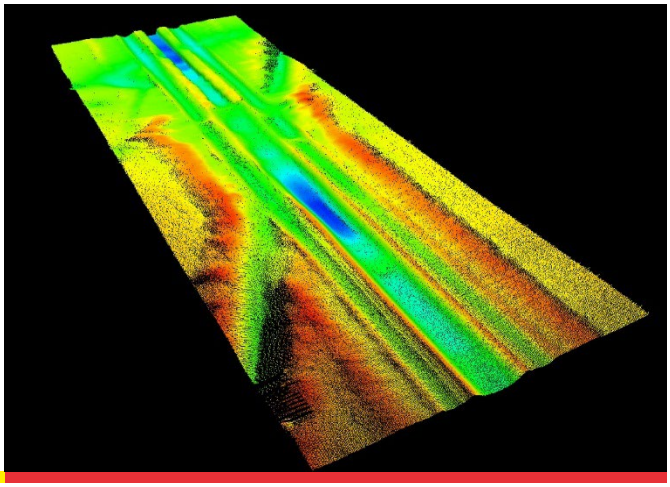
UXO SURVEY REPORT – ARTIFICIAL ISLAND PROJECT SITE

103783-ENN-MMT-SUR-REP-SURWPD
REVISION A | FOR USE
MAY 2022



ENERGINET

ENERGY ISLANDS - NORTH SEA EAST

GEOPHYSICAL SURVEY FOR OFFSHORE WIND FARMS AND ARTIFICIAL ISLAND

NORTH SEA
MAY-DECEMBER 2021

MMT SWEDEN AB | SVEN KÄLLFELTS GATA 11 | SE-426 71 VÄSTRA FRÖLUNDA, SWEDEN
PHONE: +46 (0)31 762 03 00 | **EMAIL:** INFO@MMT.SE | **WEBSITE:** MMT.SE

MMT
AN OCEAN INFINITY COMPANY

REVISION HISTORY

REVISION	DATE	STATUS	CHECK	APPROVAL	CLIENT APPROVAL
A	2022-05-25	Issue for Use	DP	KG	
02	2022-03-17	Issue for Client Review	DO	KG	
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REVISION LOG

DATE	SECTION	CHANGE
2022-05-25	Various	As per client comments Deliverable_Register_Site_Energy_Islands_WPD_rev01.xlsx

DOCUMENT CONTROL

RESPONSIBILITY	POSITION	NAME
Content	MMT Senior Data Processor	Andrew Stanley / Clayton Summers / Chris Bulford
Content	MMT Senior Geologist	Sophie Clark / Jack Turner / Jeshua Guzman Castro
Content	MMT Project Geophysicist	Gerald Bishop / Hanna Åkerblom
Content	GeoSurveys Interpreter Reviewer / Principal Interpreter	Ana Maia
Content	GeoSurveys Onshore Team Coordinator	Bruno Simao
Content	GeoSurveys Deputy Project Manager	Miguel Oliveira
Content	Geosurveys Project Manager / Deputy Project Manager	Henrique Duarte / Jhonny Miranda
Content / Check	MMT Project Report Coordinator	David Oakley / Darryl Pickworth
Check	MMT Document Controller	Pontus Frost / Rebecca Österberg
Approval	MMT Project Manager	Karin Gunnesson

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ABBREVIATIONS AND DEFINITIONS

BSB	Below Seabed
CM	Central Meridian
DTU21	Denmark Technical University 2021
DPR	Daily Progress Report
DTM	Digital Terrain Model
DVR90	Dansk Vertikal Reference 1990
EEZ	Exclusive Economic Zone
EPSG	European Petroleum Survey Group
ESRI	Environmental Systems Research Institute, Inc.
ETRS	European Terrestrial Reference System
FME	Feature Manipulation Engine
FMGT	Fledermaus GeoCoder Toolbox
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GRAD	Gradiometer (Model T)
GRS80	Geodetic Reference System 1980
HF	High Frequency
HiPAP	High Precision Acoustic Positioning
INS	Inertial Navigation System
IHO	International Hydrographic Organisation
IMU	Inertial Measurement Unit
ITRF	International Terrestrial Reference Frame
LF	Low Frequency
MAG	Magnetometer
MBBS	Multibeam Backscatter
MBES	Multibeam Echo Sounder
MMO	Man Made Object
MSL	Mean Sea Level
M/V	Motor Vessel
OWF	Offshore Wind Farm
POS MV	Position and Orientation System for Marine Vessels
POSPac	Position and Orientation System Package
PPS	Pulse Per Second
PtoP	Peak to Peak
QC	Quality Control
ROV	Remotely Operated Vehicle
RPS	UXO consultant, providing the ALARP certificate, to Energinet
S-CAN	Scalgo Combinatorial Anti Noise
SBET	Smoothed Best Estimated Trajectory
SIT	Surrogate Item Test
SOW	Scope of Work
SSS	Side Scan Sonar
THU	Total Horizontal Uncertainty
TPU	Total Propagated Uncertainty

TVU	Total Vertical Uncertainty
USBL	Ultra Short Baseline
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
WP	Work Pack – Defines survey area and requirement

EXECUTIVE SUMMARY

NORTH SEA OFFSHORE WIND FARM SITE INVESTIGATION – ARTIFICIAL ISLAND PROJECT SITE	
INTRODUCTION	
Survey Dates	M/V Relume: 04 October to 27 December 2021
Equipment	Multibeam Echo Sounder (MBES), Side Scan Sonar (SSS), Gradiometer (GRAD).
Coordinate System	Datum: European Terrestrial Reference System 1989 (ETRS89) Projection: Universal Transverse Mercator (UTM) Zone 32N, Central Meridian (CM) 9°E
BATHYMETRY AND SEAFLOOR MORPHOLOGY	
The minimum surveyed depth is 25.81 m at the north east of the surveyed area. The maximum surveyed depth is 30.62 m in the north part of the survey area. The depth range across the site is 4.81 m. Slope angles across the site are typically very gentle (<1°) and gentle (1° to 5°). The steepest slopes of approximately 4 degrees can be seen at the bottom of some of the channels in the northern half of the survey areas.	
SURFICIAL GEOLOGY	
The seabed sediments in Artificial Island project site are dominated by GRAVEL and coarse SAND (medium to high acoustic reflectivity) and SAND (medium acoustic reflectivity). Areas of ripples, indicative of mobile sediments, are present throughout the majority of the Artificial Island project site, whilst larger scale sand waves are visible in the northern half of the site.	
SEAFLOOR FEATURES AND CONTACTS	
In total, 472 individual seabed contacts and magnetic anomalies were detected in the Artificial Island project site. Of these, 41 contacts were identified using SSS and MBES. They were classified as: boulders >0.5m (22) and debris (19). A total of 431 magnetic anomalies above the threshold of 5nT/ft Peak to Peak (PtoP) were detected in the gradiometer data within the Artificial Island project site. From the total of 431 magnetic contacts, 406 of were interpreted as individual discrete anomalies, whilst 25 anomalies were interpreted to form 3 linear features. Magnetic target GRAD_0151 correlates with the position of detected SSS contact S_RE_WP-D_0097.	

1 | INTRODUCTION

1.1 | PROJECT INFORMATION

Energinet are developing the proposed Offshore Wind Farm (OWF) and Artificial Island in the Danish sector of the North Sea (Figure 1). MMT have been contracted to provide geophysical survey (including 2D UHRS) and grab sampling of the east part of the 3 GW OWF project site (the MMT OWF survey area) including the 10 km x 10 km Artificial Island area of investigation. The Artificial Island area of investigation is located in the southwest portion of the MMT OWF survey area. Within the Artificial Island area of investigation is the 2.5 km x 2.5 km Artificial Island project site. The Artificial Island project site has a central location on a shallow bank seabed structure and will be the focus area for detailed development of the artificial island.

The scope of work was divided into four separate Work Packs (WP).

This report covers the 2.5 km x 2.5 km Artificial Island project site.

A summary of the project details is presented in Table 1.

Table 1 Artificial Island project site survey details.

CLIENT:	Energinet
PROJECT:	Energy Islands - North Sea
MMT SWEDEN AB (MMT) PROJECT NUMBER:	103783
SURVEY TYPE:	Geophysical and UXO survey Artificial Island project site
AREA:	Danish North Sea
SURVEY PERIOD:	October – December 2021
SURVEY VESSELS:	M/V Relume
MMT PROJECT MANAGER:	Karin Gunnesson
CLIENT PROJECT MANAGER:	Jens Colberg-Larsen

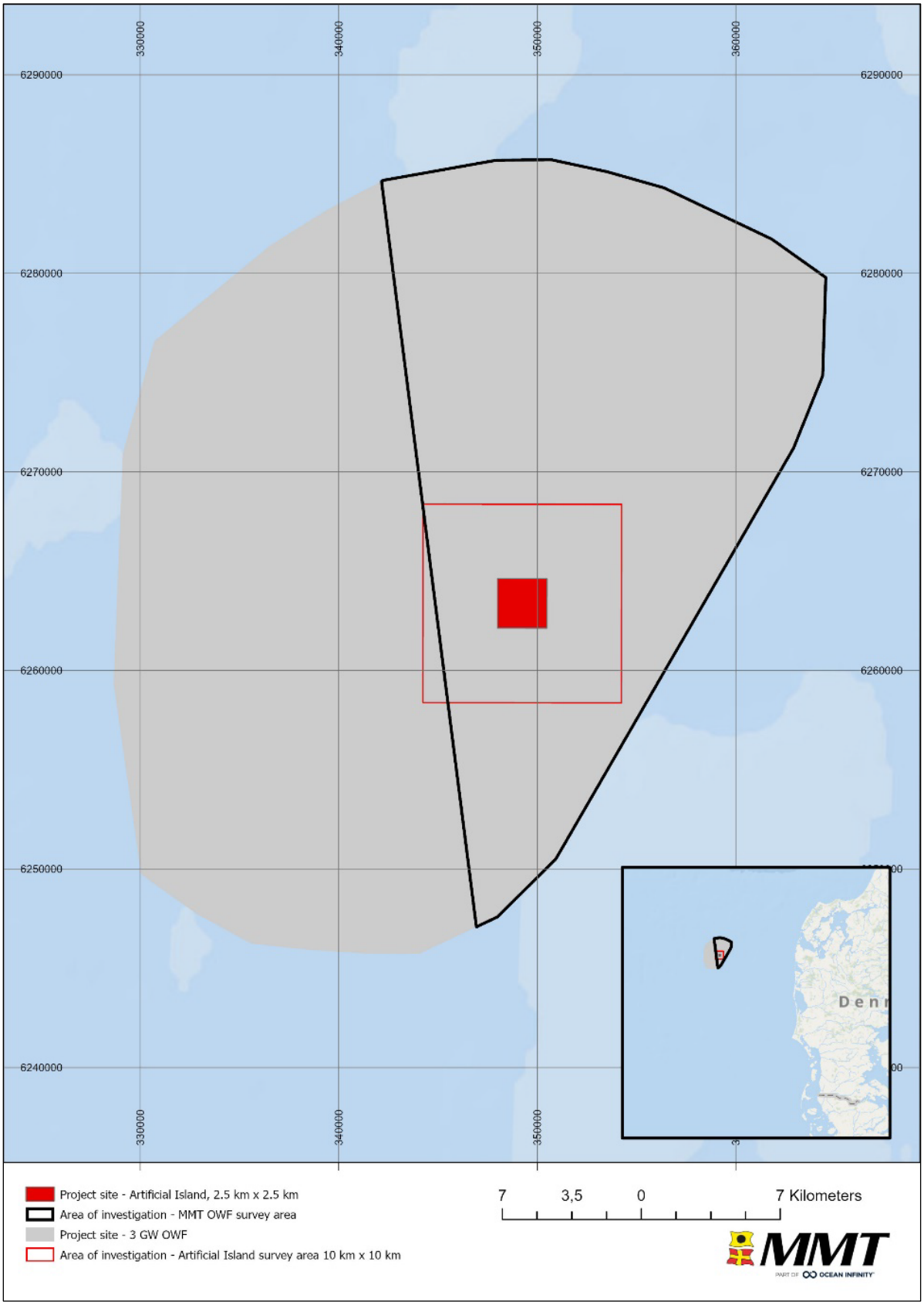


Figure 1 Overview of survey scopes performed.

1.2| SURVEY INFORMATION – ARTIFICIAL ISLAND PROJECT SITE

The Artificial Island project site work scope comprises several tasks including:

- Project Management and Administration
- Geophysical surveys (MBES, SSS)
- UXO GRAD survey

The MMT OWF Survey area site investigation covers an approximately 526 km^2 area acquired by MMT and is located roughly 90 km offshore the coast of Jutland (Figure 1). Within this the Artificial Island area of investigation covers a 100 km^2 area which is sub-divided in to a 6.25 km^2 area for UXO GRAD and ultra-high resolution MBES and SSS survey (Artificial Island project site).

This report covers the 2.5 km x 2.5 km Artificial Island project site survey acquired by MMT.

1.3| SURVEY OBJECTIVES

The survey objectives for the Artificial Island project site were to acquire bathymetric soundings, gradiometer and side scan sonar within the Artificial Island project site. The acquisition of these data sets was to provide comprehensive bathymetric soundings, seabed features maps including contact listings and magnetic anomalies in order to screen for potential UXO items. The interpretation of the datasets was charted in order to be used in the geotechnical program, subsequent UXO inspection and removal, archaeology, and at a later stage development of the Artificial Island site.

The main objectives of the surveys were:

- Acquire and interpret high quality seabed data for project planning and execution. As a minimum, this includes local bathymetry, seabed features, seabed obstructions, wrecks and archaeological sites, and evaluation of possible mobile sediments.
- Mapping of magnetic targets for UXO screening.

1.3.1| DEVIATIONS TO SCOPE OF WORK

There were no deviations during the survey of Artificial Island project site

1.4| PURPOSE OF DOCUMENT

This report details the interpretation of the geophysical and GRAD results from Artificial Island project site.

The report summarises the conditions within the survey area with regards to; bathymetry, surficial geology, contacts and GRAD anomalies.

All data obtained from the geophysical and UXO surveys have been correlated with each other and compared against the existing background information in order to ground truth the survey results.

A full list of reports is given in Table 2 (Reference Documents).

1.5| REPORT STRUCTURE

The results from Artificial Island project site survey campaign is presented in this report:

- UXO Survey Report – Artificial Island Project Site: Includes a chart series of results. A full chart list is provided within Appendix A|.

The Artificial Island Project Site UXO Survey Report (this report) chart series includes:

- Overview Chart
- Trackline Charts
- Bathymetry Charts
- Backscatter Mosaic Charts with Contacts
- Gradiometer Imagery Charts with Anomalies
- Seabed Morphology Classification Charts

1.5.1| UXO AND GEOPHYSICAL SURVEY REPORT

Attached to the report are the following appendices:

- Appendix A| List of Produced Charts
- Appendix B| Contact and Anomaly List

1.5.2| CHARTS

The MMT Charts describe and illustrate the results from the survey. The charts include an overview chart with a scale of 1:65 000, north up charts including Bathymetry, Backscatter Mosaic, Magnetometry, Seabed Morphology Classification and Tracklines, all with scales of 1:5000.

The overview and north up charts contain background data (existing infrastructure, Exclusive Economic Zones (EEZ), 12 nautical mile zone and wreck database) alongside survey results.

A list of all produced charts is presented in Appendix A|.

OVERVIEW CHART

Shows coastlines, EEZ, large scale bathymetric features and area of investigations.

TRACKLINE CHARTS

The actual performed survey lines are presented along with seabed grab sampling positions.

BATHYMETRY CHARTS

The bathymetry is presented as a shaded relief colour image with 1 m colour interval, overlain with contour lines (1 m (minor) and 5 m (major)) with depth labels.

BACKSCATTER MOSAIC CHARTS

The backscatter mosaic imagery is presented. The SSS and MBES contacts are also presented.

GRADIOMETER IMAGERY CHARTS

The gradiometer residual magnetic field imagery is presented. The GRAD anomalies are also presented.

SURFICIAL MORPHOLOGY CHARTS

The surface morphology in the MMT OWF survey area is divided into 7 different classes; Ripples, Large Ripples, Megaripples, Sand Waves, Sandbars, Area of Interest and Trawl Mark Area and are presented as hatches with patterns. In the Artificial Island project site, three of these are present, Ripples, Sand Waves and Sandbars.

1.6| REFERENCE DOCUMENTS

The documents used as references to this report are presented in Table 2.

Table 2 Reference documents.

Document Number	Title	Author
1100046209	Energy Island Danish North Sea Geoarchaeology and geological desk study	From Client
103783-ENN-MMT-QAC-PRO-PROJMANU-06	Project Manual	MMT
103783-ENN-MMT-QAC-PRO-CADGIS	CAD and GIS Specification	MMT
103783-ENN-MMT-MAC-REP-FRANKLIN-A	Mobilisation and Calibration Report – Franklin	MMT
103783-ENN-MMT-SIT-REP-RELUME-A	Mobilisation and Calibration Report – Relume	MMT
103783-ENN-MMT-SUR-REP-OPREPWP-D-REVA	Operations Report Artificial Island project site	MMT
103783-ENN-MMT-SUR-REP-SURVWPA-02	Survey Report WP-A	MMT
103783-ENN-MMT-SUR-REP-SURVWPAEI-02	Survey Report WP-A_EI	MMT

1.7| AREA LINE PLAN

The Artificial Island project site survey line spacing and minimum parameters are detailed in Table 3.

A breakdown of the survey lines is provided in Table 4.

Table 3 Survey line parameters.

GEOPHYSICAL SURVEY SETTINGS	SCOPE
Project Site	Ca. 6.25 km^2
Line spacing GRAD, SSS, MBES	10 m

Table 4 Survey line breakdown.

SURVEY LINE BREAKDOWN	SCOPE	ACTUAL SURVEYED
Artificial Island Project Site Survey Lines	627 km / 251 Lines	683 km / 379 Lines

1.7.1| ARTIFICIAL ISLAND PROJECT SITE MAIN LINES

Artificial Island project site geophysical lines were orientated north to south as illustrated in Figure 2.

