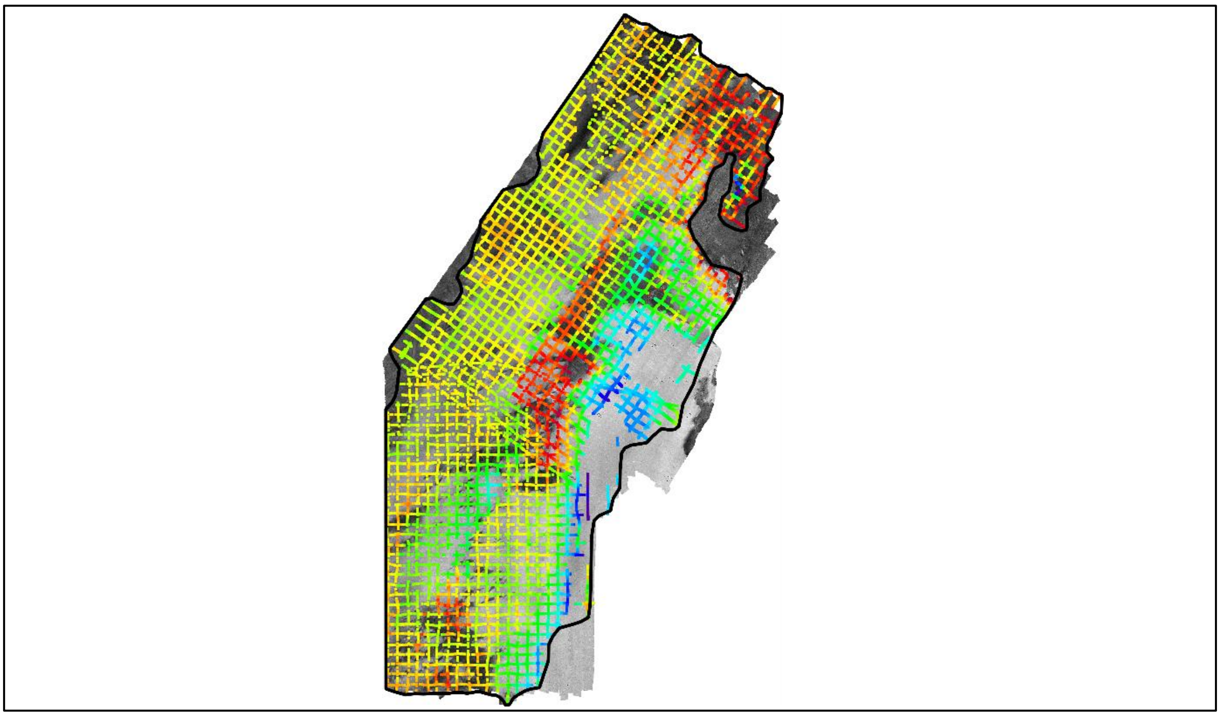


Figure 17: Area Boundary used for the Sand Volume Calculation

Volume of sand has been calculated from the SBP data and is the total of sand in the area. Volumes of sand in specific areas can be calculated if required. Below is the sand volume calculation result.

Fill Volume (m3)	Sand Surface Area (m2)
10 540 161	3 758 363

Table 16: Sand Volume Calculation Result

J.3.4 Summary

The SBP data collected as part of the June 2020 Port Stanvac survey provides some interesting insights to seabed features and sediment units across this region, complimenting the previous work done to the north of the site. The SBP data acquired were of very good quality, as resolution and vertical penetration were sufficient for addressing survey objectives. The SES-2000 system should not be viewed as a replacement for Boomer or Sparker type seismic surveys as those systems provide much greater penetration (usually) but at a much lower resolution. The SES-2000 parametric systems are designed to provide detailed information on the uppermost sediment column which in the case of sand type deposits is generally 4-8 metres.

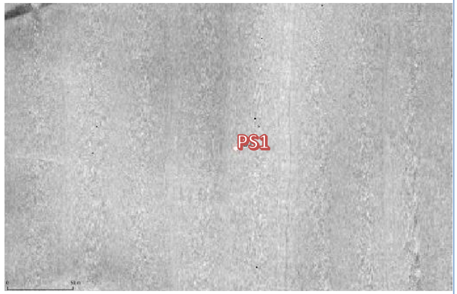
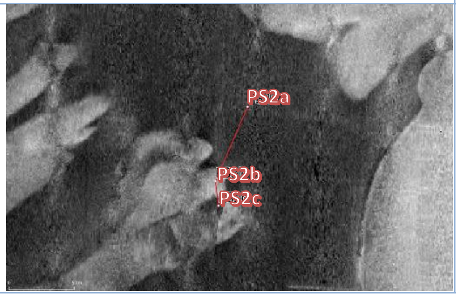
The primary sediment unit mapped as part of this interpretation was a Sand unit lying above a presumed Calcarenite unit (as determined from existing 2008 SA Water Desalination Plant core data). The reflector marking the boundary between these two units was traced as best as possible across the 2020 survey area, with the thickness derived using a sediment velocity of 1750 m/sec. The primary Sand unit thins and thickens across the site with a prominent outcrop of basement occurring in the north east corner of the survey block and a smaller area towards the centre of the block.

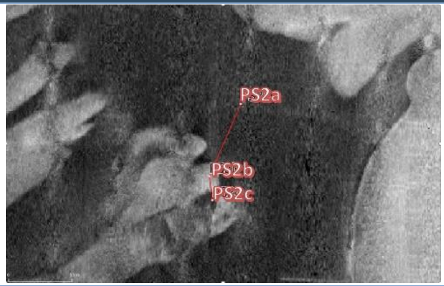
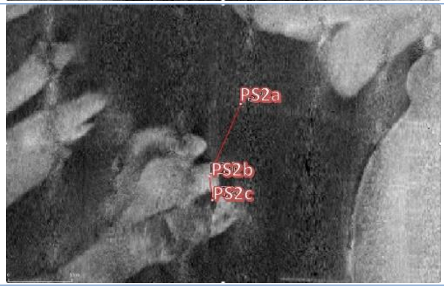
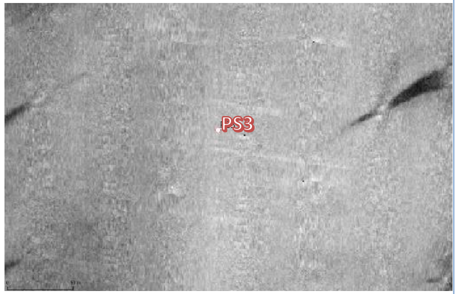
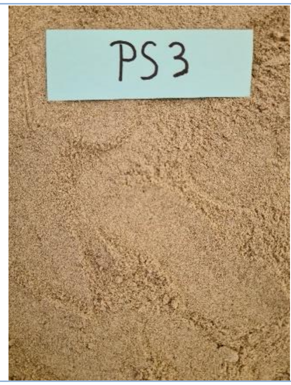
High backscatter areas of the seabed correspond to more homogeneous units in the SBP data and generally less acoustic penetration. Low backscatter areas show greater acoustic penetration and more internal layering of the primary Sand unit.

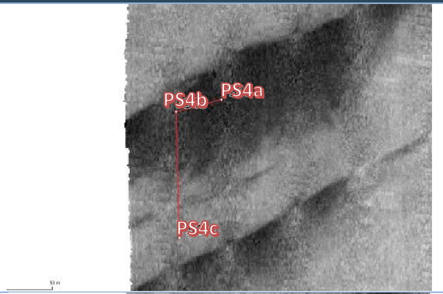
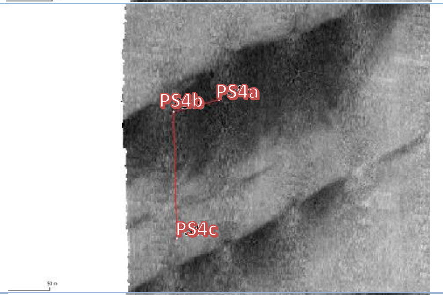
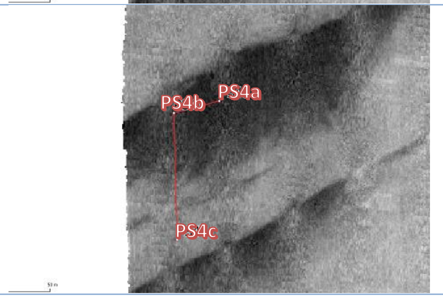
The reflector bounding the Sand unit varied in continuity and acoustic strength, and in some areas included internal reflectors. The internal reflectors mark a variety of different features including coastal lagoon/estuary facies, localised coarse sediment deposits or cementation horizons, and more mobile surficial sediments. A more detailed interpretation and possible modification of the current interpretation could be conducted after the next phase of coring if the information assists in site management.

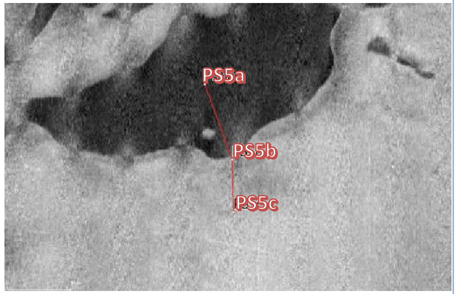
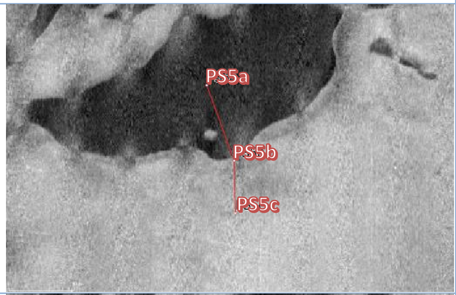
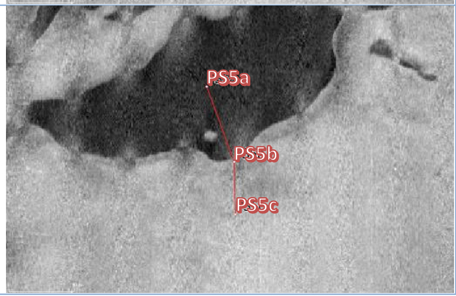
J.4 Sediment Sampling, Video Drop, and Backscatter Comparison

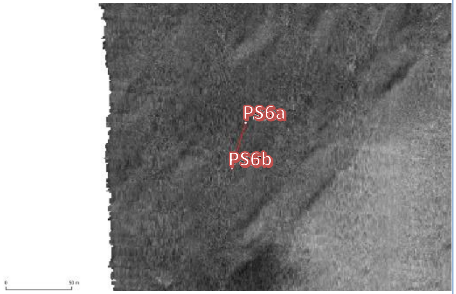
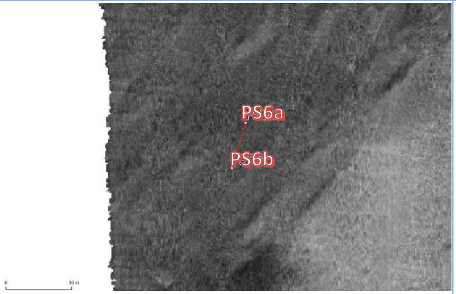
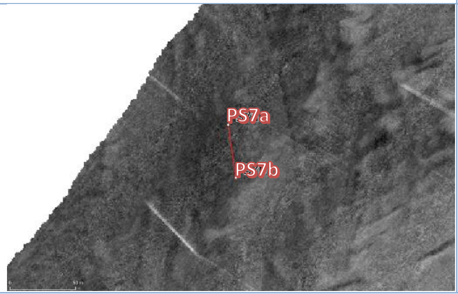
Eight sediment samples and 17 video drops were conducted. Below is a comparison showing a description of the sediment samples, backscatter mosaic, and photographs extracted from the video drops. David Miller from the Department for Environment and Water prepared the site descriptions photograph extracts.

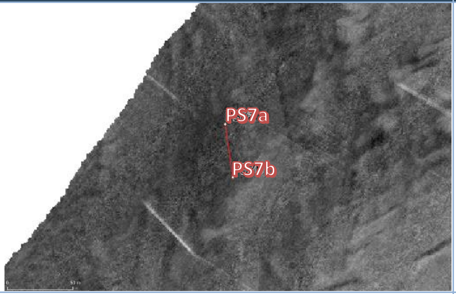
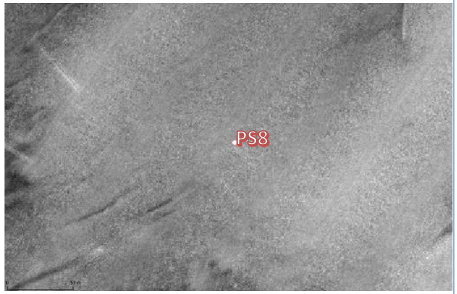
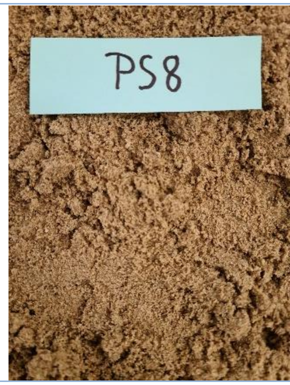
Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS1	Sediment: Fine Catami bedforms/biota: Two dimensional ripples Comment: 3 2D: Ripples (<10cm height) -CAAB 82002003 The two-dimensional features are low (<10 cm height)				E 268461 N 6110498
PS2a	Sediment: Coarse (shell hash in troughs) Catami bedforms/biota: three dimensional waves			No Sample	E 268119 N 6110283

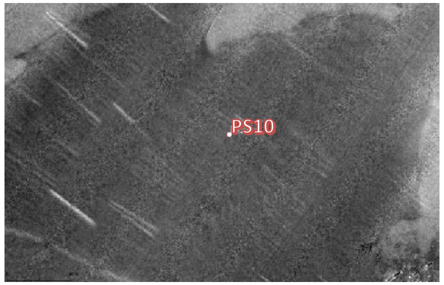
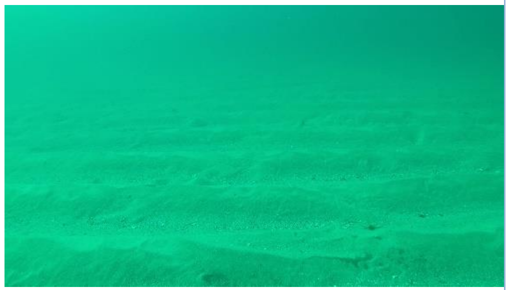
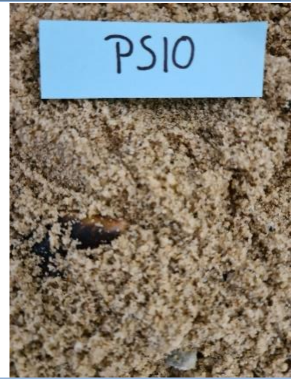
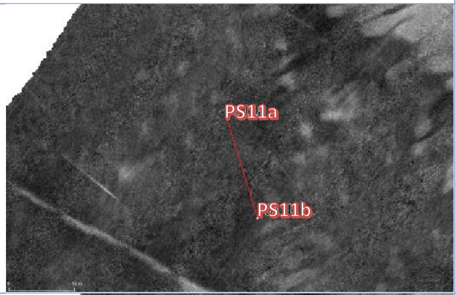
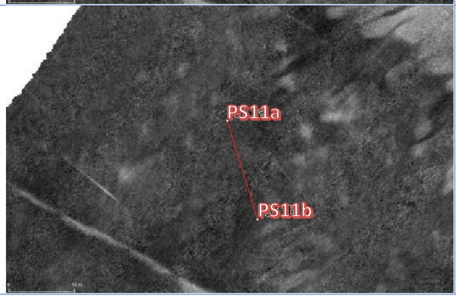
Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS2b	Sediment: Transition – Coarse - Fine Catami bedforms/biota: Two dimensional waves - ripples			No Sample	E 268095 N 6110226
PS2c	Sediment: Fine Catami bedforms/biota: Two dimensional ripples			No Sample	E 268097 N 6110208
PS3	Sediment: Fine Catami bedforms/biota: Two dimensional ripples				E 267896 N 6110724

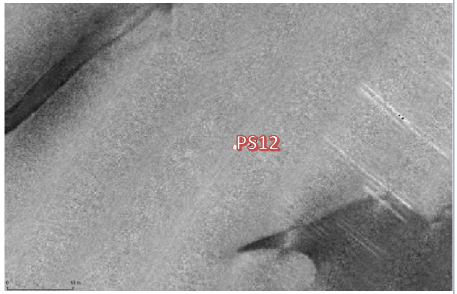
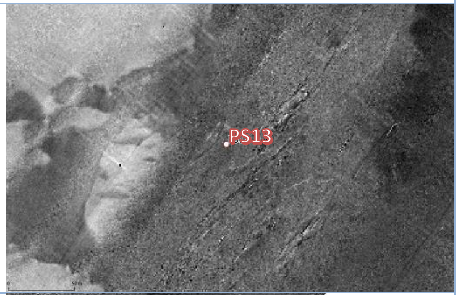
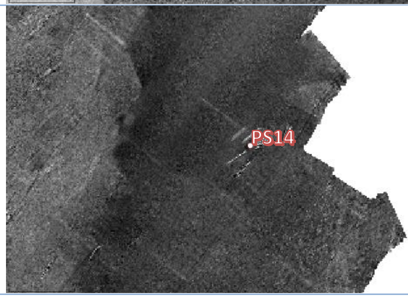
Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS4a	Sediment: Mix Catami bedforms/biota: Mixed - Two dimensional ripples / flat seagrass (Posidonia/Halophila)			No Sample	E 267758 N 6110973
PS4b	Sediment: Coarse Catami bedforms/biota: Two dimensional waves			No Sample	E 267724 N 6110964
PS4c	Sediment: Medium Catami bedforms/biota: Two dimensional ripples				E 267726 N 6110867

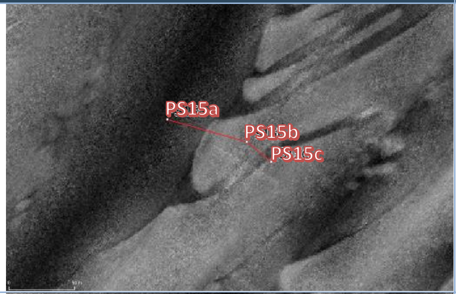
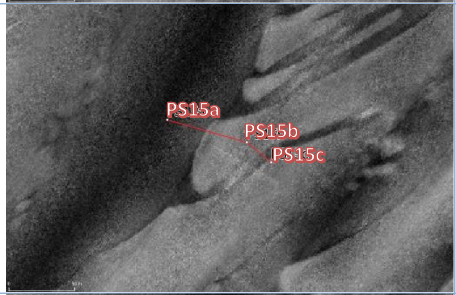
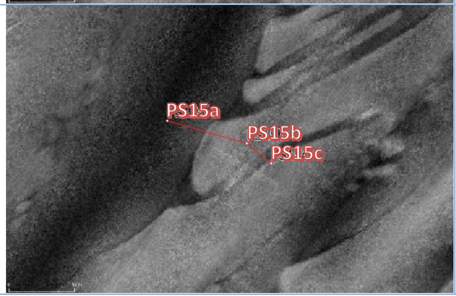
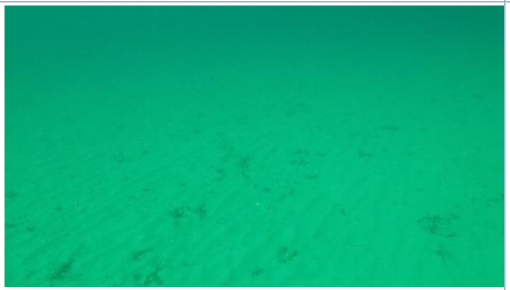
Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS5a	Sediment: Med-coarse Catami bedforms/biota: two dimensional waves Comment: 3 2D: Waves (>10cm height) -CAAB 82002004				E 268456 N 6111173
PS5b	Sediment: Coarse-fine Catami bedforms/biota: two dimensional waves-ripples			No Sample	E 268477 N 6111115
PS5c	Sediment: Fine Catami bedforms/biota: two dimensional ripples			No Sample	E 268478 N 6111075

Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS6a	Sediment: Fine-mixed Catami bedforms/biota: two dimensional ripples				E 267781 N 6111649
PS6b	Sediment: Patchy with bedrock/cobble Catami bedforms/biota: Bedrock / cobble Comment: 3 Consolidated (hard): Cobbles–CAAB 82001004			No Sample	E 267771 N 6111615
PS7a	Sediment: Mix coarse / shell hash Catami bedforms/biota: Sand / sparse rock			No Sample	E 267882 N 6111957

Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS7b	Sediment: Mix coarse / shell hash Catami bedforms/biota: Sand / sparse rock			No Sample	E 267888 N 6111916
PS8	Sediment: Fine Catami bedforms/biota: three dimensional ripples Comment: 3 3D: Ripples (<10cm height) –CAAB 82002007				E 268215 N 6111976
PS9	Sediment: Coarse Catami bedforms/biota: two dimensional waves			No Sample	E 268616 N 6111959

Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS10	Sediment: Fine (med in troughs) Catami bedforms/biota: two dimensional waves				E 268915 N 6112252
PS11a	Sediment: Mix coarse / shell hash Catami bedforms/biota: Sand / sparse rock			No Sample	E 268357 N 6112497
PS11b	Sediment: Mix coarse / shell hash / algae Catami bedforms/biota: two dimensional waves			No Sample	E 268380 N 6112422

Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS12	Sediment: Fine Catami bedforms/biota: three dimensional ripples				E 268891 N 6112611
PS13	Sediment: Low reef Catami bedforms/biota: Low reef			No Sample	E 269289 N 6112550
PS14	Sediment: Mix coarse / shell hash / pipes / rock Catami bedforms/biota: Mixed			No Sample	E 269534 N 6112642

Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS15a	Sediment: Coarse Catami bedforms/biota: two dimensional waves			No Sample	E 268672 N 6112896
PS15b	Sediment: Fine Catami bedforms/biota: three dimensional ripples			No Sample	E 268733 N 6112879
PS15c	Sediment: Fine Catami bedforms/biota: two dimensional ripples			No Sample	E 268752 N 6112864

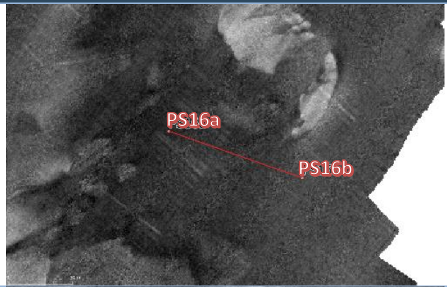
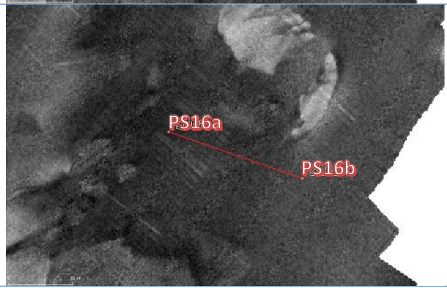
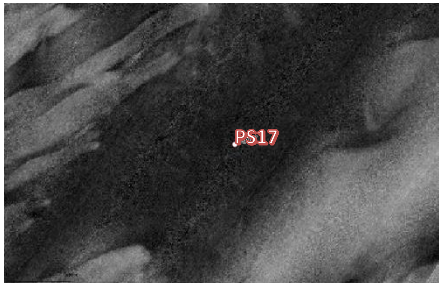
Point ID	Description	Backscatter	Camera Drop	Sediment Sample	MGA94 Z54 Coordinates (m)
PS16a	Sediment: Coarse Catami bedforms/biota: two dimensional waves / low reef			No Sample	E 269432 N 6112910
PS16b	Sediment: Coarse Catami bedforms/biota: two dimensional waves / seagrass patches			No Sample	E 269536 N 6112874
PS17	Sediment: Coarse (shell hash in troughs) Catami bedforms/biota: two dimensional waves				E 269014 N 6113182

Table 17: Comparison of Sediment Sample, Photographs, and Backscatter of Each Site

K. SURVEY UNCERTAINTY

K.1 Theoretical Uncertainty

An assessment of the total vertical and horizontal uncertainty (TVU & THU) can be determined by combining the following:

- Random errors inherent in the survey systems, as extracted from the manufacturer specifications
- Random errors associated with the measurement of each sensor position and angular offset
- Random errors caused by environmental conditions
- Tidal reduction methodology

The total uncertainty at a 68% confidence interval (1σ) is calculated by taking the square root of the sum of all contributing uncertainties squared.

Uncertainty has also been expressed at the 95% confidence level (2σ) indicating that 95% of sample data lies within the specified value. The 2 sigma value is calculated by multiplying the 1 sigma value by 1.96 for one dimensional measurements (height) and 2.45 for two dimensional measurements (position E,N).

The errors associated with this survey have been assessed as per Table 18. The uncertainties are calculated for the outer most beam of the multibeam system, operating at 400kHz using a maximum angular coverage of 130° and a signal pulse length of 15 µs.

R2Sonic 2024 Performance Summary
Marine Science

Rate of Seafloor Coverage	0.47	km^2/hr
(within the seafloor coverage limitations described below)		

Below is a summary of complex calculations based on all assessed error sources associated with this survey

Environment		
Parameter	**Value**	
Maximum Water Depth	21	m
Maximum Sea State	0.75	m
Maximum Vessel Roll	2	°
Maximum Observed Vessel Pitch	5	°
Seafloor Slope	0	°
Sound Speed	1512	m/s
Maximum Sound Speed Uncertainty	2	m/s

Coverage Summary		
Parameter	**Value**	
Sounding Speed	6	knots
Average Swath Width	100	°
Swath Overlap	25%	
Total Seafloor Coverage	125%	
Minimum Ping Rate	23.7	Hz
Maximum Swath Coverage	48	m
Maximum Distance between Pings Alongtrack	0.13	m

Depth Position Uncertainty Summary		
Parameter	**Values (95%)**	
Positioning System Error	0.096	m
Beam Footprint Error	0.338	m
Refraction Error	0.064	m
Roll Error	0.071	m
Pitch Error	0.070	m
Heading Error	0.093	m
Gridding Error	0.707	m
Total Propogated Horizontal Uncertainty	**0.804**	**m**
Number of Beams meeting Special Order	256	/ 256
Number of Beams meeting Order 1	256	/ 256

Depth Uncertainty Summary		
Parameter	**Values (95%)**	
Sounder Error	0.020	m
Refraction Error	0.049	m
Roll Error	0.090	m
Pitch Error	0.006	m
Induced Heave Error	0.004	m
Vertical Positioning System Error (incl. heave)	0.055	m
Vertical Offset Measurement Error	0.028	m
Total Propogated Vertical Uncertainty	**0.121**	**m**
Number of Beams meeting Special Order	256	/ 256
Number of Beams meeting Order 1	256	/ 256

Table 18: Theoretical Uncertainty

For a summary of all individual errors included in the TVU and THU calculation, and for a graphical representation of the position and depth uncertainties, refer to **Appendix H.**

K.2 Statistical Checks to Support Theoretical Uncertainty

The survey checks and calibrations outlined in Section G support the theoretical uncertainty calculated above in Table 18, in particular:

- The static position checks on the known reference marks and vessel are an indicator of the vessel positional uncertainty.

- The bar check and the historical data comparison as an assessment of the depth measurement uncertainty and sounding reduction uncertainty.

K.3 Overall Survey Uncertainty and Coverage

Taking the above theoretical uncertainties and statistical checks to support those uncertainties into account, the survey is considered to have the following defined accuracies:

- Horizontal Uncertainty: **+/- 1.0 m (including soundings binning method)**
- Vertical Uncertainty: **+/- 0.15 m**
- Seabed Coverage: **100%**
- Guaranteed object detection **> 0.5 m**

L. DATA DELIVERABLES

L.1 Digital

- Survey Report (.pdf)
- ASCII Data
  - MBES Bathymetry ASCII XYZ Data
    - PHS-20-033-DEW_PortStanvac_Bathy_1mShallowestGRID_MGA94_Z54_LAT_200525.pts
    - PHS-20-033-DEW_Port Stanvac_Bathy_All ProcessedSoundings_MGA94_Z54_LAT_200525.pts
  - MBES Backscatter ASCII XYI Data:
    - PHS-20-033-DEW_Port Stanvac_Backscatter_1m GRID_MGA94_Z54_200525.pts
  - SBP Primary Sand Unit Thickness Data:
    - PHS-20-033-DEW_PortStanvac_SBP PrimarySandUnitThickness_MGA94_Z54_200605.csv
- PDF and DWG Charts as listed in Table 19.
- Geotiff imagery (.kml, .tfw, .tif):
  - PHS-20-033-DEW_Port Stanvac_Bathy_1m_Shallowest_Grid_MGA94_Z54_LAT_200525
  - PHS-20-033-DEW_Port Stanvac_Backscatter_1m_MGA94_Z54_200525
  - PHS-20-033-DEW_Port Stanvac_Sub-BottomProfiler_MGA94_Z54_200605

L.2 Hard copies

- Survey Report
- Charts (4 charts)

Chart Number	Scale	Paper Size	Title
PHS-20-033-DEW-C001	1:5000	A1	Bathymetric Survey
PHS-20-033-DEW-C002	1:5000	A1	Bathymetric Survey – Sun Illumination Grid
PHS-20-033-DEW-C003	1:5000	A1	Backscatter
PHS-20-033-DEW-C004	1:5000	A1	Backscatter and Sand Thickness

Table 19: Chart List

M. WORKPLACE HEALTH AND SAFETY

A toolbox meeting was conducted at the beginning of the project to discuss scope of work and bring up any issues related to the vessel prior to survey commencing.

Two Safe Work Method Statements were created during this project, as summarised in Table 20. These are available upon request.

SWMS Number	Description
1	General Survey Operations
2	Survey Checks

Table 20: PHS Safety Documentation

N. SURVEY PERSONNEL

The following personnel conducted the survey:

- Mathieu Bestille — Surveyor in Charge (CPHS1)
- Augustin Deplante — Project Manager / Hydrographic Surveyor

O. APPROVAL

This report and the accompanying plans are respectfully submitted.

This report and the accompanying survey plans have been closely reviewed and are considered complete and adequate as per the job specification.

Supervision of field work, QC and approval of data, preparation of report by:

Mathieu Bestille, BSc Hydrographic Surveying
Certified Professional Hydrographic Surveyor Level 1
Survey and Business Development Manager - Precision Hydrographic Services

Date: 29/06/2020

APPENDIX A - BASE STATION DETAILS

BASE STATION REPORT

CONTRACT NUMBER:	**PHS-20-033-DEW**
CLIENT:	**Department For Environment and Water**
PROJECT NAME:	**Port Stanvac MBES - SBP Survey**
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante**

SETUP INFORMATION

LOCATION: **Port Stanvac**

NAME / ID: **SA_Port Stanvac**

MOBILISED ON: **11/12/2017**

POWER SOURCE: **N/A**

EQUIPMENT USED:

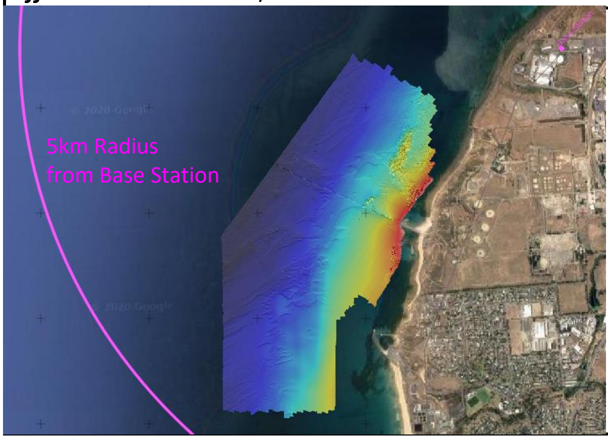
VRSnow Subscription, using Port Stanvac base station

Antenna Type: N/A

Antenna Height: N/A

Offset ARP to APC: N/A

Base station picture unavailable



Location sketch unavailable

POSITION COORDINATES

DATUM: **GDA94**		GRID: **MGA94Z50**	DATUM: **ITRF08**
LATITUDE (DMS):	**35°05'40.95686" S**	EAST:	LATITUDE (DMS):
LONGITUDE (DMS):	**138°29'08.56195" E**	NORTH:	LONGITUDE (DMS):
ELLIPSOID HEIGHT:	**57.812m**	HEIGHT:	ELLIPSOID HEIGHT:

Uncertainty (95% conf.): *East: 0.008m* *North: 0.008m* *Height: 0.017m*

METHODOLOGY: Not Applicable

COMMUNICATION / CORRECTIONS Tx

WebGUI Access:	https://vrsnow.com.au/Map/Sensoı	User: *UPGhire11*	PW: *ADEG*
LAN IP Address:	vrsnow.com.au	3G Modem port access:	2101
NTRIP Caster:	http://phs-rtkbaseX.dyndns.org	User: *UPGhire11*	PW: *ADEG*
Port: 2101	=> Choice of all mount points		
Port:	=>		
Port:	=>		
Radio Frequency: NA	**Link rate:** NA	**Protocol:**	NA
Correction format:	NA		

DATA LOGGING					
DATA LOGGING ENABLED	☑	**Mode**	*Continuous*	**Interval**	*1 seconds*
DATA TRANSFER METHOD	*Connect to VRSnow Service and download loggings*				
FORMAT	**.T02*				

ADDITIONAL INFORMATION:
The VRSnow service was contracted through UPG, and used for the entirety of the survey. As shown above the survey area was always situated within 5km of the base station.

PHS Rep: **Augustin Deplante**

Client Rep: **Robyn Morcom**

Signature:

Certificate of Verification of a Reference Standard of a Position-Measurement in Accordance with Regulation 13 of the National Measurement Regulations 1999 and the National Measurement Act 1960

Name of Verifying Authority:

Name: Geodesy Section
Organisation: Geoscience Australia
Address: Corner Jerrabomberra Ave and Hindmarsh Drive, Symonston ACT 2609 Australia
Telephone: (02) 6249 9111
Email: geodesy@ga.gov.au

Client detail:

Name: Ryan Ruddick
Organisation: Geodesy Section, Geoscience Australia
Address: Symonston ACT 2609 Australia
Telephone: (02) 6249 9426
Email: Ryan.Ruddick@ga.gov.au
Date of request: 24 October 2017

Description and denomination of standard of measurement:

The measurement was undertaken using an antenna `LEIAT504GG SCIS` (International GNSS Service antenna naming convention) with the serial number 200550 and refers to a point located 0.0019 m below the antenna reference point. This antenna is attached to a concrete pillar via a stainless steel spigot thread. The station (4 character ID: PTSV) is located at Port Stanvac in South Australia. The certificate was determined using data from 03 September 2017 to 09 September 2017 inclusive. Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position issue 2.1. The reference number of this certificate is PTSV11122017.

Permanent distinguishing marks:

Exempt under Regulation 16 (4)

Date of verification: 11 December 2017

Date of expiry of certificate: 11 December 2022

NATA Accredited for compliance with ISO/IEC 17025. Accreditation No. 15002.

Value of standard of measurement:

Station (4 character ID): PTSV

South Latitude and its uncertainty of value:

35° 5' 40.90814" ± 0.00026" (0.008 m)

East Longitude and its uncertainty of value:

138° 29' 8.58812" ± 0.00026" (0.008 m)

Elevation above Ellipsoid and its uncertainty of value:

57.702 ± 0.017 m

Geocentric Datum of Australia (GDA2020) coordinates referred to the GRS80 ellipsoid being in the ITRF2014 reference frame at the epoch 2020. The uncertainties are calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

Details of any relevant environmental or other influence factor(s) at the time of verification:

Uncertainty of the coordinates of the recognized-value standard of measurement of position (i.e. GDA2020); and Uncertainty due to instability of the GPS antenna mounting and modelling of the antenna phase centre variations.

Signature:	**Signature:**
11 December 2017	11 December 2017
Dr John Dawson NATA approved signatory	Mr Gary Johnston Geoscience Australia approved signatory
Section Leader Geodesy and Seismic Monitoring Branch Geoscience Australia	Branch Head Geodesy and Seismic Monitoring Branch Geoscience Australia

Being a person, or a person representing a body, appointed as a verifying authority under Regulations 71 and 73 of the National Measurement Regulations 1999 in accordance with the National Measurement Act 1960, I hereby certify that the above standard is verified as a reference standard of measurement in accordance with the Regulations, by the above-named authority.

TECHNOLOGY BRIEF

Trimble VRS Technology

Trimble VRS Corrections

Trimble® VRS™ corrections are more important now than ever before, due to the increasing need for real-time high-accuracy positioning. This brief explains the ease of use and benefits of VRS corrections and provides information about VRS technology as it relates to Mapping & GIS products and applications.

Highlights

- Real-time corrections for high-accuracy mapping in-the-field
- Increase productivity, save time and money

What are VRS corrections?

A Trimble VRS system is one option for providing real-time differential correction to a GNSS receiver. It is the most commonly used technology behind most network correction services worldwide. Corrections are necessary to eliminate errors and improve the accuracy of GNSS positions in collected data.

VRS corrections are available from a variety of public and commercial services. VRS networks and subscription services provide dual-frequency (L1/L2) real-time differential GPS (DGPS) and in many cases DGNSS (GPS and GLONASS) corrections to improve accuracy as data is collected.

A VRS service uses data from several (permanent) reference stations to compute corrections that are generally more accurate than corrections from a single reference station. These corrections are then broadcast over the Internet.

For more information about GNSS, refer to the following sections of the Trimble Geo 7 series User Guide—Using the GNSS receiver, Ensuring the accuracy of your GNSS data.

WHY DO I NEED VRS CORRECTIONS?

