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Document Description		**GEOPHYSICAL SURVEY REPORT**
		Marine Magnetic survey at proposed barge landing site, South Thomson Bay
Document ID		SH20191111_November_2019_RIA_South_Thomson_Bay_Magnetic_Survey
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Project Name		
Contract Number		
Client		Rottnest Island Board

REVISION HISTORY

REV	DATE	REVISION DESCRIPTION	BY	APPROVED
Rev2	15/2/2019	Final.	JMA	
Rev2a	25/2/2019	Updated with defence.gov.au/uxo classification		

DISTRIBUTION LIST

Rottnest Island Authority	ROTTNEST IS

QAS INTERNATIONAL ISO 9001:2015 REGISTERED COMPANY Certificate No. AU1649

Surrich operates under the QAS international ISO 9001:2015 quality management system.

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ABBREVIATIONS

The following abbreviations may be used in this document

AUSPOS	Online GPS base post-processing facility by Geoscience Australia
AHD	Australian Height Datum
CD	Chart Datum
GDA94	Geocentric Datum of Australia 1994
HP	High Pass
Mag	Magnetics
MM	Marine Magnetics
MGA	Map Grid Australia
nT	nanoTesla
UXO	Unexploded Ordnance

Table 1. Abbreviations

1 INTRODUCTION

In November 2019, Surrich Hydrographics was contracted by RIA to conduct a 'UXO survey over proposed dredge area'. Surrich proposed a magnetic survey as a component towards accessing the UXO risk and clearance of the site.

The survey extents were subsequently increased during acquisition to include coverage over the proposed works areas where accessible to the marine magnetic survey.

Surrich provided support to the TAMS dive team performing sediment jet-probing and follow-up investigation of the magnetic targets in the form of preliminary magnetic results, supply of positioning equipment and on-line support of the digital charts used for precise navigation and location of targets.

Figure 1. Army Jetty, South Thompson Bay. Marine Magnetic survey to cover the proposed dredge areas (red boundary).

2 UNEXPLODED ORDANANCE (UXO) RISK

It is outside the experience and capability of Surrich Hydrographics to assess the risk of UXO. The following assessment of risk is not comprehensive and is from public data published on the following web site: https://www.defence.gov.au/uxo/.

By utilizing the mapping application and this information, the user accepts the following disclaimer provided on the web site:

> ***Disclaimer:*** *The data supplied is based on Defence's assessment of information obtained from a variety of sources. It does not reflect any UXO remediation conducted on behalf of any person or organisation other than Defence. While Defence makes all reasonable efforts to ensure that the information provided is accurate, complete and up-to-date, there may be limitations to the sources available to Defence and the information may be subject to change. The information relating to a specific parcel of land should not be relied upon without additional checks and/or verification from the relevant state, territory or local government.*
>
> *Source:* https://www.defence.gov.au/UXO/Where/Default.asp

The screen capture presented in Figure 2, shows Rottnest Island has been categorized with a residual Unexploded Ordinance (UXO) potential as "slight". Although the Survey area falls outside the immediate classification boundary, for the purposes of this assessment, we shall interpret the survey area as being subjected to the same classification as the adjacent land area.

The "slight" classification is defined as follows:

> **Slight**
>
> Areas categorised as slight will have a confirmed history of military activities that have resulted in residual UXO but which Defence considers it inappropriate to assess as substantial.
>
> **Warning:** Allied Defence Forces used many areas throughout Australia, during and after World War II, for encampments, field training, live firing of weapons and other military activities. This property is on such a site. A possibility exists that dangerous items of Unexploded Ordnance (UXO) may still be found on this site. If you should find a suspicious item, that may be a UXO, do not touch or disturb it. It has been there for many years, it will not hurt you if you do not disturb it. There are no known instances, in Australia where UXO have caused injuries except when they were deliberately and intentionally disturbed. Contact police they will arrange for military experts to attend and dispose of it.
>
> **Advice:** All land usage and development, within these areas, may continue without further UXO investigation or remediation.
>
> Source: https://www.defence.gov.au/UXO/What/Categories.asp

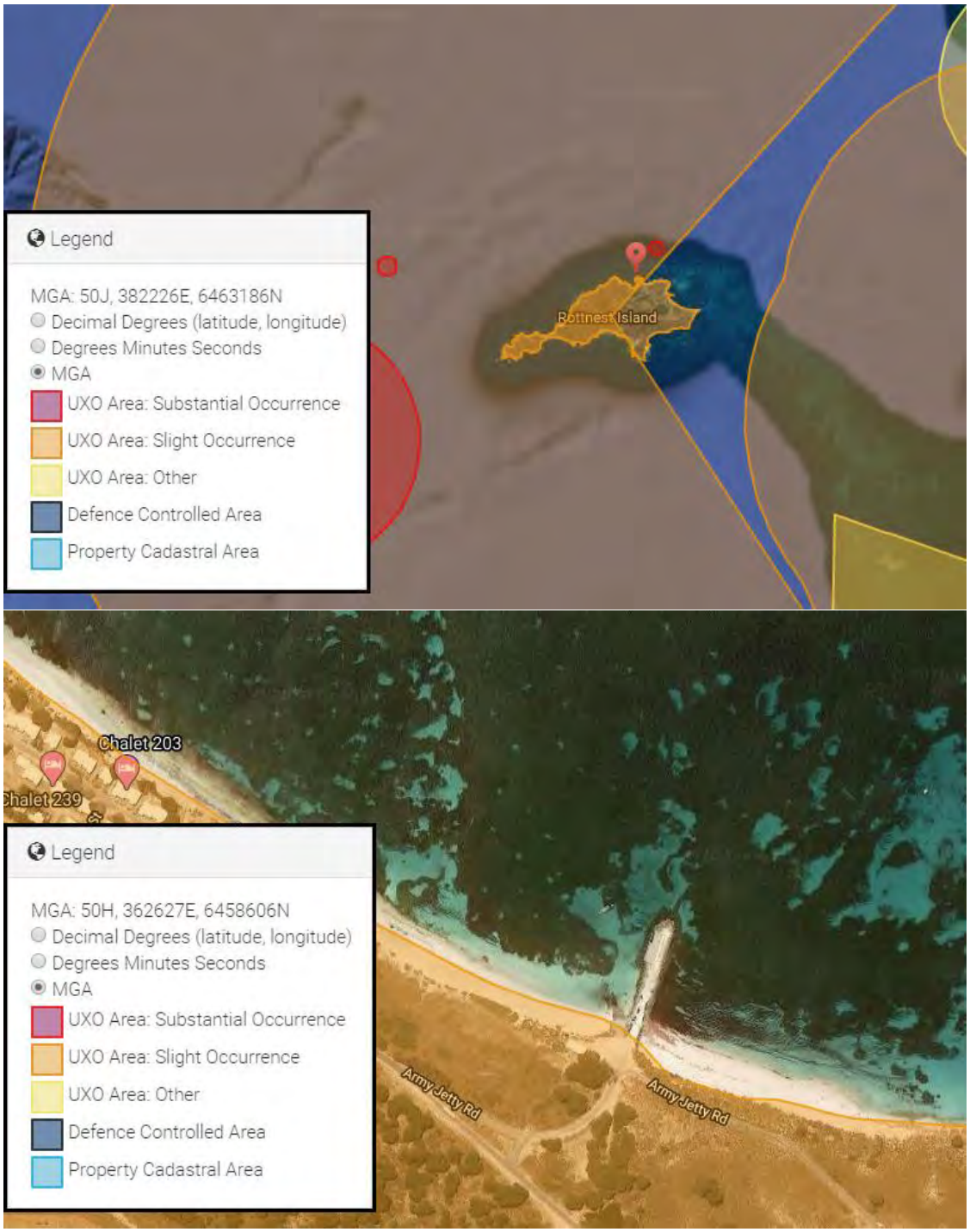

Figure 2. Screen capture from the UXO mapping application.
(Source: https://www.defence.gov.au/uxo/)

3 DISCLAIMER

The interpretations contained in this report are based on the training and experience of the author and information passed on during the investigation. As with all geophysical data, multiple interpretations are possible. 100% imaging of the seabed at consistent accuracy and resolution is unachievable. There are limitations to every geophysical technique. The client is advised to consider information from all available sources prior to deciding on how to proceed.

4 LIMITATIONS

4.1 SURVEY COVERAGE

Survey coverage was achieved across the dredge area and wharf extension footprint.

Due to the thick seagrass accumulation along the beach, it was difficult to achieve consistent coverage immediately parallel to the beach.

4.2 MARINE MAGNETICS

The marine magnetic method responds to man-made ferrous objects above and below the seabed, as well as magnetic minerals in the geology.

The magnetic method does not have the ability to locate all ferrous objects in a survey area. The probability of detection decreases as iron content becomes less and distance from the sensor increases. Operating in high gradient areas, for example, around wharves and steel vessels, reduces the ability of the technique to detect objects on the seabed.

Quantitative interpretation relies on an accurately sampled field, however in practice, even small errors in sensor positioning during marine survey reduce the reliability of the interpretation.

5 FIELD LOGISTICS

5.1 SAFETY

No safety incidents.

