Le réseau de transport d'électricité

MINISTÈRE DE LA TRANSITION ÉNERGÉTIQUE
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Document reference				*Issue information*	
Project	**Package**	**Issuer**	**Chrono**	**Revision**	**Status**
BRE_AO5	XT	TEC	62	0.1_A	A

Title	**BRE_XT_TEC_62_Results report - Geophysical-UXO survey - AO5 EC area Additional locations_0.1_A**			
Additional Metadata	**Discipline**	**Document Type**	**System**	**Activity**
	GPH-UXO			
	Contract	**Acceptance Class**	**Dossier**	**Alternative ref.**
	AO4-AO5			
	Confidentiality	**Print format**	**Subcontractor**	**Contractor ref.**
	Restricted	A4		

Date	Rev	Status	Reason for Revision	Issued by	Checked by	Approved by
27/09/2022	0.0	IFR	Issued	*JW*	*IMD*	*BMC*
09/12/2022	0.1	B	*Revision after client's comments*	*JW*	*IMD*	*BMC*
12/12/2022	0.1_A	A	*Final document (Status A)*	*JW*	*IMD*	*BMC*

Change log:

BRE_AO5 AREA **EXPORT CABLE – ADDITIONAL LOCATIONS** **GEOPHYSICAL AND UXO SURVEY**	BRE_XT_TEC_62_RESULTS REPORT – GEOPHYSICAL-UXO SURVEY – AO5 EC AREA ADDITIONAL LOCATIONS_0.1_A
	PROJECT No. 113401272
RESULTS REPORT	No. OF PAGES 54

0.1_A	*12/12/2022*	*Final document (Status A)*	*JW*	*IMD*	*BMC*	*FLO*	*BCO*
0.1	*09/12/2022*	*Revision after client's comments*	*JW*	*IMD*	*BMC*	*FLO*	*BCO*
0.0	*27/09/2022*	*Issued*	*JW*	*IMD*	*BMC*	*FLO*	*BCO*
REV	***DATE***	***DESCRIPTION***	***BY***	***CHK***	***ENG***	***PM***	***CLIENT***

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ABBREVIATIONS

AAA	Anti-Aircraft Artillery
ADCP	Acoustic Doppler Current Profiler
ALARP	As Low as Reasonable Practicable
cm	Centimetre
CoG	Center of Gravity

ABBREVIATIONS

CSAZ	Cesium Sensor Active Zone (Software)
DEMOB	Demobilisation
DGEC	Direction générale de l'énergie et du climat
DP	Dynamic Positioning
DPR	Daily production report
DTM	Digital Terrain Model
EC	Export Cable
EGN	Empirical Gain Normalization
FLO	Fisheries Liaison Officer
GEO	Geophysicist
GI	Borehole location
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS	Geodetic Reference System
h	Hour
IGRF	International Geomagnetic Reference Field
INERIS	L'Institut national de l'environnement industriel et des risques
INS	Inertial Navigation System
JSF	EdgeTech Sonar data file format
Kg	Kilogram
KHz	kilohertz
LAT	Low Astronomical Tide
LMA	Luftmine A
LMB	Luftmine B
LSA	Land Service Ammunition
m	Meters
M	Minutes

ABBREVIATIONS

MAG	Magnetometer
MBES	Multibeam echosounder
mm	Millimetre
MMO	Marine Mammals Observation
MOB	Mobilisation
MRU	Motion Reference Unit
nT	nanoTesla
OSS	Offshore substation
OWF	Offshore windfarm
PC	Party Chief
PEP	Project Execution Plan
POB	Personnel On Board
PPP	Precise Point Positioning
PPS	Pulse Per Second
PPSU	Pulse Power Supply Unit
pUXO	Possible unexploded ordnance
QA	Quality Assurance
QC	Quality Control
QGIS	Quantum GIS (Software)
QHSE	Quality, Health, Safety and Environment
REPCO	Report Coordinator
RGB	Red, green, blue
ROTV	Remotely operated towed vehicle
ROV	Remotely Operated Vehicle
RTE	Réseau de Transport d'Electricité
RTK	Real Time Kinematics
s	Second
SHOM	Service hydrographique et océanographique de la Marine

ABBREVIATIONS

SIT	Surrogate Item Trials
SRF	Ship's Reference Frame
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
SVS	Sound Velocity Sensor
TBC	To be confirmed
TXT	Standard text document file format
UHR	Ultra-High Resolution
USBL	Ultra-Short Base Line
UTC	Universal Time Coordinated or Coordinated Universal Time
UTM	Universal Transverse Mercator
UXO	Unexploded ordnance
VRF	Vertical Reference Frame
VSAT	Very Small Aperture Terminal
WGS84	World Geodetic System 1984
WT	Work time

1. INTRODUCTION

1.1. PROJECT OVERVIEW

Tecnoambiente carried out a geophysical survey over the proposed BRE_AO5 lot located in Morbihan, in the south of Brittany, close to western coast of Belle-Île-en-Mer and the southern coast of Île de Groix. The site is under consideration for a windfarm and offshore substation (Figure 1-1). This report summarises the survey operations and presents the results of the survey for the geotechnical locations at the experimental route area of the export cable corridor.

The dimensions of this area of interest are variable, being an area perpendicular to the coast with a length of 50 km, and with a corridor width of a minimum length of 1 km and a maximum of 4 km. According to the SHOM bathymetry, the site is located in water depths ranging from 0 to -100 m. The spatial surface this area represents is about 93.74 km^2 (Figure 1-2).

The objective of this report is to present the data obtained in the geophysical/UXO phase of the BRE_AO5 work area, focusing only on the additional locations carried out in the experimental route area at the Export Cable (EC).

The surveys of the UXO boxes within the export cable area of BRE_AO5 was carried out along the proposed route of the windfarm export cable from the offshore substation. A total of 5 UXO boxes were surveyed within the export cable corridor (EC). Figures 1-3, 1-4 and 1-5 indicate the locations of these boxes

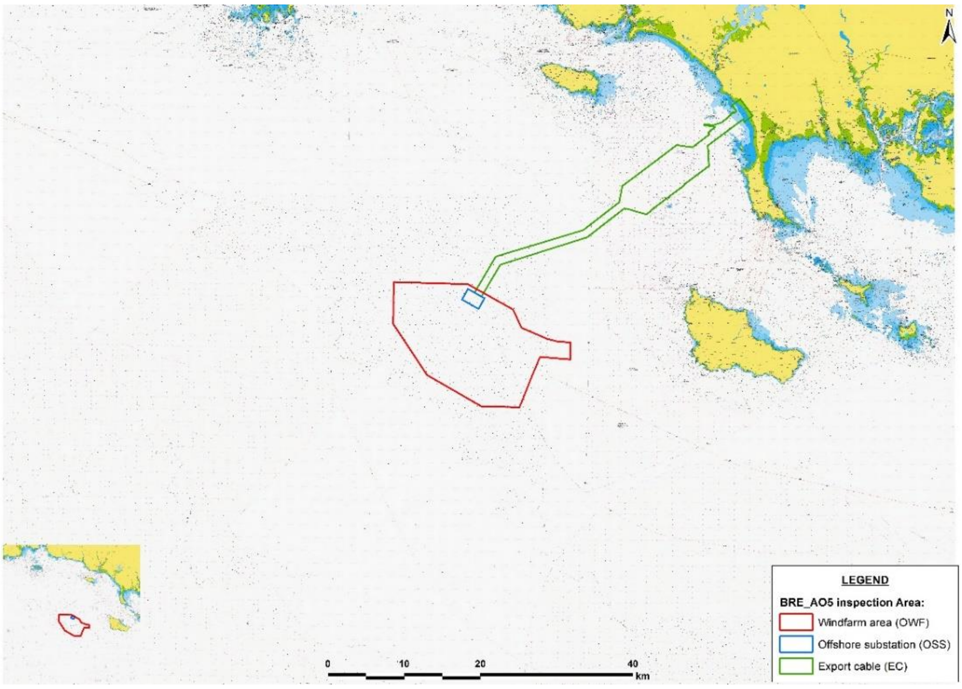


Figure 1-1: BRE_AO5 Survey area.

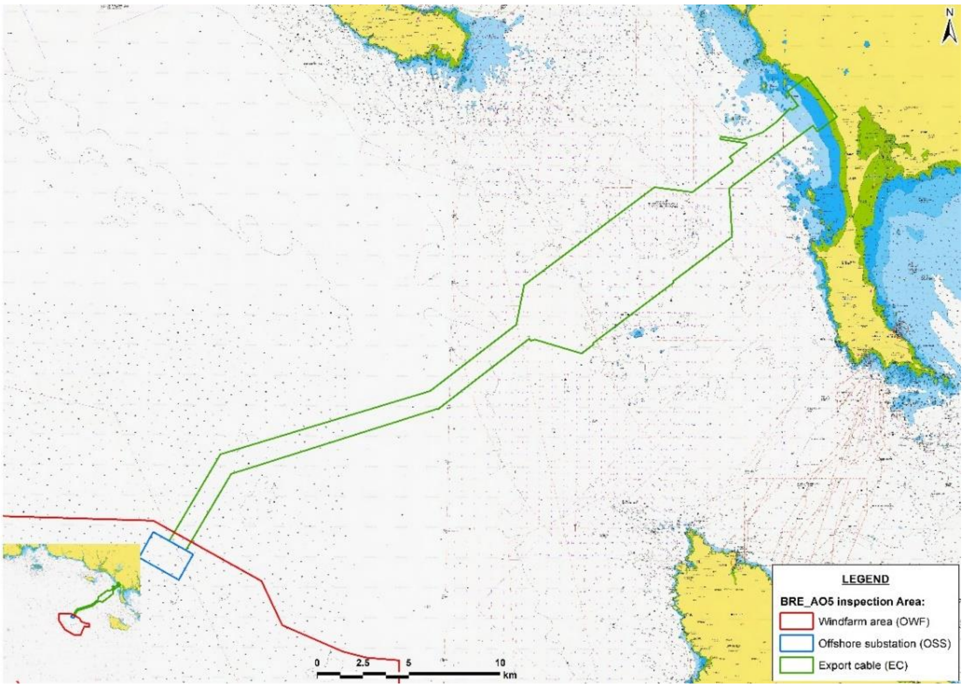


Figure 1-2: Windfarm area (OWF), Offshore Substation (OSS) and Export cable (EC) in the BRE_AO5 Survey area.

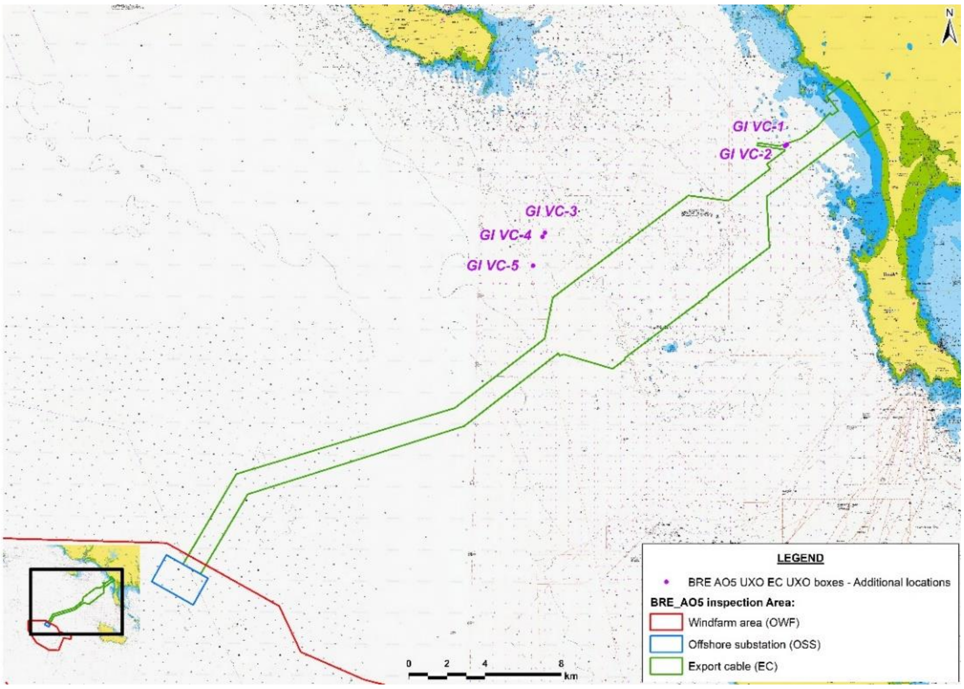


Figure 1-3: General view of the additional UXO boxes locations along the BRE_AO5 Export cable area.

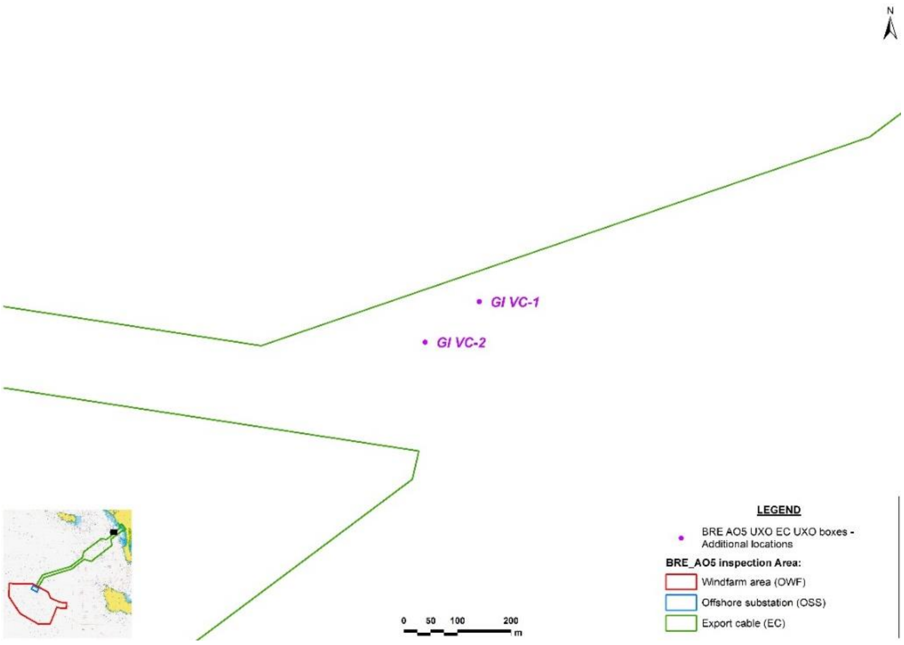


Figure 1-4: UXO boxes location and distribution at the BRE_AO5 Export cable area – Additional locations 1.