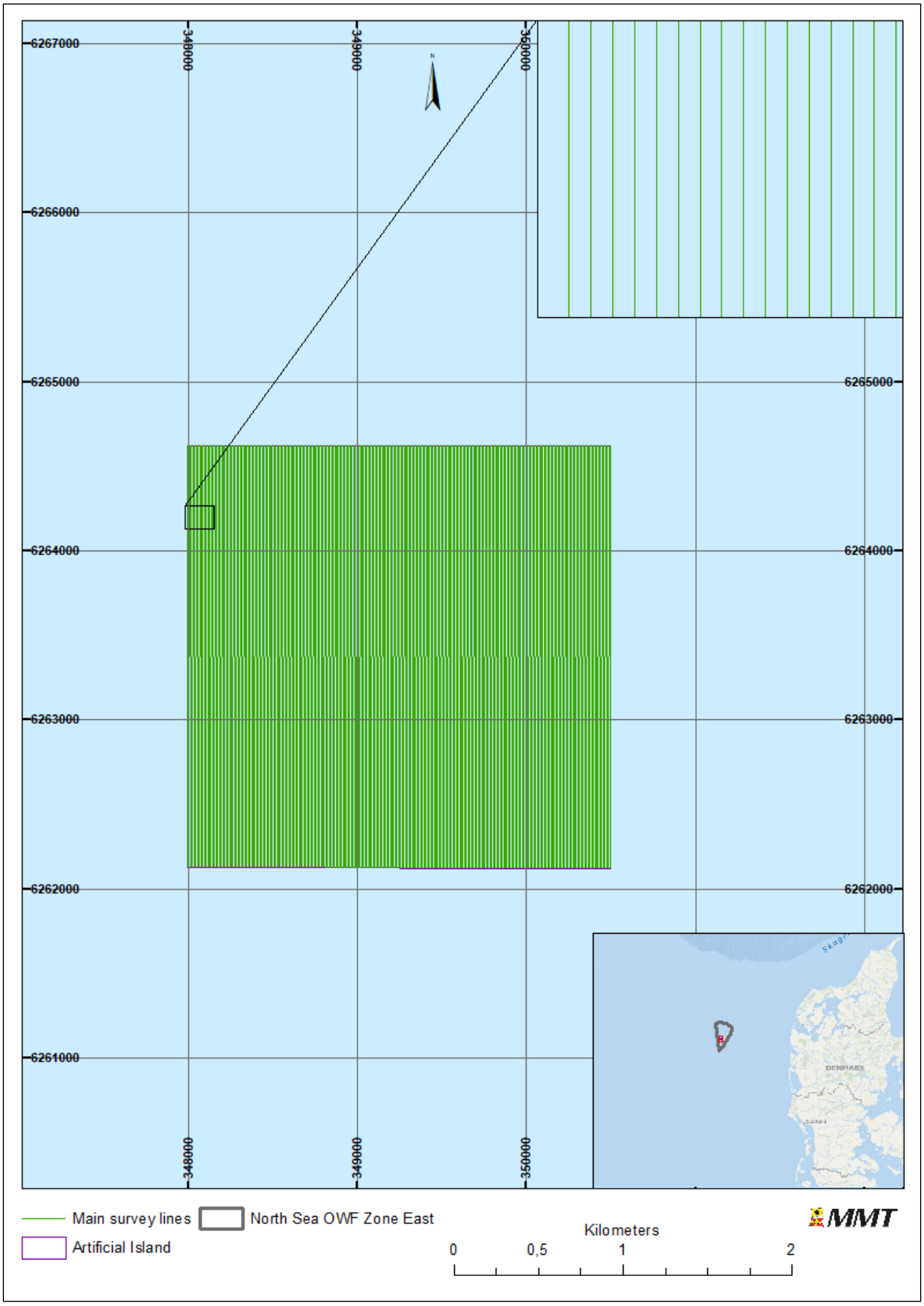


Figure 2 Line plan – Artificial Island project site.

2| SURVEY PARAMETERS

2.1| GEODETIC DATUM AND GRID COORDINATE SYSTEM

2.1.1| ACQUISITION

The geodetic datum used for survey equipment during acquisition are presented in Table 5.

Table 5 Geodetic parameters used during acquisition.

Horizontal datum: WGS 84	
Datum	World Geodetic System 1984
ESPG Datum code	6326
Spheroid	World Geodetic System 1984 (7030)
Semi-major axis	6 378 137.000m
Semi-minor axis	6 356 752.3142m
Inverse Flattening (1/f)	298.257223563

2.1.2| PROCESSING

The geodetic datum used during processing and reporting are presented in Table 6.

Table 6 Geodetic parameters used during processing.

Horizontal datum: European Terrestrial Reference System 1989 (ETRS89)	
Datum	ETRS89
European Petroleum Survey group (EPSG) Datum Code	25832
Spheroid	GRS80
Semi-major axis	6 378 137.000m
Semi-minor axis	6 356 752.314m
Inverse Flattening (1/f)	298.257222101

2.1.3| TRANSFORMATION PARAMETERS

The transformation parameters used to covert from acquisition datum (WGS 84) to processing/reporting datum (ETRS89) are presented in Table 7.

Table 7 Transformation parameters.

DATUM SHIFT FROM WGS 84 TO ETRS89 (RIGHT-HANDED CONVENTION FOR ROTATION - COORDINATE FRAME ROTATION)	
PARAMETERS	**EPOCH 2021.5**
Shift dX (m)	0.10665
Shift dY (m)	0.06613
Shift dZ (m)	-0.12873
Rotation rX (“)	-0.003409

DATUM SHIFT FROM WGS 84 TO ETRS89 (RIGHT-HANDED CONVENTION FOR ROTATION - COORDINATE FRAME ROTATION)	
Rotation rY (“)	-0.014065
Rotation rZ (“)	0.025207
Scale Factor (ppm)	0.0032

In order to verify that the transformation parameters have been correctly entered into the navigation system the following test coordinates were used (Table 8).

Table 8 Official test coordinates

UTM Zone	Datum	Easting (m)	Northing (m)	Latitude	Longitude
32	WGS84	-	-	56° 33' 00.000" N	6° 33' 00.000" E
	ETRS 89	349393.437	6269982.594	56° 32' 59.981" N	6° 32' 59.970" E

2.1.4| PROJECTION PARAMETERS

The projection parameters used for processing and reporting are presented in Table 9.

Table 9 Projection parameters.

Projection Parameters	
Projection	UTM
Zone	32 N
Central Meridian	09° 00’ 00’’ E
Latitude origin	0
False Northing	0 m
False Easting	500 000 m
Central Scale Factor	0.9996
Units	metres

2.1.5| VERTICAL REFERENCE

The vertical reference parameters used for processing and reporting are presented in Table 10.

Table 10 Vertical reference parameters.

Vertical Reference Parameters	
Vertical reference	MSL
Height model	DTU21

The difference between the vertical height models (DTU21 and DVR90) are given below in Table 11. The average for each 5 km MBES grid was compared.

Table 11 Average Height comparison between DTU21 and DVR90.

AVE HEIGHT DTU21 MSL (METRES)	**AVE HEIGHT** DVR90 **MSL (METRES)**	**DIFFERENCE (METRES)**
40.64	40.92	0.27

2.2| VERTICAL DATUM

Global navigation satellite system (GNSS) tide was used to reduce the bathymetry data to Mean Sea Level (MSL) the defined vertical reference level (Figure 3). The vertical datum for all depth measurements was MSL via DTU21 MSL Reduction from WGS84-based ellipsoid heights.

This tidal reduction methodology encompasses all vertical movement of the vessel, including tidal effect and vessel movement due to waves and currents. The short variations in height are identified as heave and the long variations as tide.

This methodology is very robust since it is not limited by the filter settings defined online and provides very good results in complicated mixed wave and swell patterns. The vessel navigation is exported into a post-processed format, Smoothed Best Estimated Trajectory (SBET) that is then applied onto the multibeam echo sounder (MBES) data.

The methodology has proven to be very accurate as it accounts for any changes in height caused by changes in atmospheric pressure, storm surge, squat, loading or any other effect not accounted for in a tidal prediction.

Within Artificial Island project site, all positions lie below the sea surface so are referred to in the results section of this report as ***depths***.

The bathymetric processing software packages EIVA NaviModel and Caris HIPS inherently stores MBES DTMs and sounding data with a positive down depth convention. Report imagery obtained from these packages show the data in this convention.

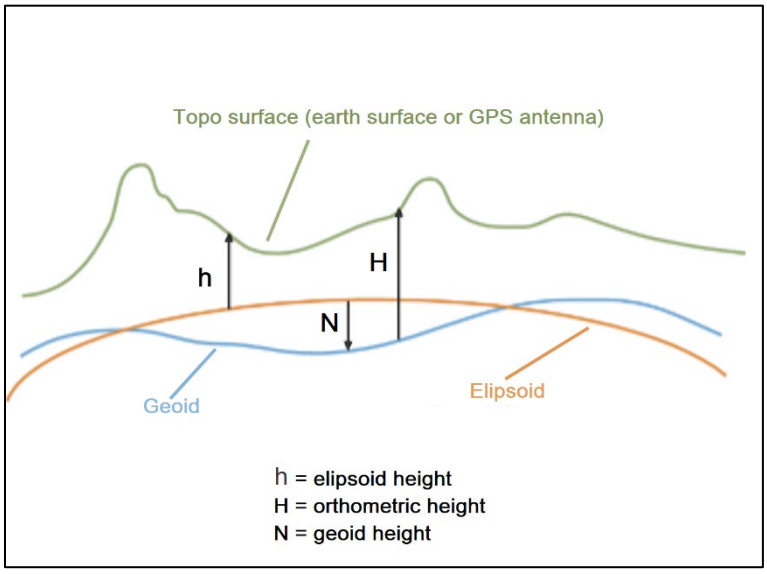


Figure 3 Overview of the relation between different vertical references.

2.3| TIME DATUM

Coordinated universal time (UTC) is used on all survey systems on board the vessel. The synchronisation of the vessels on board system is governed by the pulse per second (PPS) issued by the primary positioning system. All displays, overlays and logbooks are annotated in UTC as well as the daily progress report (DPR) that is referred to UTC.

3| SURVEY VESSEL

3.1| M/V RELUME

GEOPHYSICAL & UXO SURVEY OFFSHORE

The offshore geophysical and UXO survey operation was conducted by the survey vessel M/V Relume (Figure 4). The vessel equipment is shown in Table 12.

Figure 4 M/V Relume.

Table 12 M/V Relume equipment.

INSTRUMENT	NAME
Navigational System	
Primary Positioning	Applanix POS M/V 320 with C-NavC2 corrections on the SF1 service
Secondary Positioning	C-Nav 3050 with C-NavC2 corrections on the SF1 service
Primary Gyro and MRU	Applanix POS M/V 320
Underwater Positioning	Kongsberg HiPAP 501
Survey Navigation Software	QPS QINSy
Sound Velocity	
Sound Velocity Profiler	Valeport Midas SVX2
Geophysical Hull Mounted Equipment	
MBES	Kongsberg EM2040

Table 13 TRITON XLS-47 ROV equipment.

INSTRUMENT	NAME
Primary Positioning, Gyro and INS System	iXblue Rovins INS
Doppler Velocity Log	LinkQuest NavQuest microDVL (600 kHz)
Subsea Multiplexer	MMT/MacArtney HD Mux

INSTRUMENT	NAME
Pressure Gauge	Valeport mini IPS
Sound Velocity Sensor	Valeport mini SVS
CTD Sensor	Valeport MiniCT
Multibeam Echosounder	R2Sonic 2024 (200-400 kHz)
Model T Gradiometer	Subvision
USBL Transponder (ROV)	Kongsberg cNode MiniS 34-180
USBL Transponder (TMS)	Kongsberg MST 319
Red Dot Laser	Deepsea Sealaser 100
Edgetech Side Scan	Edgetech 2200 (300/900 kHz)
Imaging Sonar	Tritech Gemini 720is
Manipulators	Schilling T4 7-function & Rigmaster 5-function + Grabber

3.2| OPERATIONAL SUMMARY

This section provides a summary of the operations on board the M/V Relume (Table 14) during the Artificial Island project site offshore survey between 2021-10-04 and 2021-12-27. While this period covers the extents of the Artificial Island project site survey, within these dates will also be various operations for the MAG box survey.

M/V RELUME

The mobilisation for the project 103783, MAG box survey and the Artificial Island project site commenced on 04 of October 2021. Initial mobilisation was conducted during the transit from Le Harve, France to Thyborøn, Denmark.

The project's kick-off meeting was carried out alongside Thyborøn on 06 October 2021 prior to departure.

A series of calibration tests were performed between 06 and 08 October 2021 approximately 5 km Northeast of the Artificial Island project site location.

Between 08 October and 26 December 2021, M/V Relume conducted geophysical survey operation of the Artificial Island project site.

On 27 December 2021, M/V Relume demobilised in Thyborøn, Denmark.

Table 14 Survey tasks – M/V Relume.

TASK	DATE	DESCRIPTION
Transit	2021-10-04 – 2021-10-05	Transit to Thyborøn, Denmark
Mobilisation	2021-10-05	Mobilisation alongside Thyborøn, Denmark
Calibrations and verifications	2021-10-05 – 2021-10-08	Alongside Thyborøn and offshore
Geophysical/ UXO Survey	2021-10-08 – 2021-12-07 2021-12-23 – 2021-12-26	Geophysical & UXO survey operations
Demobilisation	2021-12-27	Demobilisation alongside Thyborøn, Denmark

3.3| SPATIAL ACCURACIES

A summary of positioning system accuracies on M/V Relume is provided below in Table 15.

For complete operational, QHSE and positioning accuracies details see the *Operations Report Artificial Island Project Site* and *Mobilisation and Calibration Report – Relume* referenced in Table 2.

Table 15 Summary of accuracy of positioning systems M/V Relume.

SSS (m)	MAG (m)	MBES			GPS		USBL St.Dev (m)	SVP* (ms)
		Max THU (m)	Min THU (m)	TVU (m)	Delta (m)	SD (m)		
0.18	0.42	± 0.509	± 0.362	± 0.189	0.08 (E) 0.09 (N)	0.03 (E) 0.03 (N)	0.22 (E) 0.21 (N)	0.28

*Difference between up and down casts.

4| DATA PROCESSING AND INTERPRETATION METHODS

4.1| BATHYMETRY

The objective of the processing workflow is to create a Digital Terrain Model (DTM) that provides the most realistic representation of the seabed with the highest possible detail. The processing scheme for MBES data comprised two main scopes: horizontal and vertical levelling in order to homogenise the dataset and data cleaning in order to remove outliers.

The processing of the MBES data was performed in the EIVA software suite comprising of NaviEdit and NaviModel. and IxSea DeplhINS for post processed navigation.

The ROV navigation data was post processed in DelphINS and exported then applied to the data held within the NaviEdit database.

After the post-processed position and error data is applied, a Global Navigation Satellite System (GNSS) tide is calculated from a logged ellipsoidal file and the DTU21 data model, to reduce the depths to MSL.

Several stages have been performed in the processing of the bathymetry data. These can be summarised as;

- Importation of Raw MBES data (NaviScan.SBD) in to the NaviEdit Jobplanner.
- MBES data was then corrected and compensated for the variations in sound velocity, ray bending, and other environmental/atmospheric effects.
- Post-processed navigation was applied to the data.
- Depths reduced to the project specified vertical datum
- A DTM was created in NaviModel at the project specified resolution to undertake the next stage of processing.
- The MBES data underwent iterative analysis and corrective measures to ensure that all per definition outliers are flagged as rejected.
- This used both manual editing and the use of analytical algorithms such S-CAN SCALGO filtering and/or EC-3D filter followed by manual verification of the affected area to ensure the survey objective has been met.
- The MBES data was then reviewed against the survey specifications to ensure that it has met the project criteria.
- Required products were then exported from NaviModel and NaviEdit.

The work flow diagram for MBES processing is shown in Figure 5.

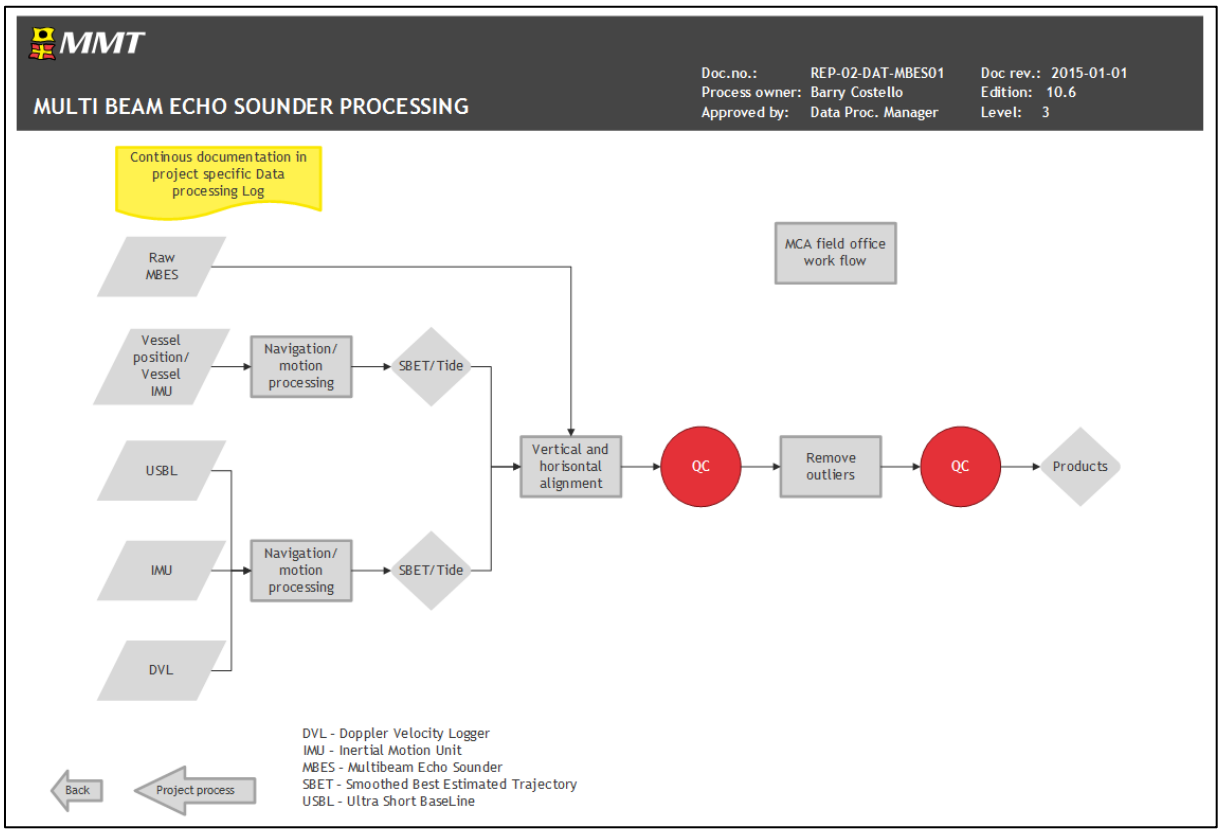


Figure 5 Workflow MBES processing.

The dataset underwent QC steps to check for vertical alignment before products were created.

Bathymetric contours were generated from the 20 cm DTM in combination with scaling factors applied to generalise the contours to ensure the charting legibility. The contour parameters used, in conjunction with a NaviModel Chart Panel with a resolution of 1 m, are shown in Figure 6 and the exported contours presented over the DTM is shown in Figure 7. This combination effectively generates contours from a surface with a 500CM resolution.

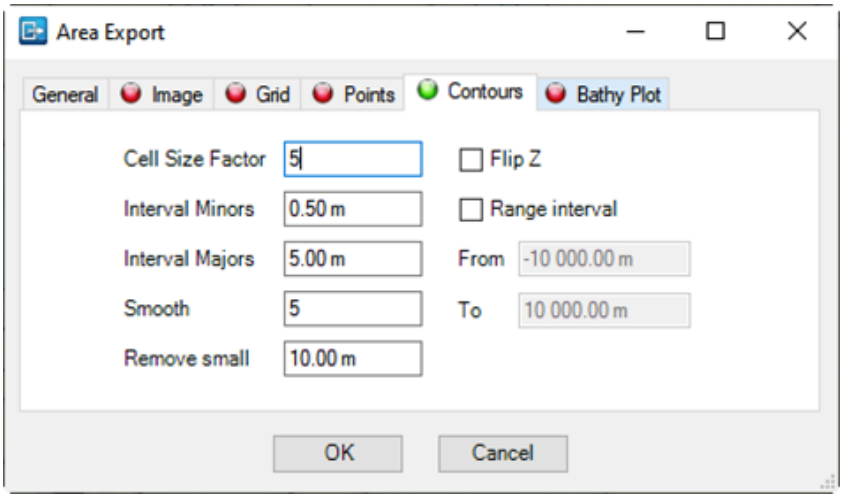


Figure 6 Artificial Island project site contour export parameters.

