


surrich

Document Description	MARINE MAGNETOMETRY SURVEY FOR FERROUS OBJECTS			
	MANDORAH, NORTHERN TERRITORY			
Document Name	SH20221103_November_2022_CMG_Mandorah_Marine_Magnetics_Report			
Document Author	Justin Anning Principal Geophysicist, Surrich Hydrographics			
Project Name	Mandorah New Marine Facilities to Service Mandorah and Cox Peninsula Communities			
Client Project Number				
Client	CMG			
REVISION HISTORY				
REV	DATE	REVISION DESCRIPTION	BY	APPROVED
Rev0	28/11/2022	Fist issue of report	JMA	AR
DISTRIBUTION LIST				
				



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

CONTENTS

1.	ABBREVIATIONS	4
2.	INTRODUCTION	5
3.	SCOPE AND METHODOLOGY	6
4.	LIMITATIONS	7
4.1.	MARINE MAGNETICS (MM) LIMITATIONS	7
4.2.	SIDE SCAN SONAR (SSS) LIMITATIONS.....	7
5.	FIELD LOGISTICS	8
5.1.	PROJECT TIMELINE.....	8
5.2.	PROJECT PERSONNEL	8
6.	COORDINATE SYSTEM	9
6.1.	HORIZONTAL DATUM.....	9
6.2.	VERTICAL DATUM	9
7.	POSITIONING SYSTEM CHECKS	9
8.	ACQUISITION	10
8.1.	SURVEY VESSEL USED DURING SSS/MM ACQUISITION	10
8.2.	SURVEY VESSEL USED DURING SURFACE TO MM ACQUISITION	10
8.3.	POSITIONING AND NAVIGATION EQUIPMENT	11
8.4.	SIDE SCAN SONAR	11
8.5.	MARINE MAGNETOMETER (MM).....	12
9.	PROCESSING	13
9.1.	SIDE SCAN SONAR (SSS)	13
9.2.	MARINE MAGNETICS	13
10.	DISCUSSION OF RESULTS	14
11.	FOLLOW UP TARGET INVESTIGATIONS	15
12.	CONCLUSIONS	15
13.	REFERENCES	15
14.	DIGITAL PRODUCTS	16

FIGURES

Figure 1.	Site Overview.	5
Figure 2.	MM sensor line coverage.....	6
Figure 3.	Survey Vessel “Category 5”	10
Figure 4.	Survey Vessel “Bluey”	10

TABLES

Table 1. Project Timeline	8
Table 2. Project Personnel.....	8
Table 3. Catategory-5 survey vessel specification	10
Table 4. Bluey survey vessel specification.....	10
Table 5. Navigation Equipment.....	11
Table 6. Side Scan Sonar Specifications	11
Table 7. Marine Magnetometer Specifications.....	12

APPENDICIES

Appendix A.1	Magnetic Survey Lines Over Bathymetry
Appendix A.2	Magnetic Survey Lines Over Site Layout
Appendix A.3	Magnetic Sensor Altitude
Appendix A.4	Magnetic First Vertical Derivative with Targets
Appendix A.5	Magnetic Analytic Signal with Targets
Appendix A.6	Targets Over Bathymetry
Appendix B.1	SSS Mosaic with Targets
Appendix B.2	SSS Targets Report
Appendix C.1	MM Target Table with Calculated Properties

1. Abbreviations

The following abbreviations may be used in this document

1VD First Vertical Derivative

AGC Automatic Gain Control

GDA94 Geocentric Datum of Australia 1994

GNSS Global Navigation Survey System

kn Knots

LAT Lowest Astronomical Tide

MGA Map Grid Australia

m Metres

ms Milliseconds

m/s Metres per second

MBES Multi-Beam Echo Sounder

MM Marine Magnetism

QA Quality Assured

QC Quality Control

SSM Standard Survey Mark

2. Introduction

During June 2022, Surrich Hydrographics was contracted to perform a marine magnetic survey for the purpose of identifying ferrous objects on and beneath the seabed at the proposed project site for the “Mandorah New Marine Facilities to Service Mandorah and Cox Peninsula Communities”.

In the deeper waters, the methodology consisted of towing a Side Scan Sonar (SSS) which in turn towed a neutrally buoyant magnetometer. This approach allowed the magnetometer to be towed at a nominal altitude of 2m above the seabed. The altitude of the magnetometer is derived from analysis of the SSS bottom track, and the side scan imagery is navigationally fine-tuned to provide superior positioning for the magnetometer..

In the shallower waters, larger vessel access was restricted a small 4m polly craft was utilized to surface tow the magnetometer. The altitude above the seabed was calculated using tides and supplied bathymetry.

Figure 1 shows the survey area and planned works supplied by the client. The existing jetty is visible to the south, and the planned construction works consists of breakwaters, dredging, piling and a floating pontoon.

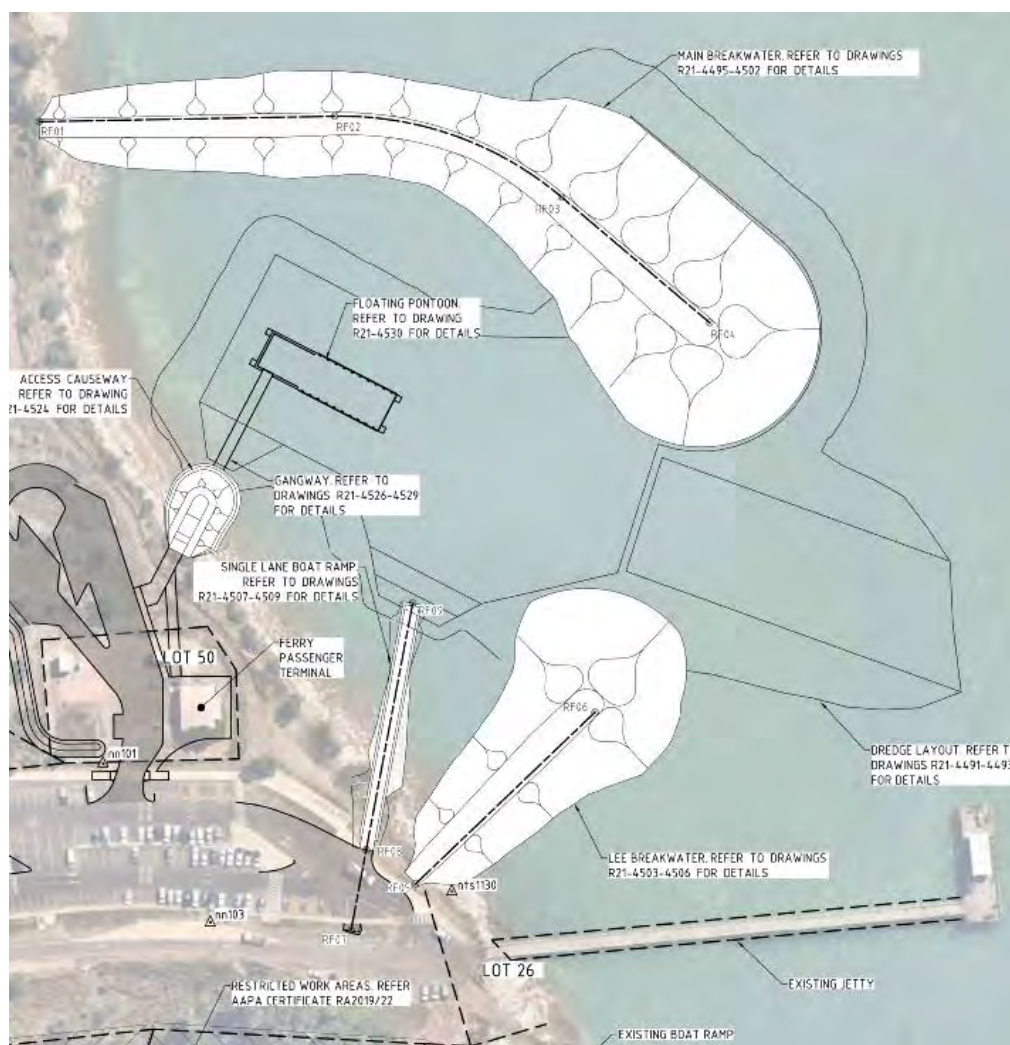


Figure 1. Site Overview.

3. Scope and Methodology

The scope was for a magnetometer survey at Mandorah to target ferrous objects for follow-up investigation by divers experienced in the search, identification, and recovery of objects on and beneath the seabed.

The scope included the requirement to identify hazards that may affect dredging and construction activities including the potential for UXO objects. Surrich is not a registered UXO contractor, however we believe this survey provides an excellent first investigation in the process of UXO risk management.

The survey areas were described as extending from North of Mandorah jetty to a distance of 50m beyond the new breakwater locations. The grey lines in Figure 2 demonstrates the magnetometer sensor coverage achieved.

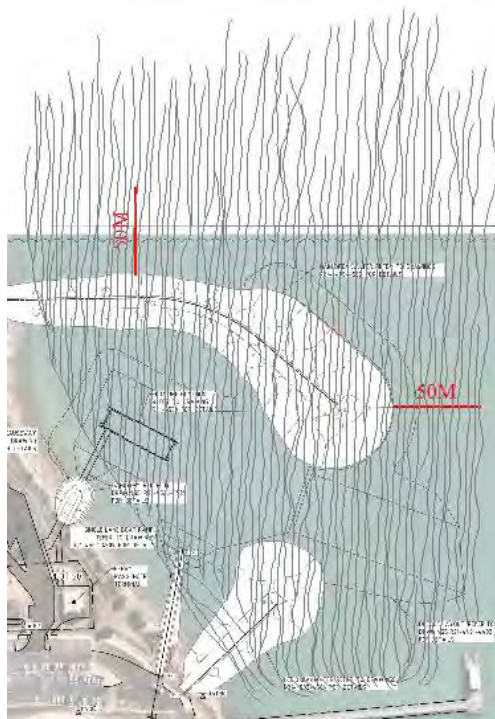


Figure 2. MM sensor line coverage.

When operating in shallow coastal locations for ferrous object detection, we typically utilize a methodology where we consider it is more important to travel slowly and get the magnetic sensor as close to the seabed, and thus as close to the ferrous targets, as possible. We achieve this by towing a weighted SSS on a winch which is used to control altitude, then the neutrally buoyant magnetic sensor is towed a fixed distance behind the SSS towfish. Operating the magnetometer in close proximity to a vessel, results in the magnetic field of the vessel being detected by the sensor. By operating in smooth waters and conducting ‘graceful’ turns, the longer wavelength interference, or heading errors, including other unwanted magnetic components including diurnal magnetic variations, may be filtered out during processing, leaving the small wavelength anomalies from shallow sources including the ferrous objects being targeted. This methodology also allows us to utilize the SSS imagery to refine the navigation of the magnetometer. Our methodology is contrary to some scopes which require the magnetometer to be towed far enough behind the vessel to reduce the interference. We maintain our methodology results in technically superior results for detection of small ferrous on this project.

4. Limitations

4.1. Marine Magnetism (MM) Limitations

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

The use of the term “ferrous” indicates a material ‘containing iron’ which typically exhibits a measurable magnetic field in the presence of the Earth’s magnetic field. Some varieties of stainless steel are ‘austenitic’ meaning they are non-magnetic and will therefore not be detectable by a magnetometer survey.

The magnetic method does not have the ability to locate all magnetically ferrous objects in a survey area. The response from smaller objects may not be distinguishable from the background. The probability of detection decreases as iron content becomes less and distance from the sensor increases.

Operating in high magnetic gradient areas, for example, around wharves and vessels, further reduces the ability of the technique to detect target objects on the seabed. In the immediate vicinity of wharves and steel pilings effectiveness of the method degrades to the level where the method becomes ineffective, and the ground should be inspected using diver search methods.