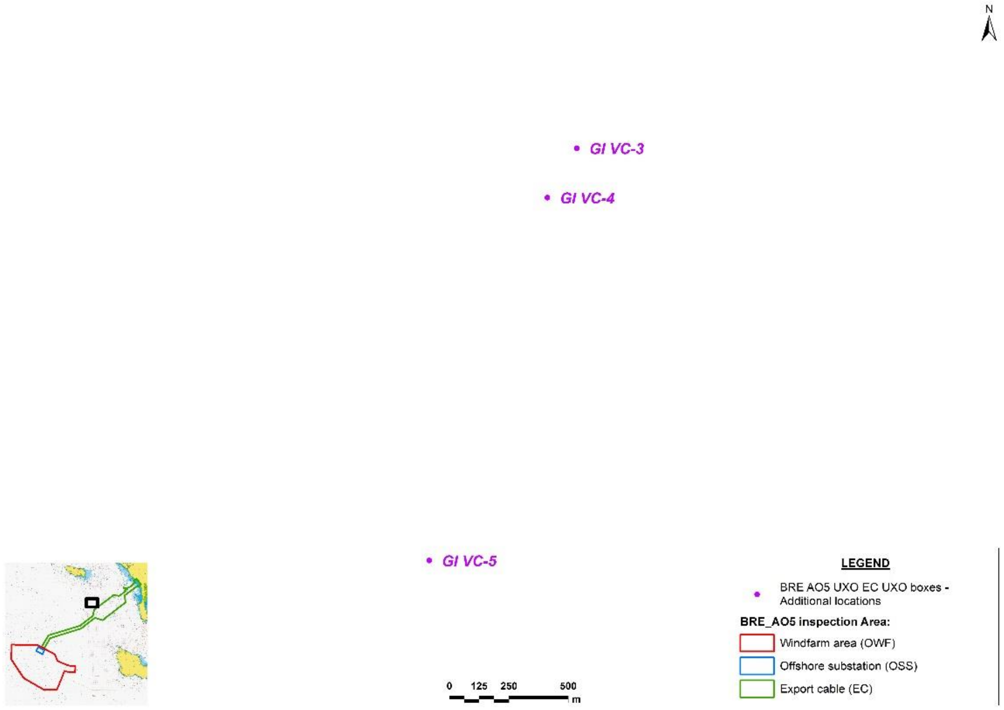


Figure 1-5: UXO boxes location and distribution at the BRE_AO5 Export cable area – Additional locations 2.

Each of the UXO boxes comprises an area of approximately 30m x 30m (900 square meters), with a run in / run out length of 400 metres utilised to optimise the acquisition of the magnetometer data. Figure 1-6 provides an example of the UXO survey boxes and Figure 1-7 illustrates the survey line plan layout at 6 m separation.

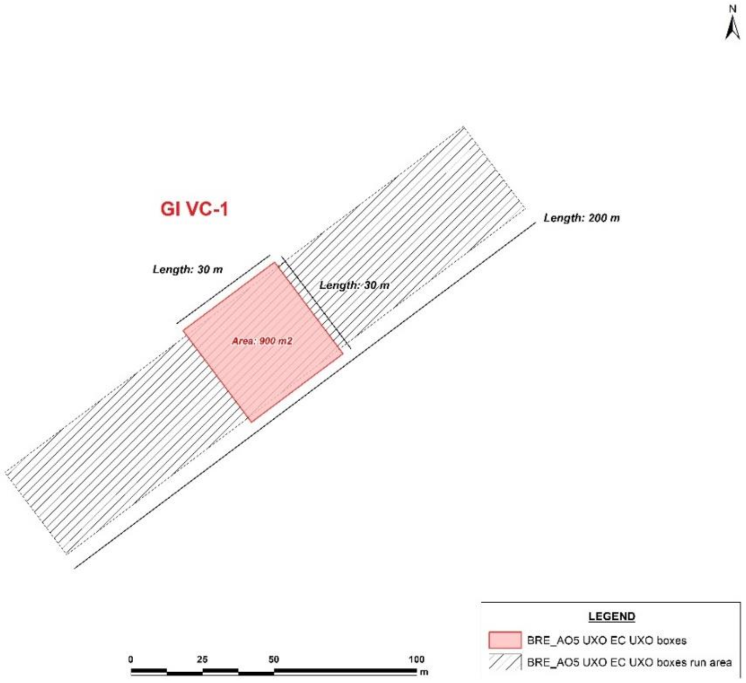


Figure 1-6: Example of UXO boxes dimensions at the BRE_AO5 Export Cable area (EC).

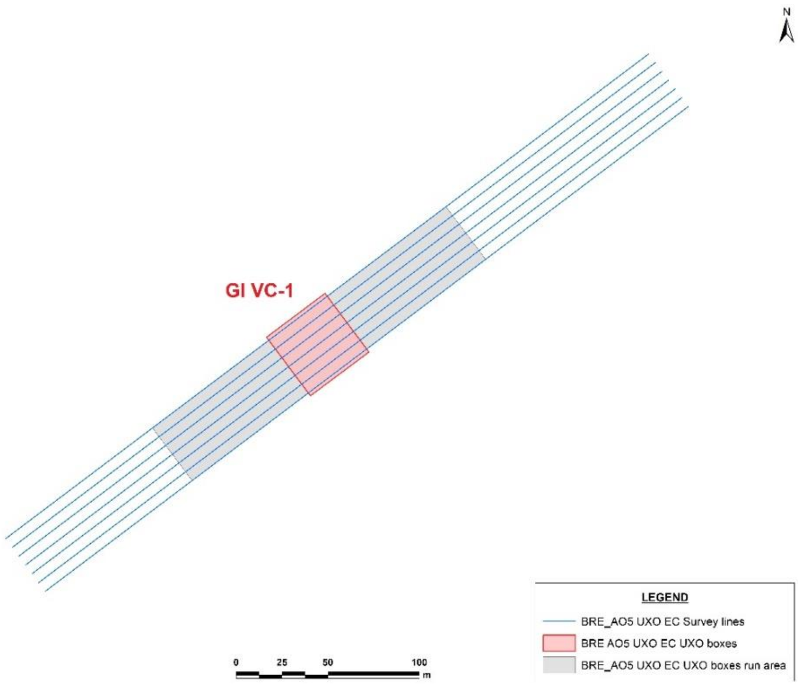


Figure 1-7: Example of UXO boxes survey line plan at the BRE_AO5 Export Cable area (EC).

1.2. SCOPE OF WORKS

The objective of the site survey was to perform a geophysical and UXO survey over the proposed UXO GI points (Borehole locations) on the EC route area, comprising MBES, SSS and MAG datasets. The purpose of this was to:

- To define the final location of the GI points on the proposed box
- To detect magnetometer anomalies, and side scan and MBES contacts
- To review proposed borehole locations for geohazards

The main purpose of the study was to provide an ALARP certificate for intrusive geotechnical sampling over the BRE_AO5 EC area.

1.3. GEODETIC PARAMETERS

1.3.1. Survey datum

These parameters are detailed below.

Table 1: Datum parameters table

DATUM	
Survey Datum:	WGS 84
Spheroid	GRS 1980
Semi-Major Axis (a)	6,378,137.000
Semi-Minor Axis (b)	6,356,752.31424
Inverse Flattening (1/f)	1/298.257223563

Table 2: Projection parameters table.

PROJECTION	
Projection	UTM
False Easting	500000
False Northing	0
Latitude of Origin	0º00'00.000000''
Central Meridian	3º00'00.000000''
UTM Zone	30 N
Scale Factor on CM	0.9996
Units:	Meters

1.3.2. Vertical datum

Vertical datum used by the Qinsy software is LAT Bathyelli v2 geoid published by the SHOM in December 2013. The Bathyelli LAT (SHOM 2013) is a surface based on the GRS 1980 spheroid. The same geoid model was used for the AO5 area during the 2021 survey.

Lorient (Arsenal) is located in the O.L.K3-12 station, which is the reference station of the Bathyelli geoid model which belongs to the levelling network of the French IGN. In order to transform the datasets to LAT it would be necessary to apply an offset to the Bathyelli hydrographic zero, for O.L.K3-12 location in Lorient this offset is 10 cm.

1.3.3. Tidal reduction

To carry out the survey as accurately as possible, Tecnoambiente utilised MarineStar PPP corrections via satellite signal. When using an accurate GNSS system (RTK correction), the tidal corrections are carried out in real-time through Qinsy computations, as shown in Figure 1-12.

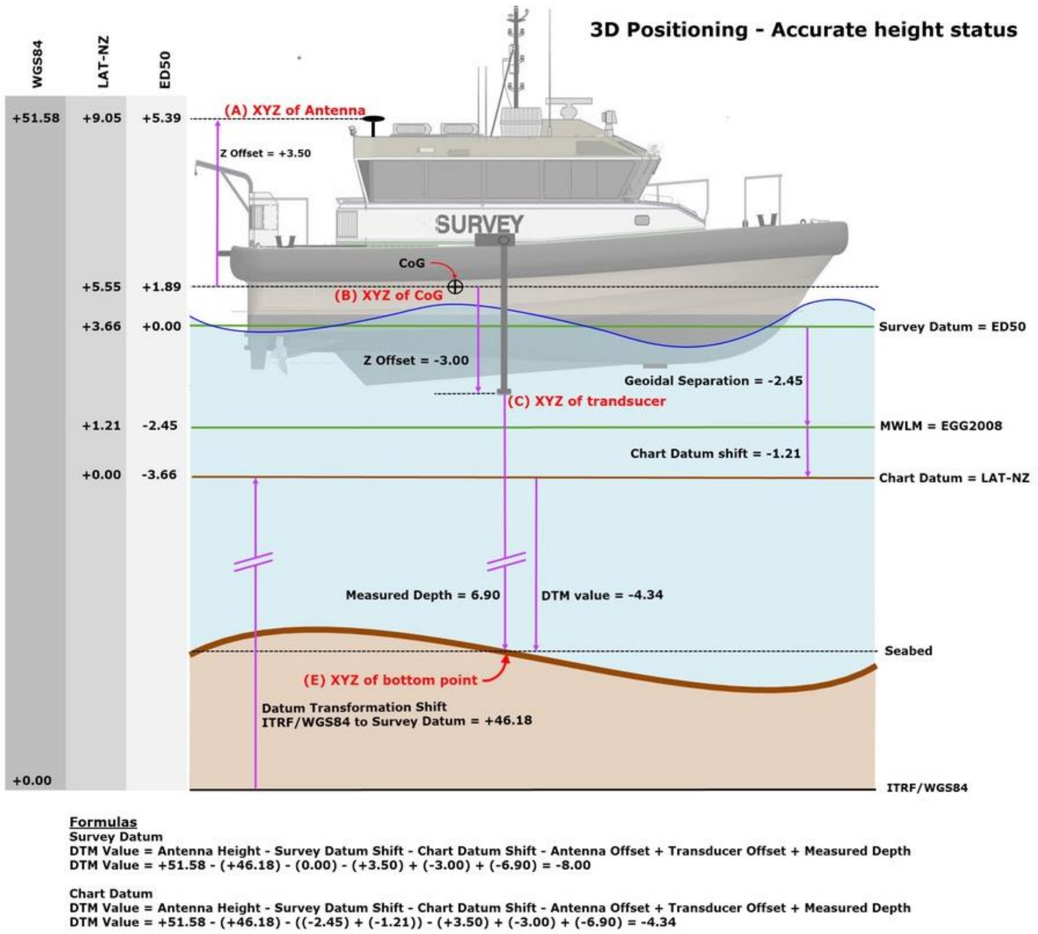


Figure 1-8: Qinsy method for accurate height calculation.

The separation between the WGS84 ellipsoid (GRS80) and the vertical datum is a model called Bathyelli v2. This comprises a set of surfaces, each of which defines the separation of one vertical datum from the WGS84 ellipsoid. If corrections drop out, they can be applied during post processing.

2. GEOPHYSICAL DATASET

2.1. QA/QC CHECK

The processed values obtained from the onboard processing team during the survey are checked before the ALARP certificate phase. This quality control check of the input data validates the quality of the processing method. Here is the QA/QC for the measurements made:

- QC0: check of the geophysical value
- QC1: Check of the sensor position
- QC2: Check of the altitude of sensor and dynamic coverage
- QC3: Check of the noise
- QC4: Check of the speed and sampling frequency

2.2. SIT SURVEY

The calibration test (SIT) was carried out using ferrous surrogates, weighing 10 kg, 25 kg and 50 kg, in order to be consistent with historical data (Ref 01), considering the lowest detectable magnetic signal and the largest ammunition size. This test makes it possible to estimate the precision of the survey positioning, the amplitude of the signal to be sought and the detectability distance.

After mapping an area to make sure it was clear of potential targets, the surrogates were immerged. Several altitudes were utilized to undertake the calibration test above the surrogate: 3 m, 5 m, and 6 m (Figure 2-1). Each of the three surrogates were detectable at all altitudes (Ref 05); however, the amplitude of the signal at the 6 m altitude for the 10kg weight was found to be only 0.8 nT/m, well under the used cut-off of 2 nT/m.