5.2 PROJECT TIMELINE

Activity	Dates
Survey acquisition	6/11/2019 - 7/11/2019

Table 2. Project Timeline

5.3 PROJECT PERSONNEL

Name	Role	Qualifications
A. Richardson	Maintain the RTK base station and positioning QC.	Bachelor of Surveying, CPHS 1
J. Anning	Geophysicist, Project Manager, coxswain. On-line support of TAMS divers positioning systems.	Bachelor of Geophysics
G. Edwards	Geophysical and hydrographic survey acquisition, coxswain.	

Table 3. Project Personnel

6 ACQUISITION

6.1 SURVEY VESSEL - BASE OF OPERATIONS

Name	Intrepid
Description	7m Aluminium catamaran. Twin 150hp outboard engines.
Survey Certificate	2C (non passenger vessel, offshore to 30nm)
Navigation Equipment	Plotter/sounder
Communications	VHF
Safety Equipment	All safety equipment as required by AMSA regulations for this class of vessel.
Safe Management System	The vessel operates under a Safety Management System (SMS) developed and maintained to AMSA standards.

Figure 3. Survey Vessel "Intrepid"

6.2 SURVEY VESSEL - TENDER TO INTREPID

Acquisition was conducted from a low magnetic vessel operated as a tender to the survey vessel "Intrepid" which remained onsite during the survey.

Figure 4. Survey tender with low magnetic properties towing the magnetometer.

6.3 POSITIONING AND NAVIGATION EQUIPMENT

Positioning System	Septentrio Altus RTK
GNSS correction source	RTK base station located at Surrich office in Mount Claremont.
Navigation System	Hypack 2019
Notes	The positioning system has centimetric accuracy. Sensor positioning is based on a layback calculation.

6.4 MARINE MAGNETOMETER

Magnetometer	Geometrics MFAM sensor.
Acquisition System	Hypack 2019
Tow point offset	Directly below RTK Rover antenna.
Sample interval	~ 5cm
Nominal vessel speed	< 2 knots
Line spacing	4m
Base station mag	None utilized.
Acquisition Notes	The magnetometer sensor is towed 9m behind the RTK antenna. The sensor was operated a fixed depth below the water surface of approximately 0.5m. Magnetometer positioning based on the Hypack layback calculation, with final parallax adjustment during processing.

7 COORDINATE SYSTEM

7.1 HORIZONTAL COORDINATES

MGA Zone 50

7.2 VERTICAL COORDINATES

NA.

8 POSITIONING CHECKS

The magnetic data acquired in this report utilized the rover RTK antenna which was also used to perform the QC checks for a MBES bathymetric survey conducted at the Main Jetty, Thomson Bay during the same visit.

For detailed information on establishing the base station and verification of the horizontal and vertical datums, refer to the Surrich bathymetric survey report:

- SH20190909_Nov_2019_RIA_Rottnest_Main_Jetty_Survey_Report_Rev0.pdf

The RTK base station established by Surrich Hydrographics, is a permanent installation located using the Geoscience Australia AUSPOS positioning service. The base station is located in the suburb of Mt Claremont, 22km from the work area. Table 4 contains the results of checks against SSM sites located on the mainland and on Rottnest.

SSM Check Sites

SSM ID	Claremont 61	A854
Datum	GDA94	GDA94
Actual Easting	384521.232	362124.949
Actual Northing	6462418.201	6459810.603
Actual Height	-14.095	-18.744
N Value	-32.869	-33.547

Observation Results

SSM ID	Claremont 61	A854
Rover Model	Septentrio Altus NR3	Septentrio Altus NR3
Antennae Model	Septentrio Altus NR3	Septentrio Altus NR3
Datum	GDA94	GDA94
Measured Easting	384521.258	362124.993
Measured Northing	6462418.215	6459810.614
Measured Height	-14.087	-18.678
No. Of Measurements	120	
Baseline Length	0.329 km	22.760 km
Delta Easting	0.026	0.044
Delta Northing	0.014	0.011
Delta Height	0.008	0.066
Easting StDev	0.005	0.002
Northing StDev	0.003	0.003
Elevation StDev	0.006	0.006

Table 4. RTK rover SSM results

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9 PROCESSING

9.1 MARINE MAGNETICS

1. Merge positioning, magnetic sensor data and altimeter data.
2. Import data into Geosoft UXO-Marine software.
3. Apply high-pass non-linear filter to level the raw magnetic field, and isolate anomalies
    - This filter also removes the following:
        - The Earths primary magnetic field
        - Long wavelength components from distant magnetic sources.
        - Magnetic "Heading Errors" associated with the sensor and acquisition setup.
    - The final result of this levelling and background removal process is referred to as the "Residual Magnetic Field"
4. Calculate the "Analytic Signal" from the gridded data.
5. Inspect results and manually pick potential UXO targets.
6. Chart data and targets.

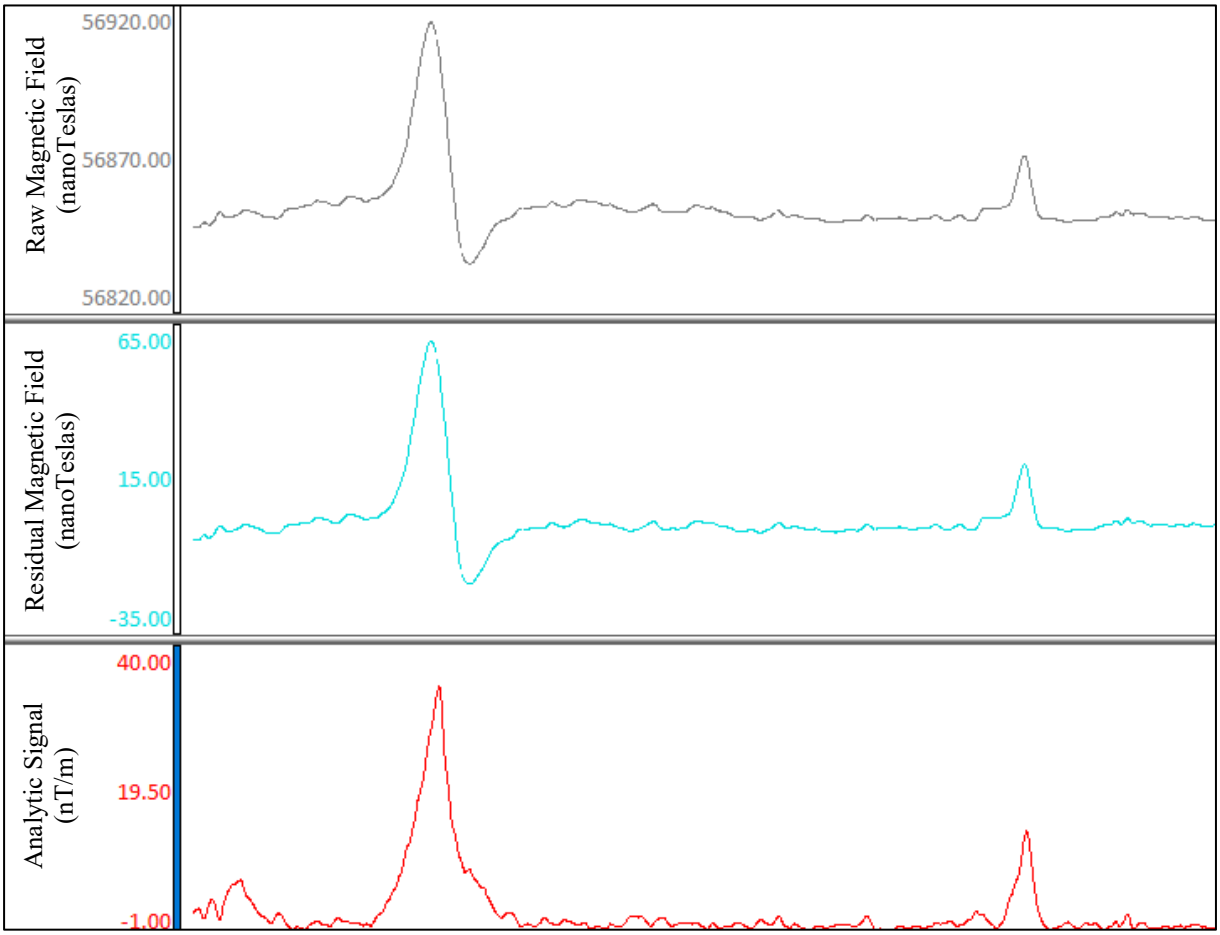


Figure 5. Example magnetic profiles comparing various processing steps.

10 RESULTS AND DISCUSSION

10.1 MAGNETOMETER NOISE LEVELS

The profile in figure 5 is a section of data acquired in the project area. Viewing a relatively flat section of profile in Figure 6, the data from the magnetic sensor has a random noise level of +/- 0.1 nT when measured from reading to reading.

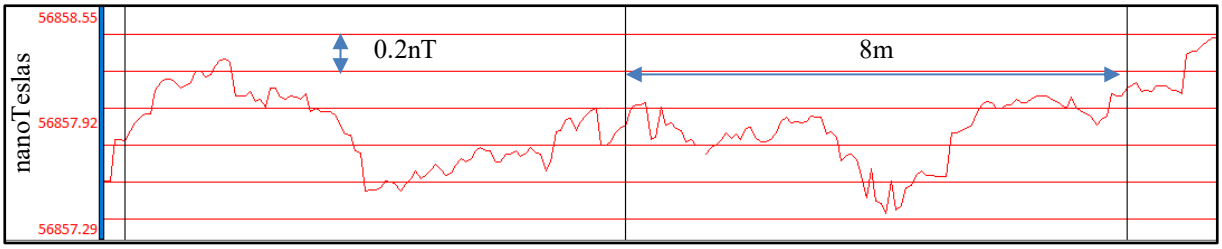


Figure 6. Raw magnetic data example from field prior to low pass filtering and down sampling.