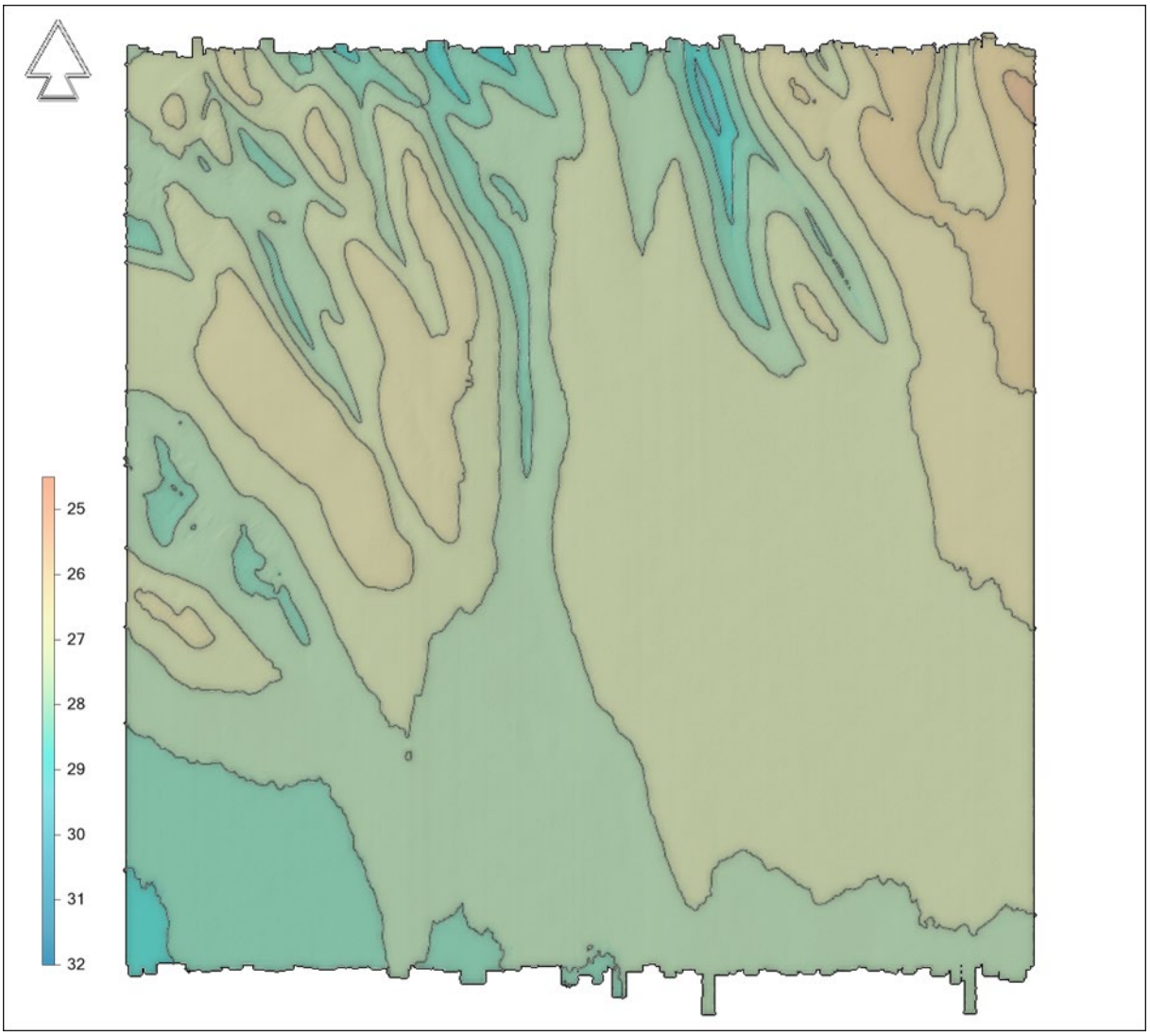


Figure 7 Exported contours with 50 cm interval over the Artificial Island project site. Depth convention is positive down.

4.2| SIDE SCAN SONAR

SSS processing and interpretation was conducted within SonarWiz. Prior to importing raw SSS JSF files the water sound velocity at towing depth was confirmed and updated within the SonarWiz import settings. The raw SSS data was then imported into SonarWiz without the application of any gains, and the following QC/processes were conducted:

1. Navigation data QC'd and any occasional spikes removed
2. Seabed auto tracked, QC'd and manually adjusted if necessary
3. User controlled gains applied to the data and manually adjusted to enhance seabed sediment contrasts and seabed features
4. SSS data QC'd against MBES data by locating features/contacts clearly distinguishable in both data sets and comparing appearance and position
5. Coverage QC'd and any gaps flagged and infilled in order to meet client coverage requirements

The SSS processing workflow is outlined in Figure 8 and Figure 9.

The processing was conducted with the following objectives:

- To classify seabed surface sediments
- To classify mobile bedforms and other potential hazards
- To identify natural and anthropogenic seabed features
- To detect contacts
- To detect cables and pipelines

The interpretation of SSS geo-boundaries was conducted within SonarWiz and AutoCAD software. Within SonarWiz geo-boundaries were digitised as features and exported as DXF files. For digitisation in AutoCAD, SSS mosaics were exported from SonarWiz loaded into AutoCAD and line and polygon features mapped. Before the mosaic were exported as a geotiffs, the files were arranged so the best available data is uppermost. The nadir was made transparent in order for data in overlapping files that cover the nadir gap to be seen. This process is conducted for both high frequency (HF) and low frequency (LF) data sets.

The geo-boundaries were reviewed against backscatter, MBES and GRAD data so an integrated interpretation was obtained based upon all available data. Seabed sediment classifications were also reconciled against the geotechnical grab sample (GS). Interpretations were QC'd and finalised by a Senior Geologist.

The interpretation of SSS contacts was initially conducted within SonarWiz. The SSS data was viewed in digitising mode and man-made objects were digitised. Any wrecks/cables were compared to existing databases. Contacts were then QC'd against the mosaics and MBES, and any missing contacts were added using SonarWiz. The contacts list was then correlated to the GRAD anomalies.

The SSS data and contact lists were then trimmed to the 2.5 km x 2.5 km Artificial Island project site area.

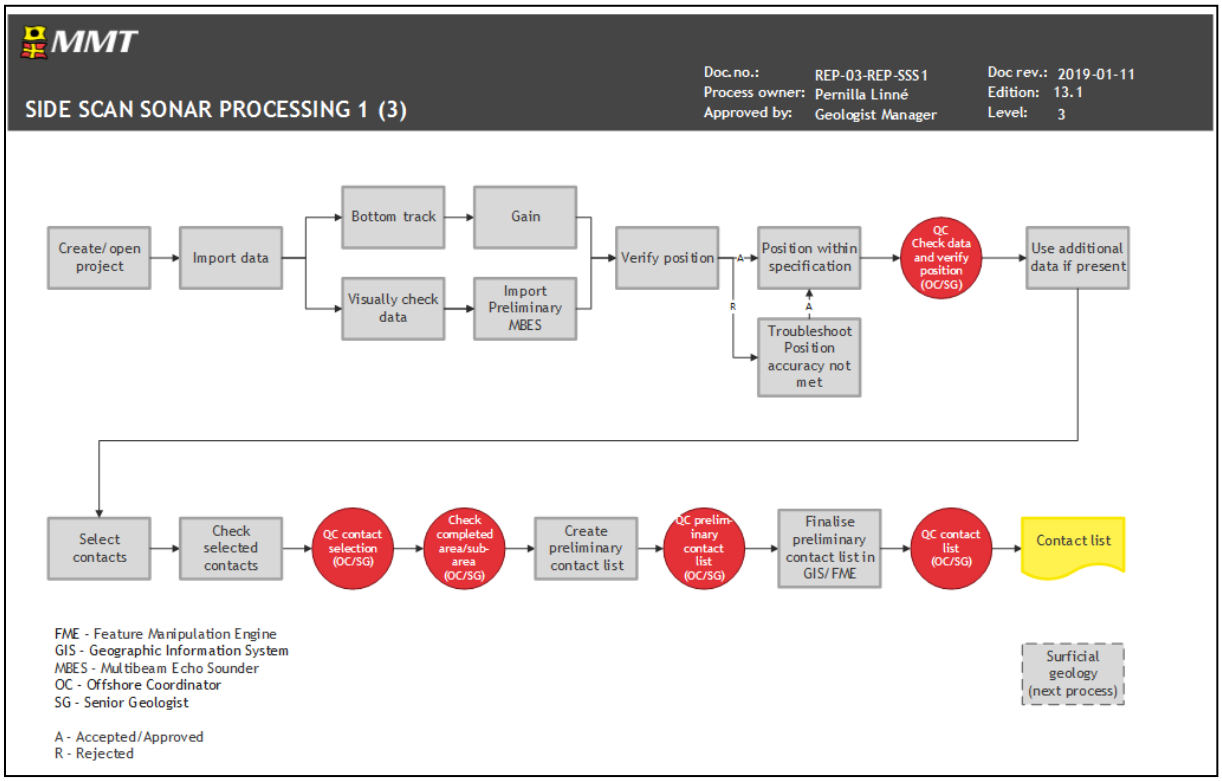


Figure 8 Workflow side scan sonar processing (1 of 2).

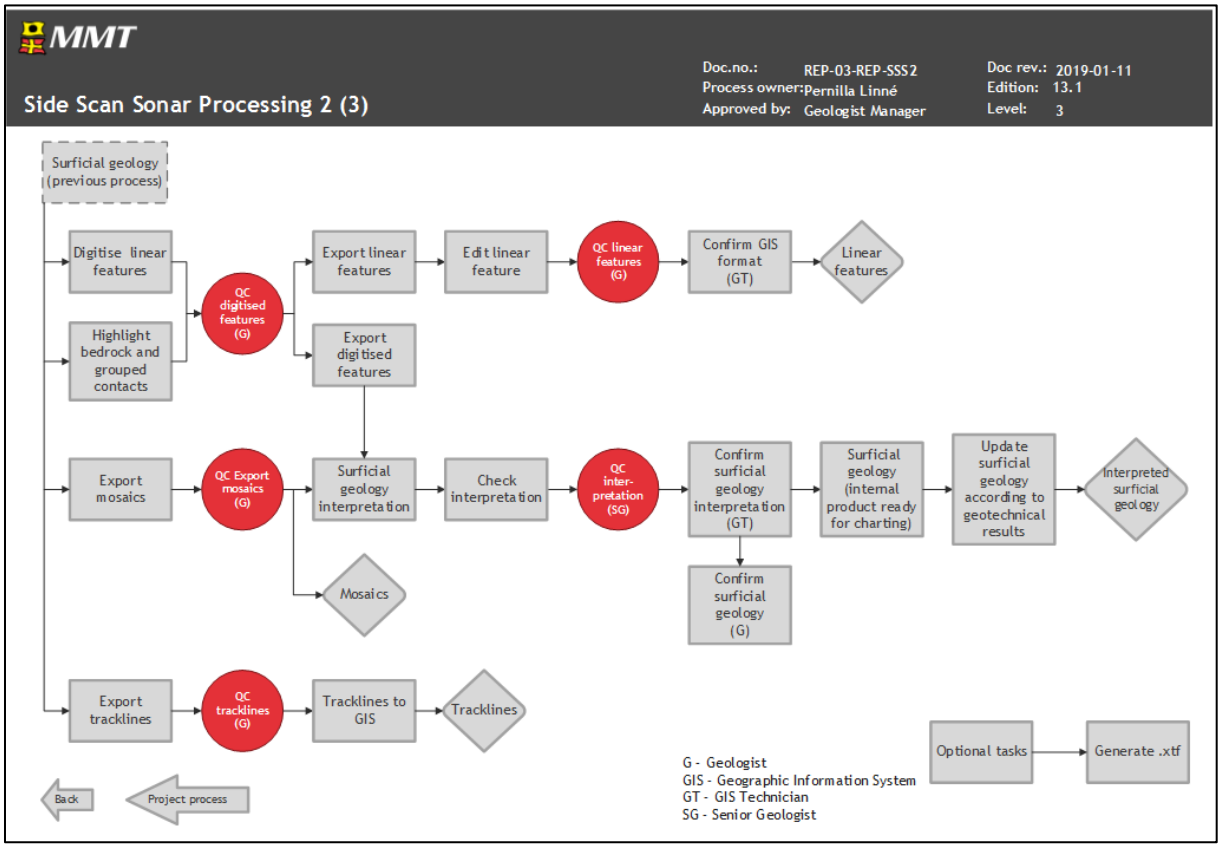


Figure 9 Workflow side scan sonar processing (2 of 2).

4.3| GRADIOMETER

The high-resolution gradiometer survey was executed with a GMA 1000 Model-T 12-pin gradiometer array, installed in a frame mounted on the front of the work-class ROV (WROV).

GRAD data was processed and interpreted within Oasis Montaj software version 9.9.1.

Navigation is despiked removing repeated values and outliers through a set distance from the navigational trend. After a manual check is performed and additional spikes are removed as needed, small gaps below approximately 5 m are interpolated, and navigational gaps above 5 m (or 100 fiducials) are flagged for infill. Once the navigation has been despiked a small rolling statistic smoothing filter with a width of 6 fiducials is applied.

Altitude, depth, and motion were despiked removing outliers through a set value that incorporates real data for each sensor but excludes spikes as these vastly differ from the real data. Next a manual check is performed and additional spikes removed as needed. Once altitude and depth have been properly despiked, a small rolling statistic smoothing filter is applied to each sensor.

Non-linear filters applied to despiked altitude, depth, pitch and roll:

- Altitude: Non-linear filter; Width = 5, Tolerance = 0.1
- Depth: Non-linear filter; Width = 10, Tolerance = 0.5
- Roll: Non-linear filter; Width = 5, Tolerance = 2
- Pitch: Non-linear filter; Width = 5, Tolerance = 2

Rolling statistics filters applied to smooth altitude and depth:

- Altitude: rolling statistics; Width = 15
- Depth: rolling statistics; Width = 15

Once the altitude is despiked and smoothed a 2 m cut-off is applied, this will remove all altitude values above 2 m.

The raw GRAD data was despiked using a reasonable cut-off from -10000 nT/ft to 10000 nT/ft, this will remove occasional spikes falling outside of these limits and minor gaps were interpolated. To generate the regional background field, one non-linear filter followed by two rolling statistic filters were used.

Applied filters to generate background:

- Non-linear filter 1; Width = 100, Tolerance = 1
- Rolling statistics 1; Width = 20
- Rolling statistics 2; Width = 10

Example of the filter result can be seen in Figure 10

The same set of filters were used over the whole dataset to remove the regional background field.

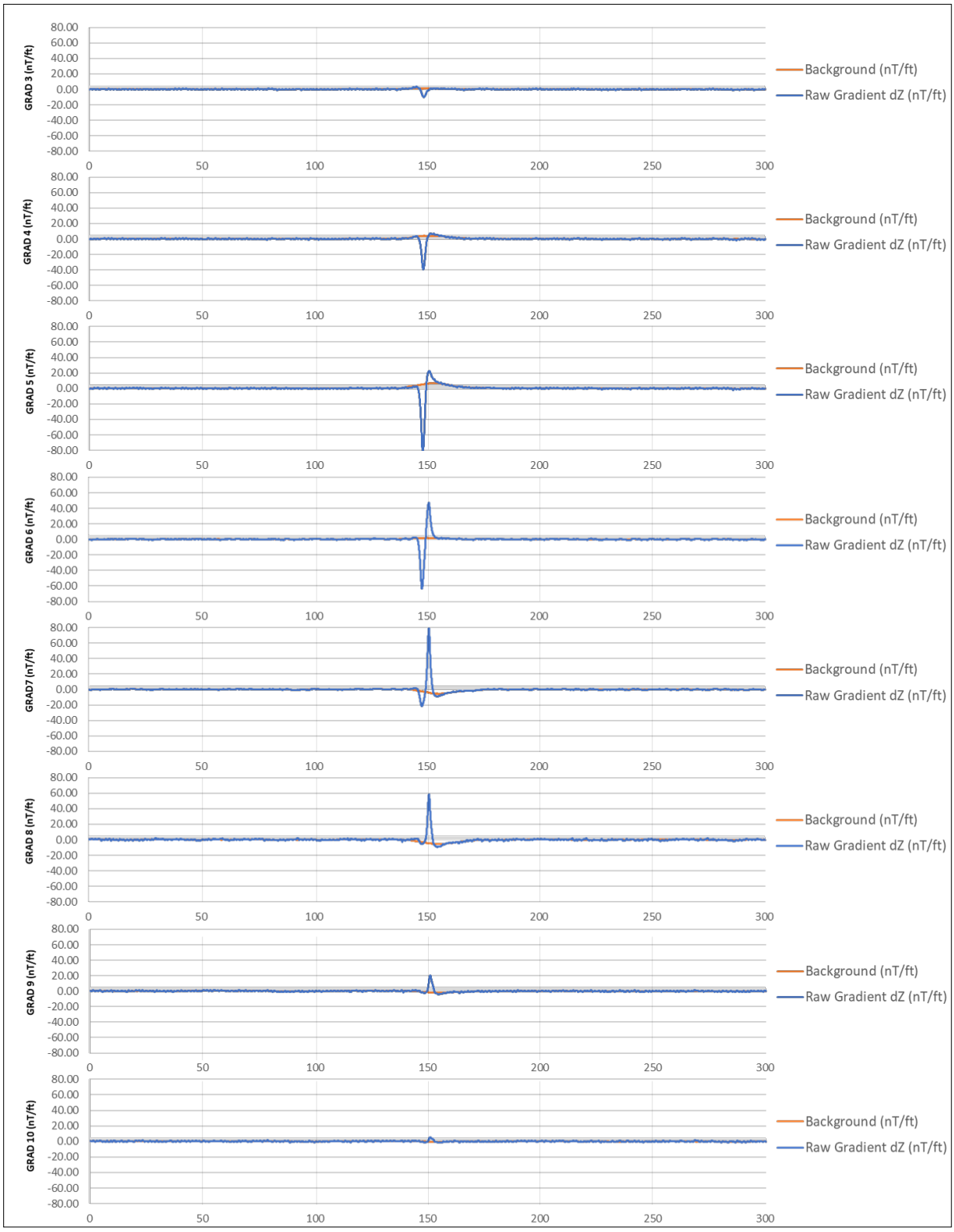


Figure 10 Data example from line EI_OWF_E_750_0004.
Raw gradient and processed background trend of the gradiometer data.

Total Magnetic Field was calculated by using the average between the top and the bottom sensor of each gradiometer, and then despiked using a cut-off from 47000 nT/ft to 54000 nT/ft. Small gaps up to 3 fiducials were interpolated and no smoothing was applied.