From these SIT data we were able to estimate:

- The uncertainty of the survey at 2.5 m average (Table 3, 4 and 5)
- A detection range of 6 m for a ferrous mass superior to 25 kg
- A detection range of 4 m for a ferrous mass of about 10 kg

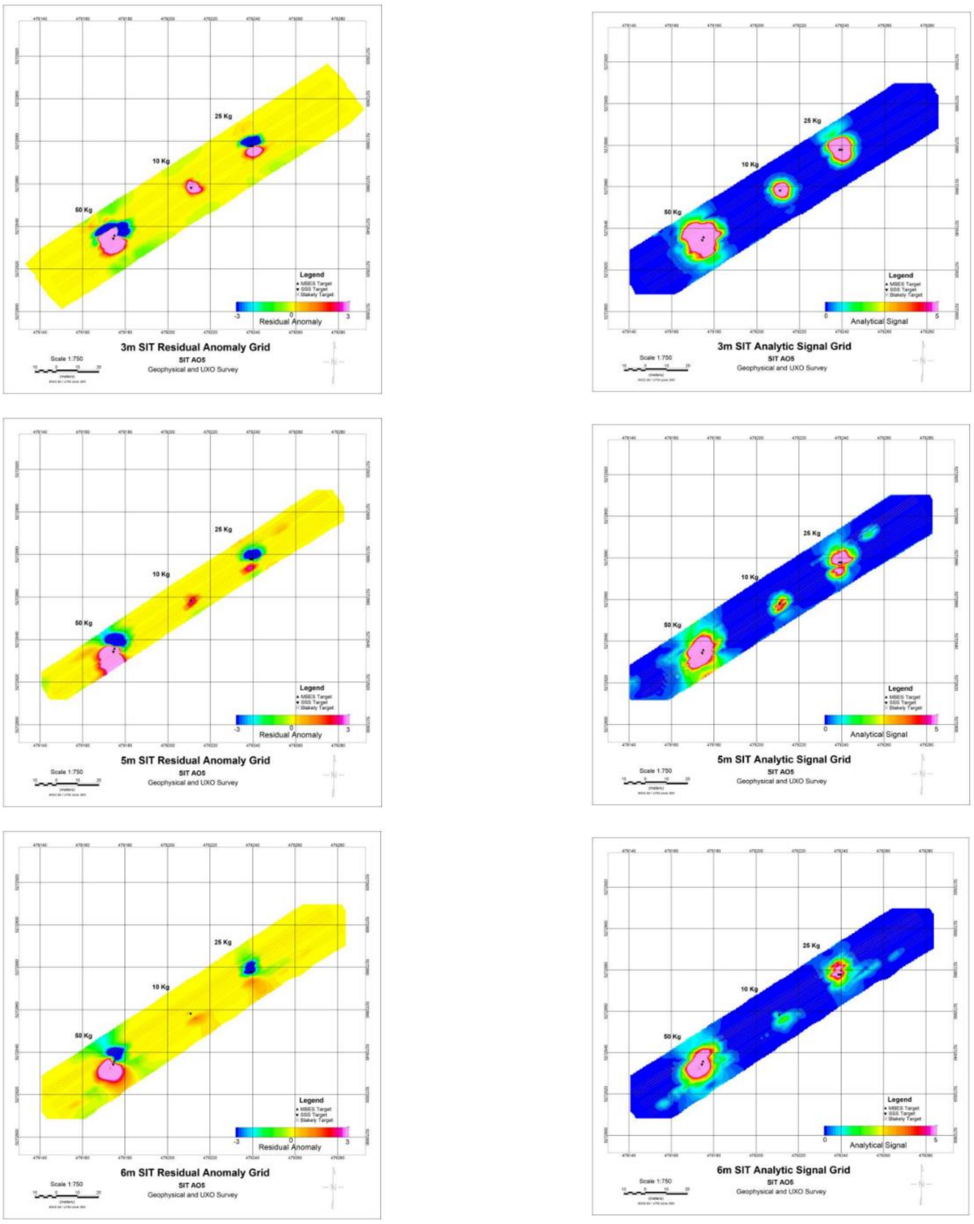


Figure 2-1: Result from the SIT, Residual field, and Analytic signal at 3m and 6 m altitude.

Table 3: Position verification of 10 Kg item.

	Source	Easting (m)	Northing (m)	Δ Easting (m)	Δ Northing (m)	Total Deviation (m)
10 Kg Surrogate Item	SSS position	479210.87	5272858.14	N/A	N/A	N/A
	Blakely test @ 3m	479211.5	5272859.0	0.63	0.87	1.08m
	Blakely test @ 5.0m	479212.50	5272857.50	1.64	0.64	1.72
	Blakely test @ 6.0m	479213.00	5272856.00	2.13	2.14	3.01

Table 4: Position verification of 25 Kg item.

	Source	Easting (m)	Northing (m)	Δ Easting (m)	Δ Northing (m)	Total Deviation (m)
25 Kg Surrogate Item	SSS position	479239.83	5272877.72	N/A	N/A	N/A
	Blakely test @ 3.0m	479239.5	5272879.00	-0.33	1.28	1.32
	Blakely test @ 5.0m	479239.00	5272880.00	0.81	2.27	2.41
	Blakely test @ 6.0m	479238.00	5272878.50	1.83	0.76	1.99

Table 5: Position verification of 72 Kg item.

	Source	Easting (m)	Northing (m)	Δ Easting (m)	Δ Northing (m)	Total Deviation (m)
50 Kg Surrogate Item	SSS position	479174.40	5272834.28	N/A	N/A	N/A
	Blakely test @ 3.0m	479174.00	5272835.00	0.40	0.26	0.47
	Blakely test @ 5.0m	479174.50	5515635.50	0.1	0.72	0.81
	Blakely test @ 6.0m	479173.00	5272832.50	1.40	1.78	2.24

3. DATA ACQUISITION

3.1. SURVEY ACQUISITION SCHEME

To ensure full coverage of the UXO boxes within the study area of the export cable area, data acquisition during the survey was carried out as follows:

Table 6: UXO data acquisition scheme information

Methodology	Survey lines	Range
Multibeam echosounder system (MBES)	6 m	75 m
Side Scan Sonar (SSS)		100 m
Gradiometer (MAG)		8 m

The following figure shows the basic data acquisition scheme for the UXO phase

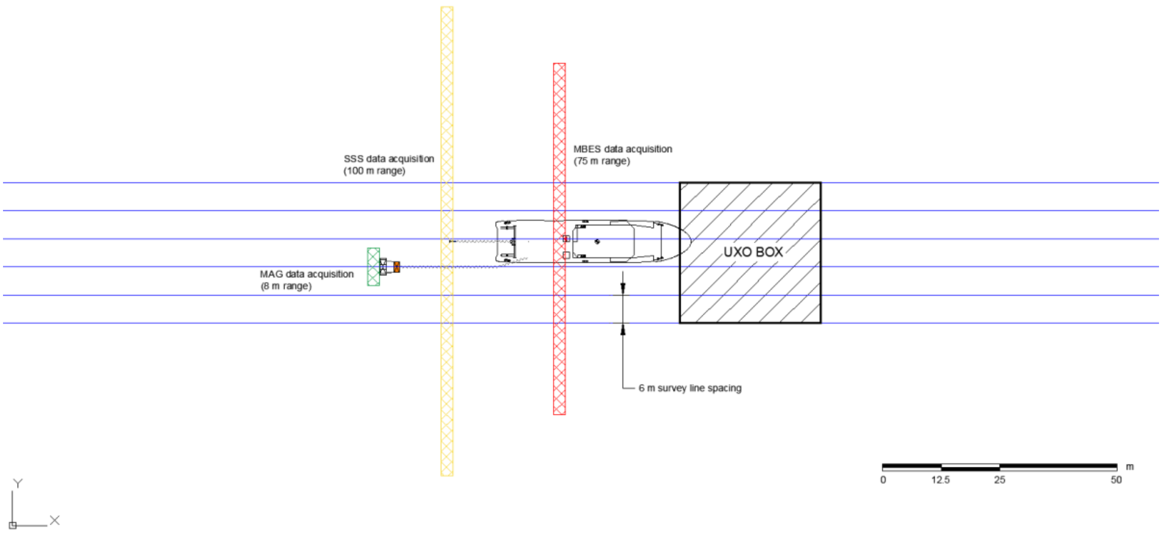


Figure 3-1: UXO data acquisition scheme.

The data acquisition of the three methodologies is performed not only in the target area, but the acquisition is extended to adjacent areas. This is done for two main reasons: on one hand, the line plan covers a larger area as a run-in/run-out zone to stabilize the sensors on the seabed; and on the other hand, to cover a larger area than the target area and thus obtain more data in case the UXO box has to be moved to a quieter area if necessary.

3.2. MULTIBEAM ECHOSOUNDER

The objective of this phase of data acquisition is the detection of possible MBES targets lying on the seabed. Due to the coverage requirements of gradiometer data acquisition, this required total coverage of the seabed within each of the UXO boxes, and hence a survey line spacing of 6 metres was utilised.

During data acquisition, the vessel's master must follow previously programmed routes along the project lines, shown on the computer screen (Helmsmann indicator). If the actual course deviates from the programmed route by more than a specified amount, or when there is a problem with a peripheral, such as a loss of GPS corrections, the vessel master is warned by the use of visual and audible alarms.

While the master follows the navigation lines, the acquisition module of the hydrography program captures all of the position data sent by the GPS, the raw values of the movement reference unit (Hydrins III) and the heading of the equipment; to correct the location of the soundings sent by the multibeam echosounder. This correction is made for each transmission pulse in real-time.

Parallel to data entry, data acquired by the equipment and peripherals are synchronized. This process is carried out by Qinsy and is complemented by the input of the time and the pulse per second (PPS) provided by the MRU, so that all data is time synchronised.

The guidelines followed by Tecnoambiente during the surveying for MBES data acquisition are as follows:

- IT-CM-36 SVP Deployment Recovery, Rev1.0
- IT-CM-01. Guidelines for Hydrography Project management, 5
- IT-CM-04. Bathymetric survey, 1
- IT-CM-14 Survey Basics Guidance, 1
- IT-CM-15 Online Surveying procedure, 3

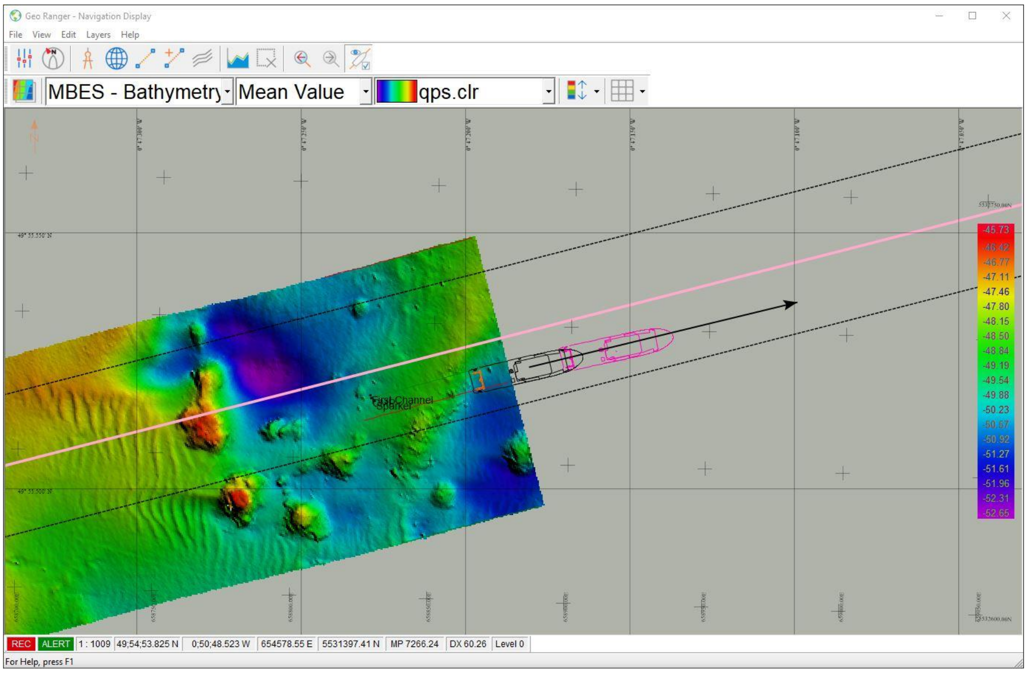


Figure 3-2: MBES bathymetry data acquisition with the Qinsy software.

During data acquisition, limits were applied to reduce soundings noise. These limits in the recording correspond to static gates of the equipment software that reduce the acquired registers noise, in accordance with statistical calculations of vertical uncertainty.

During the processing phase of acquired data, the lines on the screen are processed, in order to manually correct any noise that appears in the records. Noise is produced by multiple factors such as, multipath in position, air bubbles, cetaceans, motor interference from the vessel, etc., in the digital register of soundings. To make certain of the complete removal of any noise in the soundings, spike filters and spline filters were applied.

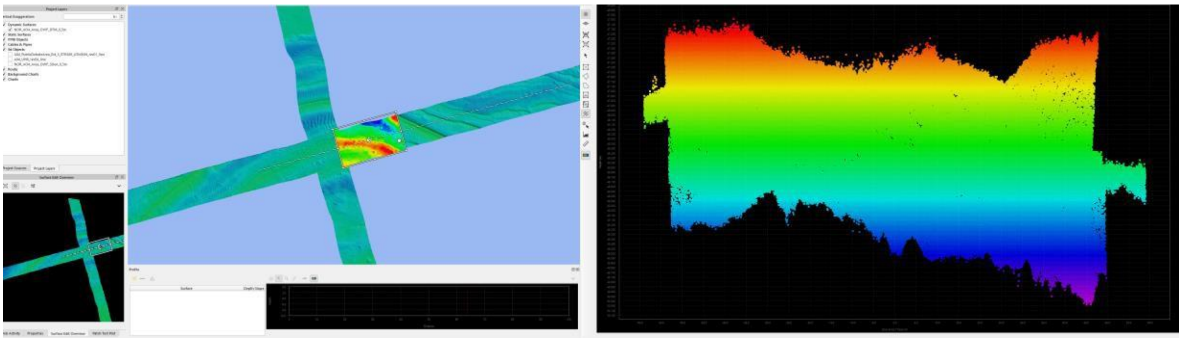


Figure 3-3: Processing screen of MBES bathymetry data with the Qimera software.

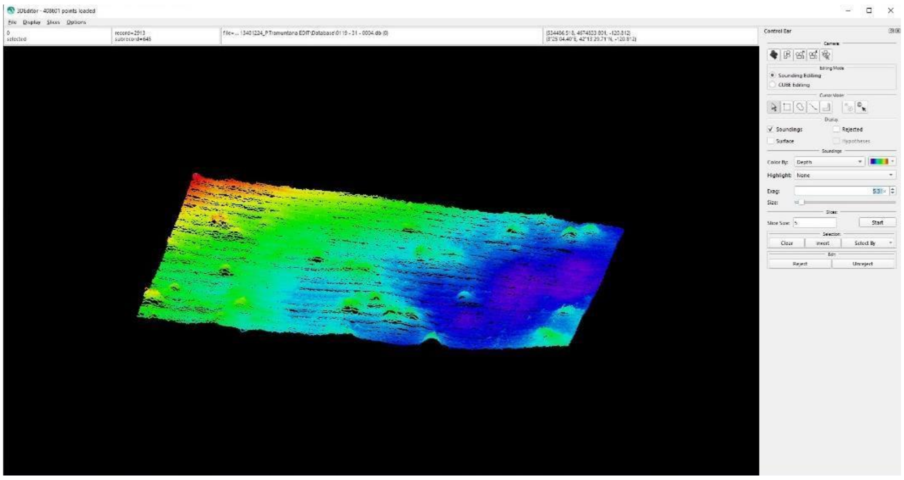


Figure 3-4: 3D image of the MBES bathymetry processing.

Once any possible existing errors in the records were deleted, a digital model of the terrain with 0.25 x 0.25 m grid size was produced, with a minimum cell size to obtain the maximum resolution of the seabed.

Digital terrain models (DTM) are created in Qimera. Once done, the DTM's are exported as 32bits RGB Geotiff, for each of the UXO boxes.