Operating in close proximity to magnetic geological sources, for example in high susceptibility magnetic gravels, or very shallow magnetic bedrock further reduces the ability of the technique to detect target objects on the seabed.

Quantitative interpretation relies on an accurately sampled field, however in practice, the inability to perfectly sample the magnetic field vectors, as well as non-ideal, complex magnetic sources, strongly reduce the reliability of the calculated target properties.

4.2. Side Scan Sonar (SSS) Limitations

Operating SSS for object detection is a trade-off between range, resolution, and required accuracy. 100% imaging of the seafloor at consistent accuracy is impossible. The position of the sensor and sonar beams are typically estimated using a layback calculation and object detection and positioning in turns may be unreliable.

Supplied SSS mosaics should not be relied upon for detailed object detection. Target interpretation is performed in an interactive software environment which allows analysis of all available information at the maximum resolution.

5. Field Logistics

Work was conducted out of the Cullen Bay Marina. Acquisition was planned to take advantage of high tides.

5.1. Project Timeline

Activity	Dates
Fly Perth to Darwin	8/11/2022
Mobilizing vessel (some delay waiting for freight to arrive)	9/11/2022 – 11/11/2022
Acquisition aboard Category 5 using the SSS/MM deployment method.	12/11/2022 – 13/11/2022
Mobilizing polycraft Bluey for surface tow.	14/11/2022
Acquisition using Bluey using the surface tow method.	15/11/2022
Demobilize vessels and ship equipment.	16/11/2022
Fly Perth to Darwin.	17/11/2022

Table 1. Project Timeline

5.2. Project Personnel

Name	Role	Qualifications
J Anning	Crew Chief, Geophysicist	BSc Geophysics, Coxswain
Various CMG personnel	Vessel master and onsite support	Appropriate commercial qualifications to master the vessels.

Table 2. Project Personnel

6. Coordinate System

6.1. Horizontal Datum

GDA94 MGA Zone 52

6.2. Vertical Datum

The vertical datum is not a major consideration with respect to the results. For planning and presentation purposes a topographic/bathymetric dataset was utilized from previous geotechnical seismic works conducted by Surrich Hydrographics at the site. The supplied bathymetric file name was:

- “20170919 - Hydrographic_Drone Survey_ Geosciences Australia Combined 1m LAT-MGA94”

This dataset proved adequate for planning purposes however we note it is not complete and we noted shoals (IE shallow rocks) in the hydrographic section of the dataset which were not adequately mapped providing a potential navigation hazard if planning under vessel clearances based on the data and tide values.

The most relevant vertical datum for a magnetometry survey is simply the seabed itself and the height of the magnetic sensor above the seabed.

7. Positioning System Checks

This survey was performed concurrently with a separate contract performing hydrographic survey by Surrich Hydrographics for the Port of Darwin. We utilized the same RTK base station established on Stokes Hill Wharf coordinated using the AUSPOS service, and verified against SSMs on land. The RTK rover utilized when performing the RTK checks for the Port of Darwin survey was also used to position the tow point for the magnetic survey work on this project.

As an additional check we verify the position system simply by establishing the SSS imagery is coordinated with the supplied bathymetric surface.

8. Acquisition

8.1. Survey Vessel used during SSS/MM acquisition

Name	Category-5
Description	12m Aluminium catamaran. Twin 350hp outboard engines.
Survey Certificate	2C

Table 3. Category-5 survey vessel specification



Figure 3. Survey Vessel “Category 5”

8.2. Survey Vessel used during surface to MM acquisition

Name	Bluey
Description	4.1m Polycraft Challenger. 30hp outboard engine.
Survey Certificate	2D

Table 4. Bluey survey vessel specification



Figure 4. Survey Vessel “Bluey”

8.3. Positioning and Navigation Equipment

Survey positioning system	Septentrio Altus NR2
GNSS correction source	Trimble base station at Stokes Hill Wharf
Offsets and configuration	Antenna mounted directly above and line with the tow point.
On-line navigation software	Sonarwiz.

Table 5. Navigation Equipment

8.4. Side Scan Sonar

Side Scan Sonar	Edgetech 4125 600/1600 kHz
Acquisition System	Edgetech Discover.
Frequency	1600kHz
Range	20m
Altitude	~2m was the target altitude above the seabed (for magnetic purposes). Actual altitude may vary according to risk.
Nominal vessel speed	~3kn
Line spacing	4m
Offsets	Tow point is directly beneath the primary positioning antenna.
Notes	The SSS was deployed via a cable counter on the survey vessel temporary A frame. A proportional winch system was used for depth control.

Table 6. Side Scan Sonar Specifications

8.5. Marine Magnetometer (MM)

Magnetometer	Marine Magnetics Explorer
Acquisition System	Data logged to Edgetech JSF file stream, in addition to the manufacturers BOB acquisition software.
Sample interval	4Hz
Nominal vessel speed	~3kn
Line spacing	4m
Base station mag	None utilized.
Offsets	7.5m aft of tow point on SSS fish 13.5m behind the primary antenna when performing the surface tow from the polycraft.
Acquisition Notes	This sensor is neutrally buoyant and is assumed to tow directly behind the path of the SSS. When performing the surface tow, floatation was attached

Table 7. Marine Magnetometer Specifications

9. Processing

9.1. Side Scan Sonar (SSS)

- Import SSS data from the Edgetech .jsf file into Sonarwiz processing software.
- Bottom track the SSS files and apply Empirical Gain Normalization to balance the intensities.
- Apply layback calculations:
 - Smooth the logged ‘cable out’ distance.
 - Fine-tune the layback calculation to improve the positional match between the SSS and the MBES.
- Work through each SSS waterfall image, identifying man-made debris type contacts only.
- Filter duplicate results down to a single target.
- Place observations in the “Description” field.
 - Because there were few targets it was not necessary to apply classifications. (IE sort the targets into different types).

9.2. Marine Magnetism

1. Locating MM data towed behind the SSS.
 - a. Export improved SSS navigation files from Soanrwiz (including the SSS fish altitude) and merge the improved positions with time-stamped magnetic data.
 - b. Layback the MM sensor data by 7.5m which is the distance from the SSS transducer to the MM sensor.
2. Locating MM data surface towed behind the polycraft.
 - a. Layback the MM sensor data by 13.5m which is the distance from the RTK GPS antenna to the MM sensor.
3. Processing in Oasis Montaj software using the Marine_UXO extension.
4. Apply altitude correction using the “upward/downward continuation” method to adjust anomalies to a uniform 2m altitude.
5. Trim start and end of lines as required by nulling the Easting channel only. This methodology maintains the entire acquired magnetic profile in a file. The advantage of this methodology is it minimizes end of line effects when filters are applied to the magnetic channel.
6. Estimate the background using appropriate filtering routine, ensuring the background estimation does not affect target anomalies.
 - a. Calculate the residual by subtracting the estimated background. We refer to the resultant dataset as the “Magnetic Anomaly”. This process effectively removes diurnal variations and heading errors for the purpose of this survey.
 - b. Subsequent analysis of the Magnetic Anomaly grid derived from the “total field with background removed” showed this methodology did not create an artifact free image due to the effect of the wharf, therefore, we resorted to the following alternate method of shallow anomaly enhancement and display:
7. The final and preferred method of background removal and shallow target enhancement was calculating the first vertical derivative (IVD) on the profile data. This calculates the rate of change in the vertical direction, enhancing near surface anomalies from ferrous targets (and shallow geologies) while suppressing longer wavelength anomalies from the wharf, diurnal effects and heading effects.
8. Pick targets by working work through each acquired profile, analysing the raw magnetic profiles, in addition to the IVD and Analytic Signal, picking anomalies that may be due to shallow ferrous objects.
9. Calculate depth and weight of the targets using Euler Deconvolution:
 - a. Create appropriate windows around the anomalies to use in property calculations
 - b. Method described by (Pennella, 1982) and (Pawlowski et al,1995)
 - c. Structural index of 2.7 was used for all targets.

10. Discussion of Results

The processed results are presented in the following appendices:

- Appendix A.1 Magnetic Survey Lines Over Bathymetry
- Appendix A.2 Magnetic Survey Lines Over Site Layout
- Appendix A.3 Magnetic Sensor Altitude
- Appendix A.4 Magnetic First Vertical Derivative with Targets
- Appendix A.5 Magnetic Analytic Signal with Targets
- Appendix A.6 Targets Over Bathymetry
- Appendix B.1 SSS Mosaic with Targets
- Appendix B.2 SSS Targets Report
- Appendix C.1 MM Target Table with Calculated Properties

The data presented in the appendices are discussed herein:

- Appendix A.1 Magnetic Survey Lines Over Bathymetry
- Appendix A.2 Magnetic Survey Lines Over Site Layout
- Appendix A.3 Magnetic Sensor Altitude

These charts demonstrate good line coverage was achieved north of the existing jetty out to a distance of 50m beyond the north and east from the planned rockwalls. Some additional data was recorded further north as it is advantageous to have a good run in towards the navigation run lines to ensure the vessel has stabilized on the line. Additionally, it is useful to map an increased area to get a better overview of the background when a relatively small survey site is being investigated.

With the available tides we were able to survey to approximately the 4m LAT contour utilizing the combination of a larger vessel where we towed the sensors just above the seabed and smaller polycraft where we performed a surface tow of the magnetic sensor over the shallows.

We were able to safely survey to approximately 10m out from the wharf in the wind and tide conditions, however performing a magnetic survey immediately adjacent to a wharf becomes problematic due to the strong magnetic field of the wharf itself. We recommend a manual search of the seabed where there is no data between the wharf and the supplied data herein.

The magnetic target altitude of 2m was set by Surrich Hydrographics – no specification for this work was actually provided by the client. It is our experience that this is a reasonable altitude to achieve good detection of smaller ferrous objects down to roughly 10kg, however it is impossible to accurately specify detectable target size and detection limits because some objects exhibit remnant magnetization, which can strongly enhance detectability (I.E. they behave more like a magnet).

We also recommended a line spacing of 5m, however we performed the work along a 4m spaced line plan to account for deviations in the vessel tracking.

The sensor altitude was typically 2m or lower in the deeper waters (eastern half of the area), where the magnetometer was deployed from the larger vessel with the assistance of the SSS to accurately track altitude above the seabed. On the western half of the site we switched to a surface tow and the altitude was dictated by the height of the tide over the seabed. Within the scoped survey area, the altitude was mostly very close to the specified 2m survey altitude although increased to 3m in places (1m above the target altitude) during the surface tow.

- Appendix A.4 Magnetic First Vertical Derivative With Targets
- Appendix A.5 Magnetic Analytic Signal With Targets

These charts show the magnetic field in two different formats. Someone experienced in magnetometry will appreciate the “First Vertical Derivative” as an effective product to enhance the near surface targets and suppress deeper and longer wavelength targets.

The “Analytic Signal” chart is a product designed to simplify the results and enhance those shallow anomalies with high gradients. It is also utilized in the calculation of the magnetic properties.

During processing we also produced a product consisting of the “*total field magnetics with background removed*” however while this was utilized in processing, the “first vertical derivative” proved to be a superior image for presentation.

Target picking was performed using all available data including the gridded results in addition to the profile results. Small targets may have been picked from the profile data which do not have a noticeable anomaly in the gridded images. The fact these targets are small make them no less significant than larger targets.

As target sampling and follow up has not been performed at this project site, it is difficult to ascertain how many of the targets may be due to shallow geological sources.

- Appendix A.6 Targets over bathymetry

This charts the identified magnetic and Side Scan Sonar targets over the supplied bathymetry. We understand the vertical datum of the bathymetry is LAT although we have not independently verified the accuracy ourselves. We also consider it to be incomplete and have observed it does not accurately map some of the shallowest rocks in the area.

