EIA Report Volume 3 Appendix 16.2 Archaeological Assessment of Marine Geophysical Survey Data for the MarramWind Offshore Wind Farm

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Volume 3, Appendix 16.2: Archaeological Assessment of Marine Geophysical Survey Data for the MarramWind Offshore Wind Farm

MarramWind Offshore Wind Farm

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Appendix A Geophysical Anomalies with Archaeological Potential within the Project OAA

1. Introduction

1.1 Overview

1.1.1.1 This Appendix of the Environmental Impact Assessment (EIA) Report should be read in conjunction with **Volume 1, Chapter 16: Marine Archaeology and Cultural Heritage**.

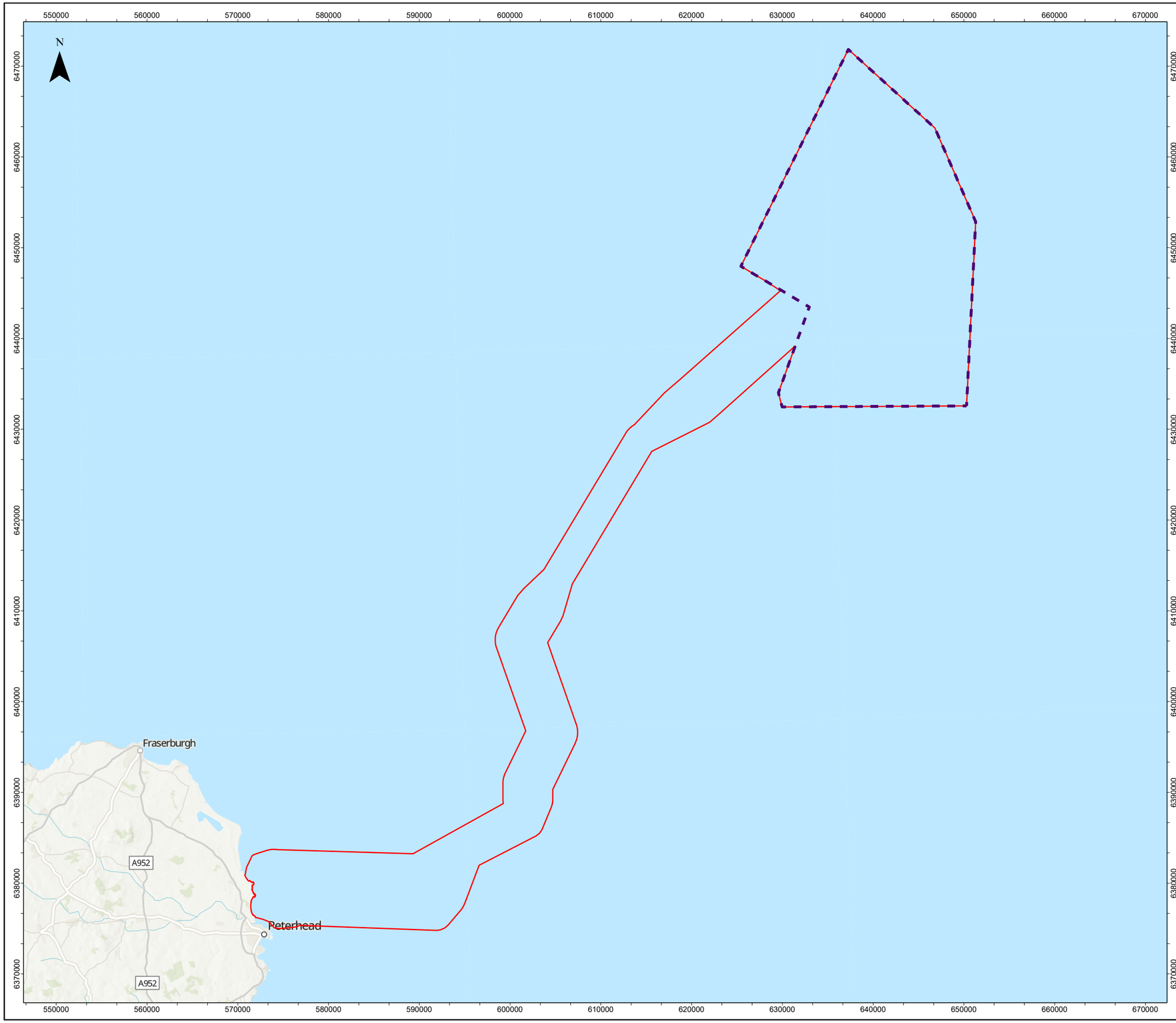
1.1.1.2 COARS, University of Southampton, was contracted by WSP to undertake an archaeological assessment of marine geophysical data collected in relation to the proposed MarramWind Offshore Wind Farm (hereafter referred to as 'the Project').

1.2 Project background

1.2.1.1 The Project is wholly owned by ScottishPower Renewables UK Limited (SPR). MarramWind Limited, a subsidiary of SPR, is the Applicant for the Project.

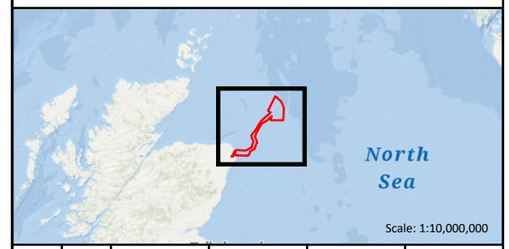
1.2.1.2 The Project is a proposed floating wind farm located in the North Sea, with a grid connection capacity of up to 3 gigawatts (GW). The location of the Project is determined by the Option Area Agreement (OAA), which is the spatial boundary of the Northeast 7 (NE7) Plan Option within which the electricity generating infrastructure will be located. The NE7 Plan Option is located north-east of Rattray Head on the Aberdeenshire coast in north-east Scotland, approximately 75 kilometres (km) at its nearest point to shore and 110km at its furthest point. An Option to Lease Agreement (OLA) for the Project within the NE7 Plan Option was signed in April 2022.

1.2.1.3 The Project's generating infrastructure will be located in the North Sea, within the 'Scottish Zone' (as defined in the Scotland Act 1998) of the United Kingdom (UK) Exclusive Economic Zone. The generating infrastructure is specifically located within the spatial extent of the NE7 Plan Option, covered by the OAA, (see **paragraph 1.2.1.1**). The Project's location is shown in **Figure 1**.



Offshore Red Line Boundary

Option Agreement Area



Scale: 1:10,000,000

2	19/09/2025	MJG	LT	LG	NC
1	27/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000114
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:400,000
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PROJECT TITLE

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Figure 1 Offshore Red Line Boundary and Option Agreement Area

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1.2.1.4 In March 2024, National Grid Electricity System Operator published the 'Beyond 2030' report, which presented the ScotWind elements of the holistic network design follow-up exercise. This report confirmed that the full 3GW connection for the Project will be connected to the Scottish and Southern Electricity Networks Netherton Hub at Longside, near Peterhead. This update informed further refinement of the Project design envelope following the EIA Scoping Stage in January 2023 (see **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives** for further details).

1.2.1.5 The Project's offshore infrastructure, located seaward of mean high water springs, includes the following:

- wind turbine generators (WTGs), including WTG floating units (platforms and station keeping system);
- array cables;
- subsea distribution centres;
- subsea substations;
- offshore substations;
- reactive compensation platform(s) (if required); and
- offshore export cables to connect the offshore infrastructure to the landfall(s).

1.3 Survey background

1.3.1.1 Survey data was collected from the OAA by Fugro between 29th April and 25th August 2022. This Appendix consists of an archaeological assessment of selected geophysical survey data, comprising multibeam echosounder (MBES), sidescan sonar (SSS), magnetometer (MAG) and sub-bottom profilers (SBP), for the purpose of informing the EIA process.

1.4 Purpose of this Appendix

1.4.1.1 The principal aim of the archaeological review of the collected marine geophysical survey dataset is to establish if potentially significant archaeological material is present on or below the seabed and the potential for submerged prehistoric remains and deposits beneath.

1.4.1.2 The objectives of the archaeological interpretation can be summarised as:

- to establish the presence of anthropogenic material with archaeological potential;
- to interpret the identified anomalies as to their potential to be of archaeological significance;
- to confirm the presence of known or previously located marine sites of archaeological potential;
- to recommend mitigation strategies for identified anomalies appropriate to their archaeological potential;
- to establish the palaeolandscape potential;
- to recommend mitigation strategies in relation to the palaeolandscape and palaeoenvironment; and
- to recommend further works that may be required and their specifications.

2. Methodology

2.1.1.1 The marine geophysical survey of the OAA was undertaken by Fugro (Fugro 2024a; b) onboard the MV *Fugro Galaxy* and MV *Fugro Venturer* between 29th April and 25th August 2022.

2.1.1.2 The geophysical data collected comprised MBES, dual frequency SSS, MAG, Innomar SBP and 2D Ultra High Resolution seismic (2DUHRS) data. The objective of each of these survey types is provided in **Table 2.1**.

Table 2.1 Objective of marine geophysical survey types

Survey type	Objective
MBES	A type of active sonar that is used to map the seabed elevation and detect objects along the seafloor.
SSS	A type of active sonar system that is used for detecting and imaging objects on the seafloor.
MAG	A passive instrument that measures changes in the Earth's magnetic field. It can be used to survey cultural heritage sites, such as ship and aircraft wrecks, and to characterise geological features on or just beneath the seafloor.
SBP and 2DUHRS data	A geophysical survey tool that uses sound to map beneath the seafloor, which can be used to determine sediment and layer composition, thickness, and other characteristics.

2.1.1.3 Geophysical data were collected to a specification that meets the requirements of Section 3 of Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects (The Crown Estate, 2021) and Marine Geophysical Guidance (Plets *et al.,* 2013). In summary, the following minimum criteria were set:

- MBES: ensonification of anomalies > 1.0 m;
- SSS: ensonification of anomalies > 0.5 m; and
- SBP: minimum penetration of 10m below the seabed, with a vertical resolution 0.3m.

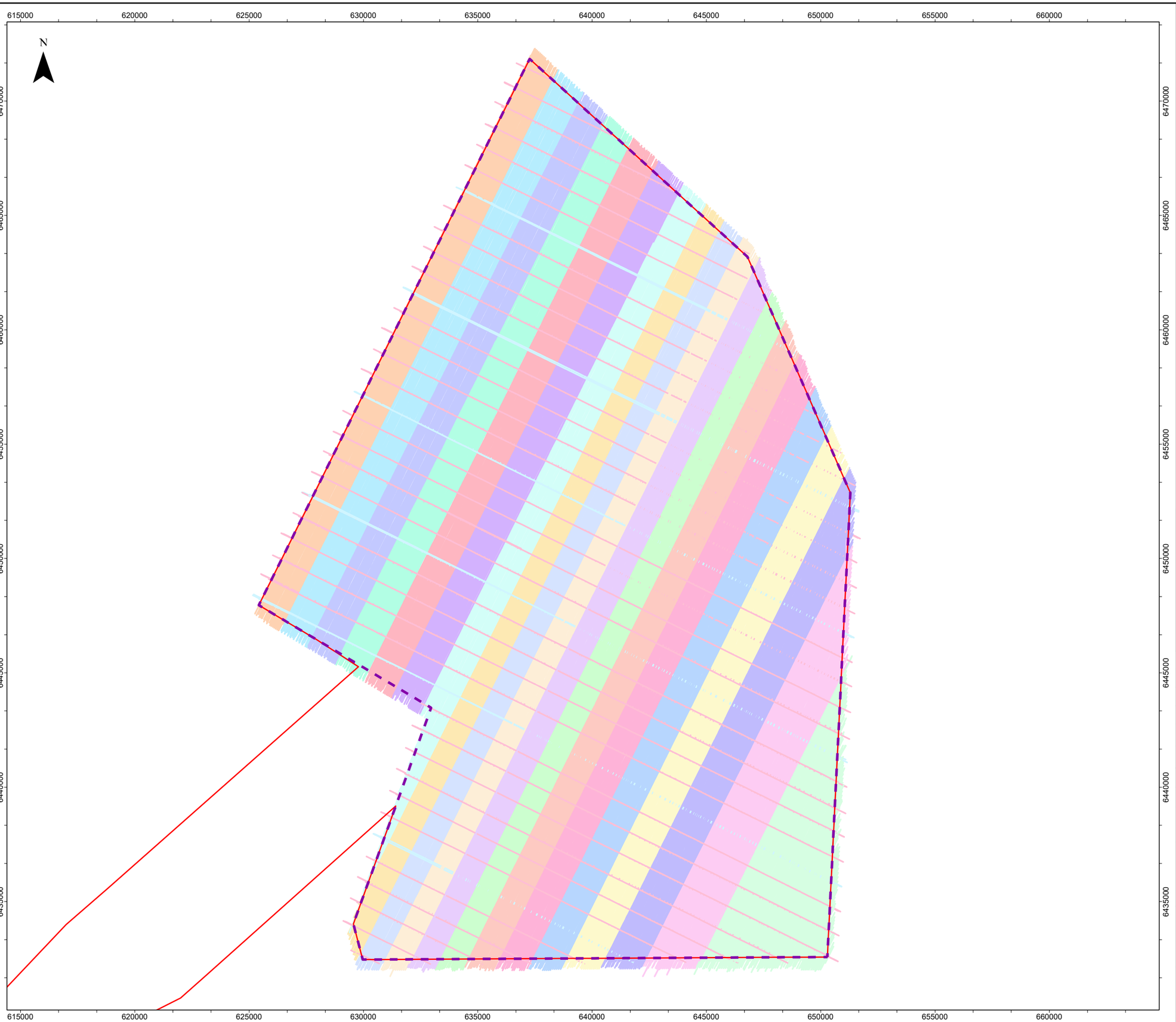
2.1.1.4 MBES was acquired using a Kongsberg Simrad EM2040 Dual Rx system at 400 kilo hertz (kHz). SSS data was acquired using an Edgetech 4205 bi-frequency system operating at 300 / 600kHz, with the towfish flown at a height of approximately 10m above the seabed and a range of 100m. The bathymetry was suitable to provide a gridded resolution of 1m across the survey area, while the SSS was suitable to identify anomalies of approximately 0.1m across track and 0.4m (at 100m from the nadir) along track. The MAG system, a Geometrics G882, was cycled at 10Hz and towed at an average survey speed of 4 knots, resulting in an along-track resolution of approximately one sample per 0.2m. The SSS and MAG used a Kongsberg HiPAP 502 Ultra Short Baseline positioning system to ensure positional accuracy throughout the survey.

2.1.1.5 SBP was acquired using an Innomar Medium-100 / SES-2000 parametric SBP at 6kHz. 2DUHRS used an Applied Acoustics Dura Spark 400 UHD source, towed at 0.3m below the sea surface, with a 72m-long Geometrics GeoEel LH-16 streamer, approximately 1.4m below the sea surface.

2.1.1.6 The horizontal datum of these datasets was referenced to ETRS89 Datum, UTM Zone 30N projection, with the vertical datum to Lowest Astronomical Tide (LAT).

2.2 Survey coverage

2.2.1.1 The OAA geophysical survey comprised 391 main lines varying in length from 0.05km to 35.4km, orientated 028° / 208°, with a variable line spacing of approximately 75m (**Figure** 2). Thirty-nine crosslines were acquired at 1km intervals, varying in length from 0.5km to 27.8km and orientated 118° / 298°. A total of 100 percent bathymetry coverage (**Figure 3**) and >100 percent (predominantly >200 percent) SSS coverage was achieved for the study area.



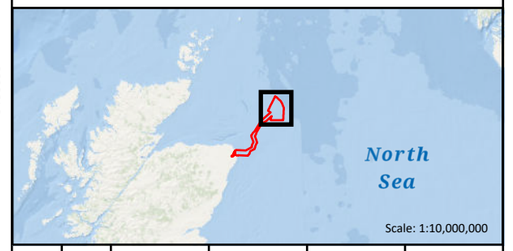
Offshore Red Line Boundary

Option Agreement Area

Geophysical Survey Lines

- Block A
- Block B
- Block C
- Block D
- Block E
- Block F
- Block G
- Block H
- Block I
- Block J
- Block K
- Block L
- Block M
- Block N
- Block O
- Block P
- Block Q
- Block R
- Block S
- CL_ Galaxy
- CL_ Venturer
- X lines Galaxy
- X lines Venturer

0 — 10 Kilometres



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1	27/05/2025	MJG	LT	TG	NC

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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000125
DATUM	ETRS 89
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Figure 2 Geophysical gurvey lines within the OAA

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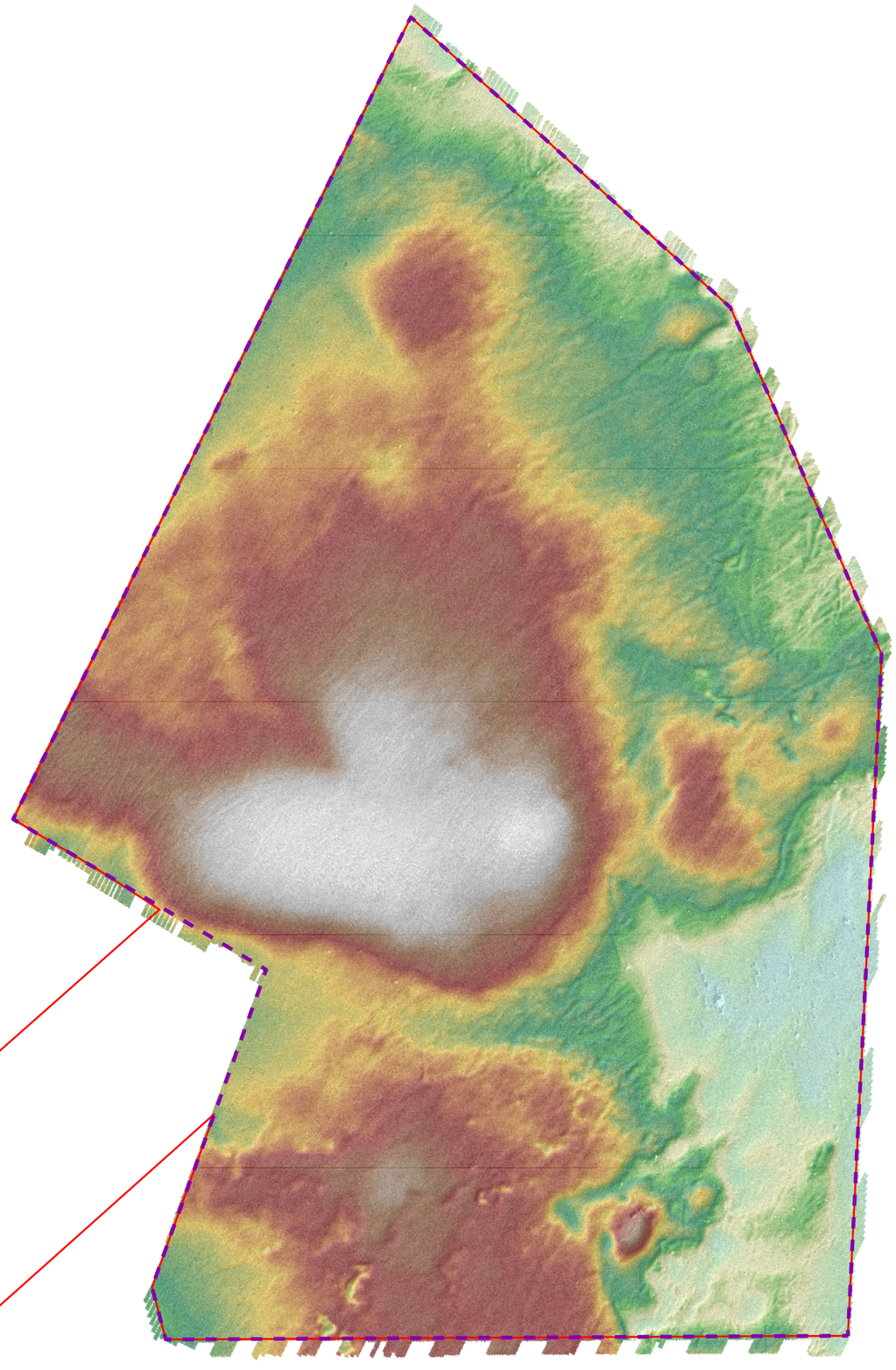
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6465000

6450000

6435000

N



Offshore Red Line Boundary

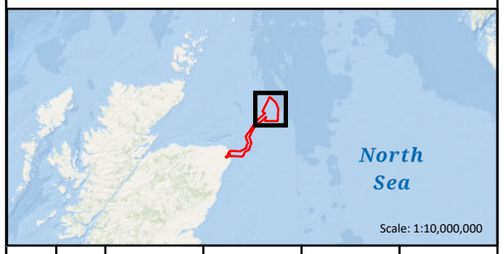
Option Agreement Area

Bathymetry (m LAT)

-87.76

-133.66

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	18/09/2025	MJG	LT	LG	NC
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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000136
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Figure 3 Bathymetry within the OAA

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2.3 Data quality and limitations

2.3.1.1 Following data collection, navigation and offsets were applied, and the data quality controlled by the contracted surveyor before being delivered to the Applicant in the formats presented in **Table 2.2**.

Table 2.2 Data formats and types supplied for archaeological assessment of marine geophysical survey from the OAA

Sensor	Deliverables
MBES	Raw multibeam data (.sbd). Gridded elevations at 0.5 m resolution (ascii xyz). Seabed features (.csv).
SSS	Unprocessed high and low frequency lines (.xtf). Navigation corrected, unprocessed high and low frequency lines (.xtf). Georeferenced mosaic (high and low frequency) at 0.2m resolution (.tif). Seabed features (.csv).
SBP and 2DUHRS survey data	Navigation corrected, unprocessed lines (.sgy). Navigation corrected, processed lines (.sgy). 2DUHRS Processed Stacks (.sgy). Horizon grids, contours and unit interpretations (ascii xyz, / .tiff / .shp).
MAG	Raw MAG data (.csv). Navigation corrected, processed lines (.csv). Total and residual magnetic field maps (.grd). Magnetic anomalies (.csv).

2.3.1.2 The data collected from the OAA was generally of good quality, with minimal interference or data degradation. The MBES data was generally of a good quality, achieving a resolution of 0.5m in most areas of the survey, which is sufficient for correlation of the MBES and SSS data at a high-level of precision. However, in some areas of the survey there was evidence of roll and heave artefacts within the datasets. While these have been partially removed in the processed datasets, this has still resulted in the persistence of along-track deviations remaining in the outer beams of the cleaned data.

2.3.1.3 The high and low frequency SSS data was collected simultaneously at a 100m range. The horizontal resolution for the high frequency SSS data is approximately 0.1m across track and 0.4m at the range limit. The majority of the seabed is covered by at least two overlapping SSS lines, providing greater certainty in the identification and interpretation of visible seabed anomalies, as recommended by Plets *et al*. (2013)

2.3.1.4 The MAG survey line spacing of approximately 75m, in some areas reducing to 10m. This provides reasonable to good positioning of small magnetic anomalies. Correlation of MAG anomalies with features visible on the seabed, such as pipelines, was possible and, when the feature coincided with the survey line, had high spatial accuracy. Even at a wide line spacing, the MAG data can indicate areas of archaeological potential as well as provide some additional information for interpretation purposes.

2.3.1.5 The penetration of the SBP dataset is limited to a maximum of 22ms two-way travel time (TWTT) below seabed (approximately 17.6m at 1600m/s). The interpretation of the 2DUHRS dataset is limited to approximately 246 to 303ms TWTT below seabed

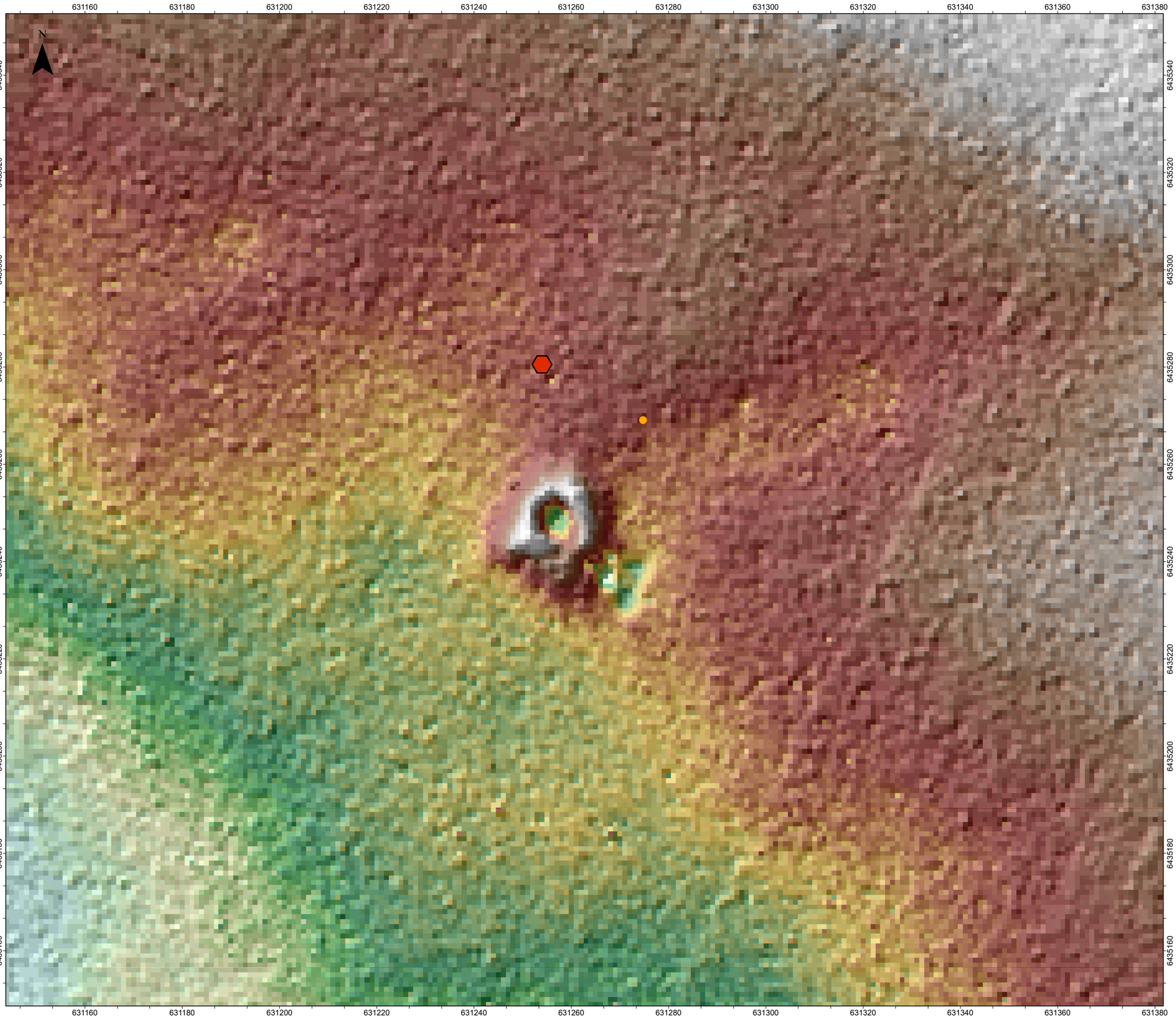
(approximately 121 to 185m below seabed), though the Coal Pit and Ling Bank Formation tunnel valleys extended beyond 312ms TWTT (approximately 162m below seabed).

2.3.1.6 The vertical resolution of the SBP data is 0.1m, though struggled to image the Quaternary geology below the base of the Holocene (approximately 0.2 to 2.8m below seabed). The 2DUHRS data is calculated to have a vertical resolution of 0.3m within the initial 10ms below the seabed, increasing to a vertical resolution of approximately 0.7m at 40m below seabed. Fugro (2024) adopted a velocity model for the 2DUHRS data, whereby the upper Holocene, Witch Ground and Swatchway Formations had a seismic velocity of 1600m/s, increasing to 1650m/s in the underlying older Quaternary Formations.

2.3.1.7 These combined datasets have permitted the mapping and identification of the principal Quaternary sedimentary formations within the OAA, permitting a characterisation of the palaeolandscape and robust assessment of the potential for submerged prehistoric remains to be present.

2.3.1.8 Positional accuracy of the datasets was assessed by cross-reference of the position of the SSS dataset to the MBES dataset and existing seabed mapping provided from the North Sea Transition Authority (NSTA). This was principally applied on pipelines and well head features within the OAA. Positional accuracy was found to be very good between the SSS and MBES, typically within the threshold of 1m accuracy, and in many instances aligned with the mapped oil and gas infrastructure on the seabed, notably pipeline PL3036, which runs through the centre of the OAA survey area. MAG anomaly alignment with this pipeline was also very good, within a 5m threshold.

2.3.1.9 In some instances, however, the existing NSTA mapping was found to be offset from the geophysical survey datasets by up to 30m. For example, well 14/27a-1, located in the southwest of the OAA survey area, shows close agreement for its position between the MBES and SSS data, with corresponding MAG anomaly Anom_I_045 20m northeast of the well, but the listed NSTA position is 31m north of the well position seen in the marine geophysical dataset (**Figure 4**). When cross-checking against all datasets and other mapped features on the seabed, offsets between the NSTA well data and collected marine geophysical data were less, <10m and in some cases no offset at all (for example, well 14/27a-2). It was determined that the offsets were in the NSTA well datasets, with the geophysical survey data providing the most accurate recording of their position on the seabed.



Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

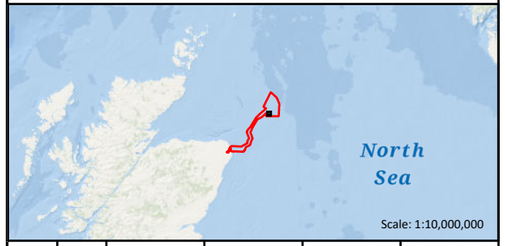
-87.76

-133.66

Magnetic Anomaly

- 5-9 nT
- 10-19 nT
- 20-29nT
- 30-49 nT
- 50-99 nT
- 100-500 nT
- 500-1000 nT
- NSTA Well 14/27a-1

0 10 20 30 40 Metres



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REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

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MarramWind DRAWING NUMBER MAR-GEN-ENV-MAP-WSP-000145

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
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PROJECT TITLE

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Figure 4 Comparison of datasets for well 14 27a-1

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2.4 Archaeological assessment of data

2.4.1.1 The archaeological assessment of geophysical data was undertaken by a qualified and experienced maritime archaeologist with a background in geophysical and hydrographic data acquisition, processing and interpretation. The archaeological assessment was undertaken utilising Chespeake's SonarWiz 8, CloudCompare 2.14 and ESRI's ArcGIS Pro 3.4.3. This permitted the assessment of both raw and processed datasets, ensuring compliance with the guidance provided by Plets *et al*. (2013) and The Crown Estate (2021). Both SonarWiz and ArcGIS Pro allow multiple datasets to be reviewed alongside each other, ensuring cross-validation of anomalies, evaluation of spatial offsets within the data, and the application of multiple lines of evidence (confirming datasets) to enhance the identification and assessment of anomalies and their archaeological potential.

2.4.1.2 Anomalies were defined by an experienced marine archaeologist based on their potential to be of archaeological interest, determined through multiple lines of evidence (historical data, geophysical datasets). Anomalies have been classified using the following criteria:

- High potential – an anomaly of anthropogenic origin and of archaeological interest.
- Medium potential – an anomaly of likely anthropogenic origin that requires further investigation in order to clarify its nature and whether it is of archaeological interest.
- Low potential – an anomaly of possible anthropogenic origin with a low likelihood to be of archaeological interest and therefore does not require further investigation.
- No potential - features such as boulders or known (and often mapped) anthropogenic features such as cables, pipelines, anchorages, etc. These are not recorded separately in this archaeological evaluation of the data.

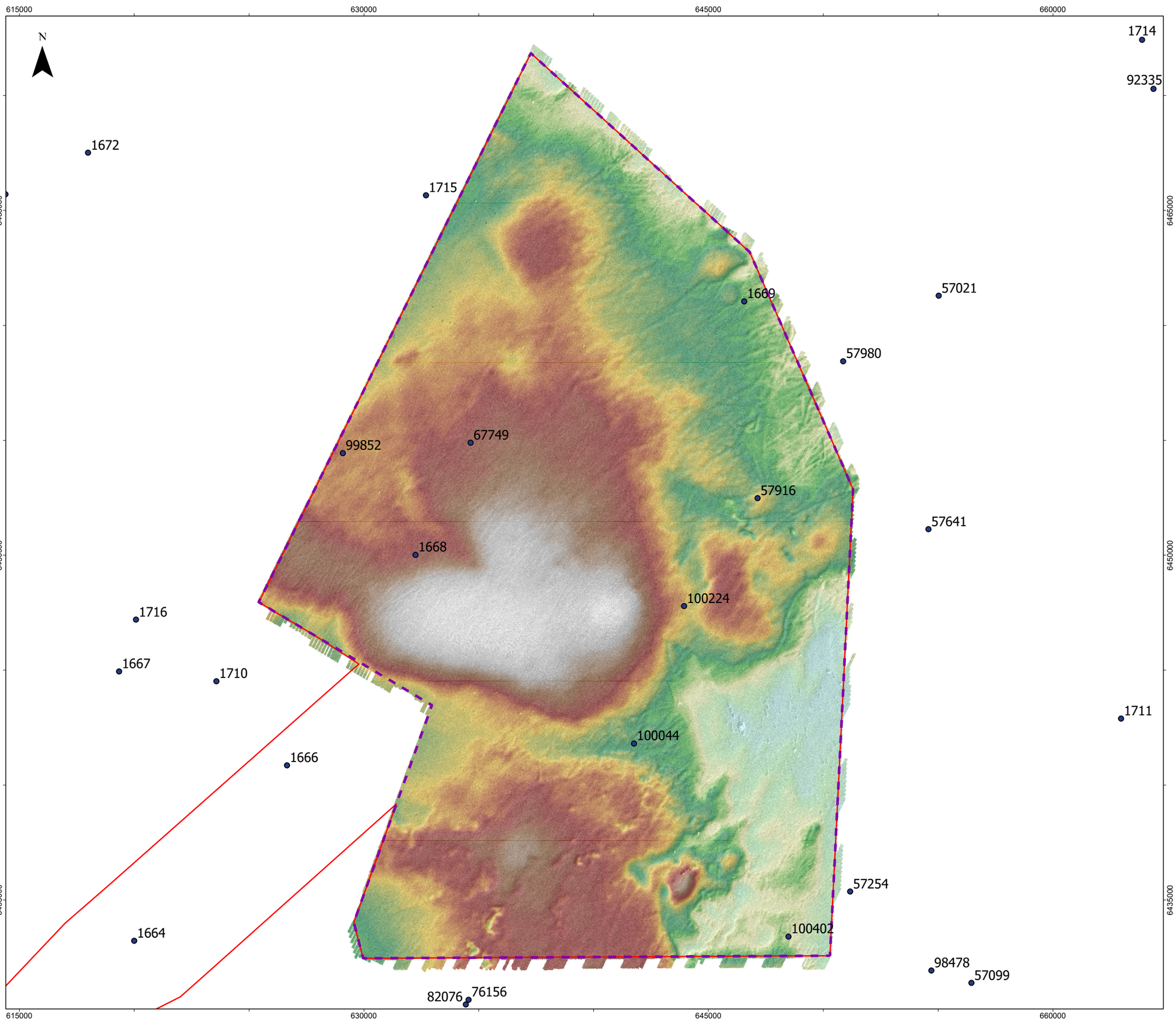
2.4.1.3 This approach follows the protocols and standard practices widely adopted and accepted internationally (see Bengtsson 2008; The Crown Estate 2021; Cadw 2020; United States Department of the Interior 2020) and is compatible with Rules 14 and 15 of the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage (see Maarleveld *et al*. 2013). Within these rules, it notes that site investigations "shall include an assessment that evaluates the significance and vulnerability of the underwater cultural heritage" (within Rules 14) and "assessment shall also include background studies of available historical and archaeological evidence and the archaeological and environmental characteristics of the site" (within Rule 15); see Maarleveld *et al*. 2013 for a full discussion of the implementation of these rules. In summary, these guidance documents and the 2001 convention require that the archaeological potential of the discovery shall be assessed in conjunction with geophysical and / or desk-based information where available, with categorising anomalies as low, medium or high archaeological potential permitting a means to evaluate the potential significance of any sites and if further archaeological investigation is required.