The use of VRS corrections helps ensure the accuracy of GNSS data, independent of the distance to the nearest reference station. One of the best ways to achieve decimeter accuracy with the high-accuracy Trimble Geo 7X handheld and Trimble R2 GNSS receiver is by using VRS corrections. This accuracy can be achieved not only after postprocessing but in real time, on the spot, in the field.

Real-time data collection means that field workers know a location has been mapped to the desired accuracy level—streamlining workflows and reducing the risk that they will need to recollect data. Using a VRS correction source provides the flexibility to work anywhere within the correction network and provides the best possible accuracy.

AREN'T VRS CORRECTIONS JUST FOR SURVEYORS?

The need for reliable and accurate positioning is not limited to surveying. Today, a variety of industries including electric and gas utilities, water and wastewater services, and land management projects require mapping products that provide decimeter or better accuracy positioning in real time.

TRIMBLE H-STAR TECHNOLOGY AND VRS CORRECTIONS

Trimble H-Star™ technology works in real time and supports real-time differential correction sources, such as corrections from a Trimble VRS network or Trimble VRS Now™ subscription service. In particular, the Trimble Geo 7X handheld with H-Star technology uses VRS corrections to attain decimeter accuracy in real time.

VRS corrections can be used with other Mapping & GIS receivers to help improve accuracy, but only the Trimble Geo 7X handheld achieves consistent real-time decimeter accuracy with H-Star.

WHERE IN THE WORLD CAN VRS CORRECTIONS BE USED?

Today, municipalities and governments are building VRS networks across the globe, and many private companies have also seen the benefits in setting up their own VRS networks. Review this online list of some of the Trimble VRS installations around the world to find out about accessing a VRS network: www.trimble.com/infrastructure/vrs-installations.aspx

For further information, please visit www.trimble.com or contact a local Trimble reseller who can advise on locally available networks or provide information on setting up a VRS network.

TRIMBLE VRS NOW SUBSCRIPTION SERVICES

Subscription services such as Trimble VRS Now provide instant access to VRS corrections on demand without the cost or work involved in setting up a VRS network.

The Trimble VRS Now subscription services are available in defined coverage areas as noted below. However, the method of usage and benefits of such subscription services are also applicable to using other VRS correction sources such as private or public VRS networks.

There are three levels of service available including the Trimble VRS Now H-star service specific to the needs of Mapping & GIS customers:

- DGNSS corrections for submeter accuracy.
- H-Star corrections for decimeter accuracy.
- RTK (real-time kinematic) corrections for centimeter accuracy.

The Trimble VRS Now H-Star correction service is currently available to users in coverage regions throughout Europe and the USA.

A subscription to the H-Star service gives the ability to obtain real-time, decimeter level accurate positions consistently and directly at the job site.

For specific queries on Trimble VRS Now subscription services contact a Trimble reseller.

WHO USES VRS CORRECTIONS AND SUBSCRIPTION SERVICES AND WHY?

Organizations around the world are already using VRS corrections and subscription services in order to improve accuracy and efficiency in their data collection and maintenance operations.

For example, one of the UK's largest metropolitan district councils utilized VRS corrections to collect spatially accurate data on more than 12,000 street signs and road markings. UK traffic management legislation required high accuracy mapping of signs and road markings, so council workers used Trimble GeoExplorer® series handhelds in conjunction with Trimble's VRS Now service to collect high-accuracy real-time data quickly and accurately. In the words of the chief surveyor for the council:

"Accessing the Trimble VRS Now service for real-time corrections in the field was easy. The field workers just received the VRS connections via a cellular connection, which then connected to the GeoExplorer handheld via Bluetooth®. There were no wires and no bulky accessories, and the precise corrections were delivered right to the handheld."

He also stated: "Being able the achieve such high accuracy in the field eliminated a lot of post-processing work back in the office, which meant we could focus on the task at hand—collecting data as efficiently and accurately as possible… with Trimble VRS Now, corrections are actually delivered directly to the handheld on the spot, so you immediately have accurate information at your fingertips."

To find information about how other Mapping & GIS customers are using Trimble solutions, go to www.trimble.com/mappingGIS.

Contact your local Trimble Authorized Distribution Partner for more information

NORTH AMERICA
Trimble Navigation Limited
10368 Westmoor Drive
Wesminster CO 80021
USA

EUROPE
Trimble Germany GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY

ASIA-PACIFIC
Trimble Navigation
Singapore Pty Limited
80 Marine Parade Road
#22-06, Parkway Parade
Singapore 449269
Singapore

APPENDIX B - VESSEL MOBILISATION REPORT

VESSEL MOBILISATION REPORT

CONTRACT NUMBER:	**PHS-20-033-DEW**	Date	**23/05/2020**
CLIENT:	**Department For Environment and Water**		
PROJECT NAME:	**Port Stanvac Multibeam and Sub-Bottom Profiler Survey**		
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante (Online)**		
VESSEL:	**Marine Science / David Miller (Skipper)**		

Vessel Length (Fore/Aft)	8.1
Vessel Width (Port/Stbd)	2.8
Vessel Draft	0.7

Vessel CRP	IMU Ref Point
GPS Antennas node	Phase center
GPS Antennas Model / Phase Center Offset	

Sign Convention

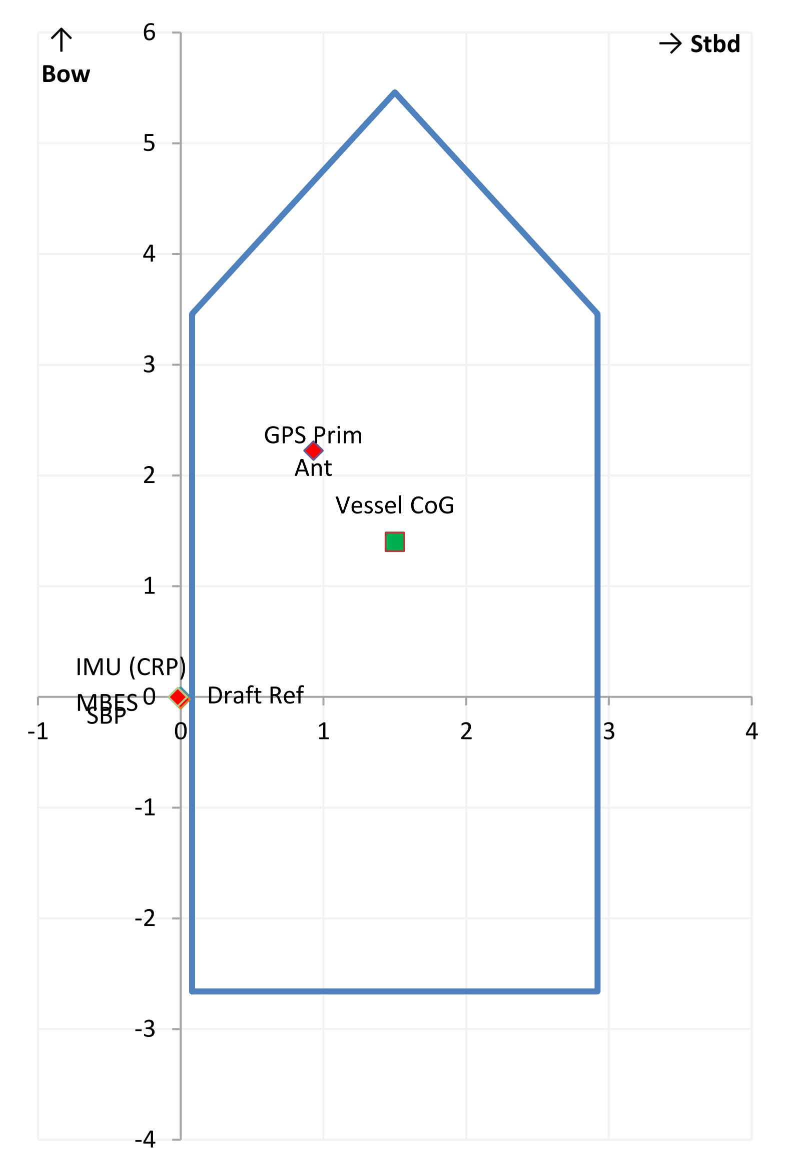
Vessel Offsets Report / QINSy	
X	Stbd +
Y	Bow +
Z	Up +

3rd party system	POSMV
X	Bow +
Y	Stbd +
Z	Up -

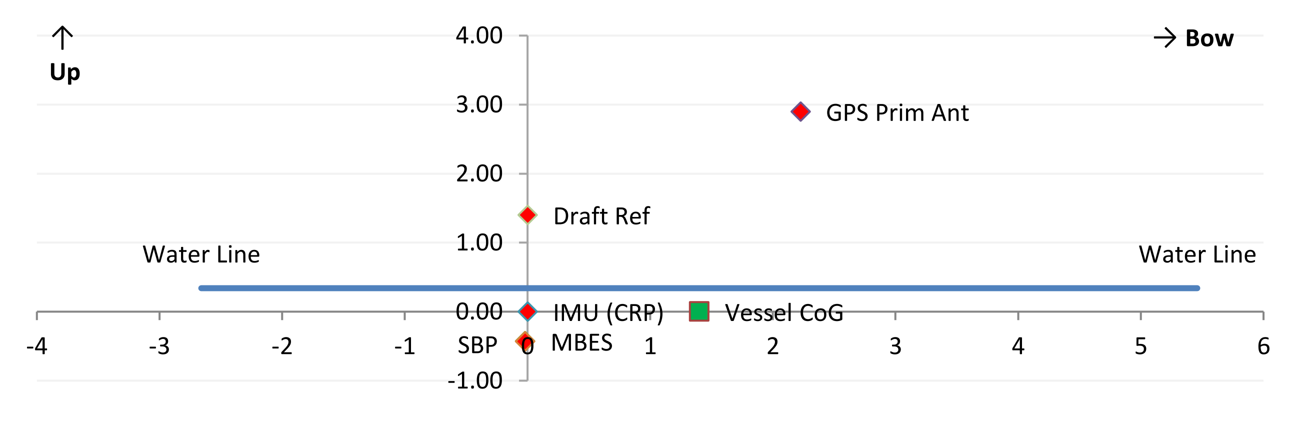
Vessel Nodes (QINSy sign convention) - m

Name	X	Y	Z
Vessel CoG	1.50	1.40	0.00
MBES	0.00	-0.02	-0.43
GPS Prim Ant	0.93	2.23	2.90
IMU (CRP)	0.00	0.00	0.00
SBP	0.00	-0.02	-0.43
Draft Ref	-0.02	0.00	1.40
Water Line			0.34

PLAN VIEW



STARBOARD VIEW

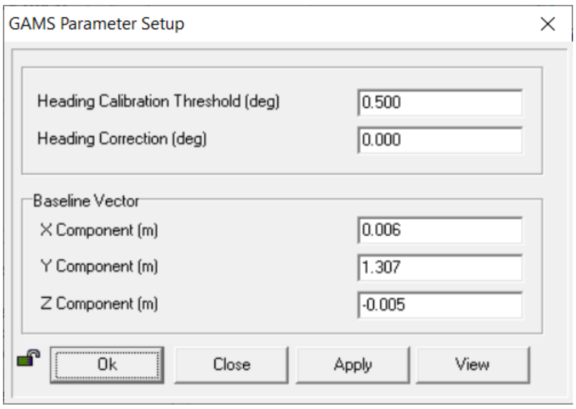


EQUIPMENT SETTINGS

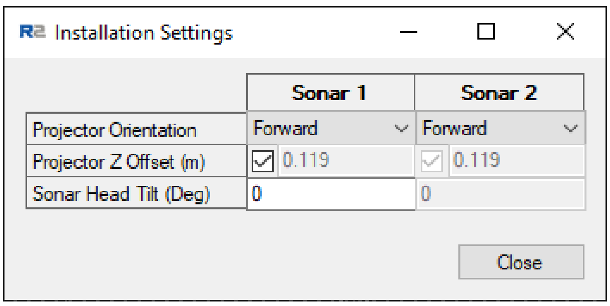
Echsounder	R2Sonic 2024	Other Equipment	Type	Serial No.	Asset No.
Serial Number	101307	Positioning System	POS MV	7139	10
PHS Asset Number	346	Motion Sensor	POS MV	2960	13
Frequency	400 KHz	Sound Velocity Sensor	Valeport Mini SVS	70285	521
Pulse Length	15 µs	Sound Velocity Profiler	Valeport Swift SVP	70351	460
Absorption Co-efficient	130 db/km	Sub Bottom Profiler	Innomar SES-2000	Compact	Rental
Scattering Value	30 db				
TX-RX Offset Value	-0.119 m				
Mounting	Side Pole				
Sector Coverage	130 deg				
Sonar Head Tilt	0				
Bottom Sampling	Equidistant				
Projector Orientation	Projector Forward				
Roll Stabilised	Yes				
SVS Used	Yes				

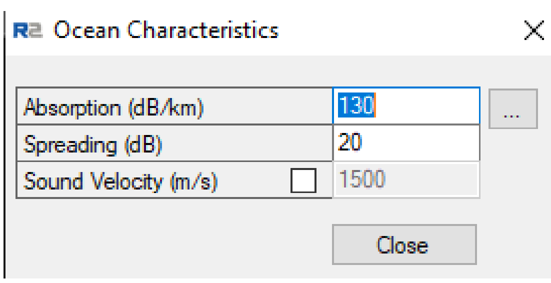
SCREENSHOTS OF R2SONIC and POS MV SETTINGS

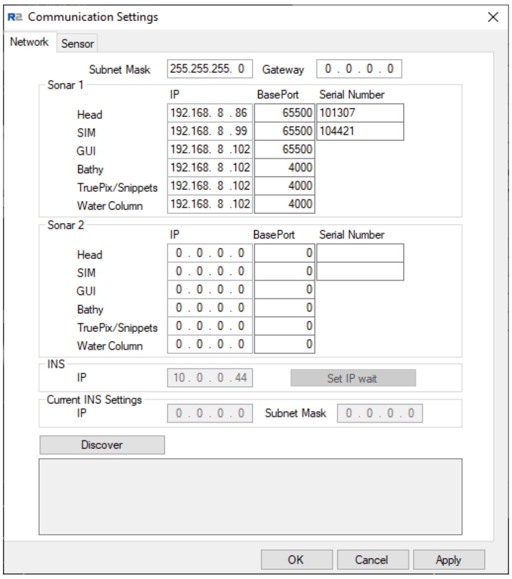
POS MV

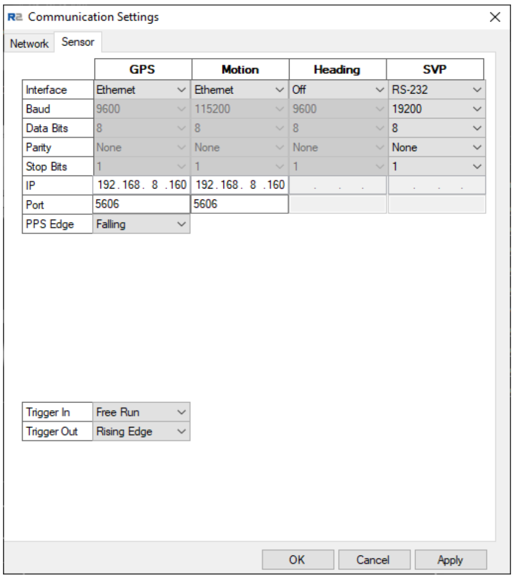


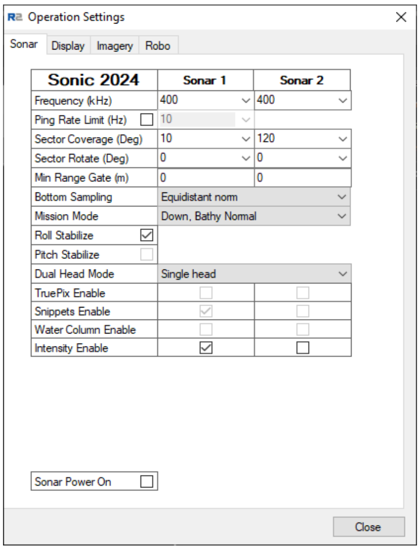
R2 Sonic 2024



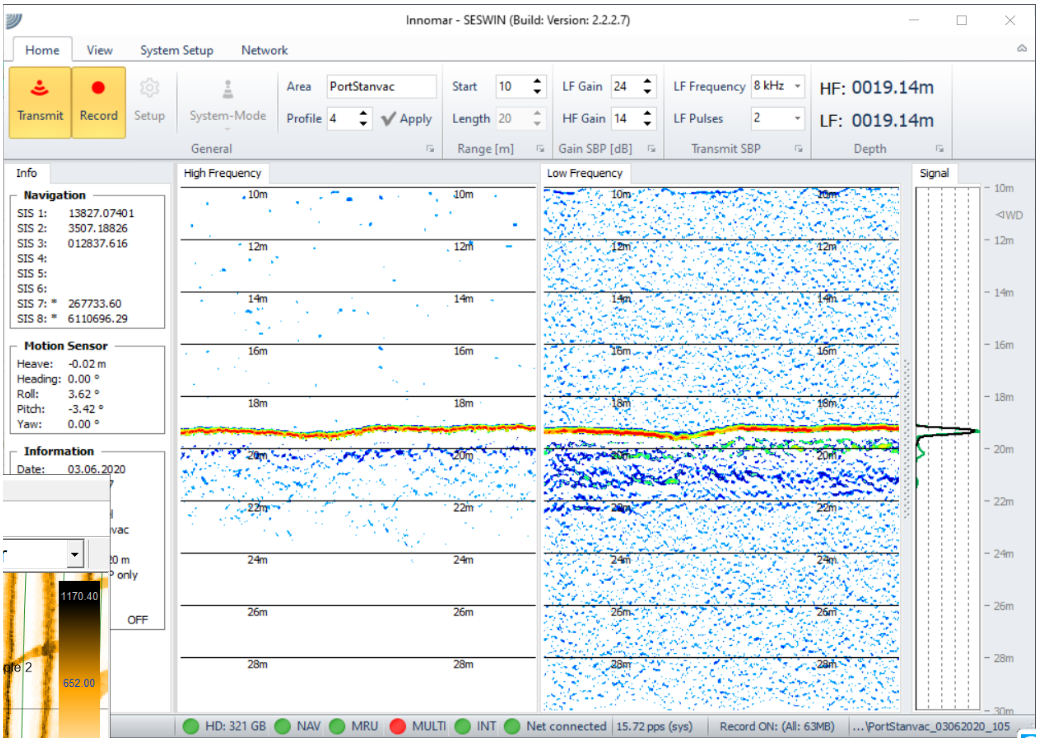



Communication Settings
Network
Sensor
Subnet Mask
Gateway
Sonar 1
Sonar 2
INS
Current INS Settings
Discover
OK
Cancel
Apply

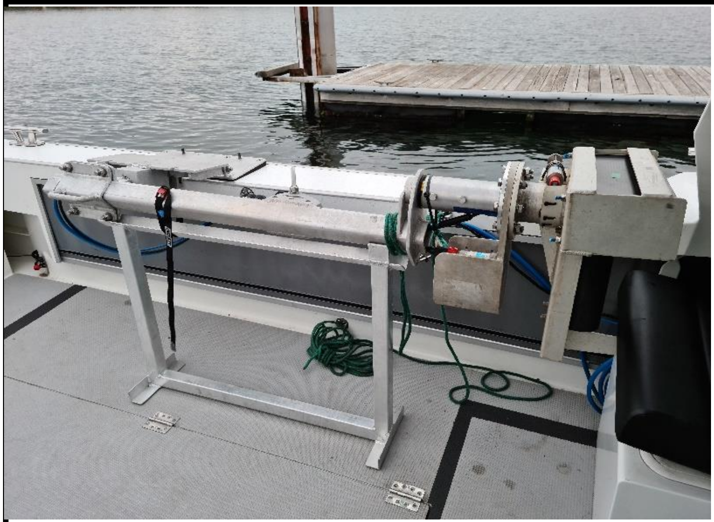

Communication Settings
GPS
Motion
Heading
SVP
Interface
Baud
Data Bits
Parity
Stop Bits
IP
Port
PPS Edge
Trigger In
Trigger Out
OK
Cancel
Apply


Operation Settings
Sonic 2024
Sonar 1
Sonar 2
Frequency (kHz)
Ping Rate Limit (Hz)
Sector Coverage (Deg)
Sector Rotate (Deg)
Min Range Gate (m)
Bottom Sampling
Mission Mode
Roll Stabilize
Pitch Stabilize
Dual Head Mode
TruePix Enable
Snippets Enable
Water Column Enable
Intensity Enable
Sonar Power On
Close

Innomar


Innomar - SESWIN (Build: Version: 2.2.2.7)
HF: 0019.14m
LF: 0019.14m
High Frequency
Low Frequency
Signal
Navigation
Motion Sensor
Information

MOBILISATION PHOTOGRAPHS (MBES, GPS Antennas, Motion Sensor location)



COMMENTS:
A SBP was also mounted at a later stage in place of the Multibeam. The same offsets as the Multibeam were used.