10.2 POSITIONING ERRORS

Data logging was only conducted when a good RTK positioning solution was available. A shallow tow was utilized with a short (9m) umbilical and constant layback distance to the sensor. This contributes to sub-meter horizontal positional errors, however for purposes of uncertainty calculations we shall specify a Root Mean Square Error (RMSE), of 1m.

Horizontal positional uncertainty in the interpreted target location caused by line spacing combined with the need to interpret the location of the object from its magnetic signature, is estimated to have an RMSE of 2m.

Therefor when locating targets it is reasonable to expect an RMSE of 2.2m, calculated by taking the square root of the sum of the squares of the previous estimated uncertainties.

10.3 BACKGROUND REMOVAL

The aim of the background removal filter was to remove diurnal magnetic variations, as well as anomalies from nearby infrastructure while preserving the shorter wavelength anomalies from the ferrous debris targets. The background removal process is typically not perfect and can introduce artefacts into the data, however it can be relied on to preserves the shape of the target anomalies. Introduced artefacts are ignored by examining the raw magnetic data in addition to the processed data when evaluating targets.

10.4 TARGET PICKING

There is very little magnetic response from within the shallow sediments and all magnetic anomalies in this dataset are assumed to be caused by ferrous objects. Potential ferrous objects include the following:

- Anchors
- Anchor chain
- Mooring infrastructure (shackles, clump weights)
- Mooring chain
- Railway track
- Steel pylons
- Debris dropped in the water from general wharf operations including discarded equipment.
- UXO accidently lost during transfer operations

Targets have been selected from the gridded and profile data with the following characteristics:

- Localized anomaly distinct from the background.
- Linear anomalies spanning several lines are ignored.
- Target anomaly may positive, negative or dipolar (positive and negative spikes) in the raw and residual magnetic field data.
- Targets are not picked in complex magnetic areas likely to be associated with existing or historical infrastructure unless the anomaly is suspected to be discrete and a possible ferrous debris object in the seabed.

There are areas where complex and strong magnetic fields associated with existing or historical infrastructure may mask smaller UXO type anomalies. These areas are identified and discussed in the following section.

10.5 TARGET DISCUSSION

The water depth ranges from 0 to 3m (LAT datum). Predicted tide values were 0.59 to 0.75m in Fremantle during the survey days. The sensor was estimated to 0.5m below the water surface. Expected sensor altitude off the seabed varies from 0 m to 3.25m.

The targets are tabulated in Appendix B.

The column “Mag Analytic Signal Amplitude” is a calculation relating to the gradient of the gridded magnetic field, which highlights the presence of near surface ferrous objects. The peak in the Analytic Signal also provides an estimation of the location of the target. The amplitude of the analytic signal relates to a combination of the size of the target object as well as its proximity to the magnetic sensor.

Target properties (size and weight) have not been calculated from the magnetic field data as these are typically erroneous and misleading in single sensor, marine magnetic surveys. All targets identified are ferrous objects.

The targets in Appendix B have been classified with a “high”, “medium” or “low priority” for the benefit of prioritizing the follow-up diver investigation. The “priority” classification is not related to likelihood that the target represents a UXO.

High Priority = Targets located within the dredge boundary.

Medium Priority = Targets located just outside the dredge boundary, which may be impacted by the dredging operations.

Low Priority = Targets outside the dredge boundary.

10.6 TARGET REVISIONS SINCE PRELIMINARY DATA SUPPLIED

The initial target spreadsheet provided for the November 2019 diver investigation was named “rev1”. The latest revision is named “rev2” (revision 2). This report is the first report supplied, however is also named “rev2” to correspond to the latest target spreadsheet revision.

Rev 2 changes are as follows:

Target 31 has been relocated 5m to the SW. This was previously investigated by divers and nothing located in the preliminary location. Re-investigation of the profile data showed a weak anomaly in the preliminary position, and a stronger and more definitive anomaly in the new location on adjacent lines.

Target 47 has been deleted. This weak anomaly was originally prioritized as 'high' as it was within the dredge area, however the anomaly is now considered to be background variation and has been deleted.

10.7 MASKED AREAS

The end user should be aware there is potential for small anomalies to be masked by larger anomalies. This is typical in magnetic surveys, and has the following implications:

1. Complex magnetic areas around wharf infrastructure or from multiple ferrous objects spaced in close proximity such that their magnetic anomalies overlap, strongly decrease the probability than a discrete uxo-style anomaly may be detected in this area.
2. Any magnetic anomaly caused by a ferrous object, may mask the presence of another ferrous object in the same location with a weaker magnetic field.

The potential of missed anomalies shall be taken into account by the end-user when evaluating the UXO risk. For example if the UXO risk is 'low', it may be considered pragmatic to perform a single magnetic survey and follow up sampling/removal program to confirm the risk assessment, however if the UXO risk is 'high', then several cycles of survey and target removal might be considered.

There are 2 areas exhibiting a strong magnetic response from historical steel infrastructure, either in-situ (e.g., pylons), or dumped objects (e.g., gantry cranes or railway tracks). One is associated with the existing jetty structure. The other area is to the South West of the survey area which maps a considerable, previously unknown structure buried below the present beach surface.

10.8 DIVER INVESTIGATION OF TARGETS

On the 11th and 14th of November, TAMS investigated a selection of targets using metal detector equipped divers.

Surrich facilitated the divers with an RTK rover antenna and appropriate data layers to allow them to utilize a moving map display to accurately locate targets for investigation while in the field.

The results from the dive investigation are detailed in TAMS report "REC_A01_C13_FOR_C14_0016-02.pdf".

10.9 DIVER FOLLOW-UP RECOMMENDATIONS

It is recommended that diver follow-up of targets trial both flux-gate style metal detector in addition to electromagnetic metal detectors.

Flux-gate type metal detectors sensors are the preference, measuring the same physical property as measured in this marine magnetic survey.

11 CONCLUSIONS

- This survey identified 42 ferrous debris targets. 17 of these have been prioritized as 'high' to help direct/prioritize the diver investigation based on them being within or on the dredge boundary. 'Medium' and 'low' priority targets are outside the dredge area, however the end-user should consider the overall works being performed and re-prioritize any targets as appropriate.

- The potential for missed or masked targets shall be taken into account by the end-user when evaluating the UXO risk. For example if the UXO risk is 'low' from a desktop evaluation, it may be considered pragmatic to perform a single magnetic survey and target removal cycle to confirm the risk assessment, however if the UXO risk is 'high', then several cycles of survey and target removal might be considered.

- Diver follow-up should utilize metal detection equipment. Fluxgate sensors are the preference when following up marine magnetic targets.

12 REFERENCES

Keating, P., Pinet, P., 2011, Use of non-linear filtering for the regional-residual separation of potential field data. Journal of Applied Geophysics 73, 315-322.

Blakely, R. J. and Simpson, R. W., 1986, Approximating edges of source bodies from magnetic or gravity anomalies: Geophysics, v.51, p. 1494-1498.

Pennella J. (1982) Magnetometer Techniques in the Detection of Projectiles. NAVEODTECHCEN Technical Report TR-239, Navel Explosive Ordnance Disposal Technology Center, Indian Head Maryland.

Pawlowski J., Lewis R., Dobush T., Valleau N. (1995) An Integrated Approach for Measuring and Processing Geophysical Data for the Detection of Unexploded Ordnance, Proceedings of SAGEEP 1995, Orlando Florida.