2.4.1.4 Each anomaly with archaeological potential has been provided a unique identification number, following the convention of MW_Arr_Arch_XXXX for those located within the OAA area.

2.4.1.5 Archaeological exclusion zones (AEZs) were constructed around anomalies identified as having medium or high archaeological potential. AEZs have been constructed, following the recommendations of Dix (2008), based on the size of the anomaly, the extents of any debris, the pattern and nature of site processes and the potential significance of the anomaly. AEZs have not been constructed as a radius from the centre point of the anomaly or distance from its extents, but instead provided as polygons, which can account for the previously stated factors. The recommended AEZs for each of the medium and high potential anomalies are discussed below, alongside the identification of the anomalies, with illustrations provided to show their extent.

2.5 Existing infrastructure and known archaeological sites.

2.5.1.1 Datasets mapping existing and decommissioned oil and gas infrastructure within the area were obtained from the NSTA. Archaeological data was obtained by WSP for the purposes of the marine desk based assessment and provided for use in the archaeological assessment of the geophysical datasets. Sources for these included Canmore and the UK Hydrographic Office (UKHO) Wreck List (**Figure 5**). Additional information was obtained from the Wreck Site.



Offshore Red Line Boundary

Option Agreement Area

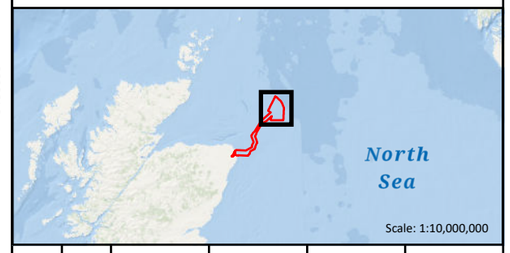
Bathymetry (m LAT)

-87.76

-133.66

UKHO Wrecks

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-21323
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000146
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:400,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 5 Distribution of wreck sites recorded by the UKHO within the OAA

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3. Results

3.1 Seabed character

3.1.1.1 Water depths within the OAA survey area ranged between -88m and -134m LAT (**Figure** 3). The seabed very gently deepens from a raised central region to a maximum depth in the southeast of the survey area. The average gradient between these shallowest and deepest areas is less than 1°.

3.1.1.2 The seabed within the survey area is primarily characterised by Holocene sediments. Bedforms are present on the bathymetric high in the central region. Large depressions are interpreted as pockmarks. Other irregular seafloor areas contain erosional features such as relict ploughmarks.

3.1.1.3 Across the survey area, the seafloor sediments mainly comprise a combination of sand and silt. Sands are predominantly found in the central and southern regions, while silts are more commonly found within areas where the sub-seafloor Witch Ground Formation is found, usually in deeper water depths in the southeast.

3.2 Anthropogenic anomalies with no archaeological potential

3.2.1.1 Within the OAA, a number of anomalies of both natural and anthropogenic origin were present. The principal anomaly types are discussed below and, due to their identified origin, are categorised as having no archaeological potential and are therefore not mapped individually in this assessment.

3.2.2 Wells and pipelines

3.2.2.1 The predominant Oil and Gas infrastructure object within the OAA area is the PL3036 Golden Eagle to Claymore oil export pipeline that crosses through the centre of the OAA in a northeast to southwest direction (**Figure 6**). This pipeline is clearly observed in both the MBES and SSS data, showing a linear trench with raised margins along the full length of the pipeline, approximately 22m in width. This pipeline is also associated with 94 MAG anomalies along its length.

615000 630000 645000 660000

6465000 6450000 6435000

N

Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-87.76

-133.66

Pipelines

- Condensate; mixed hydrocarbons
- Gas
- Oil
- Other

Offshore Wells

- Location
- Drilling
- Hydrocarbon Indications
- Dry Hole
- Gas Show
- Gas Well
- Oil Show
- Oil Well
- Oil and Gas Shows
- Gas Well with Oil Show
- Oil Well with Gas Show
- Gas and Oil Well
- Gas and Condensate
- Junked Well
- 15
- Water Injection Well
- Gas Injection Well
- Gas Producing Well
- Oil Producing Well
- 20
- 21
- Gas or Water Injector
- 23
- Suspended above TD
- Gas and Condensate Show
- Water Producer
- Observation Well
- Gas Producer/Injector
- 29
- Oil and Condensate Well
- Oil Well with Condensate Shows
- 32
- Gas Oil and Condensate Well
- Gas Oil and Condensate Shows
- 35
- Condensate Well with Oil and Gas Shows
- 37
- Condensate Producer
- Borehole
- Subsea Template

0 10 Kilometres

REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	25/09/2025	MJG	LT	LG	NC
1	27/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-94146
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000147
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:160,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 6 Oil and gas infrastructure within the OAA

Environmental Impact Assessment Report

Appendix 16.2

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Contains information provided by the North Sea Transition Authority and/or other third parties.

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MarramWind

3.2.2.2 Five former hydrocarbon well heads are also present south of the OAA (**Figure 6**). These are listed in **Table 3.1**. Each well is clearly identified in the MBES, SSS and MAG datasets, with their exact positions differing, to different extents, from the NSTA recorded positions.

Table 3.1 Offset between well position seen in geophysical survey data and NSTA recorded position

Well	Easting	Northing	NSTA Offset from true position
Well 14/27a-1	631257	6435249	31m
Well 14/27a-2	633497	6436298	15m
Well 14/28a-1	648712	6438220	4m
Well 14/28A-3A	649826	6436253	20m
Well 14/28b-4	643163	6432879	1m

3.2.3 Debris within the OAA

3.2.3.1 Evidence of fishing activity is plentiful within the OAA, numerous seafloor scars probably from fishing activity across the area. Some seafloor scars are also likely to be anchor scars, as well as associated anchor pull-out pits, which are most commonly found in close association with the well locations. Linear debris, including possible pipes, are also found on the seabed, such as a 13.4m-long linear anomaly in Block K at 633108E 6432670N. Other linear debris within the OAA appear to be sections of cable or fishing gear left on the seabed.

3.2.3.2 For this reason, the occurrence of fishing gear or hydrocarbon exploration debris within the OAA are categorised as having no potential and their specific locations are not recorded individually within this Appendix.

3.3 Geological anomalies within the OAA

3.3.1.1 The most prominent non-anthropogenic anomalies on the seabed are boulders, which are present across much of the OAA, though forming particularly dense patches within the raised areas in the centre and south of the OAA. Boulder density is significantly lower associated with the Witch Ground Formation in the southeast of the OAA. They are clearly identifiable on the SSS data and often observed in the MBES as being positioned within small depressions, indicating some localised scour around them.

3.3.1.2 Pockmarks (>0.2m deep) are predominantly associated with the Witch Ground and Swatchway Formations, with the highest densities found along the northeastern and eastern side of the OAA, with deeper pockmarks (>0.8m) particularly associated with the Witch Ground Formation in the southeast. The Witch Ground Formation is well known for having an abundance of pockmarks (Böttner *et al.*, 2019), which originate from focused fluid migration at the seafloor. Within the OAA, the pockmarks were identifiable by a relatively large depression with high reflectivity, a mottled appearance or a cluster of multiple smaller

depressions. Many of the pockmarks were observed as being infilled within the SBP and therefore interpreted as relict pockmarks, with no indication of active fluid escape. Based on the definitions of Böttner *et al*. (2019), the pockmarks observed within the Witch Ground Formation of the OAA were interpreted as compaction related dewatering structures (Class 2).

3.3.1.3 Relict ploughmarks are present throughout the survey area, with the majority on the eastern and southern areas away from the bathymetric high. These are typically orientated northeast to southwest.

3.4 Anomalies with archaeological potential

3.4.1.1 A total of 71 anomalies of potential archaeological interest were within the OAA area (**Figure** 7). The anomalies are categorised by archaeological potential, as defined in **Section 4.4** with the total for each category summarised in **Table 3.2**.

615000 630000 645000 660000

6465000 6450000 6435000

N

MW_Arr_Arch_011
MW_Arr_Arch_010
MW_Arr_Arch_065
MW_Arr_Arch_014
MW_Arr_Arch_013
MW_Arr_Arch_009
MW_Arr_Arch_017
MW_Arr_Arch_008
MW_Arr_Arch_018
MW_Arr_Arch_066
MW_Arr_Arch_064
MW_Arr_Arch_007
MW_Arr_Arch_021
MW_Arr_Arch_067
MW_Arr_Arch_068
MW_Arr_Arch_006
MW_Arr_Arch_019
MW_Arr_Arch_056
MW_Arr_Arch_012
MW_Arr_Arch_069
MW_Arr_Arch_063
MW_Arr_Arch_016
MW_Arr_Arch_020
MW_Arr_Arch_004
MW_Arr_Arch_005
MW_Arr_Arch_022
MW_Arr_Arch_055
MW_Arr_Arch_023
MW_Arr_Arch_025
MW_Arr_Arch_037
MW_Arr_Arch_043
MW_Arr_Arch_070
MW_Arr_Arch_026
MW_Arr_Arch_015
MW_Arr_Arch_003
MW_Arr_Arch_001
MW_Arr_Arch_002
MW_Arr_Arch_044
MW_Arr_Arch_071
MW_Arr_Arch_059
MW_Arr_Arch_053
MW_Arr_Arch_024
MW_Arr_Arch_058
MW_Arr_Arch_038
MW_Arr_Arch_027
MW_Arr_Arch_062
MW_Arr_Arch_028
MW_Arr_Arch_039
MW_Arr_Arch_047
MW_Arr_Arch_034
MW_Arr_Arch_040
MW_Arr_Arch_035
MW_Arr_Arch_041
MW_Arr_Arch_042
MW_Arr_Arch_029
MW_Arr_Arch_061
MW_Arr_Arch_045
MW_Arr_Arch_030
MW_Arr_Arch_050
MW_Arr_Arch_057
MW_Arr_Arch_054
MW_Arr_Arch_051
MW_Arr_Arch_049
MW_Arr_Arch_031
MW_Arr_Arch_032
MW_Arr_Arch_060
MW_Arr_Arch_046
MW_Arr_Arch_052
MW_Arr_Arch_033
MW_Arr_Arch_036
MW_Arr_Arch_048

Offshore Red Line Boundary

Option Agreement Area

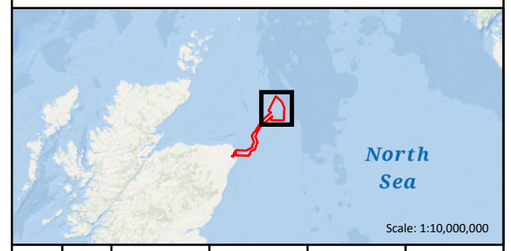
Bathymetry (m LAT)

-87.76

-133.66

Geophysical anomalies with archaeological potential

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-18376
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000148

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:400,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 7 Distribution of geophysical anopmalies with archaeological potential within the OAA

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Table 3.2 Summary of archaeological potential assigned to anomalies within the OAA area

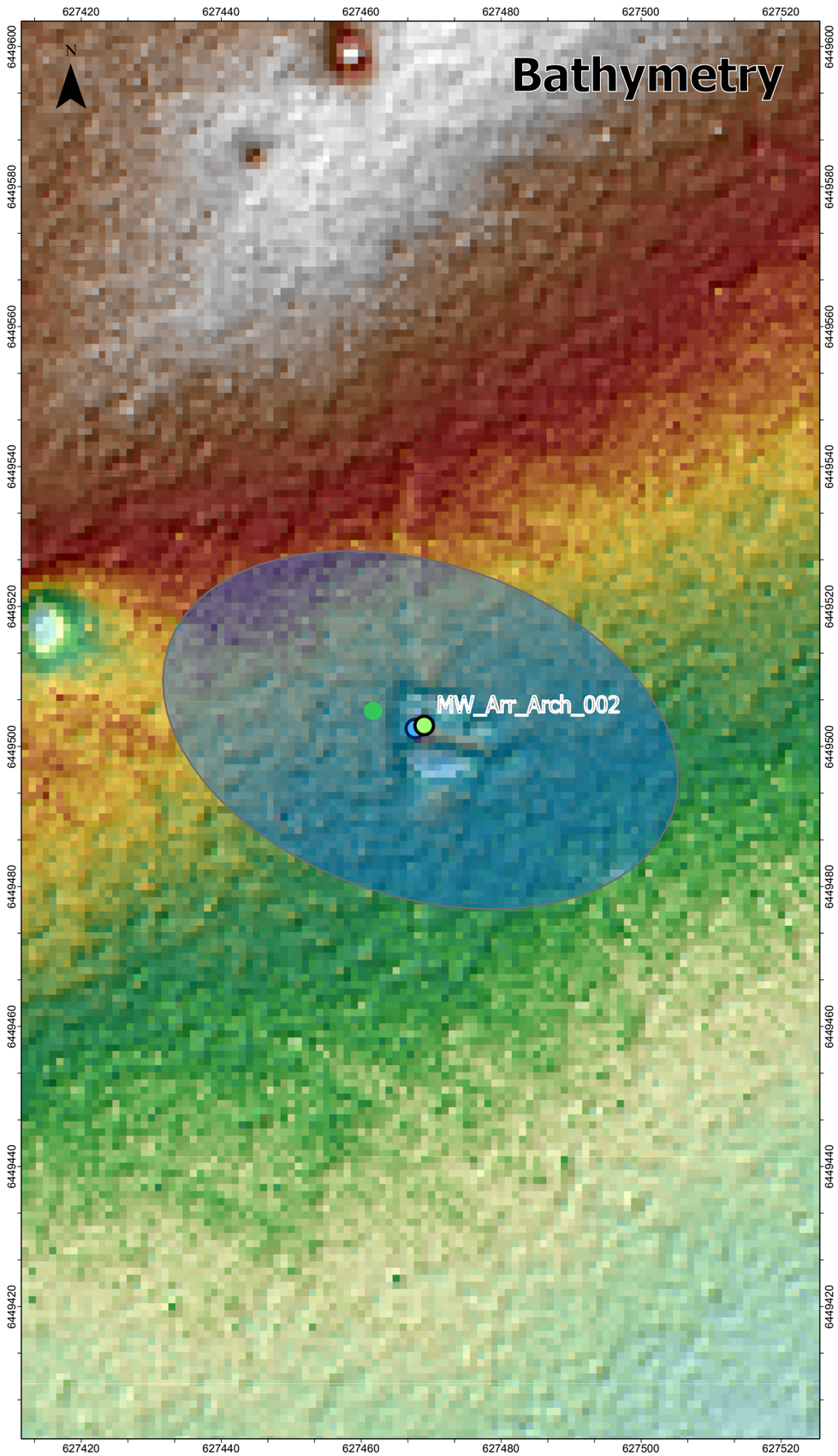
Archaeological potential	Number of anomalies
Low	48
Medium	17
High	6
Total	71

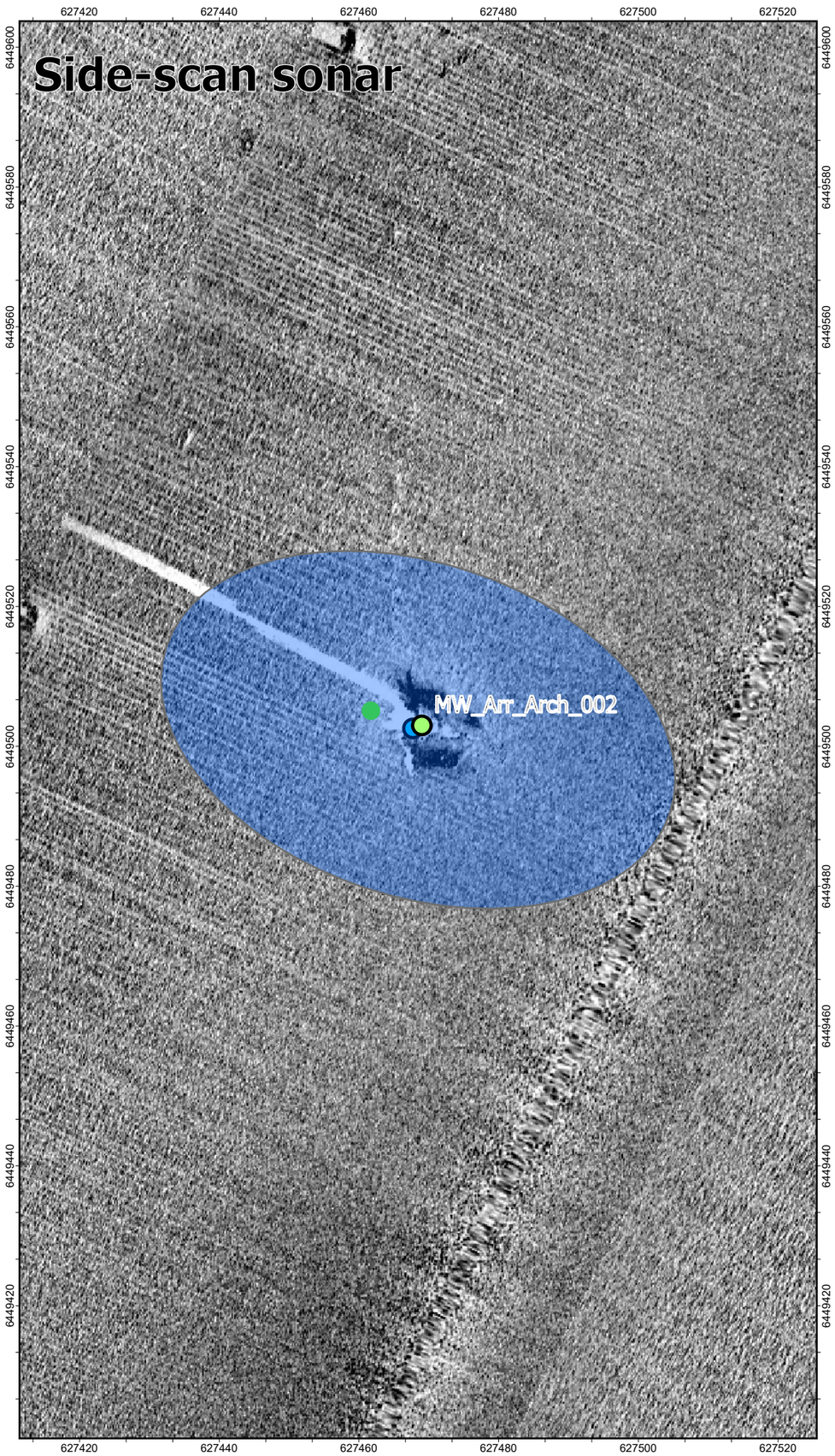
3.4.1.2 Within the OAA, the anomalies with archaeological potential are fairly evenly distributed across the area, though there is a cluster along the northern edge of the central bathymetric high. The ratios between high, medium and low potential anomalies are relatively consistent with a typical archaeological assessment of data. Details of each of the identified anomalies are provided in **Appendix A**, with those of medium to high potential discussed below in **Section 3.4.2** and **Section 3.4.3**.

3.4.2 Medium archaeological potential anomalies

3.4.2.1 Seventeen anomalies with medium archaeological potential were identified within the OAA. These are described below.

3.4.2.2 MW_Arr_Arch_0002 (**Figure 8**) consists of a light angular SSS reflector, measuring 5.6m x 5.3m x 9.0m. This is associated with an area of scour visible within the MBES surrounding a linear feature measuring 15.1m x 2.25m x 0.27m and associated with MAG Anomaly Anom_A_014 (5nT). The origin of this feature is unclear but is likely to be anthropogenic. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 48m and major axis of 75m, the latter orientated 114°parallel to the direction of the linear anomaly and scour extension.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-98.20

-99.46

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

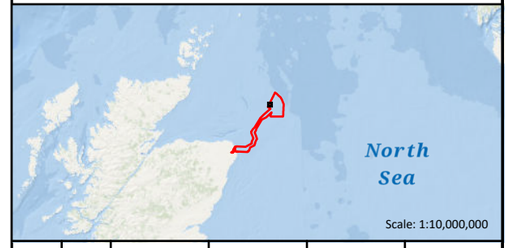
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
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1	21/07/2025	MJG	LT	TG	NC

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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000149
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:750
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 8 Geophysical anomaly MW_Arr_Arch_0002

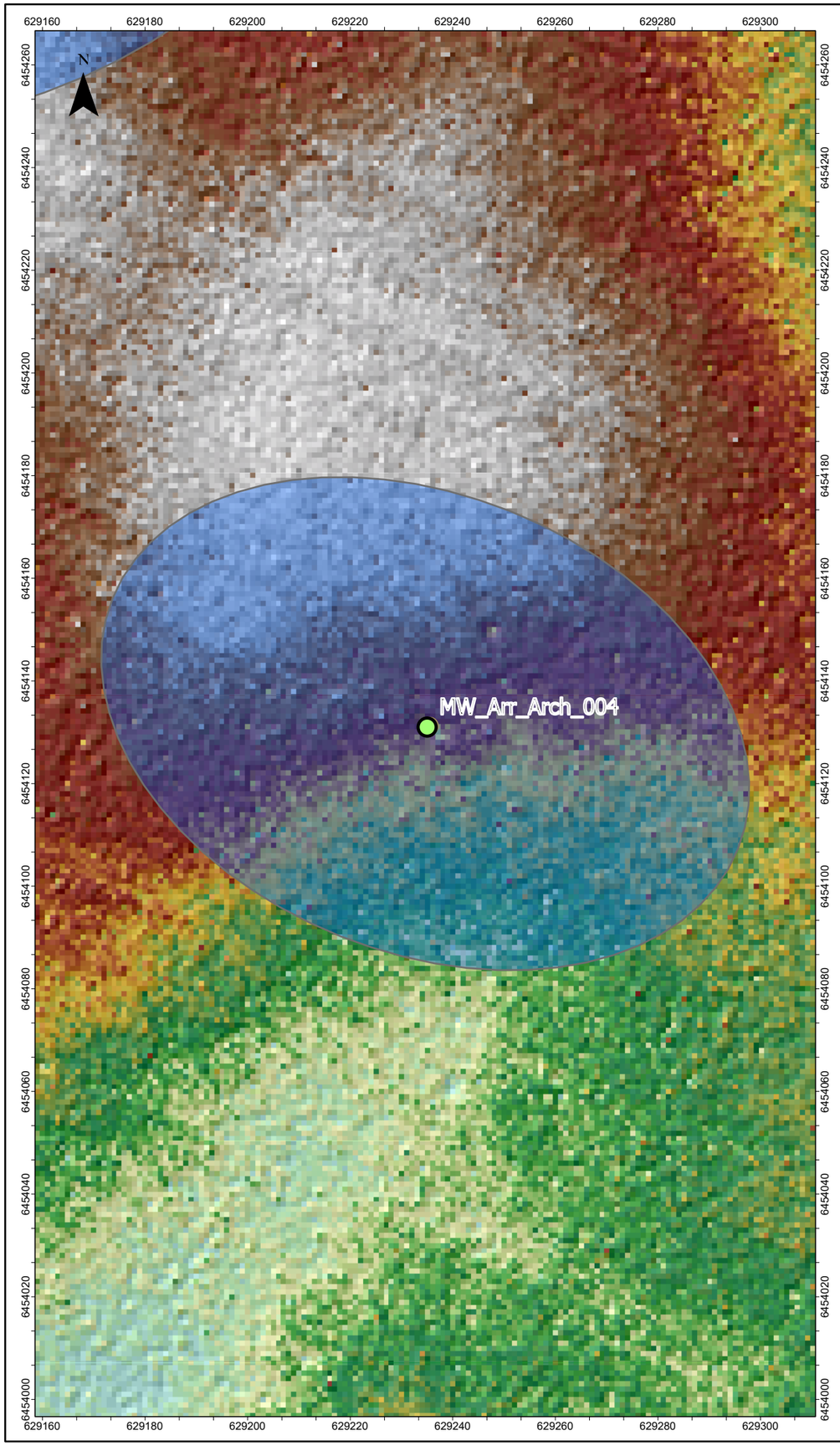
Environmental Impact Assessment Report
Appendix 16.2

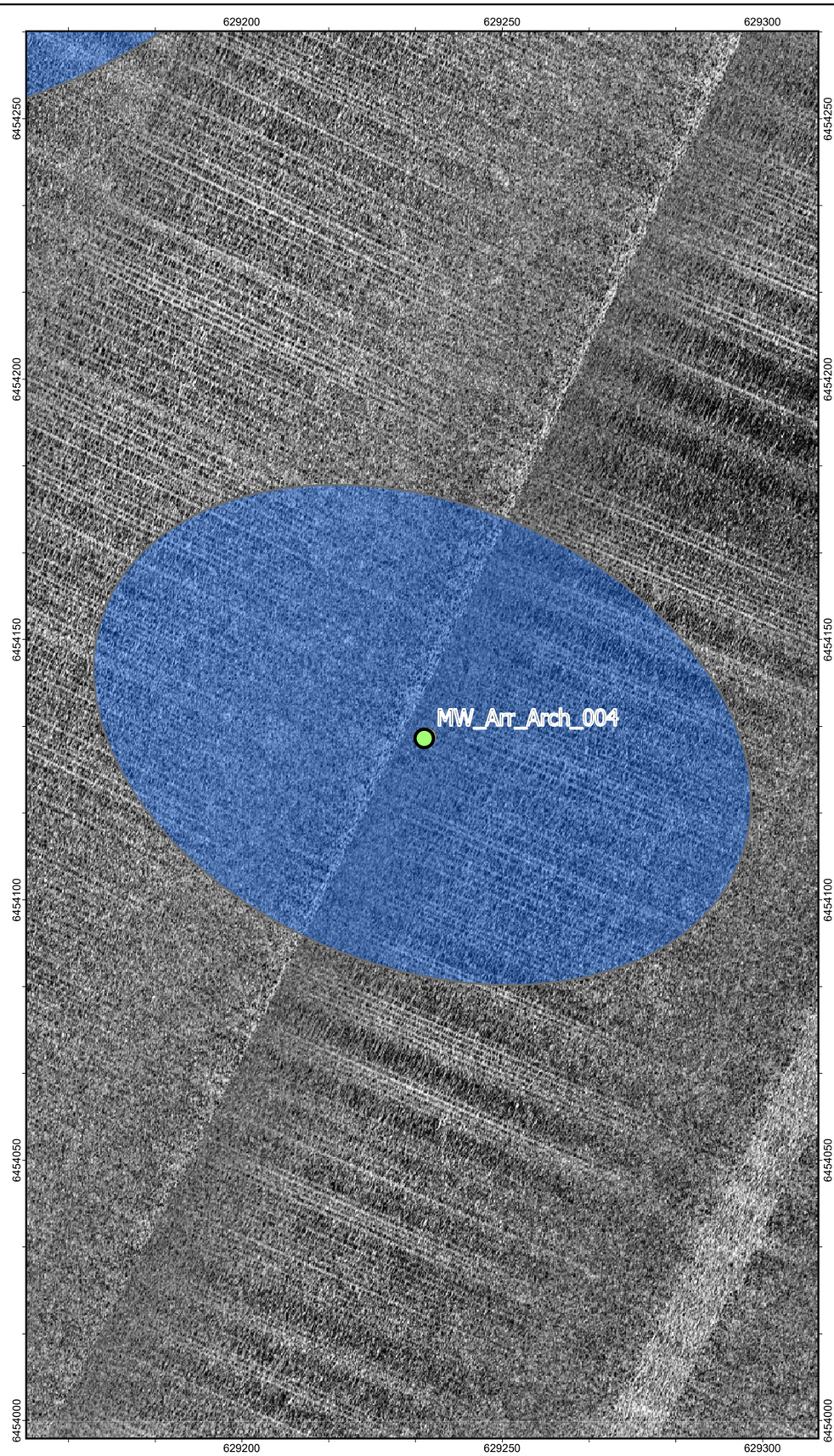
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3.4.2.3 MW_Arr_Arch_0004 (**Figure 9**) consists of a SSS reflector, measuring 0.5m x 0.2m (SSS_A_0172), associated with an MBES depression, 6.2m x 2.0m x 0.2m and MAG anomaly Anom_A_002 (36nT). The origin of this feature is unclear but likely to be anthropogenic and indicates the presence of ferrous material, at least partially buried. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 90m and major axis of 130m, the latter orientated 118° parallel to the direction of the linear anomaly and scour extension.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-105.39

-105.73

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

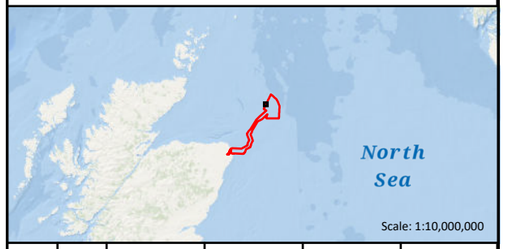
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 Meters



2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-58322
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000150

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 9 Geophysical anomaly MW_Arr_Arch_0004

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Appendix 16.2

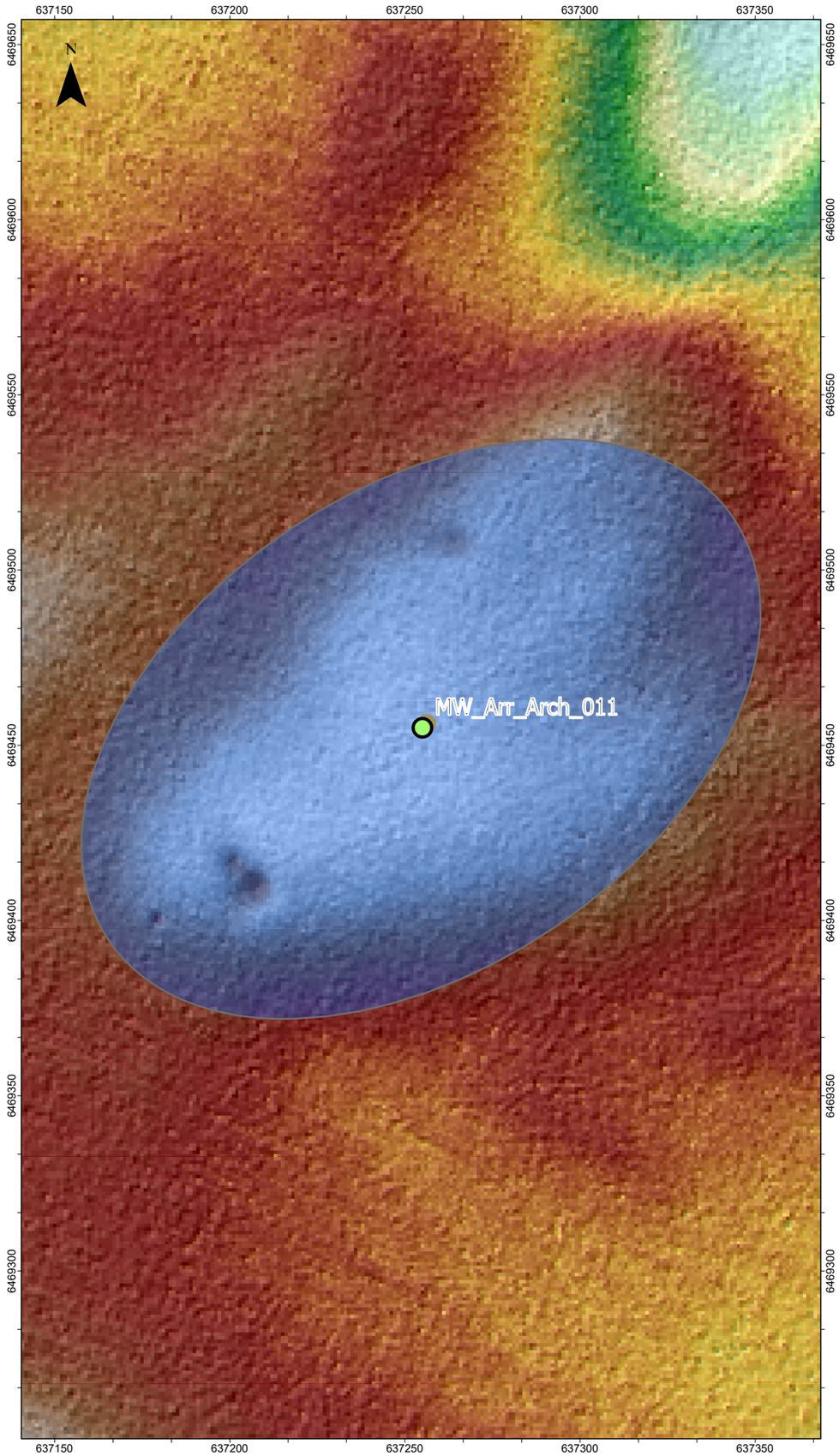
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Data Sources:
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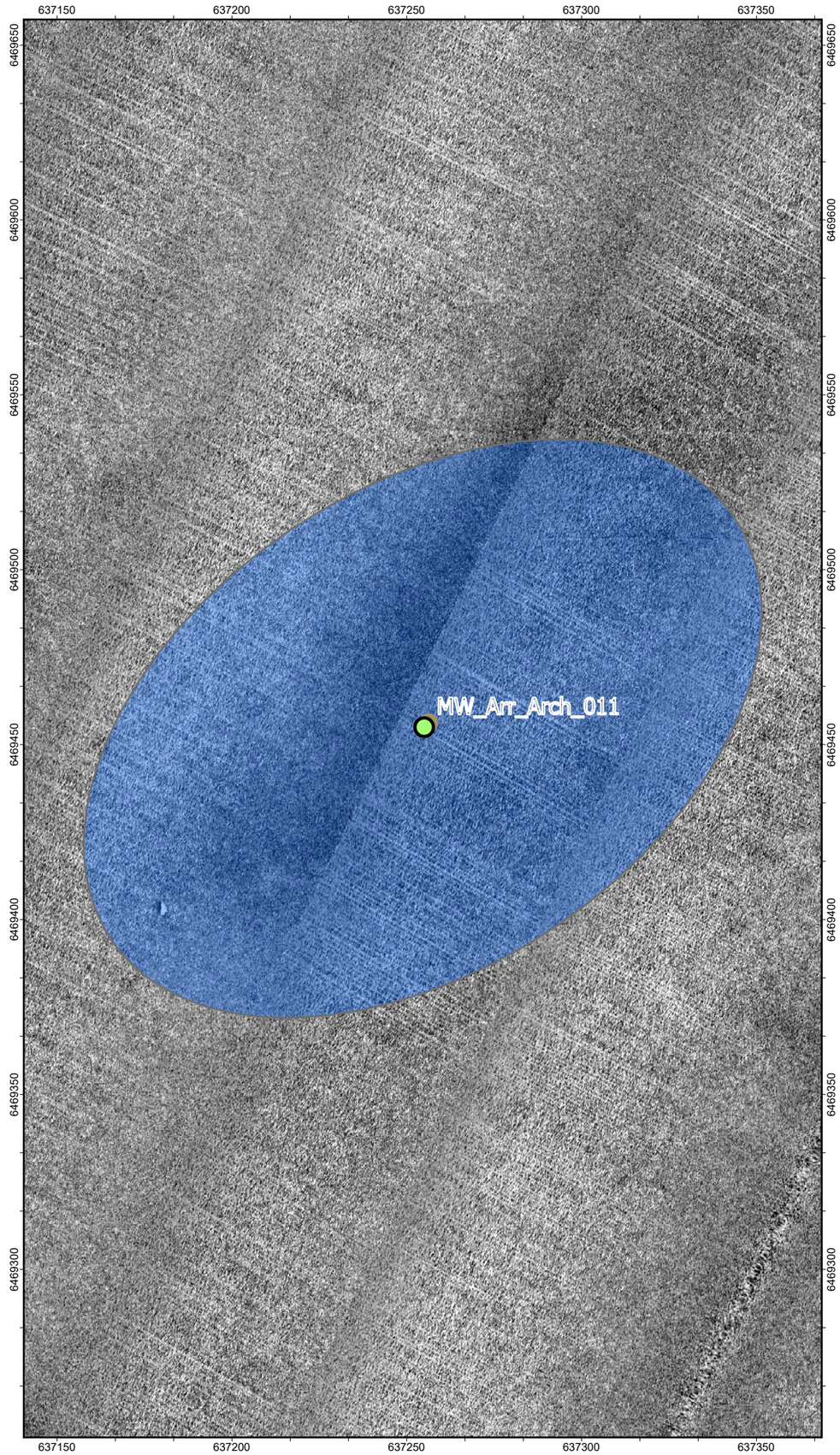
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.4 MW_Arr_Arch_0011 (**Figure 10**) consists of MAG anomaly Anom_A_012 (42nT) situated within an area of slightly elevated seabed, measuring 200m x 140m. There are no anomalies within the MBES or SSS datasets, though there is a depression on the southwest side of the bathymetric high, measuring 17m x 11m x 0.3m. The MAG Anomaly suggests that ferrous material may be buried beneath the seabed within this bathymetric height. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 140m and major axis of 210m, the latter orientated 051° parallel to the direction of the bathymetric high.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-114.07