PHS Rep : **Augustin Deplante**

Client Rep: **Robyn Morcom**

Signature:

APPENDIX C - BENCHMARKS CHECKS

BENCHMARK POSITION CHECK

TO BE PERFORMED PRIOR TO THE START OF SURVEYING OPERATIONS AND ON A REGULAR BASIS

DATE: **25/05/2020**	CONTRACT NUMBER: **PHS-20-033-DEW**	CLIENT: **Department for Environment & Water**
PROJECT NAME: **Port Stanvac Multibeam and Sub-Bottom Profiler Survey**		
SURVEY PERSONNEL: **Augustin Deplante**		LOCATION: **O'Sullivan**

BASE STATION INFORMATION

Base Station ID	Location	Datum	Latitude	Longitude	Height	Antenna Type	Corrections	Frequency	NTRIP IP address:port
PTSV	**Port Stanvac**	**GDA94**	**35° 5' 40.90814"**	**138° 29' 8.58812"**	**57.702**	**LEIAT504GG SCIS**	**NTRIP**	**N/A**	**vrsnow.com.au:2101**

Base Station position last checked/updated on: **11/12/2017** Note:

DATUM TRANSFORMATION PARAMETERS (not applicable)

From **N/A**	7 Parameters Transformation	Dx (m)		Rx (")		Scale Factor (ppm)	
To		Dy (m)		Ry (")			
Epoch	*Source:* Geoscience Australia	Dz (m)		Rz (")			

POSITION CHECK ON SURVEY BENCHMARKS

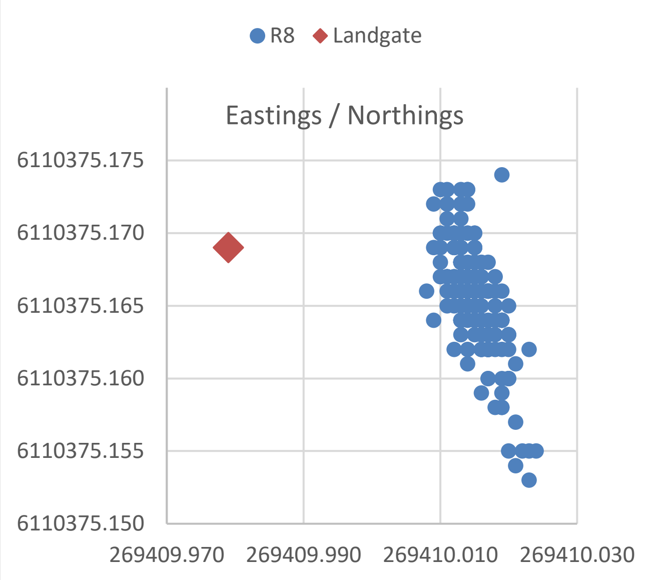
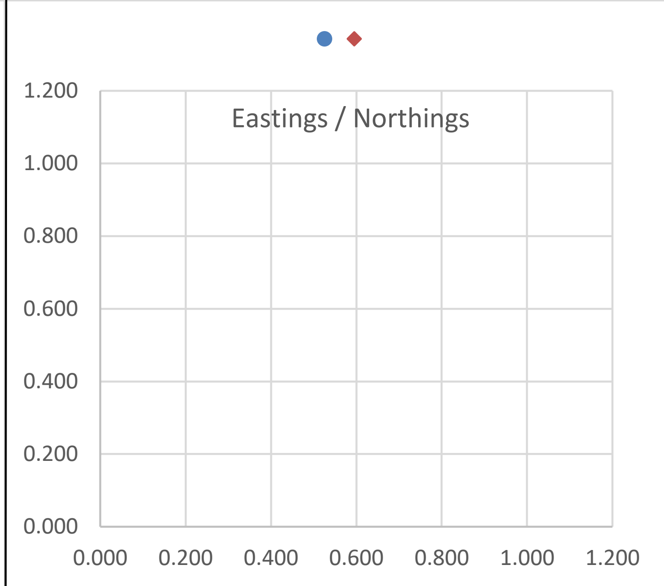
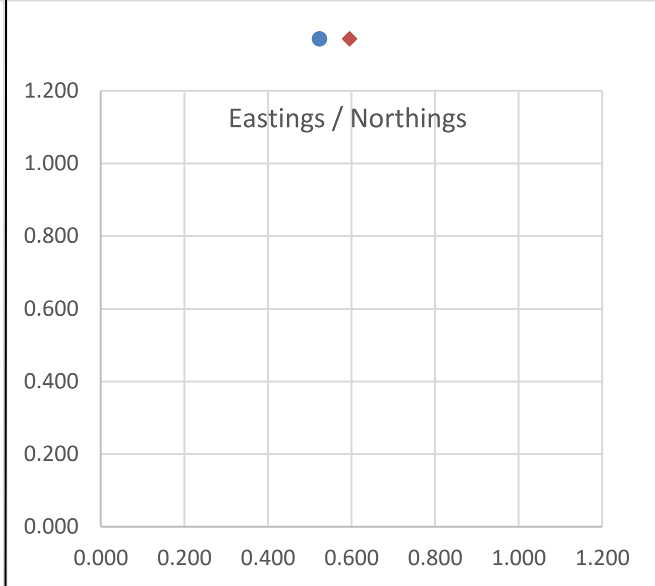
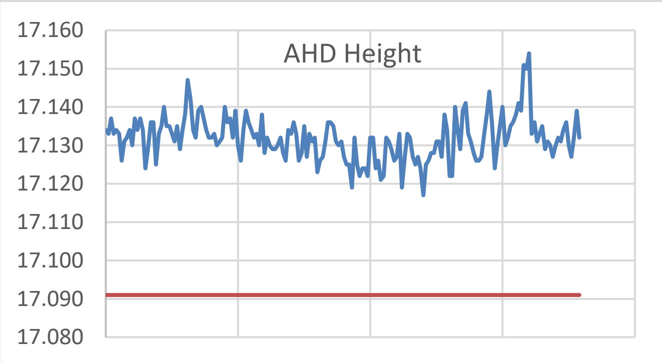
Rover Observations Averaging: **3 min** Antenna Height: **2.02 metres** Geoid Model used: **AusGeoid09** Corrections Rx: **Radio**

SSM ID	**6527/7678**		GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:	Landgate				**269409.979**	**6110375.169**	**17.091**			
Observed data	Rover:	R8				**269410.015**	**6110375.166**	**17.132**	0.006	0.008	0.011
				Difference		***-0.036***	***0.003***	***-0.041***			

SSM ID			GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:										
Observed data	Rover:										
				Difference							

SSM ID			GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:										
Observed data	Rover:										
				Difference							

BENCHMARK POSITION CHECK

6527/7678	0	0
		
		

COMMENTS:

The position and height compares well against the known benchmark position

PHS rep: **Jacob Burrows** *Client rep:* **Robyn Morcom**

Signature: JBurrows

BENCHMARK POSITION CHECK

TO BE PERFORMED PRIOR TO THE START OF SURVEYING OPERATIONS AND ON A REGULAR BASIS

DATE: **18/06/2020**	CONTRACT NUMBER: **PHS-20-033-DEW**		CLIENT: **Department for Environment & Water**
PROJECT NAME:	**Port Stanvac Multibeam and Sub-Bottom Profiler Survey**		
SURVEY PERSONNEL:	**Augustin Deplante**		LOCATION: **O'Sullivan**

BASE STATION INFORMATION

Base Station ID	Location	Datum	Latitude	Longitude	Height	Antenna Type	Corrections	Frequency	NTRIP IP address:port
PTSV	**Port Stanvac**	**GDA94**	**35° 5' 40.90814"**	**138° 29' 8.58812"**	**57.702**	**LEIAT504GG SCIS**	**NTRIP**	**N/A**	**vrsnow.com.au:2101**

Base Station position last checked/updated on: **11/12/2017** Note:

DATUM TRANSFORMATION PARAMETERS (not applicable)

From	7 Parameters Transformation	Dx (m)		Rx (")		Scale Factor (ppm)	
To		Dy (m)		Ry (")			
Epoch	*Source:* Geoscience Australia	Dz (m)		Rz (")			

POSITION CHECK ON SURVEY BENCHMARKS

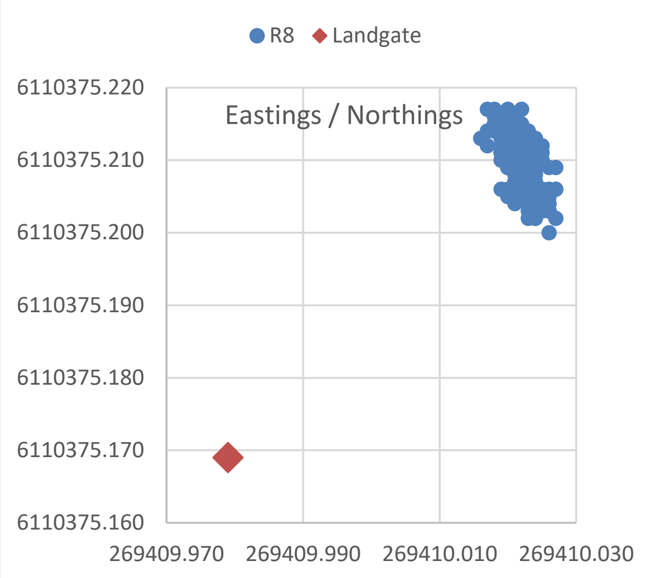
Rover Observations Averaging: **3 min** Antenna Height: **2.02 metres** Geoid Model used: **AusGeoid09** Corrections Rx: **Radio**

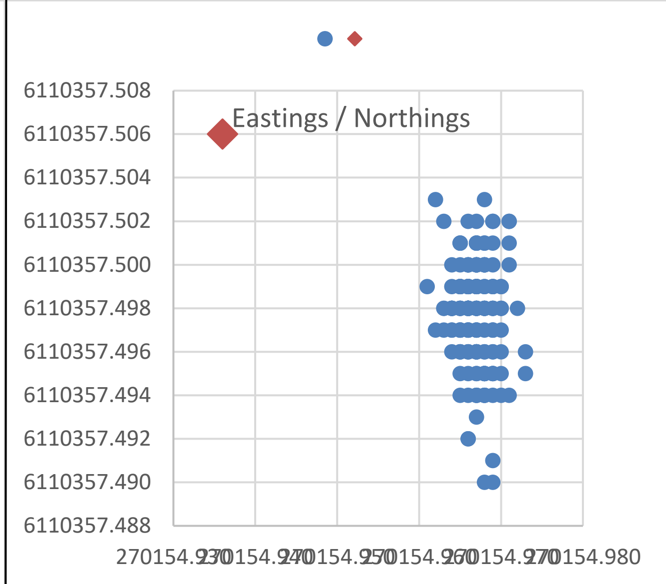
SSM ID	**6527/7678**		GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:	Landgate				**269409.979**	**6110375.169**	**17.091**			
Observed data	Rover:	R8				**269410.022**	**6110375.210**	**17.126**	0.004	0.007	0.008
				Difference		***-0.043***	***-0.041***	***-0.035***			

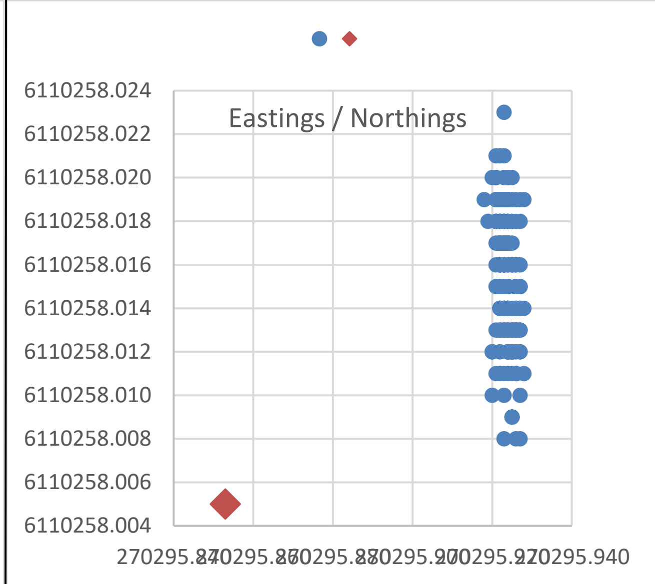
SSM ID	**6527/1071**		GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:					**270154.936**	**6110357.506**	**23.407**			
Observed data	Rover:					**270154.967**	**6110357.498**	**23.426**	0.004	0.005	0.010
				Difference		***-0.031***	***0.008***	***-0.019***			

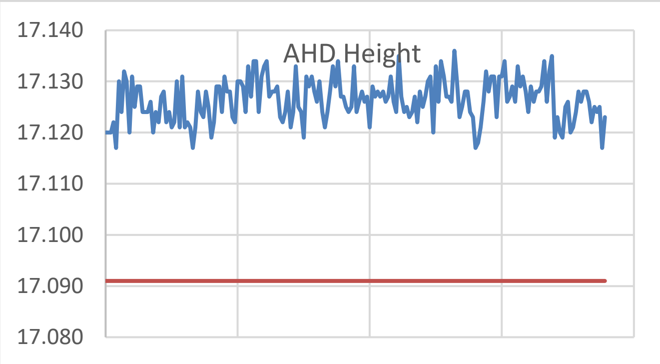
SSM ID	**6527/8223**		GDA94		GDA94	MGA94 Zone 54		AHD	Position Uncertainty (95%)		
			Latitude	Longitude	Elevation	Eastings	Northings	Height	X	Y	Z
Benchmark data	Source:					**270295.853**	**6110258.005**	**23.208**			
Observed data	Rover:					**270295.924**	**6110258.015**	**23.213**	0.004	0.006	0.013
				Difference		***-0.071***	***-0.010***	***-0.005***			

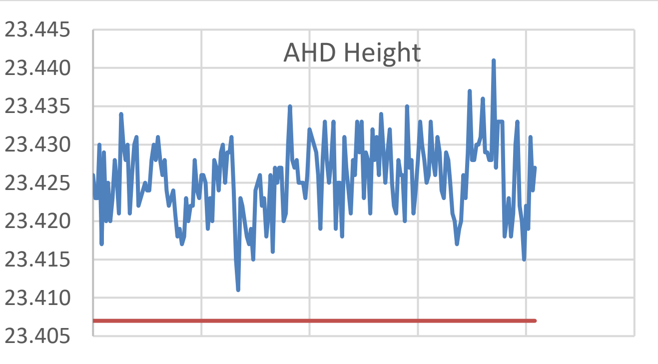
6527/7678	6527/1071	6527/8223

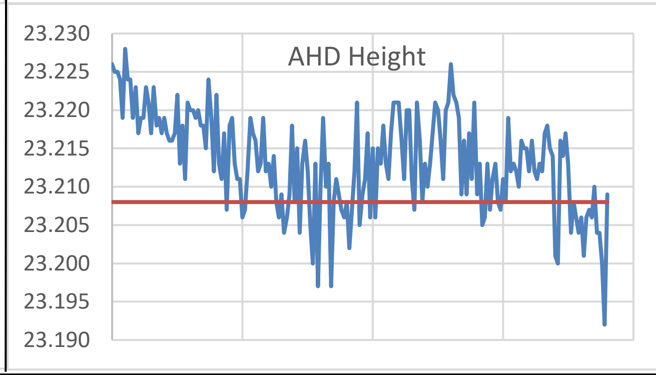












COMMENTS:

All positions and heights compare well against the known benchmark.

PHS rep: **Jacob Burrows** *Client rep:* **Robyn Morcom**

Signature: J Burrows

APPENDIX D - HEADING CHECKS

HEADING CHECK

TO BE PERFORMED PRIOR TO THE START OF SURVEYING AND ON A REGULAR BASIS

DATE:	**24/05/2020**	CONTRACT NUMBER:	**PHS-20-033-DEW**
CLIENT:	**Department for Environment and Water**		
PROJECT NAME:	**Port Stanvac MBES - SBP Survey**		
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante (Online), David Miller (Skipper)**		
VESSEL:	**Marine Science**		
LOCATION	**Port Stanvac**		

HEADING DEVICE *(select from list)* : GPS Based Heading (True Bearing)

CONVERGENCE: -1.458 *Source:* Qinsy

VESSEL - BOW / STERN RTK POSITIONS

Obs.	Stern Position (A)		Bow Position (B)	
	Easting	Northing	Easting	Northing
1	269215.97	6110764.45	269221.53	6110760.30
2				
3				
4				
5				
6				
7				
8				
9				
10				
AVERAGE	**269215.97**	**6110764.45**	**269221.53**	**6110760.30**
Std Dev				

RTK DERIVED VESSEL GRID BEARING	**126.744**

NB: Make sure the axis AB match with the vessel centreline

VESSEL (OBSERVED) HEADING (ddd.ddd)	
Number of observations	**360**
Logging start time	9:42:00
Logging end time	9:47:00
Standard Deviation	0.792
AVERAGE HEADING	128.890

RTK Derived True Bearing:	128.20
Difference (degrees):	**-0.69**

COMMENTS:
3 minute observations at bow and stern. The heading difference was not entered into the POSMV as it was within the accuracy tolerances of the heading check methodology. Also due to the short lever arms, the heading difference would have a minimal impact on the positioning of any calculated nodes.