Coverage was calculated using Dyanamic coverage. Meaning that for each point along the line we calculate the width of a circle based on three parameters: detection radius, altitude and detection depth Figure 11

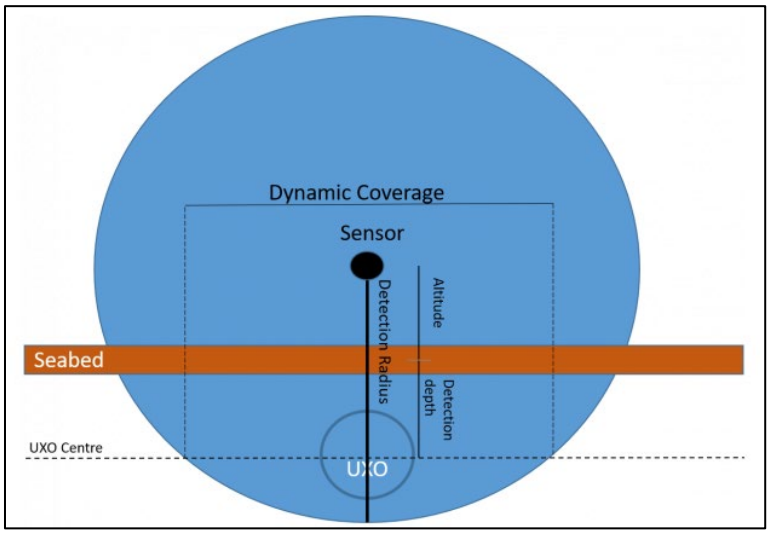


Figure 11 Dynamic Coverage parameters.

The Detection Radius (DR) was determined during the SIT and confirmed by the UXO company RPS, as 4 m. Altitude is the sensor distance from the seabed. The Detection Depth (DD) is defined as the vertical distance from the seabed to the centre of mass of the buried object. This was defined as 2 m by RPS.

The dynamic coverage takes into account the bigger detection range, with a lower altitude. For this to be implemented two crucial parameters need to be known; Detection Depth (2 m) and Detection Radius (4 m). The below formula was implemented in this project to calculate dynamic coverage:

$$Mag\ or\ Model\ T\ Coverage_{XY\_Final}[m] = 2 * \sqrt[2]{DR^2 - (Alt + DD)^2}$$

Induced noise due to weather, currents or motion was manually masked. The noise threshold was 2.5nT/ft peak to peak. Lines showing high levels of noise were flagged for rerun according to the below RPS criteria:

- Areas where more than 3 sensors are above the 2.5 nT/ft PtoP noise threshold.
- Area where more than 2 adjacent sensors are above the 2.5 nT/ft PtoP noise threshold.
- If anomalies are detected where a sensor has been turned off or completely masked, RPS may request a rerun/infill.

No altitude correction has been performed on the gradiometer data set.

Each line was individually assessed for anomalies. The picking target threshold criteria for magnetic anomalies is 5 nT/ft (peak to peak).

Once an anomaly was identified a comparison was carried out between the different sensor information available (altitude, depth, motion and navigation) to determine if the anomaly is real or induced by motion noise or rapid changes in altitude. Once an anomaly was confirmed to be real the location was added to a target database and the anomaly's amplitude and wavelength was manually measured. Once completed, each picked anomaly was individually Quality Checked to confirm each value.

The general workflow of the GRAD processing is outlined in Figure 12 and Figure 13

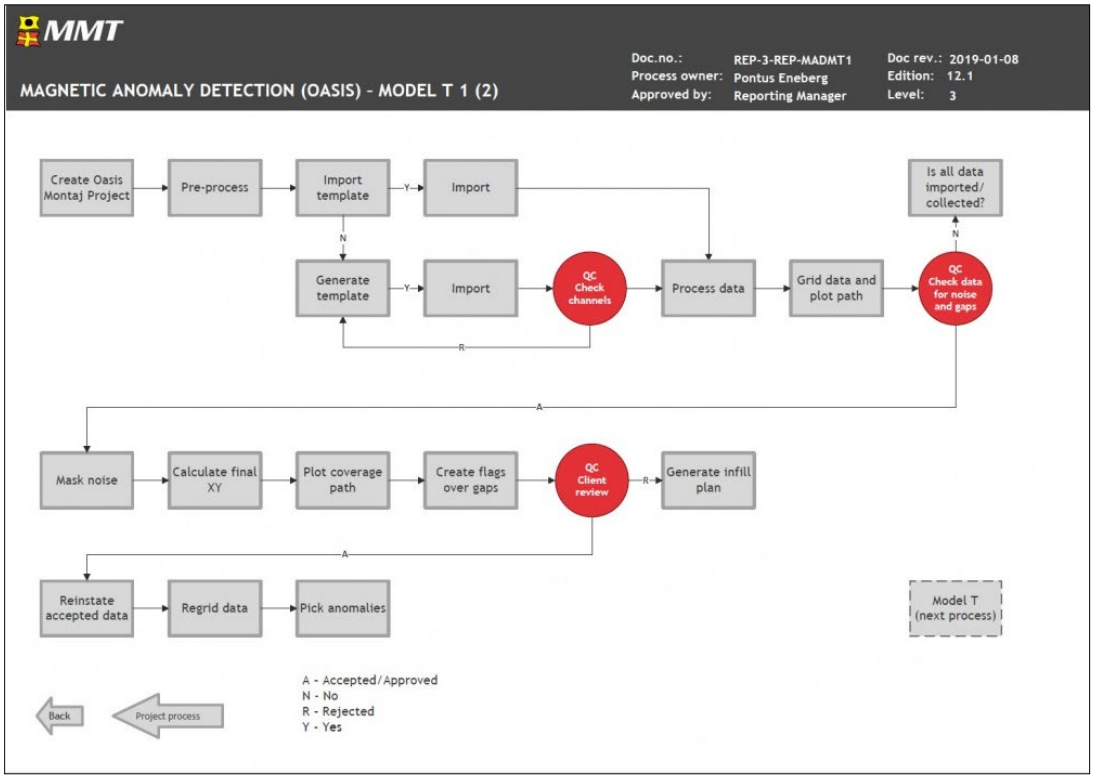


Figure 12 Workflow GRAD processing (1 of 2).

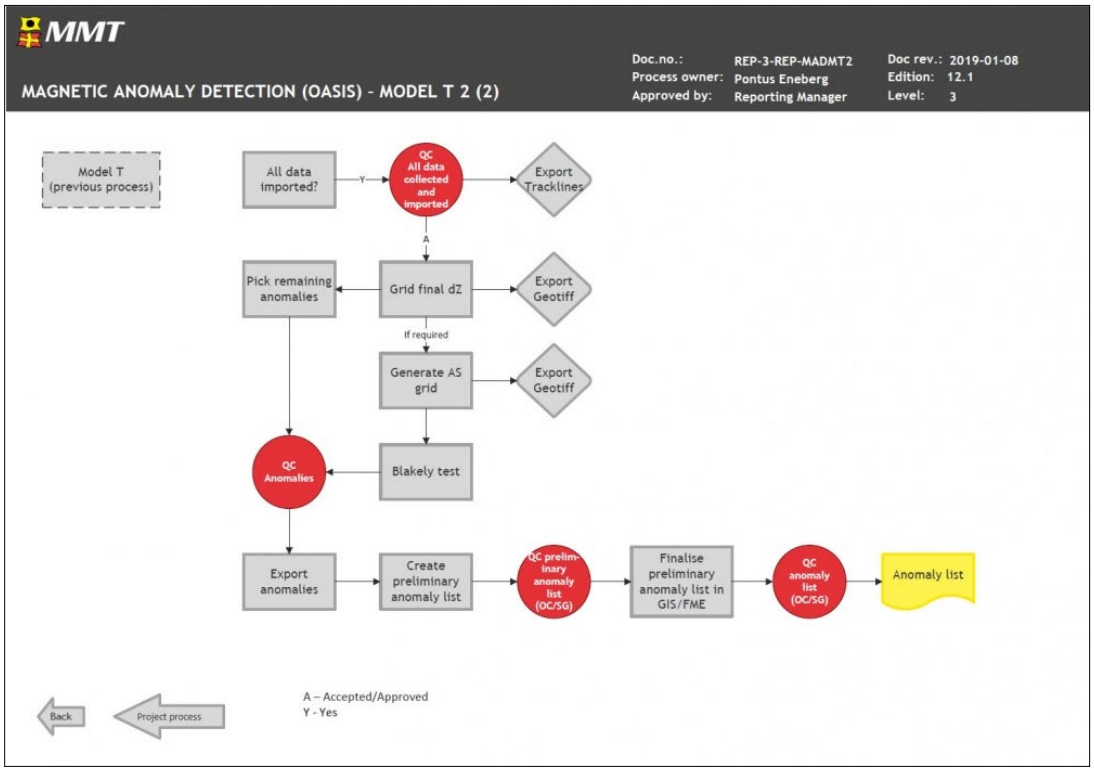


Figure 13 Workflow GRAD processing (2 of 2).

5| PROCESSED DATA QUALITY

5.1| BATHYMETRY DATA

The processed MBES bathymetry data meets the required specifications. Checks were made during acquisition and in post-processing to ensure that sounding density conformed to the 16 soundings per 1 m cell criteria (Figure 14). The close line spacing required for the gradiometer survey meant that the data density achieved far exceeded the required density with some cells having thousands of soundings. This excessive sounding density means that surface generation relatively time consuming for the size of the survey area but once surfaces are created this has no impact on the visualisation and data analysis.

An example profile showing the vertical alignment of the sounding data can be seen in Figure 15. This shows that the survey lines were well aligned

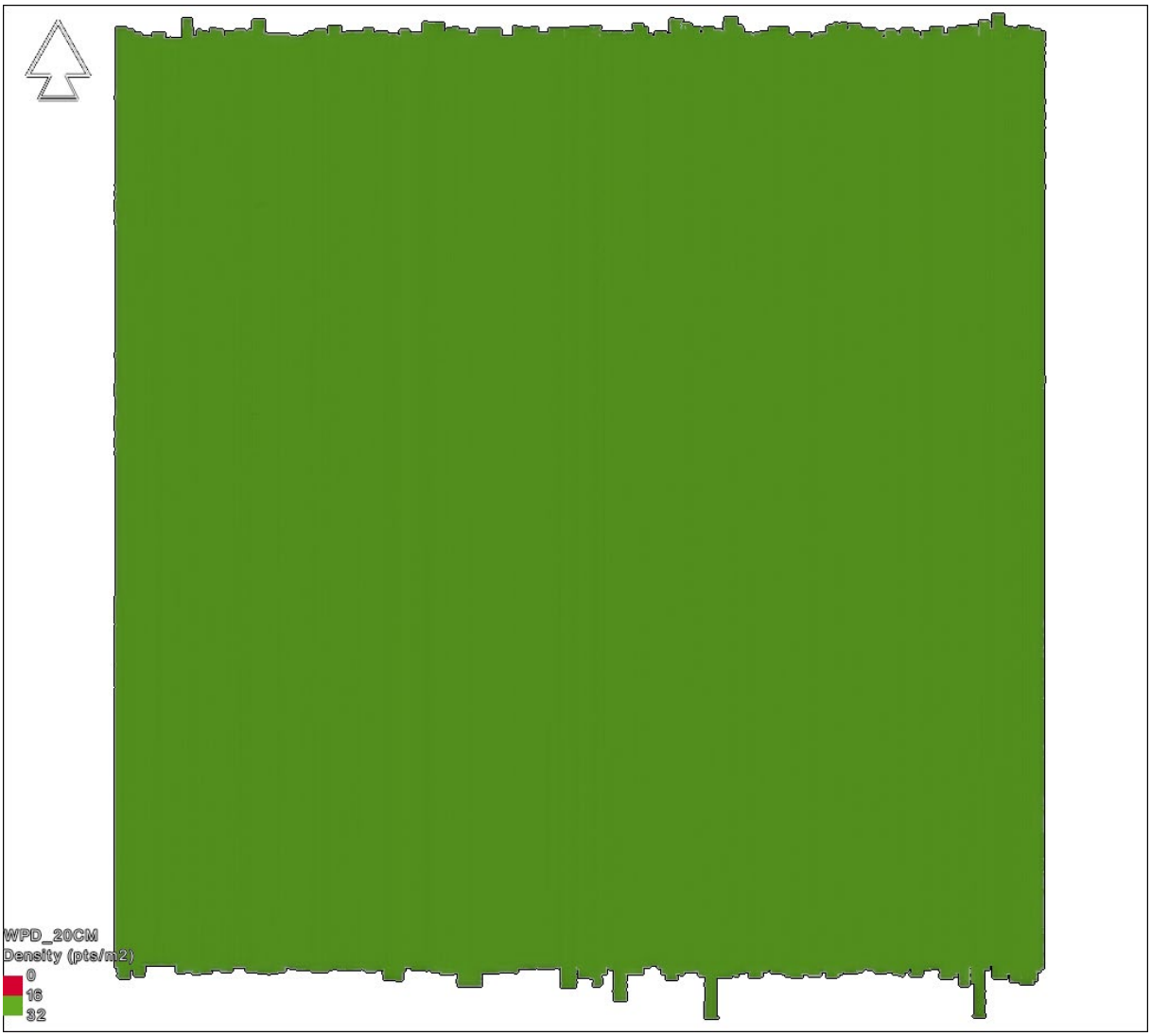


Figure 14 Artificial Island project site sounding density per 1m cell.

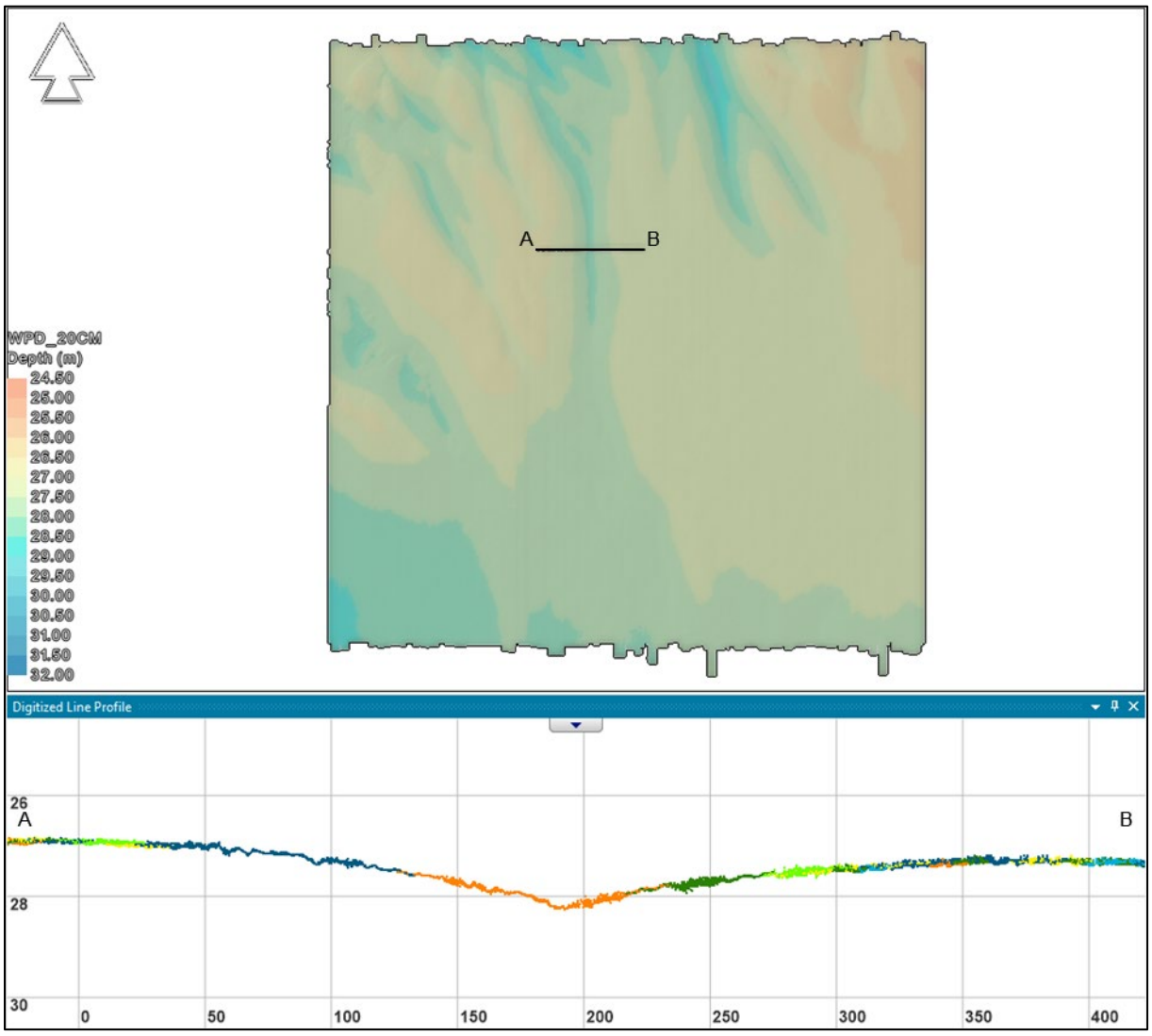


Figure 15 Profile showing vertical alignment of soundings in the Artificial Island project site. Vertical exaggeration of the profile is x20.

A surface showing the standard deviation at the 95% confidence interval across the site at 1.0 m resolution was created from the soundings. An overview image for the full site is shown in Figure 16. The maximum standard deviation within the Artificial Island project site bathymetry dataset is 0.18 m which indicates the dataset is very well aligned with a tight spread of data.

Regions with high standard deviations can occur as a result of sound velocity errors, issues with the post-processed navigation and where there are steep seabed slopes or contacts. The data has been processed to reduce the impact of any potential systematic errors and shows that there are no significant slopes or contacts within the 2.5 km by 2.5 km site.

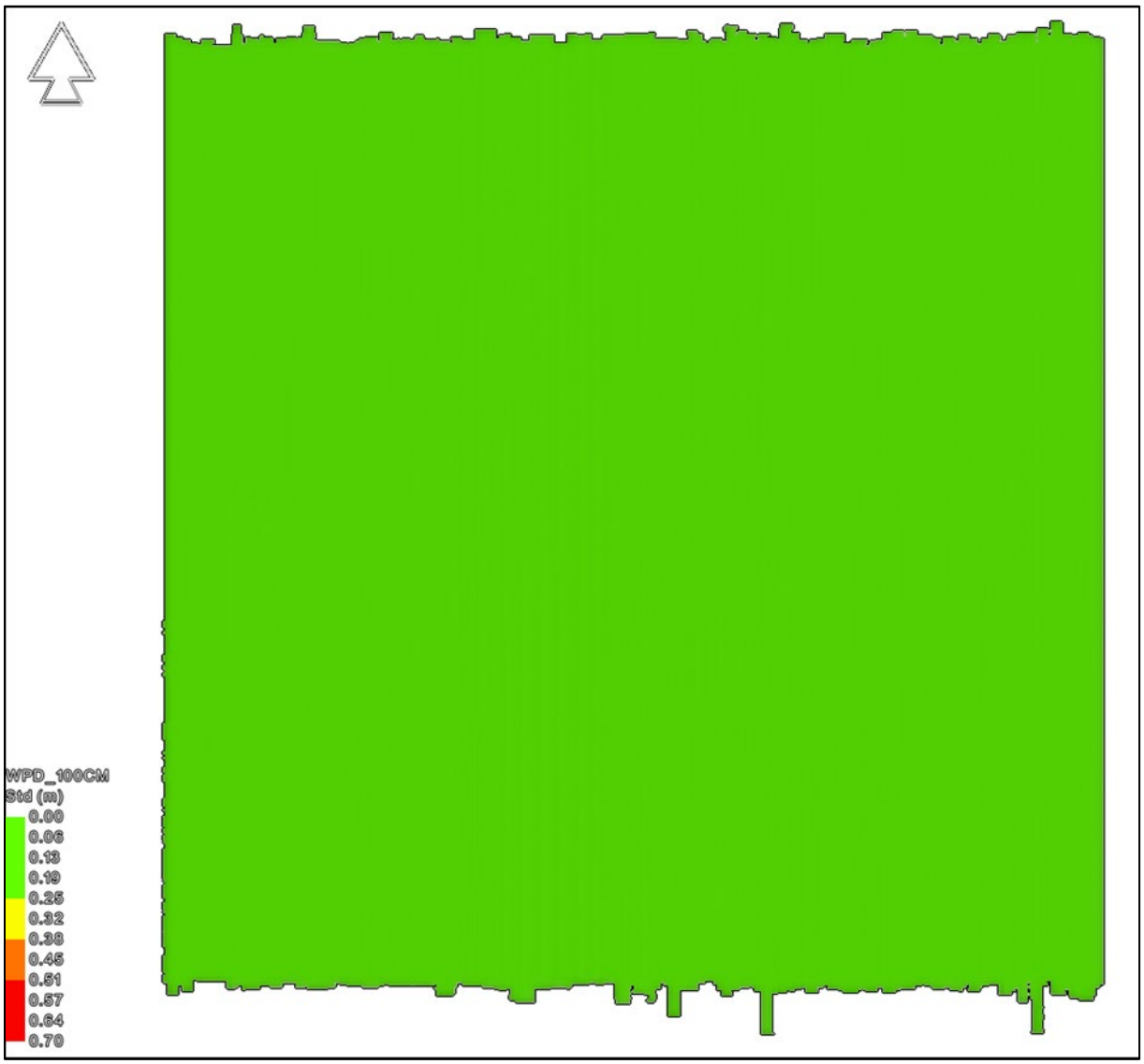


Figure 16 Artificial Island project site- Standard Deviation surface at 1m resolution.