13 DIGITAL PRODUCTS

\---rev2

20200215_Targets_Rev2.pdf

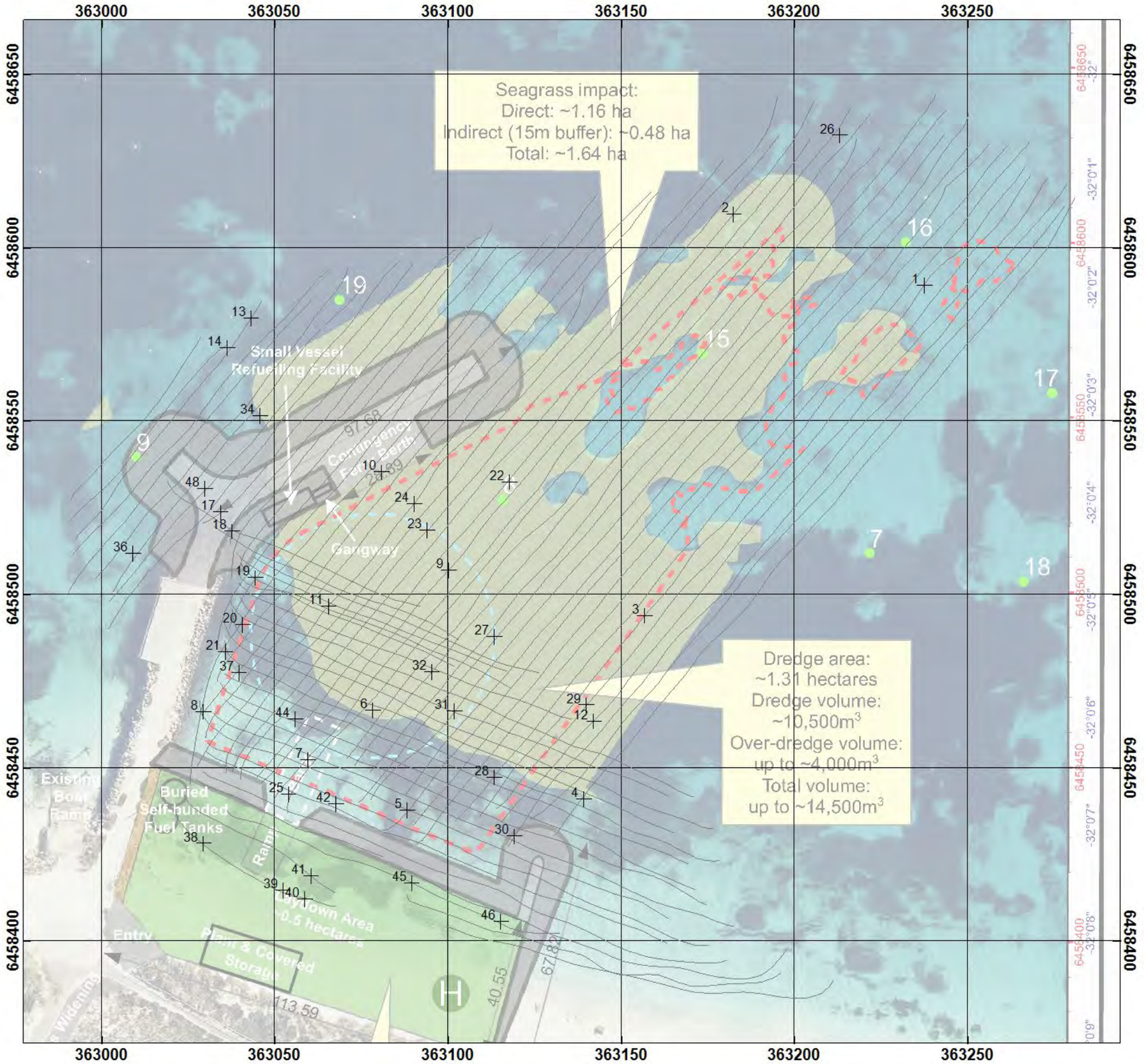
20200215_Targets_Rev2.xlsx

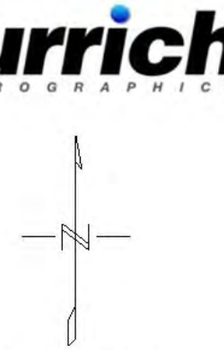
Appendix_B_Residual_Magnetic_Intensity.tif

Appendix_C_Analytic_Signal_Low.tif

Appendix_D_Analytic_Signal_High.tif

SH20191111_November_2019_RIA_Army_Jetty_Magnetic_Survey_rev2.pdf





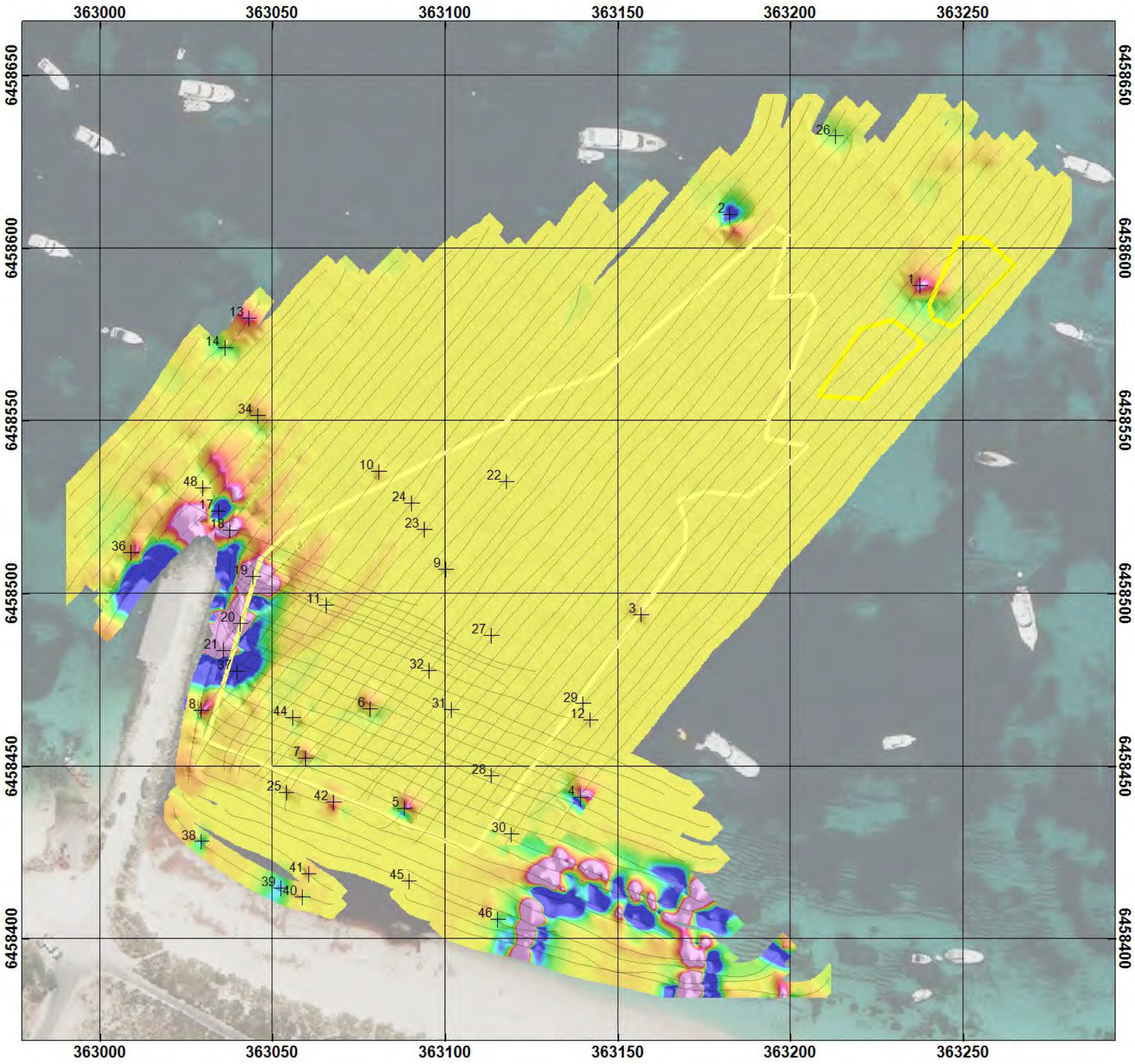
+ Magnetic Target

ROTTNEST ISLAND AUTHORITY

South Thomsons Bay
Magnetic Survey for UXO

Appendix A - Scope Document

Contractor: Surrich Hydrographics
Chart Date: 9/11/2019
Survey Date: 6 to 7/11/2019



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HYDROGRAPHICS

Scale 1:1300

25 0 25

metres

179
149
118
87
56
26
-5
-36
-67
-97
-128
-159
-190

Residual Magnetic Intensity
Uncorrected for Altitude above seabed
Altitude ranges from 0.5 to 4m