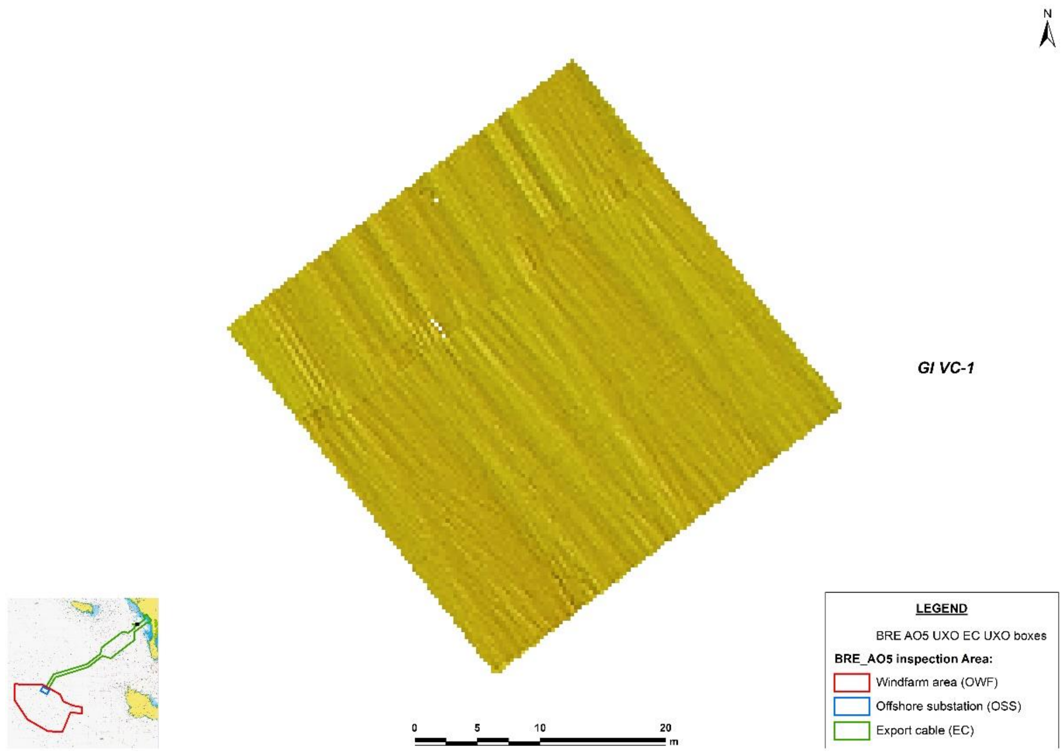


Figure 3-5: Example of the bathymetric data for GI VC-5.

3.3. SIDE SCAN SONAR – UXO SURVEY

The objective of this phase of data acquisition is the detection of possible sonar targets lying on the seabed. Due to the coverage requirements of gradiometer data acquisition, this required total coverage of the seabed within each of the UXO boxes, and hence a survey line spacing of 6 metres was utilised.

A side scan sonar system comprises a processing unit connected through a cable to a wet unit that transmits and receives acoustic energy. Side scan sonar can determine seabed morphology and configuration by means of acoustic signals. It can also determine its composition, identifying different seabed strata as hard (rocky or consolidated), soft or sedimentary, as well as identifying areas of seagrass.

Side scan sonar systems can work in different frequency ranges: systems working in high frequencies, (between 500 kHz and 900kHz) offer higher resolution but lower ranges, with systems working in low frequencies (100 kHz), offer lower resolution but higher ranges. For this survey, a frequency of 900KHz was utilised. The reflection of the signal coming from the seabed is detected by the same transducers, amplified, and transmitted to the control unit, and recorded and displayed on the computer screen, providing an acoustic map. With this data, it is possible to identify different seabed morphologies, together with the visualization of any seabed objects.

When the vessel is underway, the winch operator can start deploying cable until the fish gets to the desired working depth of about 6 m above the seabed.

The guidelines followed by Tecnoambiente during the surveying for SSS data acquisition are:

- IT-CM-01. SBL-SSS,1
- IT-CM-21. SSS Launch and Recovery, 0
- IT-CM-13. Geophysical Data Acquisition. General Procedure, 2
- IT-CM-14. Survey Basics Guidance, 0
- IT-CM-15. Online Surveying procedure, 3
- IT-CM-18. USBL Pole Deployment, 1

Once the SSS data were acquired and then exported into JSF format, the files are imported into the SonarWiz 7 software. Channels 3 and 4 were used for recording the high frequency data.

After data importation into the SonarWiz 7 software, an initial navigation correction was made for each imported file, applying smoothing filters to avoid errors in the heading of the tow fish. The track position was smoothed using a mean value of 300 pings.

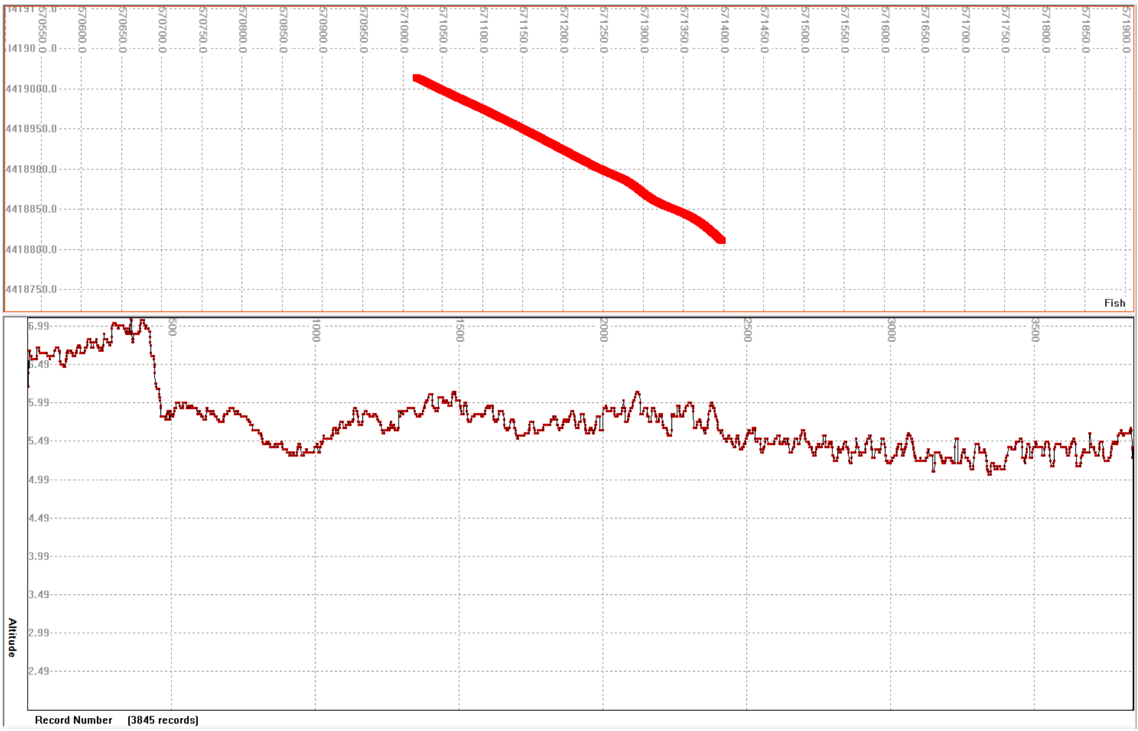


Figure 3-6: Navigation editor in SonarWiz 7.

After the aforementioned corrections were implemented, the water column for each file was eliminated, by applying the bottom-tracking acquired during the survey, as shown in Figure 3-7. If bottom-tracking of the tow fish failed during the survey, it was done automatically by applying filters or by drawing the seabed manually during post-processing. This enables slant range corrections for the digital data to be as accurate as possible.

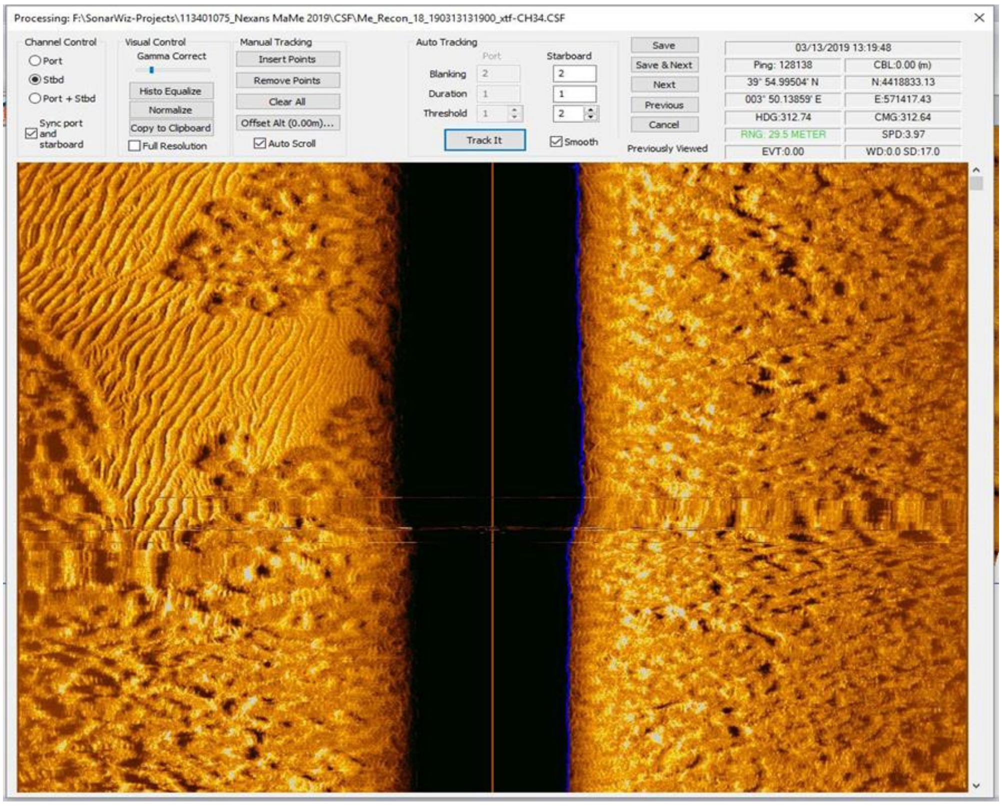


Figure 3-7: Bottom tracking processing drawn in blue in the SonarWiz software.

The following steps during SSS processing in the SonarWiz 7 software are the application and enabling of the EGN filter, and the enabling of the de-stripe filter.

At this point during data processing, a processed MBES geotiff is imported into the project. Using the MBES information, rotations to the SSS file are applied, in order to match feature orientations seen in the MBES data. Where necessary, a move offset can be applied to the SSS file, in order to match features within the MBES data.

Any observable contact within the area of interest is picked and its dimensions are measured.

The final processing step is the export of the sonar files into a GIS software package, where all of the information is integrated and a sonar mosaic is generated. This is carried out by converting the JSF files into 32bits RGB Geotiff images, to obtain georeferenced images of the processed data, with a resolution of 0.1 m.

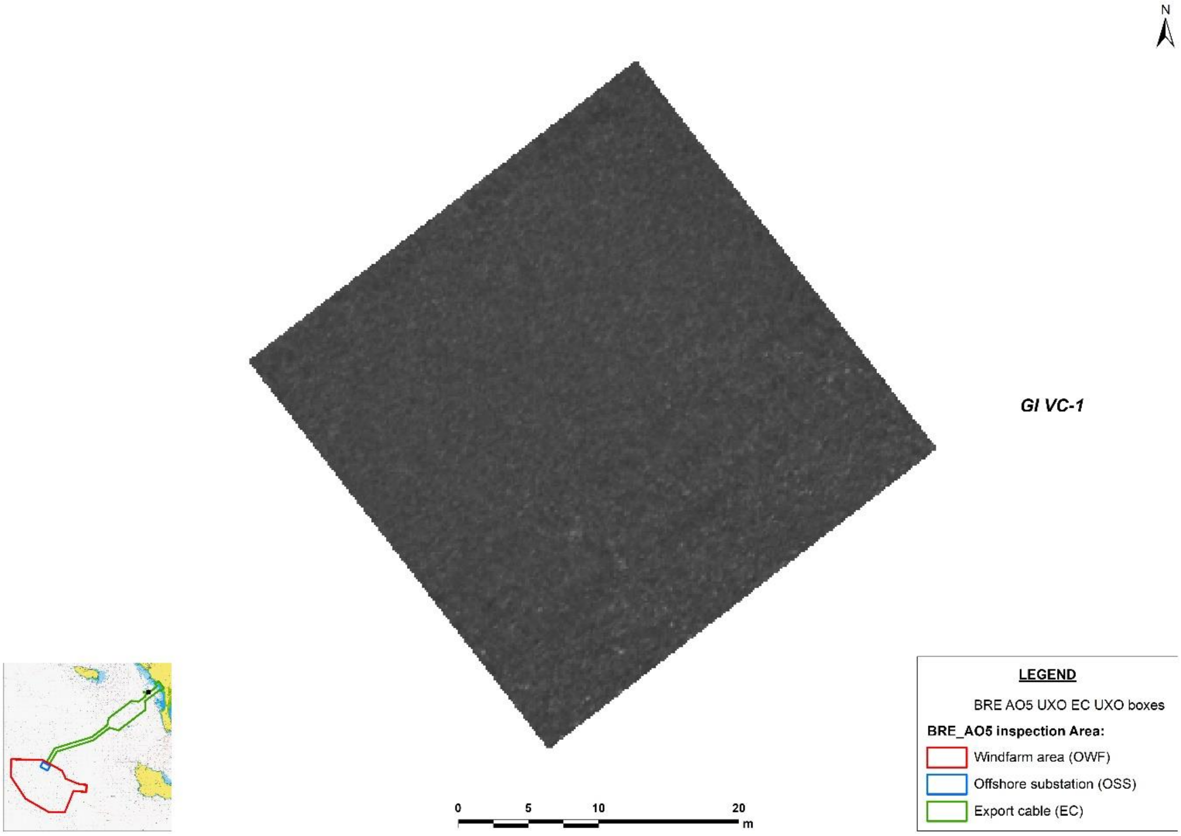


Figure 3-8: Example of the side scan sonar data for GI VC-5.

The guidelines followed by Tecnoambiente during the surveying for SSS data processing are:

- IT-CM-01. SBL-SSS,1
- IT-CM-27. SSS Processing procedure, 0

3.4. GRADIOMETER – UXO SURVEY

Magnetometer data were recorded using four Geometrics G-882 magnetometers fitted in a custom frame and spaced 1.1 metres apart, horizontally. Survey line spacing was set at 6 metres. The frame has an automated bottom tracking function, allowing it to keep a fixed height above the seabed. After merging in Qinsy, all raw data were timestamped and output as .txt files were recorded for each magnetometer (Mag 1, Mag 2, Mag 3, and Mag 4).