-115.50

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

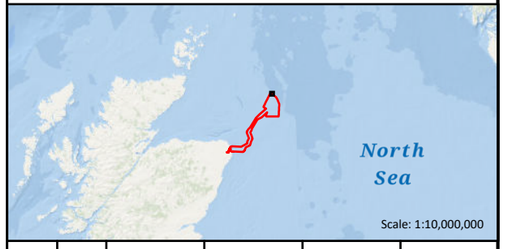
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



			--	--	--
2	19/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-43077
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000115

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 10 Geophysical anomaly MW_Arr_Arch_0011

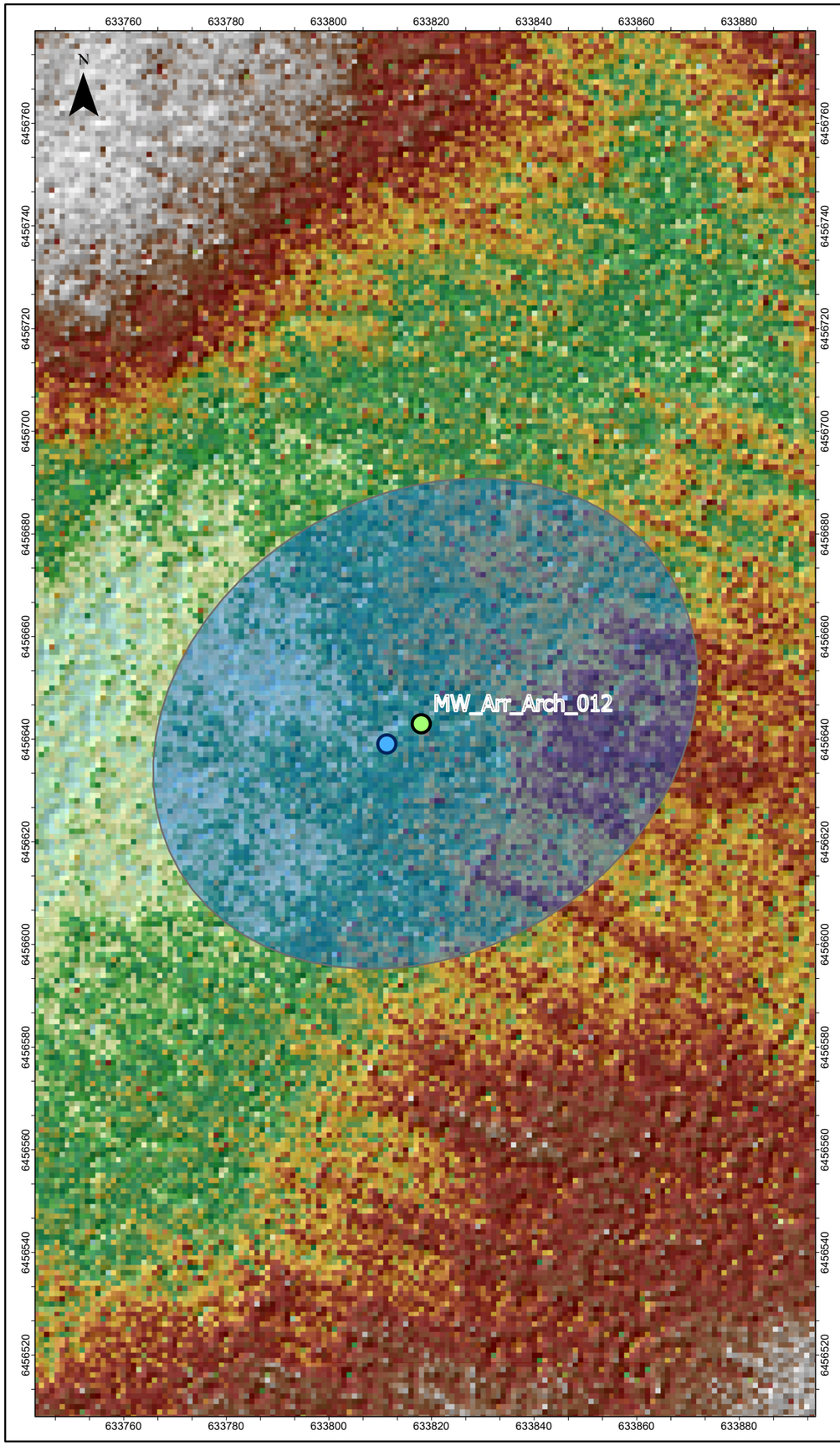
Environmental Impact Assessment Report
Appendix 16.2

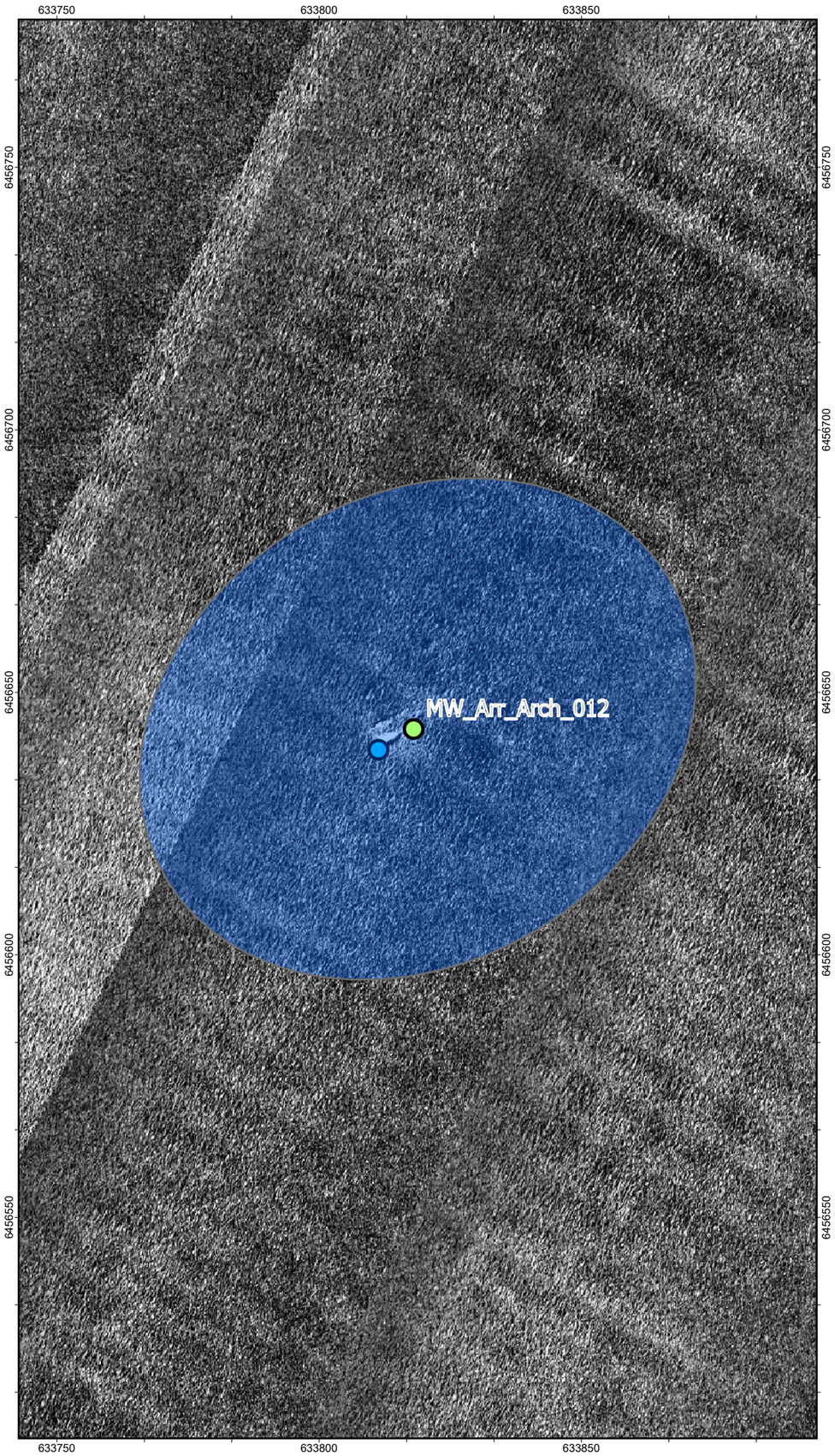
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Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

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wsp MarramWind

3.4.2.5 MW_Arr_Arch_0012 (**Figure 11**) consists of a linear dark SSS reflector (SSS_C_1463), measuring 7.8m x 1.2m x 0.4m. This is located within an area of increased seabed roughness visible in both the SSS and MBES, suggesting a debris spread. There is no associated MAG anomaly. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 90m and major axis of 110m, the latter orientated 059° parallel to the direction of the SSS anomaly.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.39

-104.74

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

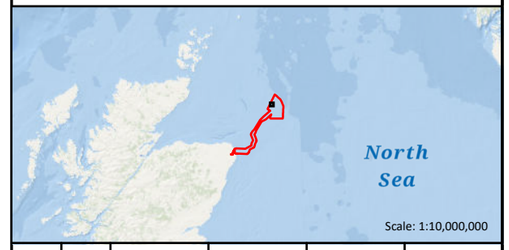
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-20525
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000116

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 11 Geophysical anomaly MW_Arr_Arch_0012

Environmental Impact Assessment Report
Appendix 16.2

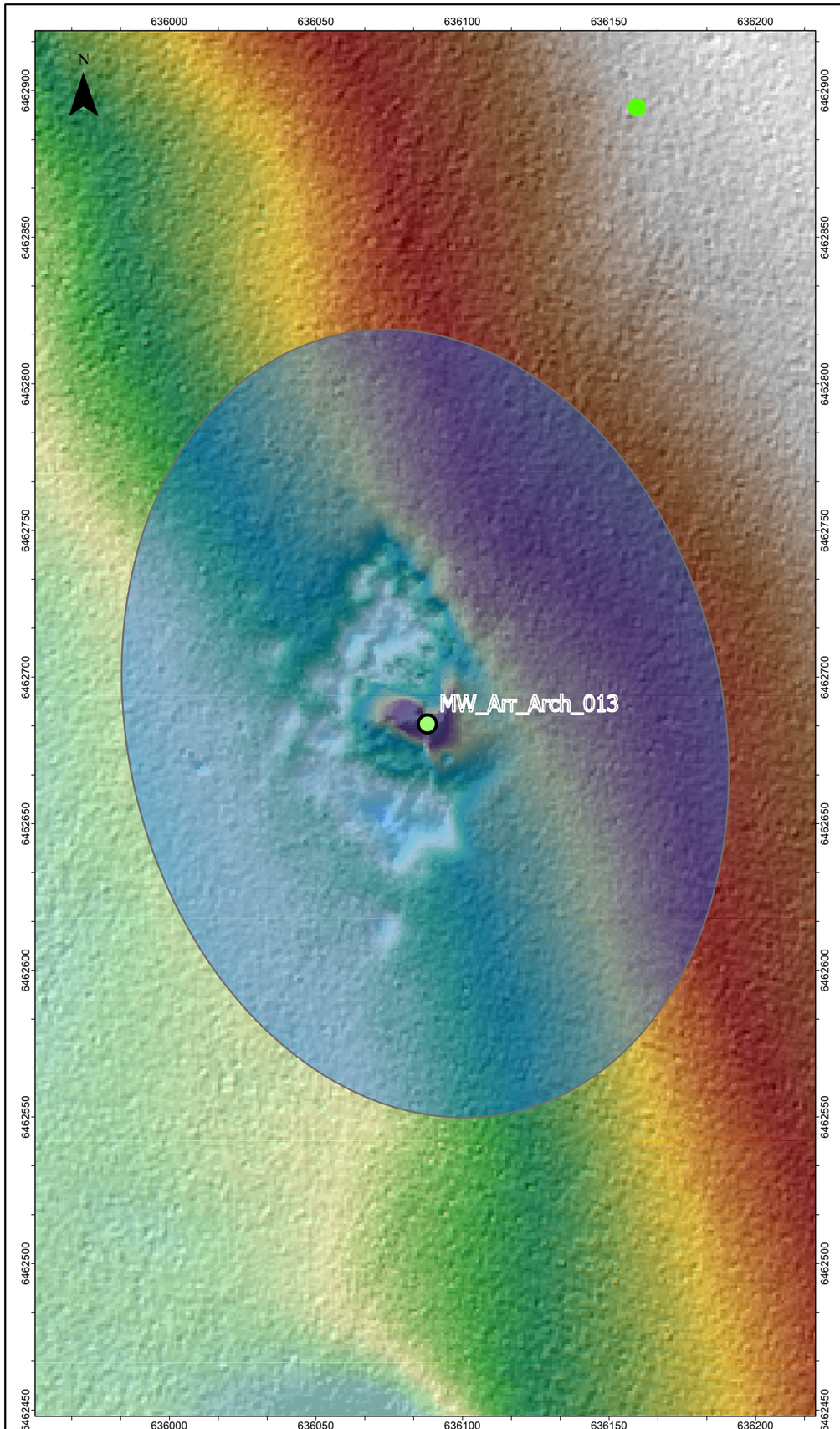
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

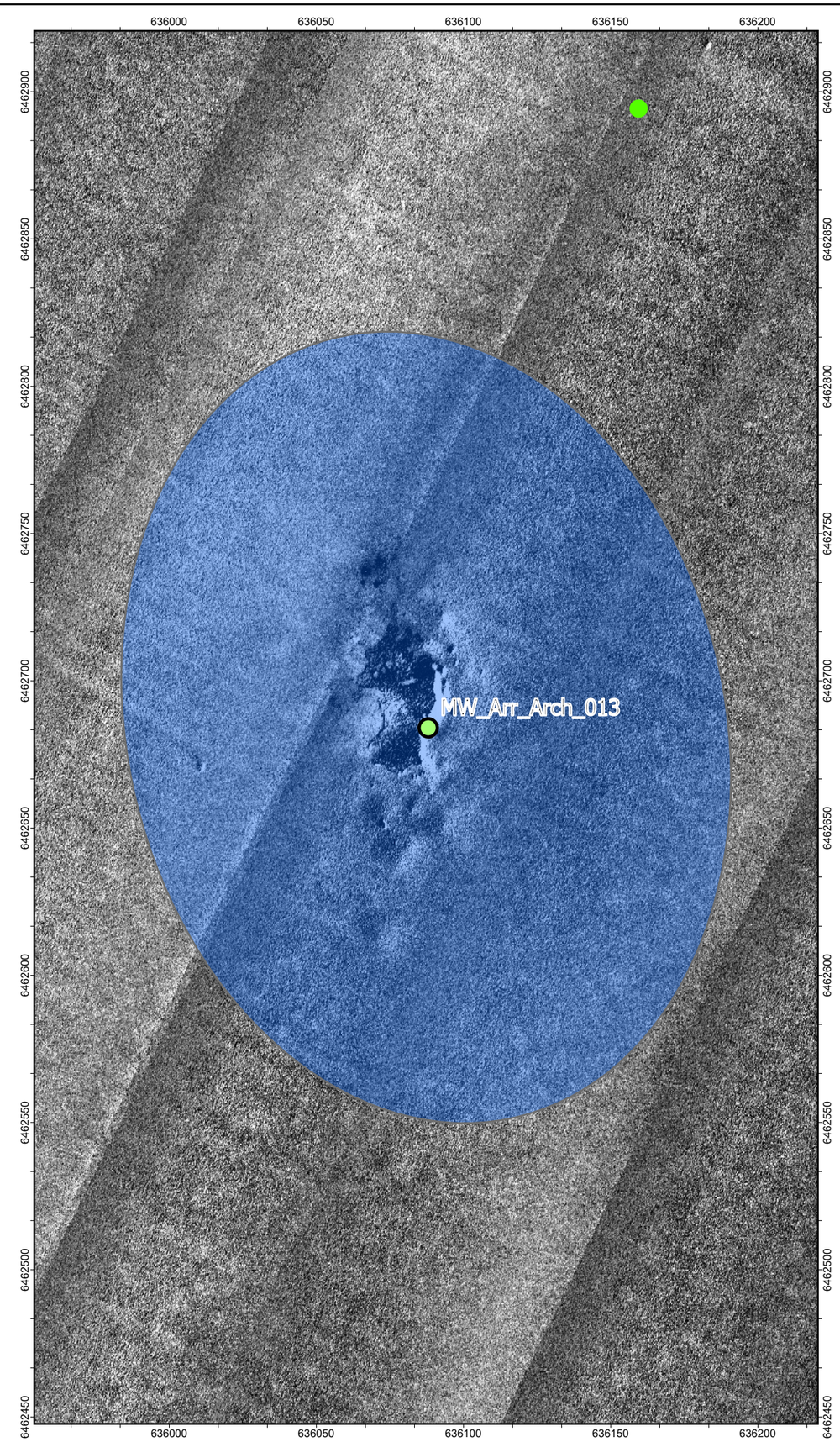
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.6 MW_Arr_Arch_0013 (**Figure 12**) consists of an area of increased seabed roughness visible in both the MBES and SSS, covering an area 67m x 38m, within a central upstanding feature visible in the MBES measuring 38m x 21m x 1.5m. This anomaly is located on the western margin of a bathymetric high. This anomaly differs from nearby boulder anomalies, which consist of simple depressions with a central boulder feature. The presence of a central upstanding feature would suggest that this is unlikely to be a pockmark but instead may be a buried feature around which scour has occurred. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 205m and major axis of 270m, the latter orientated 165° parallel to the direction of the seabed scour.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-106.72

-109.56

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

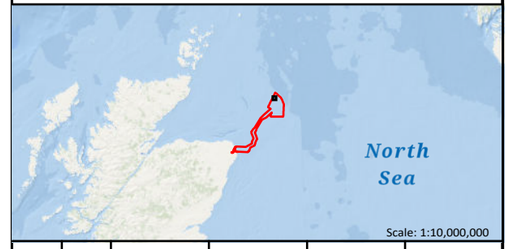
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
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2	18/09/2025	MJG	LT	TG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-40703
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000117
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:1,750
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 12 Geophysical anomaly MW_Arr_Arch_0013

Environmental Impact Assessment Report
Appendix 16.2

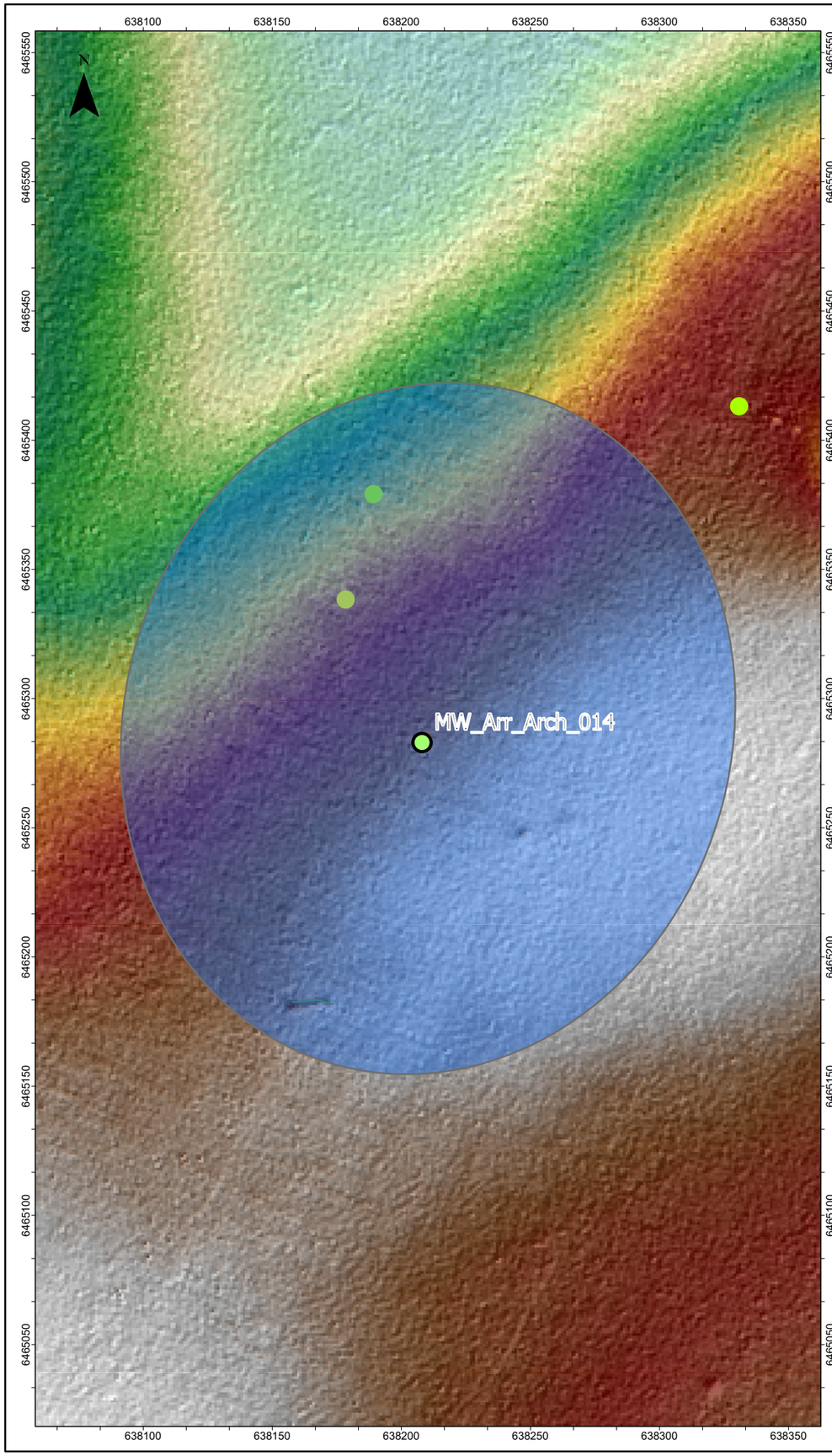
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

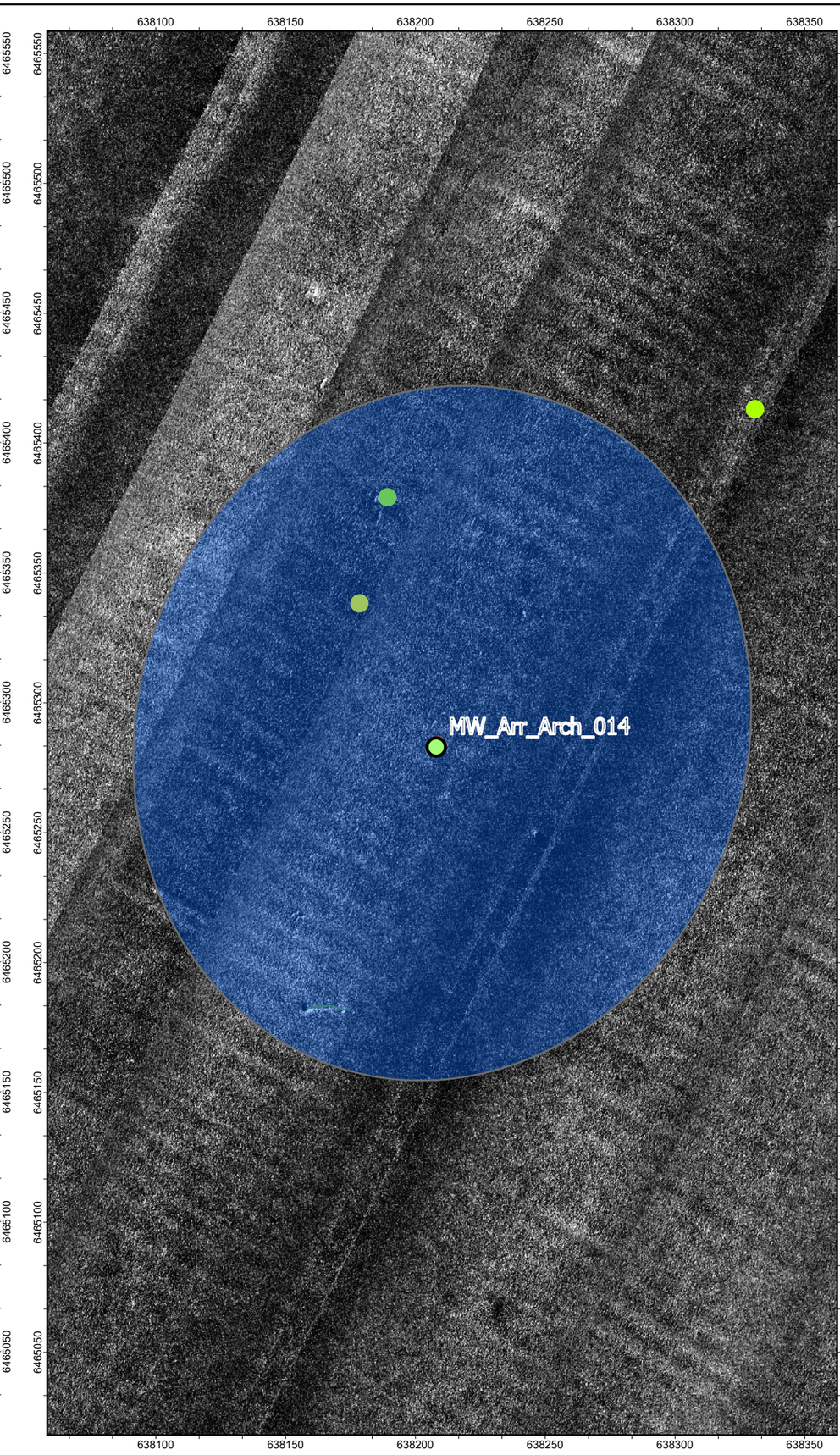
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.7 MW_Arr_Arch_0014 (**Figure 13**) consists of MAG anomaly ANOM_C_022 (78nT), situated within an area where a series of small (<0.5m) light angular SSS reflectors are visible on the seabed, with additional MAG anomalies 63m (ANOM_C_020; 26nT) and 97m (Anom_C_027; 19nT) further north. This possible debris spread is located on the northern edge of the central bathymetric high. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 240m and major axis of 270m, the latter orientated 016° parallel to the direction SSS reflectors.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.85

-106.90

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

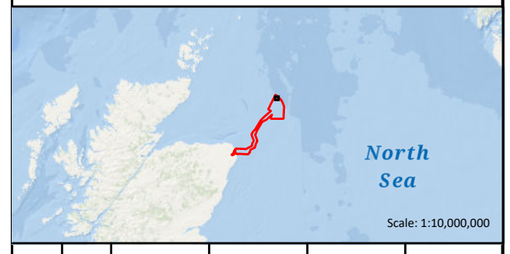
SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

- 5-9 nT
- 10-19 nT
- 20-29nT
- 30-49 nT
- 50-99 nT
- 100-500 nT
- 500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 110 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-13127
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000118

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:2,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 13 Geophysical anomaly MW_Arr_Arch_0014

Environmental Impact Assessment Report
Appendix 16.2

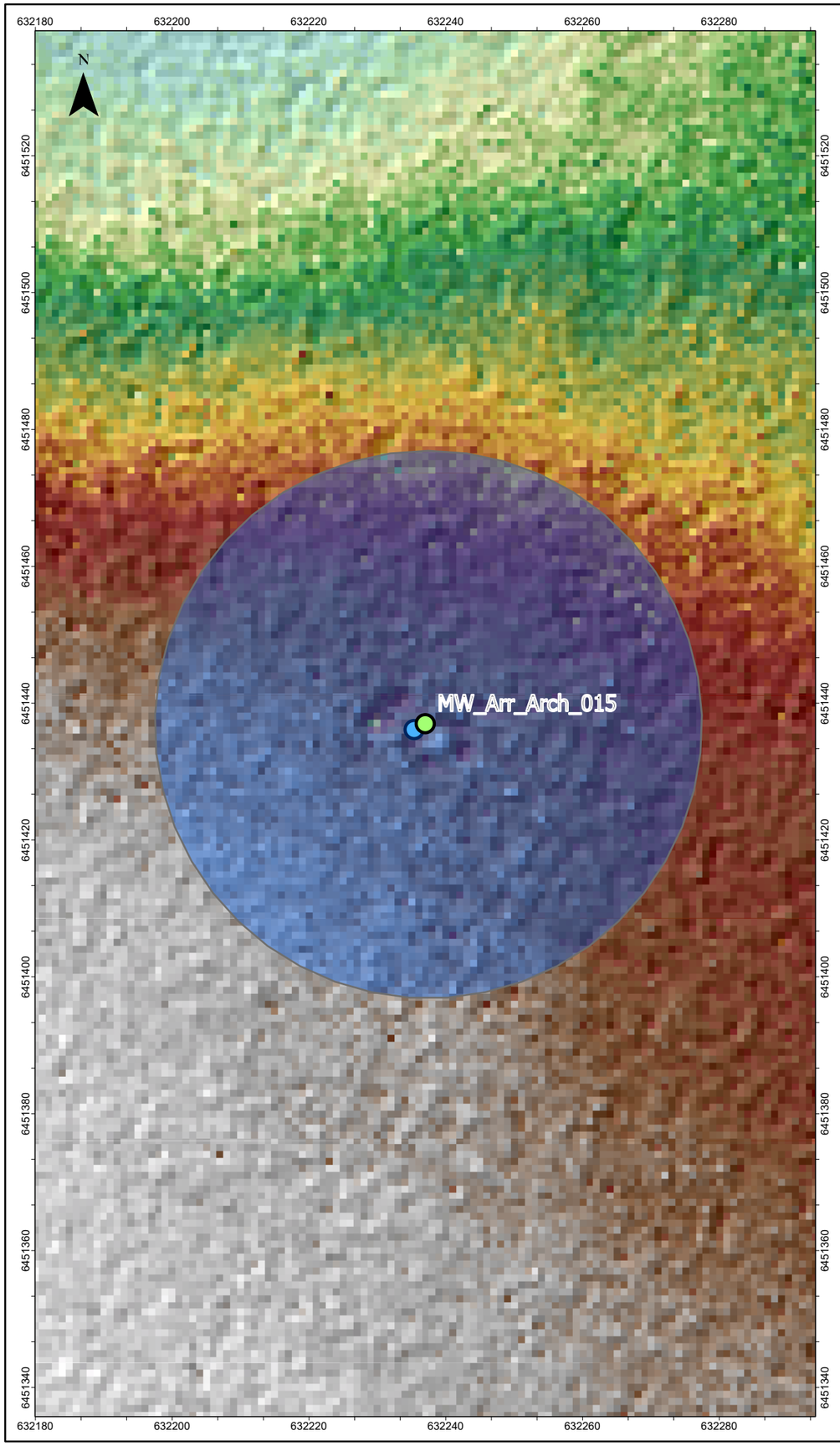
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

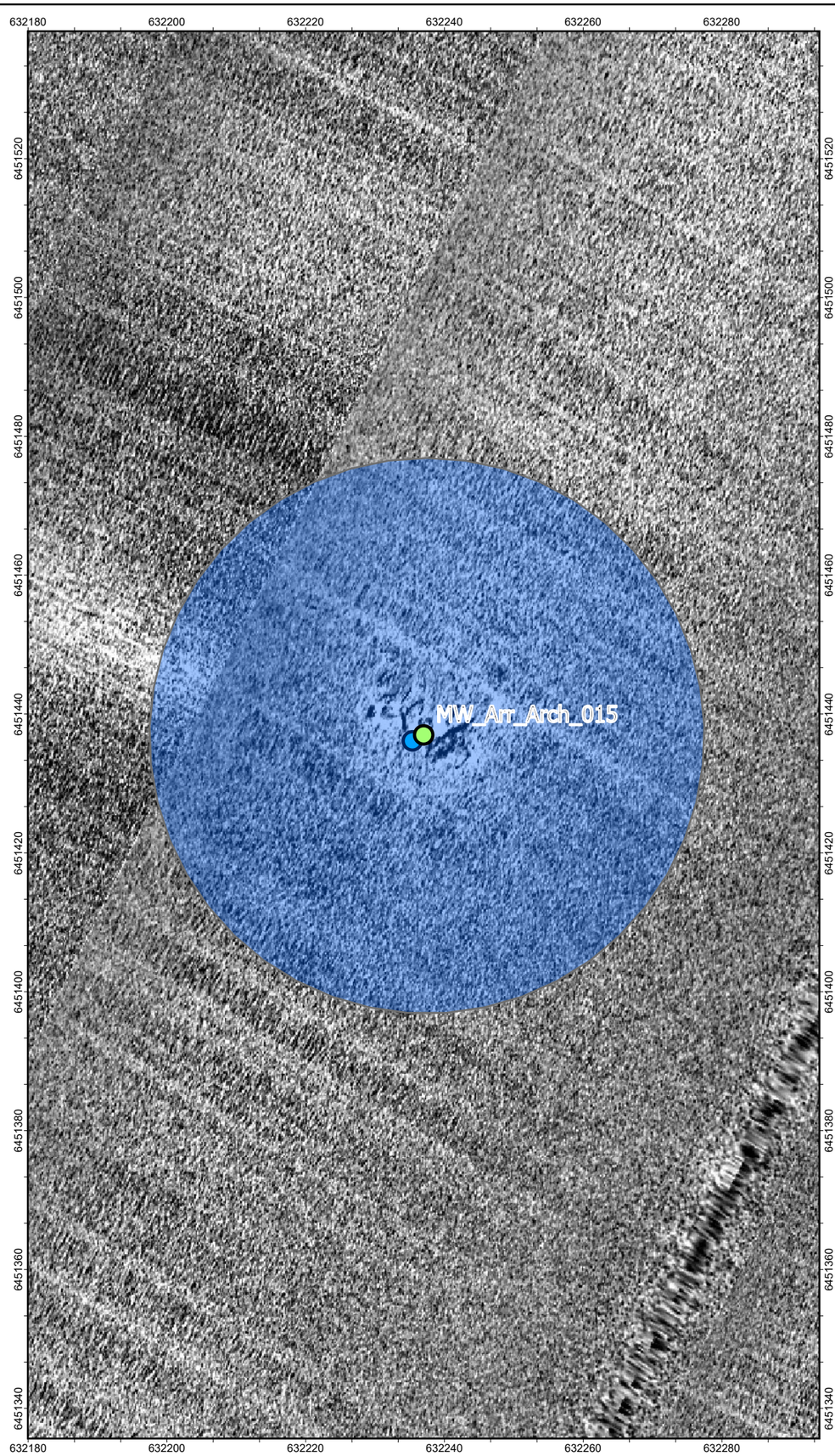
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.8 MW_Arr_Arch_0015 (**Figure 14**) consists of a group of linear dark angular SSS reflectors (SSS_D_0386), covering an area 17.3m x 10.9m x 0.5m, coinciding with an area of increased roughness in MBES, 24m x 21m. This may be a small debris field. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 80m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.29

-105.01

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

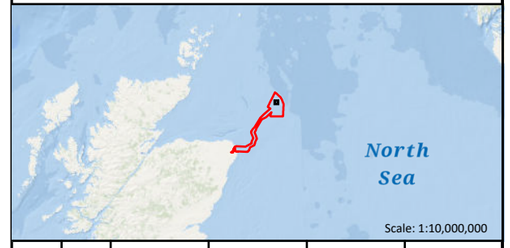
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 Meters



			--	--	--
2	18/09/2025	MJG	LT	TG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER 808368-WEIS-IA-E5-FG-M2-15179

MarramWind DRAWING NUMBER MAR-GEN-ENV-MAP-WSP-000119

DATUM ETRS 89 | PROJECTION UTM Zone 30N

SCALE 1:750 | PAGE SIZE A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 14 Geophysical anomaly MW_Arr_Arch_0015