This chart is useful for follow-up planning purposes and demonstrates that some of the areas may be examined on foot during a suitable low tide.

- Appendix B.1 SSS Mosaic with targets
- Appendix B.2 SSS Targets Report

Appendix B1 shows the SSS mosaic and the SSS imagery extents acquired. For object detection the supplied mosaiced image is typically not suitable for detailed analysis. Each acquired line of data is examined in detail using specialist software and the target report contains the best imagery of any SSS targets/contacts detected.

- Appendix C1 Magnetic Targets Table

This table contains the calculated properties of the magnetic targets. These are indicative only and should only be used as a very rough guide. The “mag depth” is below the seabed. The weights and depths may easily be twice or half of the indicated values (or more!), and the numbers are incapable of separating out ferrous objects from geological sources.

11. Follow up target investigations

If requested, we can assist with setting up a laptop showing imagery and targets on a moving map type display to assist with navigation and target follow up.

12. Conclusions

- We believe the survey was performed to a high standard and our methodology was well suited to meet the survey objectives.
- We believe that many of the targets represent ferrous objects however we expect that there may also be geological sources.
- Magnetic detection immediately adjacent to the wharf becomes problematic due to the strong magnetic field of the wharf and risk involved in operating too closely to the wharf in wind and current. Therefore there is a section of missing magnetic data adjacent, and on the north side of the wharf, where no magnetic data exists.

13. References

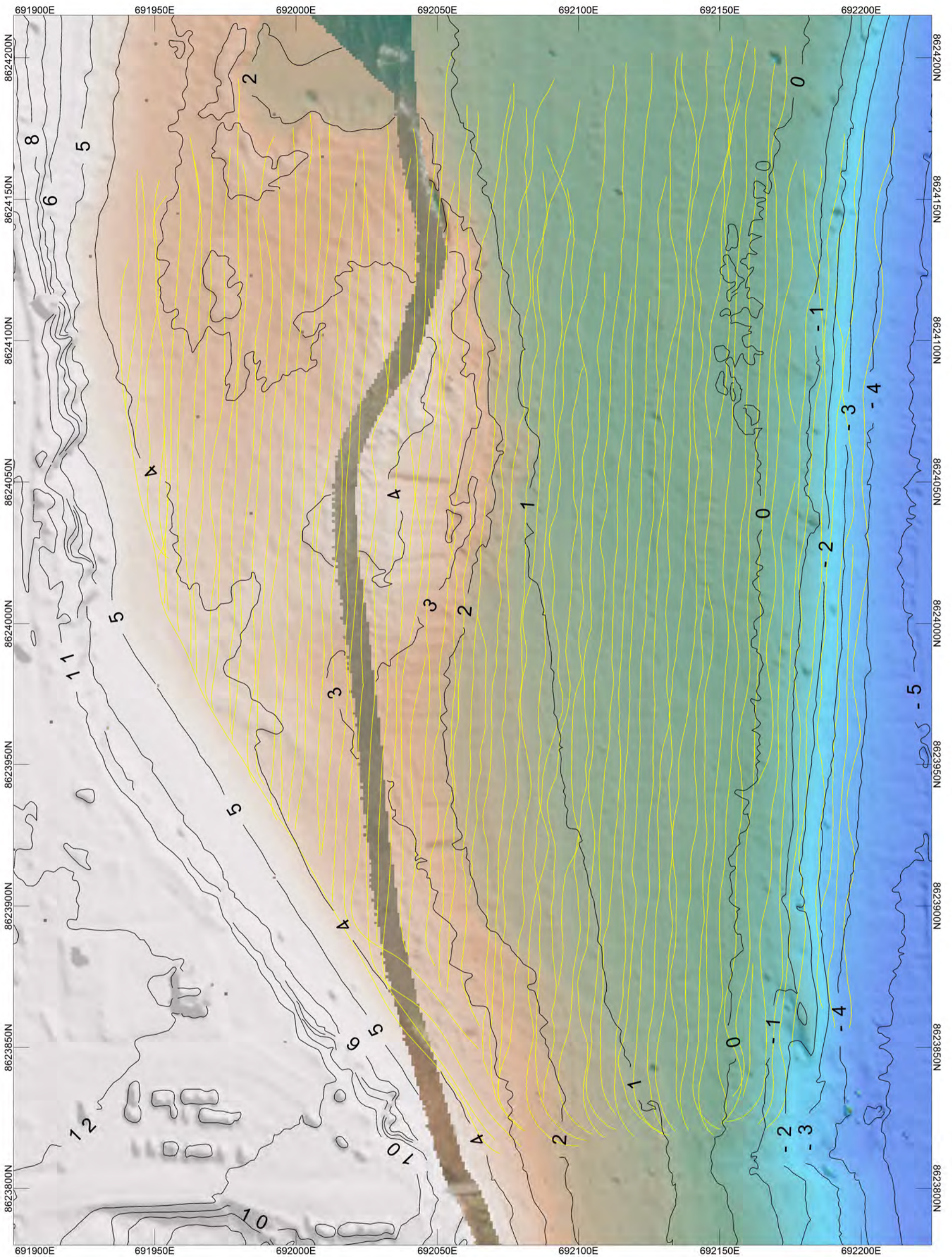
Pennella J. (1982) Magnetometer Techniques in the Detection of Projectiles. NAVEODTECHCEN Technical Report TR-239, Naval Explosive Ordnance Disposal Technology Center, Indian Head Maryland.

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.

14.Digital Products

The digital data has been supplied in the following directory tree:

```
+---0. Report
|   SH20221103_November_2022_CMG_Mandorah_Marine_Magnetics_Report_rev0.pdf
|
+---1. MM_geotiff
|   Appendix_A4_first_vertical_derivative_magnetic_imagery_and_targets.tif
|   Appendix_A5_analytic_signal_magnetic_imagery_and_targets.tif
|
+---2. MM_ascii_targets
|   Appendix_C1_Magnetic_Targets_Table_rev0.xlsx
|
+---3. SSS_geotiff
|   Mandorah_MM_2022_10cm.tif
|   Mandorah_MM_2022_5cm.tif
|
+---4. SSS_ascii_targets
|   SSS_Contacts_ASCII_Table_rev0.csv
|
\---5. Bathymetry_3rd_Party_Supplied
     20170919 - Hydrographic_Drone Survey_Geosciences Australia Combined 1m LAT-MGA94.xyz
```



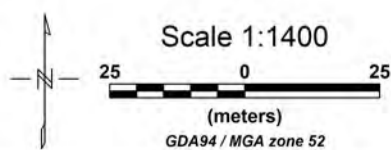
Mandorah Marine Facilities, NT
Marine Magnetic Survey

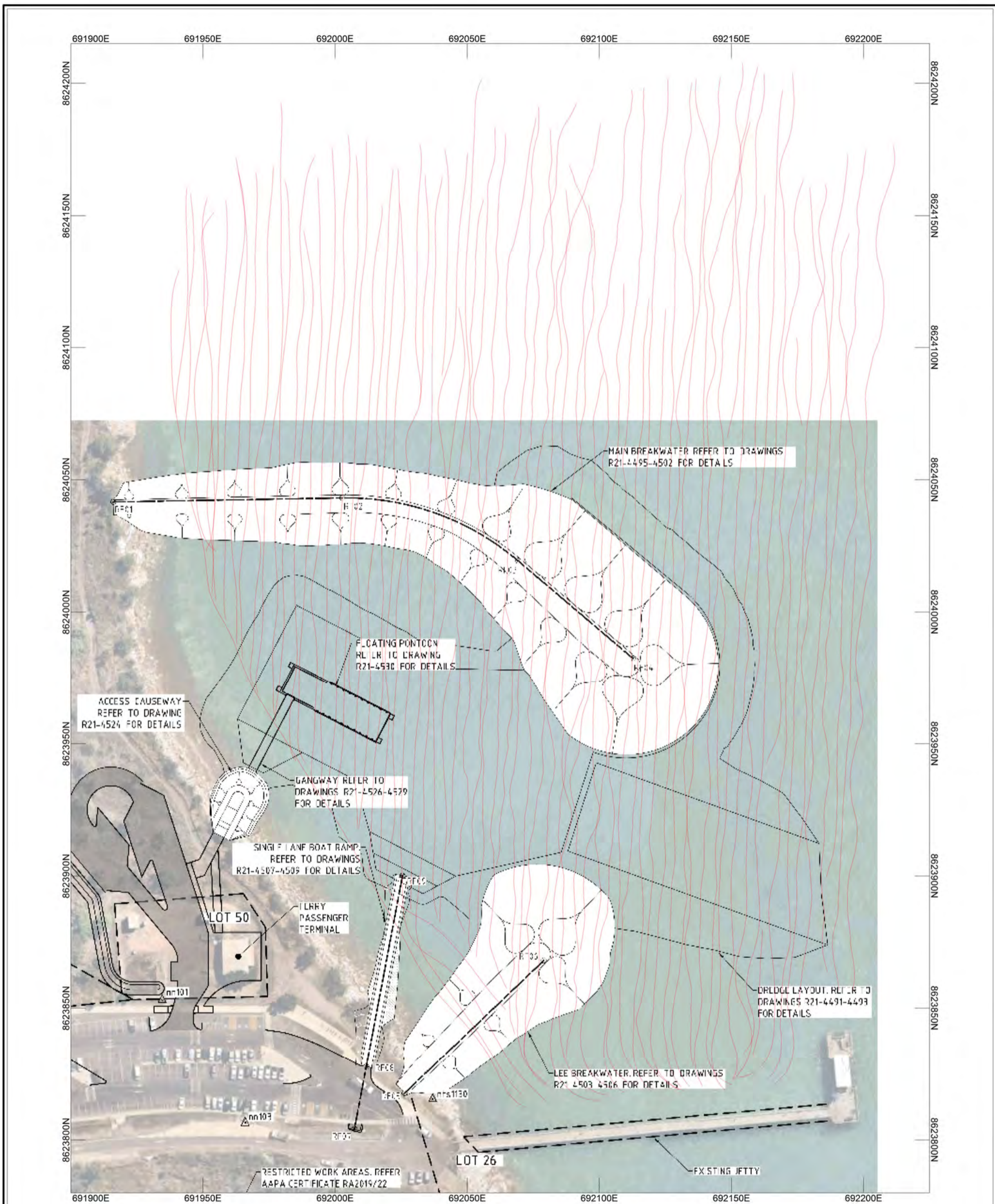
Appendix A.1 - Magnetic Survey Lines
3rd Party Supplied Bathymetry Base Map
LAT Datum

Horizontal Datum: GDA94
Projection: MGA52

Vertical Datum: 3rd party data supplied
as LAT however accuracy not verified.

Acquisition date: Nov 2022
By Surrich Hydrographics

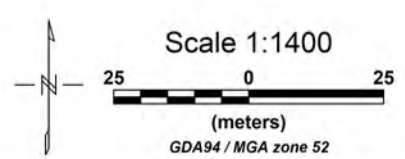




Horizontal Datum: GDA94
 Projection: MGA52



Vertical Datum: 3rd party data supplied as LAT however accuracy not verified.