Figure 3-9: ROTV with the fixed frame system for MAG acquisition.

The guidelines followed by Tecnoambiente during the surveying for MAG-UXO data acquisition are the following ones:

- IT-CM-25. UXO Mooring Procedures,0
- IT-CM-18. USBL Pole Deployment, 1
- IT-CM-26. UXO Scanfish Launch and Recovery, 0

Data was processed, using the UXO Marine Mag module from OASIS software.

Positioning and altitude data were corrected to eliminate outliers (despiked), then filtered, and smoothed. Incorrect positions were removed, and the positions were filtered using a non-linear filter. All altitudes greater than 4 m were removed from the database.

The magnetometer data were corrected to eliminate aberrant values ("despiking"). They were also interpolated, but were also slightly smoothed, so as not to lose the weaker components of the signal.

The magnetometer values were then processed, in order to compensate for variations in the altitude of the fish (increase in the signal when the magnetometer approaches the seabed). The magnetometer values were recalculated at a constant virtual altitude of 3 m above the seabed. The altitudes were smoothed, using a B-Spline filter. Processed positions and altitudes were then exported, to calculate dynamic coverage.
Finally, the long-wavelength component of the Earth's magnetic field was calculated using several successive non-linear filters. This long wavelength component includes diurnal variations, geological variations, and noise, as well as the International Geomagnetic Reference Field (IGRF). This was then eliminated from the data set, resulting in a residual component, comprising primarily anthropogenic magnetic anomalies.

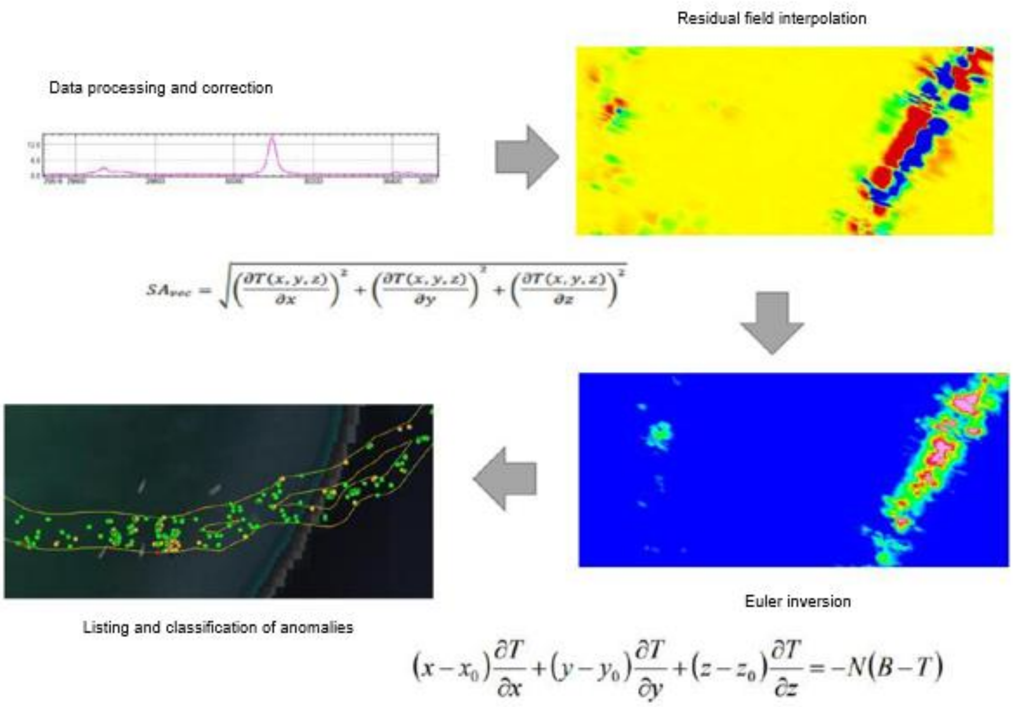
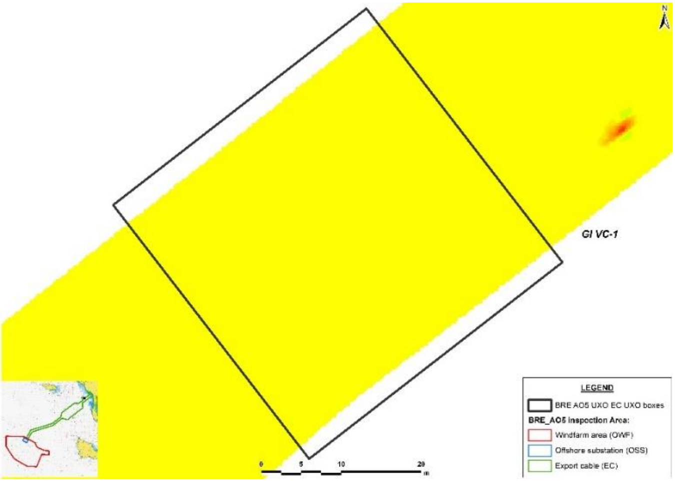


Figure 3-10: Processing workflow of magnetometer data.

A 2D map of the magnetic anomalies within the survey area was produced by interpolating these data, using a 0.25 m grid and 5 m blanking distance. The amplitude of the analytic signal was calculated using a 3D grid. The analytic signal is utilized for the mapping of structures and for the more precise positioning of any targets.

The results of the magnetometer measurements are included as two maps:

- A map of the residual magnetic field (in nT)
- A map of the analytical signal (in nT/m)



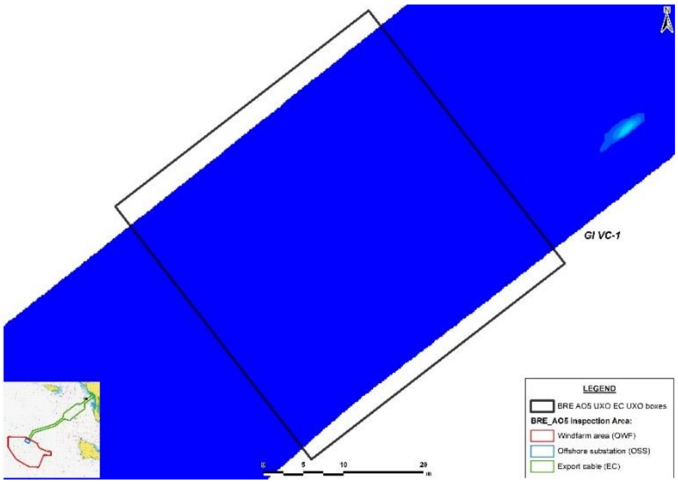


Figure 3-11: Residual field and analytic signal chart examples for position GI VC-5.

The magnetometer coverage depended on the spacing width of the surveyed lines and the height above seabed of the measuring device, making it possible to ensure the detection of an object at any point, by knowing the distance between the measuring sensor and the object. The requirements of the Scope of Work were met throughout the surveyed areas, i.e. detection of a 25 kg ferrous mass at a depth of 2 m and a maximum detection distance of 6 m (Penella 1982).

The dynamic coverage was calculated for a detection range (Δ) determined by the mass of the smallest object we were looking for and the depth below seabed of the soil intrusive activity.

The detection radius (d) under sensor was then calculated for each point, using the formula:

$$d = \sqrt{\Delta^2 - (alt + DBSF)^2}$$

Where:

Δ = Detection range

DBSF= Depth below seafloor

alt= Altitude of sensor

For the detection range of 6 m and depth of 2 m defined for this survey, the formula is defined as follows:

$$d = \sqrt{6^2 - (alt + 2)^2}$$

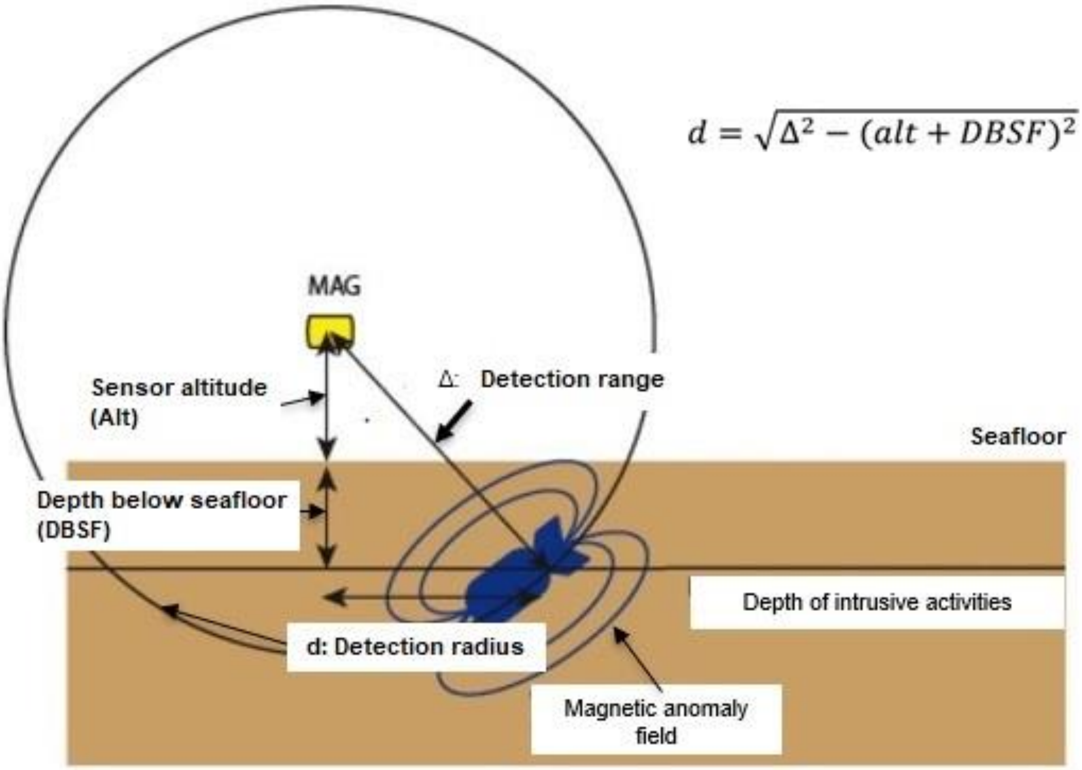


Figure 3-12:.Dynamic coverage calculations.

This means that for each point of data, a circle of detection with radius d is drawn around this point. The data were opened within a GIS software package (QGIS). Drawing these circles in the GIS software, using a buffer of detection ranges, enables us to map the detection coverage and identify any data gaps.

4. RESULTS

4.1. COVERAGE AREA

The survey took place over the EC GI boxes for a magnetometer coverage of 500 m^2.

Table 7: Magnetometer coverage area (centroid of the GI box).

BOX	MAGNETOMETER SURVEY AREA WITH 100% DYNAMIC COVERAGE (m^2)
GI VC1	100
GI VC2_A	100
GI VC3_A	100
GI VC4_A	100
GI VC5_A	100
TOTAL	500

4.2. ANOMALY PICKING

4.2.1. Magnetic anomalies

Visualization of the residual field map (in nT) makes it possible to locate any dipole anomalies present. The map analysis threshold (sensitivity of the display via the adjustment of the colour scale) is very important to validate the interpretation. By gradually decreasing the analysis threshold, it is possible to image anomalies of lower intensity. After analysis of the data, anomalies were manually picked, using the colour scale presented in Figure 4-1

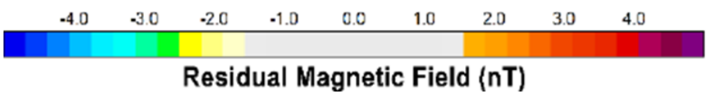


Figure 4-1: Colour scale and threshold used for analysis of magnetic anomalies.

Anomalies were also detected automatically from the analytical signal grid with a 1.0 nT/m threshold (grid value cut-off of 1nT/m).

To execute the survey more efficiently, in the EC corridor, GI locations were linked by running longer lines.

For the EC corridor, longer survey lines were acquired, in order to survey several GI locations in a row. Using this method, the clearance strategy was to define quiet areas within a kilometre of the vicinity of the each of the theoretical proposed GI locations and therefore, the magnetic anomalies were not plotted along the whole of the route. Consequently, in line with the above methodology, a list of magnetic anomalies has not been issued, as they would not be exhaustive on the surveyed zones.

This methodology had two main objectives:

- To reduce the survey time and amount of line turns.
- To have the possibility of moving the locations several meters away of any obstructions or magnetic anomaly to ensure the clearance for geotechnical locations. When a contact or obstruction was detected within the GI box, this could be moved to a magnetically quiet and free of obstruction area. Therefore, no contact list has been issued as the final locations are fully cleared.

4.2.2. MBES and side scan sonar anomalies

MBES and side scan sonar data were only analysed on 30 m x 30 m area around the original GI box locations, or around the alternative GI box locations. None anomalies were detected at the additional locations along the EC survey corridor (Appendixes II and III)

4.3. DISCRIMINATION OF pUXO TARGETS

Magnetic anomalies indicate the presence of ferrous elements at or below the seabed. This is true for most types of unexploded ordnance (UXO).

Any magnetic anomaly can therefore correspond to a potential UXO

Therefore:

- Any side scan sonar or MBES contact with a magnetic signature is considered as pUXO.
- The shapes and lengths of side scan sonar and MBES contacts were analysed carefully for discrimination as non-UXO.
- Side scan sonar and MBES contacts without magnetic signatures and without any corresponding shape and length criteria are considered as non-UXO. But as these contacts correspond to potential obstructions on the seabed, they were mapped without any avoidance area indicated on the ALARP certificate maps.