PHS Rep: **Augustin Deplante** *Client Rep:* **David Miller**

Signature:

HEADING CHECK

TO BE PERFORMED PRIOR TO THE START OF SURVEYING AND ON A REGULAR BASIS

DATE:	**25/05/2020**	CONTRACT NUMBER:	**PHS-20-033-DEW**
CLIENT:	**Department for Environment and Water**		
PROJECT NAME:	**Port Stanvac MBES - SBP Survey**		
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante (Online), David Miller (Skipper)**		
VESSEL:	**Marine Science**		
LOCATION	**Port Stanvac**		

HEADING DEVICE *(select from list)* : GPS Based Heading (True Bearing)

CONVERGENCE: -1.458 *Source:* Qinsy

VESSEL - BOW / STERN RTK POSITIONS

Obs.	Stern Position (A)		Bow Position (B)	
	Easting	Northing	Easting	Northing
1	269232.41	6110643.68	269239.28	6110643.97
2				
3				
4				
5				
6				
7				
8				
9				
10				
AVERAGE	**269232.41**	**6110643.68**	**269239.28**	**6110643.97**
Std Dev				

RTK DERIVED VESSEL GRID BEARING	**87.585**

NB: Make sure the axis AB match with the vessel centreline

VESSEL (OBSERVED) HEADING (ddd.ddd)	
Number of observations	**360**
Logging start time	16:39:11
Logging end time	16:45:09
Standard Deviation	0.022
AVERAGE HEADING	88.864

RTK Derived True Bearing:	89.04
Difference (degrees):	**0.18**

COMMENTS:
This check was done with the vessel on the trailer. 3 minute observations at bow and stern. The heading difference was not entered into the POSMV as it was within the accuracy tolerances of the heading check methodology. Also due to the short lever arms, the heading difference would have a minimal impact on the positioning of any calculated nodes.

PHS Rep: **Augustin Deplante** *Client Rep:* **Robyn Morcom**

Signature: [signature]

APPENDIX E - VESSEL POSITION CHECKS

VESSEL POSITION CHECK

TO BE PERFORMED PRIOR TO THE START OF SURVEYING AND ON A REGULAR BASIS

DATE:	**25/05/2020**	CONTRACT NUMBER:	**PHS-20-033-DEW**
CLIENT:	**Department for Environment and Water**		
PROJECT NAME:	**Port Stanvac Multibeam and Sub-Bottom Profiler Survey**		
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante (Online), David Miller (Skipper)**		
VESSEL:	**Marine Science**		
LOCATION	**Port Stanvac**		

POSITION CHECK WITH KNOWN POINT (SURVEY BENCHMARK) *Ref. form OPS-FOR-003*

	Survey Benchmark	**RTK Rover**	**Difference**
Name / Node	6527/7678	Trimble SP585 rover	N/A
Geodetic System	MGA94	MGA94	N/A
Eastings (m)	269409.979	269410.015	-0.036
Northings (m)	6110375.169	6110375.166	0.003
Height AHD (m)	17.091	17.091	0.000

GNSS Height reduction to vertical datum (LAT) verified ☐ *Method:*

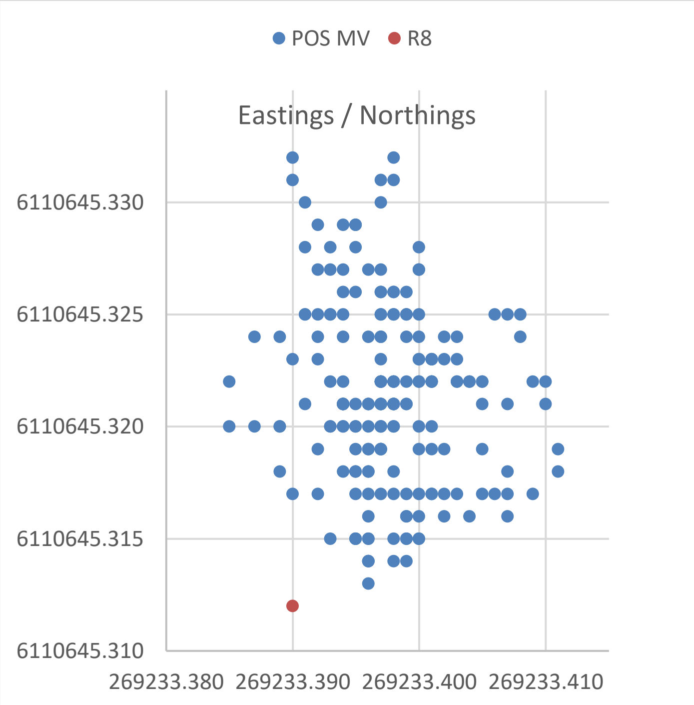
COMPARISON WITH VESSEL PRIMARY POSITIONING SYSTEM

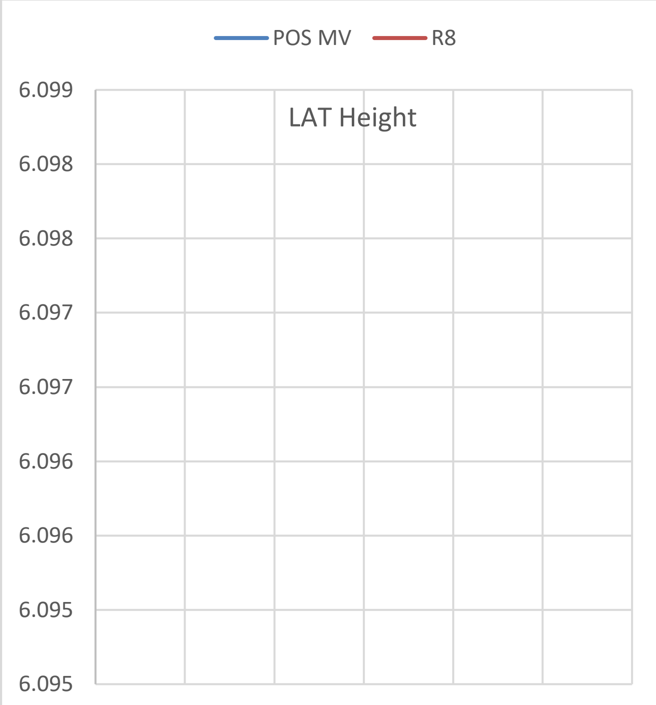
From the vessel primary positioning system through the navigation software, observe the position of a known point and compare with the position given by the verified GNSS unit (with unchanged configuration and GNSS correction source).

Observed node: ***Geodetic Settings:*** MGA94

Nav Software: ***AHD to LAT offset:*** -1.280 *negative value*

Observed period (s):	**Vessel Positioning**	**Verified GNSS unit**	
Equipment name	**POS MV**	**R8**	**Difference**
Eastings (m)	269233.398	269233.390	**-0.008**
Northings (m)	6110645.321	6110645.312	**-0.009**
LAT Height (m)	6.097	6.095	**-0.002**





COMMENTS:
The independent RTK check compares well against the POS MV derived node postion

PHS Rep: **Augustin Deplante** *Client Rep:* **Robyn Morcom**

Signature:

APPENDIX F - PATCH TEST REPORTS

PATCH TEST REPORT

TO BE PERFORMED PRIOR TO THE START OF SURVEYING AND ON A REGULAR BASIS

DATE:	**24/05/2020**	CONTRACT NUMBER:	**PHS-20-033-DEW**
CLIENT:	**Department for Environment and Water**		
PROJECT NAME:	**Port Stanvac MBES - SBP Survey**		
PERSONNEL:	**Mathieu Bestille (CPHS1), Augustin Deplante (Online), David Miller (Skipper)**		
VESSEL:	**Marine Science**		
LOCATION:	**Port Stanvac**		
COORDINATES:	**268581mE, 6112251mN (MGA94 Z54)**		

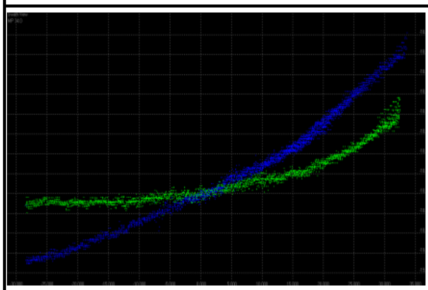
	Name	Direction	Used for	Transducer
Line 1	0002-Centre	NE	Roll	N/A
Line 2	0003-Centre	SW	Roll	N/A
Line 3	0006-Port	NE	Roll	N/A
Line 4	0007-Port	SW	Roll	N/A
Line 5			Roll	N/A
Line 6			Roll	N/A

Multibeam System used	R2Sonic202
Sonar Mounting	Pole
PPS Time synchro.	Yes
Positioning mode	RTK
Motion sensor	POSMV
Heading sensor	POSMV

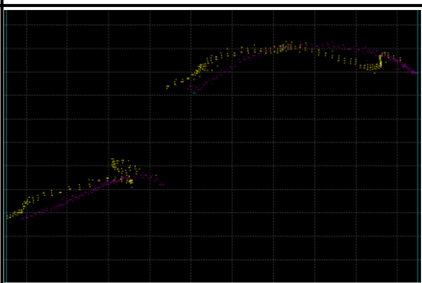
ROLL		PITCH		YAW	
C-O:	**-1.44**	C-O:	**2.1**	C-O:	**2.8**
Std dev.		Std dev.		Std dev.	

Manually derived	*Manually derived*	*Manually derived*

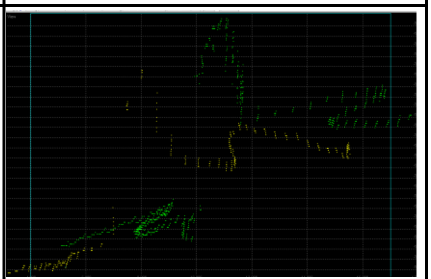
Before Roll Calibration



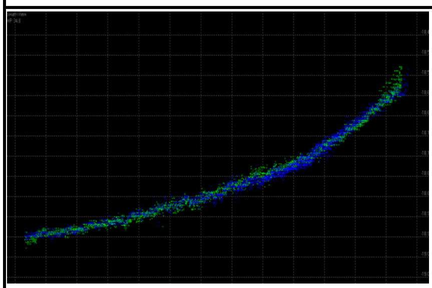
Before Pitch Calibration



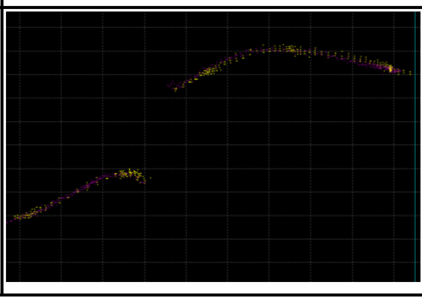
Before Yaw Calibration



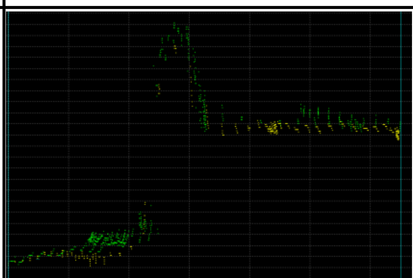
After Roll Calibration



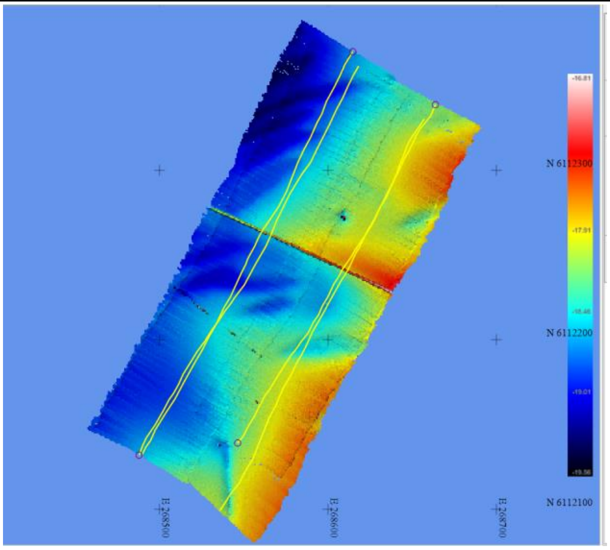
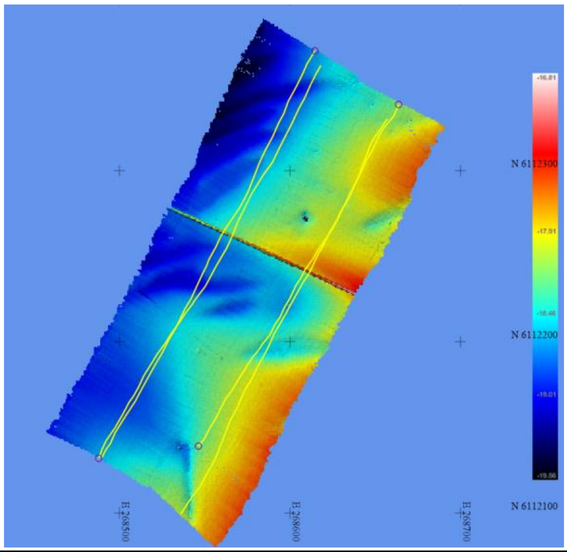
After Pitch Calibration

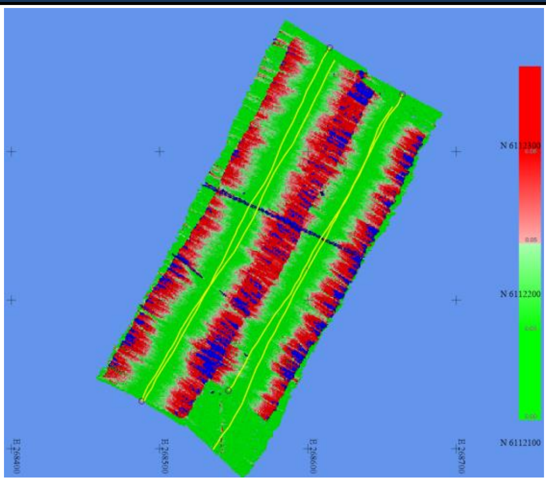
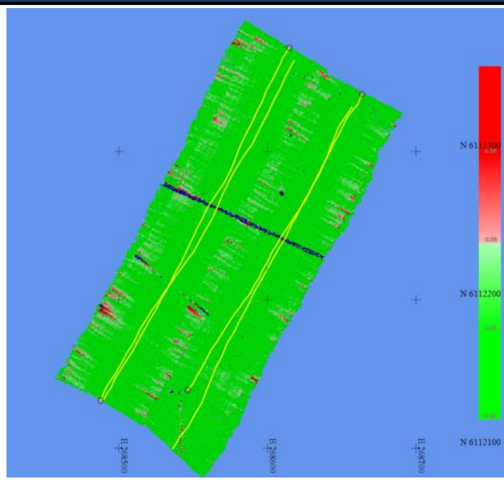


After Yaw Calibration



PATCH TEST REPORT

DTM BEFORE CALIBRATION	DTM AFTER CALIBRATION
	

95% CONFIDENCE BEFORE CALIBRATION	95% CONFIDENCE AFTER CALIBRATION
	

ANGULAR OFFSETS	Previous values	Measured angular offset	Difference
Roll (degrees)	0.00	-1.44	**-1.44**
Pitch (degrees)	0.00	2.10	**2.10**
Yaw (degrees)	0.00	2.80	**2.80**

LATENCIES	Previous values	Measured latency	Difference
Position (seconds)			**N/A - PPS in use**
Motion (seconds)			**N/A - PPS in use**

COMMENTS:
Patch test values entered in Qinsy

PHS Rep: **Augustin Deplante** *Client Rep:* **Robyn Morcom**

Signature:

APPENDIX G - BAR CHECK REPORT

BAR CHECK FORM

TO BE PERFORMED PRIOR TO THE START OF SURVEYING OPERATIONS AND ON A REGULAR BASIS

DATE: **25/05/2020** CONTRACT NUMBER: **PHS-20-033-DEW** CLIENT: **Department of Environment and Water**

PROJECT NAME: **Port Stanvac MBES - SBP Survey** VESSEL: **Marine Science**

SURVEY PERSONNEL: **Mathieu Bestilles (CPHS1), Augustin Deplante** LOCATION: **Port Stanvac (1km from jetty, open water)**

SOUNDING METHODOLOGY

Echosounder Type	Echosounder Model	S/N	Frequency	Pulse Width	SVS	SVP	Reduction Method	Vert. Datum	Nearest Tide Gauge
MBES	**R2Sonic 2024**		**400 kHz**	**15 us**	☑	☑	**RTK**	**LAT**	**Outer Harbour (Predicted)**

CONDITIONS — **Tide:** Slack (low) **Current:** **Sea State:** Good **Note:** Predicted tide only

VESSEL SETUP

VERTICAL OFFSETS		
	CRP	0.000
	Sounder Depth ref.	-0.430
	Draft ref. above CRP	1.400

Draf ref. to WL measurement	-1.080
Resulting Sounder Draft	-0.750

Refer to Draft Log Form OPS-FOR-007
with reference to the water line (neg. only)

BAR CHECK RESULTS

Observations averaged over minimum 30 sec. Sign Convention: Depth below transducer and below sounding datum always negative SVP applied: ☑ TX-RX Offset Checked ☑

Time local	Bar Depth negative	Tide from nearest tide gauge	Raw Depth Nadir beam negative only	Resulting Draft observed	Draft Difference with measured draft	Computed Depth LAT	Theoretical Depth LAT	Depth Difference	RTK Tide	Tide Difference	Validation
16:00:00	-3.23	2.20	-2.400	-0.830	0.080	-0.980	-1.030	-0.050	2.19	-0.01	☑
											☐
											☐
											☐
											☐

Diff. Threshold 0.100 Diff. Threshold 0.100 Diff. Threshold 0.100

COMMENTS: The weather and the survey location did not permit a proper bar check to be conducted. The bar check was conducted while the vessel was alongside as this was the most stable location, however the water depth was only 3m. A tape measure was used to measure the depth to the sea floor, and this was compared against the MBES depth. The MBES draft difference and LAT computed depth compared well against the computed tape values. The RTk water level compared well against predicted tides. Note that no tide gauge was available in this location.