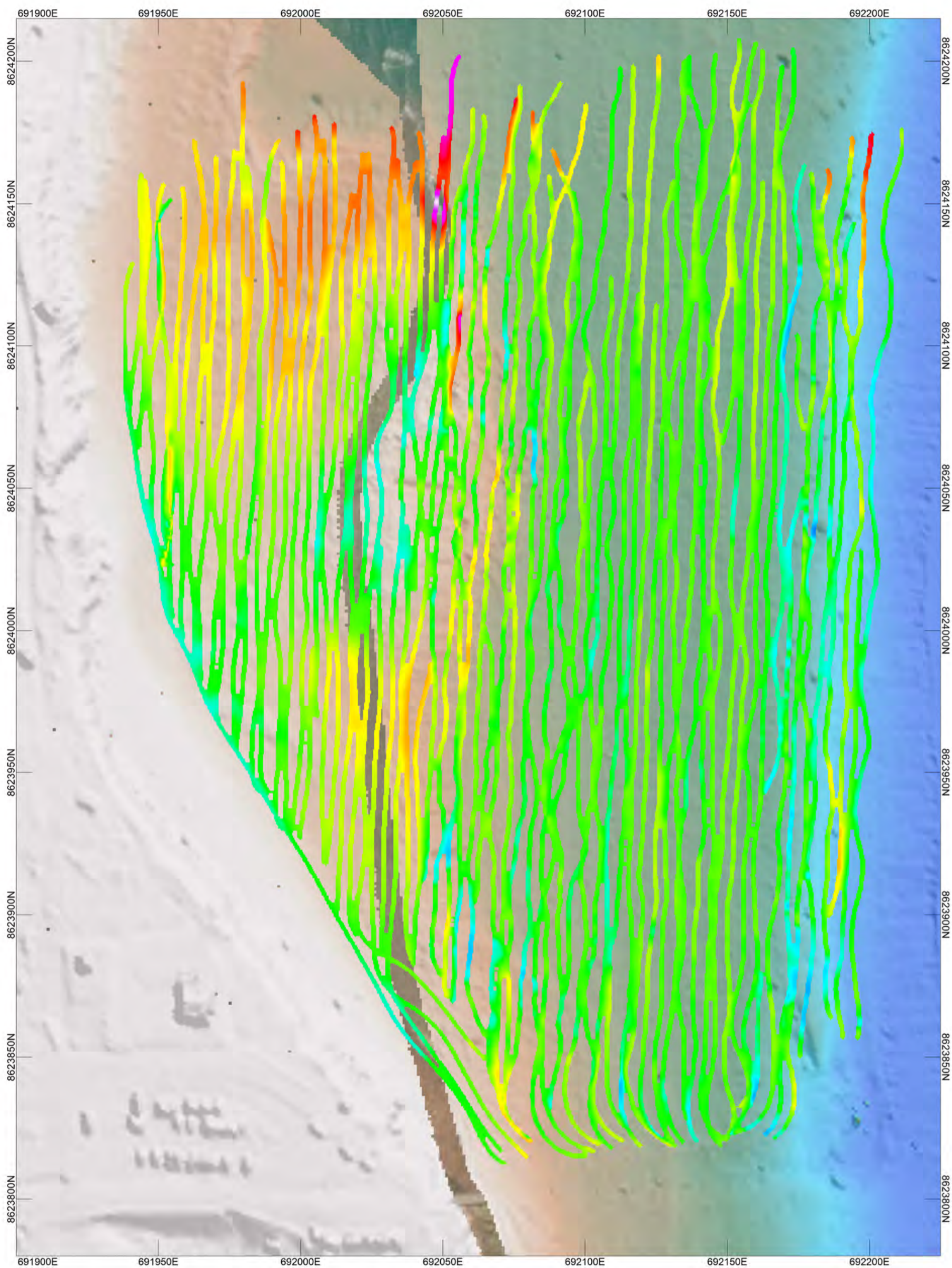
Acquisition date: Nov 2022
 By Surrich Hydrographics



**Mandorah Marine Facilities, NT
 Marine Magnetic Survey**

Appendix A.2 - Magnetic Survey Lines
 Planned site layout base image
 from NTG Drawing R21-4488

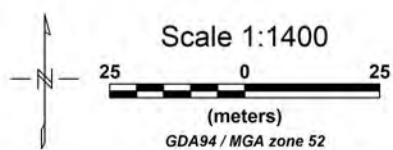





Horizontal Datum: GDA94
Projection: MGA52

Vertical Datum: 3rd party data supplied as LAT however accuracy not verified.

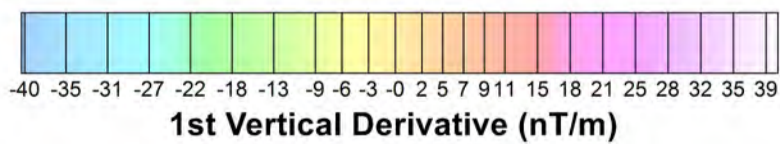
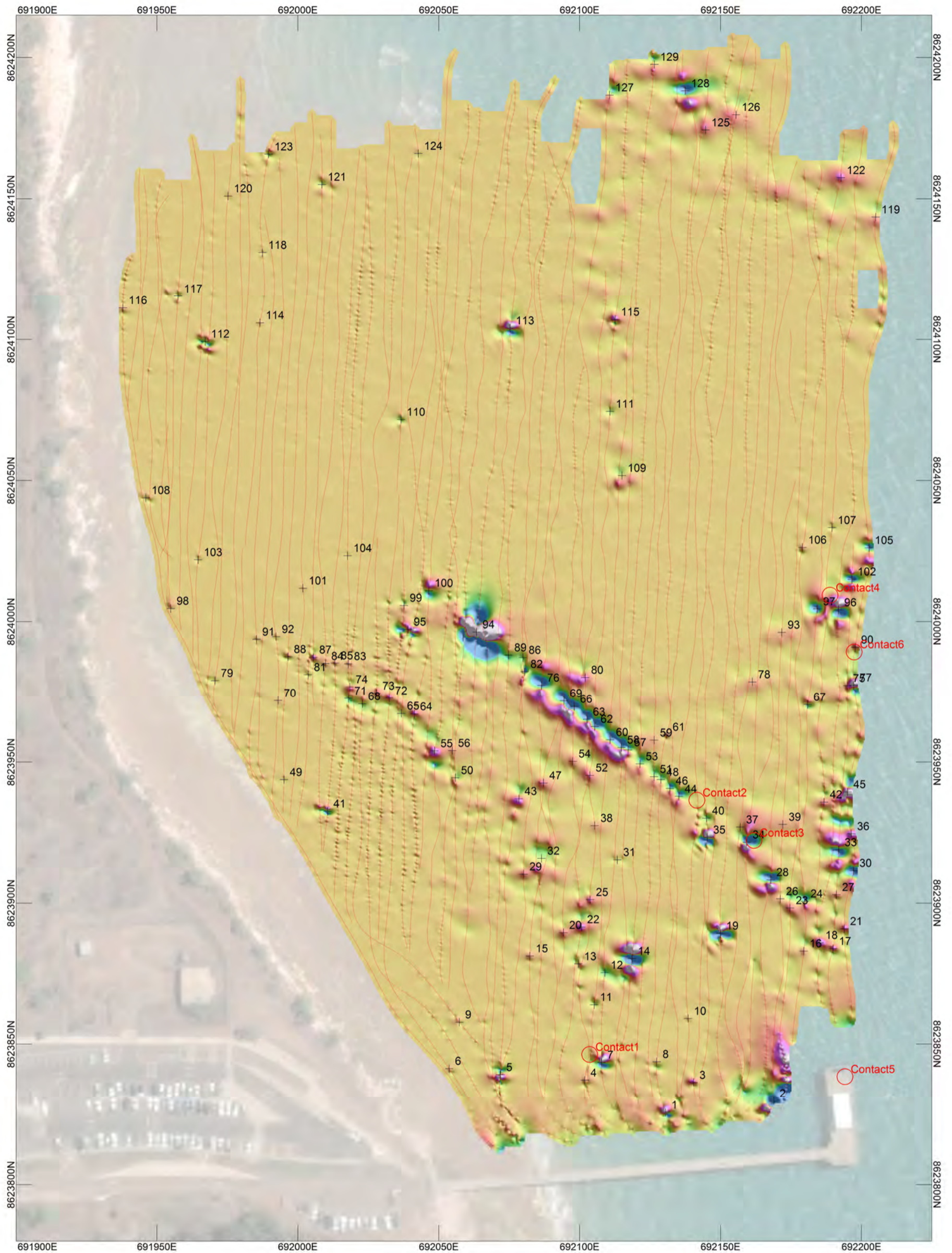
Acquisition date: Nov 2022
By Surrich Hydrographics



Mandorah Marine Facilities, NT
Marine Magnetic Survey

Appendix A.3 - Altitude difference above/below
2m target altitude above seabed

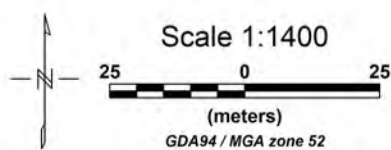




Horizontal Datum: GDA94
Projection: MGA52

Vertical Datum: 3rd party data supplied as LAT however accuracy not verified.

Acquisition date: Nov 2022
By Surrich Hydrographics



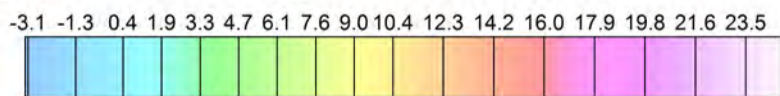
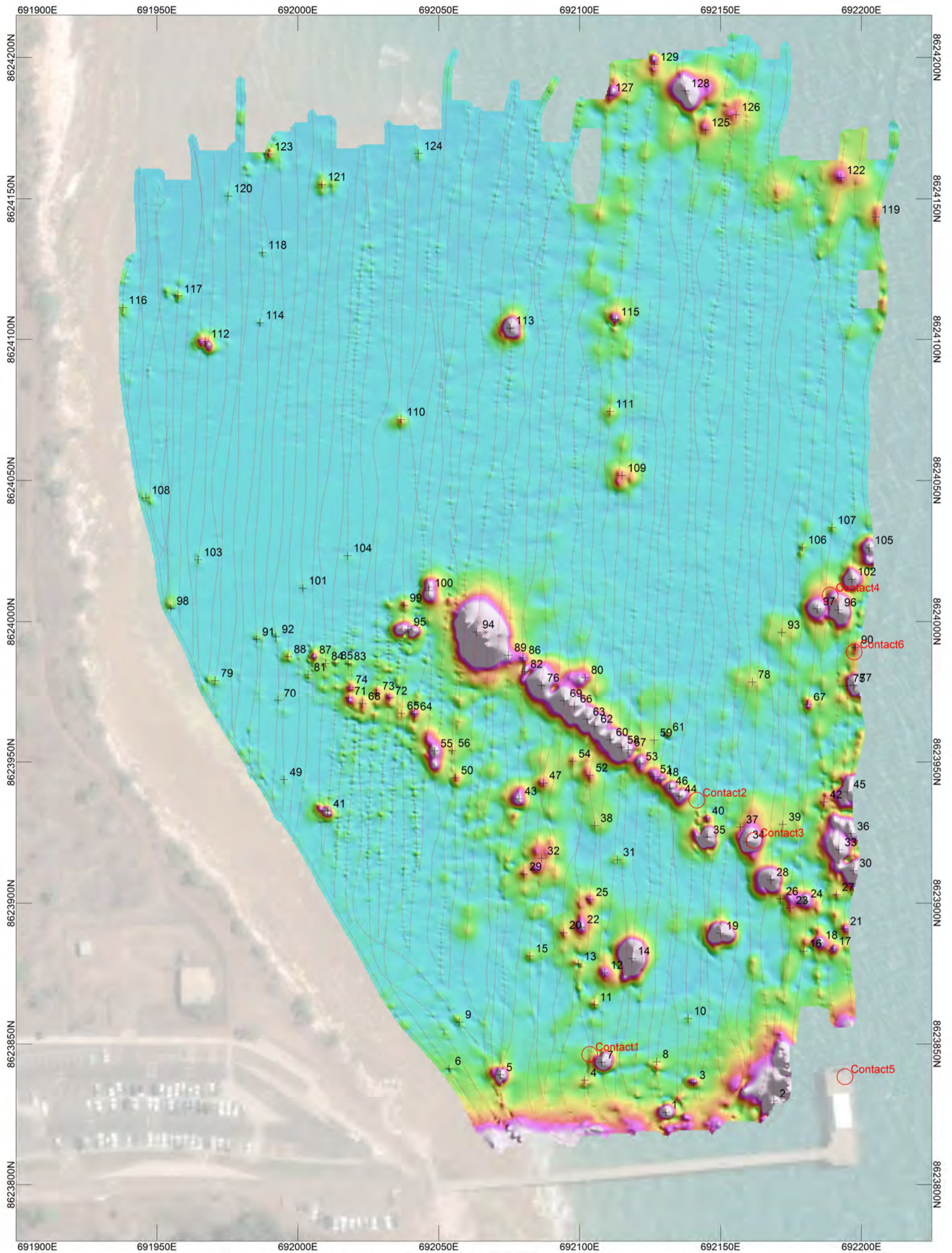
KEY