5. AVOIDANCE DISTANCES

Following the analysis, we are looking for as low as reasonably practicable (ALARP), areas that can be considered clear of any pUXO. The avoidance criteria have been defined following the UXO threat and risk assessment, with geotechnical investigation risk mitigation strategy recognised and the desktop studies (**Ref. 01**):

Thus, the avoidance distance can be calculated as follows (Figure 5-1):

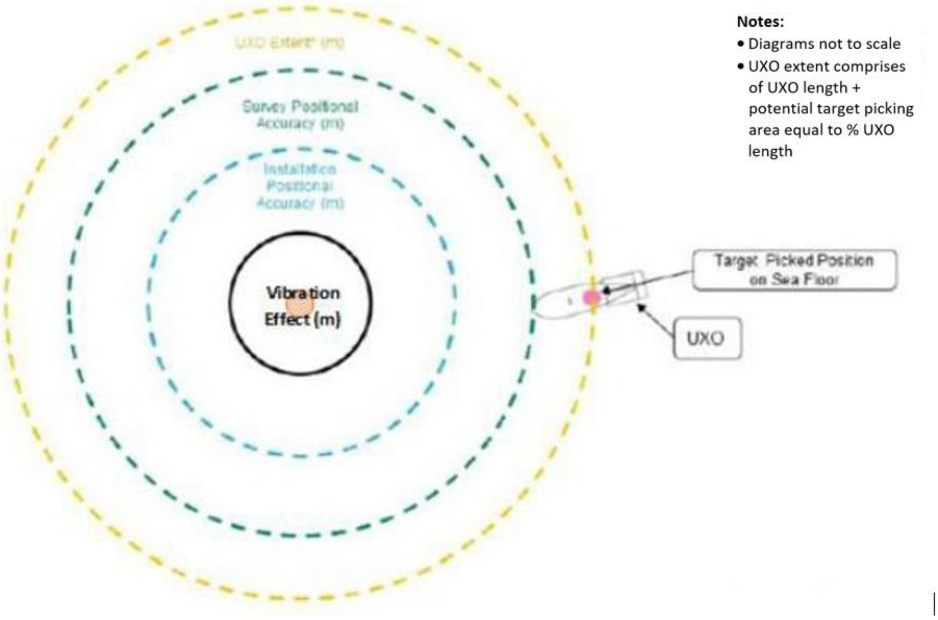


Figure 5-1: Avoidance distances.

Avoidance distance = Geotechnical tool width + Vibration effect distance + Geotechnical tool positioning accuracy + UXO survey accuracy + Ammunition length

The effect of the generation of seismic waves during vibro-driving or pile driving has to be considered in the case of geotechnical drilling or pile driving. These machines generate a wide variety of seismic waves (pressure, Rayleigh, shear) (Study report DRS17-164706-

11171B, INERIS) that can trigger UXO detonation. This effect need not be considered for other geotechnical work, such as jack up or anchor installation.
In order to reduce the safety buffer to the necessary distance, a precise calculation of avoidance distance was explained and detailed in a Technical advisory note (Ref. 07) for the EC corridor. The calculation considers the following elements:

Avoidance distance: Vibration effect (6m) + Geophysical survey accuracy distance (1.9m) + Geotechnical frame (1.25m) + Geotechnical survey accuracy (1m) + UXO extent (3.12m) = 13.27m

A safety buffer of 13.5 m for EC corridor is to be employed from any isolated magnetic anomaly.

This was achieved through geospatial processing by QGIS software.

Firstly, the areas that could not be considered as clear of any pUXO are mapped, grouping the pUXO targets (magnetic anomalies and/or sonar and MBES contacts) and potential saturated areas. Afterwards, the “avoidance areas” were mapped with an avoidance zone of 13.5 metres radius (a 13.5 m safety buffer around the anomaly) away from all the potential UXO (pUXO) anomalies or any saturated or excluded areas. This avoidance area was also applied from the edge of the dataset inwards, towards the centre of the survey area.

The free space between these avoidance areas and the detection surface and the survey limits was then mapped, and a workable area was obtained. This defined the outline of the ALARP certificate (Figure 5-2).

When no ALARP zone was identified (Figure 5-3), an alternative location for the GI box was proposed.

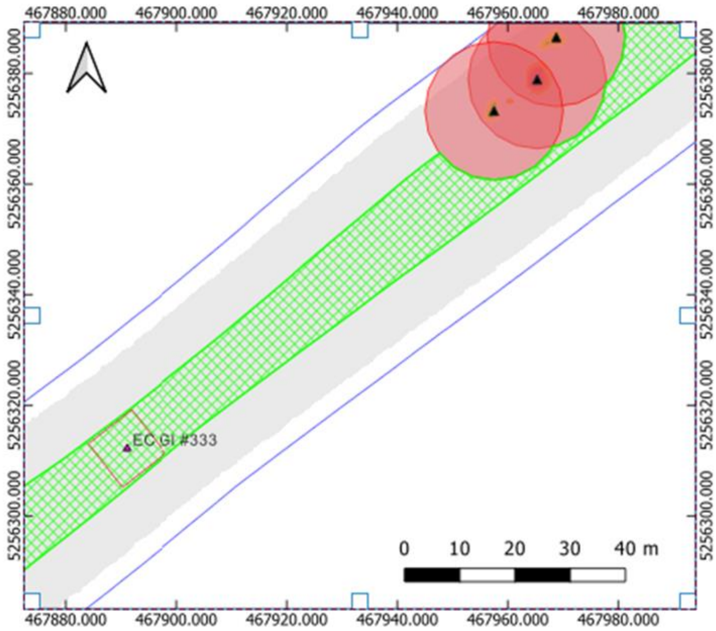


Figure 5-2: Case where the GI boxes location are not impacted or little impacted by avoidance areas: an ALARP zone is defined (in green)

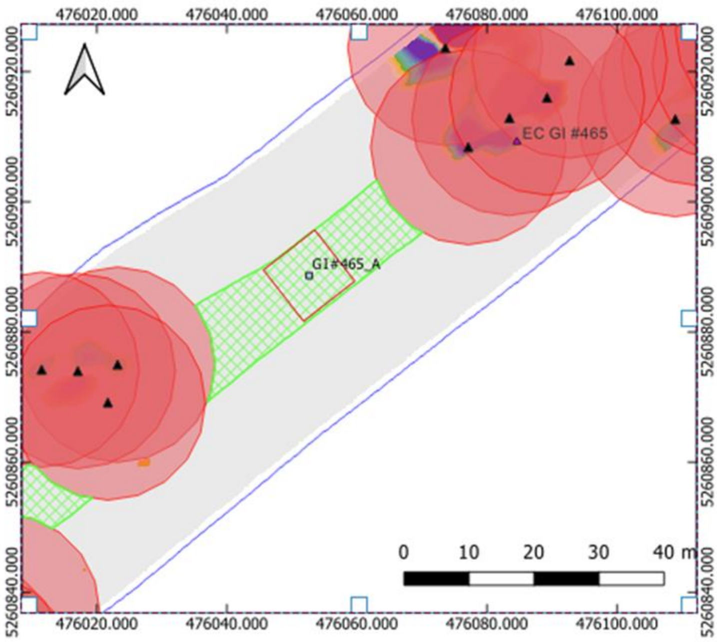


Figure 5-3: Case where the GI boxes location are largely or completely impacted by avoidance areas and an alternative location is proposed

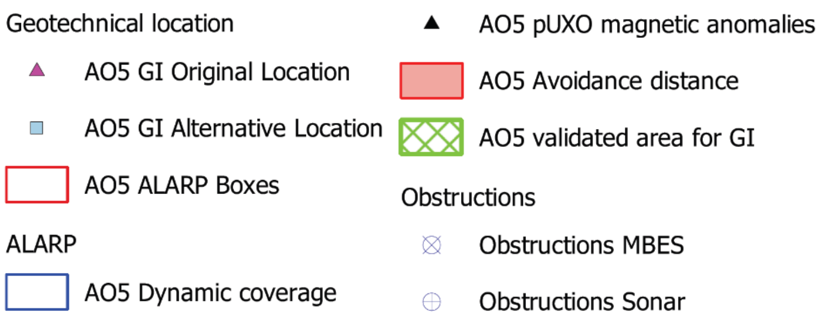


Figure 5-4: Legend of the ALARP maps.

6. CONCLUSION

ALARP areas of 500 m^2 were identified for the 5 GI locations. Alternative locations had to be identified for 4 of the GI locations (Table 8). These alternative locations are indicated in grey in Table 8.

Table 8: Final ALARP workable areas and GI box location.

ID	GI box	Easting UTM30N	Northing UTM30N	Workable area (m^2)
1	GI VC1	484138.32	5269887.09	100
2	GI VC2_A	484238.59	5269963.13	100
3	GI VC3_A	471545.13	5265341.50	100
4	GI VC4_A	471430.44	5265152.79	100
5	GI VC5_A	470921.63	5263641.16	100

Total	500

REFERENCES

In accordance with:

- Letter the "*Inspection des poudres et explosifs*" of the French Ministry of Defence and the *"Direction générale du Travail*" of the French Ministry of Labour of September 18th, 2013, relating to pyrotechnic clearance carried out on civil land.
- Decree No. 2014-381 of March 28, 2014, regulatory part Art. R.733-1 to 16 and legislative part Art. L. 733-1 to 3.

In reference to:

- Decree No. 2005-1325 of October 26, 2005, amended from the Ministry of Defence relating to the safety rules applicable during work in the context of a pyrotechnic clearance site and the two implementing decrees.

Ref.01. Unexploded Ordnance Threat and Risk Assessment with Risk Mitigation Strategy: *8811_UXOTARA_with_RMS_A05 Brittany_DNVGL_Client Draft_V1.0*

Ref.02. Project AO5 De-risk Surveys Scope Of Work: *SOS-01 - Scope Of Service AO5*

Ref.03. Employer's Requirements Marine Operations: *SVY-ERS-03 – Survey Specification*

Ref.04. Specification for UXO Survey Verification Test RTE Export Cables: *ERS-03-A – SVT Specification*

Ref.05. UXO Surrogate Items report: *SIT report – AO4 and A05 geophysical and UXO survey*

Ref.06. BRE_AO5 Area - Geophysical and UXO survey - Mobilization Report: *BRE_TEC_21_Mob report - AO5 survey 2022_1.2*

Ref.07. Technical advisory note - Avoidance distance AO5

Pennella 1982 Magnetometer techniques in the detection of projectiles Final Report, TR239, Naval explosive ordnance technology center

Rapport d'étude DRS 17-164706-11171-B, Impact des vibrations sur la stabilité des carrières souterraines, INERIS, 2017.

APPENDIX I – LIST OF THE MAGNETIC ANOMALIES DETECTED

None. Intentionally left blank.

For more information see section 4.2.1 of this report.

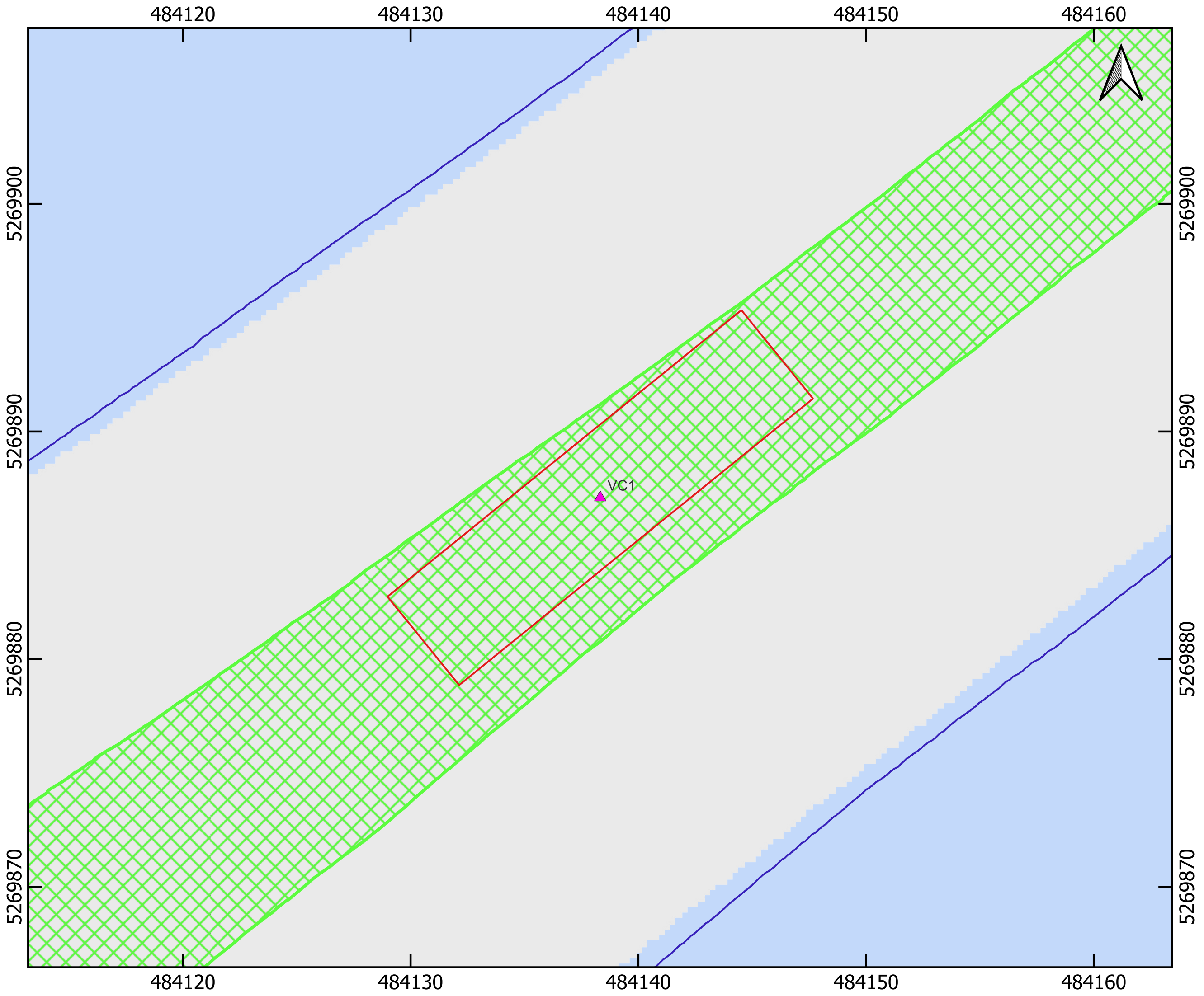
APPENDIX II – LIST OF THE SIDE SCAN CONTACTS DETECTED

None. Intentionally left blank.

APPENDIX III – LIST OF THE MBES CONTACTS DETECTED

None. Intentionally left blank.