Presented below, in Figure 17, is a 3D image of some of the sand ripples apparent in the Artificial Island project site. This image is used to highlight the alignment of the MBES data since it shows no deviations in the form of the ripples which may show tearing or blurring where overlapping lines are misaligned.

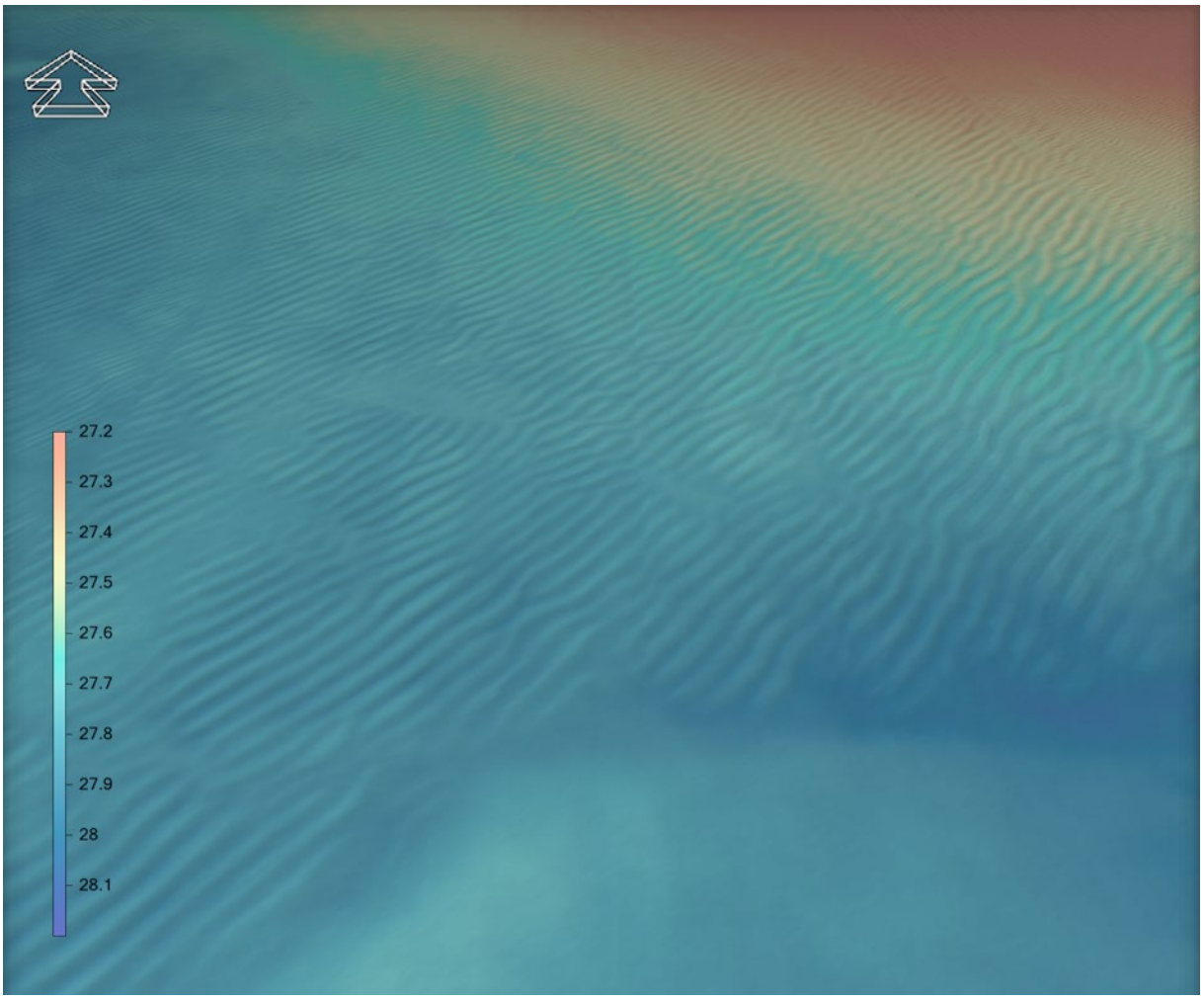


Figure 17 3D image of an area of ripples within the Artificial Island project site.

5.2| SIDE SCAN SONAR DATA

For this project the SSS was the secondary sensor, with the main focus on the gradiometer results. The SSS data was acquired at 25 m range with a 300/900 kHz frequency. In order to gather high quality GRAD data, the ROV was flying low (between 1.5-2.5 m), with the SSS situated 0.8 m higher than the gradiometer frame. Although the altitude of the gradiometer was given priority, the altitude of the SSS was maintained at 10-15% of the range throughout, with an average of 2.62 m across the survey area.

The 10 m line spacing and 25 m range exceeded the project specification of covering the adjacent nadir and provided almost 300% coverage throughout.

Other than a few periods of weather down time (68 hours), the weather was generally good throughout the survey, with limited effects seen within the data, meaning data quality was good for the majority of the project (Figure 18 and Figure 19).

Mild pitch and roll effects can be seen throughout the survey as a result of manual flying with low vessel speeds and strong underwater currents and was flagged to all relevant personnel (Figure 21 and Figure 22). Since the positioning of the SSS data compared with the MBES data remained well within the 2 m specification, this good accuracy, combined with the >300% coverage, meant that the data was accepted and deemed suitable for the project requirements. To ensure a comprehensive interpretation of seabed contacts and features and to further mitigate any observed pitch and roll and environmental effects on the sonar data, the multibeam was also used in conjunction with the SSS data during the interpretation phase.

Rare cases of mild electrical noise were observed in the outer range of the data; however, this did not significantly reduce the data quality (Figure 22).

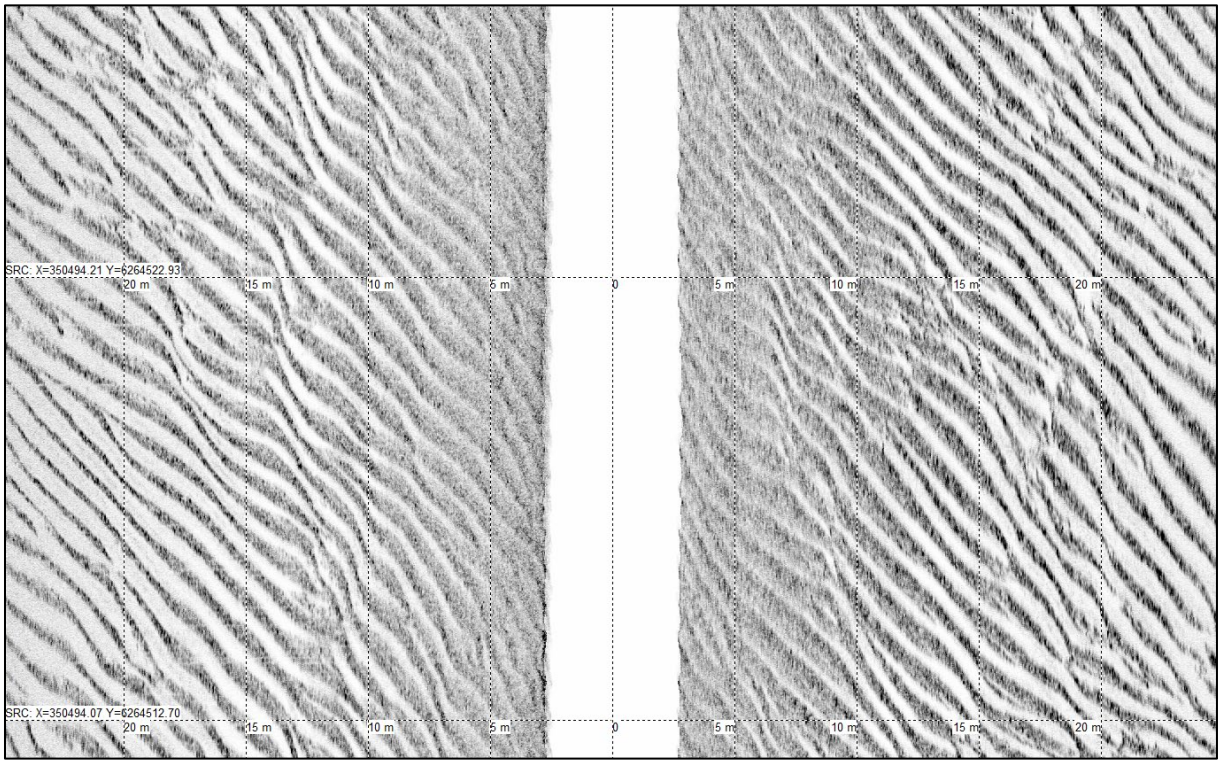


Figure 18 Example of good high frequency SSS data, showing ripples.
The data is from line 2500 in waterfall view. Horizontal scale lines at 5 m intervals.

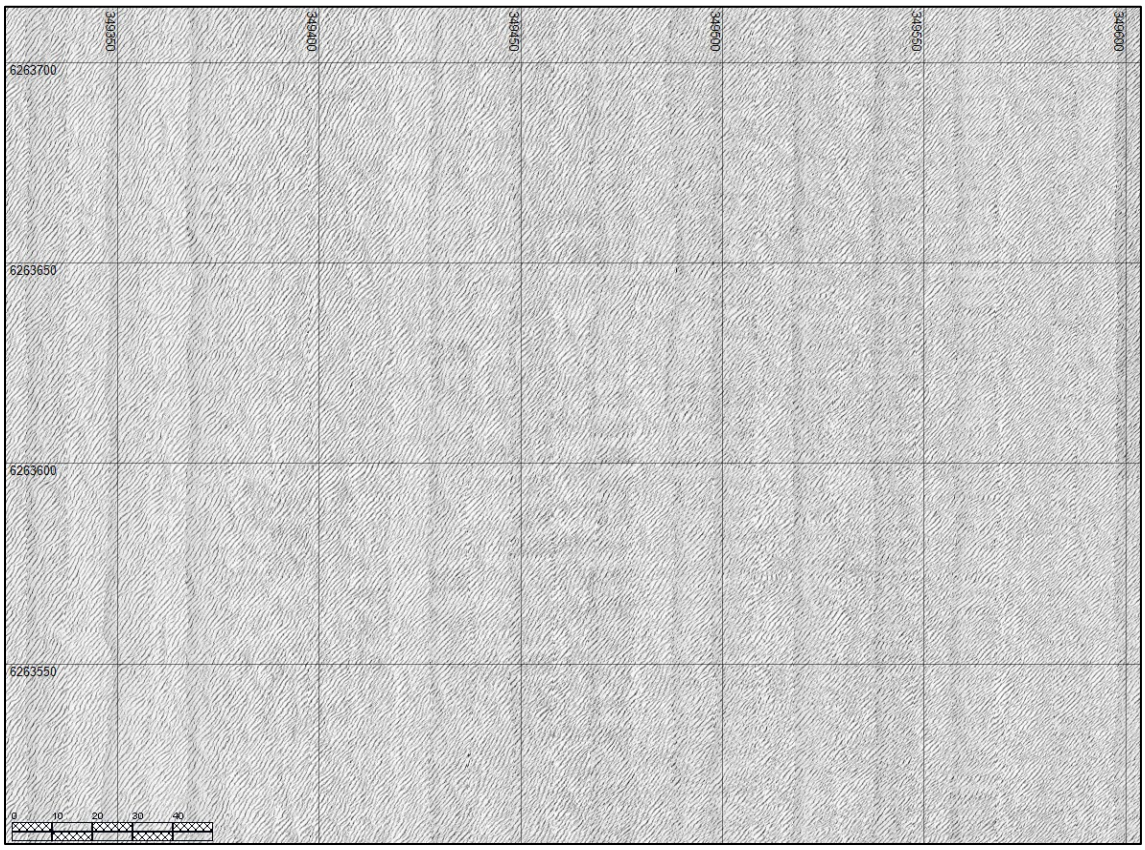


Figure 19 Example of good high frequency SSS in mosaic plan view, showing ripples.

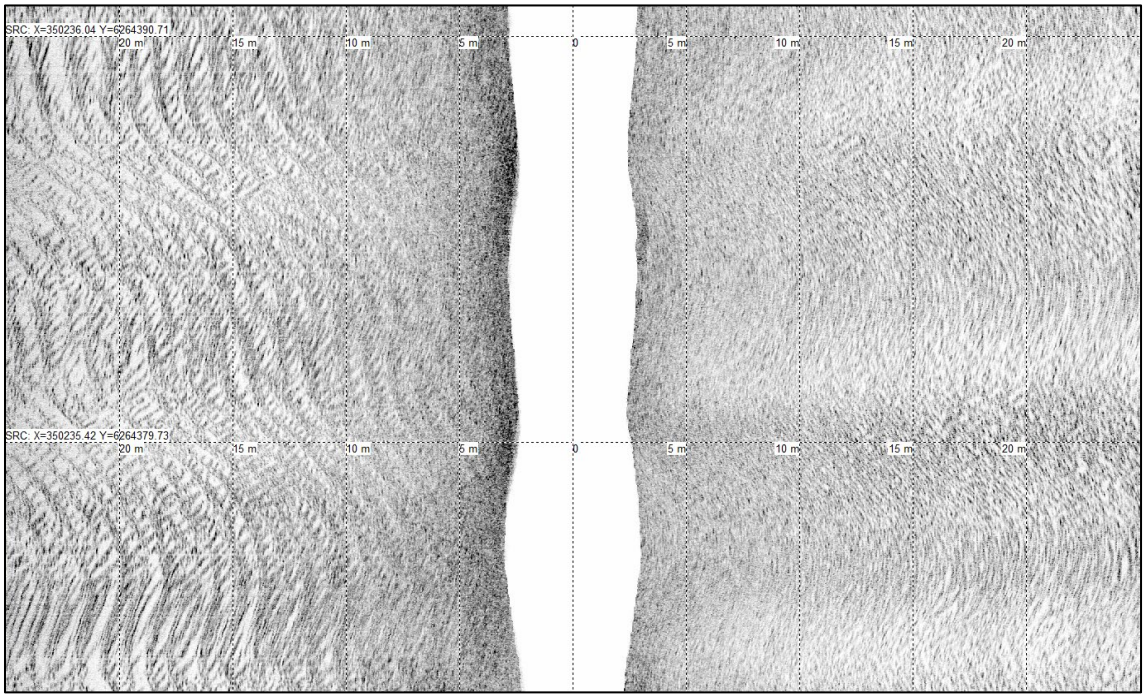


Figure 20 Moderate pitch and roll effects in an area of ripples.
The example shows high frequency SSS data from line 2240, with Horizontal scale lines at 5 m intervals, in waterfall view.

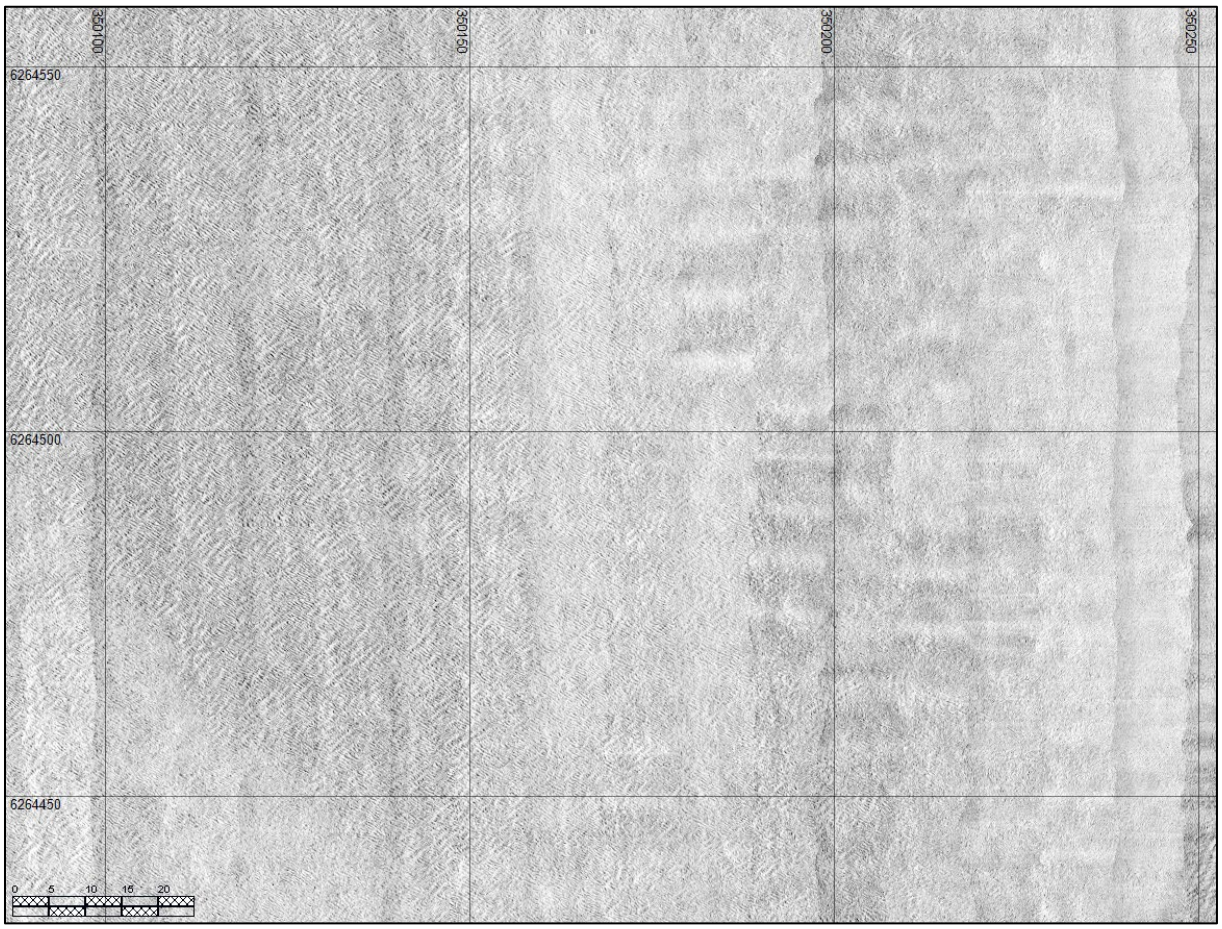


Figure 21 Example of striping in SSS data from moderate pitch and roll effects, in mosaic plan view.