- Contact1 SSS Target and ID
- + 50 Magnetic Target and ID

Mandorah Marine Facilities, NT
Marine Magnetic Survey

Appendix A.4 - Magnetic Anomaly
First Vertical Derivative
With Interpreted Target IDs



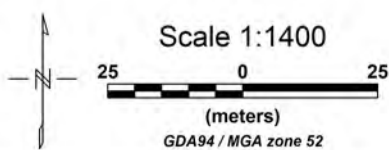


(with target size windows for property size calculations)

Horizontal Datum: GDA94
Projection: MGA52

Vertical Datum: 3rd party data supplied as LAT however accuracy not verified.

Acquisition date: Nov 2022
By Surrich Hydrographics



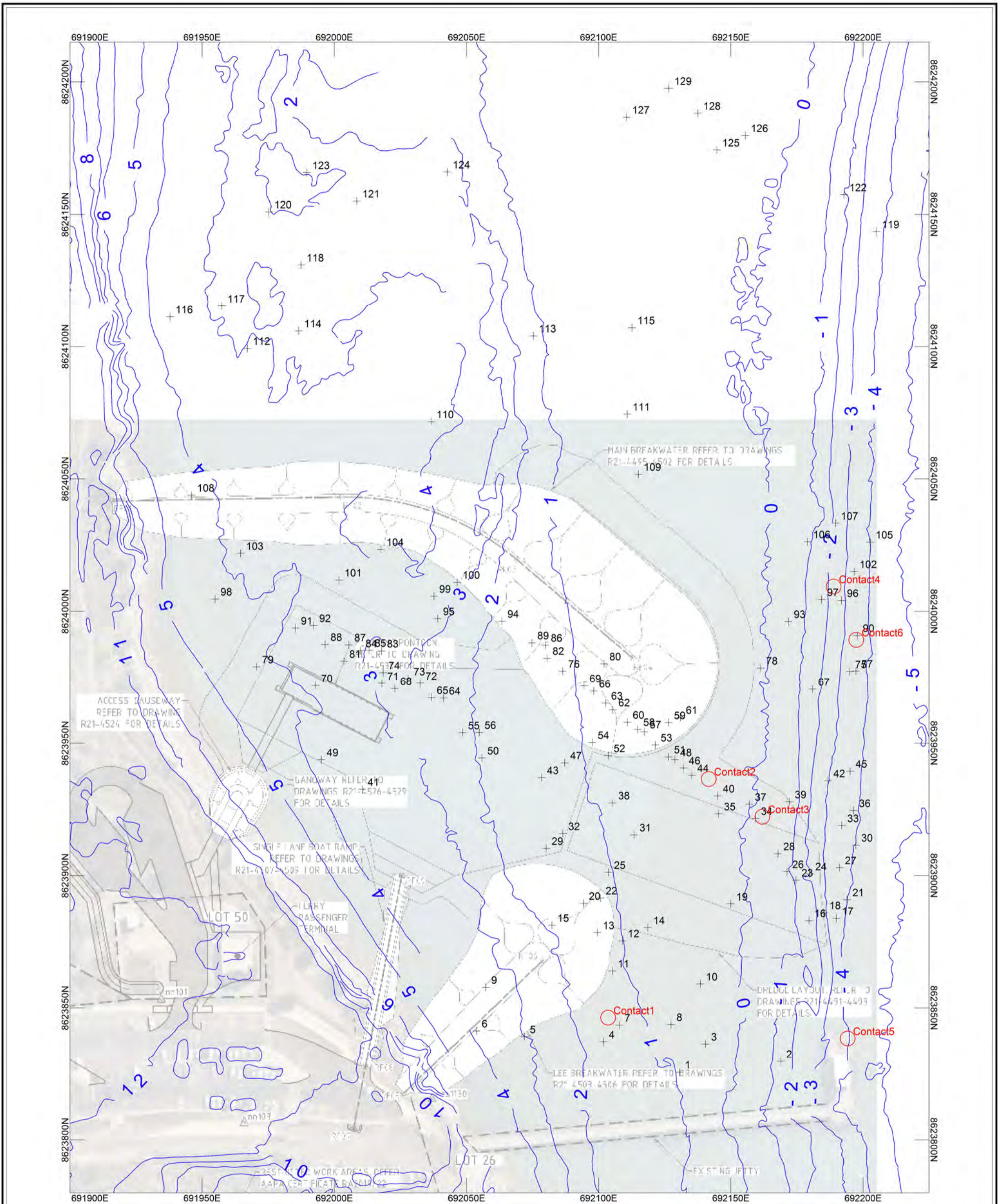
KEY

-  Contact1 SSS Target and ID
-  50 Magnetic Target and ID

Mandorah Marine Facilities, NT
Marine Magnetic Survey

Appendix A.5 - Magnetic Anomaly
Analytic Signal
With Interpreted Target IDs





Horizontal Datum: GDA94
 Projection: MGA52

Vertical Datum: 3rd party data supplied as LAT however accuracy not verified.

Acquisition date: Nov 2022
 By Surrich Hydrographics



KEY

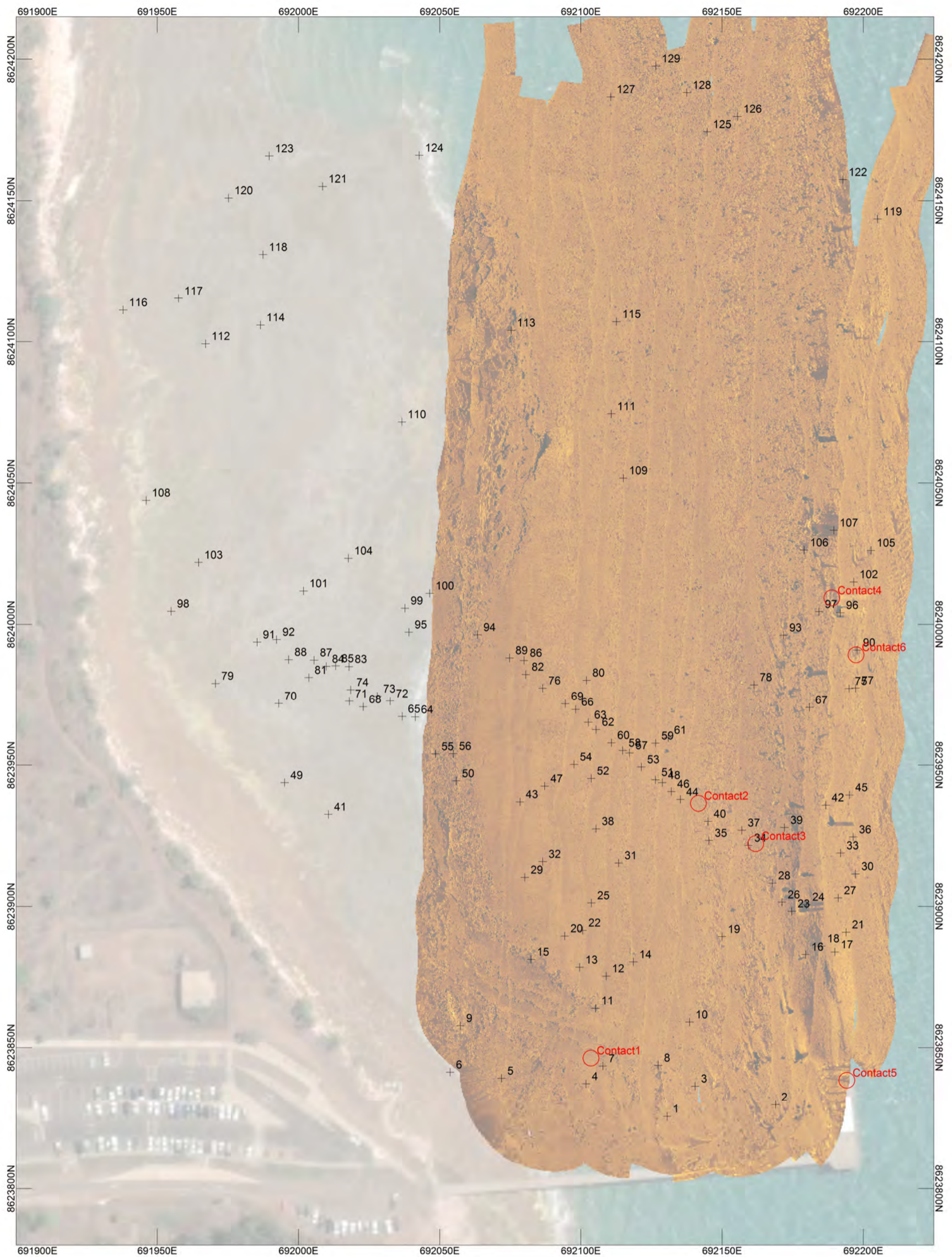
 Contact1 SSS Target and ID

 50 Magnetic Target and ID

**Mandorah Marine Facilities, NT
 Marine Magnetic Survey**

**Appendix A.6 - Magnetic Targets
 Bathymetric Contours (LAT)
 Constriction Plan Base Map**



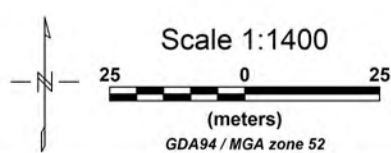
Mandorah Marine Facilities, NT
Marine Magnetic Survey

Appendix B.1- Side Scan Sonar
SSS Mosaic

Horizontal Datum: GDA94
Projection: MGA52

Vertical Datum: 3rd party data supplied
as LAT however accuracy not verified.