APPENDIX IV – ALARP CERTIFICATE MAPS



ANNEXE A: AO5 - EC GI #VC1
MBES DATA AT ALARP POSITION

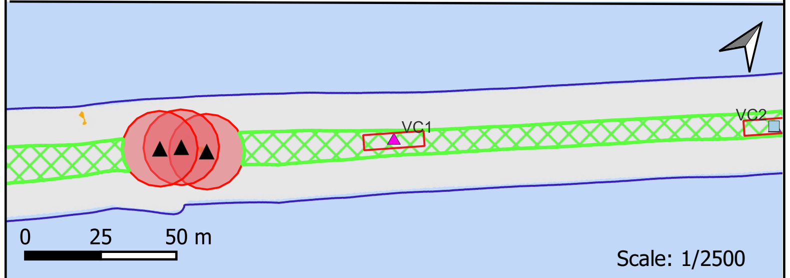
Scale: 1/300

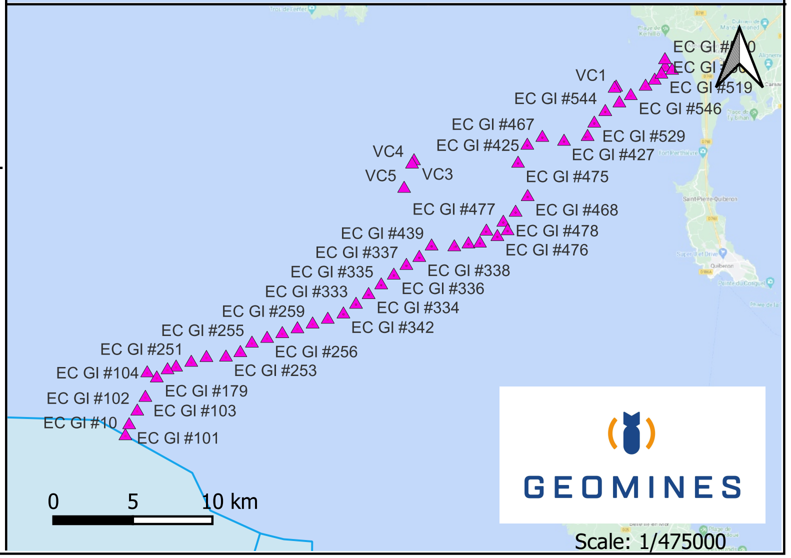
Date: 2022-05-18

Geodesy : WGS 84 - UTM 30N

Version: V1

0 5 10 15 20 m





Concession

AO5 OWF

Geotechnical location

AO5 GI Original Location

AO5 GI Alternative Location

AO5 ALARP Boxes

ALARP

AO5 Dynamic coverage

AO5 pUXO magnetic anomalies

AO5 Avoidance distance

AO5 validated area for GI

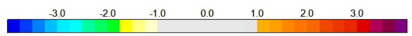
Obstructions

Obstructions MBES

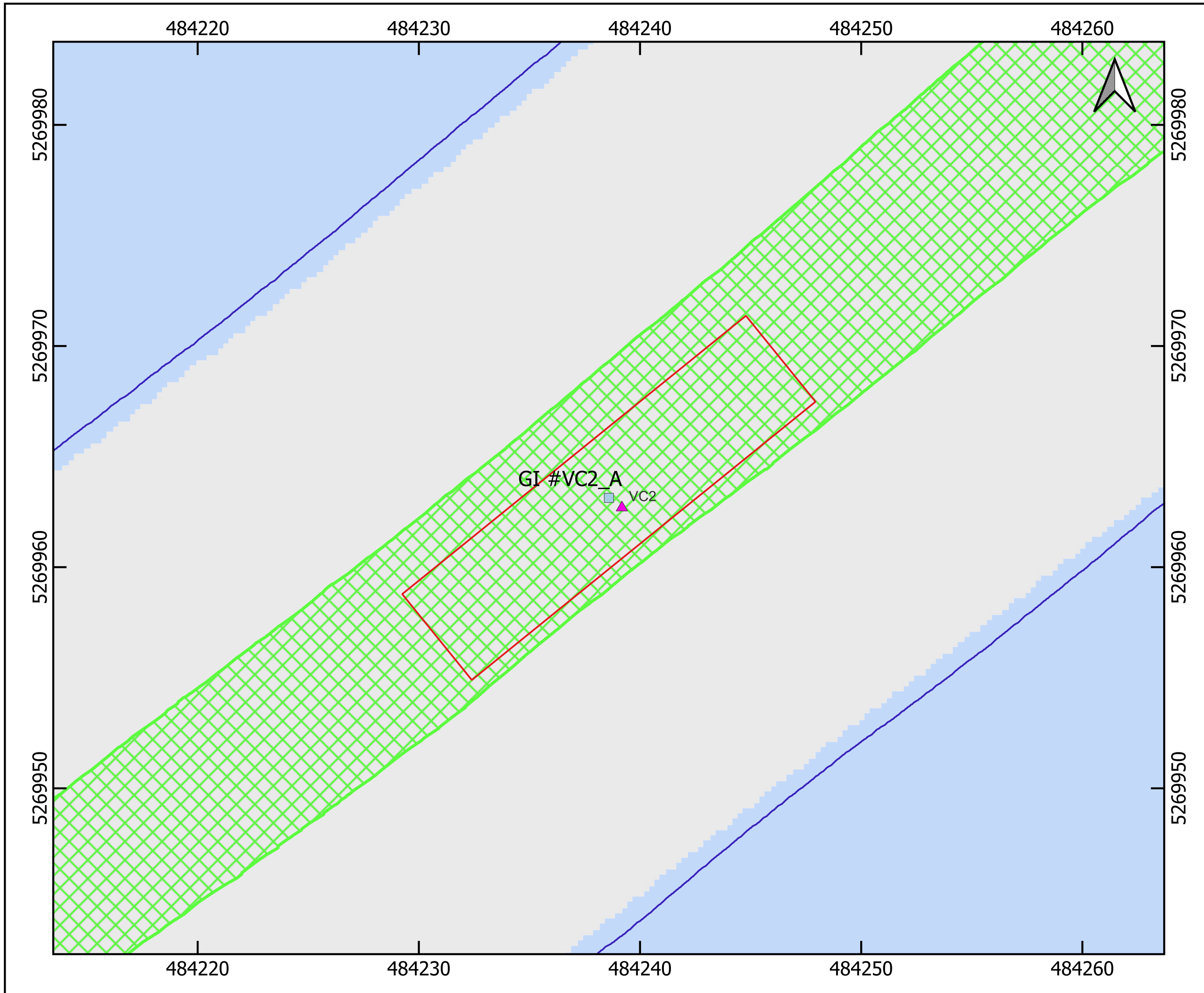
Obstructions Sonar

Location of center point:

Easting: 484138.32 , Northing: 5269887.09



Residual total magnetic field (nT)



Rte

TECNOAMBIENTE
A TRADEBE COMPANY

MINISTÈRE
DE LA TRANSITION
ÉCOLOGIQUE

GEOQUIPMARINE

ANNEXE A: AO5 - EC GI #VC2_A
MBES DATA AT ALARP POSITION

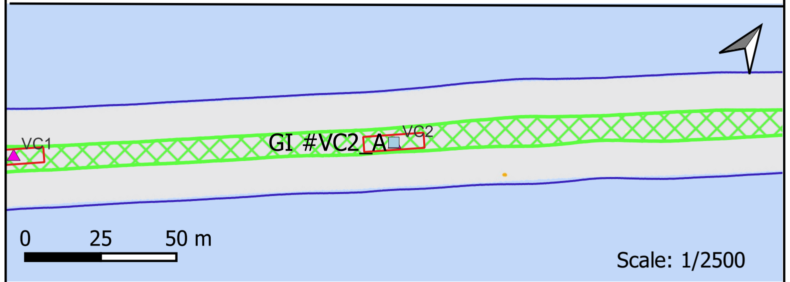
Scale: 1/300

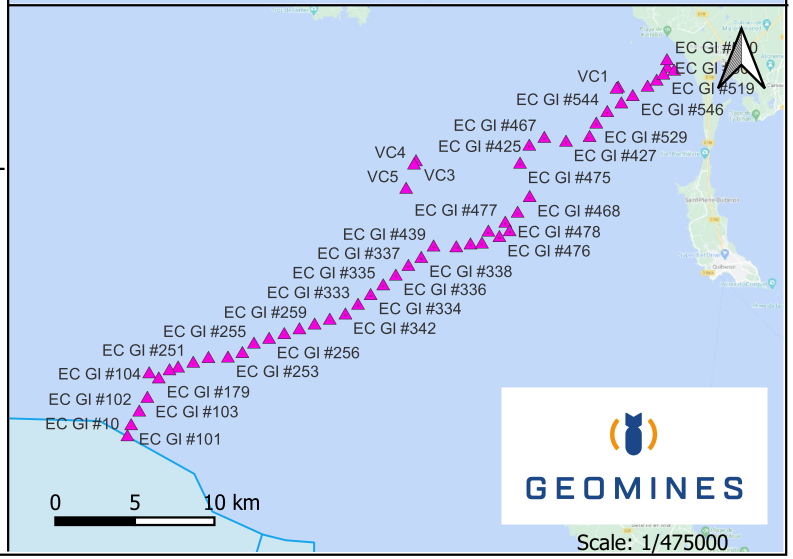
Date: 2022-05-18

Geodesy : WGS 84 - UTM 30N

Version: V1

0 5 10 15 20 m





GEOMINES

Concession

AO5 OWF

Geotechnical location

AO5 GI Original Location

AO5 GI Alternative Location

AO5 ALARP Boxes

ALARP

AO5 Dynamic coverage

AO5 pUXO magnetic anomalies

AO5 Avoidance distance

AO5 validated area for GI

Obstructions

Obstructions MBES

Obstructions Sonar

Location of center point:

Easting: 484238.59 , Northing: 5269963.13

-3.0 -2.0 -1.0 0.0 1.0 2.0 3.0

Residual total magnetic field
(nT)

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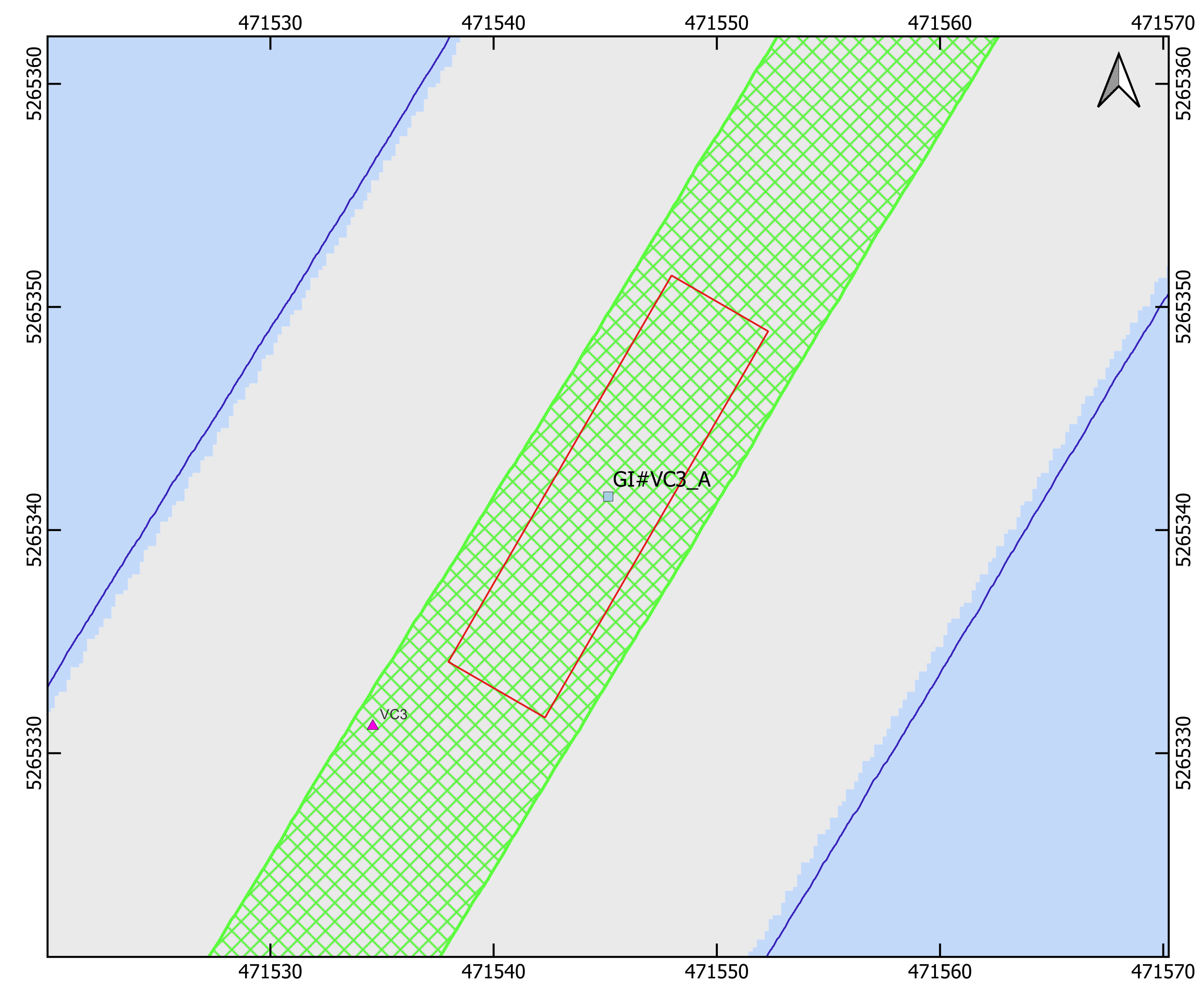
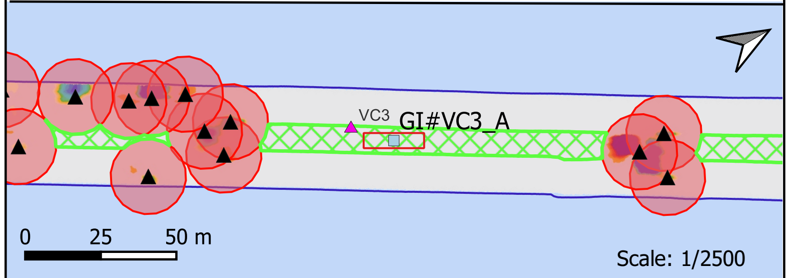
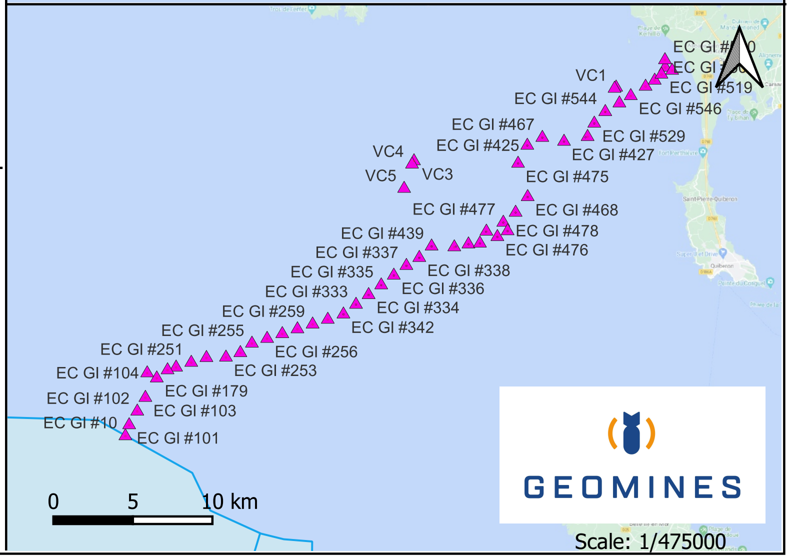
ANNEXE A: AO5 - EC GI#VC3_A
MBES DATA AT ALARP POSITION