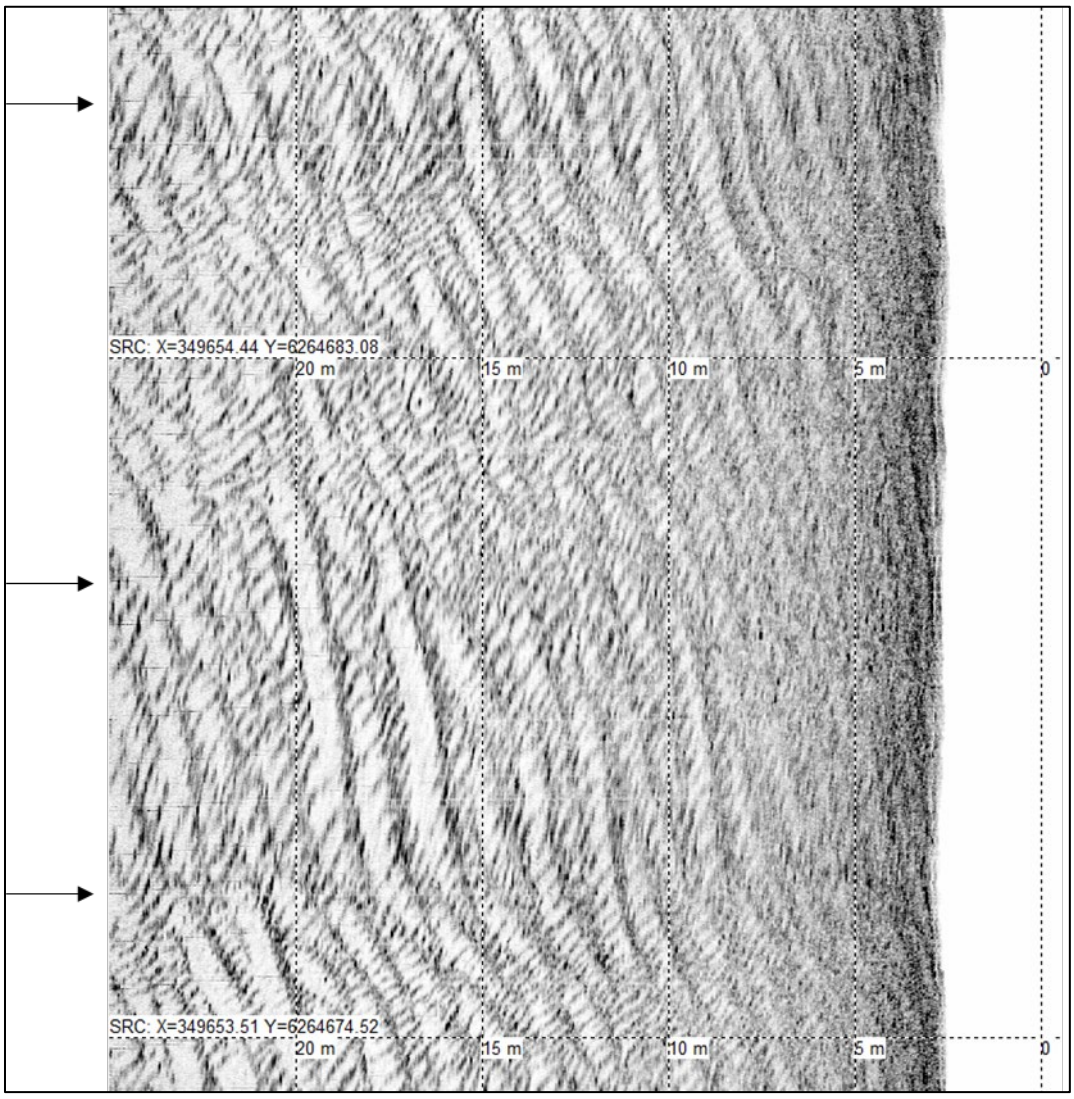


Figure 22 Example of mild electrical noise (horizontal dashed lines across the record) in SSS data on the outer range of the port channel. The image shows line 1660, in waterfall view. Horizontal scale lines at 5 m intervals, in waterfall view.

5.3| GRADIOMETER DATA

GRAD data quality was mainly relative to weather conditions and currents, with background noise levels below 2.5 nT/ft PtoP (peak to peak) during good weather (Figure 23) and presence of noise above 2.5 nT/ft PtoP during poor or marginal weather.

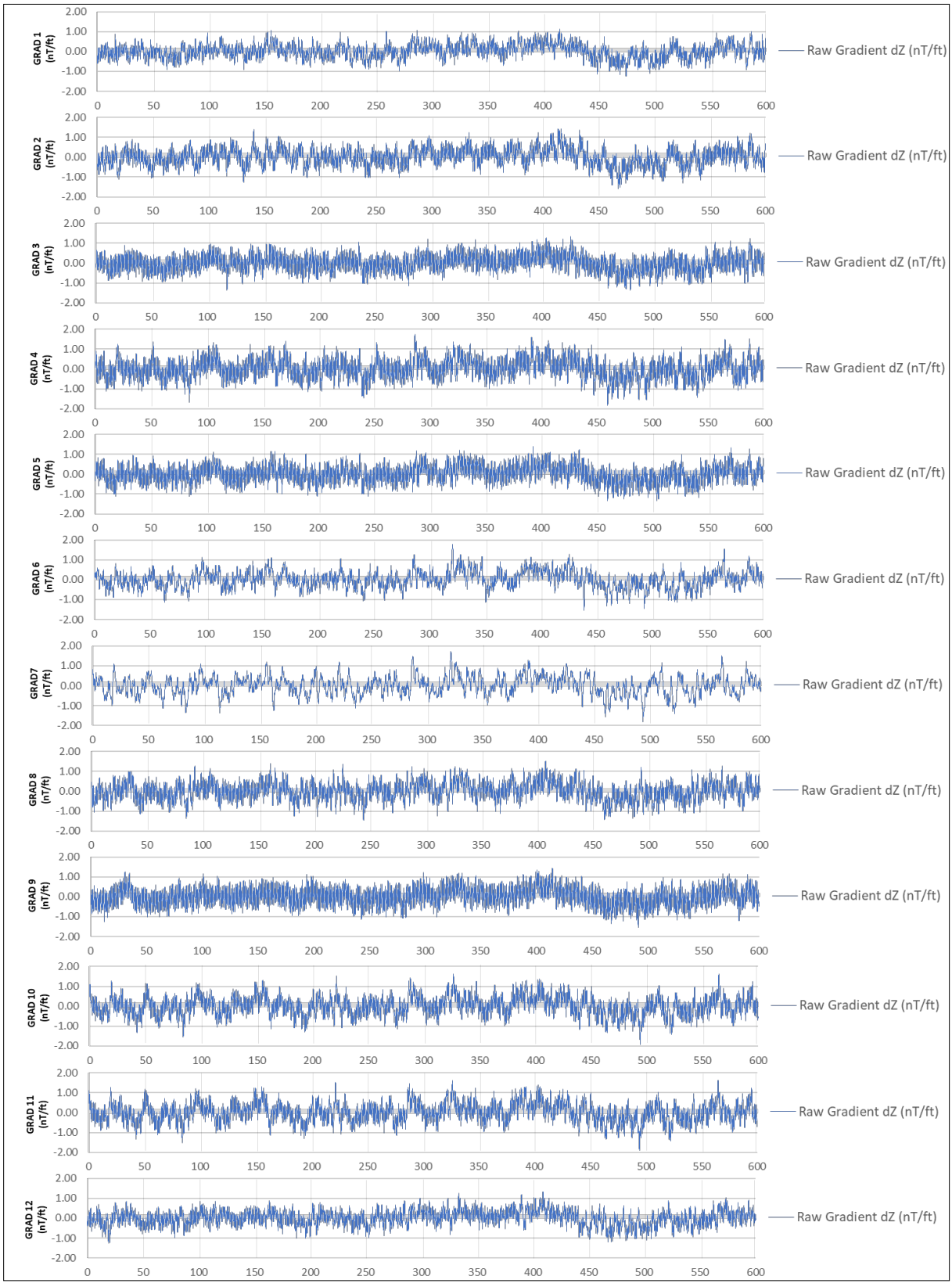


Figure 23 Gradiometer profile of line showing background noise levels below 2.5nT/ft PtoP. All twelve gradiometer pins shown.

Unfavourable currents played a role in the GRAD data quality causing WROV motion during the acquisition of lines heading south, especially in the western part of the survey area where undesired motion due to currents was more evident.

Periodic noise due to vessel proximity was observed at the beginning of the survey, leading to 7 reruns. A 20 m exclusion radius between WROV and the vessel was introduced showing a clear improvement in signal to noise ratio.

Noise above 2.5nT/ft in each sensor was manually masked by applying RPS criteria, (see section 4.3| for more details regarding the RPS rules) resulting in a significant number (1202) of reruns/infills initially flagged by MMT to be acquired. This initial assessment involved 238 lines (Line 0 – 2370) acquired from 08 October to 24 November 2021.

A comprehensive list of reruns/infills was submitted to RPS for assessment. The document "EES1228 - Energy Island Infill Analysis" (sent by RPS on 03 December 2021) reduced considerably the final number of infills/reruns to be acquired, categorising the reruns/infills into 3 main groups: Priority 1, Priority 2 and Priority 3.

- **Priority 1:** Reduced data quality creates data gap or unusable sections of data. These may be highlighted on ALARP as exclusion if not rerun/infilled.
- **Priority 2:** Reduced data quality will make target analysis more difficult, possibly leading to increased number of pUXO to investigate. Small data gaps may be present but won't be highlighted as exclusion on ALARP.
- **Priority 3:** Data quality is out-of-spec, but good coverage and absence of targets means infill won't offer much more information

12 remaining lines (Line 2380 – 2490) to the East of the survey area were acquired during marginal weather between 04 and 06 of December 2021. A new list of reruns/infills including the east part of survey area was sent to RPS for evaluation. An updated infill/rerun assessment in the form of shapefile was submitted by RPS on 22 December 2021 totalling a final number of combined Priority 1 and Priority 2 reruns/infills to 168.

All Priority 1 and 2 reruns/infills were acquired as per RPS and Energinet decision during the infill/rerun campaign between 23 to 26 of December 2021, while all Priority 3 reruns were disregarded.

A total of 168 reruns/infills with 13 Full lines and 155 part lines (Table 16) were acquired mostly due to currents, vessel proximities and weather conditions causing motion in the GRAD frame and inducing pitch/roll noise. Pitch noise was more evident in the central pins, especially pins 5, 7 and 8.

Table 16 Priority 1 and 2 Reruns / Infills acquired in Artificial Island project site.

TYPE	NUMBER	REASON
Rerun full line	8	Weather
Rerun full line	2	Currents Primarily (Vessel noise Secondary)
Rerun full line	1	Vessel noise
Rerun full line	2	Vessel noise and currents
Rerun section of line	135	Weather
Rerun section of line	14	Currents
Rerun section of line	4	Vessel noise and currents
Infill section of line	2	Weather

Altitude was very consistent in most of the lines, oscillating between 1 m and 1.5 m.

In general, navigation was good and minimal dropouts from the USBL system were observed. Where navigation was lost the total time of dropout had negligible impact on the overall gradiometer positioning.

6| BACKGROUND DATA AND CLASSIFICATIONS

Client provided background information and the GIS database was the main resources used during data interpretation.

6.1| SEABED GRADIENT CLASSIFICATION

The seabed gradient is classified according to Table 17.

Table 17 Seabed gradient classification.

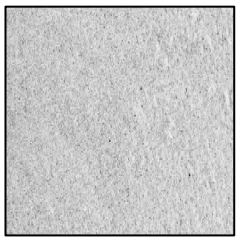
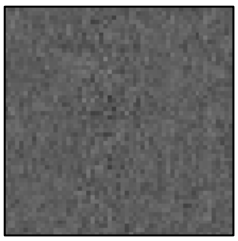
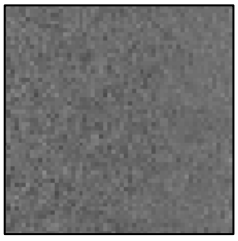
CLASSIFICATION	GRADIENT
Very Gentle	< 1°
Gentle	1° - 4.9 °
Moderate	5° - 9.9°
Steep	10° - 14.9°
Very Steep	> 15°

6.2| SEABED SEDIMENT CLASSIFICATION

The interpretation of surficial sediment types was derived from the acoustic character of the high frequency side scan sonar (SSS) data, and the interpretations aided by multibeam echo sounder (MBES) bathymetric 3D surfaces, multibeam backscatter (MBBS) and sub-bottom profiler (SBP) data, along with the results from the grab sample campaign (the latter two datasets from the MMT OWF survey area). During the review of the SSS survey data, higher intensity sonar returns (darker grey to black colours) were interpreted as relatively coarser grained sediments, and lower intensity sonar returns (lighter grey colours) were interpreted as relatively finer grained sediments. Bathymetric data was used to assist in boulder field interpretation and to correct for the effects of seabed slope on sonar returns

The ID column in Table 18 defines the colour in the charts for the specific sediment type. All particle sizes refer to the soil classification in ISO 14688-1 (2002).

Table 18 Sediment classification.

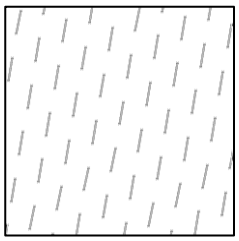
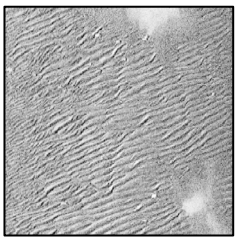
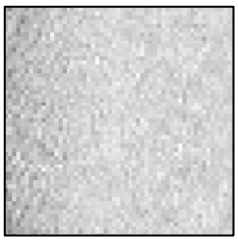
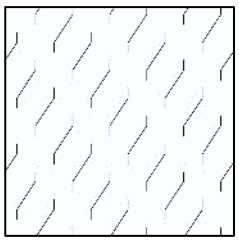
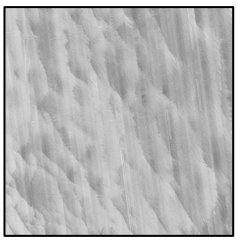
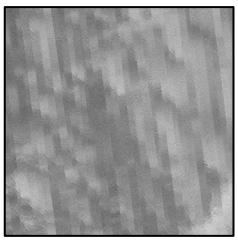
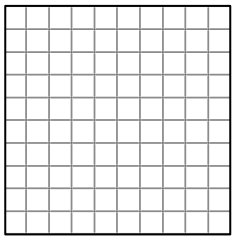
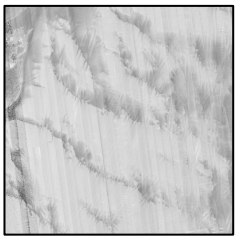
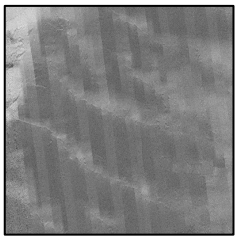
ID	SSS Image	BS Image	Acoustic Description	Lithological Interpretation
			Medium acoustic reflectivity, slightly grainy texture.	**SAND** Predominantly sand, may have minor fractions of clay, silt and/or gravel.
			Medium to high acoustic reflectivity. Slightly grainy to grainy texture, coarse texture in places.	**GRAVEL and coarse SAND** Predominantly gravelly sand, may contain silt. The ratio between sand and gravel can vary within this sediment type.

6.3| SEABED FEATURE/MORPHOLOGY CLASSIFICATION

The ID column in Table 19 defines the pattern in the charts for the specific feature type.

SSS, MBES and MBBS data have been used for interpretation of the seabed feature boundaries.

Table 19 Seabed features classification.

ID	SSS Image	BS Image	Seabed Feature	Criteria
			Ripples	Wavelength <5 m Height < 0.1 m Wavelength is the primary classifier.
			Sand Waves	Wavelength 50 - 200 m Height 3 - 5 m Wavelength is the primary classifier.
			Sandbars	Wavelength > 200 m Area of large-scale sediment transport/migration forming massive bedforms such as sandbars, sand ridges and sand dunes. This feature was added post scriptum to account for sediment formations which are larger than 200 m WL.

The SSS and MBES contacts were classified according to the following criteria:

- Boulder
- Man-made object (MMO) (Debris, fishing gear, man-made structures etc.)
- Other
- Wreck (none observed within Artificial Island area)

Boulder density was not high enough to classify any boulder fields (boulder density was required to be >5 boulders per 100 m x 100 m to classify as a boulder field). All boulders ≥ 0.5 m were interpreted.

Boulders were primarily interpreted in the SSS data, with support of the MBES, to ensure a comprehensive interpretation of seabed contacts and features.

In the GIS database all GRAD anomalies are categorized as MMO, due to the inherent uncertainties of magnetic anomaly interpretation. Best efforts were made to avoid selecting anomalies that are likely to be geological in nature, but it the cases where differentiation between man-made or geologically derived anomalies were not possible, the anomaly was selected but with a comment of “Likely Geology”.

All GRAD anomalies were compared to all MBES and SSS contacts. If a GRAD anomaly was within 5 m of any contact detected in either MBES or SSS, it was automatically deemed a correlation and commented on in the contact listing, as well as in the GIS database.

GRAD anomalies forming a linear pattern were commented as such as these could indicate the presence of fishing gear, cables, wire/chain or anything of a ferrous linear nature. Some linear anomalies were inferred to be of a geological nature and these were also commented as such.

7| RESULTS

7.1| GENERAL

The results from the Artificial Island project site UXO and geophysical survey are presented in this report together with associated north-up charts. A list of charts is presented in Appendix A|.

7.2| BATHYMETRY

Overall, the bathymetric depth changes moderately across Artificial Island project site. The minimum surveyed depth is 25.81 m at 350485.0 m E, 6264532.0 m N at the northeast of the area surveyed. The maximum surveyed depth is 30.62 m at 348848.0 m E, 6264623.0 m N in the north part of the survey area. The depth range across the site is 4.81 m. Figure 24 shows an overview of the bathymetry within Artificial Island project site. Two profile lines are shown running from west to east across the site.

Profile data derived from these lines is shown in Figure 24. The profiles have a strong vertical exaggeration (x25) so that the depth variations across the site are visible in the profiles. The profiles are used to manage the presentation of the bathymetry results over the Artificial Island project site, with a sub-section of the report for each profile and regionally related features of interest.

7.2.1| PROFILE 1

Profile 1 (Figure 24) crosses the north of Artificial Island project site. This profile shows the depth varies across the site with a slight overall trend shoaling to the east. High frequency variations in depth which relate to ripples can be seen throughout the profile.

The depth variation along this profile is 2.19 m from a minimum depth of 26.27 m at 350498 m E, 6264000 m N to a maximum depth of 28.46 m at 349697.0 m E, 6264000.0 m N.

A series of channels between bedforms were observed in the northern half of the site and have typically 200-300 m wide and up to 1.5 m deep. Examples of these are shown in Figure 25 and Figure 26.