Environmental Impact Assessment Report
Appendix 16.2

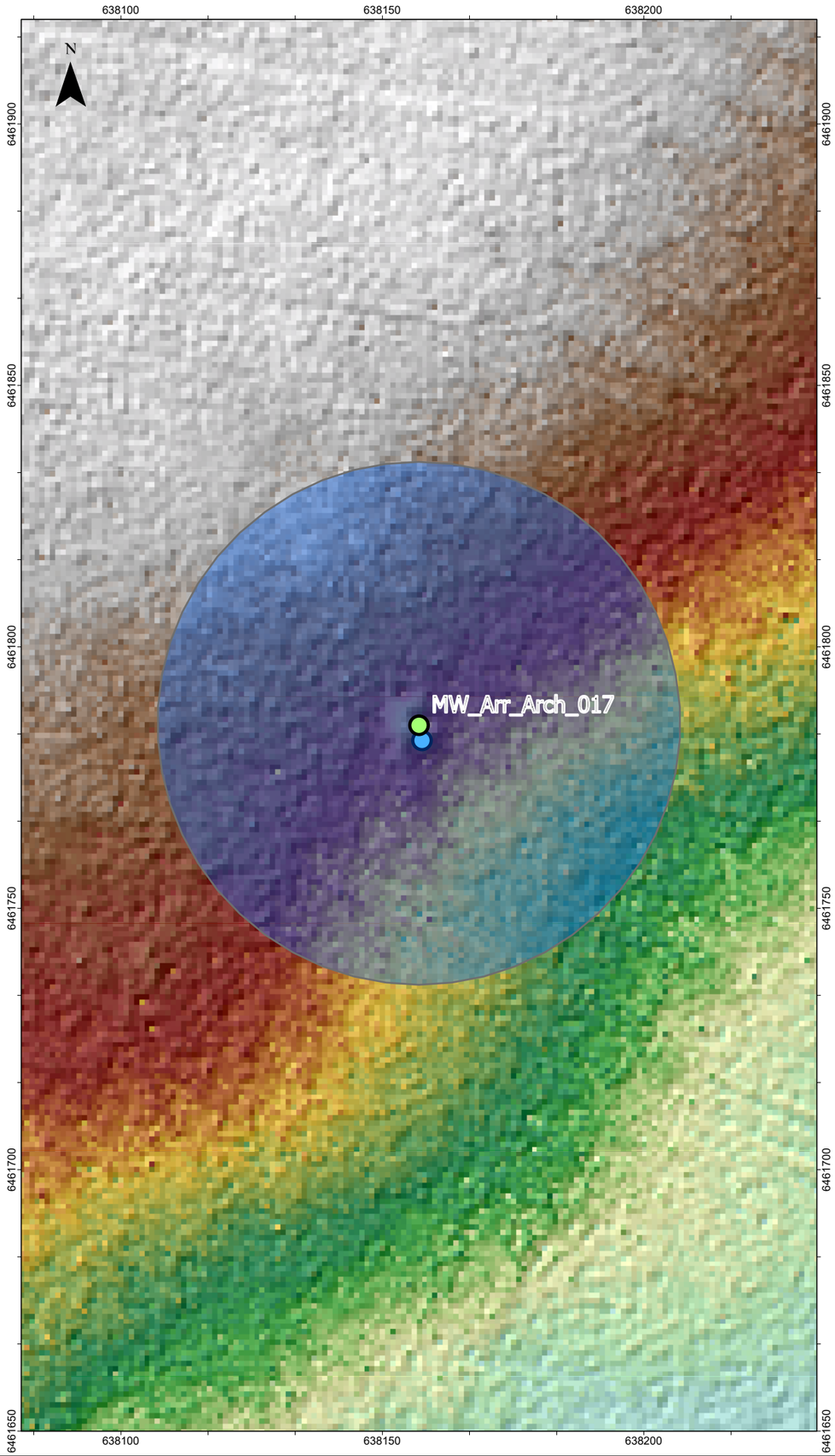
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

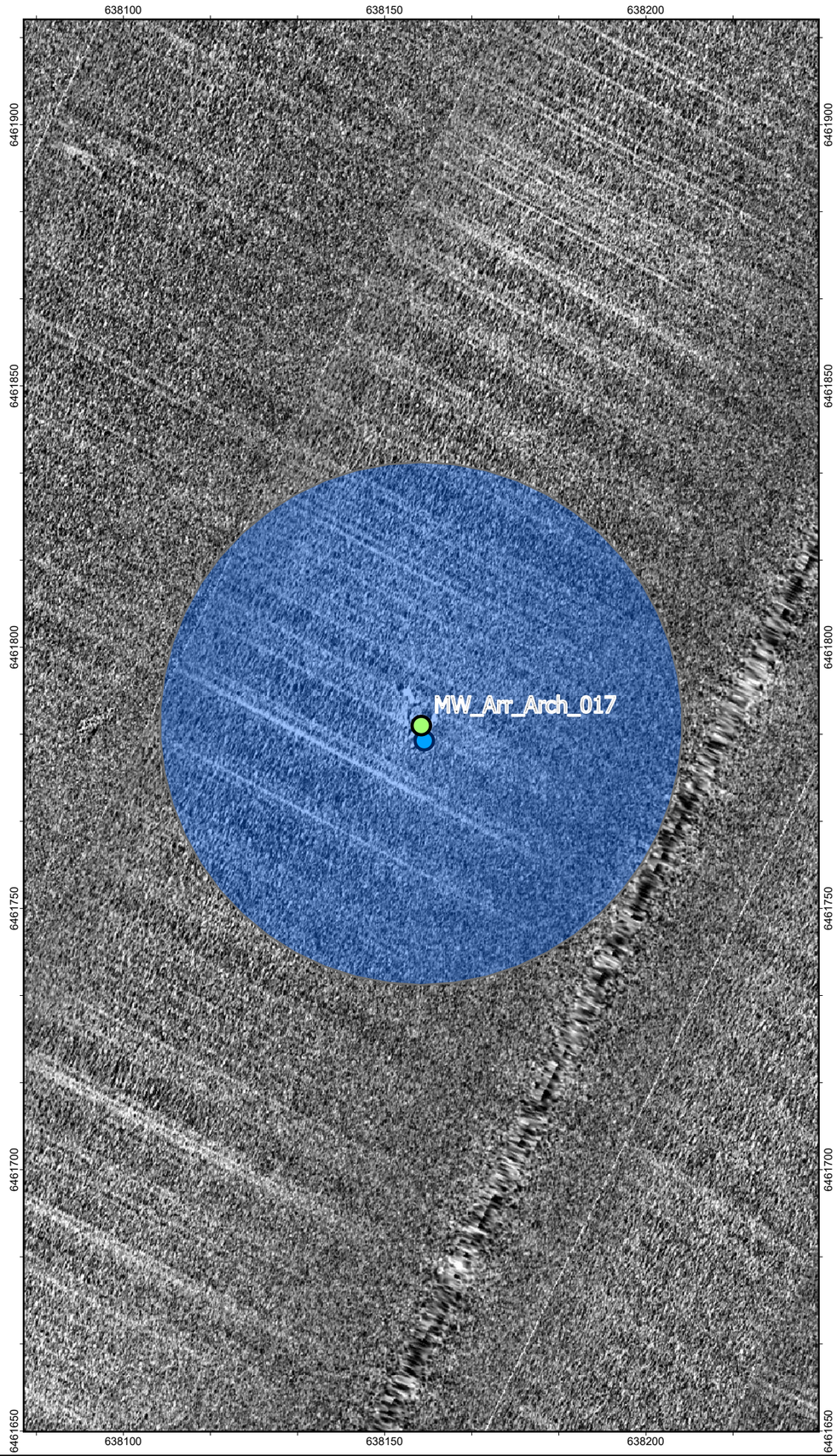
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.9 MW_Arr_Arch_0017 (**Figure 15**) consists of a group of linear dark angular SSS reflectors (SSS_D_0950), up to 5.4m long each, covering an area 14.5m x 10.1m. These are centred on an area of raised seabed in the MBES, measuring 10.7m x 10.4m x 0.3m. This may reflect a concentration of debris. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 100m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.60

-105.51

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

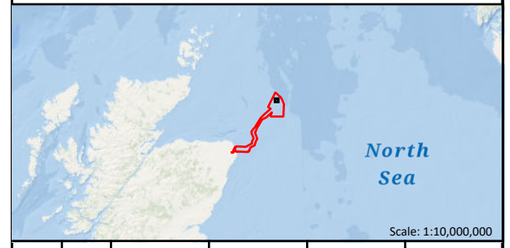
SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

- 5-9 nT
- 10-19 nT
- 20-29nT
- 30-49 nT
- 50-99 nT
- 100-500 nT
- 500-1000 nT

0 10 20 30 40 50 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-14084
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000120

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 15 Geophysical anomaly MW_Arr_Arch_0017

Environmental Impact Assessment Report
Appendix 16.2

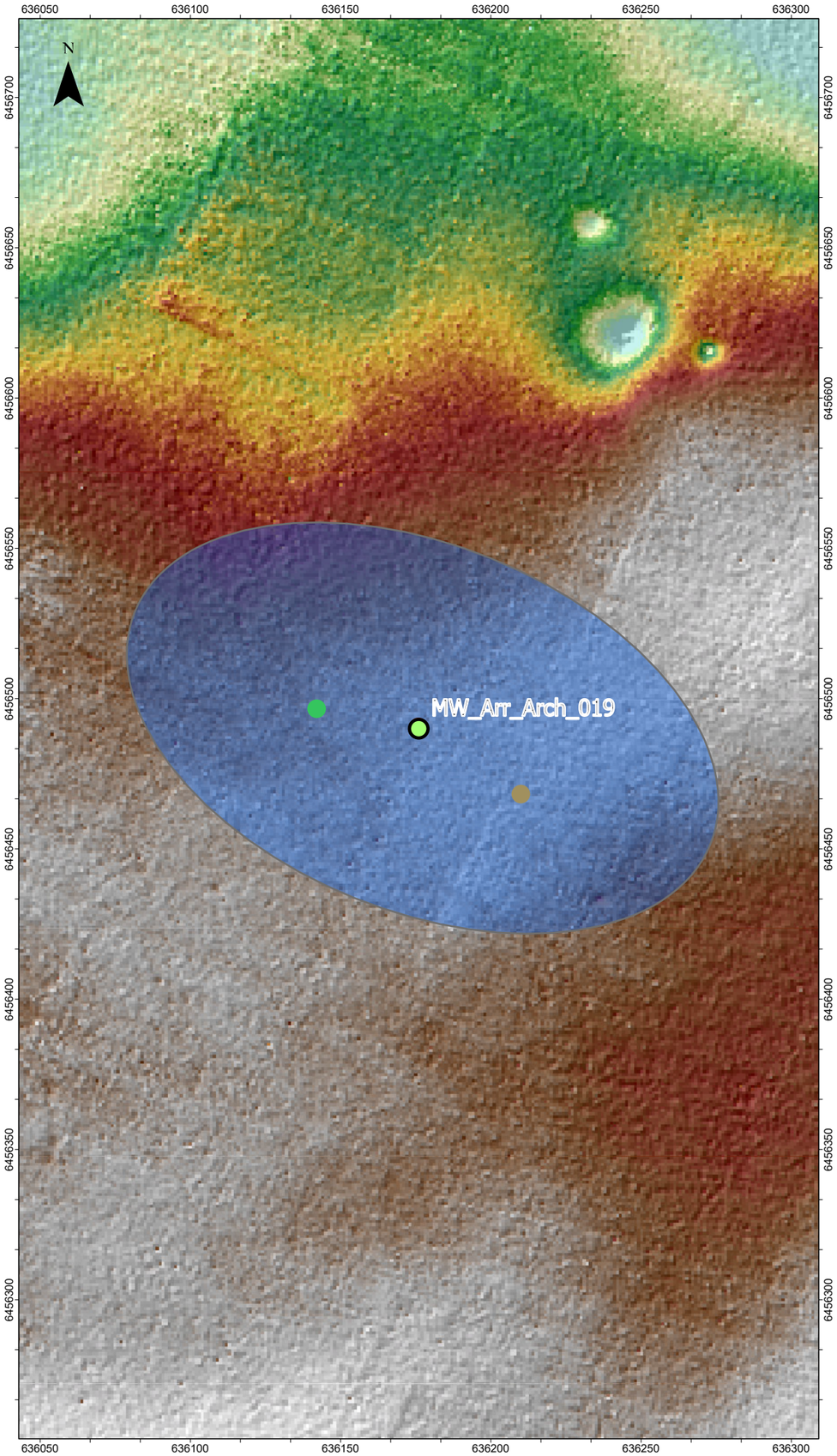
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

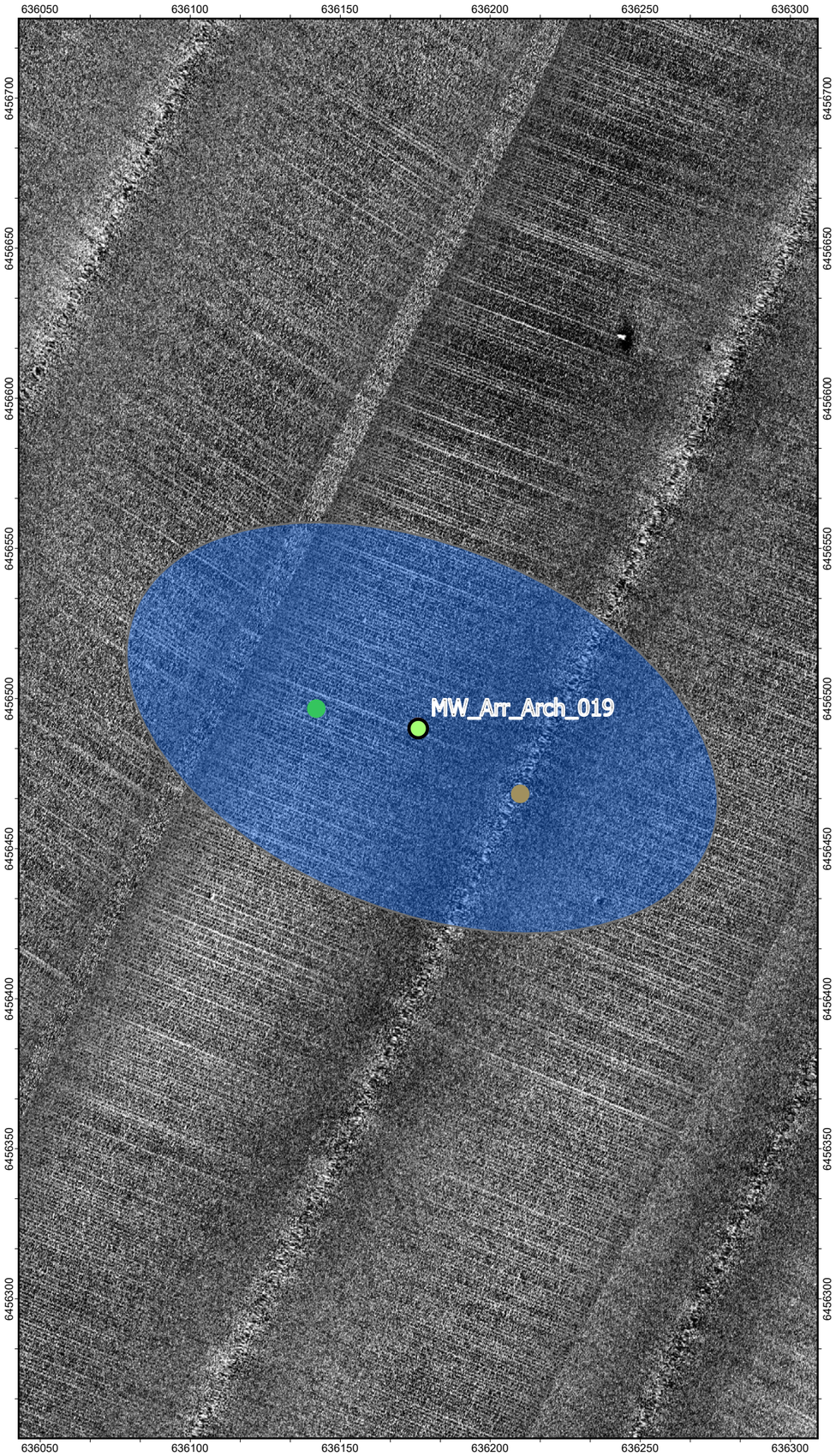
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.10 MW_Arr_Arch_0019 (**Figure 16**) consists of MAG anomaly Anom_E_001 (52nT) within an area of flat featureless seabed. 36m west is MAG anomaly Anom_E_005 (5nT) while 40m east is MAG anomaly Anom_E_020 (44nT). This would strongly suggest the presence of buried ferrous material in this area. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 125m and major axis of 205m, the latter orientated 117° parallel to the MAG anomaly alignment.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-101.59

-102.95

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

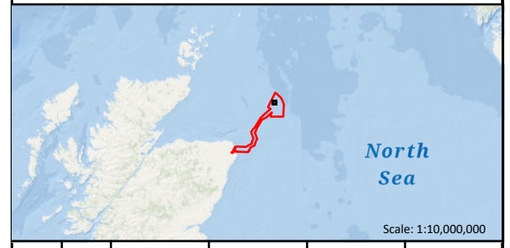
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-62927
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000121
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:1,750
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 16 Geophysical anomaly MW_Arr_Arch_0019

Environmental Impact Assessment Report
Appendix 16.2

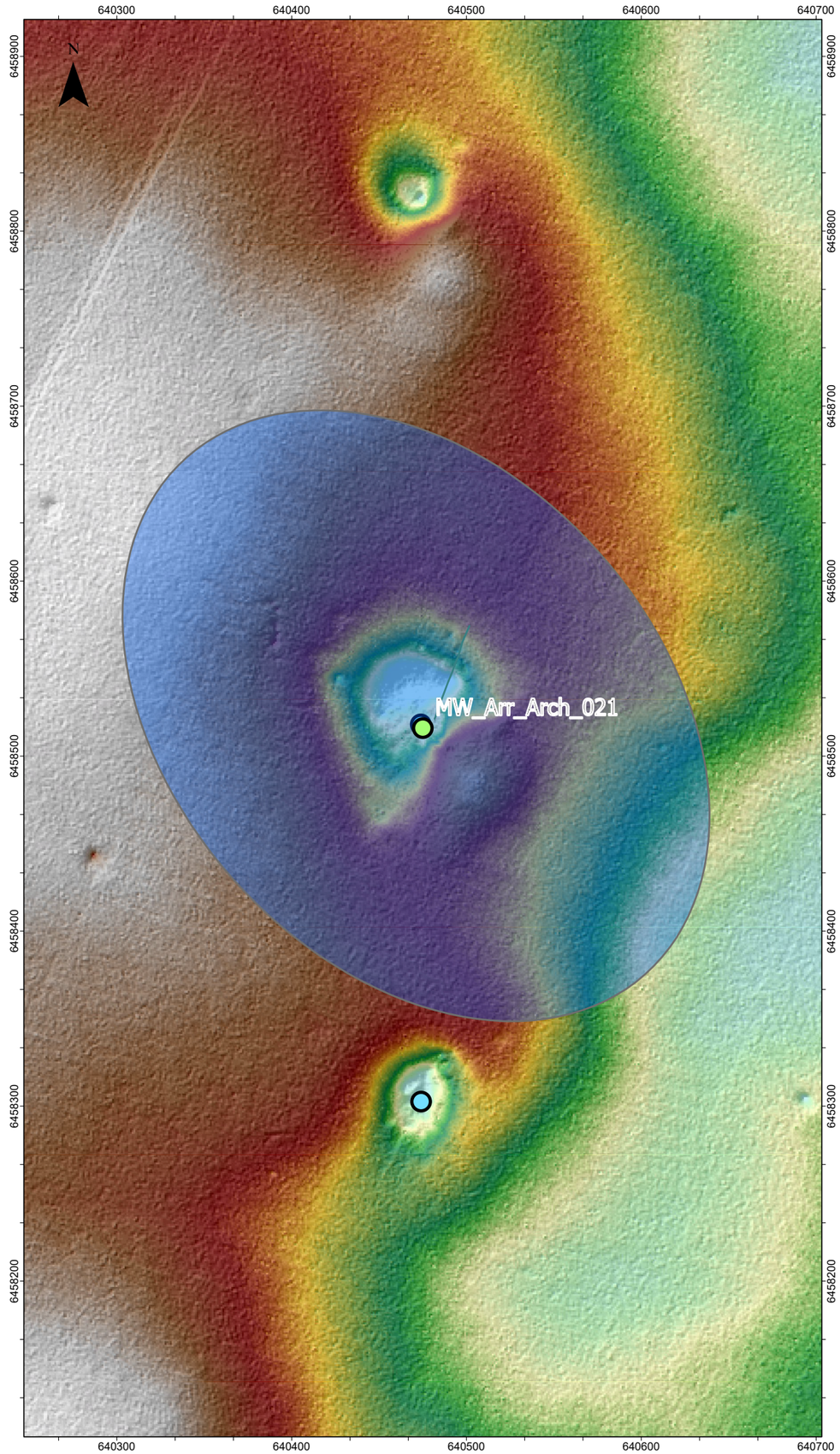
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

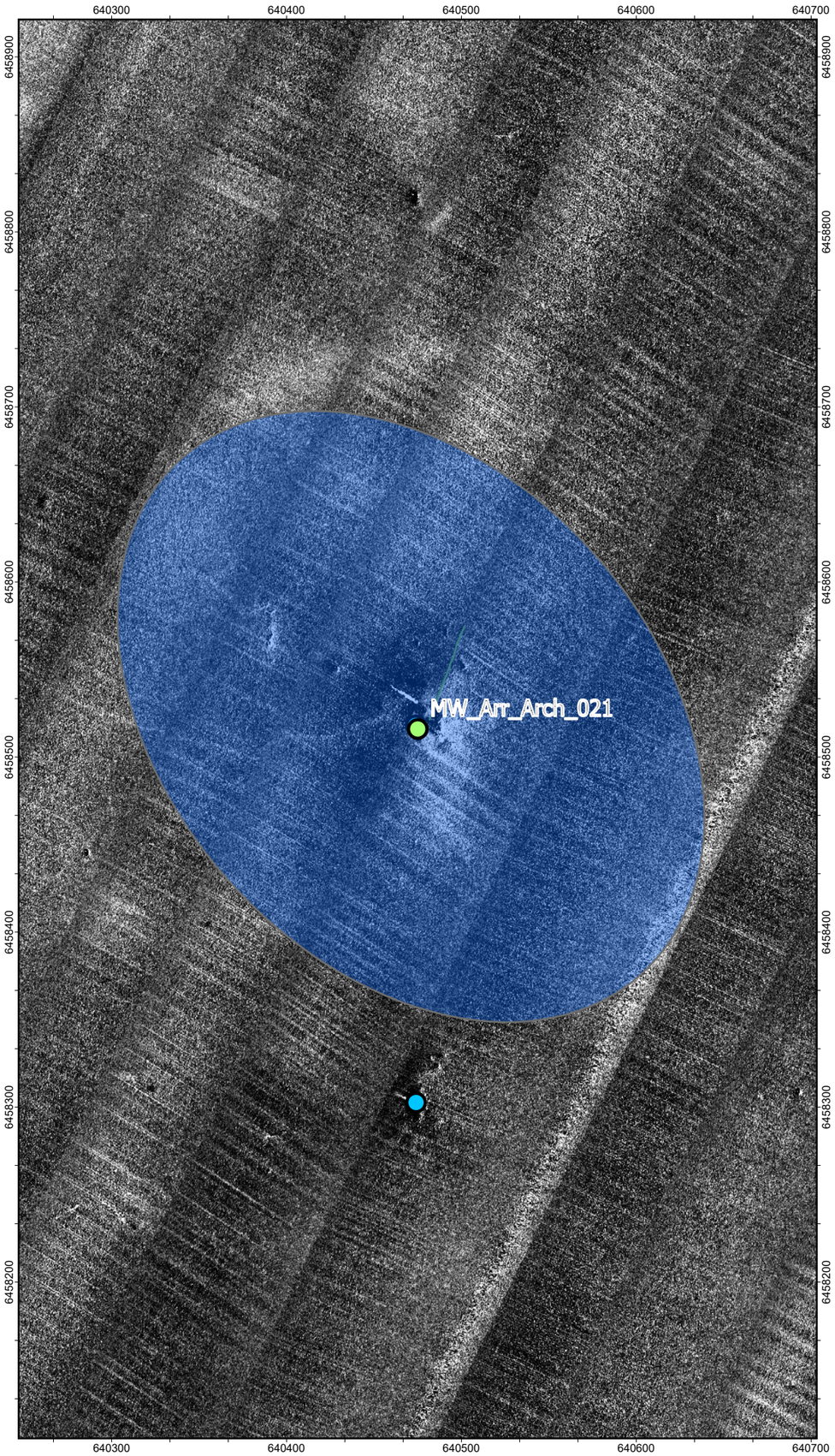
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.11 MW_Arr_Arch_0021 (**Figure 17**) consists of a dark angular SSS reflector (SSS_G_0048), 4m x 3.1m x 2.2m, located on the southeast corner of an area of scour visible in MBES, measuring 120m x 114m x 1.2m, with an elevated mound on its southeastern edge, measuring 65m x 52m x 0.6m. There are a series of similar depressions in the surrounding area, but these appear to be associated with boulders rather than debris. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 280m and major axis of 390m, the latter orientated 140° parallel to the scour and anomaly alignment.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-105.52

-107.76

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

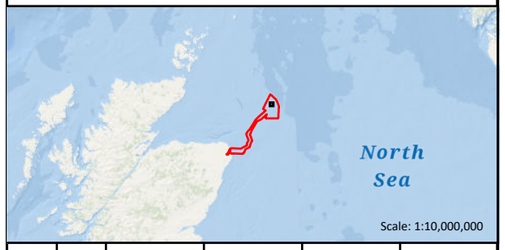
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 20 40 60 80 100 120 140 160 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-75631		
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000122		
DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:3,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 17 Geophysical anomaly MW_Arr_Arch_0021

Environmental Impact Assessment Report
Appendix 16.2

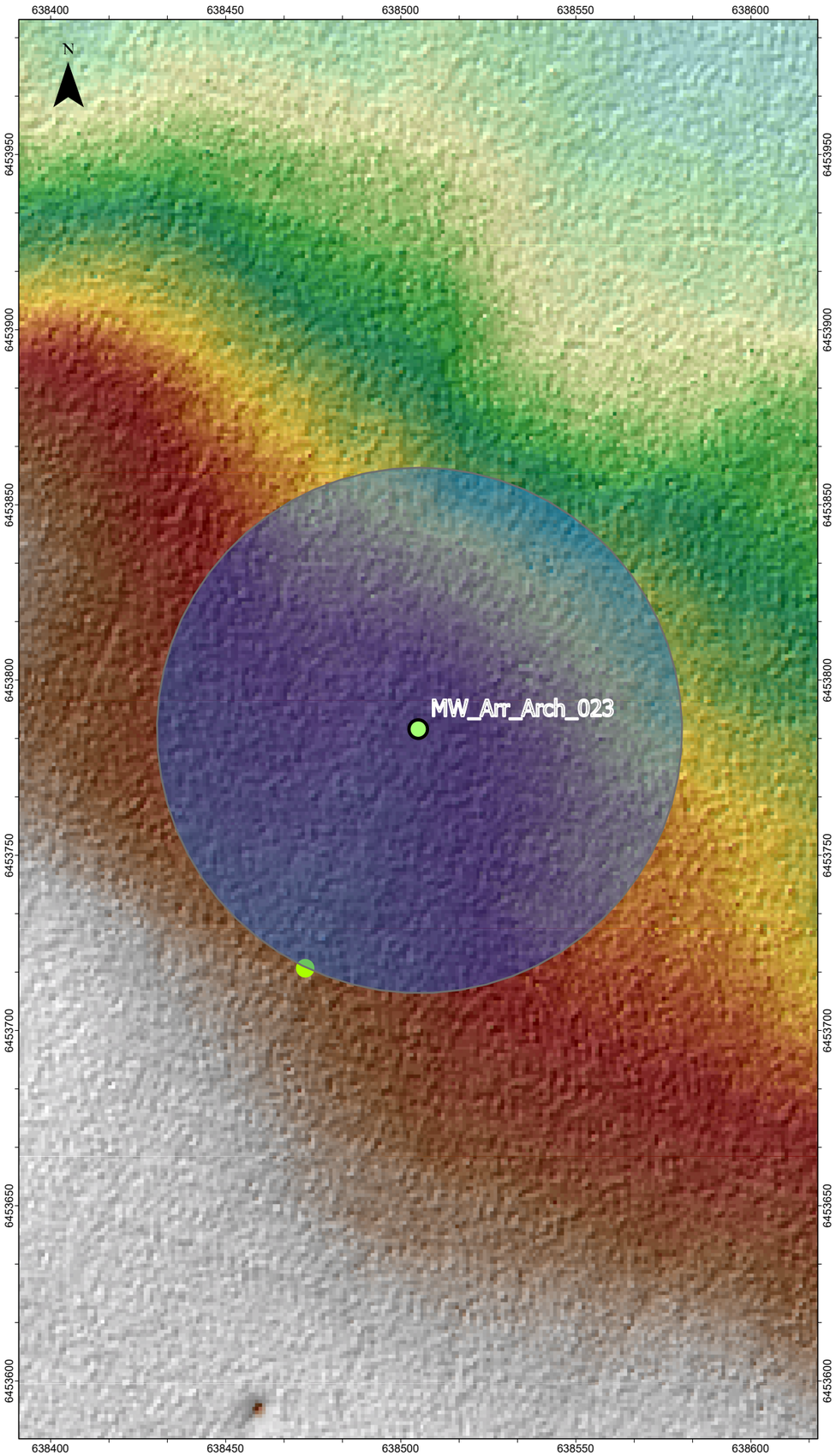
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

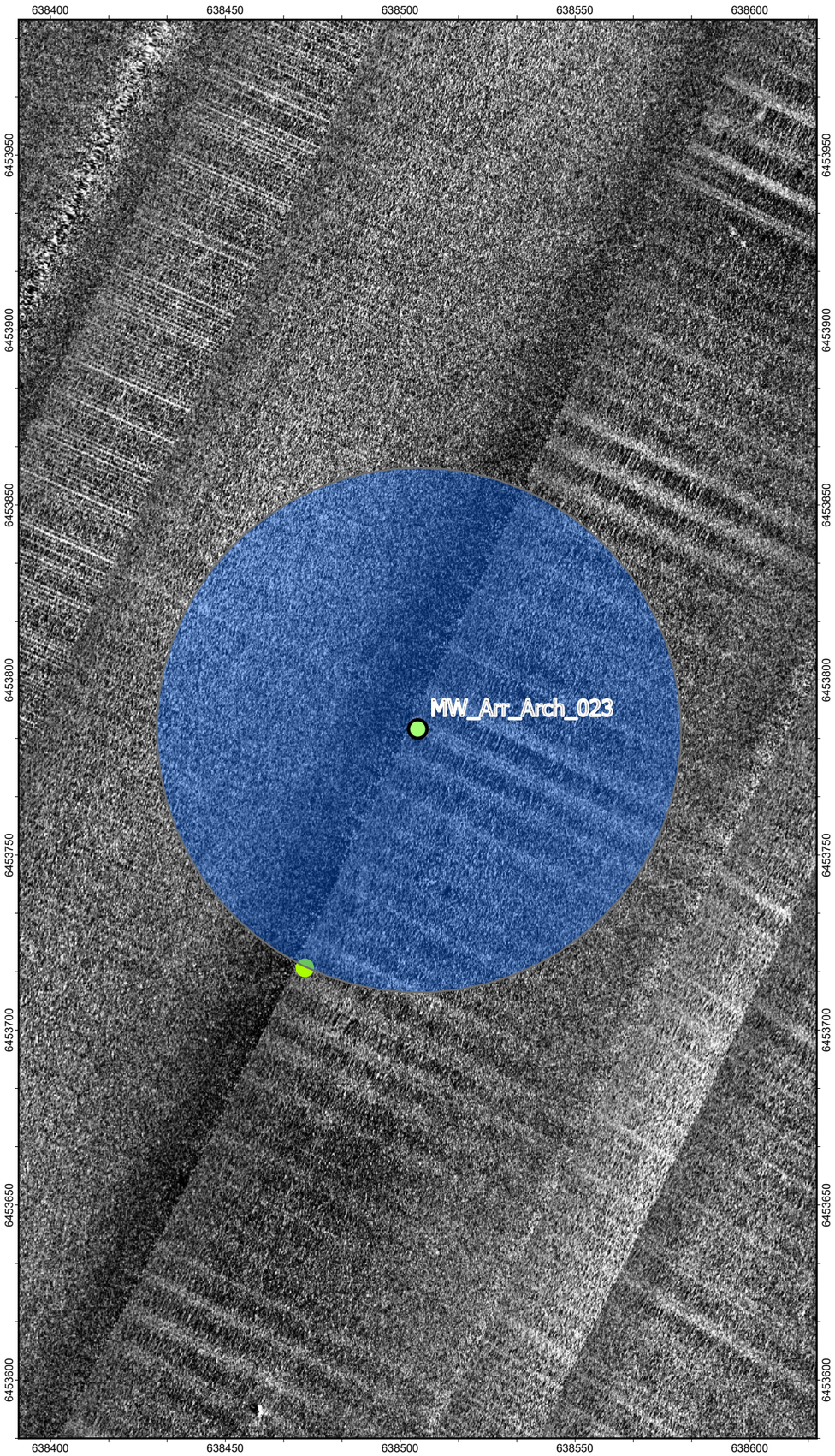
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.12 MW_Arr_Arch_0023 (**Figure 18**) consists of MAG anomaly Anom_G_004 (79nT). A second MAG anomaly, Anom_G_005 (12nT), is located 75m south. There are no visible features within the MBES or SSS. This pair of MAG anomalies may indicate the presence of buried ferrous material in this area. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 150m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-99.97

-101.38

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

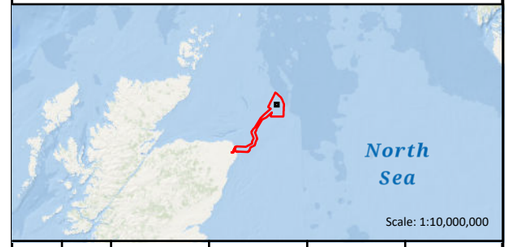
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-83953
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000123

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 18 Geophysical anomaly MW_Arr_Arch_0023

Environmental Impact Assessment Report
Appendix 16.2

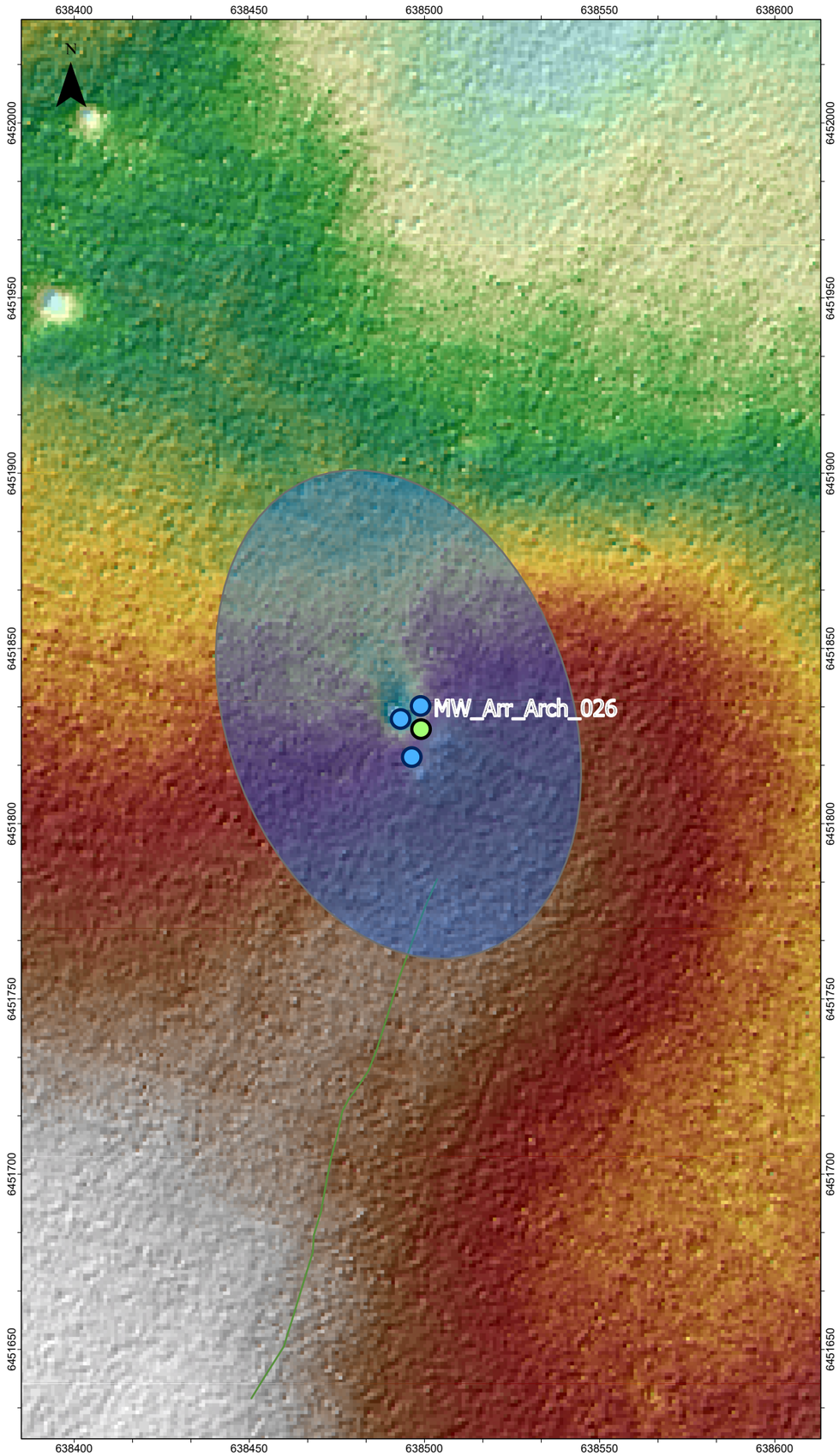
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