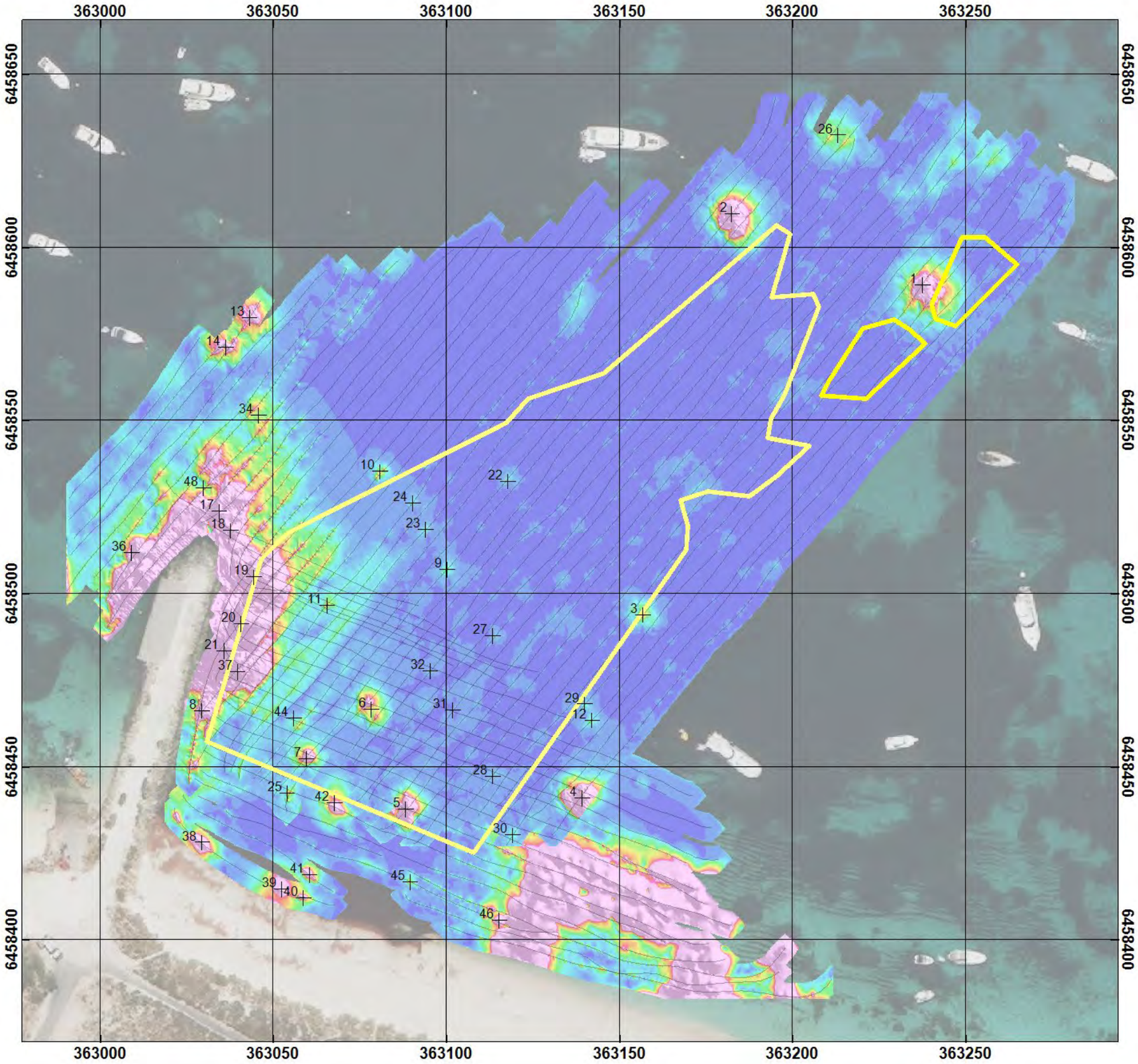
\+ Magnetic Target

ROTTNEST ISLAND AUTHORITY

South Thomson Bay Magnetic Survey for UXO

Appendix B Residual Magnetic Intensity

Contractor: Surrich Hydrographics
Chart Date: 09/11/2019
Survey Date: 6 to 7/11/2019



surrich
HYDROGRAPHICS

Scale 1:1300

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metres

47
45
42
40
37
35
32
29
27
24
22
19
17
14
12
9
6
4
1

Analytic Signal (nT/m)
Uncorrected for Altitude above seabed
Altitude ranges from 0.5 to 4m

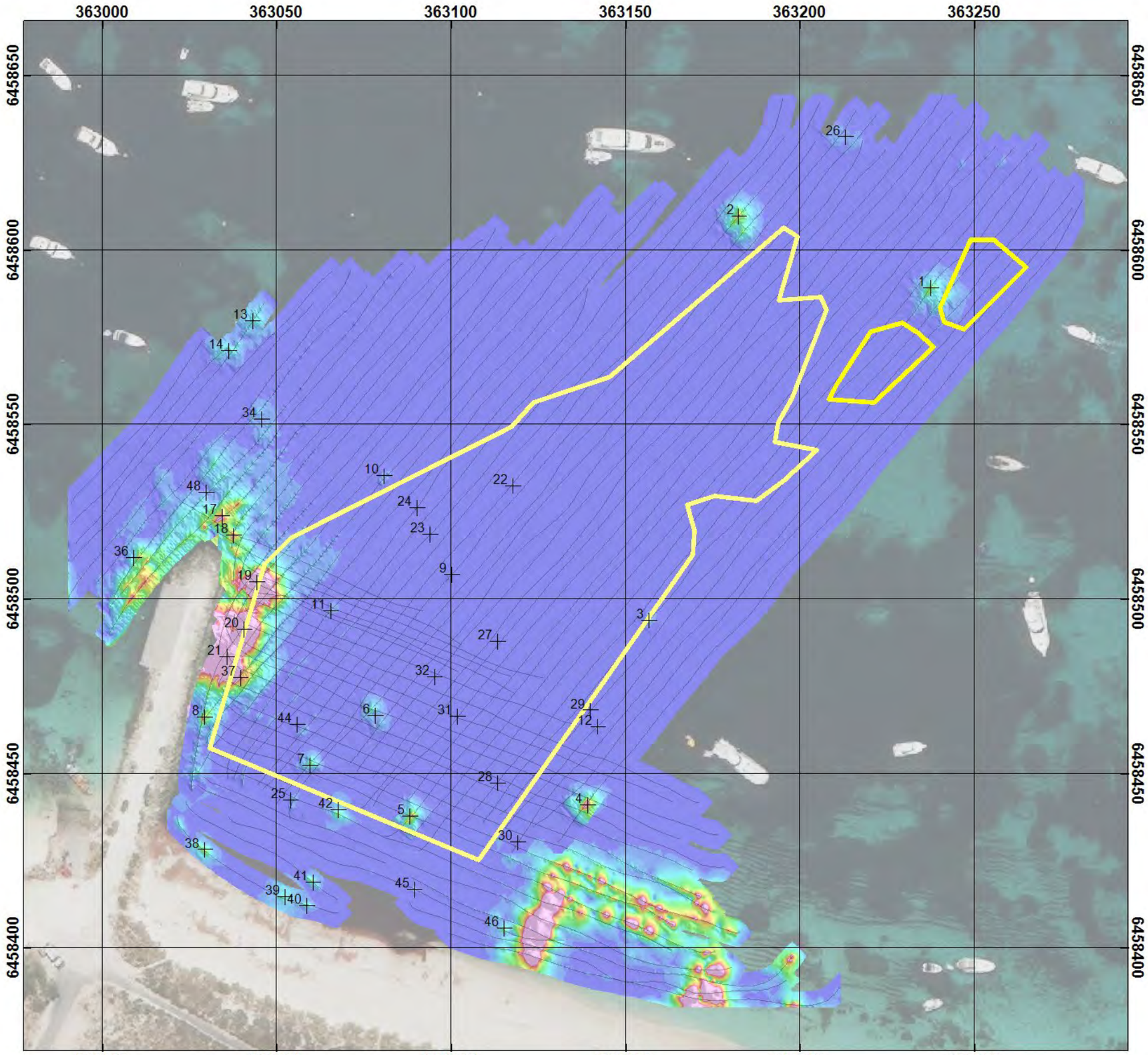
\+ Magnetic Target

ROTTNEST ISLAND AUTHORITY

South Thomsons Bay Magnetic Survey for UXO

Appendix C - Analytic Signal Low Amplitude Colour Scale

Contractor: Surrich Hydrographics
Chart Date: 9/112019
Survey Date: 6 to 7/11/2019



surrich
HYDROGRAPHICS

Scale 1:1300
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metres

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436
397
359
321
282
244
205
167
128
90
51
13

Analytic Signal (nT/m)
Uncorrected for Altitude above seabed
Altitude ranges from 0.5 to 4m

\+ Magnetic Target

ROTTNEST ISLAND AUTHORITY

South Thomsons Bay
Magnetic Survey for UXO

Appendix D - Analytic Signal
High Amplitude Colour Scale

Contractor: Surrich Hydrographics
Chart Date: 9/11/2019
Survey Date: 6 to 7/11/2019

Appendix E. Magnetic Targets (Ferrous Objects)

MGA_E	MGA_N	Target ID	Analytic Signal Amplitude (nT/m)	Priority	Comments	Dive Investigation Results (From TAMS Report "REC_A01_C13_FOR_C14_0016-02.pdf")
363237.5	6458589	1	226	medium	Just outside dredge area. It is probable that identifying this may also indicate the nature of target 2, which is similar.	14/11/2019 RIA mooring chain.
363182.5	6458610	2	334	low	Outside dredge area.	
363156.8	6458494	3	54	high	Moderate to strong anomaly.	11/11/2019 Nothing found requires revisit.
363139.2	6458441	4	999	low	Outside dredge area.	
363088.2	6458438	5	275	high	Strong anomaly.	11/11/2019 Nothing found requires revisit.
363078.2	6458467	6	25	high	Strong anomaly.	11/11/2019. Large metal object. Appears to be structural.
363059.6	6458452	7	247	high	Strong anomaly.	11/11/2019 Nothing found requires revisit.
363029.3	6458466	8	605	medium	Strong anomaly just outside dredge area.	
363100.1	6458507	9	19	high	Moderate anomaly	14/11/2019 Engine block recovered 300mm from target location on seabed, half buried.
363080.8	6458535	10	32	medium	Small object, outside but close to dredge boundary.	
363065.5	6458497	11	30	high	Anomaly seen in both the NS and EW lines.	14/11/2019 Nothing found requires revisit.
363142.1	6458463	12	19	medium	May be related to target 29 on the dredge boundary.	
363043.1	6458580	13	118	low	Outside dredge area.	
363036.3	6458571	14	147	low	Outside dredge area.	
363034.3	6458524	17	884	low	Outside dredge area.	
363037.6	6458518	18	574	low	Outside dredge area.	
363044.4	6458505	19	3474	medium	Likely this is a large object such as and old wharf pylon. On dredge area boundary.	
363040.7	6458491	20	11754	medium	Likely this is a large object such as and old wharf pylon. On dredge area boundary.	