Acquisition date: Nov 2022
By Surrich Hydrographics

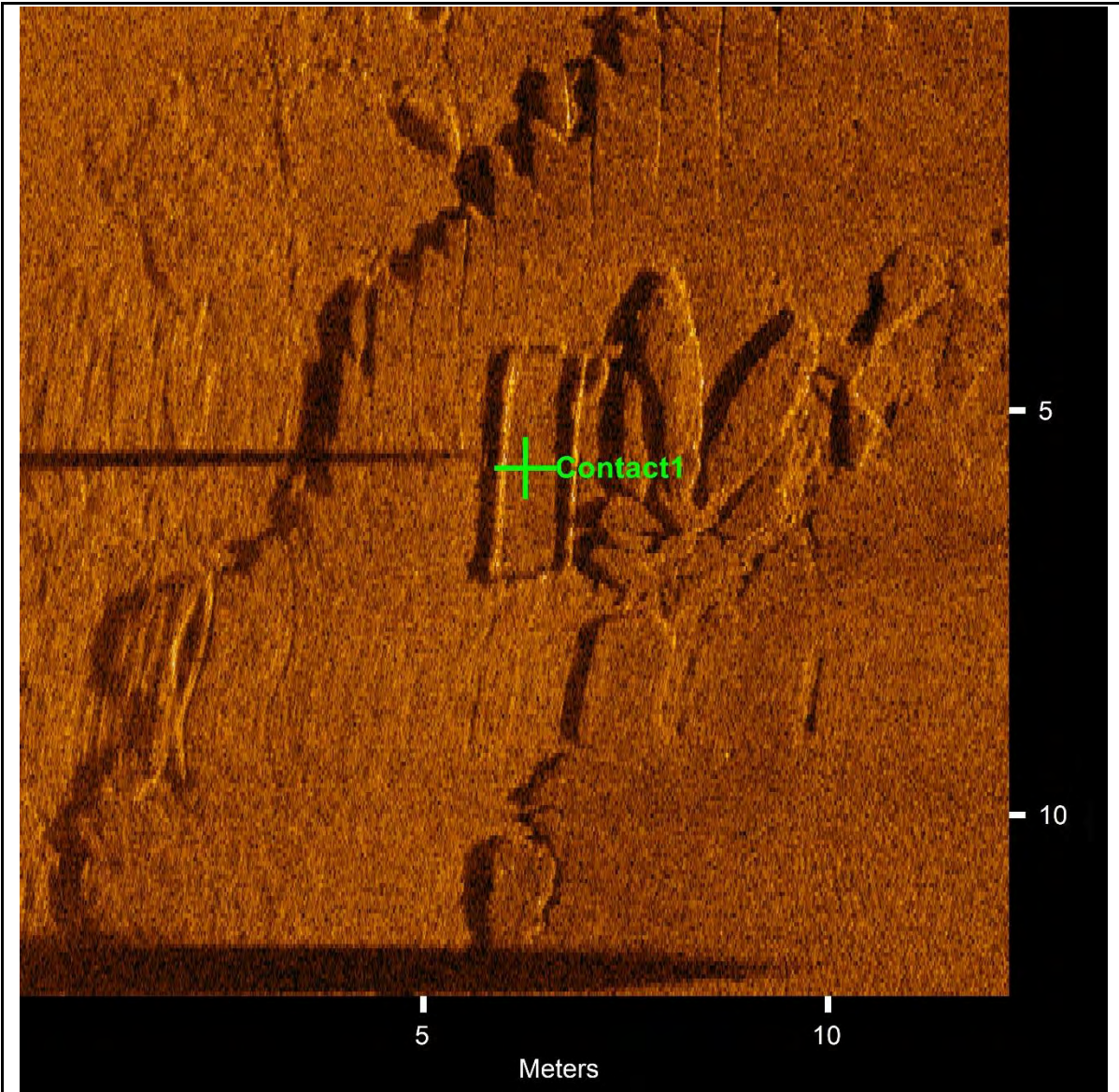


Appendix B.2 – SSS Report Mandorah2022

Generated on 28/11/2022 07:33:45

Contact Position Summary, GDA94 Datum.

Contact1	12/11/2022 21:23:05	12° 26.56540' S	130° 46.04336' E
Contact2	13/11/2022 01:18:43	12° 26.51639' S	130° 46.06402' E
Contact3	13/11/2022 01:28:07	12° 26.52404' S	130° 46.07527' E
Contact4	12/11/2022 02:02:06	12° 26.47670' S	130° 46.08983' E
Contact5	12/11/2022 02:44:42	12° 26.56935' S	130° 46.09338' E
Contact6	12/11/2022 02:02:19	12° 26.48759' S	130° 46.09462' E

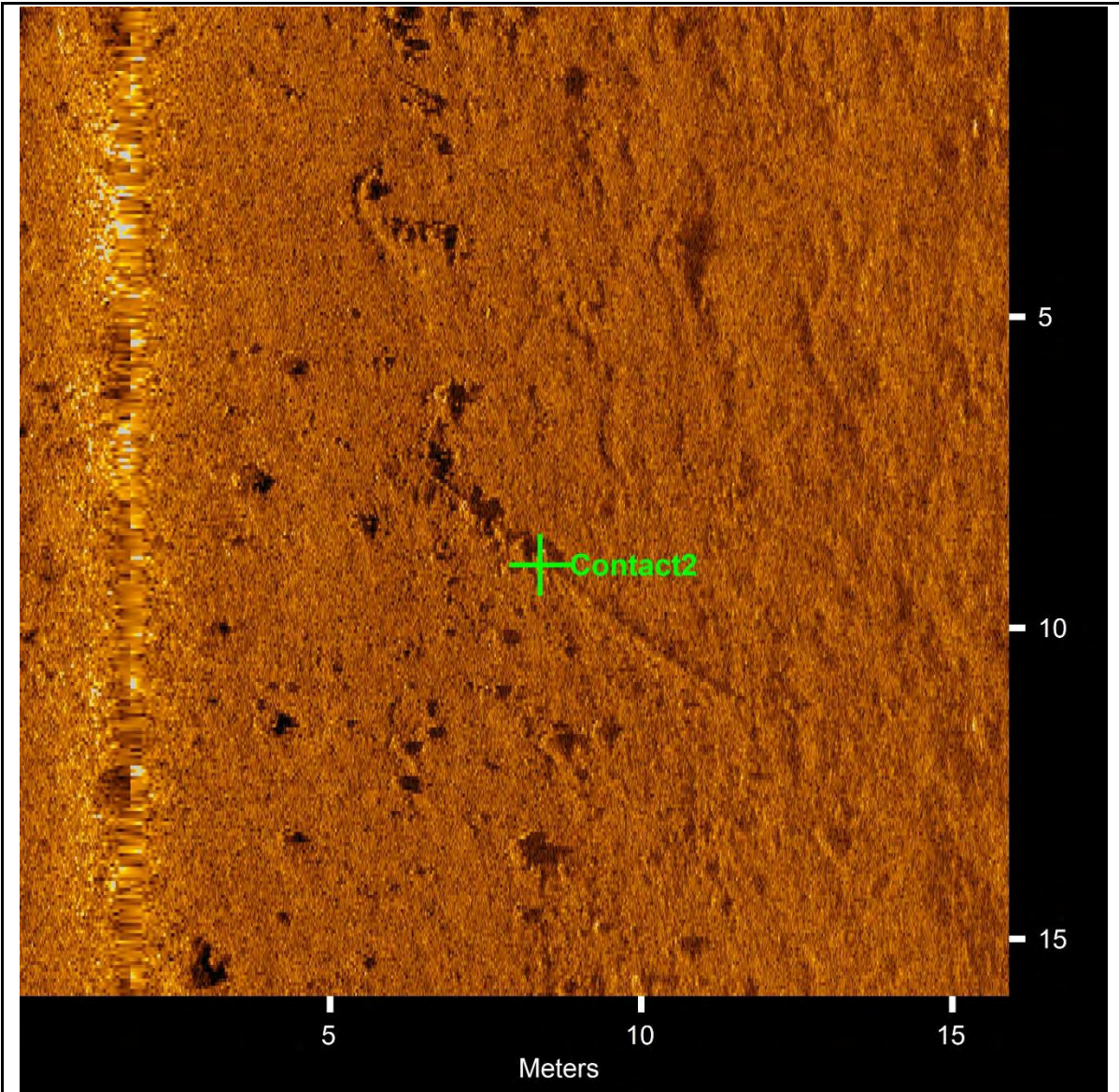


Contact1

- Sonar Time at Target: 12/11/2022 21:23:05
- Click Position
12° 26.56540' S 130° 46.04336' E (WGS84)
(X) 692103.58 (Y) 8623846.34 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221112211949.jsf
- Ping Number: 30069
- Range to target: 10.52 Meters
- Fish Height: 4.03 Meters
- Heading: 84.419 Degrees
- Water Depth: 0.15 Meters

Dimensions and attributes

- Target Width: 0.94 Meters
- Target Height: 0.00 Meters
- Target Length: 2.06 Meters
- Target Shadow: 0.00 Meters
- Area:
- Description: Geometrical shape suggests man made object. Nearby magnetic anomaly however does not exactly coincide.

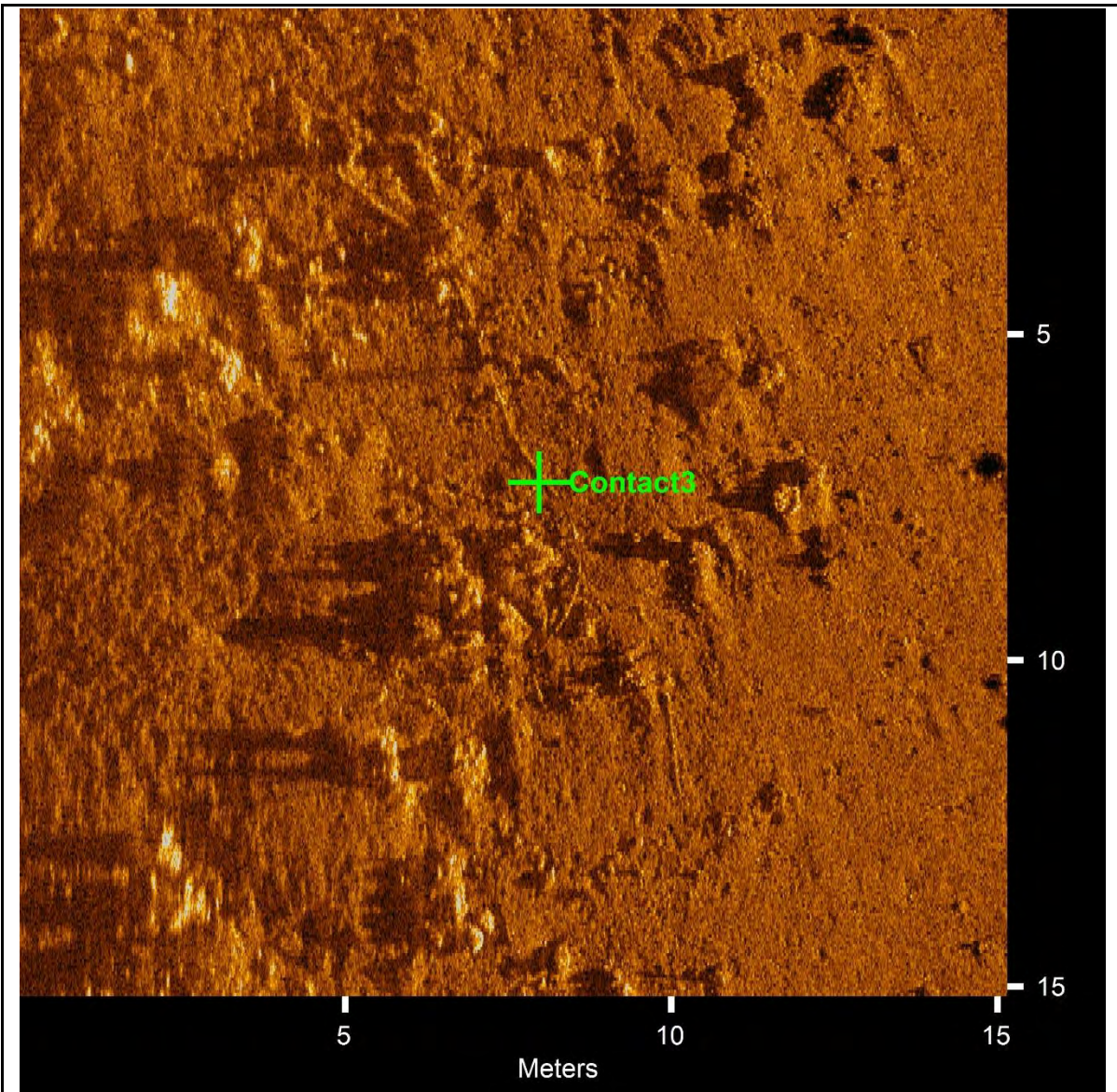


Contact2

- Sonar Time at Target: 13/11/2022 01:18:43
- Click Position
12° 26.51639' S 130° 46.06402' E (WGS84)
(X) 692141.62 (Y) 8623936.47 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221113011604.jsf
- Ping Number: 352649
- Range to target: 6.59 Meters
- Fish Height: 1.91 Meters
- Heading: 178.861 Degrees
- Water Depth: 1.50 Meters

Dimensions and attributes

- Target Width: 0.00 Meters
- Target Height: 0.00 Meters
- Target Length: 0.00 Meters
- Target Shadow: 0.00 Meters
- Area:
- Description: Rope or cable. Doesn't appear to be magnetic however on surface and possibly connected to a chain or similar causing the long linear magnetic feature (unless it s a geological anomaly). Shoud certainly be investigated as a priority.