PHS Rep: **Augustin Deplante** *Client Rep:* **Robyn Morcom**

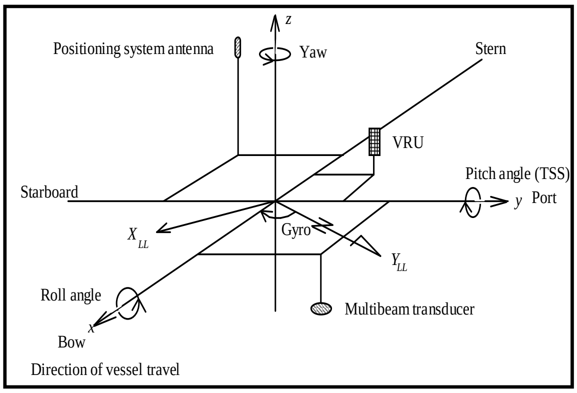
Signature

APPENDIX H - THEORETICAL UNCERTAINTY

Summary of Vessel Parameters and System Errors used to Calculate Uncertainty
Error values at 68% (1 Sigma)

Vessel Configuration		
Parameters	**Value**	**Comment**
Vessel	Marine Science	
Vessel noise (dB)	30	
Sounding speed (knots)	6	Maximum
Swath overlap (percent)	25	100% Coverage
Echosounder Frequency (KHz)	400	R2Sonic Setting
Number of Beams in Swath	256	R2Sonic Spec
Average Swath Width (degrees)	100	
Sector Steering Angle (degrees)	0	
Beamwidth Along Track (degrees)	1	R2Sonic 2024 Spec
Beamwidth Across Track (degrees)	0.5	R2Sonic 2024 Spec
Source Level (dB)	221	Power setting adopted on R2Sonic
Maximum Ping Rate Limit (Hz)	60	No Limit Enforced
Pulse Length (msec)	0.015	R2Sonic Setting
Speed Error (m/s)	1	
Motion Sensor	POS MV	
Heading Sensor	POS MV	
Positioning System	POS MV	
Multibeam System	R2Sonic 2024	
Sound Velocity Profiler	Valeport SWIFT SVP	
Surface Sound Speed Sensor	Valeport Mini SVS	

Environmental Factors		
Parameters	**Value**	**Comments**
Maximum Water Depth (m)	21	
Water Temperature (deg C)	15	From SV Profiles
Salinity (ppt)	38	From SV Profiles
pH	7.9	
Sound Speed (m/s)	1512	From SV Profiles
Peak-to-Peak Swell (m)	0.75	
Ambient Noise (dB)	30	
Highest Roll Angle Experienced (deg)	2	Transducer roll compensated
Highest Pitch Angle Experienced (deg)	5	Observed by POS MV
F-A Seafloor Slope (deg)	0	Generally flat seabed
P-S Seafloor Slope (deg)	0	Generally flat seabed
Backscatter Normal Incidence (dB)	-15	
Backscatter Oblique Incidence (dB)	-35	
Sound Speed Sensor Error (m/s)	0.2	Valeport Spec.
Surface Sound Speed Error (m/s)	0.02	Valeport Spec.
Spatio-Temporal Variation (m/s)	2	Assessed from Profiles
Thickness of S-T layer (m)	19	Well mixed water column
Sound Speed Error beyond Profile Depth (m/s)	0	Profiles taken to full depth
Maximum Sound Speed Profile Depth (m)	21	Profiles taken to full depth



Summary of Vessel Parameters and System Errors used to Calculate Uncertainty

Error values at 68% (1 Sigma)

Sensor Coordinate Offsets	Value	Comment
Positioning X (m)	0.93	From Vessel offset Report
Positioning Y (m)	2.226	From Vessel offset Report
Positioning Z (m)	2.899	From Vessel offset Report
Motion Sensor X (m)	0	From Vessel offset Report
Motion Sensor Y (m)	0	From Vessel offset Report
Motion Sensor Z (m)	0	From Vessel offset Report
Transducer X (m)	0	From Vessel offset Report
Transducer Y (m)	-0.02	From Vessel offset Report
Transducer Z (m)	-0.43	From Vessel offset Report
Roll Offset Angle of Transducer (deg)	-1.44	From Patch Test Report
Pitch Offset Angle of Transducer (deg)	2.10	From Patch Test Report
Heading Offset Angle of Transducer (deg)	2.80	From Patch Test Report
Transducer Draft (m)	0.77	From Vessel offset Report

Auxillary Sensor Errors	Value	Comment
Heave - Fixed Error (m)	0.00	Heave incorporated in the blended POSMV RTK height
Heave (% error of heave Amplitude)	0.00	
Roll (deg)	0.02	POSMV Spec.
Pitch (deg)	0.02	POSMV Spec.
Heading Error (deg)	0.03	POSMV Spec.

Patch Test Offset Precision	Value	Comment
Roll (deg)	0.10	From Patch Test Processing
Pitch (deg)	0.10	From Patch Test Processing
Yaw (deg)	0.10	From Patch Test Processing

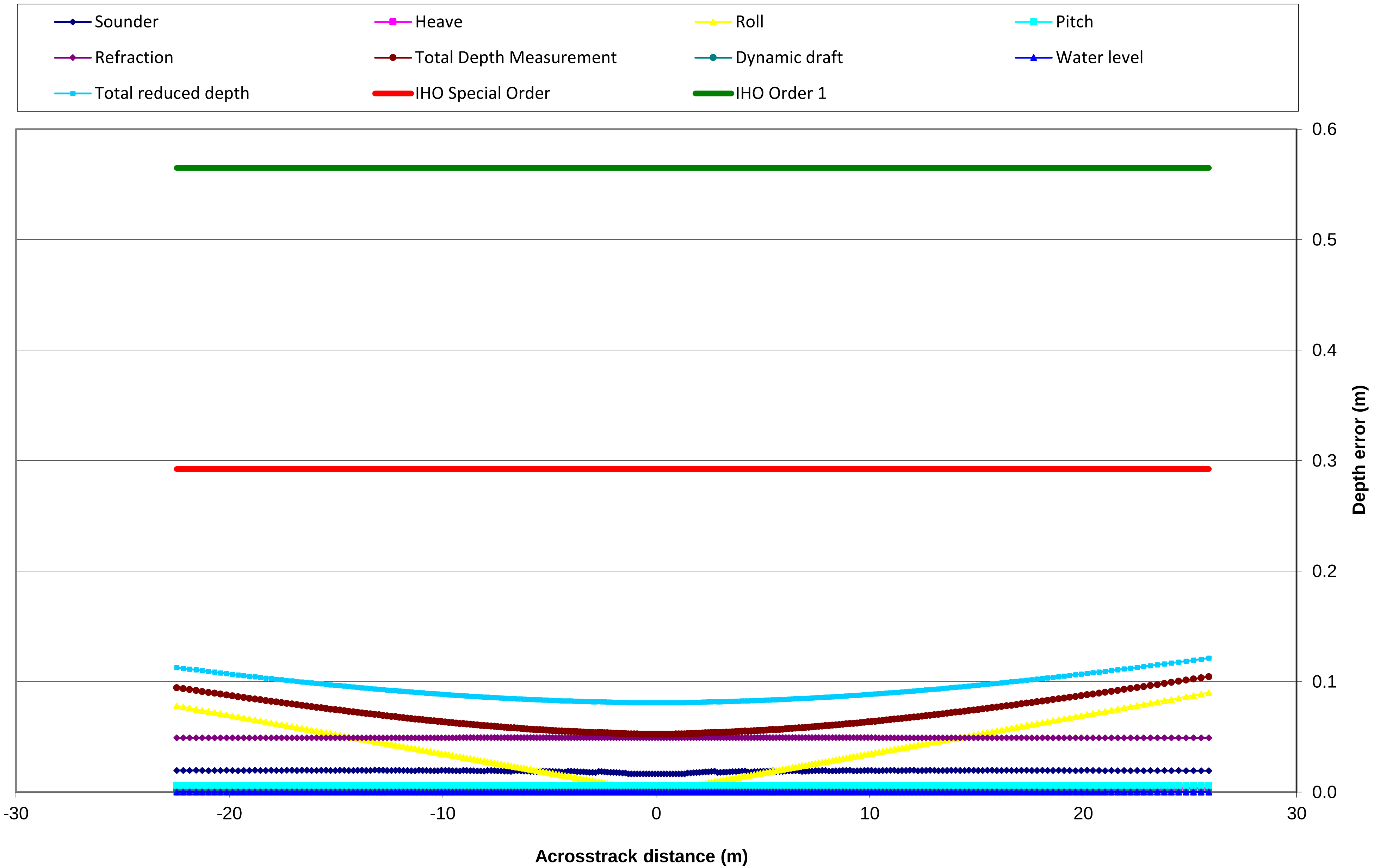
Positioning Errors	Value	
Base Station Positional Uncertainty (m)	0.008	From GA Report
GNSS Baseline (km)	5	Max distance from RTK Base
Horizontal Positioning System Error	0.013	Calculated from POS MV Spec
Vertical Positioning System Error (incl. heave)	0.028	Calculated from POS MV Spec

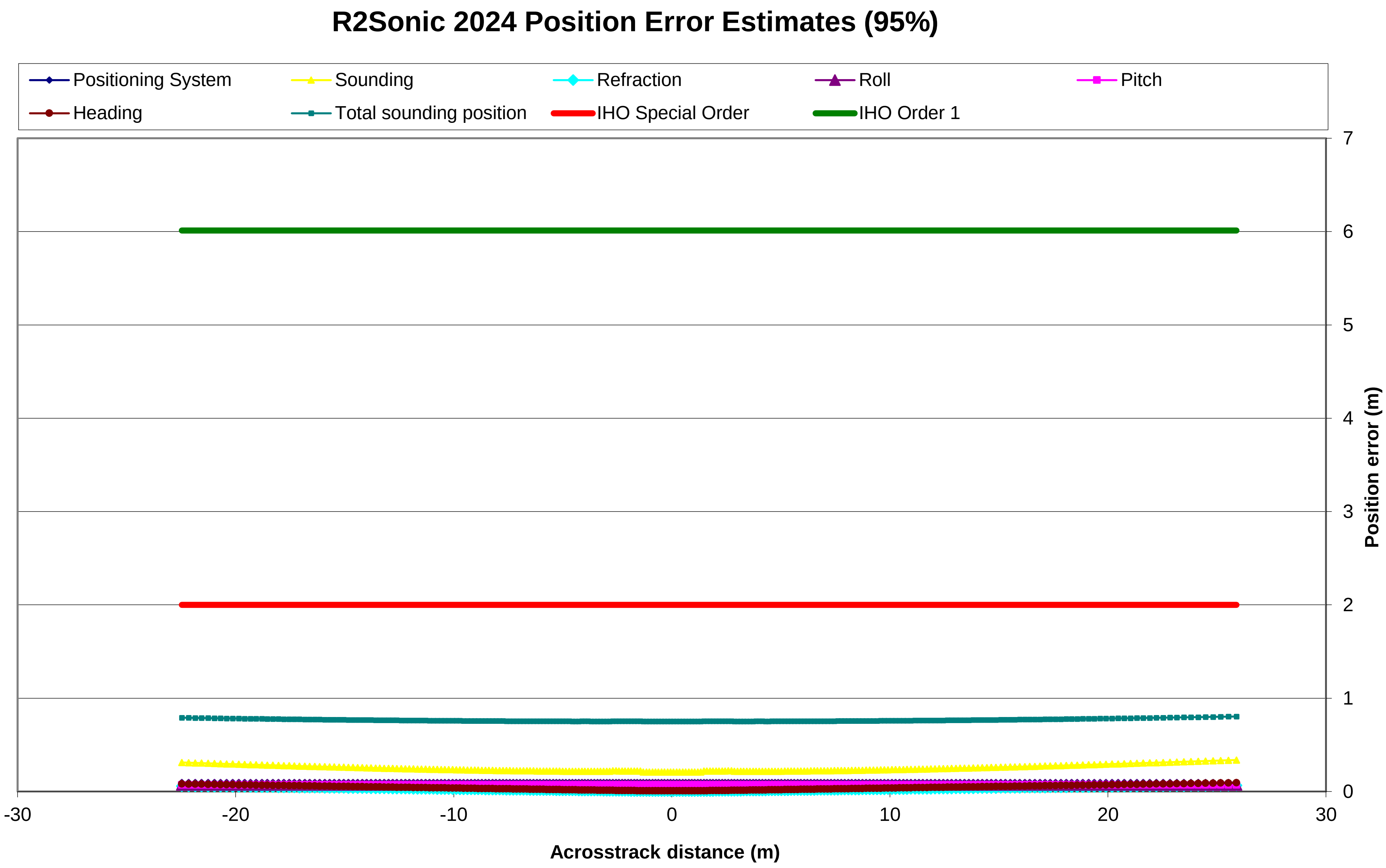
Sensor Coordinate Offset Precision	Value	
Positioning X (m)	0.01	Estimated measurement error
Positioning Y (m)	0.01	Estimated measurement error
Positioning Z (m)	0.01	Estimated measurement error
Motion Sensor X (m)	0.00	Estimated measurement error
Motion Sensor Y (m)	0.00	Estimated measurement error
Motion Sensor Z (m)	0.00	Estimated measurement error
Transducer X (m)	0.01	Estimated measurement error
Transducer Y (m)	0.01	Estimated measurement error
Transducer Z (m)	0.01	Estimated measurement error

Latency		
Positioning time lag (ms)	0.005	PPS Pulse = 5ms
VRU time lag (s)	0.005	PPS Pulse = 5ms
Transducer time lag (s)	0.005	PPS Pulse = 5ms
Latency (s)	0.005	PPS Pulse = 5ms

Reduction of Soundings		
Squat error (m)	0.00	N/A - RTK Heighting
Loading changes (m)	0.00	N/A - RTK Heighting
Gridding error	0.71	1m Mean Grid

R2Sonic 2024 Depth Error Estimates (95%)

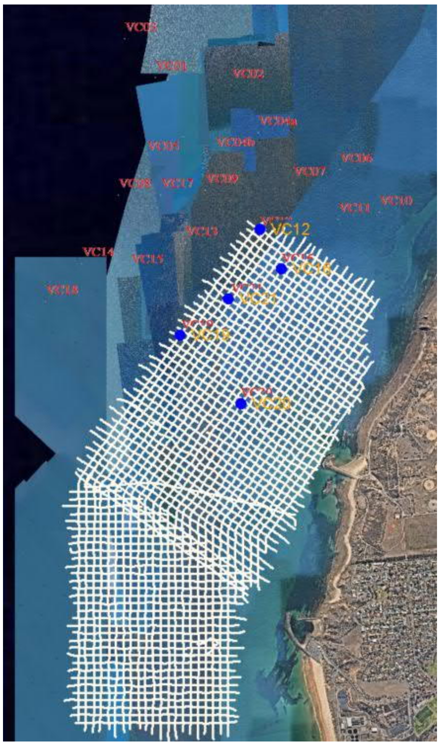


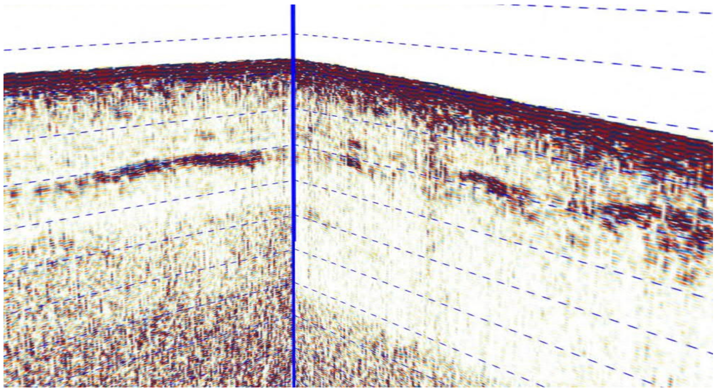

R2Sonic 2024 Position Error Estimates (95%)
Positioning System
Sounding
Refraction
Roll
Pitch
Heading
Total sounding position
IHO Special Order
IHO Order 1
7
6
5
4
3
2
1
0
Position error (m)
-30
-20
-10
0
10
20
30
Acrosstrack distance (m)

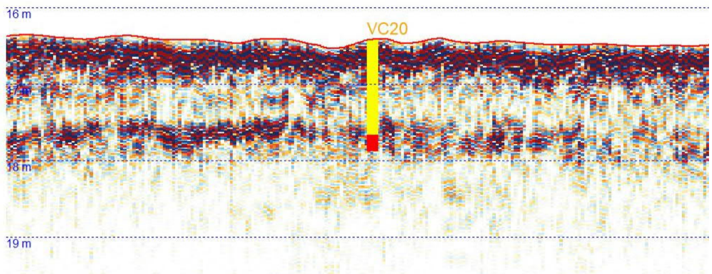
APPENDIX I – ACOUSTING IMAGING REPORT

Port Stanvac SBP Survey
June 2020

Precision Hydrographic Services







Assembled by D. Bergersen
June 19, 2020
Version 1.0

Introduction

Acoustic Imaging Pty Ltd (AI) was contracted by Precision Hydrographic Services (PHS) to process and interpret a set of subbottom profiler (SBP) data acquired around the Port Stanvac region of South Australia (Figure 1).

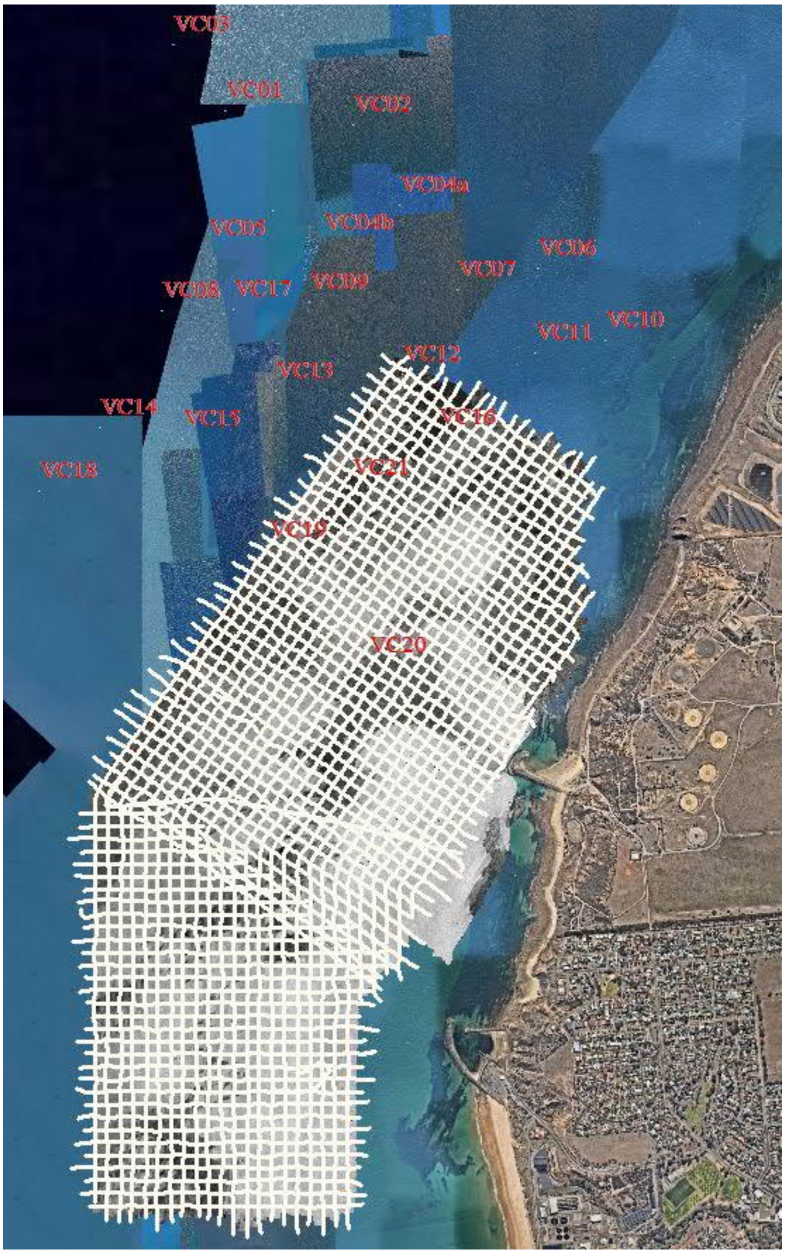


Figure 1: Location of Port Stanvac survey area. The 2020 SBP survey lines are shown as white tracks and cores from the SA Water 2008 Desalination Plant project shown as red text.