MGA_E	MGA_N	Target ID	Analytic Signal Amplitude (nT/m)	Priority	Comments	Dive Investigation Results (From TAMS Report "REC_A01_C13_FOR_C14_0016-02.pdf")
363035.7	6458483	21	18173	medium	Likely this is a large object such as and old wharf pylon. On dredge area boundary.	
363117.8	6458532	22	9	high	Moderately strong anomaly.	14/11/2019. Small anchor recovered. 500mm from marked location, 400mm deep.
363094	6458518	23	10	high	Moderately strong anomaly.	14/11/2019. Two large links of chain recovered.
363090.3	6458526	24	13	high	Moderately strong anomaly.	14/11/2019. Nothing found requires revisit.
363053.9	6458442	25	29	high	Moderately strong anomaly.	14/11/2019. Small anchor recovered.
363213	6458632	26	17	low	Probable mooring infrastructure.	
363113.3	6458488	27	6	high	Weak dipole anomaly. May be background variations. I.e not real. Search anyway.	14/11/2019. Nothing found requires revisit.
363113.3	6458447	28	5	high	Weak anomaly.	14/11/2019. Nothing found requires revisit. Waist deep weed.
363139.9	6458468	29	11	high	Weak anomaly.	
363119.1	6458430	30	11	low	Outside dredge area.	
363101.8	6458466	31	6	high	This anomaly has been re-evaluated and moved 5m to the South-West based on close assessment of the profile data. This re-alignment has been performed after the initial diver investigation. The anomaly is week however difenitive in	14/11/2019. Nothing found requires revisit.
363095.3	6458478	32	6	high	Weak anomaly however it is a definitive dipole in the NS lines. Reasonable probability a ferrous object exists here. No anomaly in the EW lines	
363045.7	6458551	34	19	low	Outside dredge area.	
363009	6458512	36	75	low	Outside dredge area.	

MGA_E	MGA_N	Target ID	Analytic Signal Amplitude (nT/m)	Priority	Comments	Dive Investigation Results (From TAMS Report "REC_A01_C13_FOR_C14_0016-02.pdf")
363039.7	6458477	37	650	medium	Strong anomaly withn dredge boundary, however this is thought to be the edge of the same anomaly designated target 21 to the west which is outside the dredge boundary. Downgraded to medium priority.	
363029.4	6458428	38	367	low	Outside dredge area.	
363052.3	6458415	39	133	low	Outside dredge area.	
363058.7	6458412	40	132	low	Outside dredge area.	
363060.4	6458419	41	166	low	Outside dredge area.	
363067.6	6458440	42	261	high	Strong anomaly on edge of derge area.	14/11/2019. Nothing found requires revisit. Waist deep weed.
363055.9	6458464	44	148	high	Weak anomaly however anomaly exists in EW and NS lines so high probablilit a ferrous object exists here.	14/11/2019. Nothing found requires revisit.
363089.5	6458417	45	45	low	Outside dredge area.	
363115.3	6458406	46	253	low	Outside dredge area.	
363029.8	6458530	48	17	low	New target outside dredge area whaich was not included in the preliminary data supplied to the drvers for the November 2019 investigation.	

Details			
Project/Client	Rottnest Island Authority - Geological Investigation - Thomson Bay South and UXO investigation/anomaly recovery	**Date**	06-Dec-2019
Subcontract	PO: PER107047	**Job No.**	3032-2
Document No.	REC_A01_C13_FOR_C14_0016	**Revision**	02
Location	Rottnest Island		
Project Manager	Maarten Terwal	**Project Supervisor**	Brendan O' Leary
Personnel	Tony Henson and Matt Webb		

Introduction and Scope of Work

TAMS was engaged by Rottnest Island Authority to supply a vessel and dive team to complete geotechnical investigation at Thompsons Bay South.

The works completed were carried out over 5 days from 15 November to 19 November 2019

- UXO investigation – Number of locations: Total 47 with 14 location inspections completed
- Push tube Sample collection with scientist rep from RPS on board – Number of locations: 7 with a total of 46 Sample tubes collected as per table 1
- Geo sampling with Geologist rep from Douglas Partners on board – Number of locations: 6 with a total of 18 samples collected as per table 2
- Water Jet Probing – Number of locations: 37 with 37 completed as per table 3

Figure 1. Location of area sampled South Thomson Bay

Figure 2. Jet Probe locations (1 to 37)

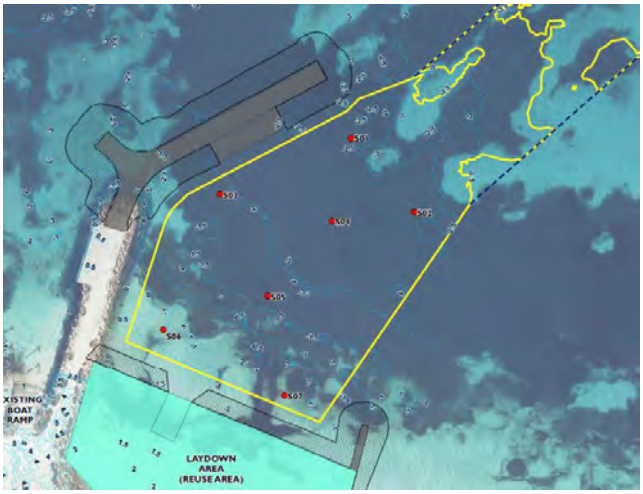

Figure 3. Sediment Sampling Locations (S01 to S07)

Figure 4. Diver searching for UXO with underwater metal detector

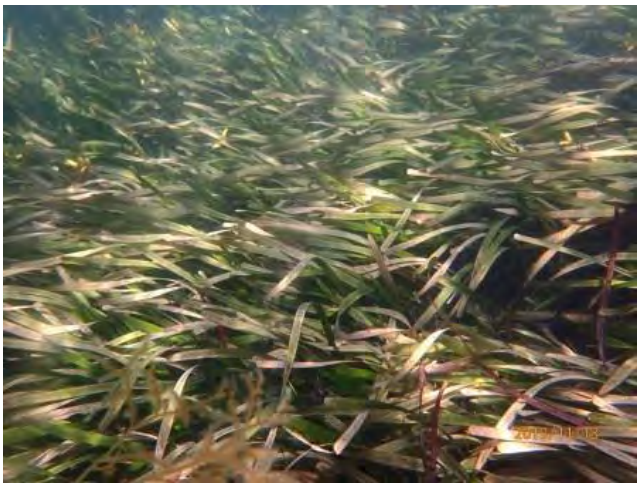

Figure 5. Heavy seagrass cover over 80% of the area

Figure 6. Diver extracting push tube samples

Figure 7. Shallow water jet probing

Figure 8. Diver working in on one of the shallow sample locations

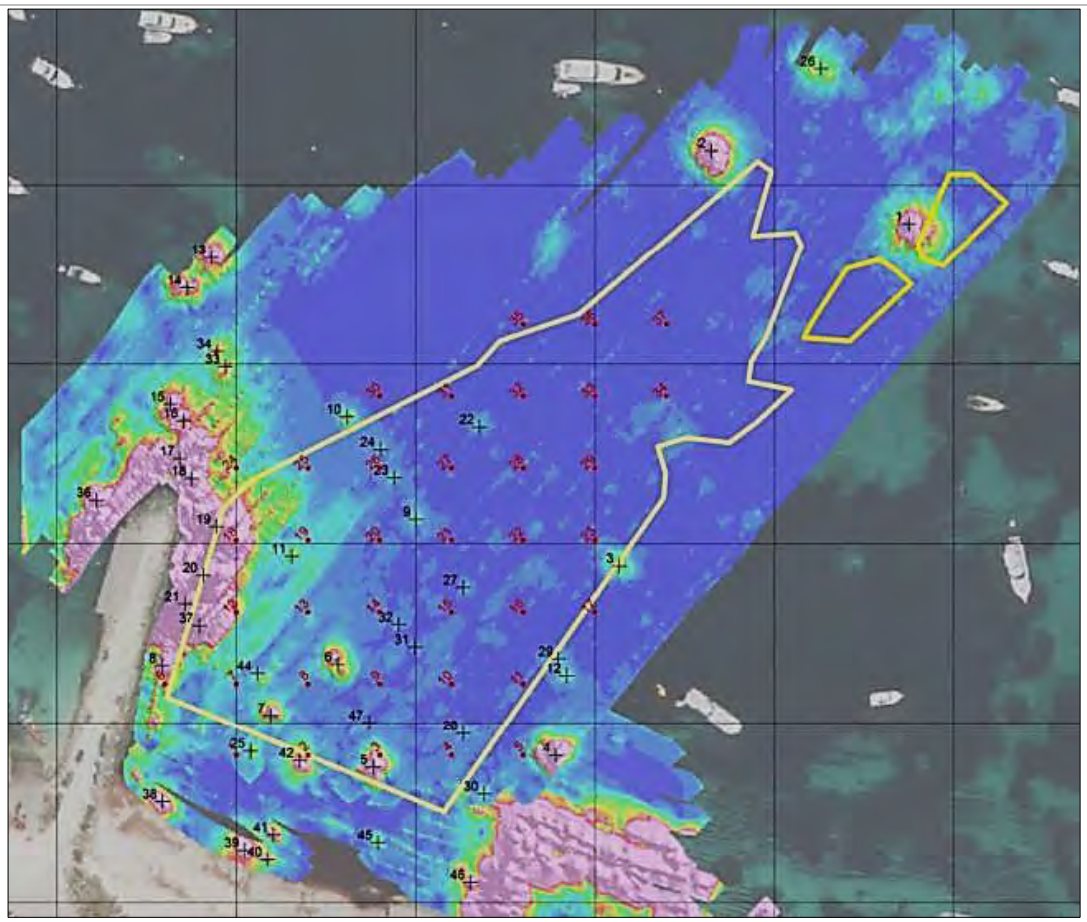

Figure 9. UXO Anomalies

Table 1. **Scientific Push Tube Soil Sample Summary – ID numbers all refer to Figure 3**