7.2.2| PROFILE 2

Profile 2 (Figure 24) crosses the south of the Artificial Island project site. This profile shows the depth varies across the site but does not show an overall trend in one direction. High frequency variations in depth which relate to ripples can be seen throughout the profile though these are less pronounced than they are in Profile 1.

The depth variation along this profile is 0.95 m from a minimum depth of 27.11 m at 349824.0 m E, 6262750.0 m N to a maximum depth of 28.06 m at 347999.0 m E, 6262750.0 m N.

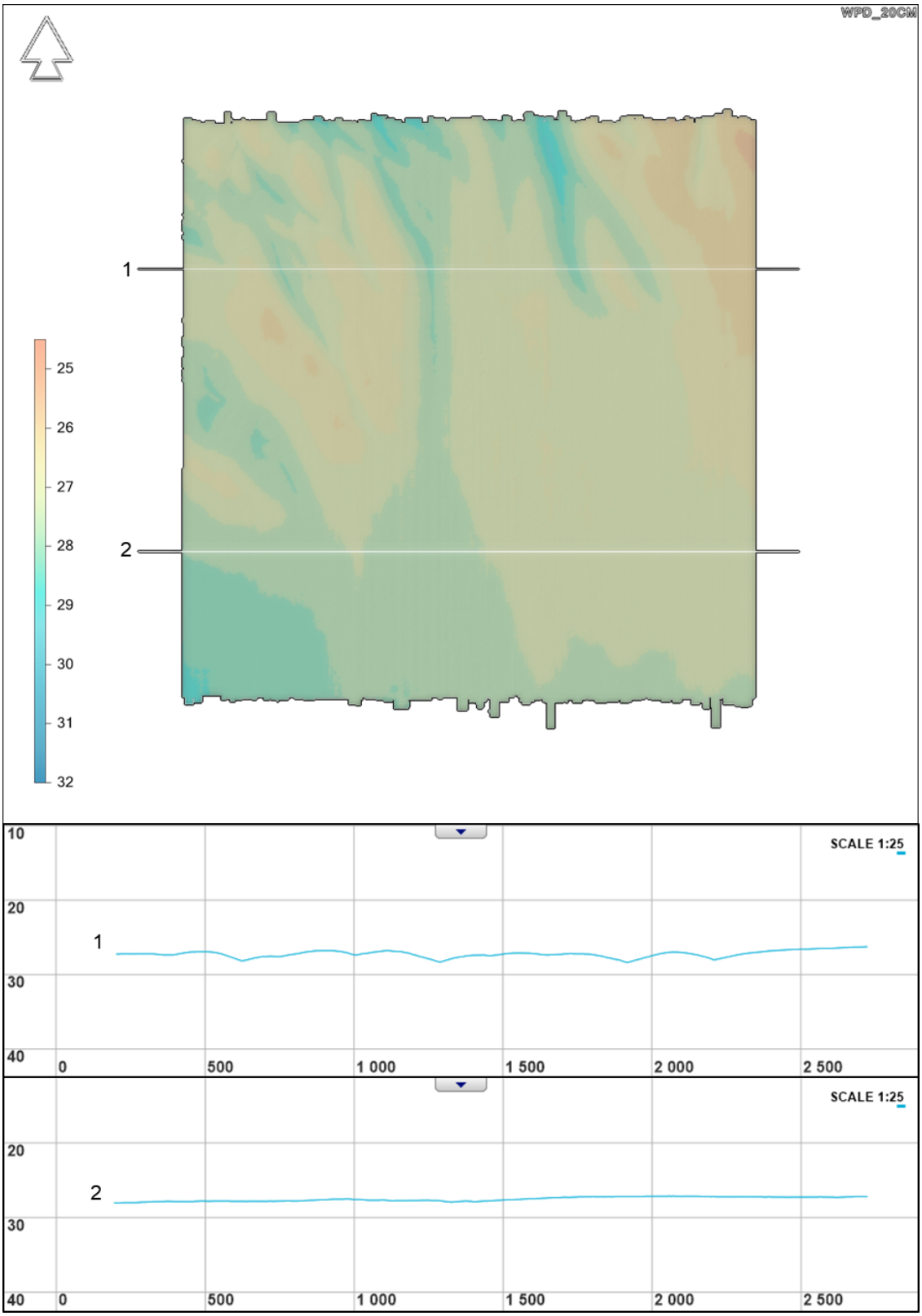


Figure 24 Overview of bathymetry data
The image shows the locations of Artificial Island project site Reporting Profiles (uppermost) and Profiles 1 and 2 across the project site, showing depth relative to DTU21 MSL. NaviModel depth convention positive down.

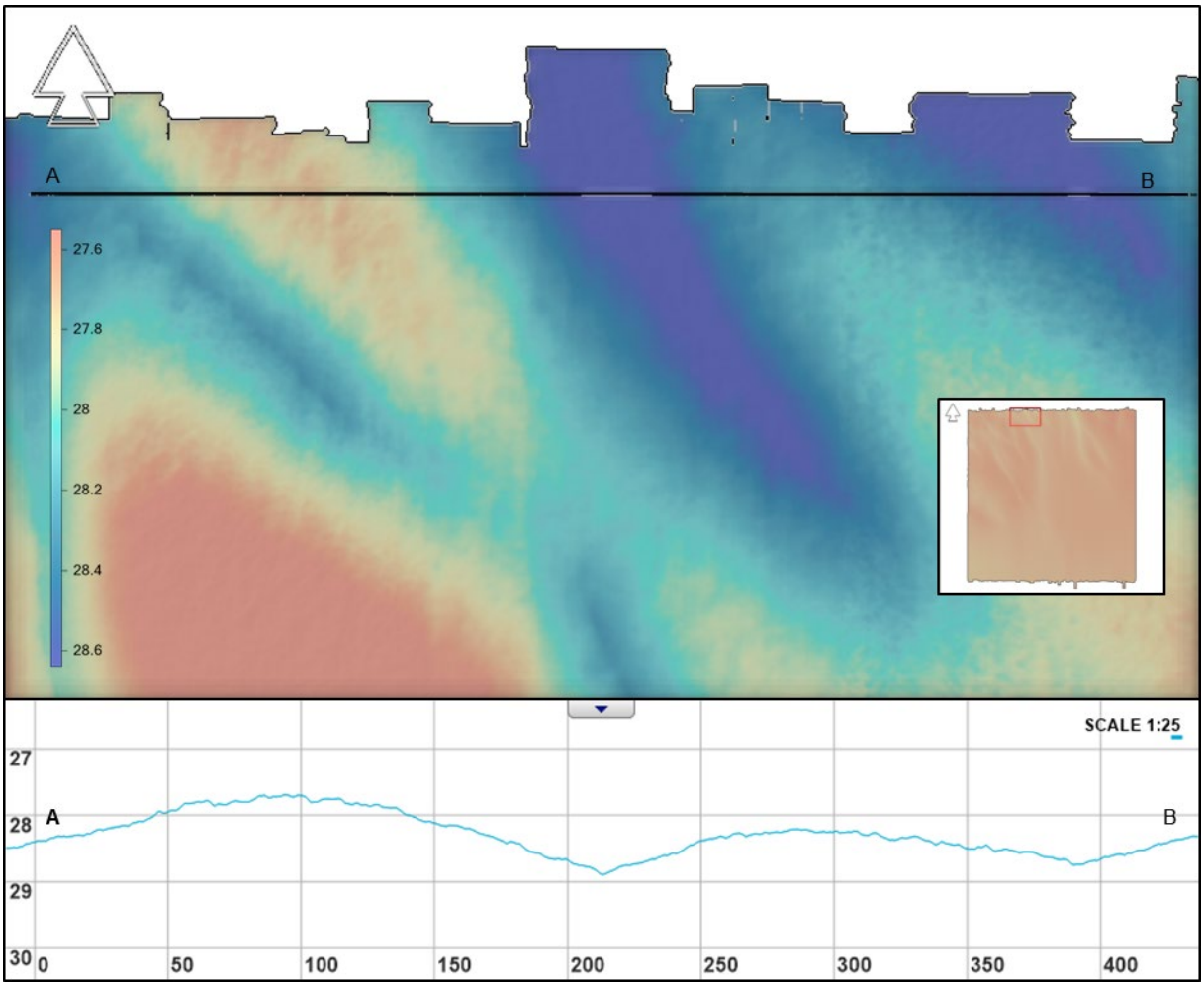


Figure 25 MBES image showing the maximum depth of the Artificial Island project site and surrounding seabed.
NaviModel depth convention is positive down, vertical exaggeration of profile is 25. Red box in inset map highlights figure location.

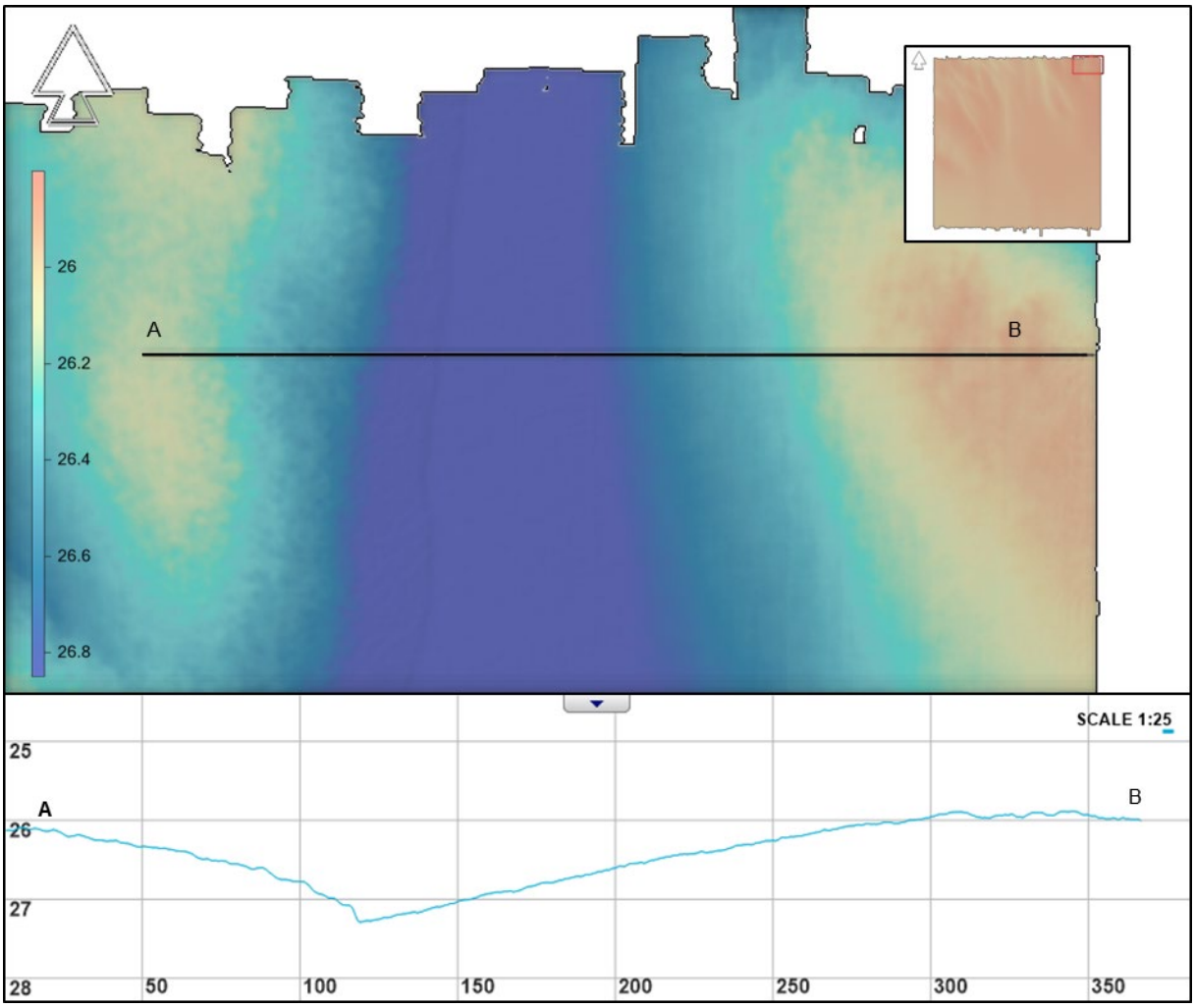


Figure 26 MBES Image showing 300m wide, 1.5m deep channel and shallowest depth of the Artificial Island project site.
NaviModel depth convention is positive down, vertical exaggeration of profile is 25. Red box in inset map highlights figure location.

7.2.3| SLOPE ANALYSIS

Slope angles were derived from the 1 m resolution bathymetry data in NaviModel. This data has been used as the basis for examining gradients across the site as it is less susceptible to picking up system noise as areas with high angles of slope.

Slope angles across the site are typically very gentle (<1°) and gentle (1° to 5°).

The steepest slopes within the project site were observed at the bottom of some of the channels in the northern half of the site. The maximum slope angle measured is 3.8° and the location of this is shown in Figure 28.

Slight artefacts within the bathymetry data are highlighted within the slope data. These result from pauses in survey operations caused by bad weather and the bedforms have shifted position during the intervening period. Where data is combined before and after the break in operations there may be a small offset in the surface which emphasises the mobile nature of the seabed.

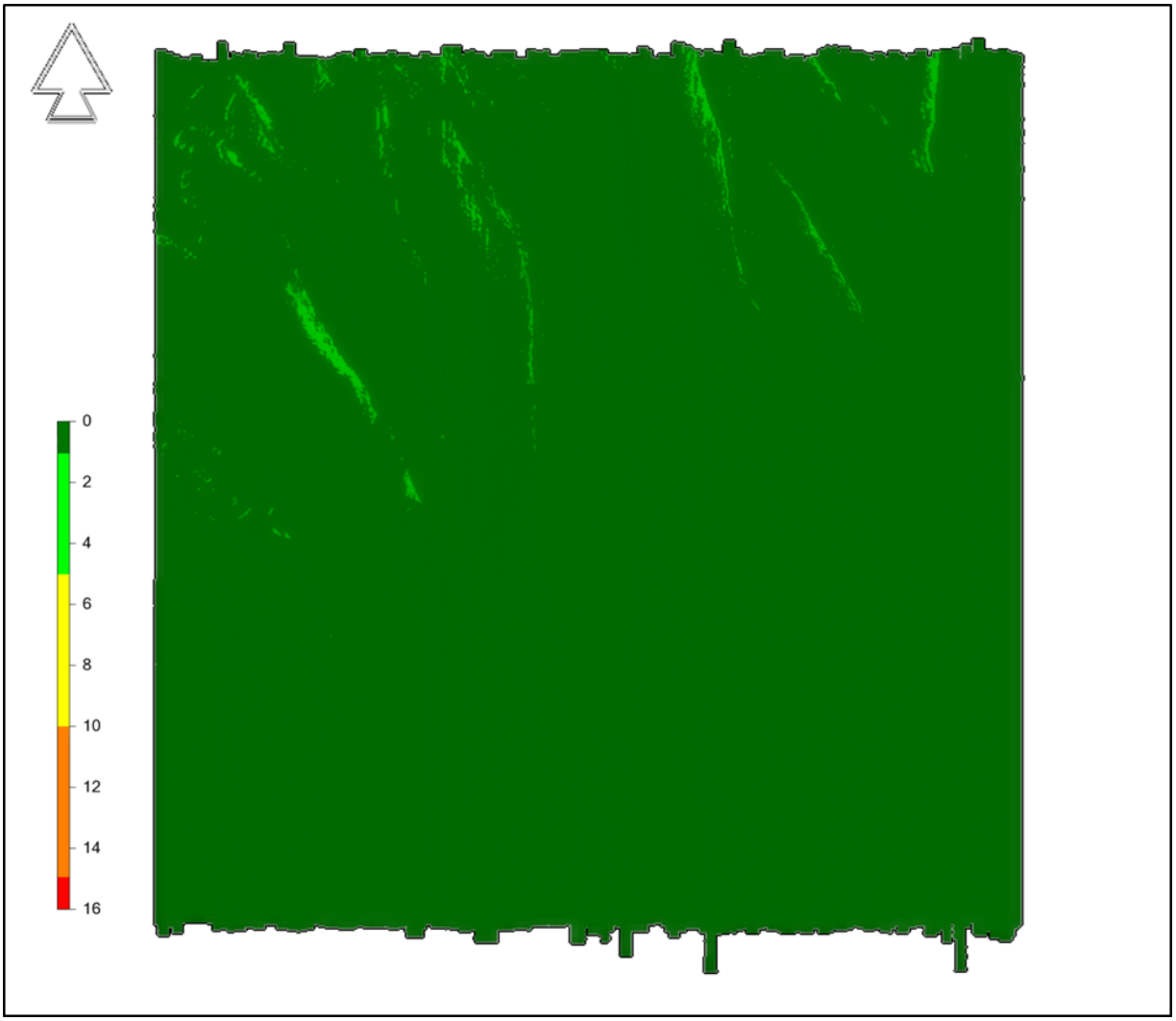


Figure 27 Slope across the Artificial Island project site.

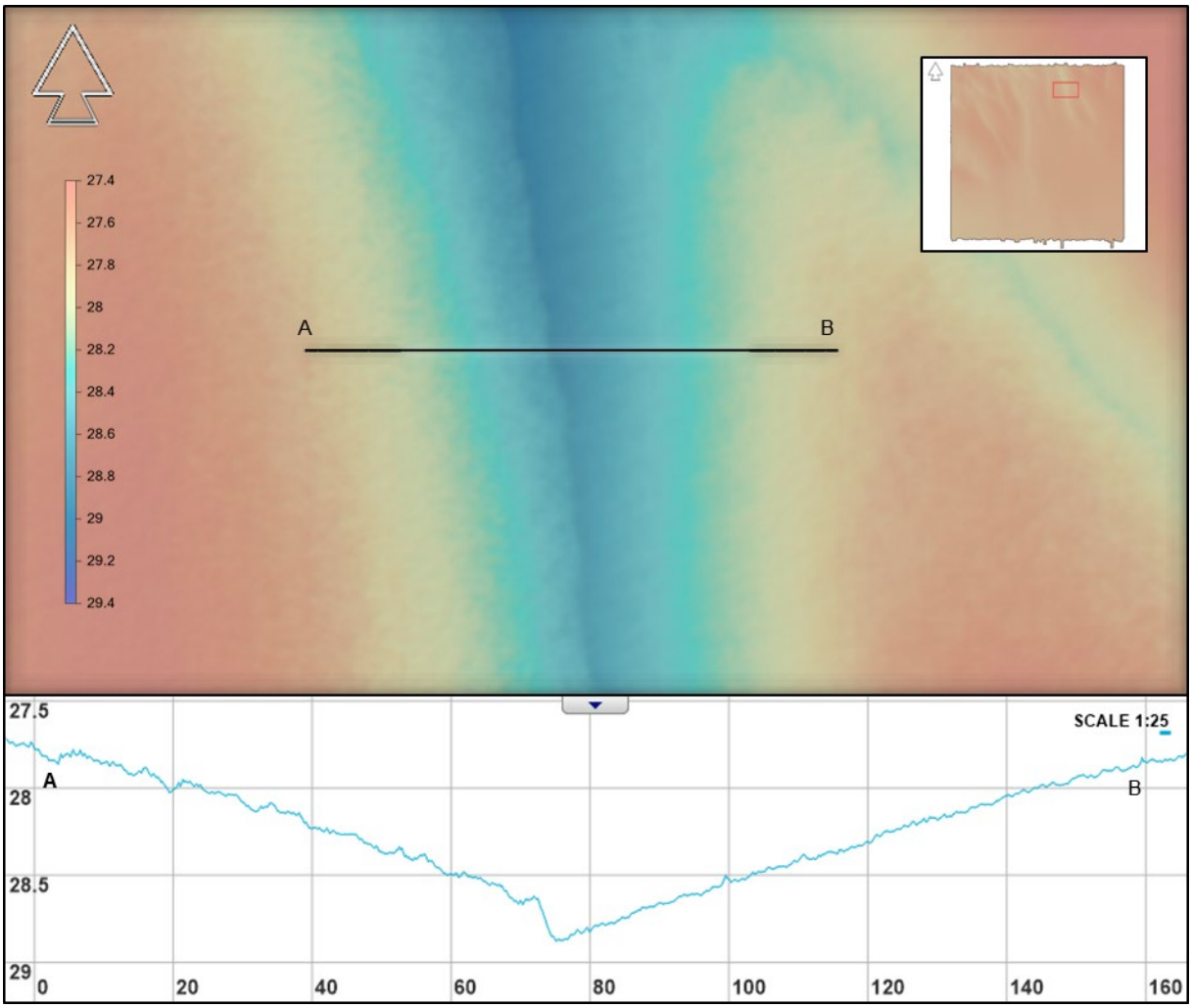


Figure 28 MBES data with profile across a channel.
The steepest slope shown above is 3.8° and classified as gentle. Vertical exaggeration of the profile is 25. Red box in inset map highlights figure location.