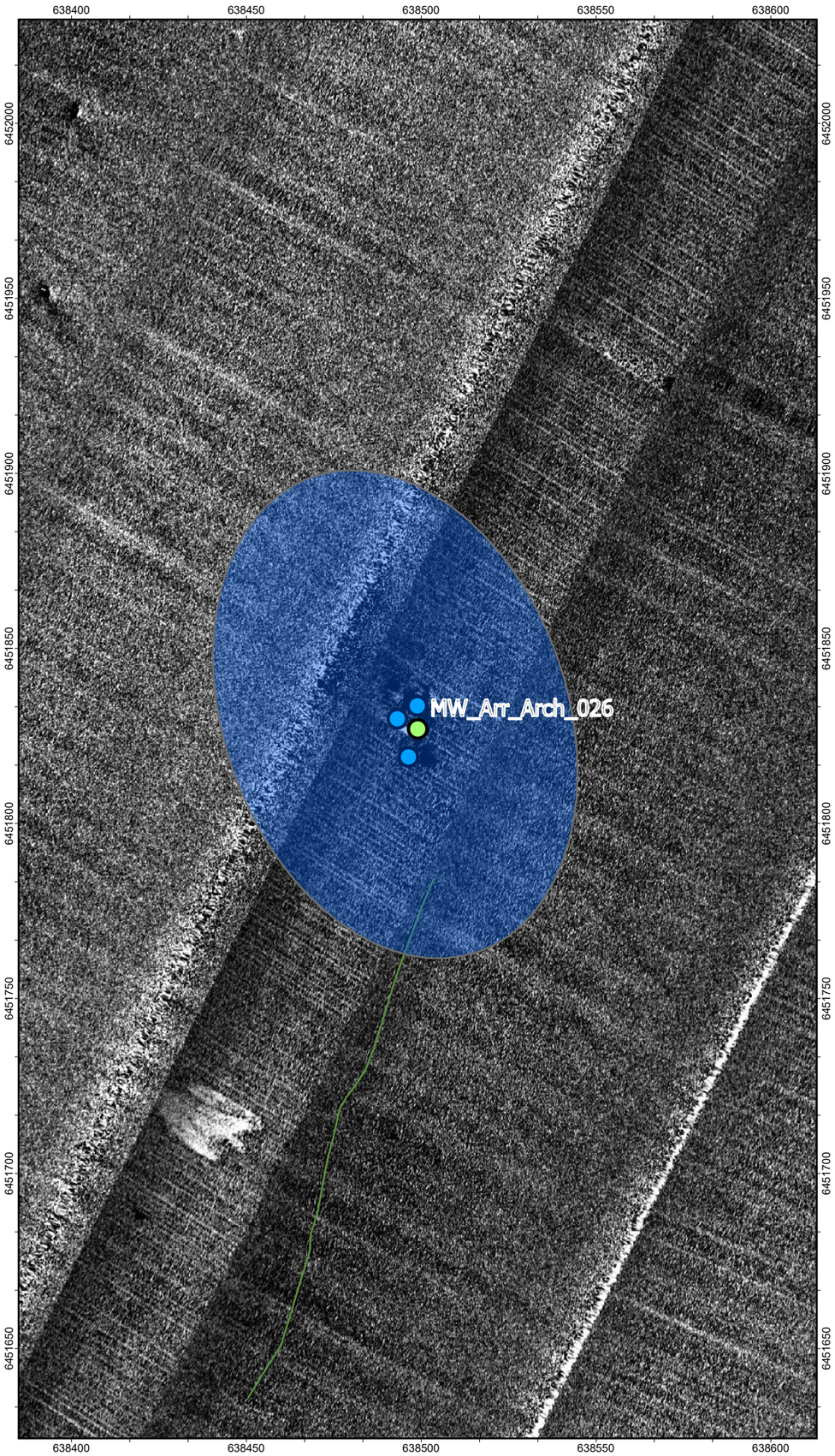
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.13 MW_Arr_Arch_0026 (**Figure 19**) consists of a cluster of dark angular SSS reflectors (SSS_H_0260, SSS_H_0261 and SSS_H_0262), up to 2.6m in length, associated with an area of scour extending 40m north of a small mound, 7m x 4m x 0.5m, visible in the MBES. This may indicate a concentration of debris on the seabed. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 100m and major axis of 140m, the latter orientated 160° parallel to the scour and anomaly alignment.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-96.49

-97.66

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

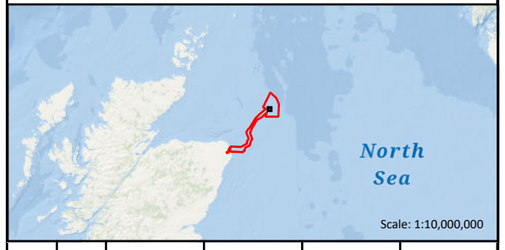
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



	dd/mm/yyy		--	--	--
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1	27/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER 808368-WEIS-IA-E5-FG-M2-15004

MarramWind DRAWING NUMBER MAR-GEN-ENV-MAP-WSP-000124

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 19 Geophysical anomaly MW_Arr_Arch_0026

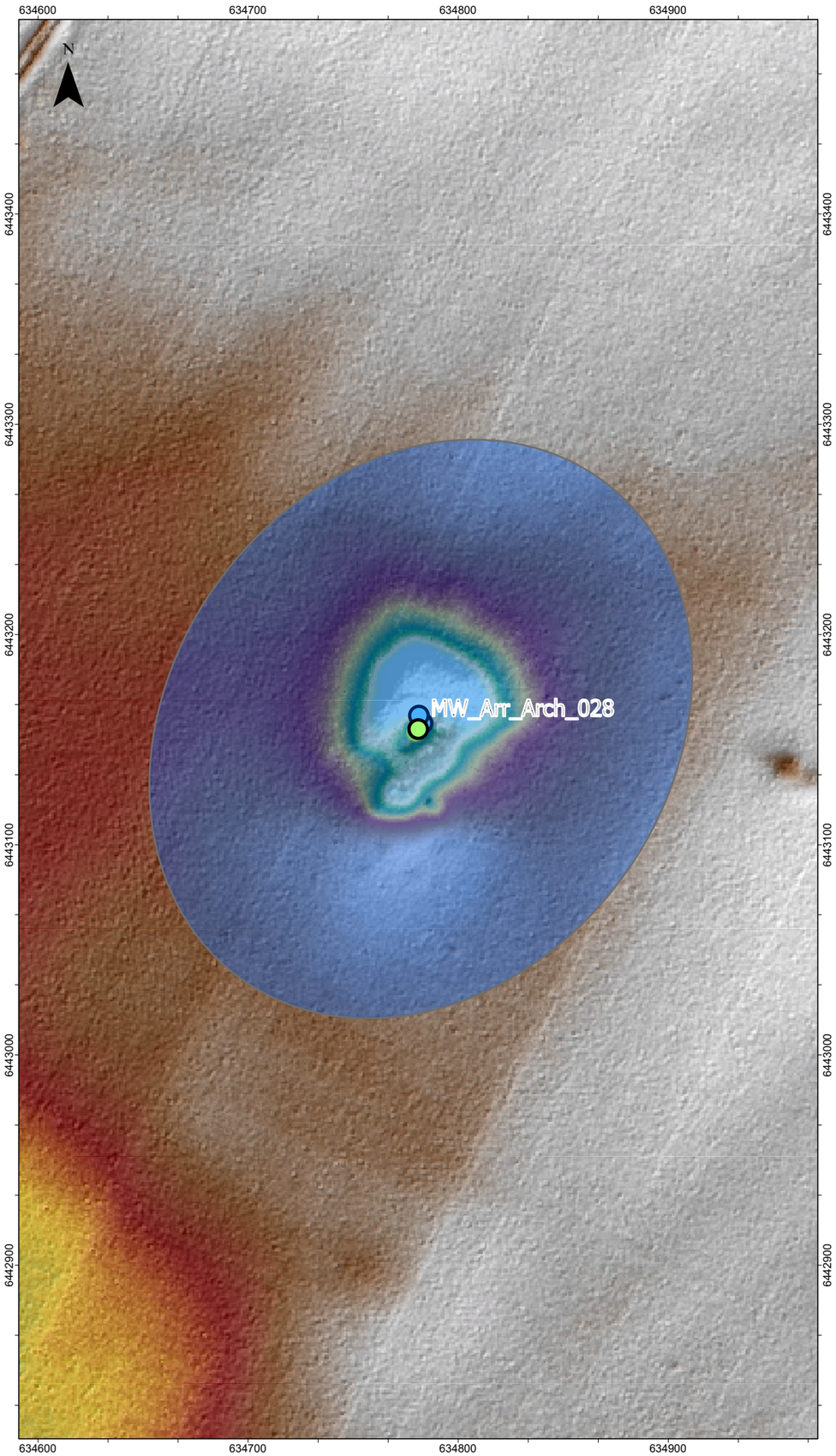
Environmental Impact Assessment Report
Appendix 16.2

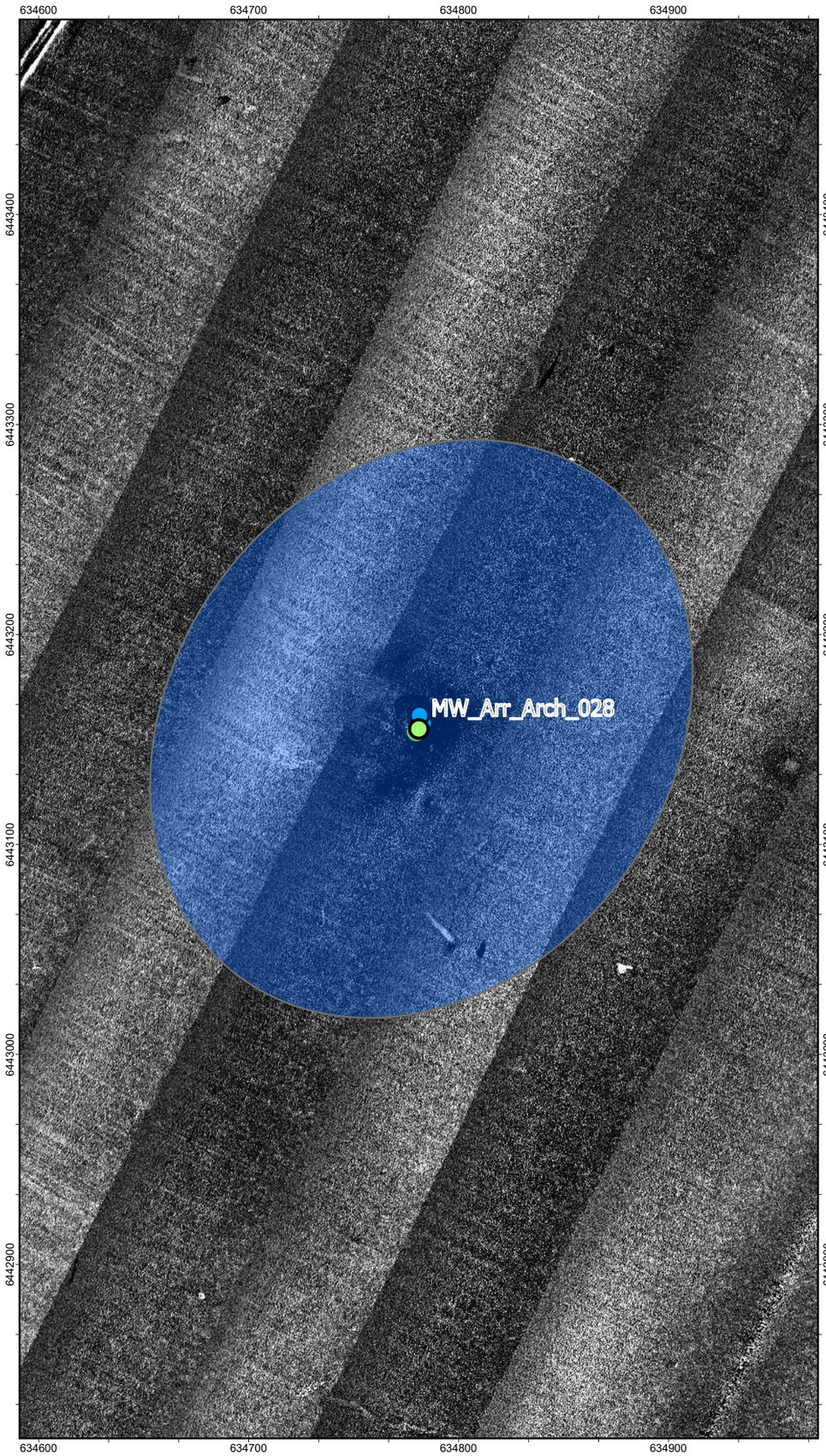
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Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

NOT TO BE USED FOR NAVIGATION

wsp MarramWind

3.4.2.14 MW_Arr_Arch_0028 (Figure 20) consists of a cluster of dark angular SSS reflectors (SSS_H_0867 and SSS_H_0869) associated with an MBES depression, 96m x 86m x 1.5m. Within the centre of the depression is an upstanding feature, measuring 22m x 17m x 1.1m, associated with MAG anomaly Anom_H_015 (15nT). This suggests the presence of an in situ ferrous object. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 235m and major axis of 290m, the latter orientated 40° parallel to the scour and anomaly alignment.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-107.40

-109.40

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

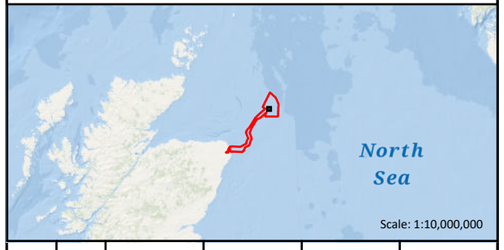
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	27/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-51684
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000126

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:2,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 20 Geophysical anomaly MW_Arr_Arch_0028

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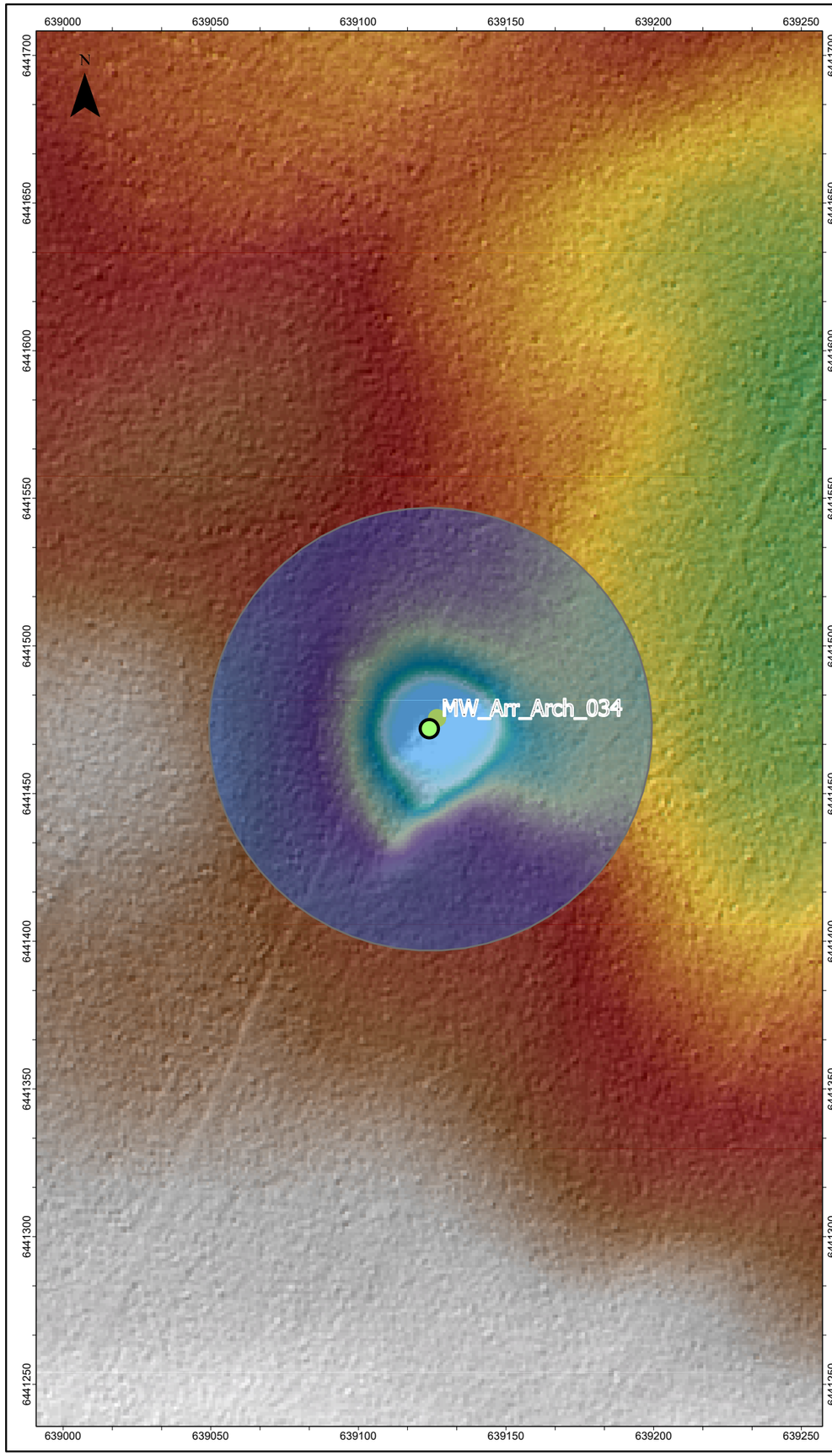
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

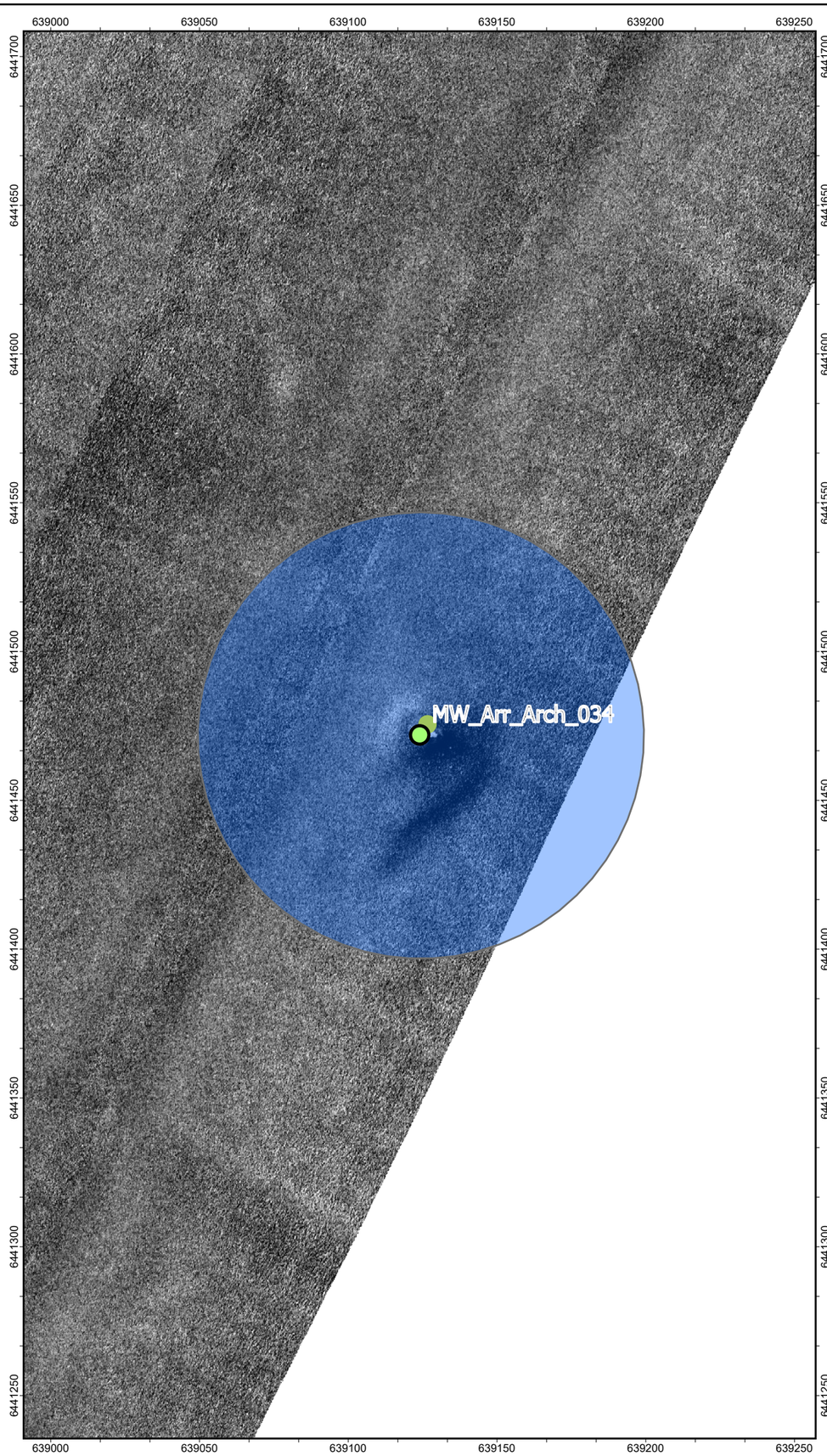
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.15 MW_Arr_Arch_0034 (**Figure 21**) consists of a light angular SSS reflector (SSS_M_0063), 3.7m x 1.8m x 0.9m, situated within the centre of an MBES depression, 72m x 63m x 2.1m, and associated with MAG anomaly Anom_M_016 (24nT). An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 150m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-108.70

-112.14

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

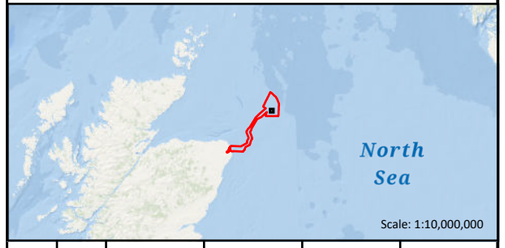
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-38550
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000127
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:1,750
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 21 Geophysical anomaly MW_Arr_Arch_0034

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Appendix 16.2

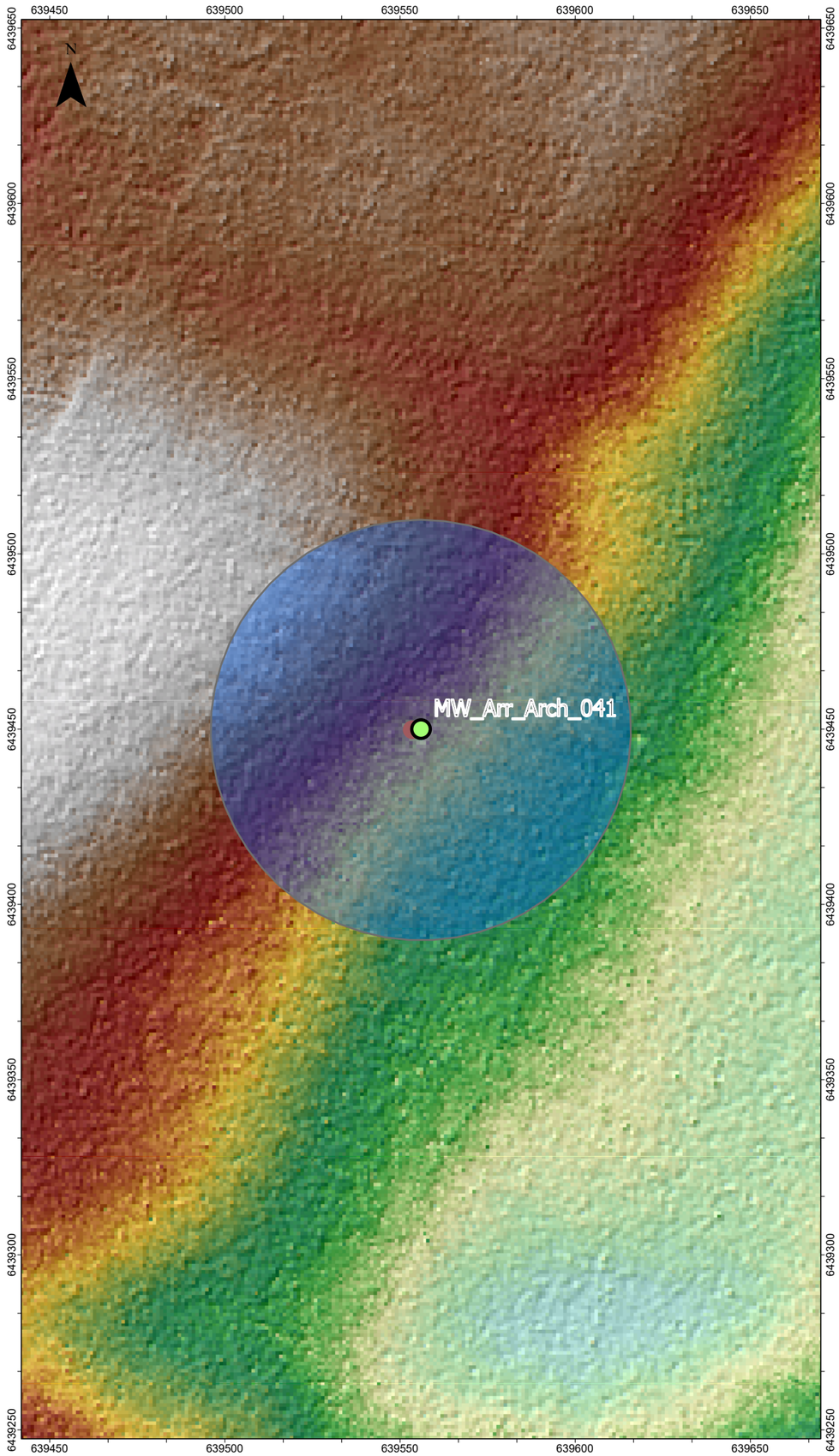
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Data Sources:
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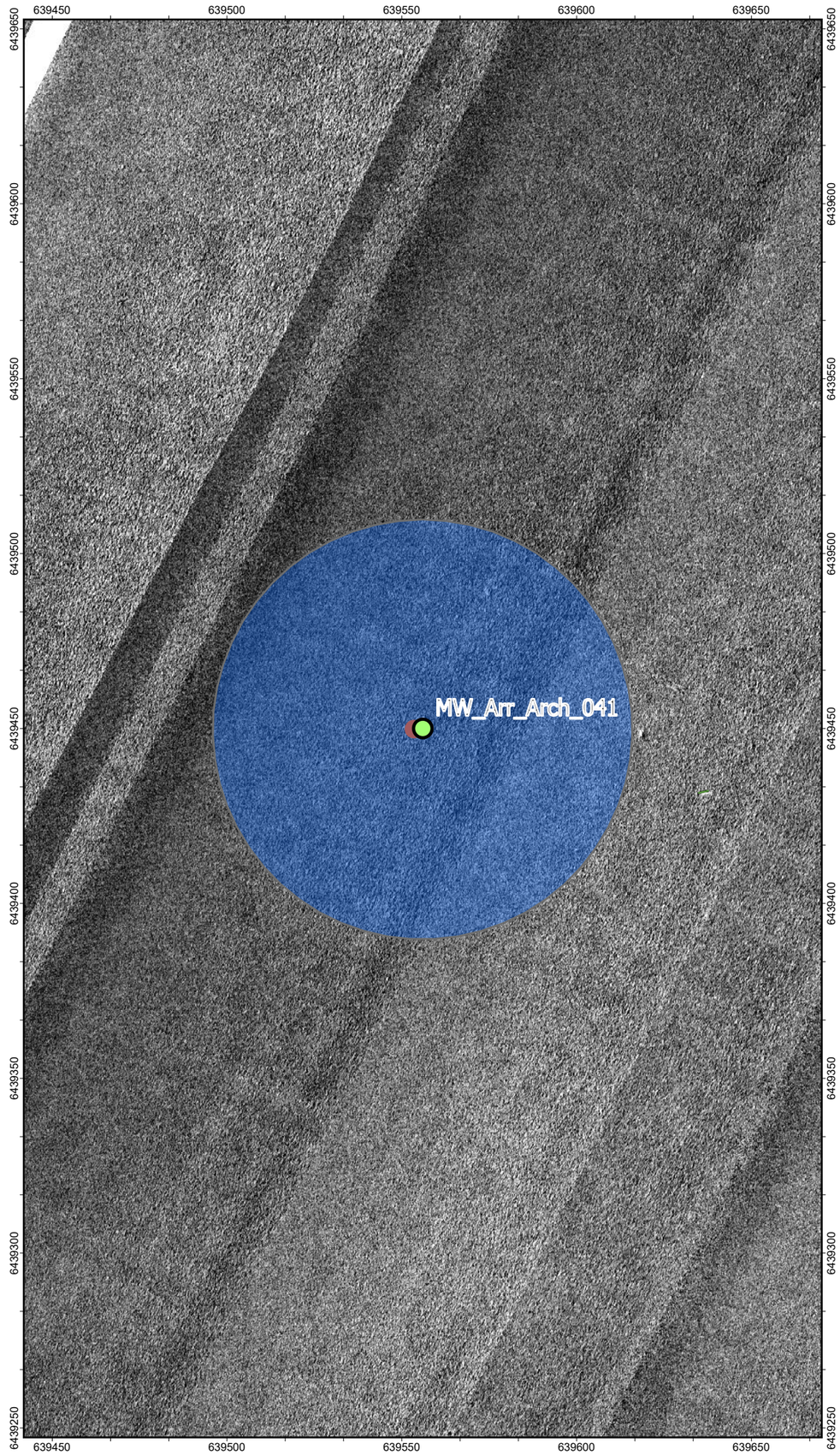
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.16 MW_Arr_Arch_0041 (**Figure 22**) consists of MAG anomaly Anom_N_003 (78nT), coinciding with a cluster of small light angular SSS reflectors, covering an area 5.3m x 4.2m, situated within a small MBES depression, 7m x 4.4m x 0.2m. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 120m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.55

-105.49

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

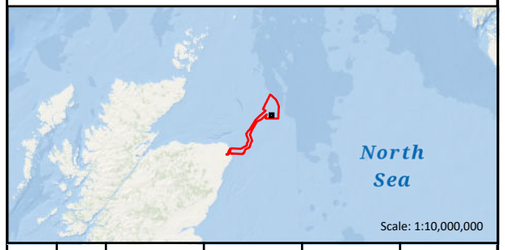
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	27/05/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-78136
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000128

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 22 Geophysical anomaly MW_Arr_Arch_0041

Environmental Impact Assessment Report
Appendix 16.2

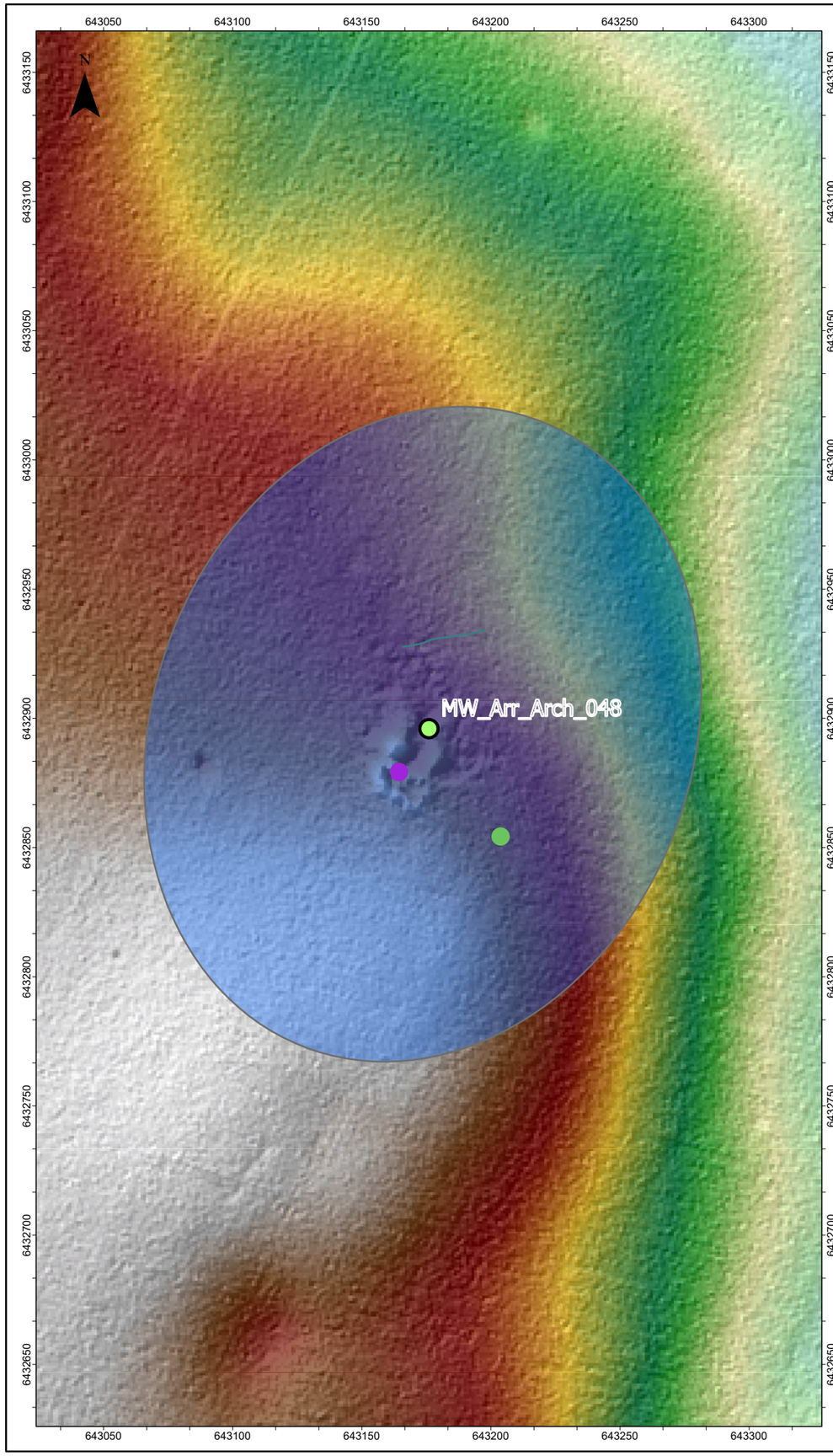
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