Bore Hole ID	DIVER	DATE	TIME	NO. SAMPLES TAKEN	DEPTH - 1.2M OR REFUSAL	ADDITIONAL SAMPLES
S01	TH	12.11.19	8:56 AM - 10:09 AM	1	1.2M	
				2	1.2M	
				3	1.2M	
				4	1.2M	
				5	1.2M	
				6	1.2M	
				EXTRA SAMPLE 7	0.3M	REVISIT - 16:35 TO 16:50
				EXTRA SAMPLE 8	0.3M	REVISIT - 16:35 TO 16:50
S02	TH	12.11.19	11:00AM - 11:40AM	1	1.1M	
				2	1M	
				3	1M	
				4	1M	
				5	0.6M (As Required)	
				EXTRA SAMPLE 6	0.3M	REVISIT - 16:15 TO 16:25
				EXTRA SAMPLE 7	0.3M	REVISIT - 16:15 TO 16:25
S06	TH	12.11.19	12:10AM - 13:02PM	1	1.2M	
				2	1.2M	
				3	1.2M	
				4	0.6M (As Required)	
				5	0.6M (As Required)	
				EXTRA SAMPLE 6		REVISIT - 15:45 TO 15:50
S07	TH	12.11.19	13:19PM - 14:10PM	1	1.2M	
				2	1.2M	
				3	1.2M	

				4	0.6M (As Required)	
				5	0.6M (As Required)	
				EXTRA SAMPLE 6	0.3M	REVISIT - 15:55 TO 16:10
				EXTRA SAMPLE 7	0.3M	REVISIT - 15:55 TO 16:10
MOVE LOCATION						
S03	TH	12.11.19	14:25PM - 15:29PM	1	1.2M	
				2	0.9M	
				3	1.2M	
				4	1.2M	
				5	0.6M (As Required)	
				6	0.6M (As Required)	
S04	MW	13.11.19	08:00AM -09:10AM	1	0.95M	
				2	0.9M	
				3	0.85M	
				4	0.95M	
				5	1M	
				6	0.6M	
MOVE LOCATION						
S05	MW	13.11.19	09:20AM - 10:45AM	1	1.2M	
				2	1.2M	
				3	1.1M	
				4	1.2M	
				5	1.2M	
				6	1.2M	

Table 2. **Geo Core Sample Summary - ID numbers all refer to Figure 2**

BORE HOLE ID	TIME	DATE	MAX DEPTH OF CORE SAMPLES	DEPTH OF WATER	TOTAL	TIDE M	CORE SAMPLE BELOW CHART DATUM
2	13:00	14.11.2019	1.1m x 3 samples	1800mm	2900mm	0.4m	2500mm
4	13:30	14.11.2019	1.1m x 3 samples	2200mm	3300mm	0.4m	2900mm
13	12:17	14.11.2019	0.95m x 3 Samples	2800mm	3750mm	0.4m	3350mm
16	11:30	14.11.2019	1m X 3 Samples	3300mm	4300mm	0.4m	3900mm
25	10:50	14.11.2019	1m X 3 Samples	3100mm	4100mm	0.4m	3700mm
27	10:08	14.11.2019	1m X 3 Samples	3200mm	4200mm	0.3m	3900mm

Table 3. **Jet Probe Locations and depths attained - ID numbers all refer to Figure 2**

ID	Easting (MGA50)	Northing (MGA50)	DATE	TIME	DEPTH OF PENETRATION TO REFUSAL	DEPTH OF WATER	TOTAL	TIDE M	PROBE DEPTH BELOW CHART DATUM
1	363050	6458441	13/11/2019	12:19	1500mm	1300mm	2800mm	0.4	2400mm
2	363070	6458441	13/11/2019	12:42	1350mm	1620mm	2970mm	0.4	2570mm
3	363090	6458441	13/11/2019	13:08	1120mm	1870mm	2990mm	0.4	2590mm
4	363110	6458441	13/11/2019	13:02	1270mm	2040mm	3310mm	0.4	2910mm
5	363130	6458441	13/11/2019	13:20	1030mm	2270mm	3300mm	0.4	2900mm
6	363030	6458461	13/11/2019	13:26	1750mm	1450mm	3200mm	0.4	2800mm
7	363050	6458461	13/11/2019	13:35	1500mm	1830mm	3330mm	0.4	2930mm
8	363070	6458461	13/11/2019	13:50	1570mm	2070mm	3640mm	0.4	3240mm
9	363090	6458461	13/11/2019	14:01	1100mm	2430mm	3530mm	0.4	3130mm
10	363110	6458461	13/11/2019	14:31	1050mm	2580mm	3630mm	0.4	3230mm

11	363130	6458461	13/11/2019	14:36	940mm	2870mm	3810mm	0.4	3410mm
12	363050	6458481	13/11/2019	14:45	1000mm	2200mm	3200mm	0.4	2800mm
13	363070	6458481	13/11/2019	14:57	1230mm	2600mm	3830mm	0.4	3430mm
14	363090	6458481	13/11/2019	15:12	1040mm	2860mm	3900mm	0.4	3500mm
15	363110	6458481	13/11/2019	15:22	1000mm	3200mm	4200mm	0.4	3800mm
16	363130	6458481	13/11/2019	15:27	1340mm	3200mm	4540mm	0.4	4140mm
17	363150	6458481	13/11/2019	15:15	1060mm	3300mm	4360mm	0.4	3960mm
18	363050	6458501	13/11/2019	15:57	1640mm	2700mm	4340mm	0.5	3840mm
19	363070	6458501	13/11/2019	16:00	2810mm	2650mm	5460mm	0.5	4960mm
20	363090	6458501	13/11/2019	16:06	1000mm	3200mm	4200mm	0.5	3700mm
21	363110	6458501	13/11/2019	16:14	1300mm	3200mm	4500mm	0.5	4000mm
22	363130	6458501	13/11/2019	16:20	1100mm	3400mm	4500mm	0.5	4000mm
23	363150	6458501	13/11/2019	16:28	1250mm	3500mm	4750mm	0.5	4250mm
24	363050	6458521	13/11/2019	16:36	2000mm	3200mm	5200mm	0.5	4700mm
25	363070	6458521	13/11/2019	16:47	1750mm	3200mm	4950mm	0.5	4450mm
26	363090	6458521	13/11/2019	16:55	1320mm	3400mm	4720mm	0.5	4220mm
27	363110	6458521	13/11/2019	17:00	1450mm	3300mm	4750mm	0.5	4250mm
28	363130	6458521	14/11/2019	7:40	1180mm	3400mm	4580mm	0.2	4380mm
29	363150	6458521	14/11/2019	7:47	1400mm	3370mm	4770mm	0.2	4570mm
30	363090	6458541	14/11/2019	8:00	1770mm	3200mm	4970mm	0.2	4770mm
31	363110	6458541	14/11/2019	8:05	1560mm	3300mm	4860mm	0.2	4660mm
32	363130	6458541	14/11/2019	8:15	1350mm	3350mm	4700mm	0.2	4500mm
33	363150	6458541	14/11/2019	8:24	1240mm	3350mm	4590mm	0.2	4390mm
34	363170	6458541	14/11/2019	8:34	1150mm	3700mm	4850mm	0.3	4550mm
35	363130	6458561	14/11/2019	8:49	2050mm	3500mm	5550mm	0.3	5250mm
36	363150	6458561	14/11/2019	8:59	1080mm	4300mm	5380mm	0.3	5080mm
37	363170	6458561	14/11/2019	9:05	1420mm	3900mm	5320mm	0.3	5020mm

Table 4. **UXO Findings - ID numbers all refer to Figure 4**

HIGH PRIORITY	SEAGRASS	DRIFT SEAWEED	SAND	DATE AND TIME	RESULT	PHOTO
3	X			11.11.19 - 15:30	Nothing found - requires revisit	
5	X	X		11.11.19 - 14:30 14.11.19 - 08:45	Nothing found (beer can) - revisit - Nothing found second check - requires revisit	
6	X			11.11.19 - 11:45	Large metal object *appears* to be structural and not UXO	YES
7			X	14.11.19 - 15:35 15.11.19 - 07:45	Nothing found - requires revisit	
9	X			14.11.19 - 09:30	Engine block recovered 300mm from location on seabed/half buried	YES
11	X			14.11.19 - 10:30	Nothing found - requires revisit	
22	X			11.11.19 - 13:59	Small anchor recovered - 1000mm from marked location / 300mm deep	YES
23	X			14.11.19 - 11:37	Piece of large link chain recovered - 150mm deep and 1m from mark	YES
24	X			14.11.19 - 13:36	Nothing found - requires revisit (toothpaste tube only)	
25			X	14.11.19 - 07:10	Small anchor recovered - 500mm from marked location / 400mm deep	YES
27	X			11.11.19 - 13:00	Nothing found - requires revisit	
28	X	X		14.11.19 - 02:17	Nothing found - requires revisit (waist deep weed, and drift weed)	
29	X					
31	X			14.11.19 - 15:00	Nothing found - requires revisit	

32	X					
42		X	X	14.11.19 - 12:57	Nothing found - requires revisit (waist deep weed)	
44			X	14.11.19 08:55	Nothing found - airlifting 0.5m then no feedback - requires revisit	
47		X	X			
HIGH PRIORITY	**SEAGRASS**	**DRIFT SEAWEED**	**SAND**	**DATE AND TIME**	**RESULT**	
1			X	14.11.19	RIA Mooring anchor chain	
8		X	X			
10	X					
12	X					
19			X			
20	X					
21	X	X	X			
37	X					

Methodology and Results

Mobilisation of personnel and equipment to Rottnest Island on board the AMS3 on Monday 11 November. Setup of survey was conducted on site with vertical and horizontal accuracy of the sample and water jet location positions undertaken using the CMW DGPS unit during dive operations. On site work was completed by COB on Friday 15th November.