Scale: 1/300 Date: 2022-05-18
Geodesy : WGS 84 - UTM 30N Version: V1







Concession
- AO5 OWF

Geotechnical location
- AO5 GI Original Location
- AO5 GI Alternative Location
- AO5 ALARP Boxes

ALARP
- AO5 Dynamic coverage

- AO5 pUXO magnetic anomalies
- AO5 Avoidance distance
- AO5 validated area for GI

Obstructions
- Obstructions MBES
- Obstructions Sonar

Location of center point:

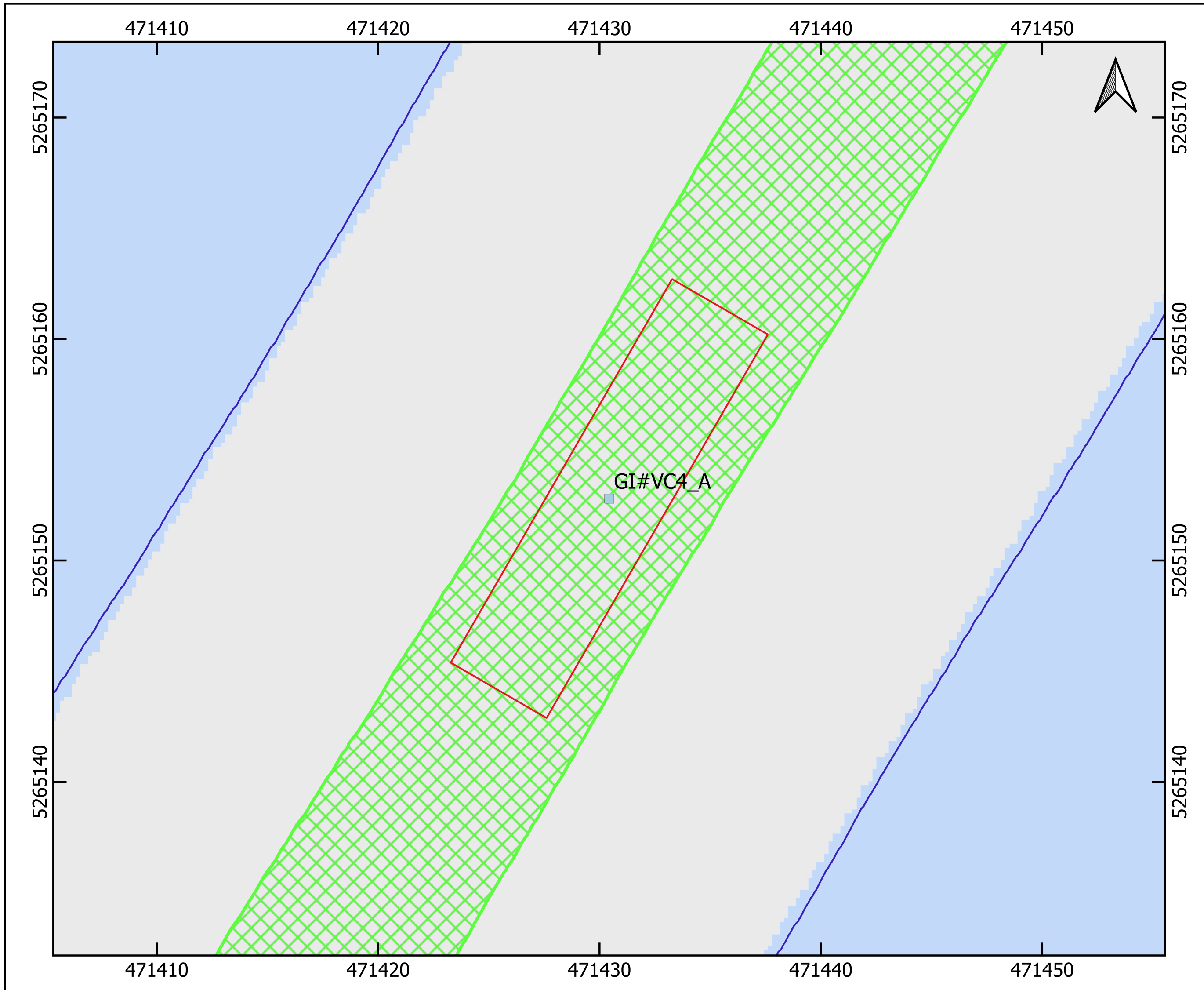
Easting: 471545.13 , Northing: 5265341.5

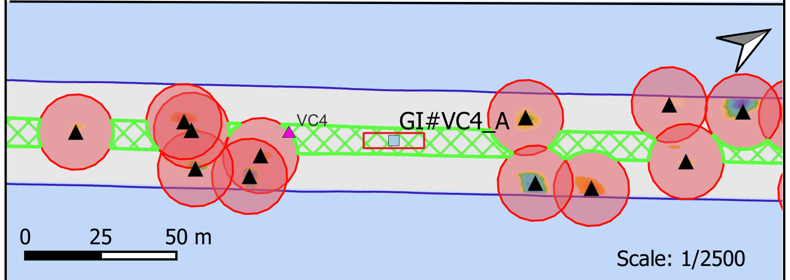
-3.0 -2.0 -1.0 0.0 1.0 2.0 3.0

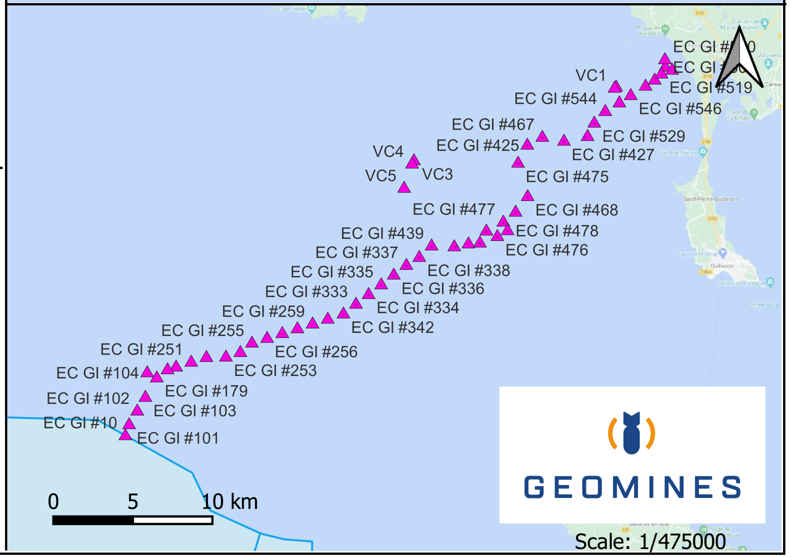
Residual total magnetic field
(nT)

ANNEXE A: AO5 - EC GI#VC4_A
MBES DATA AT ALARP POSITION

Scale: 1/300 | Date: 2022-05-18
Geodesy : WGS 84 - UTM 30N | Version: V1







Concession

AO5 OWF

Geotechnical location

AO5 GI Original Location

AO5 GI Alternative Location

AO5 ALARP Boxes

ALARP

AO5 Dynamic coverage

AO5 pUXO magnetic anomalies

AO5 Avoidance distance

AO5 validated area for GI

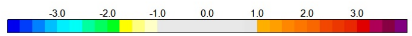
Obstructions

Obstructions MBES

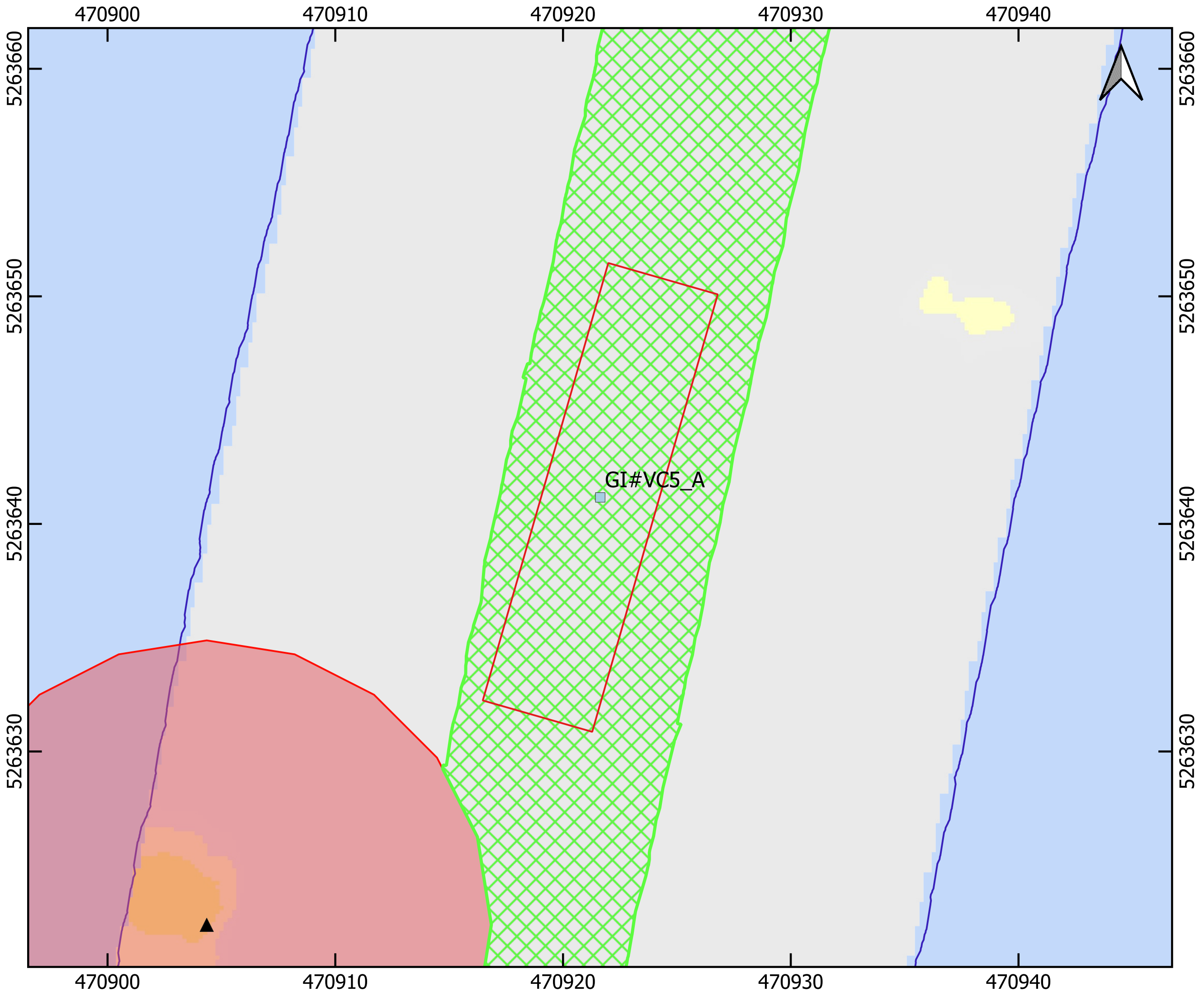
Obstructions Sonar

Location of center point:

Easting: 471430.44 , Northing: 5265152.79



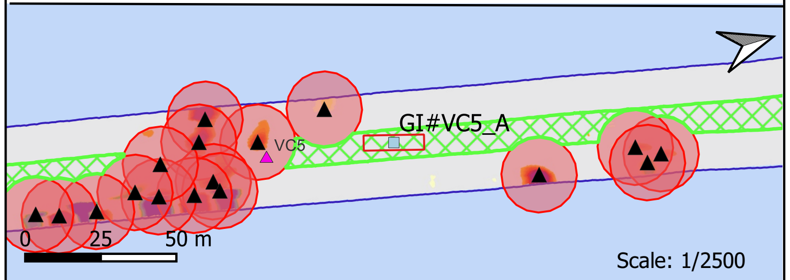
Residual total magnetic field
(nT)

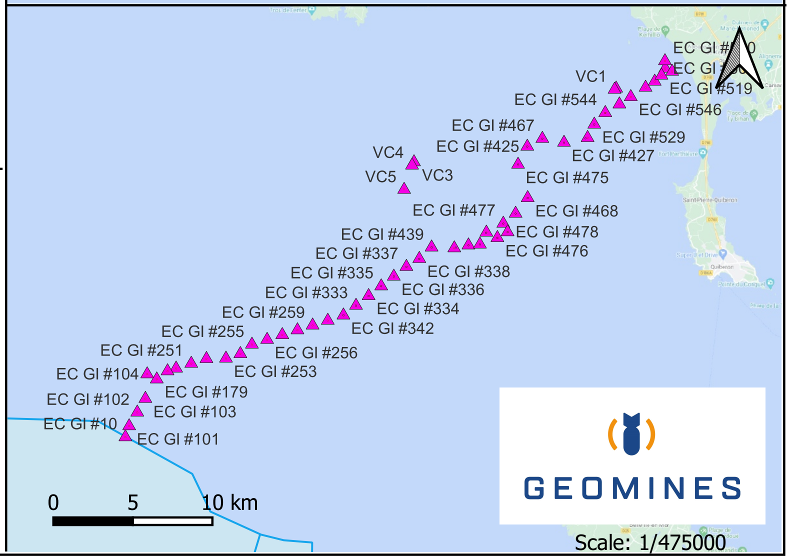


ANNEXE A: AO5 - EC GI#VC5_A
MBES DATA AT ALARP POSITION

Scale: 1/300
Date: 2022-05-18
Geodesy : WGS 84 - UTM 30N
Version: V1

0 5 10 15 20 m





Concession

AO5 OWF

Geotechnical location

AO5 GI Original Location

AO5 GI Alternative Location

AO5 ALARP Boxes

ALARP

AO5 Dynamic coverage

AO5 pUXO magnetic anomalies

AO5 Avoidance distance

AO5 validated area for GI

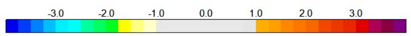
Obstructions

Obstructions MBES

Obstructions Sonar

Location of center point:

Easting: 470921.63 , Northing: 5263641.16



Residual total magnetic field (nT)

GEOMINES