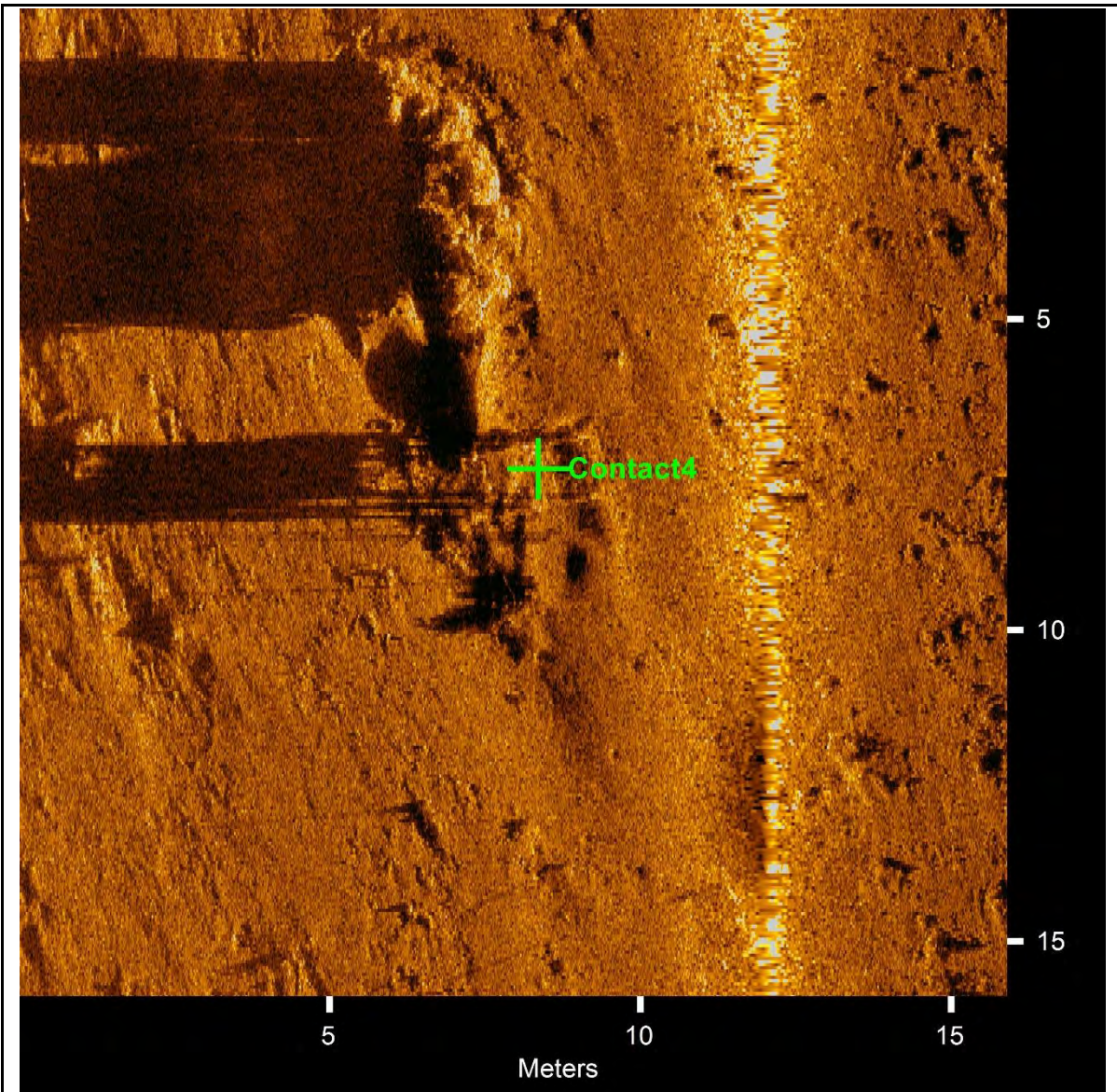


Contact3

- Sonar Time at Target: 13/11/2022 01:28:07
- Click Position
12° 26.52404' S 130° 46.07527' E (WGS84)
(X) 692161.91 (Y) 8623922.22 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221113012547.jsf
- Ping Number: 372707
- Range to target: 9.74 Meters
- Fish Height: 1.94 Meters
- Heading: 176.439 Degrees
- Water Depth: 1.39 Meters

Dimensions and attributes

- Target Width: 0.00 Meters
- Target Height: 0.00 Meters
- Target Length: 0.00 Meters
- Target Shadow: 0.00 Meters
- Area:
- Description: Coincides with strong magnetic anomaly so may be a chain.

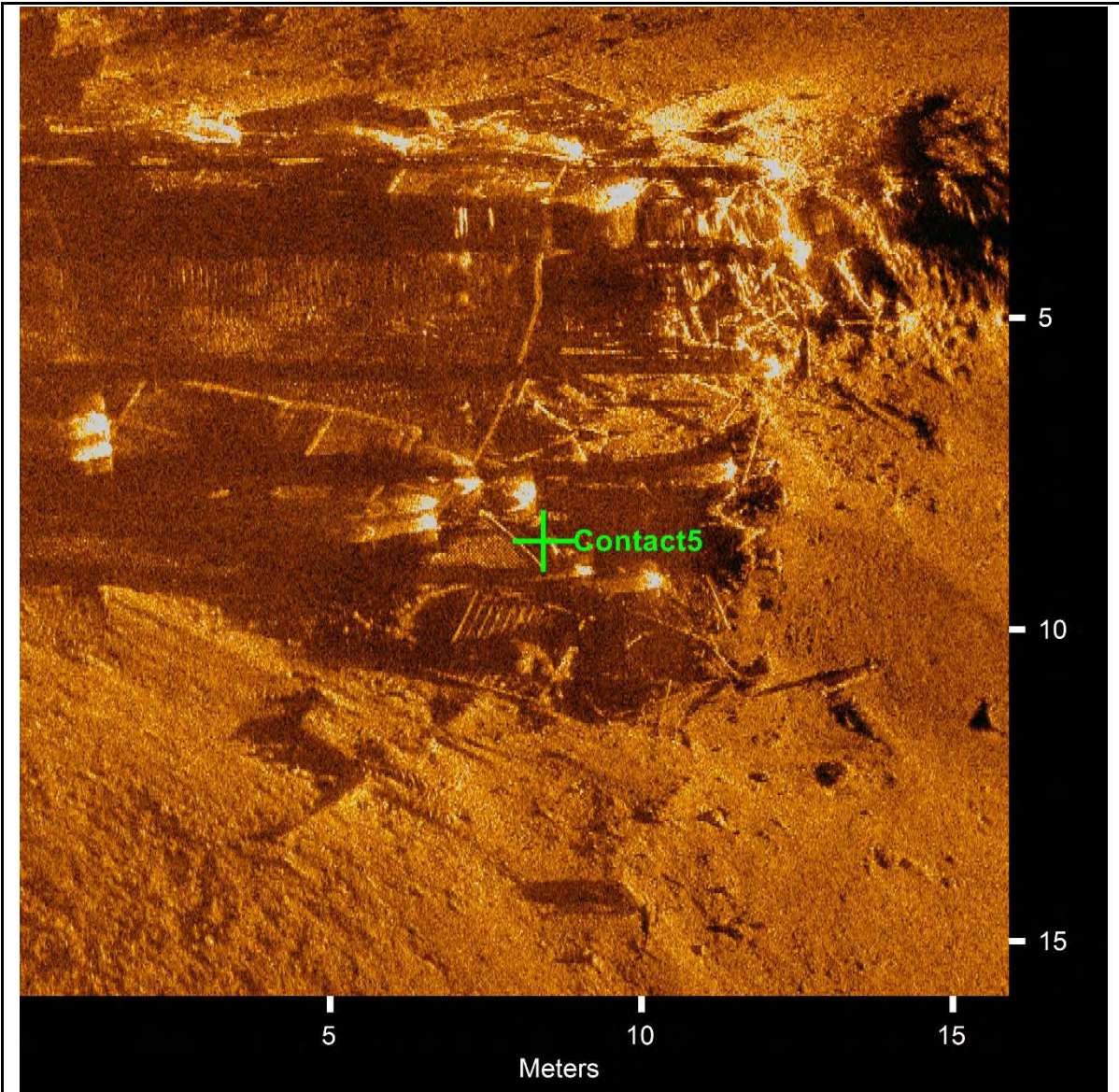


Contact4

- Sonar Time at Target: 12/11/2022 02:02:06
- Click Position
12° 26.47670' S 130° 46.08983' E (WGS84)
(X) 692188.87 (Y) 8624009.32 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221112015951.jsf
- Ping Number: 81997
- Range to target: 3.70 Meters
- Fish Height: 1.53 Meters
- Heading: 185.112 Degrees
- Water Depth: 3.40 Meters

Dimensions and attributes

- Target Width: 0.95 Meters
- Target Height: 1.01 Meters
- Target Length: 3.12 Meters
- Target Shadow: 7.19 Meters
- Area:
- Description: Frame structure. Nearby magnetic anomaly however this structure by itself cant explain all the localized magnetic anomalies. Possibly sits 1m above seabed but may not be detected by MBES bathymetry surveys so possible navigational hazard.