7.3| SURFICIAL GEOLOGY AND SEABED FEATURES

The seabed sediments in Artificial Island project site are dominated by GRAVEL and coarse SAND (medium to high acoustic reflectivity) and SAND (medium acoustic reflectivity).

Areas of ripples, indicative of mobile sediments, are present throughout the majority of the Artificial Island project site, whilst larger scale sand waves are visible in the northern half of the site. A limited area of Sandbars are present in the western part of the Artificial Island project site.

The ripples are most prominent in areas of GRAVEL and coarse SAND and generally exhibit a northeast-southwest orientation, with the dominating current regime (and hence direction of sediment transport) from northwest to southeast. Wavelengths are approximately 1 m, with heights of 0.1 m. Towards the eastern edge of the survey area, the ripple direction appears to change between adjacent lines, causing a mismatch (Figure 29). Whilst the heights and wavelength are similar, the direction appears to rotate 90 degrees, displaying a northwest-southeast orientation and hence dominating current regime of northeast to southwest. This appears on lines 2440 to 2490, suggesting that this change in orientation may have occurred whilst waiting on weather on 04 December. When the final line (2500) was acquired on 22 December 2021, the ripples appear to have returned to their original orientation.

An area of sand waves occupies the central and northern part of the Artificial Island area with wavelengths ranging between 50 m - 200 m with N-S/NNW-SSE orientation and direction of sediment roughly northeast to southwest.

Whilst trawl marks were common in this area for the initial MMT OWF survey, little evidence of trawling is evident in this area now. No boulder fields are visible in the Artificial Island project site.

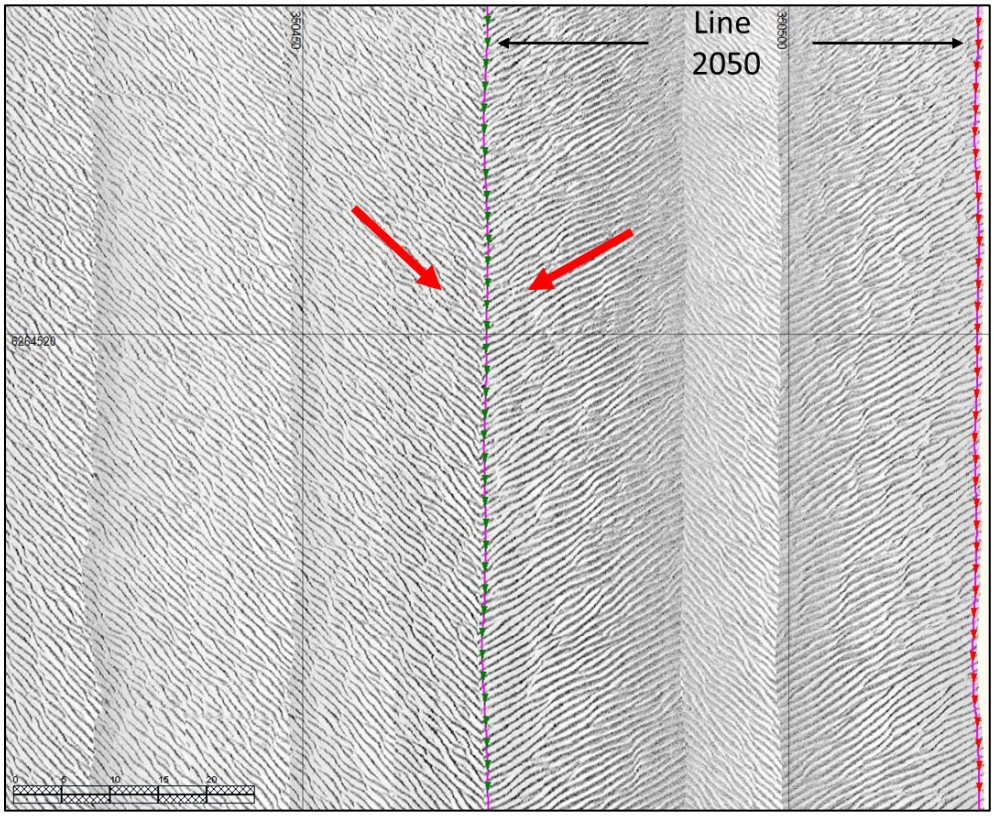


Figure 29 Change in ripple orientation observed in adjacent lines acquired on different days. The left side of the image acquired after waiting on weather and line 2050 acquired 2 weeks later.

7.4| CONTACTS AND ANOMALIES

In total, 472 individual seabed contacts and magnetic anomalies were detected in the Artificial Island project site. The distribution of these are shown in Figure 30.

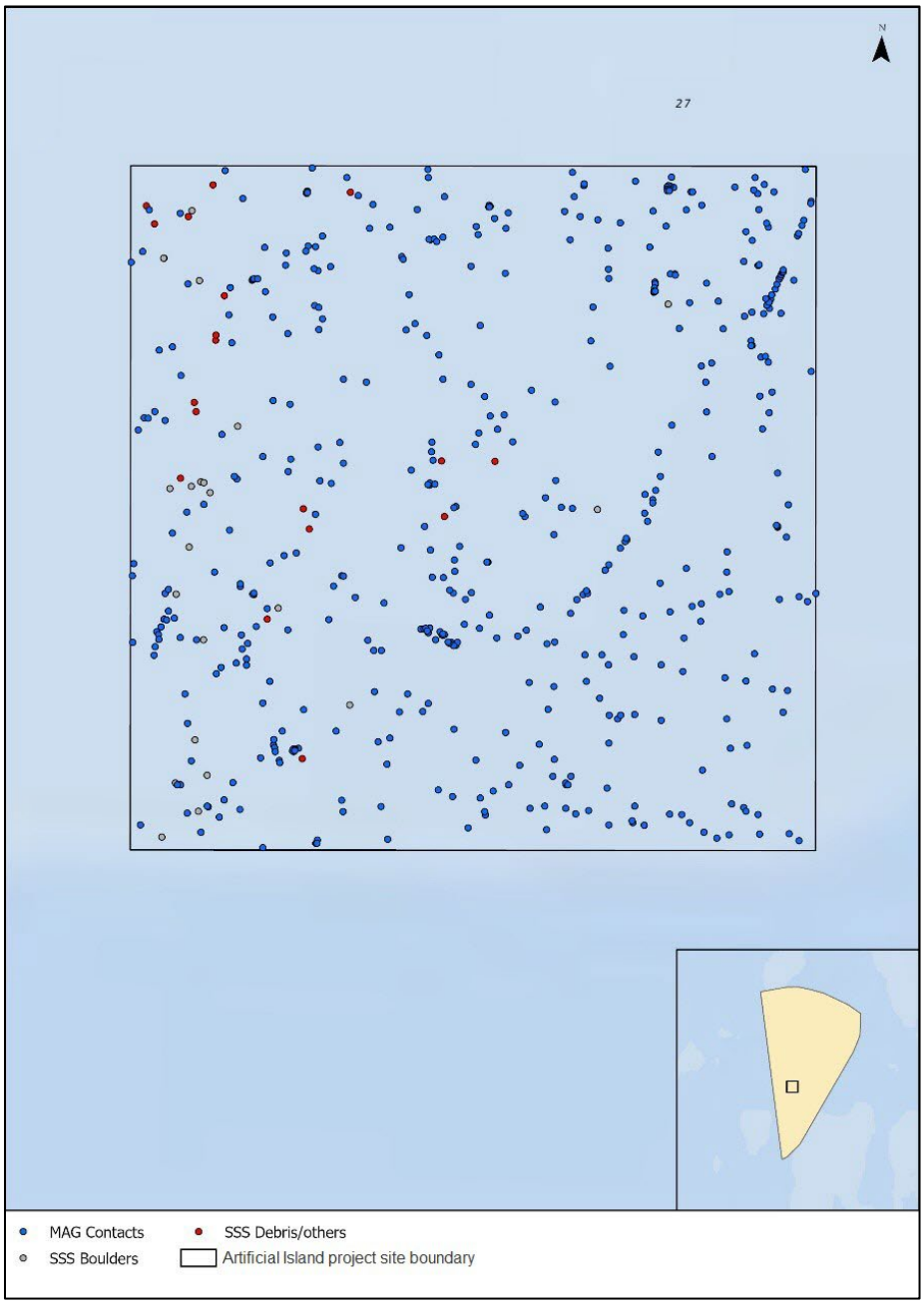


Figure 30 Distribution of contacts and anomalies within the Artificial Island project site.

These were detected with SSS, MBES and/or GRAD. Positional accuracy between contacts visible in the MBES and SSS data is good, less than 2 m.

A total of 41 contacts were identified using SSS and MBES. They were classified as: boulders >0.5m (22) and debris (19). Some debris observed has been interpreted as fishing gear which is mobile and appeared on various lines within the survey area, possibly corresponding to the same object which may have moved during stormy weather.

A total of 33 contacts were selected by RPS for UXO investigations at a later survey stage. Full details are provided in Appendix C|.

No boulder fields were observed within the Artificial Island project site, however a higher concentration of boulders can be seen to the west of the site.

No wrecks were observed within the Artificial Island project site.

SSS and MBES contacts are summarised in Table 20.

Table 20 Summary of SSS and MBES contacts.

CLASSIFICATION	NUMBER OF CONTACTS
Boulder	22
Debris	19
Total	**41**
Correlations with GRAD anomalies	1

A total of 431 magnetic anomalies above the threshold of 5 nT/ft Peak to Peak (PtoP) were detected in the gradiometer data within the Artificial Island project site.

A total of 289 anomalies, representing the 67.1% of magnetic contacts, ranged between 5 - 20 nT/ft PtoP. A summary of magnetic anomalies classified according to amplitude (nT/ft) are shown in Table 21 and Figure 31.

Table 21 Number and percentage of magnetic anomalies according to Amplitude (nT/ft).

AMPLITUDE (nT/ft)	NUMBER OF GRAD ANOMALIES	PERCENTAGE
5 - 10 (nT/ft)	173	40.2 %
10 - 20 (nT/ft)	116	26.9 %
20 - 30 (nT/ft)	47	10.9 %
30 - 40 (nT/ft)	18	4.2 %
40 - 50 (nT/ft)	15	3.5 %
50 - 60 (nT/ft)	8	1.9 %
60 - 70 (nT/ft)	4	0.9 %
70 - 80 (nT/ft)	13	3.0 %
80 - 90 (nT/ft)	4	0.9 %
90 - 100 (nT/ft)	4	0.9 %
> 100 (nT/ft)	29	6.7 %

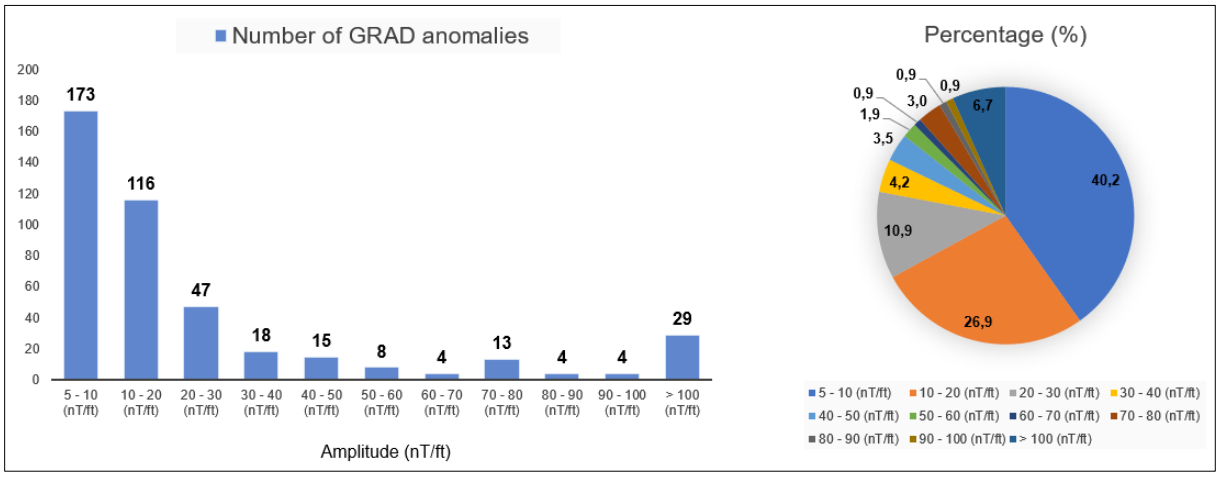


Figure 31 Histogram and pie chart illustrating the number and percentage of magnetic anomalies classified according to amplitude (nT/ft).

From the total of 431 magnetic contacts, 406 of these were interpreted as individual discrete anomalies, whilst 25 anomalies were interpreted to form 3 linear features. Magnetic target GRAD_0151 correlates with the position of detected SSS contact S_RE_WPD_0097.

Magnetic anomalies are summarised in Table 22.

Table 22 Summary of magnetic anomalies.

CLASSIFICATION	NUMBER OF ANOMALIES	LENGTH (m)
Discrete	406	-
Discrete forming linear - WPD_Linear_Feature_001	6	137m
Discrete forming linear - WPD_Linear_Feature_002	14	142m
Discrete forming linear - WPD_Linear_Feature_003	5	31m
Total	**431**	**-**
Correlations with SSS contacts	1	-

Full details of all anomalies are presented in Appendix B|.

8 | CONCLUSIONS

The results of the bathymetric survey found that the water depth overall changes moderately across Artificial Island project site. The depth range across the site is 4.81 m, varying between 25.81 m and 30.62 m.

In the northern part of the Artificial Island project site, the depth decreases slightly to the east. A series of channels are also seen in this area, being approximately 200-300 m wide and 1.5 m deep.

In the southern part of the area the depth varies very little and does not show a clear trend in one direction.

Slope angles across the site are typically very gentle (<1°) and gentle (1° to 5°).

The steepest slopes of approximately 4 degrees can be seen at the bottom of some of the channels in the northern half of the survey areas.

The seabed sediments in the Artificial Island project site are dominated by GRAVEL and coarse SAND and SAND.

Areas of ripples, indicative of mobile sediments, are present throughout the majority of the Artificial Island project site, whilst larger scale sand waves are visible in the northern half.

In total, 472 individual seabed contacts and magnetic anomalies were detected in Artificial Island area. A total of 41 contacts were identified using SSS and MBES. They were classified as: boulders >0.5m (22) and debris (19).

A total of 431 magnetic anomalies above the threshold of 5 nT/ft Peak to Peak (PtoP) were detected in the gradiometer data within the Artificial Island project site, 406 of these were interpreted as individual discrete anomalies, whilst 25 anomalies were interpreted to form 3 linear features.

Magnetic target GRAD_0151 correlates with the position of detected SSS contact S_RE_WPD_0097.

9 | RESERVATIONS AND RECOMMENDATIONS

The results in this report, both geological descriptions and contact selection, are based on interpretations of geophysical data obtained during the survey. It should be taken into account that there is a natural limitation in the accuracy of interpretation.

Not all existing contacts are detectable in the SSS data due to resolution, material, and orientation of the object.

10 | DATA INDEX

The deliverables listed in Table 23 accompany this report.

Table 23 Deliverables.

Item	Group	Data Product
1	Bathy data	Bathymetry - Un-gridded soundings, (X,Y,Z) values in ASCII format.
2	Bathy data	Bathymetry - Gridded soundings, 0.20m resolution, (X,Y,Z) values in ASCII format (tiled following the UTM grid).
3	Bathy data	Bathymetry - Gridded soundings, 0.20m resolution, geotiff stored in esri file geodatabase (untiled).
4	Bathy data	Bathymetry - Gridded soundings, 1.00m resolution, (X,Y,Z) values in ASCII format (tiled following the UTM grid).
5	Bathy data	Bathymetry - Gridded soundings, 1.00m resolution, geotiff stored in esri file geodatabase (untiled).
6	Bathy data_GIS	Bathymetry - Bathymetric contour curves with 50cm interval, as TSG object CONTOURS_LIN
7	Bathy data_GIS	Bathymetry - Vessel tracks, as TSG object TRACKS_LIN, indicate equipment carrier and equipment type in attributes.
8	Bathy data	SVP - sound velocity profiles as SVP comparison spreadsheet. Additional delivery.
9	Bathy data_GIS	MBES - Anomaly target list, as TSG object MBES_ANOMALY_PTS, anomaly characteristics provided in attributes.
10	SSS data	SSS - XTF-files with corrected navigation, High frequency.
11	SSS data	SSS - XTF-files with corrected navigation, Low frequency.
12	SSS data	SSS - Navigation files, CSV-format.
13	SSS data_GIS	SSS instrument tracks, as TSG object TRACKS_LIN, indicate equipment carrier and equipment type in attributes
14	SSS data, GIS	SSS Anomaly target list, as TSG object SSS_ANOMALY_PTS, anomaly characteristics provided in attributes.
15	SSS data	SonarWiz 7 project including the bottom tracked and suitably processed .XTF files and SSS and Magnetometer targets.
16	GRAD data	GRAD measurements, CSV-format.
17	GRAD data_GIS	GRAD instrument tracks, as TSG object TRACKS_LIN, indicate equipment carrier and equipment type in attributes.
18	GRAD data_GIS	GRAD Anomaly target list, as TSG object GRAD_ANOMALY_PTS, anomaly characteristics provided in attributes.
19	GRAD data	Gridded magnetic data as a relevant file (.flt).
20	GRAD data	Oasis Montaj Project.

Item	Group	Data Product
21	Interpreted Data_GIS	Man-Made-Objects, as TSG object MMO_PTS with the following characteristics in-cluded in the attributes– bathymetry, side scan sonar and magnetometer
22	Interpreted Data_GIS	Magnetic Linear Anomalies - Man-Made-Objects, as TSG object MMO_LIN, indicate interpreted source in the MMO-TYPE attribute.
23	Report	Geophysical UXO survey report (charts as enclosures)
24	Report	Operations report.

APPENDIX A| LIST OF PRODUCED CHARTS

APPENDIX B| CONTACT AND ANOMALY LIST

APPENDIX C| UXO MASTER TARGET LIST