The SBP data were acquired on June 3-5, 2020 for the purpose of understanding sand unit thickness along this section of the coast, and hence the focus of this report is to describe the stratigraphic units observed in the SBP data and estimate sand unit thickness using an assumed sediment velocity.

Core data from the 2008 SA Water Desalination Plant Project was incorporated into the interpretation to identify the reflector most likely to represent the base of the primary sand unit. These cores are located across the northern third of the 2020 survey area, and extrapolation to the southern two-thirds was complicated as shallower reflectors appeared and disappeared across the site. The interpretation made for this report was intentionally kept simple because of time allocated to the project and presumed modification of the results as more core data becomes available (in particular to the significance of shallower reflectors observed above the interpreted "basal" reflector.

Data deliverables consist of this report and an ASCII file containing X,Y,Thickness information. A few suggestions for additional core locations are also provided.

Survey Methodology and Data Processing

The SBP data were acquired with an Innomar SES-2000 *compact* parametric sub-bottom profiler system pole-mounted on a Department of Environment and Water survey vessel. A set of 26 primary lines were run parallel to the coast and approximately 77 cross lines were surveyed perpendicular to the coast. All lines were spaced at 50m.

All data were acquired using an 8 kHz secondary frequency with 2 pulse cycles resulting in a pulse length of ~250 µsec. Reflector resolution in this case is around 35cm. These settings were selected based on trial lines run parallel and perpendicular to the coast before the commencement of main survey activities.

Table 1 Acquisition parameter for SES-2000 *compact* system

Parameter	Settings for bedload thickness survey
Primary source level	> 236 dB re 1µPa @ 1 m
Secondary source level	> 200 dB re 1µPa @ 1 m
Primary centre frequency	100 kHz
Secondary frequency	8 kHz @ 2 pulse cycles
Beam angle	2.0° @ -3 dB
Transmitter pulse length	250 µsec
Recording range	20-22m
Sampling interval	126 µs
Ping rate	approx. 20 Hz

Data supplied for this report consisted of full waveform .RAW files. Data were analysed with both the Innomar ISE software and Chesapeake SonarWiz software.

The RAW files were first converted to SEG-Y format and then imported to SonarWiz. The SBP data were enhanced through application of an Automatic Gain Control (AGC) algorithm and noise-reduction filters.

Interpretation techniques included automated picking of the seabed reflector and manual picking of the reflector marking the base of the primary sand unit lying above a calcarenite unit observed in the 2008 core data.

Core data results as shown in the document "*ADP SV300 321 logs 2008.doc*" were extrapolated from their listed GDA94 location to the nearest SBP line within SonarWiz (unfortunately these core locations were not incorporated into the line plan and hence no lines were run directly over them). The table below shows all the cores that are located within the 2020 survey area and their associated SEGY files.

Table 2: 2008 Desalination Plant cores and associated 2020 SBP lines

SA Water Core Id	SBP Profile	Offset (m)	Core Direction
VC12	05062020_150042	16	SW
VC16	03062020_130151	9	NW
VC19	03062020_095602	3	NW
VC20	03062020_151947	12	NW
VC21	05062020_134451	8	NE

The consistency/brightness of the sand/calcarenite reflector varied across the survey area, largely due to the amount of overburden at any given location and other reflector horizons within the sediment column. Examples are shown in the Interpretation section below.

A 1500 m/sec sound velocity was used for initial display of profiles in SonarWiz (conversion of the two-way time associated with the SBP trace data to a metric measurement) and calculation of sand unit thickness. These values were then scaled up using the velocity assigned to the 2008 seismic survey conducted for the SA Water Desalination Plant project (1750 m/sec) for the sake of consistency.

Interpretation

Overview

Gridded bathymetry and backscatter data were provided to assist with the SBP interpretation but a detailed description of those data sets isn't included in this report as it's outside the scope of the contracted work.

General observations from the bathymetry data include:

- Clear outcrops of rock/reef material existing in the NE corner of the survey area.
- The Desalination Plant outfall pipe and transfer station appear across the central section of the area.
- Isolated patches of higher rugosity seabed exist north of the outfall pipe and across the southern half of the survey area suggesting coarser, more cemented sediments in these regions.

For the backscatter data, observations include:

- Pronounced regions of high and low backscatter intensities (PHS applied a colour palette whereby lower backscatter areas are denoted by whiter pixels and higher backscatter regions are marked by dark grey or black pixels).
- Darker regions mostly confined to seabed depressions or regions of local erosion across the bulk of the survey area.
- Reef/rock areas adopt a dark grey tone with additional finer scale structure apparent in the imagery.

The SBP interpretation proceeded by first loading in the 2008 SA Water Desalination Plant Project core results on to the closest associated SBP survey line as listed in Table 2. Cores VC19, VC20, and VC21 proved to be the most useful for identifying the reflector associated with the primary Sand unit overlying a Calcarenite "base" unit (Figure 3). The other available cores located across the 2020 survey area highlighted the complexity of stratigraphic units existing across this area (e.g., the Clay and mixed Clay/Silt/Sand units in VC16 representing Holocene coastal lagoon and estuarine sediments). The interpretation in this report limited the scope to identifying the primary sand unit thickness. Much more work can be done on mapping the internal reflectors to the sand unit once additional core data is available.

Next, the reflector marking the Sand/Calcarenite boundary at the key core locations was traced as far as possible along each of the nominated SBP lines shown in Table 2. The reflector was then traced along the nearest cross lines before finally extending the interpretation across the entire surveyed region.

Cross ties between lines were computed in SonarWiz and used to display where the interpreted reflector appeared on any new lines. Modifications were made as the interpretation/analysis proceeded because the Sand/Calcarenite reflector appeared and disappeared across different parts of the survey area.

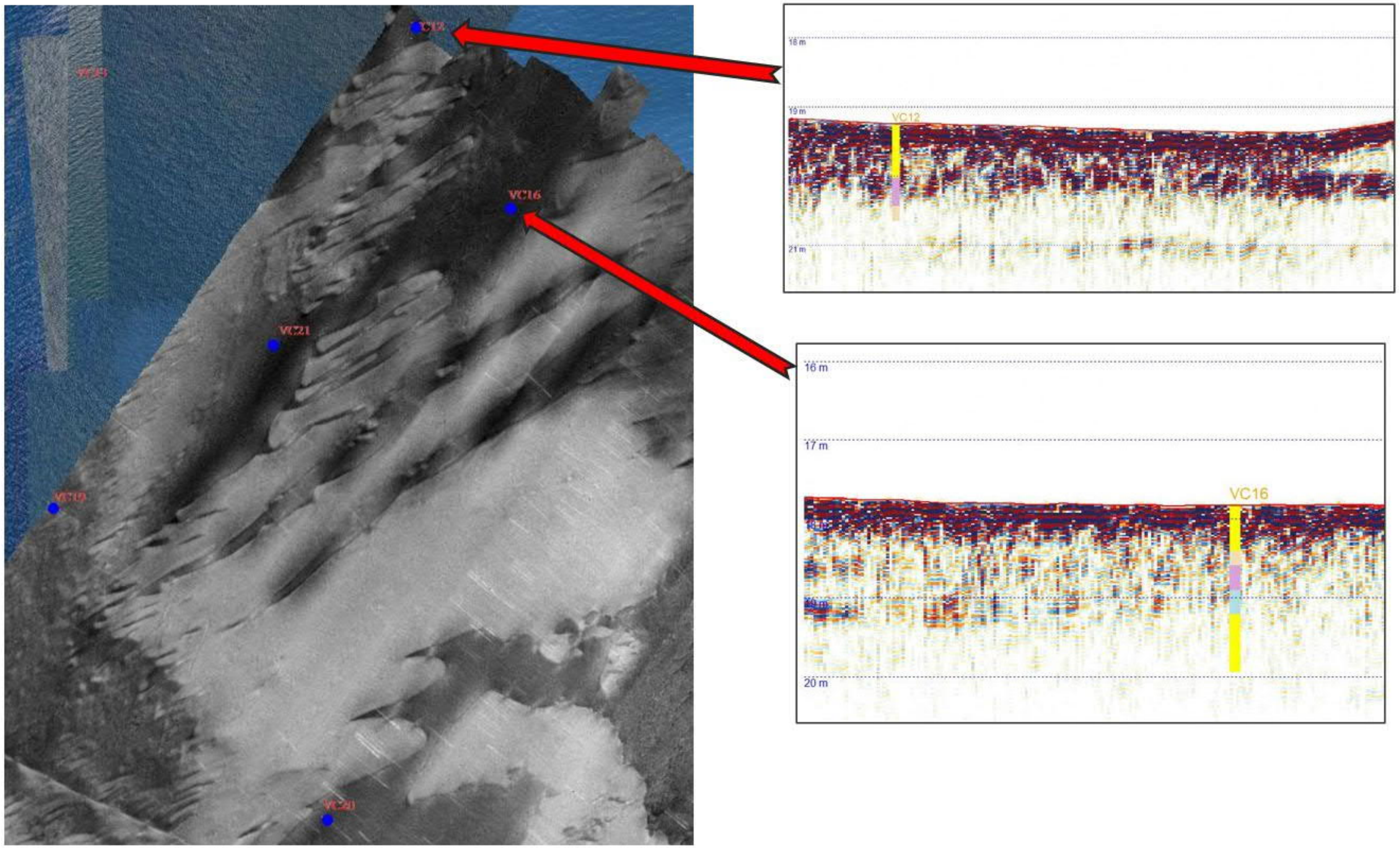


Figure 2: Location of 2008 SA Water Desalination Plant cores VC12 (top) and VC16 (bottom) relative to backscatter mosaic. Colour coding of core contents is Yellow = Sand, Wheat = Coarse Sand, Plum = Clay, Blue = Mixture of Clay/Silt/Sand.

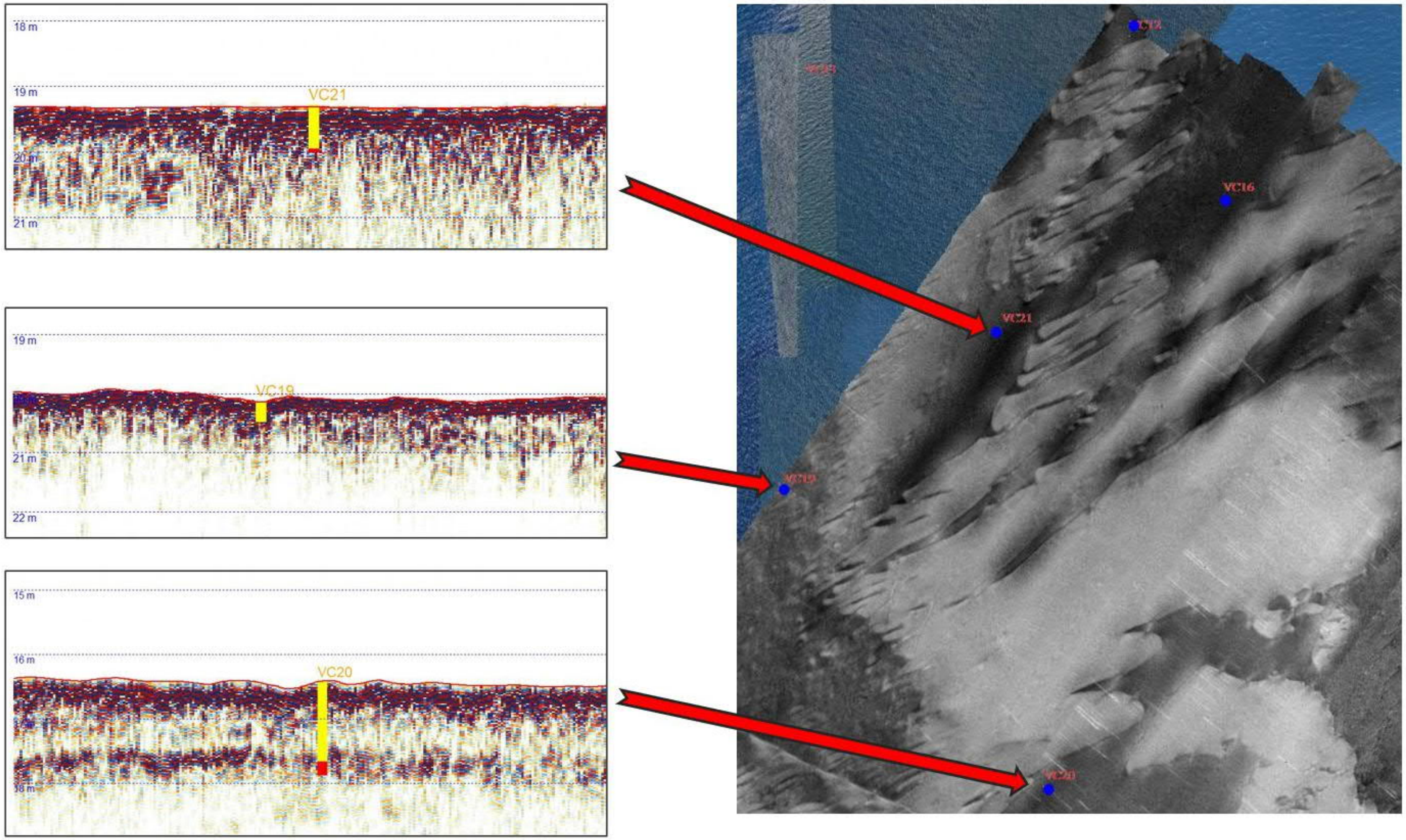


Figure 3: Location of 2008 SA Water Desalination Plant cores VC21 (top), VC19 (middle), and VC20 (bottom) relative to backscatter mosaic. Colour coding of core contents is Yellow = Sand, Red = Calcarenite.

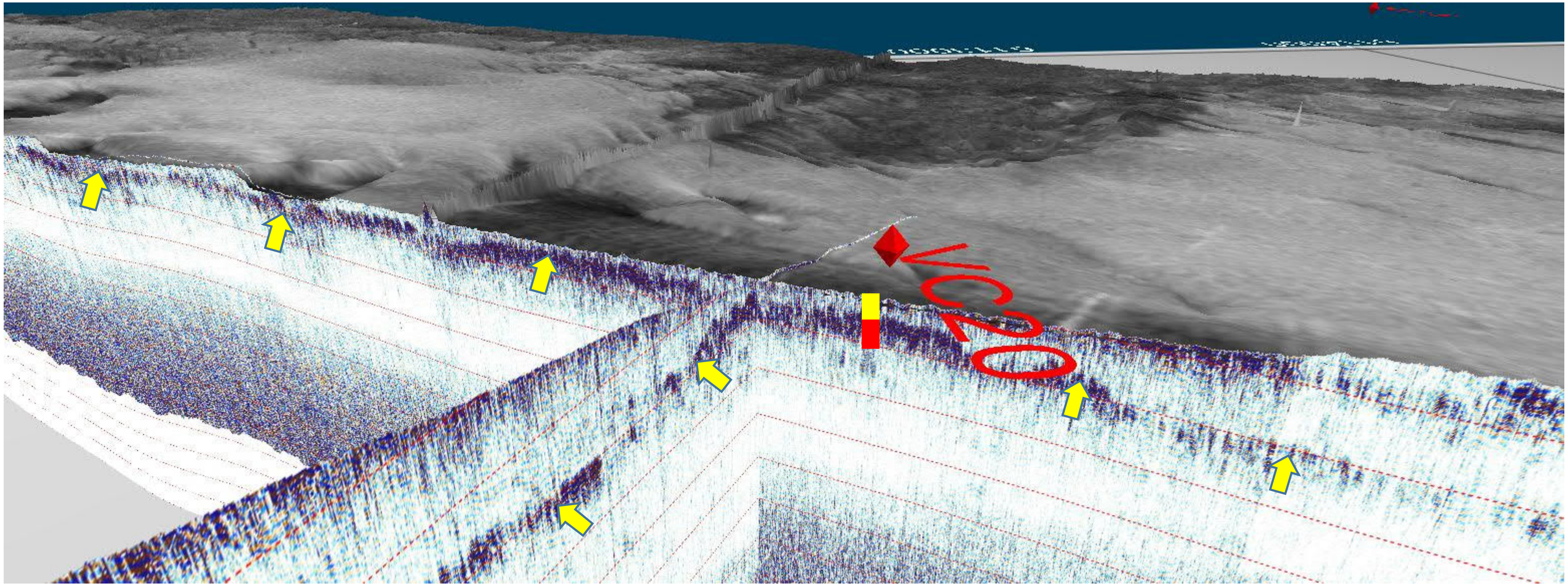


Figure 4: Perspective view of two SBP lines crossing near the location of core VC20. Sand/Calcarenite boundary reflector highlighted by Yellow arrows.

Primary Sand Unit

The figure below provides an overview of the primary Sand unit thickness across the 2020 survey area. The colour palette applied was somewhat arbitrary because no critical thicknesses were defined in advance of this analysis. In essence, thinner sand areas are denoted by Red/Yellow colours and thicker sand sections are shown as Green/Blue. Thinner sand sections exist across the NE corner of the survey area where reef/rock outcrops occur, across a section in the centre where a rough topography and a seabed lineation suggest fault may lie, and in the south where localised cementation may occur.