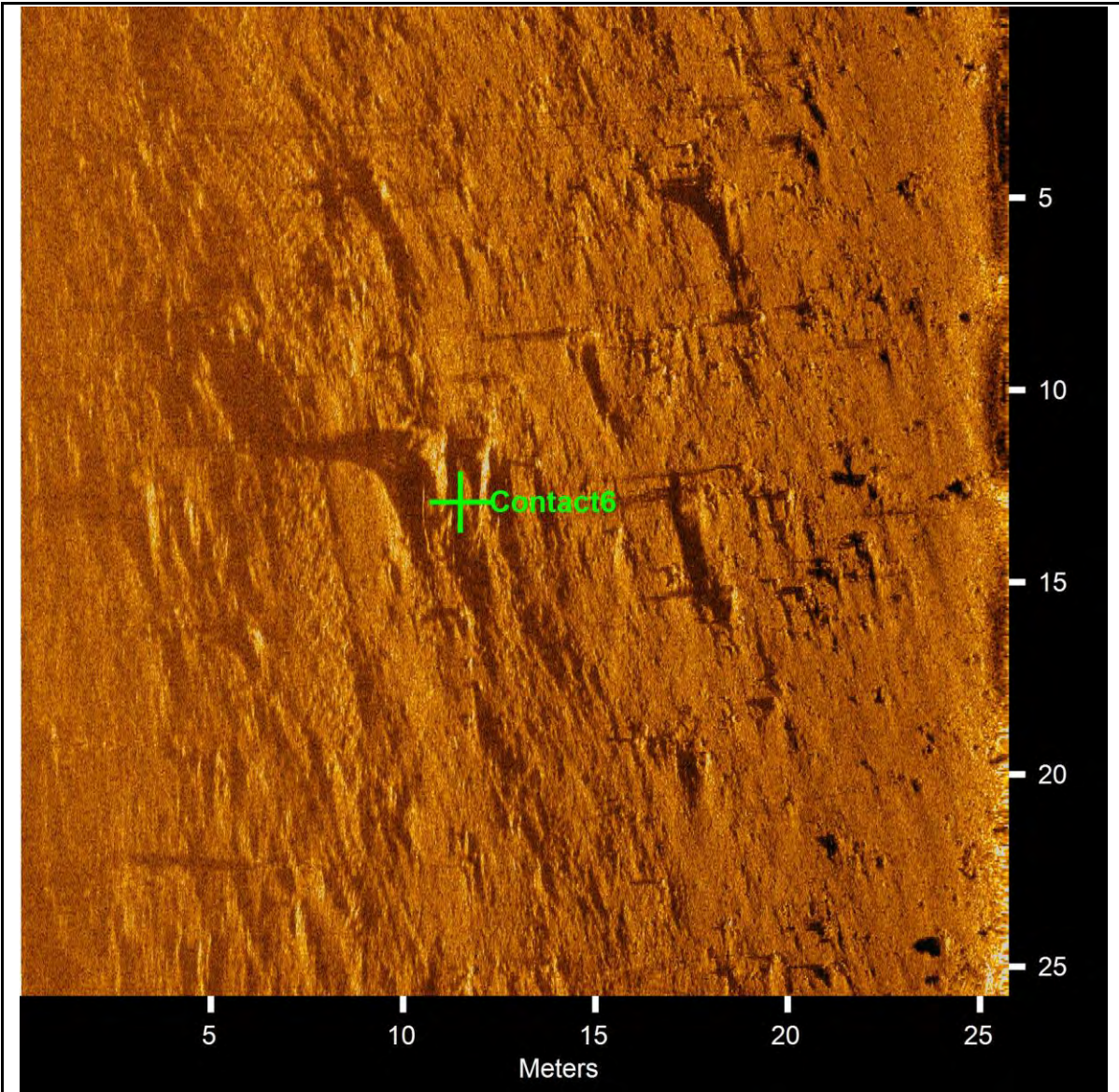


Contact5

- Sonar Time at Target: 12/11/2022 02:44:42
- Click Position
12° 26.56935' S 130° 46.09338' E (WGS84)
(X) 692194.17 (Y) 8623838.46 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221112024055.jsf
- Ping Number: 153668
- Range to target: 9.54 Meters
- Fish Height: 0.88 Meters
- Heading: 243.778 Degrees
- Water Depth: 4.49 Meters

Dimensions and attributes

- Target Width: 0.00 Meters
- Target Height: 0.00 Meters
- Target Length: 0.00 Meters
- Target Shadow: 0.00 Meters
- Area:
- Description: Numerous construction debris objects beneath base of wharf. If inspected during dive operations, consider leaving in place as a fish habitat.



Contact6

- Sonar Time at Target: 12/11/2022 02:02:19
- Click Position
 12° 26.48759' S 130° 46.09462' E (WGS84)
 (X) 692197.43 (Y) 8623989.20 (Projected)
- Map Projection: EPSG:28352
- Acoustic Source File: 20221112015951.jsf
- Ping Number: 82394
- Range to target: 14.26 Meters
- Fish Height: 1.23 Meters
- Heading: 180.388 Degrees
- Water Depth: 3.40 Meters

Dimensions and attributes

- Target Width: 1.61 Meters
- Target Height: 0.00 Meters
- Target Length: 2.56 Meters
- Target Shadow: 0.00 Meters
- Area:
- Description: Unrecognisable seabed feature coincides with magnetic anomaly.

Appendix C.1 Magnetic Targets

Mag_Target_ID	MGA52_N	MGA52_E	Analytic_Signal	App_weight (kg)	Mag_Depth (m)	Depth_err (%)
1	692130.55	8623825.61	68.3	281.5	1.5	3.8
3	692140.48	8623836.37	24.2	50.2	0.6	3.9
4	692101.84	8623837.2	11.3	25	0.2	5.3
6	692053.71	8623841.34	4.8	108.6	2.1	2.3
7	692107.79	8623843.52	85.4	46.8	0.1	1.3
8	692127.37	8623843.76	7.6	0	-1.6	58.8
9	692057.32	8623857.82	4.5	8.4	0.6	3.5
10	692138.51	8623859.07	4.2	1	-0.6	7.4
11	692105.17	8623863.95	11.8	27	0.8	1.9
12	692108.98	8623875.34	23.6	138.5	1.9	1.5
13	692099.54	8623878.45	6.5	24.7	0.8	2.5
14	692118.59	8623880.36	213.4	228.1	0.6	1
15	692082.33	8623881.24	9.3	99.4	2.5	2.1
16	692179.54	8623883.01	8.3	72.3	2	2.7
17	692189.97	8623883.85	24.4	70.3	1.1	3.7
18	692185.17	8623885.95	34.4	207.3	1.9	1.1
19	692149.97	8623889.3	158.7	59.2	0	1
20	692094.27	8623889.52	15.3	69.2	1.6	3.6
22	692100.61	8623891.53	28.5	165.9	1.9	1.2
23	692174.66	8623898.29	15.6	141.1	2.3	4.5
24	692179.88	8623900.64	37.5	321.6	2.6	1
25	692103.74	8623901.21	19.3	152.2	2.2	1.7
26	692171.19	8623901.51	9.1	441.4	5.5	2.2
27	692191.11	8623903	13.4	213	2.9	4
28	692167.83	8623908.23	89.9	314.7	1.6	0.8
29	692080.13	8623910.25	15.4	294.3	3.6	3.2
31	692113.4	8623915.35	3.9	9.2	1.2	1.2
32	692086.47	8623915.85	14.5	82.5	2.1	1.3
34	692159.32	8623921.58	138.1	307.5	1.2	1.1
35	692145.33	8623923.33	149.3	85.2	0.2	0.7
37	692156.99	8623926.94	11.6	674.4	6.6	2.5
38	692105.35	8623927.46	6.9	121	3.2	1
39	692172.11	8623927.89	8.5	455.7	5	2.3
40	692144.99	8623930.07	20.2	148.3	2.3	5.5
41	692010.59	8623932.58	30.2	13.4	-0.1	1.8
42	692186.77	8623935.78	15	55.6	1.4	2.6
43	692078.45	8623936.99	28.9	168.5	2.1	0.8
44	692135.25	8623937.84	39.2	259.5	2.3	1
46	692132.07	8623940.67	36.7	288.7	2.3	1.2
47	692087.19	8623942.57	16.8	108.7	2	3
48	692128.82	8623943.76	24.2	303.3	2.9	1.2
49	691995.08	8623943.76	2.2	4.7	0.7	1.6
50	692055.86	8623944.41	13.9	14.5	-0.2	3

51	692126.44	8623944.8	21.5	403.1	3.5	1
52	692103.63	8623945.3	16.1	110.8	2.2	2.3
53	692121.41	8623949.34	27	641.3	4.1	1.6
54	692097.57	8623950.27	13.3	151.7	2.2	2.8
55	692048.55	8623953.96	36.3	261.3	2.2	1.1
56	692054.79	8623954.06	9.2	27.7	1.1	5.9
57	692117.23	8623954.28	43.3	358.8	2.9	0.7
58	692114.81	8623955.2	74.3	667.4	2.9	0.7
59	692126.45	8623957.76	7.2	62.5	2.3	6.2
60	692110.84	8623957.91	61.9	538.7	2.8	1.1
61	692130.92	8623959.73	9.3	41.6	1.4	3.6
62	692105.38	8623962.58	76.4	674.4	3.3	0.9
63	692102.64	8623965.17	76.6	556.5	2.4	1.2
64	692041.33	8623967.06	22.7	92	1.5	1.6
65	692036.72	8623967.25	10.1	123.4	2.8	2.8
66	692098.13	8623969.74	83	327	2	1.2
67	692180.96	8623970.46	21.3	23.8	0.4	2
68	692022.91	8623970.72	13.7	77.3	2	1.7
69	692094.46	8623971.79	65.3	360.6	2.2	1.1
70	691992.99	8623971.86	2.4	10.8	1.3	1.8
71	692017.99	8623972.69	20	86.7	1.6	1.8
72	692032.44	8623972.74	18.4	117.6	1.9	1.8
73	692027.91	8623974.48	15.8	143.6	2.3	2.2
74	692018.48	8623976.74	17.4	9.8	0	6.9
75	692194.97	8623977.21	18.8	49.1	1.3	1.8
76	692086.45	8623977.35	76.4	667.4	2.9	1.3
78	692161.31	8623978.53	8.3	210.8	3.9	1.4
79	691970.62	8623979.01	4.5	5.4	0.4	2.6
80	692102.02	8623980.14	21.2	39.5	0.8	4.6
81	692003.66	8623981.11	6	8.6	0.5	4.6
82	692080.5	8623982.2	46.8	26.7	-0.4	4.6
83	692017.87	8623984.97	6.2	30.9	1.4	4.6
84	692009.81	8623985.08	7.4	258.4	4.5	1.6
85	692013.15	8623985.27	8.7	169.8	3.4	4.7
86	692079.87	8623987.18	22.3	225.9	2.8	4.5
87	692005.51	8623987.29	28.4	23.5	0.1	2.1
88	691996.51	8623987.48	9.6	6.1	0	1.9
89	692074.73	8623988.06	27	517.8	4.6	2.5
91	691985.33	8623993.67	2.8	10.2	1.1	1.6
92	691992.23	8623994.61	2.4	5.9	0.5	1.6
93	692171.78	8623996.13	7.5	292	4.9	1.2
94	692063.44	8623996.27	637.4	674.4	2	0.5
95	692039.1	8623997.21	25	21.2	0.3	2.2
96	692191.84	8624004.06	107.5	225.2	1.1	1.1
97	692184.34	8624004.46	51.4	517.3	2.5	1.7
99	692037.68	8624005.67	14.3	29.4	1	1.3
100	692046.46	8624010.96	30.2	72.8	1.1	1

101	692001.8	8624011.78	2	9	1.1	2.1
102	692196.63	8624014.97	83.8	123	0.7	1.3
103	691964.6	8624021.87	2.8	2.1	-0.1	1.7
104	692017.65	8624023.33	2.2	4.9	0.7	1.7
106	692179.06	8624026.23	7.2	12.1	0.5	1.8
107	692189.57	8624033.27	7	78.9	2.1	2.1
109	692115	8624051.73	14.9	75.1	1.8	1
110	692036.61	8624071.6	11.7	26.6	0.8	0.9
111	692110.79	8624074.46	10.5	52.5	1.4	0.7
112	691967.11	8624099.25	15.9	4.5	-0.3	1.6
113	692075.31	8624103.98	79	80.1	0.4	0.5
114	691986.55	8624105.89	3.1	6.3	0.5	2.2
115	692112.61	8624107.07	31.2	79.5	1.1	2
117	691957.5	8624115.4	10.2	5.8	-0.2	1.9
118	691987.45	8624130.93	3.5	3	0	3.2
120	691975.24	8624150.92	2.2	6.8	1	1.3
121	692008.53	8624155.04	10.8	15.7	0.4	1.4
122	692192.78	8624157.43	20	674.4	4.7	1.2
124	692042.75	8624166.03	3.1	3.8	0.2	2.1
126	692155.48	8624179.73	14.7	489.5	4.9	0.8
128	692137.49	8624188.18	57.4	515	2.7	0.7