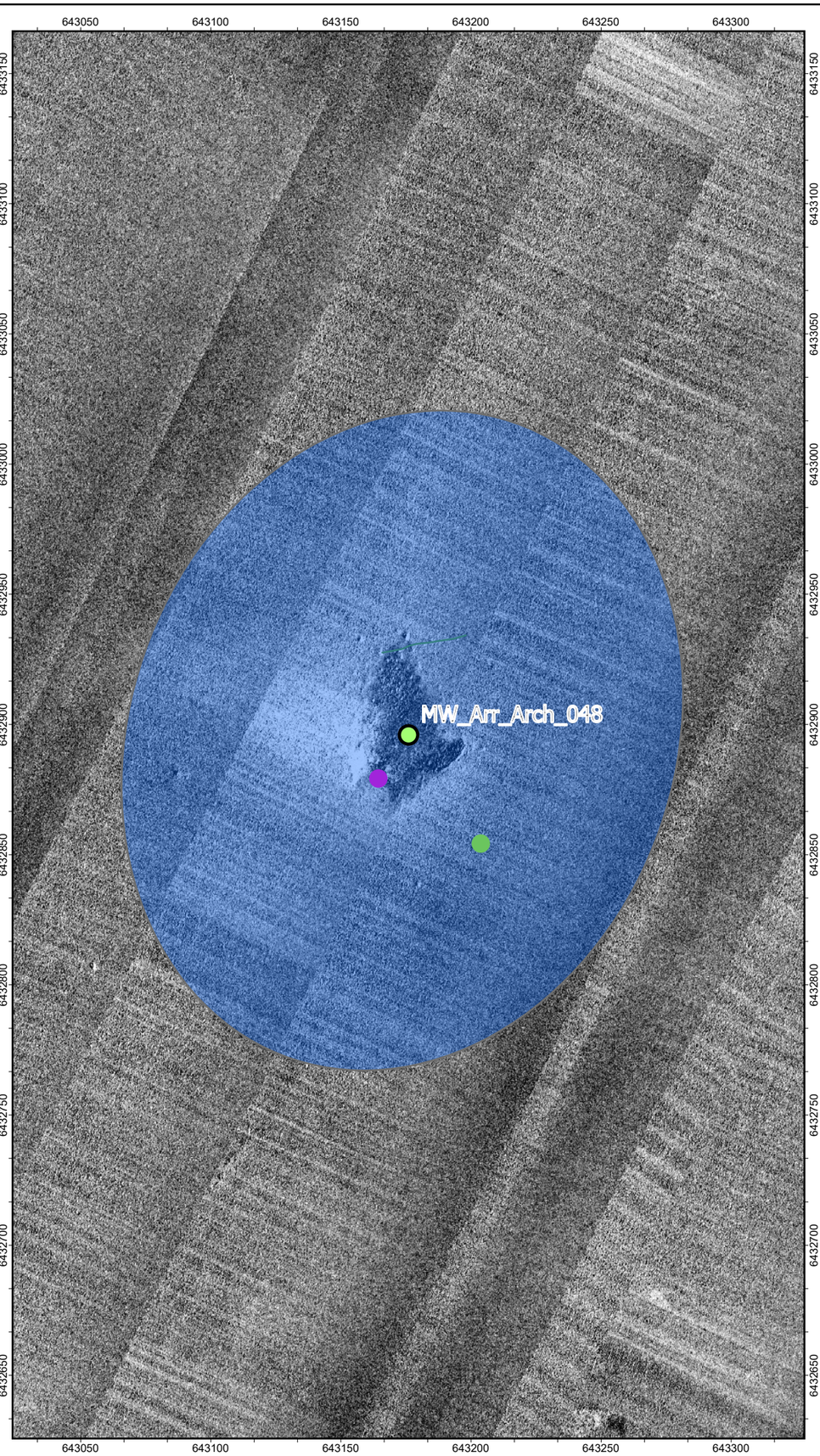
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.17 MW_Arr_Arch_0048 (**Figure 23**) consists of an area of increased seabed roughness visible in both the MBES and SSS, covering an area 66m x 43m, associated with MAG anomalies Anom_R_008 (1270nT) and Anom_R_001 (19nT). A linear SSS reflector (SSS_R_0173), measuring 33m in length, is present on the northern edge of the area of increased seabed roughness. These large MAG anomalies suggest the presence of a large ferrous object buried beneath the seabed. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 210m and major axis of 260m, the latter orientated 20° parallel to the area of increased seabed roughness.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-105.35

-108.39

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

30-49 nT

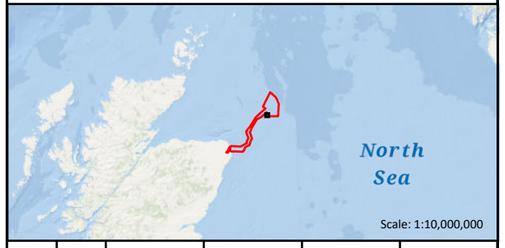
50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 90 100 110

Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-96933
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000129
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:2,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 23 Geophysical anomaly MW_Arr_Arch_0048

Environmental Impact Assessment Report
Appendix 16.2

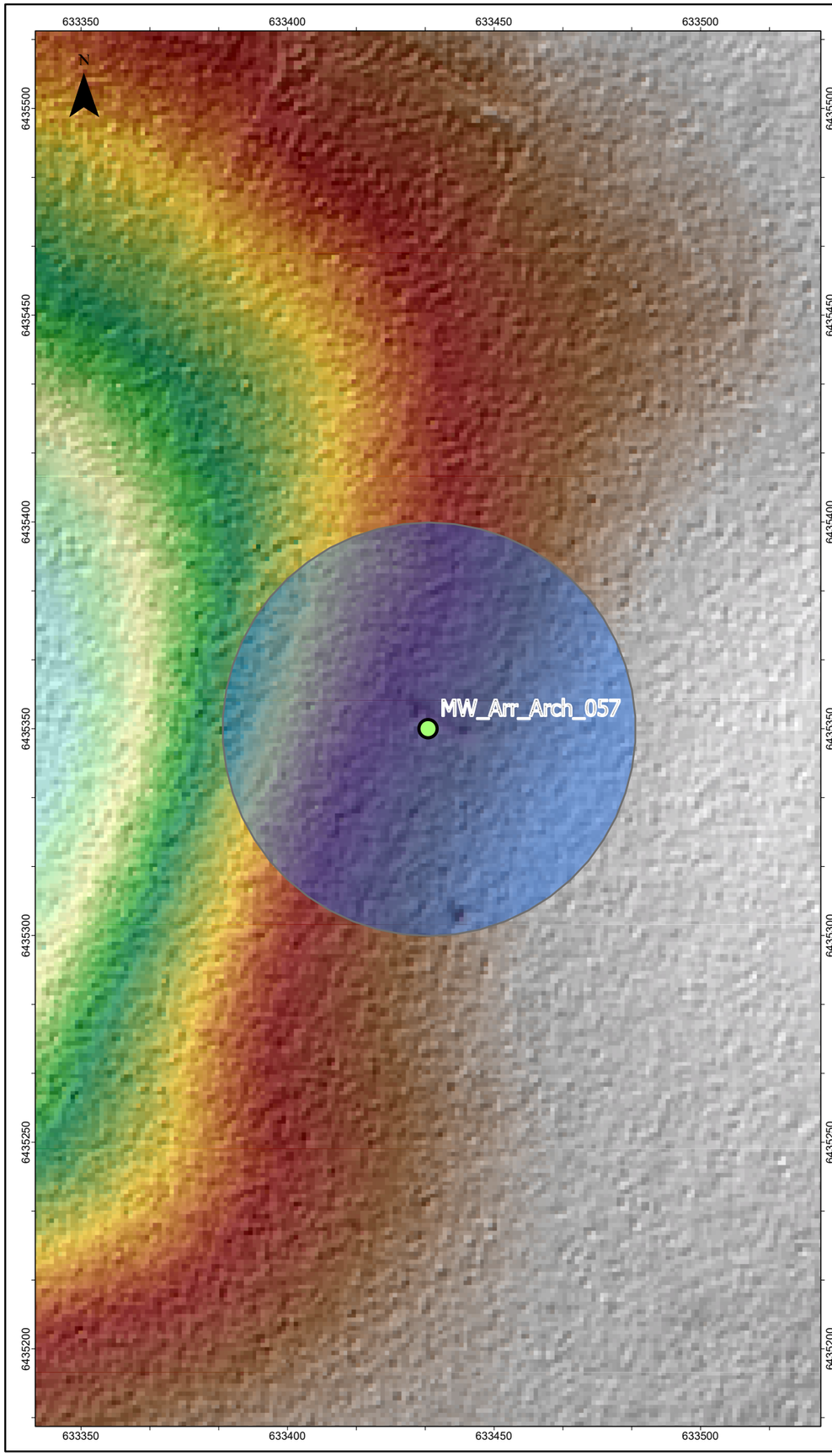
© COPYRIGHT NOTES
Data Sources:
Service Layer Credits: OS from Zoomstack (2025), Esri, Garmin, FAO, NOAA, USGS, and other contributors

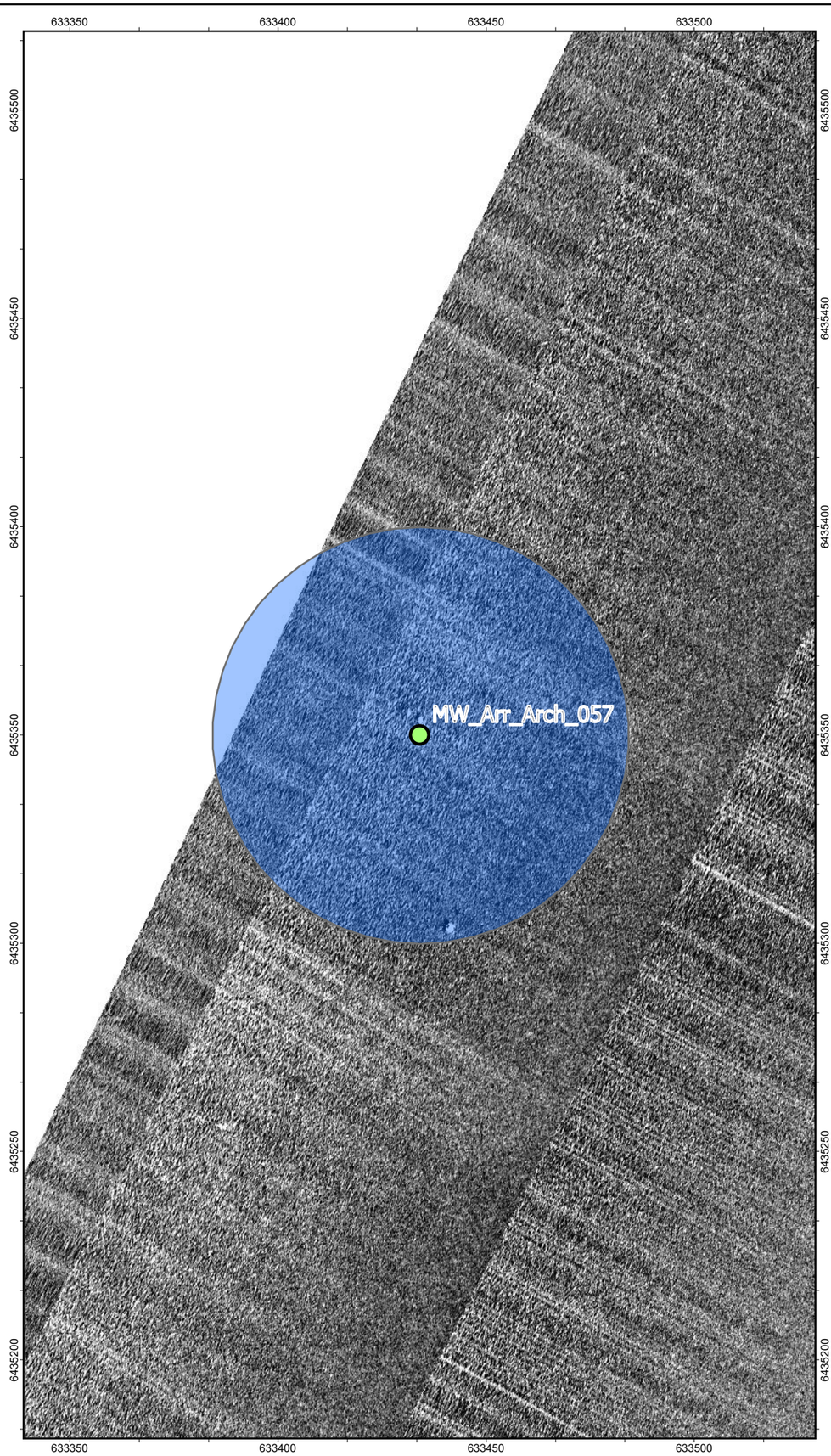
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.2.18 MW_Arr_Arch_0057 (**Figure 24**) consists of MAG anomaly Anom_J_047 (402nT). This anomaly may be associated with linear or dispersed debris visible within the SSS covering an area 14m x 10m. This may therefore represent a partially buried debris concentration. An AEZ should be applied to this anomaly, and therefore it is categorised as having medium archaeological potential. An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 100m.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-104.92

-106.85

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

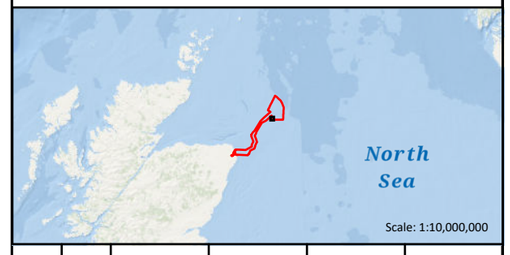
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-33274
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000130

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,250	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 24 Geophysical anomaly MW_Arr_Arch_0057

Environmental Impact Assessment Report

Appendix 16.2

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NOT TO BE USED FOR NAVIGATION

wsp

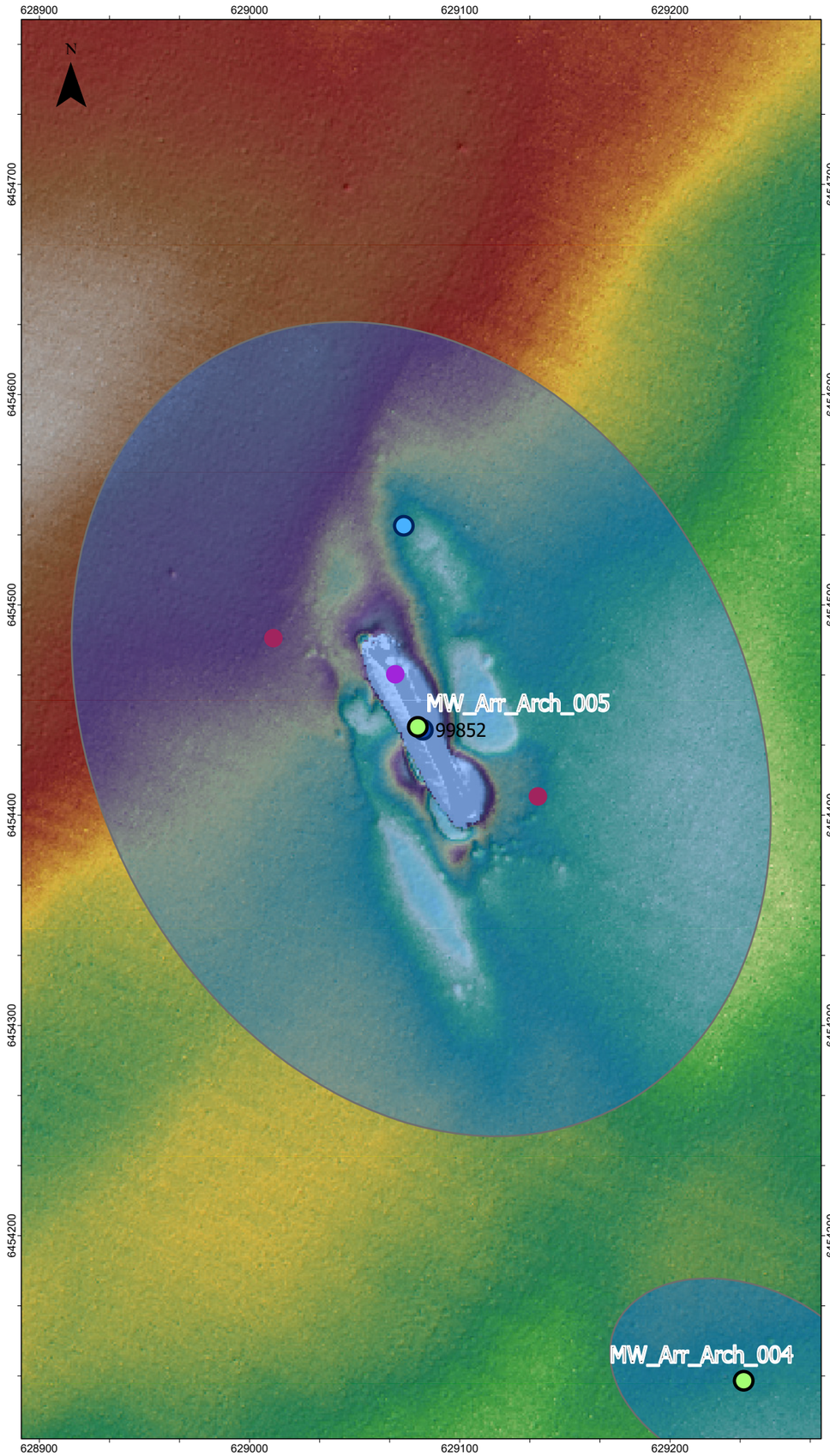
MarramWind

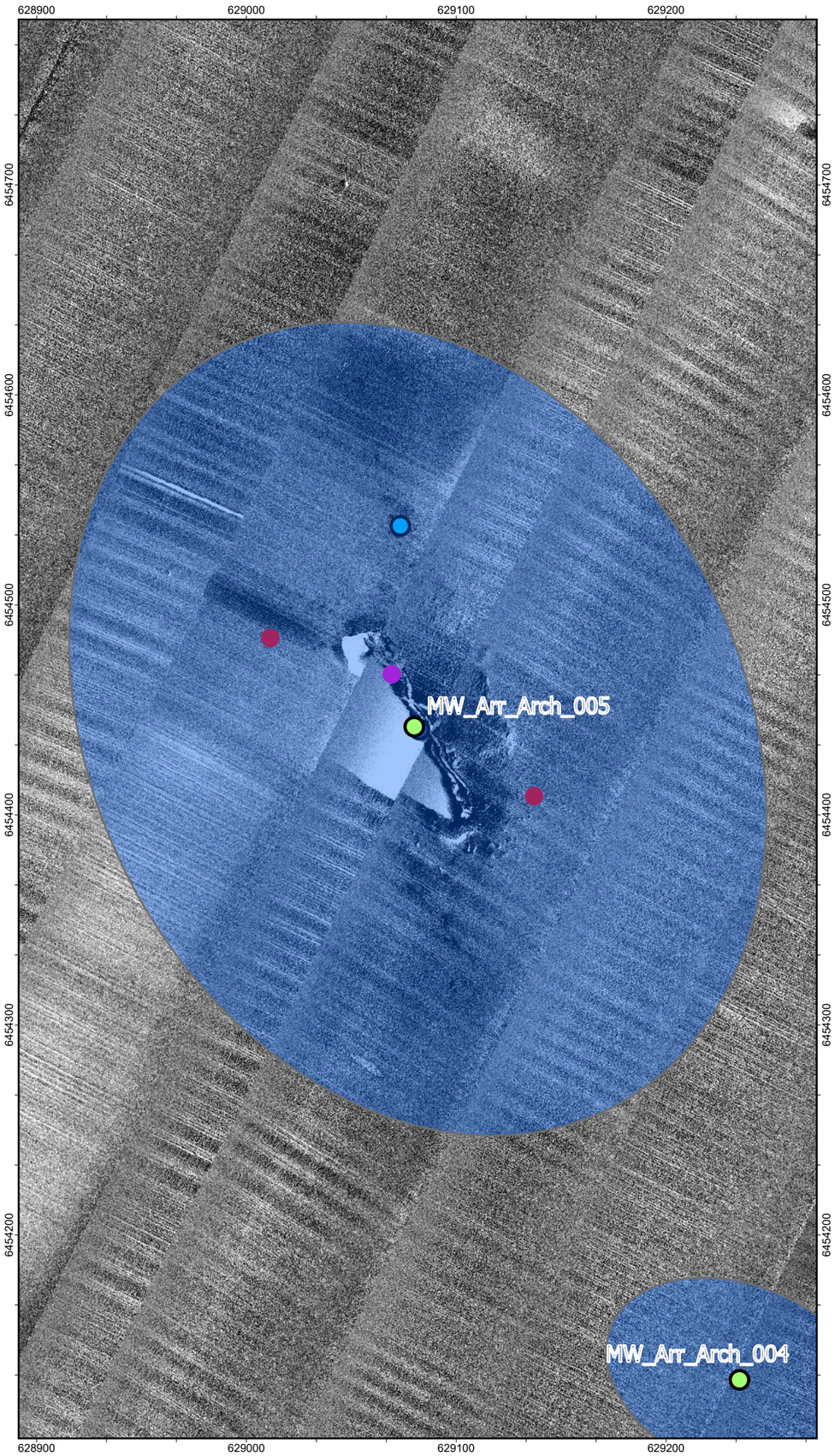
3.4.3 High archaeological potential anomalies within the OAA

3.4.3.1 Six geophysical anomalies with high archaeological potential were identified within the OAA. Each of the wrecks encountered were reported through the Protocol for Archaeological Discoveries (PAD) during the geophysical survey (see **Appendix 16.5: Protocol for Archaeological Discoveries**).

MW_Arr_Arch_0005 – possibly the SS *Tobol*

3.4.3.2 MW_Arr_Arch_0005 (**Figure 25**) is an unknown wreck site located within Survey Block A. The wreck is centred upon 629080 6454440 within an average water depth of approximately 102m, with the maximum measured elevation of the wreck at 95.7m. The wreck is orientated approximately north- northwest (NNW)- south-southeast (SSE), with the bow at the northern end. The wreck measures approximately 101m in length and 14.2m high. The exact width of the wreck cannot be measured, as it is lying on its starboard side at an angle and partially buried within the seabed, though it is likely to exceed 13m. The wreck is pointing downwards at a 45° angle, clearly exposing the base of the hull but obscuring much of the deck, though some features are visible from the SSS.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-102.60

-105.84

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

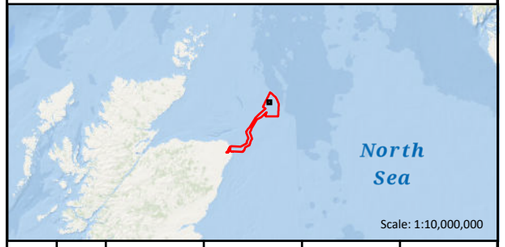
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 25 50 75 100 125 Meters



			--	--	--
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000131

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:2,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 25 Geophysical anomaly MW_Arr_Arch_0005

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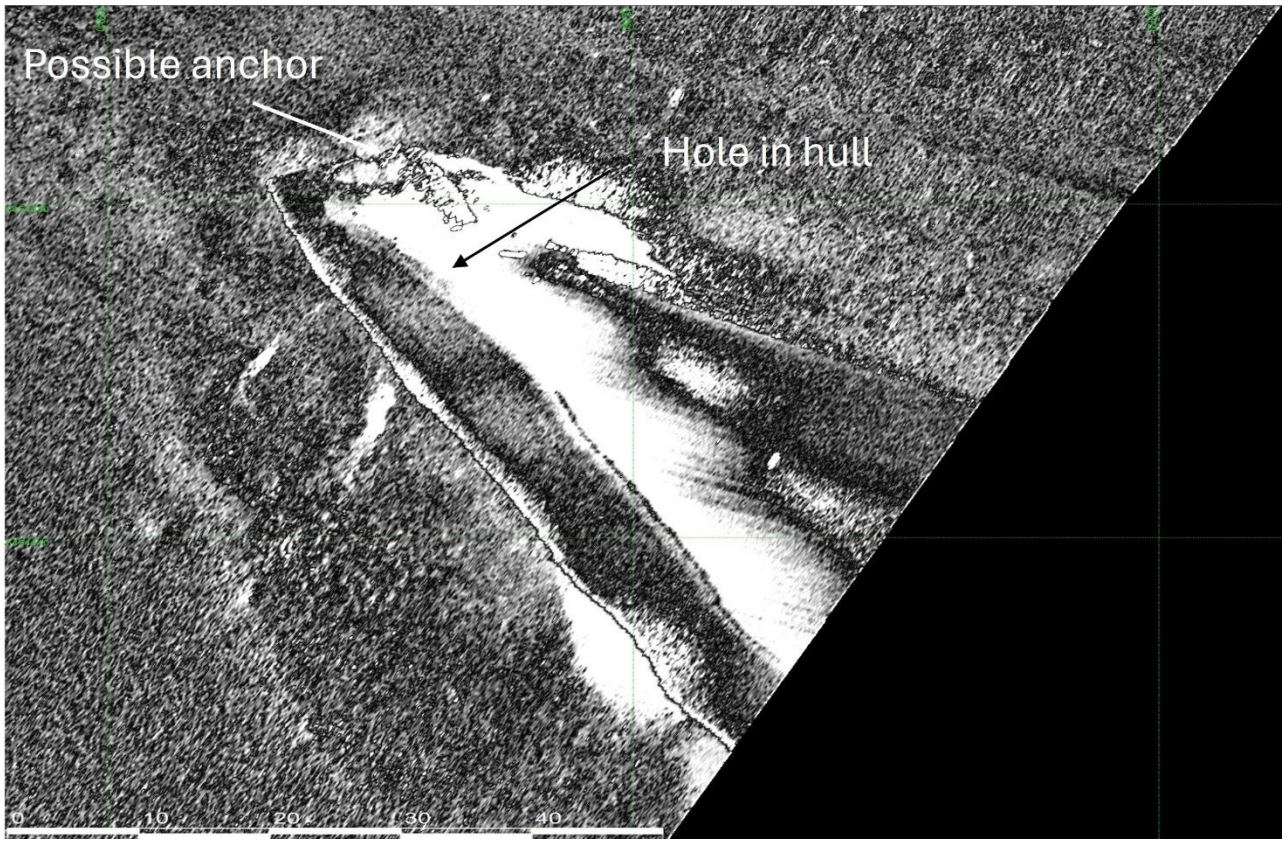
NOT TO BE USED FOR NAVIGATION

wsp MarramWind

3.4.3.3 The wreck is associated with SSS anomaly SSS_A_0158 and MAG anomalies Anom_A_003 (310nT), Anom_A_004 (2233nT) and Anom_A_005 (188nT).

3.4.3.4 The bow of the ship is at the northern end of the wreck and it appears that the port-side anchor is still attached. Just behind the bow is a large hole at the waterline on the port side, likely to originate from an explosion such as a torpedo (**Plate 3.1**). This is most clearly visible in the MBES point cloud data (**Plate 3.3**).

Plate 3.1 SSS image of the probable bow of wreck MW_Arr_Arch_0005

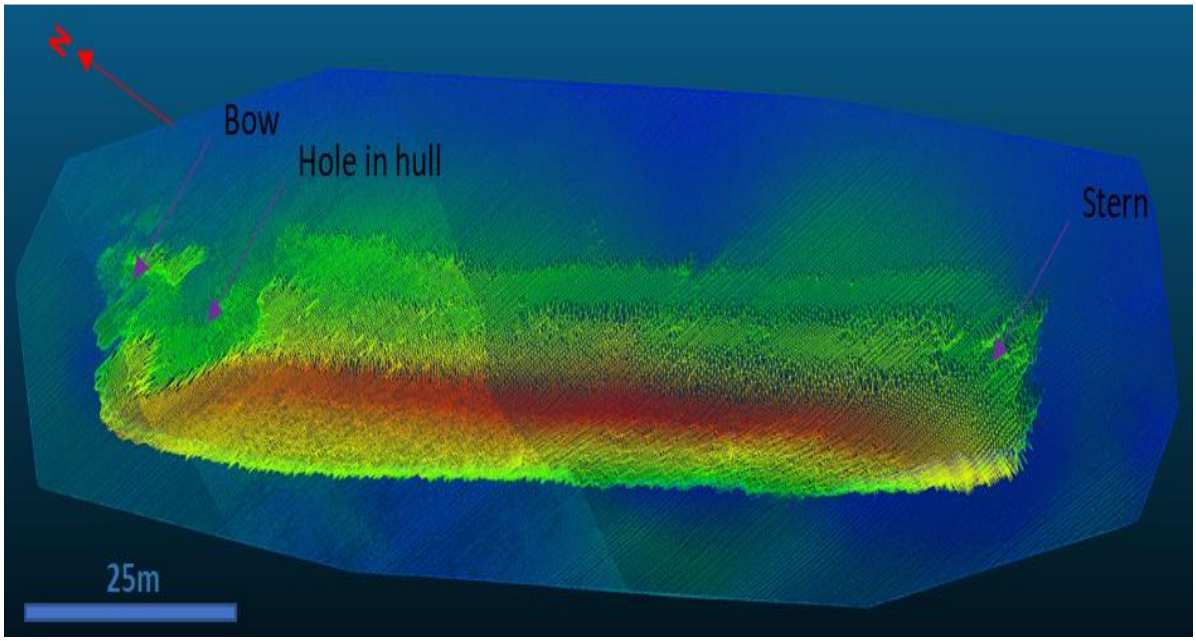


3.4.3.5 Within the centre of the wreck, some of the superstructure is visible (**Plate 3.2**). This consists of a collapsed mast with attached rigging, probably collapsed backwards over the main cabin. Behind this is the intact funnel, with a smaller collapsed aft cabin behind that. Beyond these upstanding features, the ship appears to have a flush deck with no clearly defined poop deck structures and only a slightly elevated forecastle.

Plate 3.2 SSS image of the visible superstructure upon wreck MW_Arr_Arch_0005

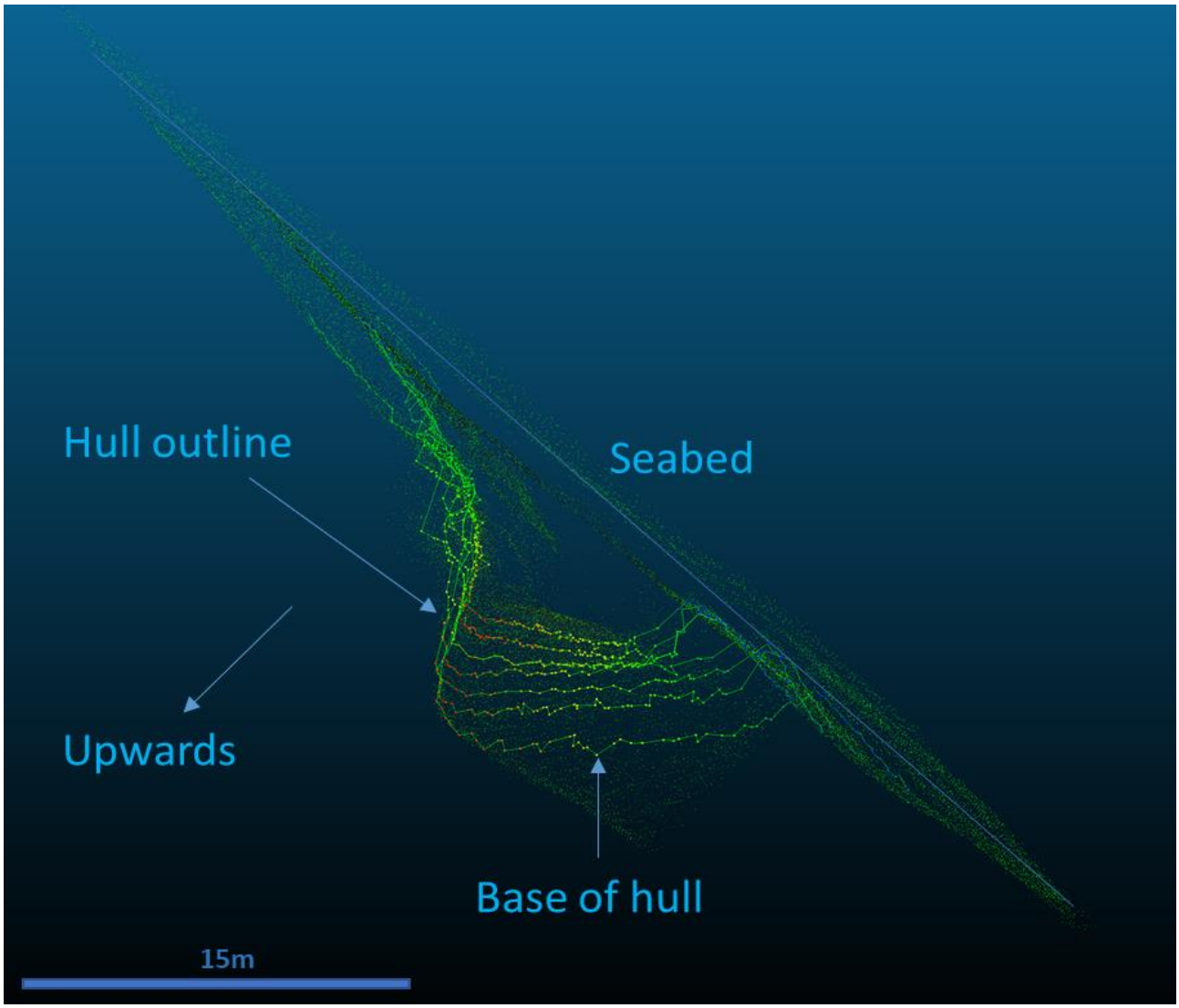


Plate 3.3 Point cloud showing the port side of wreck MW_Arr_Arch_0005



3.4.3.6 The most notable characteristic of the wreck is its unusual hull design, consisting of a flat base with a stepped hull form that is rounded and stepped inwards above the waterline. This style of ship is known as a turret deck ship, which was a merchant ship designed and built in the late 19th and early 20th centuries. Over 180 ships of this type were built, 176 of them by William Doxford and Sons in Sunderland, England. The MBES point cloud data suggests that the hull has twisted slightly after its impact with the seabed, with an approximately 10° offset between the stern and bow (**Plate 3.4**).

Plate 3.4 Cross sections through the point cloud of wreck MW_Arr_Arch_0005, showing the bulbous curvature of the hull. Note, image is inverted



3.4.3.7 The most likely candidate for this wreck is the *SS Tobol* which was built in 1901 by Doxford and Sons. This ship had a tonnage of 3741 grt, measured 104.4m x 14.2m x 7.6m, and was powered by a 1 x 3-cyl triple expansion steam engine with a single shaft and screw. The ship was originally owned by Austin Friars Steam Shipping Co Ltd, London, between 1901-1905 before being acquired by the Imperial Russian Navy (1905-1916) and finally sold to the Dobrovolny Flot (Russian Volunteer Association) in 1916. This was a state-controlled ship transport association established in the Russian Empire in 1878 funded from voluntary contributions collected by subscription.