After consultation with the client the decision was made to commence operations in the following order.

- UXO investigation close to sample locations
- Scientific Sample collections
- Water Jet Probing
- Geo. Core Sample collection
- Continue UXO investigation

UXO investigation - With the RTK aerial mounted on the starboard bow gunwale the vessel moved onto location and utilising the RTK positioning system with Global Mapper software, a drop weight was deployed. AMS3 was anchored in location and the diver entered the water. Once the diver was in the water the metal drop weight was recovered and replaced by a PVC tube as a marker. Using the Excalibur 2 underwater metal detector, an area of at least 3 meters around the marker was searched. It was noted that the presence of seagrass over approximately 80% of the area searched resulted in difficulty reading the signal from the metal detector.

In areas the grass was up to 400mm in length and the metal detector had to be pushed down into the grass to obtain the required distance from seabed, in these cases the seagrass touching the sensor resulted readings which were difficult to decipher. Ideally the skid plate should be swept across the seabed approximately 50mm from the ground surface.

In cases where the diver suspected there may be a metal object, the air lift was requested and deployed, and the diver would airlift in the location, digging below the seabed to locate a target object. On completion, the area was once again scanned with the metal detector to check there were no further items. The works completed and results are listed below.

Monday 11.11.2019: Investigate UXO anomalies that were close to sample locations

- UXO Searching 6 - Diver to airlift - object found by diver seemed large and was marked - small stream of bubbles coming from object
- UXO Searching 27 - Nothing found – requires revisit
- UXO Searching 22 - Old buried anchor found and recovered
- UXO Searching 5 - Located old beer can – requires revisit

Thursday 14.11.2019: Complete water jet probing, complete collection of Geo core samples and continue UXO investigation

- UXO Searching location 7 – Nothing found
- UXO Searching location 1 – found anchor chain from (RIA) Rottnest mooring
- UXO Searching location 25, object located 0.5m below seabed buy airlifting – requires revisit, attach subsea marker

Friday 15 November 2019: Continue UXO investigation

- Revisit UXO Searching location 25 – Small anchor recovered
- Revisit UXO Searching location 7 – Nothing found – requires revisit
- UXO Searching location 5 – Nothing found – requires revisit

- UXO Searching location 9 – Old engine Block UXO found and recovered
- UXO Searching location 11 – Nothing found – requires revisit
- UXO Searching location23 – 2 x large links of chain found and recovered
- UXO Searching location 42 – Nothing found – requires revisit
- UXO Searching location 24 – Toothpaste tube found – requires revisit
- UXO Searching location 28 – Nothing found – requires revisit
- UXO Searching location 31 – Nothing found – requires revisit

Note: Items recovered were transported back to Rouse Head and disposed of in the appropriate scrap metal skip bins.

Scientific Sample collections – Table 1

With the RTK aerial mounted on the starboard bow gunwale the vessel moved onto location and using the RTK positioning system a drop weight was deployed. AMS3 was anchored in location and the diver entered the water. Once in the water and under the guidance of the Scientist on board the diver used PVC piping to penetrate the seabed to required depth or refusal, the pipe was capped and sealed resulting in a vacuum and then drawn from the seabed. The other end was capped and the pipe with sample recovered to the AMS 3 for sorting and storage by the onboard scientist. Once adequate sample material was recovered the diver was to exit the water and AMS 3 move to next location with the process being repeated.

Tuesday 12.11.2019: Scientific sample collections

- Sample collection S01 - 6 samples as per XL
- Sample collection S02 - 5 samples as per XL
- Sample collection S06 - 5 samples as per XL
- Sample collection S07 - 5 samples as per XL
- Sample collection S03 - 6 samples as per XL
- Additional sample collection S06 - 1 samples as per XL
- Additional sample collection S07 - 2 samples as per XL
- Additional sample collection S02 - 2 samples as per XL
- Additional sample collection S01 - 2 samples as per XL

Wednesday 13.11.2019: Complete Scientific sample collection

- Sample collection S04 - 6 samples as per XL
- Sample collection S05 - 6 samples as per XL

Water Jet Probing – Table 3 - From seabed to the highest of rock surface or -3.3 m CD at locations defined in document Thomson Bay South Jet Probing Plan Figure 2 and including the correlation of seabed levels to chart datum levels (Thomson Bay) Results as shown on Table 3.

With the RTK aerial mounted on the starboard bow gunwale the vessel moved onto location and using the RTK positioning system a drop weight was deployed. The diver was to enter the water and with a 4m water jet probe and completed a probe to a minimum of 3.3m depth. The RTK was monitored for positioning with no less than 50mm vertical and 35mm horizontal accuracy. In addition, the water jet probe had a horizontal and vertical spirit level attached helping the diver with monitoring these levels during the probing operation.

Wednesday 13.11.2019: Commence water jet probing locations 1 to 27 completed

Thursday 14.11.2019: Complete water jet probing, complete collection of Geo core samples, survey and highlight locations with heavy weed cover and continue UXO investigation

- Water Jet Probing: Locations 28 through to 37 water jet probes completed

Geo. Sample collections – Table 2

With the RTK aerial mounted on the starboard bow gunwale the vessel moved onto location and using the RTK positioning system a drop weight was deployed. AMS3 was anchored in location and the diver entered the water. Once in the water and under the guidance of the Geologist on board the diver drove PVC piping into the seabed penetrating to required depth or refusal, the pipe was capped and sealed resulting in a vacuum and then drawn from the seabed. The other end was capped and the pipe with sample recovered to the AMS 3 for sorting and storage by the onboard scientist. Once adequate sample material was recovered the diver was to exit the water and AMS 3 move to next location with the process being repeated. No drilling was undertaken on this occasion.

Thursday 14.11.2019: Complete water jet probing, complete collection of Geo core samples and continue UXO investigation

- Geo. Core sampling: Locations 27,25, 16, 13, 4 and 2. Three samples taken from each site as per Table 2

Figure 10. HP. Small steel sample broken off item at UXO location 6

Figure 11. HP. Engine block recovered location at UXO location 9

Figure 12. HP. Small anchor recovered UXO location 22

Photo card water damaged, photo lost

Figure 13. HP. Large link chain recovered UXO location 23

Figure 14. HP. Small anchor recovered UXO location 25

Photo card water damaged, photo lost

Figure 15. MP. Ground leg chain from RIA active mooring UXO location 1

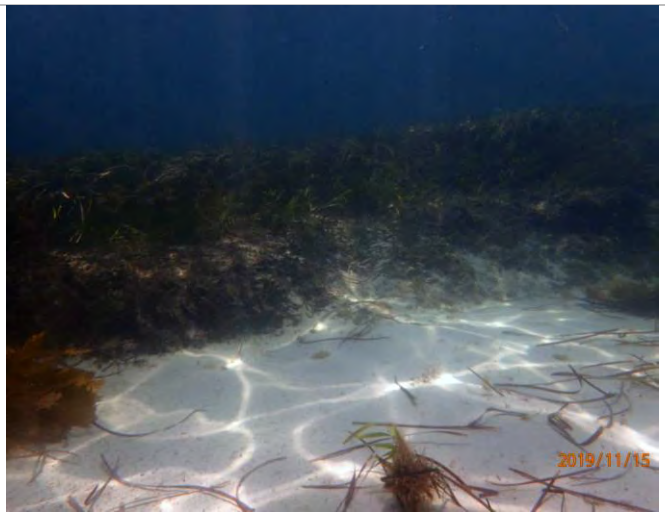

Figure 16. Example of heavy seagrass cover with thick root penetration

Figure 17. Diver working in Seagrass to access seabed

Comments and Discussion
• UXO anomalies require further investigation as time frame was to short to cover a full inspection at each site. The unexpected presence of heavy Sea grass cover and drift seaweed also resulted in slowing progress, it is suggested a more powerful magnetometer which can be used above the weed and with penetration depth of at least 1m be sourced for further investigation of these areas. • All scientific samples were collected to the satisfaction of the onsite scientist. • All Geo. samples were recovered down to refusal depth, there are a few remaining sample locations in the shallows which require core drilling to penetrate the rock and reach the required depth. • All Water Jet Probing locations were successfully completed to the required depth or refusal. **NOTE: TABLES IN THIS REPORT CONATIN RAW FIELD DATA AND SHOUD BE READ IN CONJUNCTION WITH THE FINAL SURVEYORS REPORT AND TABLE - (Jet_Probe_Results_Final_Rev1)**

Approvals		
TAMS Dive Supervisor Name	**Signature**	**Date**
Brendan O'Leary		06-Dec-2019
Client Representative	**Signature**	**Date**