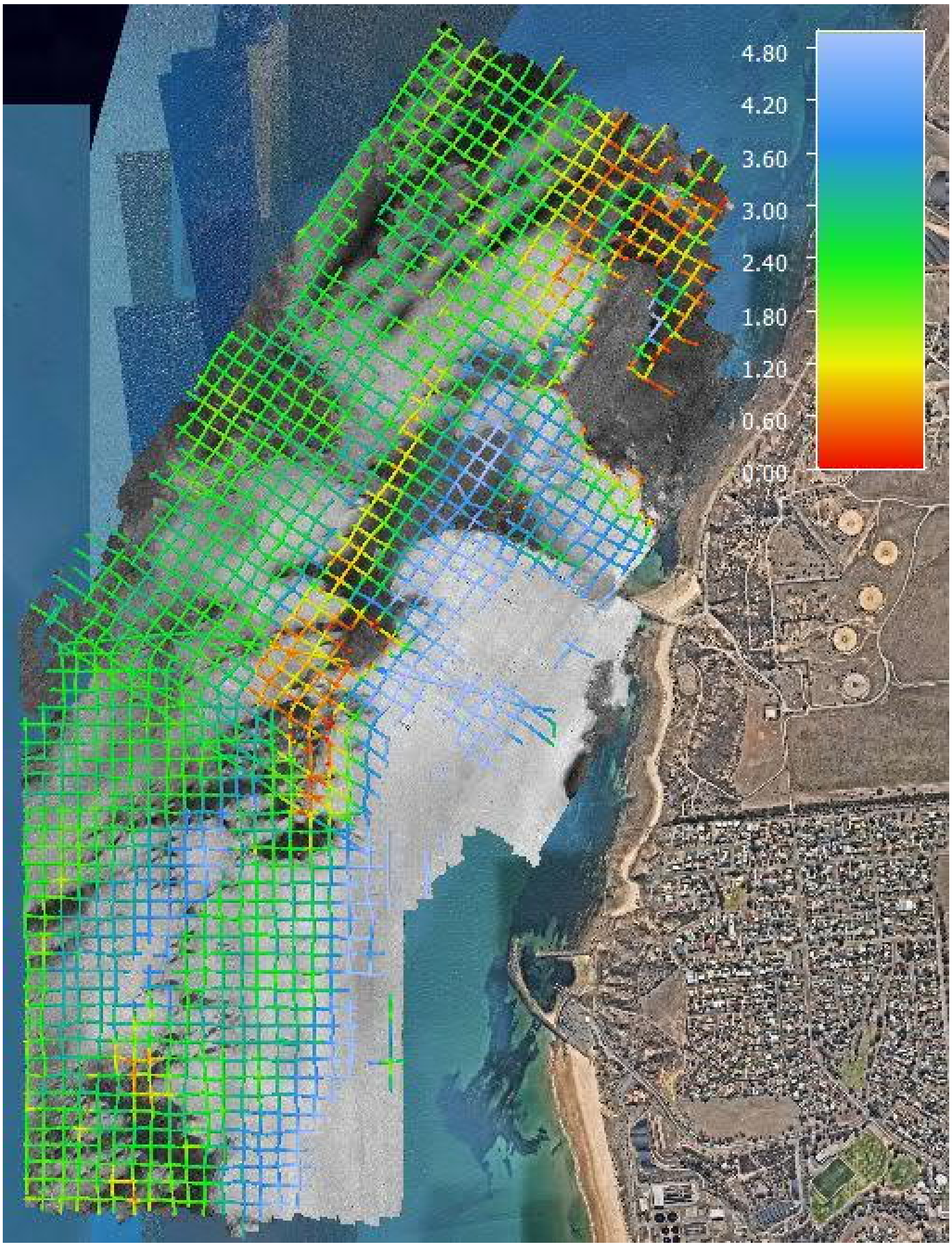


Figure 5: Overview of Primary Sand unit thickness across 2020 survey area.

In the NE corner the tilted basement reflectors are clearly visible in the SBP data. A thin secondary sediment unit overlies the primary Sand unit in the figure below. A similar unit appears along the entire coastal section but was not mapped in detail as part of this report as it's importance for sand assessment was unknown (and beyond the scope of contracted work). In this case the Sand-Calcarenite reflector represents the exposed basement section. Farther south along the coast the reflector dips beneath the overlying sediments and can only be traced a certain distance landward along the SBP transect.

Biogenic growth on top of the reef/rock outcrop was apparent in the SBP but was not mapped in detail as part of this report.

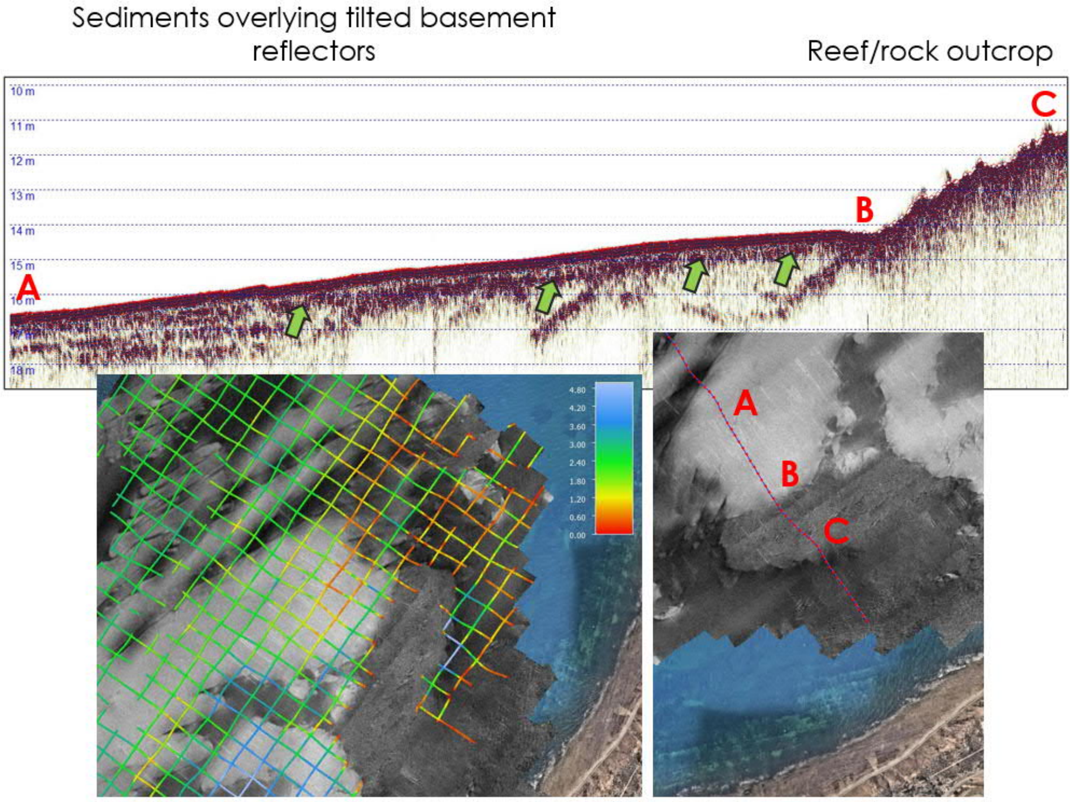


Figure 6: SBP transect across exposed reef/rock outcrop along with Sand thickness around this region. Green arrows mark a thin sediment unit overlying the primary Sand unit.

Another area where the Calcarenite unit appears to be exposed lies in the central section of the survey area, approximately 400m to the SW of the outfall pipe.

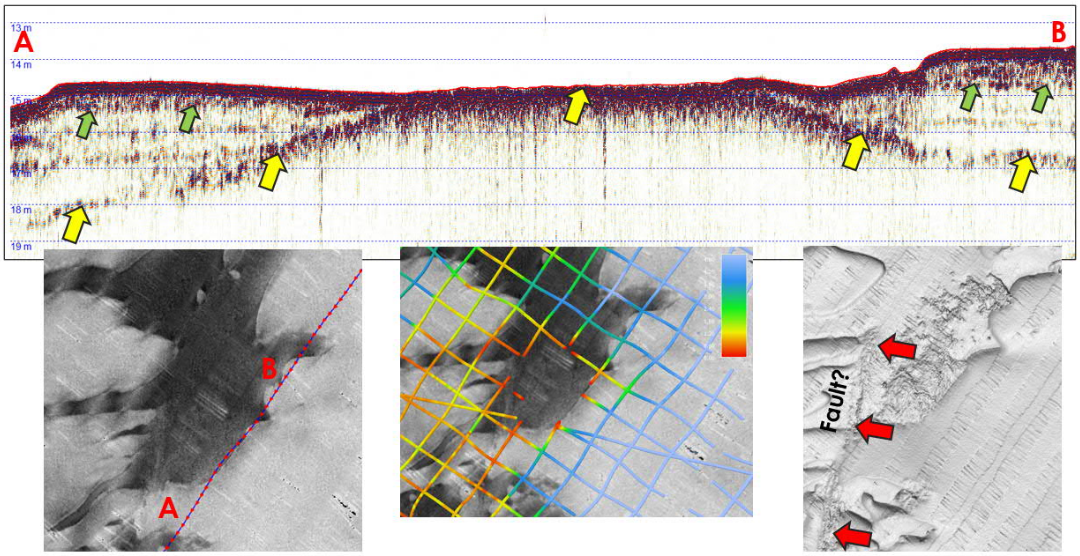


Figure 7: Local exposure of Calcarenite unit. Yellow arrows mark the Sand/Calcarenite boundary reflector whereas Green arrows mark the base of a surface unit lying on top of the primary Sand unit. Red arrows in lower left figure show possible fault scar visible in the bathymetry data.

Areas which exhibit low and high backscatter seabed generally show good acoustic penetration within the low backscatter sections with some degree of internal bedding. The high backscatter sections are more acoustically homogenous and provide less penetration (and hence more difficult to trace the primary Sand/Calcarenite reflector). The figure below is a representative example.

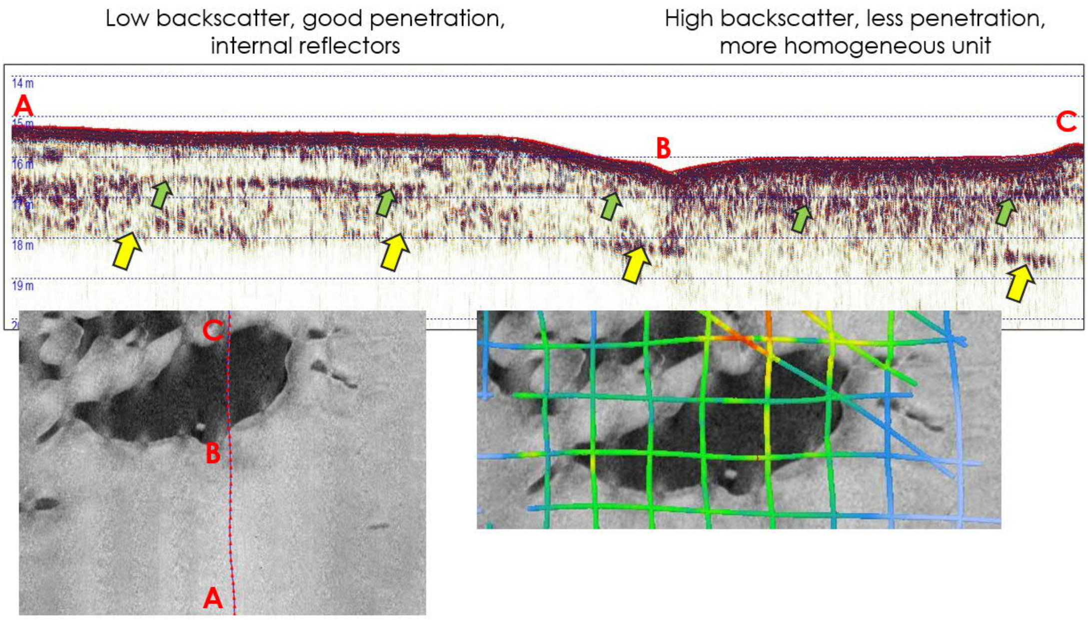


Figure 8: Typical seismic stratigraphic structure of areas transitioning from low backscatter seafloor to high backscatter seafloor. Yellow arrows mark the Sand/Calcarenite boundary reflector whereas Green arrows mark the base of a surface unit lying on top of the primary Sand unit..

This pattern holds for the southern section of the survey as well (Figure 9).

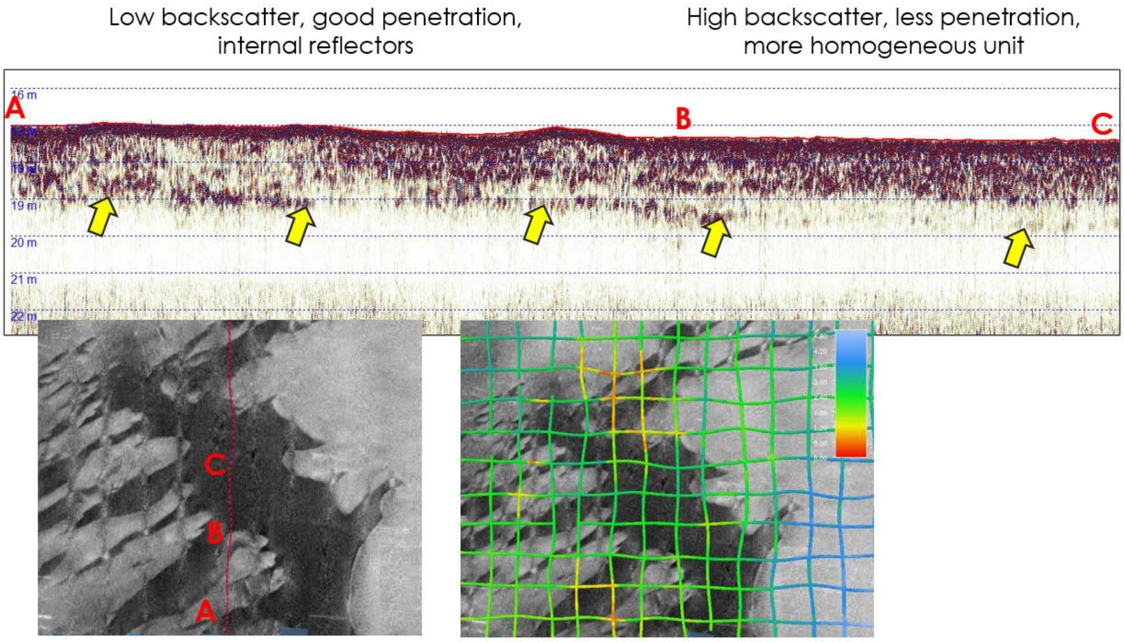


Figure 9: Transitional area in southern half of 2020 survey block. Yellow arrows mark the Sand/Calcarenite boundary reflector.

As noted previously the analysis for this report was limited to the interpreted primary Sand unit lying above a presumed Calcarenite unit. However, a number of subunits exist within the primary Sand unit as shown in the figure below. The reflectors defining these units are generally not continuous across the entire site, and may represent local clay horizons or areas of cementation or deposits of coarser material.

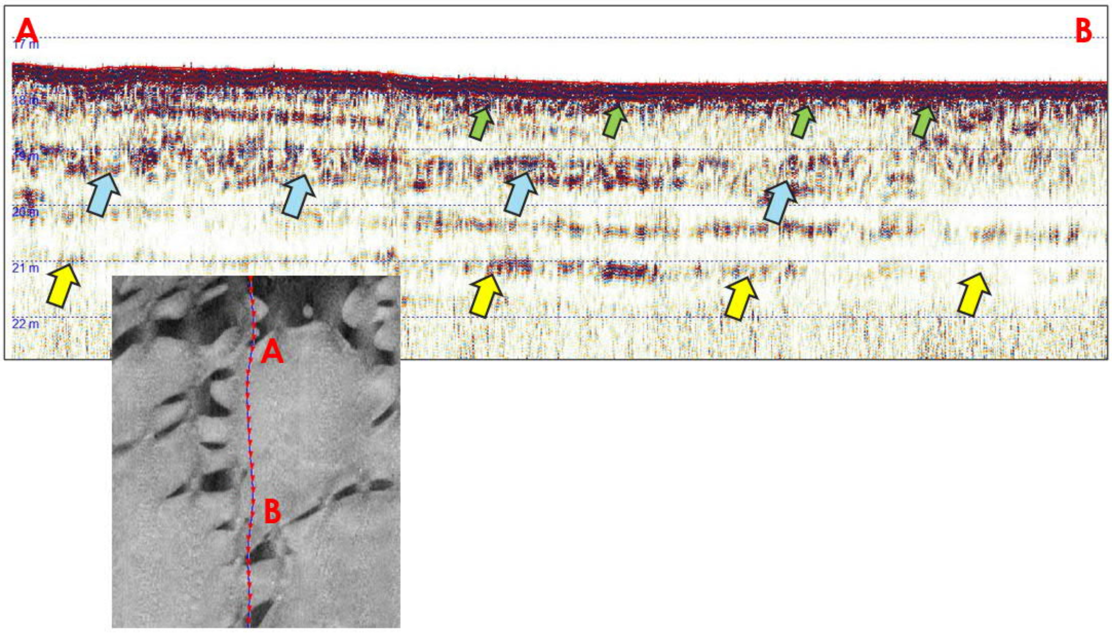


Figure 10: Examples of stratification within a section of low backscatter seabed. Yellow arrows mark the Sand/Calcarenite boundary reflector, Blue and Green arrows mark horizons and subunits within the primary Sand unit.

The current interpretation will no doubt undergo modification once more core data becomes available, especially across the southern half of the survey block. The table below provides recommendations for core locations to assist in understanding the stratigraphy shown in the SBP data. These may or may not be best suited for sand dredging objectives and hence are only suggestions.

EASTING	NORTHING	OBJECTIVE
268182.59189799	6112130.07940938	Multiple reflectors, seaward extent of block
268560.57978819	6111618.10516997	Fault Zone
268489.78338774	6111149.64631723	High Backscatter area
268142.15315030	6111055.12205975	Subunit definition
267991.74066340	6110452.20897602	Transition zone; southern extent of block

Summary

The SBP data collected as part of the June 2020 Port Stanvac survey provides some interesting insights to seabed features and sediment units across this region, complimenting the previous work done to the north of the site. The SBP data acquired were of very good quality, as resolution and vertical penetration were sufficient for addressing survey objectives. The SES-2000 system should not be viewed as a replacement for boomer or sparker type seismic surveys as those systems provide much greater penetration (usually) but at a much lower resolution. The SES-2000 parametric systems are designed to provide detailed information on the uppermost sediment column which in the case of sand type deposits is generally 4-8m.

The primary sediment unit mapped as part of this interpretation was a Sand unit lying above a presumed Calcarenite unit (as determined from existing 2008 SA Water Desalination Plant core data). The reflector marking the boundary between these 2 units was traced as best as possible across the 2020 survey area, with the thickness derived using a sediment velocity of 1750 m/sec. The primary Sand unit thins and thickens across the site with a prominent outcrop of basement occurring in the NE corner of the survey block and a smaller area towards the center of the block.

High backscatter areas of the seabed correspond to more homogeneous units in the SBP data and generally less acoustic penetration. Low backscatter areas show greater acoustic penetration and more internal layering of the primary Sand unit.

The reflector bounding the Sand unit varied in continuity and acoustic strength, and in some areas included internal reflectors. The internal reflectors mark a variety of different features including coastal lagoon/estuary facies, localised coarse sediment deposits or cementation horizons, and more mobile surficial sediments. A more detailed interpretation and possible modification of the current interpretation could be conducted after the next phase of coring if the information assists in site management.