3.4.3.8 On 11th September 1917, the SS *Tobol* was on a voyage from Blyth to Archangelsk but was sunk by a torpedo from the German submarine U-52, located about 70 miles east-southeast of Duncansby Head. There is no record for the *SS Tobol* having been discovered within the wider area, and an approximate position of this wreck (based upon the distance and bearing off Duncansby Head) would have placed the loss approximately 17.8km northeast of this wreck site. With the exception of the *SS Tobol*, there are two other reported lost Turret Deck Ships within the wider area, both built by Doxford and Sons. The first is the known wreck site of the SS *Malmland* (UKHO 2372), found within an area closer inshore, approximately

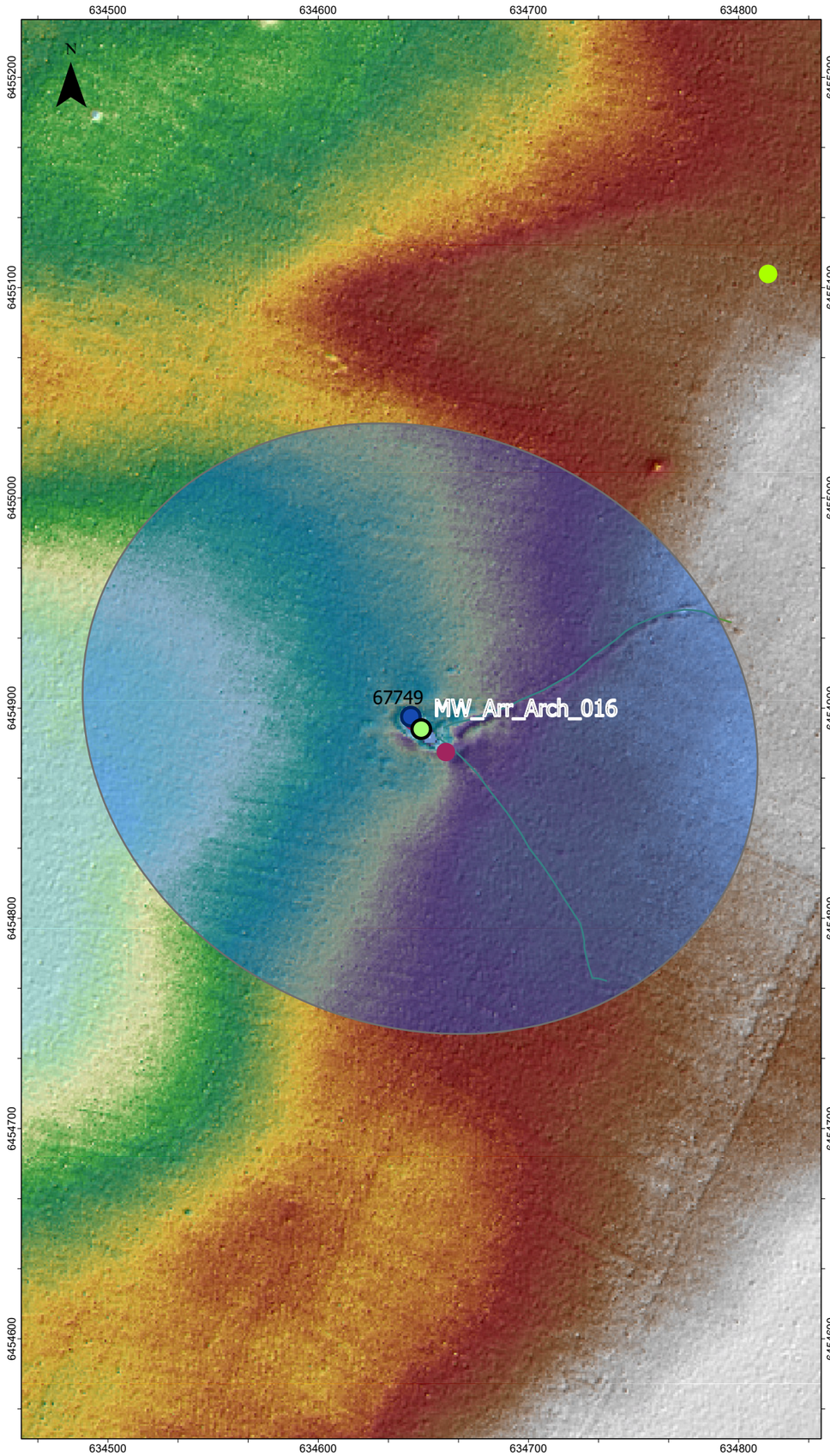
6.5km east of Rattray Head. This was sunk by U-17 on the 8th August 1915. The second is that of the SS *Atland* (UKHO 2276), which sunk off Peterhead on the 25th March 1943 after it was rammed by another ship within the same Atlantic convoy. It is therefore highly probable that the newly discovered wreck is that of the *SS Tobol*. As the *SS Tobol* was not a serving military vessel at the time of its loss, it would not be subject to the Protection of Military Remains Act 1986, though may be subject to Foreign state (or sovereign) immunity.

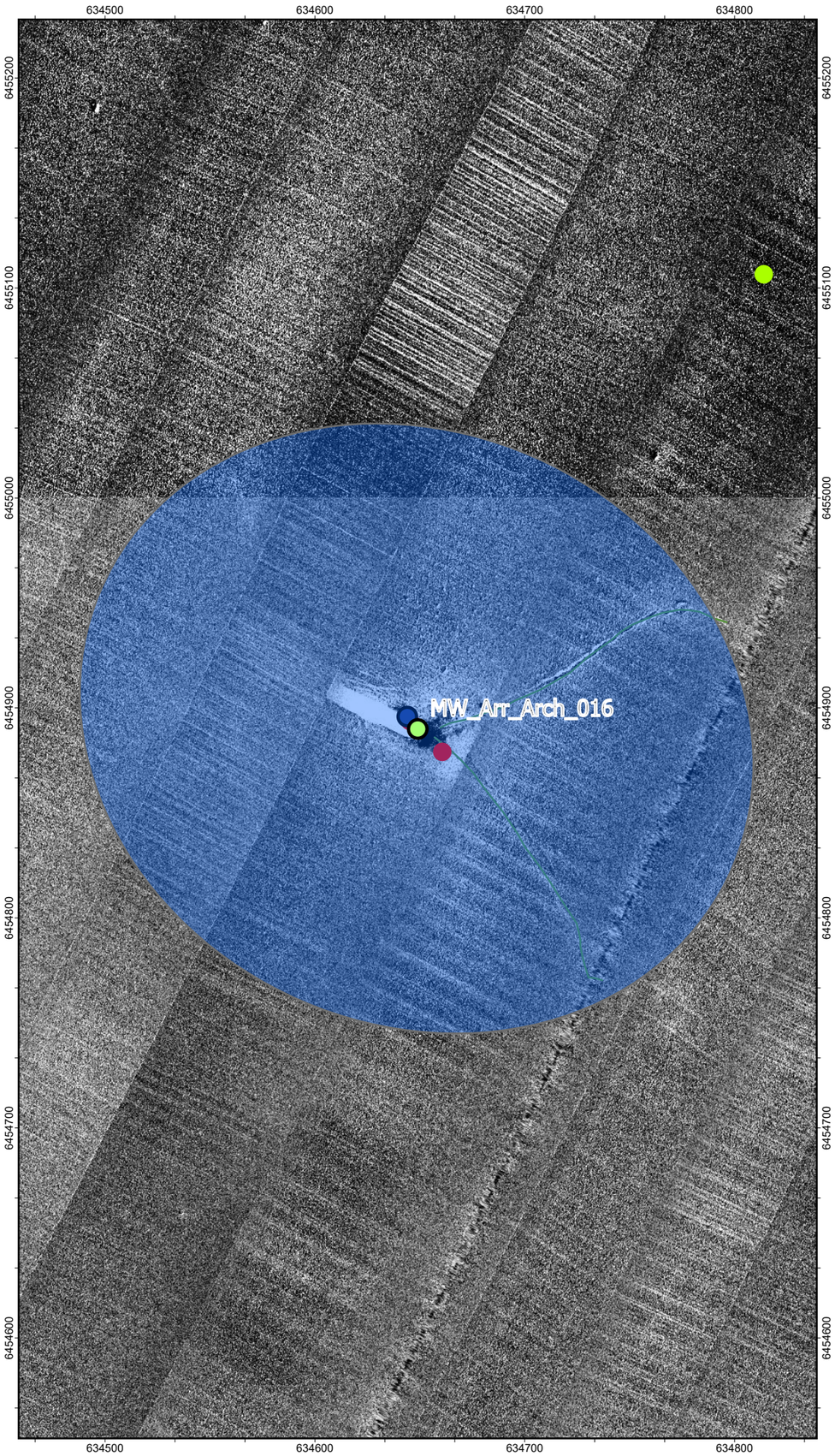
3.4.3.9 The seabed immediately surrounding the wreck site shows a series of small (<2m) anomalies around the bow and stern, within 45m of the wreck, and along the northeast side of the wreck where the deck is partially buried within the seabed. Scour is parallel to the wreck, also orientated in NNW-SSE direction either side of the wreck site, extending up to 80m south and 70m north. SSS anomaly SSS_A_0157, possible debris, is located 54m north of the wreck. No other anomalies have been identified upon the seabed, to suggest a wider debris spread.

3.4.3.10 This wreck site is clearly of high archaeological potential. An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 310m and major axis of 400m, the latter orientated 112°parallel to the wreck and scour alignment.

MW_Arr_Arch_0016 – MFV *Ocean challenge*

3.4.3.11 MW_Arr_Arch_0016 (**Figure 26**) is a known wreck site, recorded by the UKHO as the *Ocean Challenge* (UKHO 67749), located within Survey Block D. The wreck is centred upon 634644 6454896 within an average water depth of approximately 102m, with the maximum measured elevation of the wreck at 96.6m. The wreck site is 54m north-northeast (NNE) of the UKHO position.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-100.97

-102.18

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

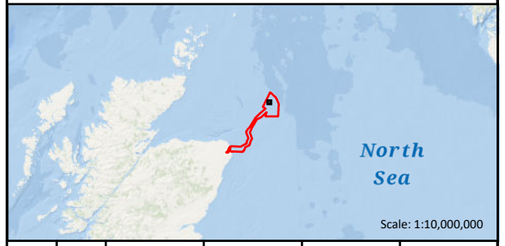
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 25 50 75 100 125 Meters



			--	--	--
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-31330
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000132

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:2,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 26 Geophysical anomaly MW_Arr_Arch_0016

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wsp MarramWind

3.4.3.12 The wreck is orientated approximately northwest to southeast, with the bow at the northern end. The wreck measures approximately 21m in length, 6m wide and 5.2m high. The wreck is sitting upright with its deck fully exposed. The length and breadth of the wreck match the original dimensions of the *Ocean Challenge*, which was 19.9m x 6.2m x 2.4m, though pictures of the ship suggest a greater height as there was the trawling superstructure above the main cabin.

3.4.3.13 The wreck is associated with SSS anomaly SSS_A_1072 (**Plate 3.5**) and MAG anomalies ANOM_D_021 (396nT) and ANOM_D_015 (366nT).

3.4.3.14 The *Ocean Challenge* was a 20m wooden fishing vessel built in 1980 by James N Miller & Sons, St Monans. At the time of its loss, it was owned by Westward BF350 Fishing Limited, Fraserburgh, Aberdeenshire. On the 18th March 2006 the vessel suffered an engine room fire, thought to be caused by a fault in the electrical system. The fire was so severe that the crew closed down the vessel, activated CO_2 and evacuated to the life raft from where they were safely rescued.

3.4.3.15 Two linear SSS anomalies, SSS_D_1111 and SSS_D_1110 (visible on **Plate 3.5** to the right of the wreck), extend up to 150m east and southeast from the stern of the wreck at its southeast end. While this could possibly be snagged fishing gear on the wreck site, it might also be deployed trawler gear that was being used when the ship caught fire and therefore sunk with the gear still deployed.

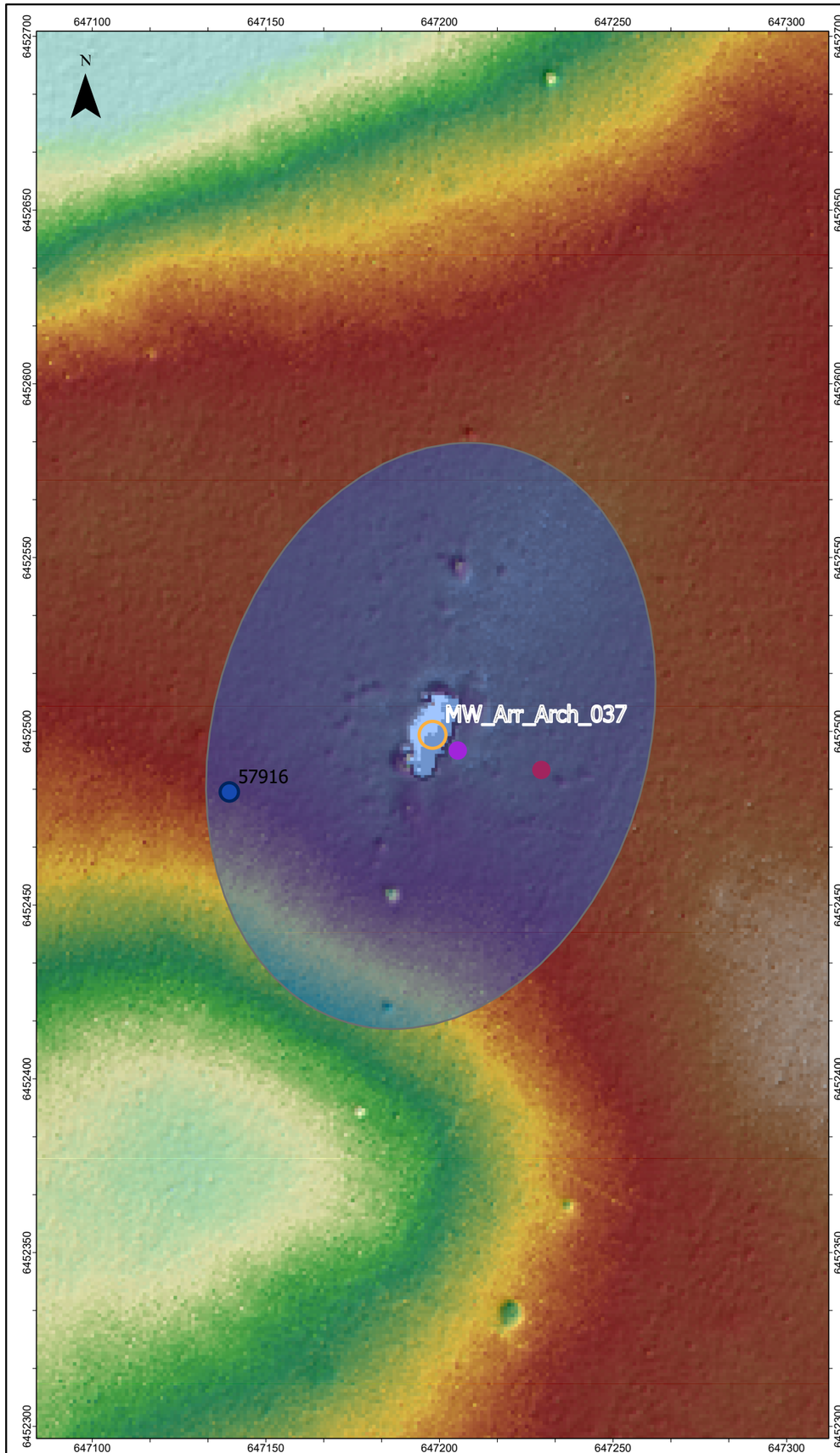
Plate 3.5 SSS of wreck MW_Arr_Arch_0016

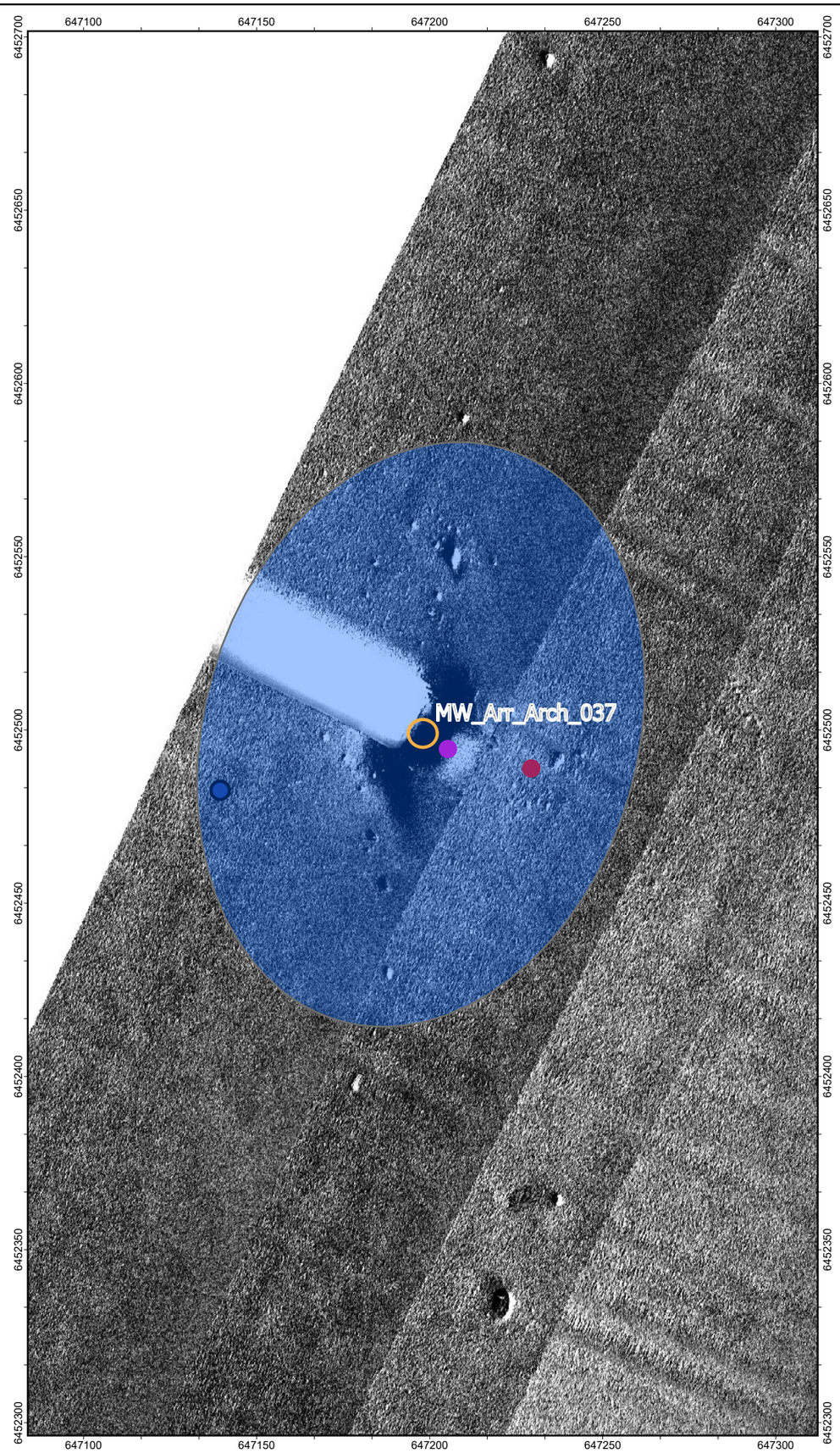


3.4.3.16 This wreck site is clearly of high archaeological potential. An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 280m and major axis of 325m, the latter orientated 120°parallel to the wreck alignment and also includes the likely deployed gear from the stern of the vessel.

MW_Arr_Arch_0037 – MFV *Emma Jayne*

3.4.3.17 MW_Arr_Arch_0037 (**Figure 27**) is thought to be the known wreck site, recorded by the UKHO as the *Emma Jayne* (UKHO 57916), located within Survey Block N. The wreck is centred upon 647197 6452499 within an average water depth of approximately 107.5m, with the maximum measured elevation of the wreck at 99.8m. The wreck site is 275m northeast of the UKHO position.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-107.36

-108.87

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

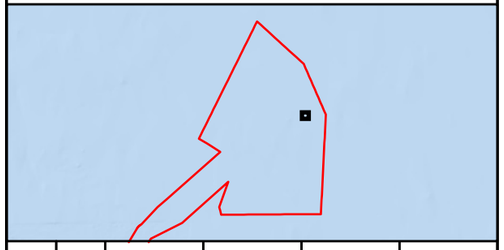
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	25/09/2025	MJG	LT	LG	NC
1	27/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-1259
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000133

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 27 Geophysical anomaly MW_Arr_Arch_0037

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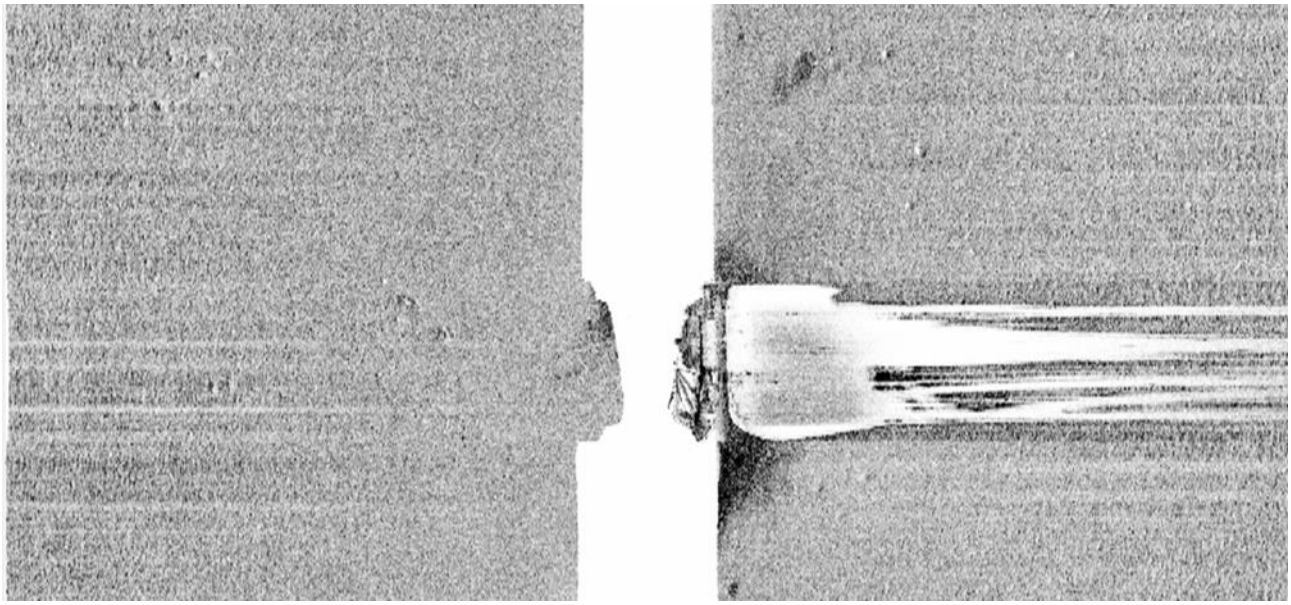
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.3.18 The wreck is orientated approximately south-southwest - NNE, with the bow at the southern end. The wreck measures approximately 24m in length, 7m wide and 7.7m hight. The wreck is sitting upright with its deck fully exposed (**Plate 3.6**). The length and breadth of the wreck match the original dimensions of the *Emma Jayne*, which was 24.5m x 7.2m x 4m.

Plate 3.6 SSS of wreck MW_Arr_Arch_0037



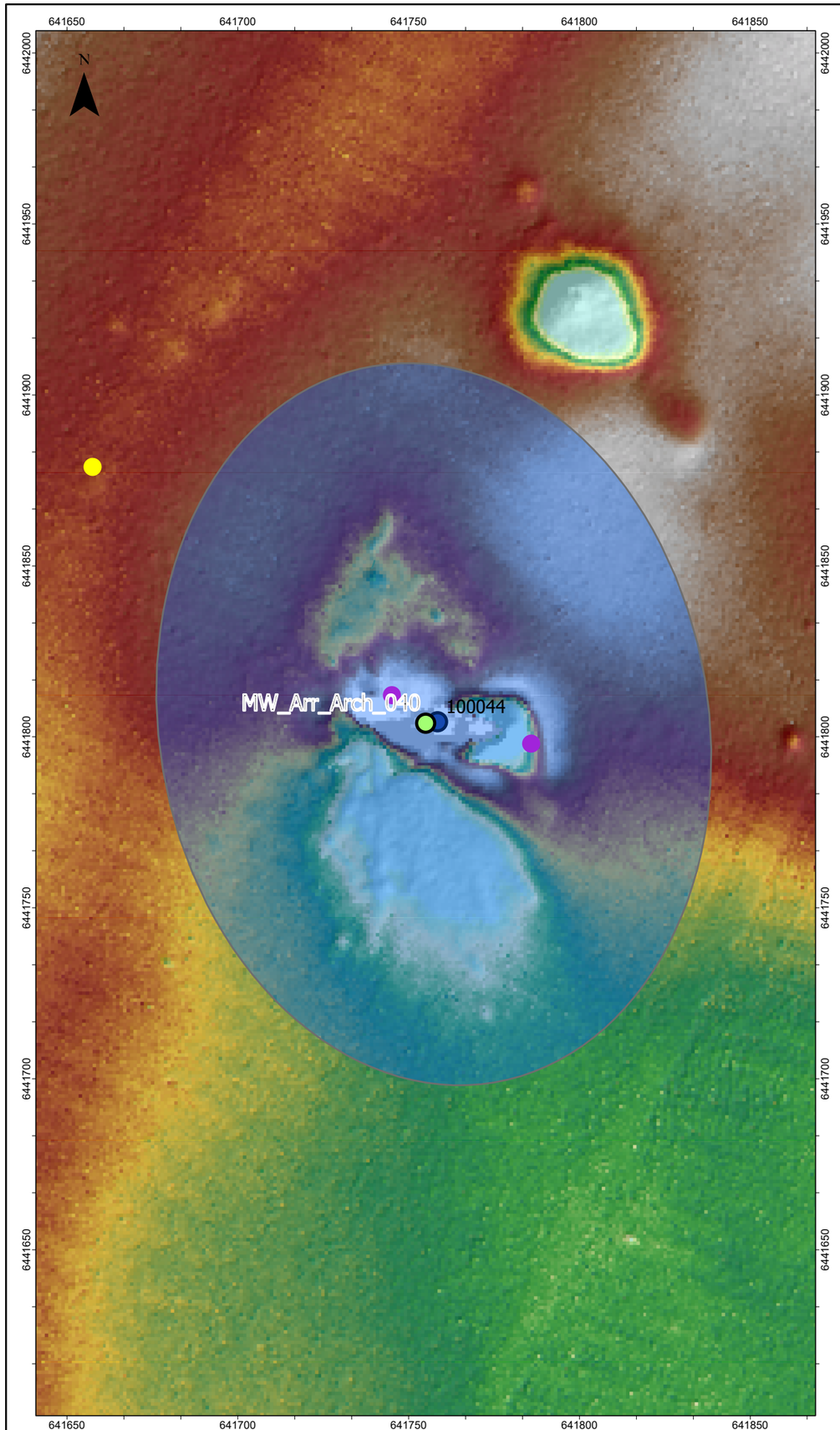
3.4.3.19 The *Emma Jayne* was a British Trawler, built in 1987. On the 25th November 1999, the vessel sprung a leak in the engine room, sinking the next day. All crew were safely recovered.

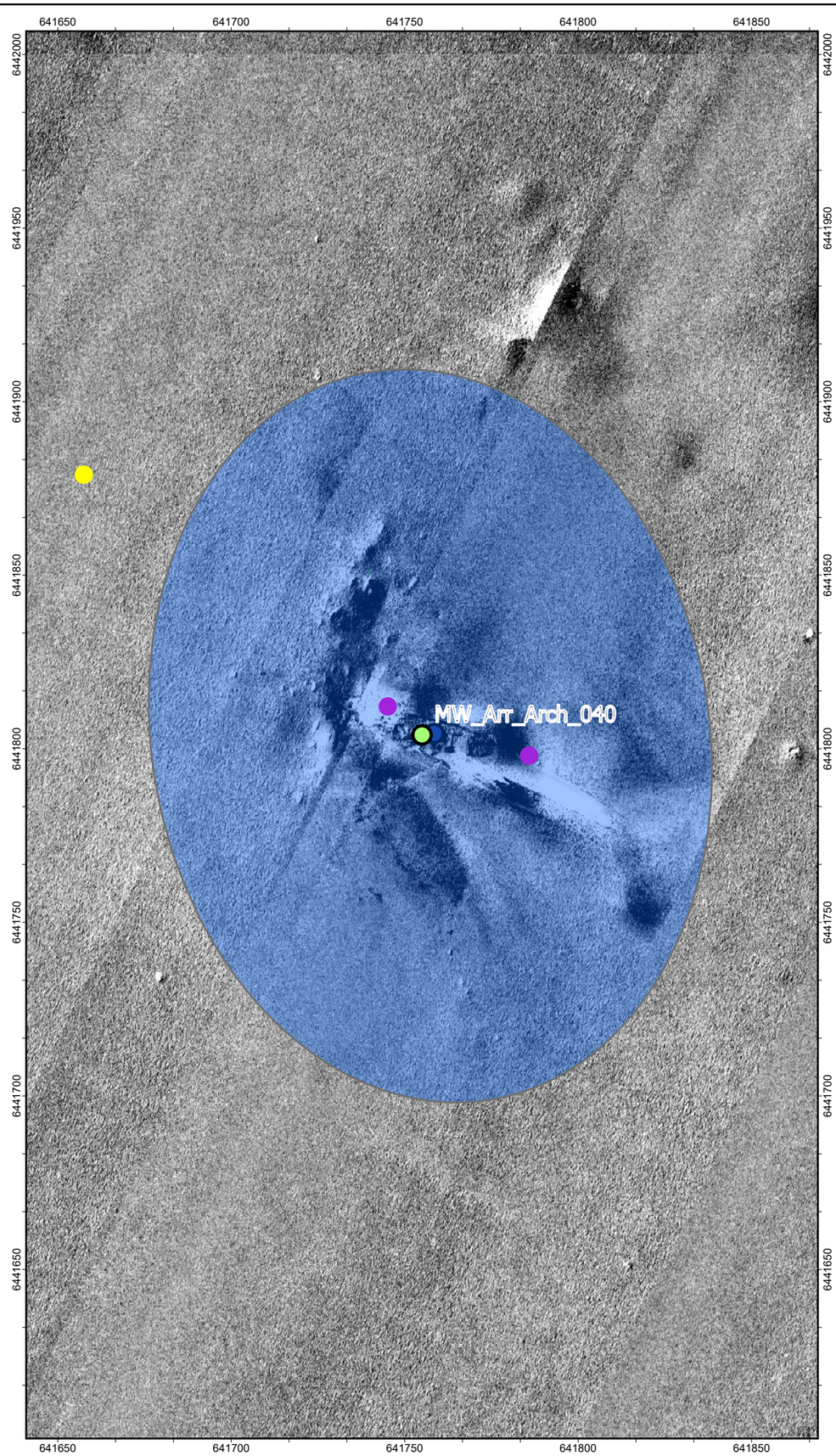
3.4.3.20 The wreck is associated with SSS anomaly SSS_A_0172 and Mag anomalies ANOM_N_0030 (238nT) and ANOM_N_0031 (5386nT). Surrounding the wreck are a series of small depressions in the seabed which may relate to debris from the sinking vessel. These extend out to 50m port and starboard of the vessel, extending up to 65m north and south of the stern and bow respectively.

3.4.3.21 This wreck site is clearly of high archaeological potential. An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 125m and major axis of 172m, the latter orientated 018° parallel to the wreck alignment.

MW_Arr_Arch_0040 – possibly the *Compass Rose 3*

3.4.3.22 MW_Arr_Arch_0040 (Figure 28) is a formerly unknown wreck located within Survey Block N. The wreck is centred upon 641755 6441804 within an average water depth of approximately 112m with the maximum measured elevation of the wreck at 107.8m. The wreck has been assigned UKHO record 100044.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-111.14

-112.85

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

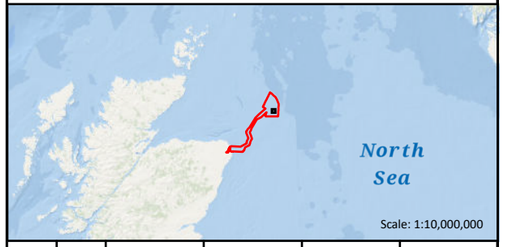
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	25/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER: 808368-WEIS-IA-E5-FG-M2-51753

MarramWind DRAWING NUMBER: MAR-GEN-ENV-MAP-WSP-000134

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 28 Geophysical anomaly MW_Arr_Arch_0040

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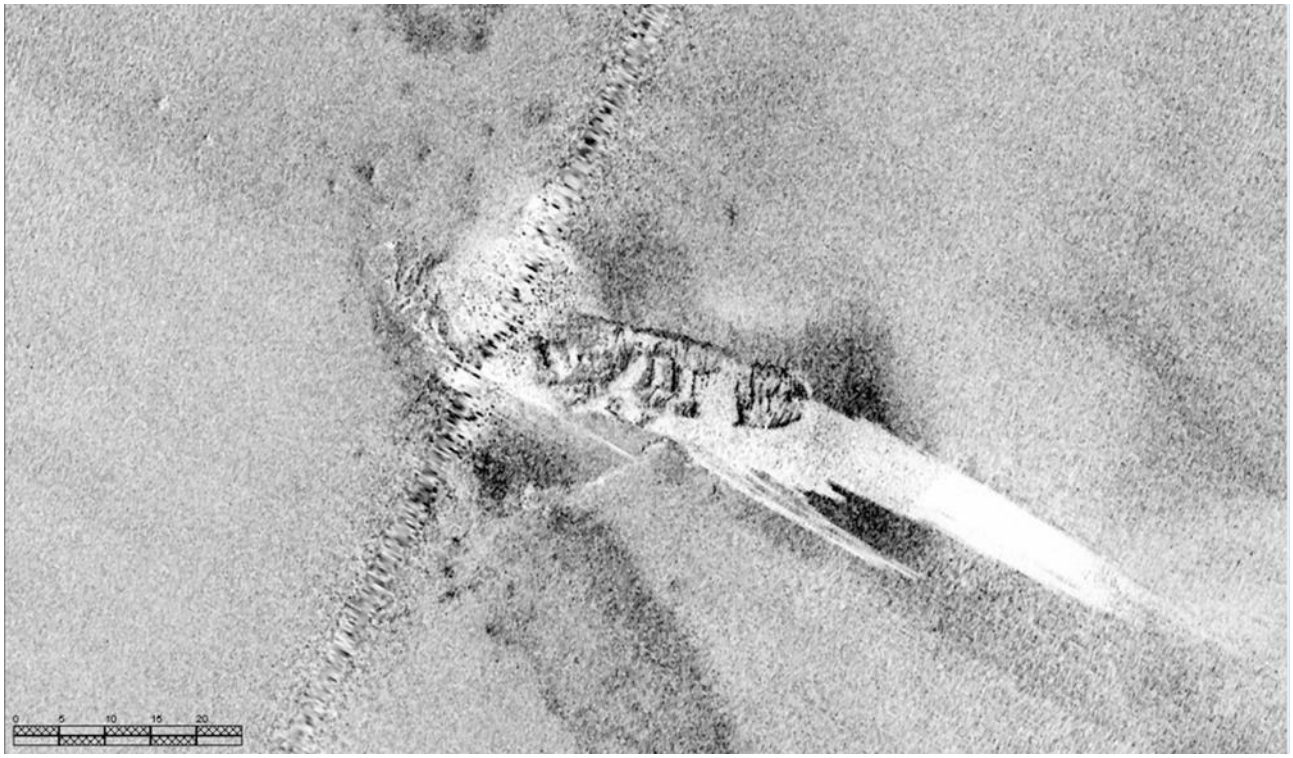
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.4.3.23 The wreck is orientated east-west, with the bow at the eastern end. The wreck measures approximately 41.5m in length, 7.8m wide and 5.5m high at the bow. The wreck is sitting upright with its deck fully exposed **Plate 3.7**).

Plate 3.7 SSS of wreck MW_Arr_Arch_0040



3.4.3.24 The dimensions of this wreck match those of the *Compass Rose 3*, which measured 41.5m x 7.5m x 2.4m (though ship plans shown the vessel was much taller), which was lost in the wider area during a gale in 1975.

3.4.3.25 The *Compass Rose 3* was a YMS-1 class motor minesweeper laid down on the 5th August 1942 as YMS-167 by the Daschel-Carter Shipbuilding Corp., Benton Harbor, Michigan, USA, and launched 12th June 1943. It was completed on the 31st July 1943 and transferred to British Navy on the 10th August 1943 and reclassified HMS J-967. It was reclassified as HMS BYMS-2167 and struck from the Naval Register 28th August 1947. Following its transfer to the State Department, Foreign Liquidation Commission in June 1948, it was sold to Romdals Fylkebatar of Molde, Norway and converted to a car ferry named Valldall. In 1962 it was sold to a shipping company in Eckero, Finland and renamed Rospiggen-II. Further sold in 1963 to a shipping company in Skargardsfarjan, Mariehamn, Finland and renamed Skarkardsfarjan. Finally, it was sold in 1972 to C.R. Lines, SA of Panama and renamed *Compass Rose 3*, whose ownership it remained in until it disappeared in 1975.

3.4.3.26 The disappearance occurred during a gale while on passage from Beryl oilfield to Fraserburgh on the 7th or 8th April 1975. The ship could not be located during an air search launched on the 16th April 1975 when it had been out of radio contact for more than one week, with the body of one crew recovered 20 miles northeast of Fraserburgh. The search was abandoned in the 18th April. On the 5th May 1975 some fishermen believed that they had located the wreck about 40 miles northeast of Fraserburgh, with reports that the wreckage bore similar coloured paint to that on the *Compass Rose 3*, The following day, a large contact was identified during a Decca survey though this might have matched an earlier contact also encountered by HMS *Palliser* in 1963, predating the sinking of the

Compass Rose 3. The position for UKHO record 1353, and its attribution to the *Compass Rose 3*, may therefore not be correct. This UKHO live record is positioned 30.8km east-northeast of wreck MW_Arr_Arch_0040.

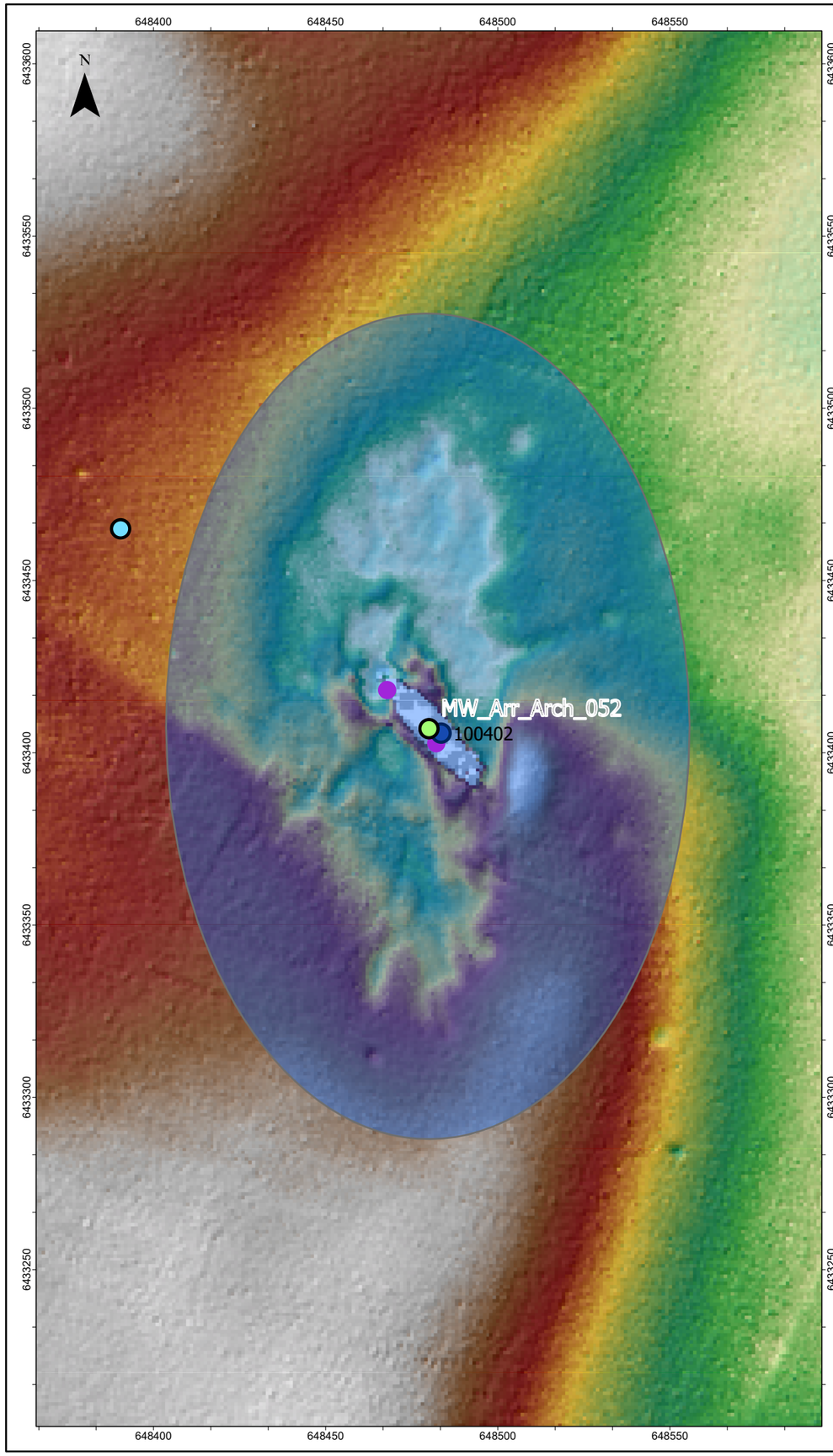
3.4.3.27 Within the wider area, the *Compass Rose 3* is the only known loss with dimensions that match wreck MW_Arr_Arch_0040, making this the most likely candidate. In addition, the MBES and SSS show a similar deck and superstructure layout to a YMS-1 class motor minesweeper, with the rounded bow at the eastern end of the wreck which features an elevated deck, the main cabin forward of midship and funnel aft of midship, while towards the stern is a lowered open deck with a square stern. The size and shape of the vessel, coupled with the matching positions for key superstructure elements, make this wreck a good candidate for the lost *Compass Rose 3*.

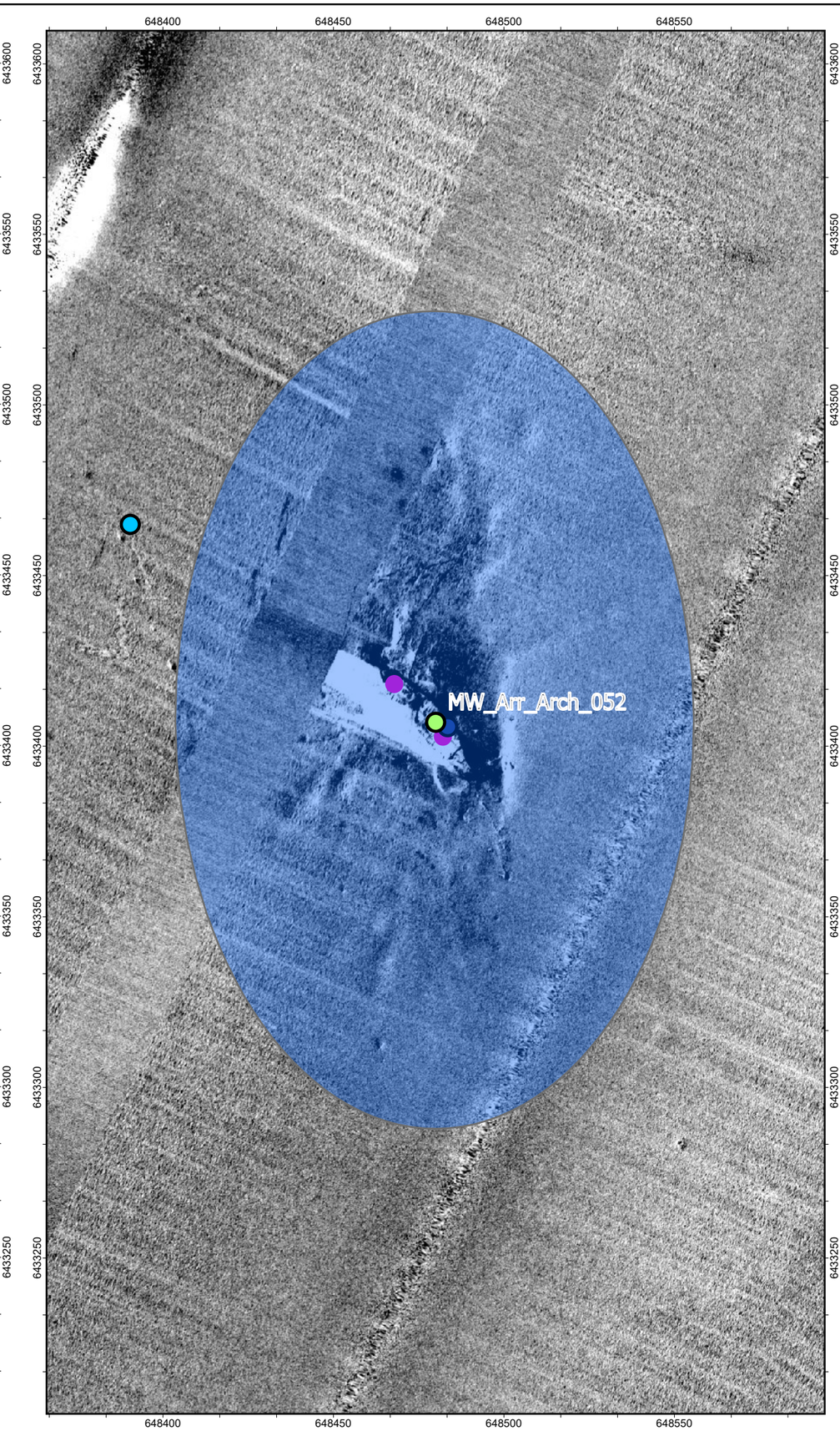
3.4.3.28 The wreck is associated with SSS anomaly SSS_N_0148 and MAG anomalies ANOM_N_0023 (6252nT) and ANOM_N_0024 (596nT). Scour around the wreck site is deepest at the bow at its eastern end, though north-south shallow scour is also seen extending north and south of the wreck for up to 70m. This includes a series of small SSS anomalies, probably exposed boulders but also possibly a debris field, extending north and south within these scour areas.

3.4.3.29 This wreck site is clearly of high archaeological potential. An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 160m and major axis of 210m, the latter orientated 172°parallel to the north-south scour alignment.

MW_Arr_Arch_0052 – possibly the FV *Lucerne*

3.4.3.30 MW_Arr_Arch_0052 (**Figure 29**) is a formerly unknown wreck located within Survey Block S. The wreck is centred upon 643889 6447760 within an average water depth of approximately 116m with the maximum measured elevation of the wreck at 112.4m. The wreck has been assigned UKHO record 100044.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-114.72

-116.42

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

5-9 nT

10-19 nT

20-29nT

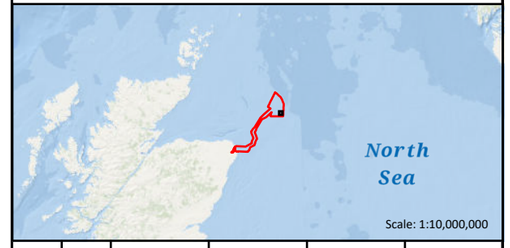
30-49 nT

50-99 nT

100-500 nT

500-1000 nT

0 10 20 30 40 50 60 70 80 Meters



			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER 808368-WEIS-IA-E5-FG-M2-22827

MarramWind DRAWING NUMBER MAR-GEN-ENV-MAP-WSP-000135

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:1,500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 29 Geophysical anomaly MW_Arr_Arch_0052

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wsp MarramWind

3.4.3.31 The wreck is orientated northwest to southeast, with the bow at the southern end. The wreck measures approximately 34.5m in length, 7m wide and 3.2m high. The wreck is sitting upright with its deck fully exposed (**Plate 3.8**). Debris is seen on the seabed surrounding the wreck, including what looks like collapsed masts and rigging. The stern of the ship appears to have been damaged, especially on its starboard side at the bow. The main mast appears to be lying along the southern edge of the wreck, while the collapsed wheelhouse is just aft of midships.

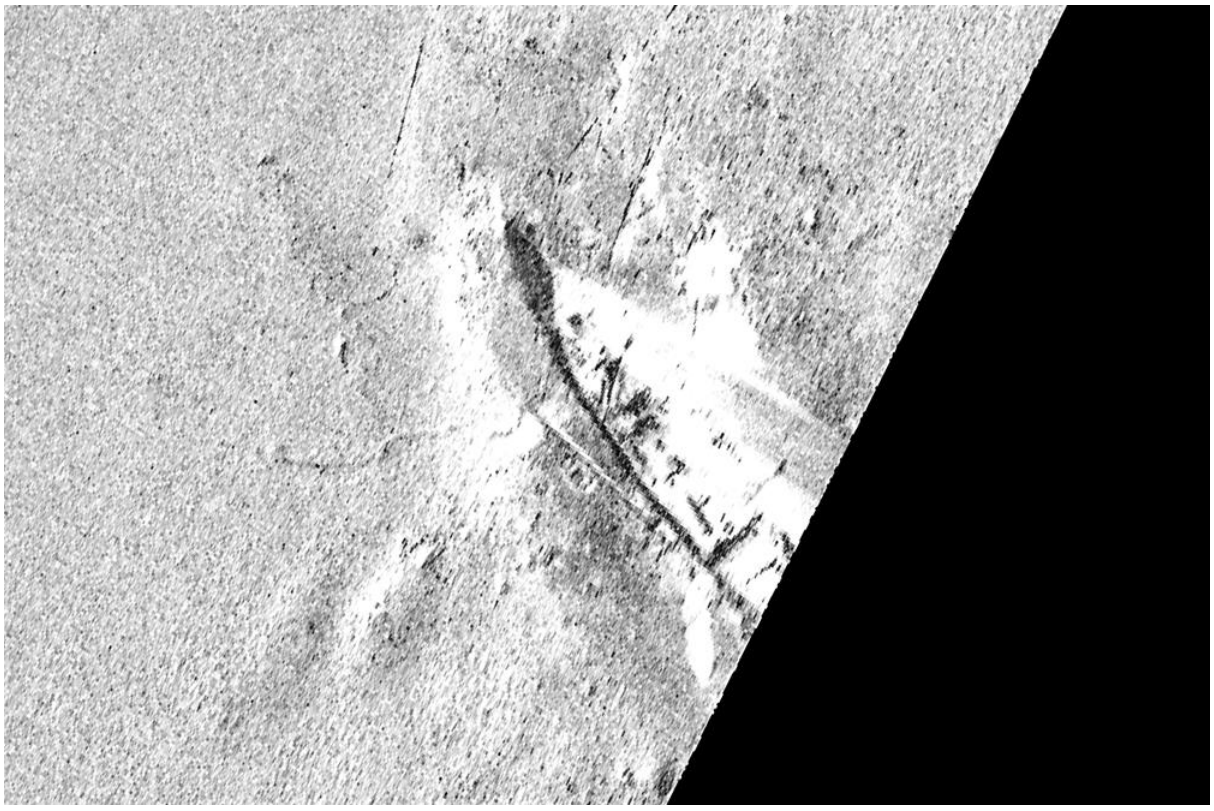
3.4.3.32 Within the wider area, there is the reported loss of the FV *Lucerne*, a steam trawler built by the Edwards Brothers in 1896 and operated by R.J. Moon of Aberdeen when it was lost in 1915. It was captured by the German submarine U-23 on the 19th May 1915 when fishing 50miles northeast by north off Rattray Head. The ship was sunk by charges / explosives, though all crew evacuated the ship before it was sunk.

3.4.3.33 The vessel is reported as having been 32.3m x 6.3m x 3.3m, which is slightly smaller than wreck MW_Arr_Arch_0052, though damage to the bow makes establishing the exact length of the vessel difficult. However, the similarity in vessel size, damage to the vessel's hull, and other superstructure items visible on and around the wreck, make the FV *Lucerne* a possible candidate for this ship. The approximate loss position is approximately 5km west-southwest of the wreck site.

3.4.3.34 The wreck is associated with SSS anomaly SSS_N_0227 and MAG anomalies Anom_S_012 (641nT) and Anom_S_013 (526nT). Scour is visible to both the north and south of the wreck site, extending up to 100m in both directions. Debris associated with the wreck, notably collapsed rigging, is seen spread up to 60m north and south of the wreck.

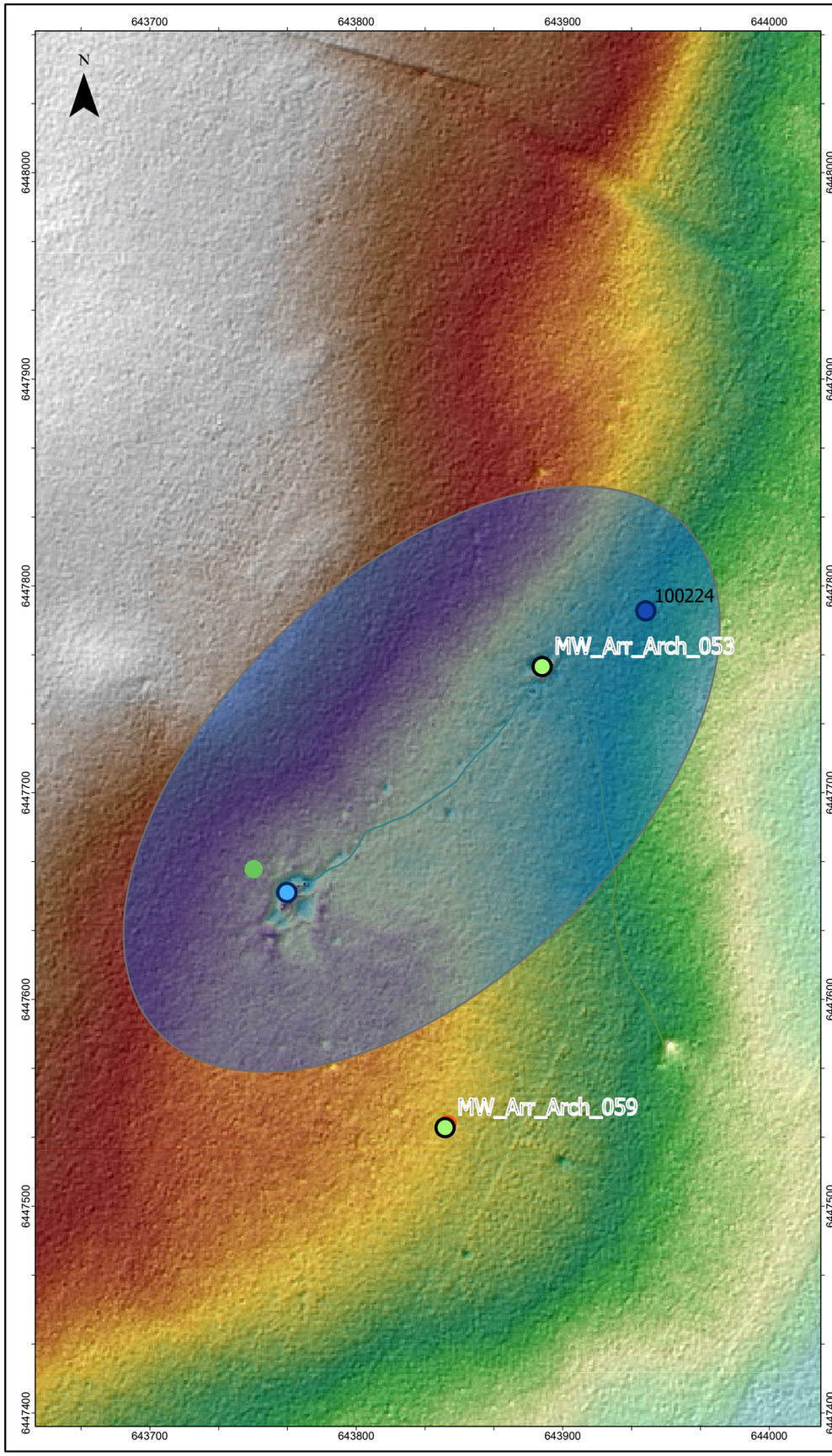
3.4.3.35 This wreck site is clearly of high archaeological potential. An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 155m and major axis of 250m, the latter orientated 180°parallel to the north-south scour alignment.

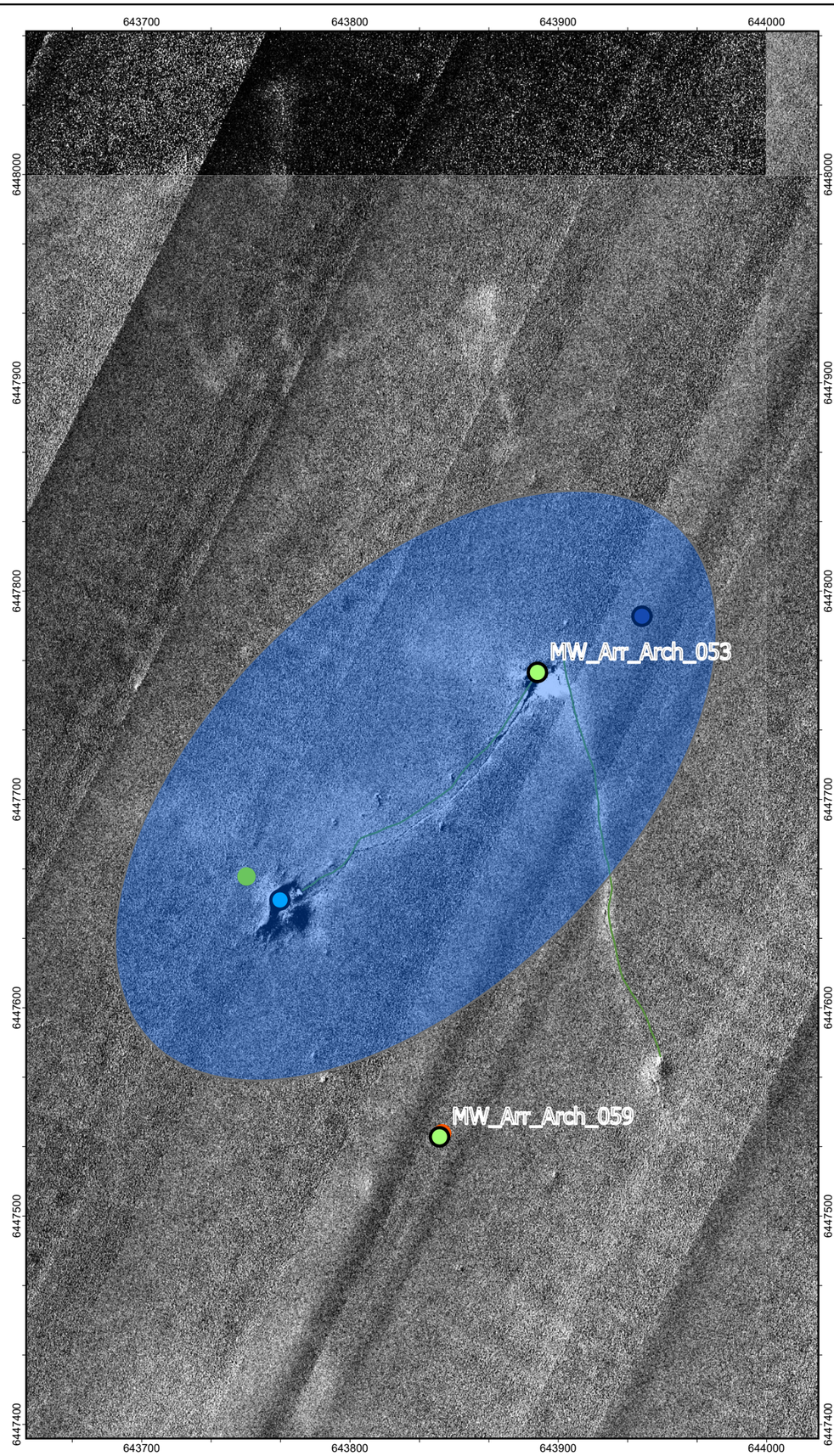
Plate 3.8 SSS of wreck MW_Arr_Arch_0052



MW_Arr_Arch_0053

3.4.3.36 MW_Arr_Arch_0053 (**Figure 30**) is a formerly unknown wreck located within Survey Block N. The wreck is centred upon 641755 6441804 within an average water depth of approximately 109m with the maximum measured elevation of the wreck at 105.1m. Confirmation that this is a wreck was through an Environmental Video Transect (NTR04) Survey in July 2022. The wreck has been assigned UKHO record 100224.





Offshore Red Line Boundary

Option Agreement Area

Bathymetry (m LAT)

-105.58

-107.61

Geophysical Anomalies with Archaeological Potential

Archaeological Exclusion Zone

UKHO Wrecks

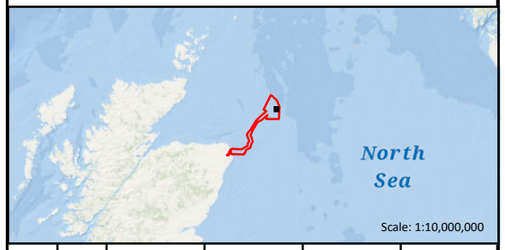
SSS Anomaly

Linear SSS Anomaly

Magnetic Anomaly

- 5-9 nT
- 10-19 nT
- 20-29nT
- 30-49 nT
- 50-99 nT
- 100-500 nT
- 500-1000 nT

0 25 50 75 100 125 Metres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-6688
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000137

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:2500	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 30 Geophysical anomaly MW_Arr_Arch_0053

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wsp MarramWind

3.4.3.37 The wreck is associated with SSS anomaly SSS_N_0141 (**Plate 3.9**) and is clearly defined within the MBES as measuring 5.4m x 2.2m x 1.8m **Plate 3.10**). The wreck is orientated northwest to southeast, with the bow possibly at the northwest end. The wreck is sitting upright with its deck fully exposed. Video footage (**Plate 3.11**) shows that the wreck is covered by fishing gear (nets and cables) which appear to have snagged on the wreck. Video footage shows the preservation of the outer hull (where observed), which appears to be constructed from steel, with a solid double rail around the forecastle and what appears to be a wheelhouse that extends laterally to the hull edge and contains stadium-shaped windows. Hawesholes also appear to be present beneath the rails. A yellow colouration visible on the hull may relate to the ship's original painted colour.

3.4.3.38 Scour can be observed around the northwest of the wreck by the bow, extending up to 40m. Two linear reflectors, likely fishing gear, can be seen extending south (SSS_N_0239) and southwest (SSS_N_0281) of the wreck. SSS linear anomaly SSS_N_0281 extends for approximately 160m where it meets a second large anomaly on the seabed.

3.4.3.39 This second anomaly, centred on 643768 6447651, measures 12m x 4m x 1m (**Plate 3.12**) and is associated with ANOM_N_0017 (11nT). Localised scour can be seen around the anomaly, extending up to 25m. The origin of this second anomaly is unclear, with no clear definition of what it might be (beyond likely containing some debris) in the SSS.

3.4.3.40 Along the margins of linear SSS anomaly SSS_N_0281, between the two upstanding objects, are a series of smaller angular SSS reflectors <2m. This may indicate a debris spread between the two anomalies, possibly with the wreck broken into two segments on the seabed.

Plate 3.9 SSS of the northern anomaly associated with MW_Arr_Arch_053

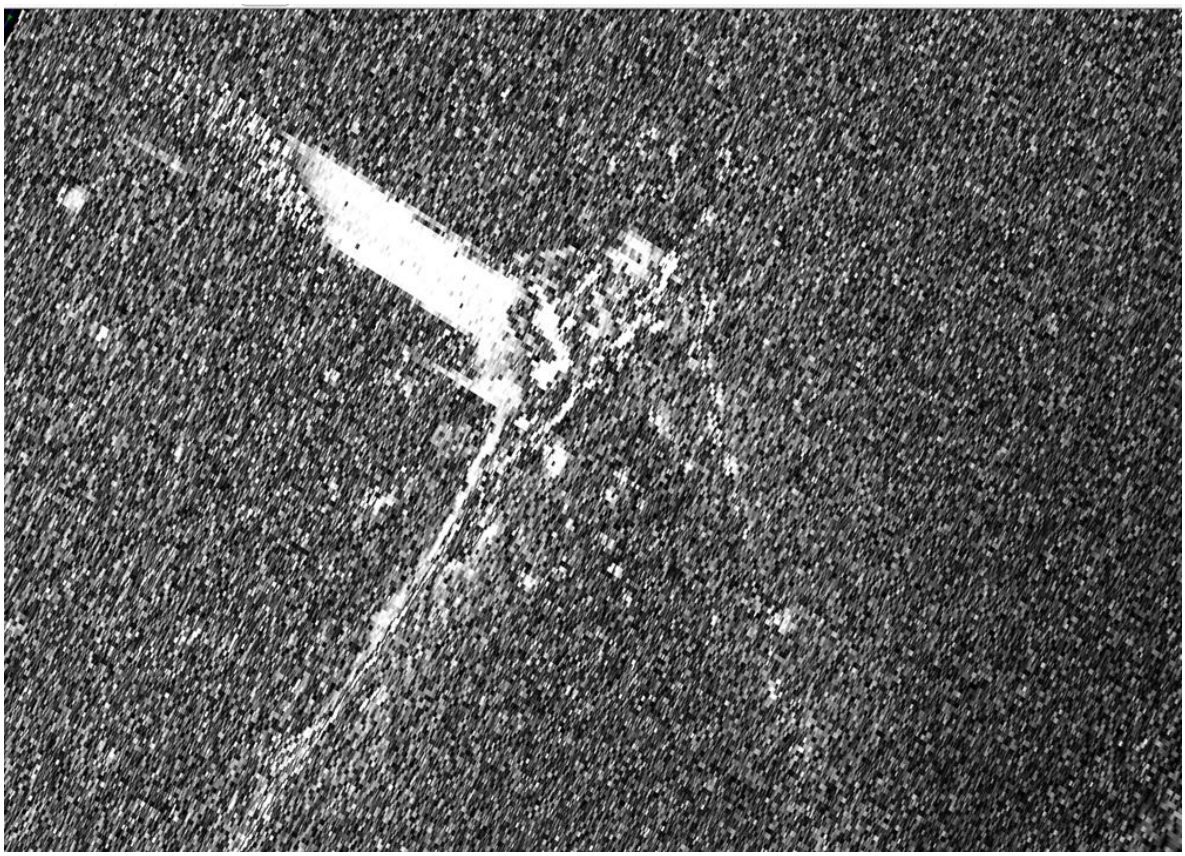


Plate 3.10 Point cloud of the northern anomaly associated with MW_Arr_Arch_053

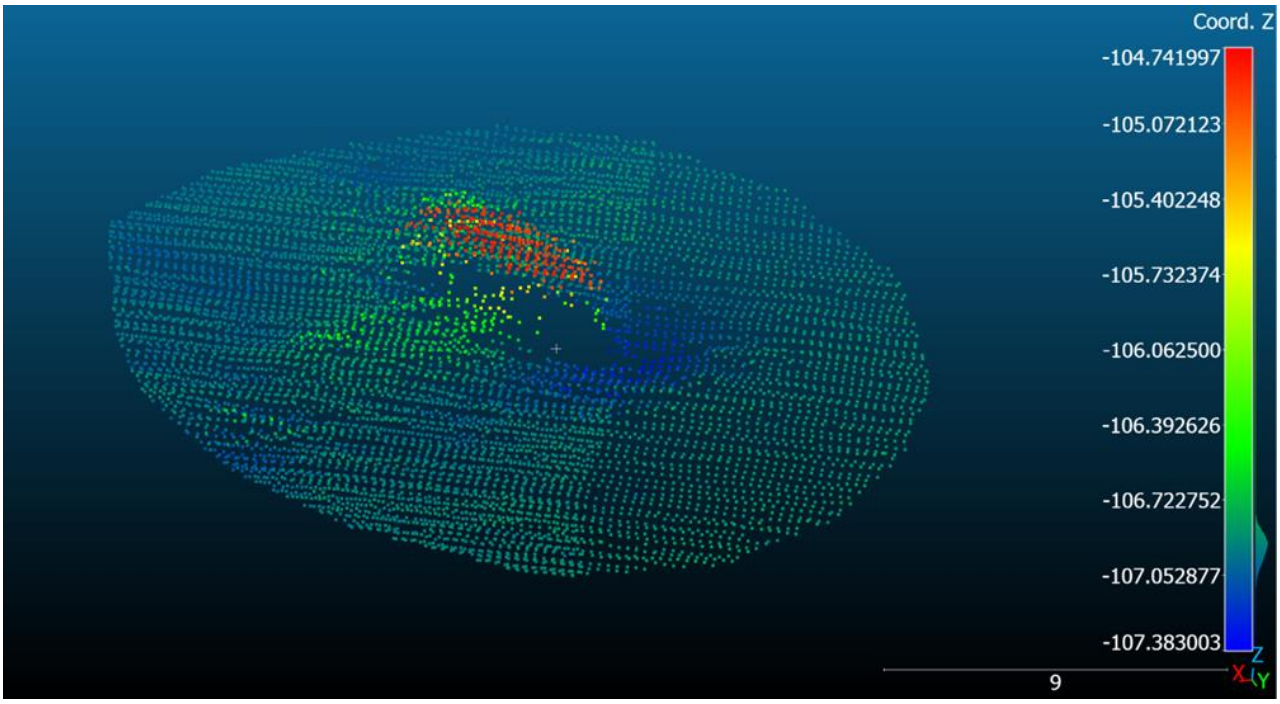
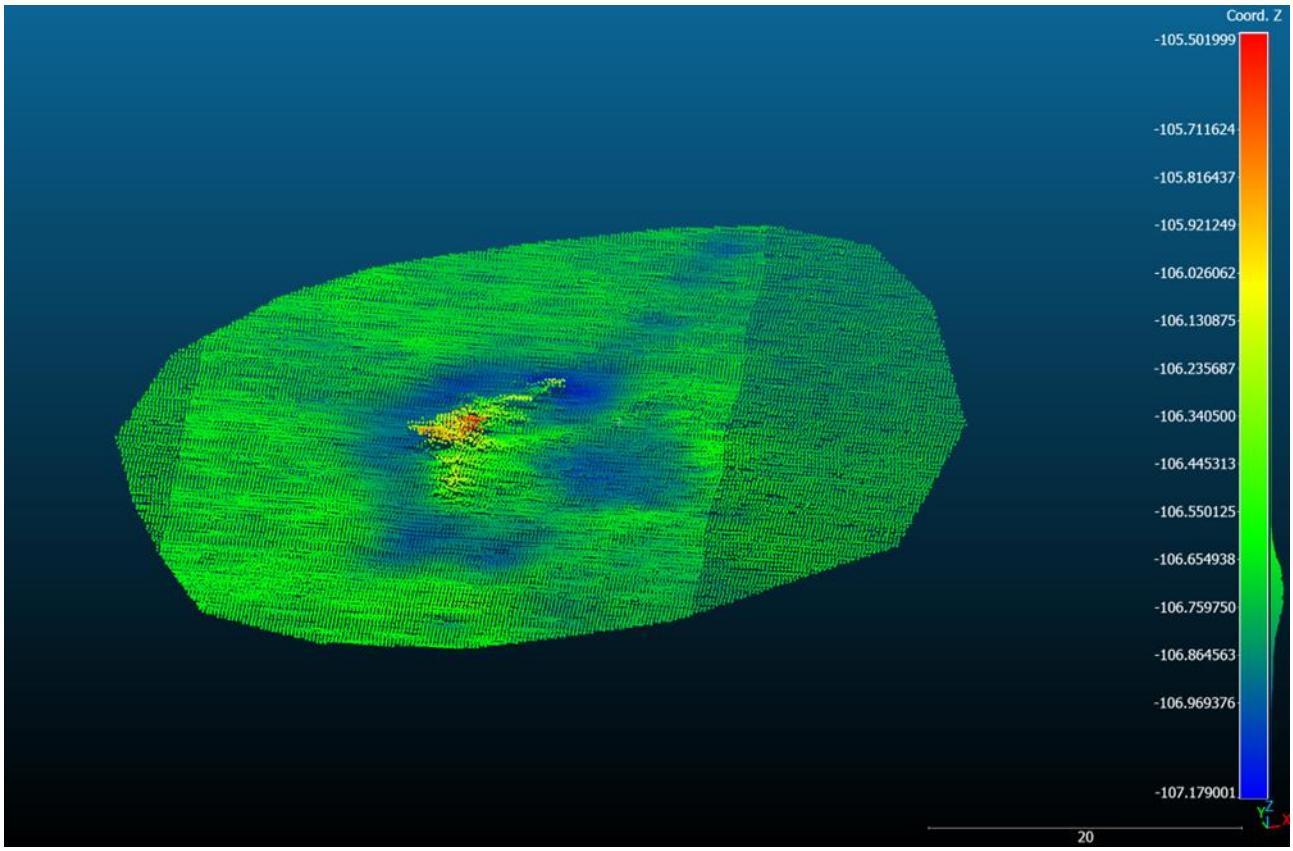


Plate 3.11 Still from Environmental Video Transect (NTR04) Survey of the wreck, showing the hull, rail and probable wheelhouse at 643890 6447762 associated with the northern anomaly at MW_Arr_Arch_053



Plate 3.12 Point cloud of the southern anomaly associated with MW_Arr_Arch_053



3.4.3.41 No possible known vessel is associated with this wreck site, though the unique structural features visible within the video footage may permit an identification following further review. Based upon the features visible, it is probable that this is a trawler, probably mid to late 20th century.

3.4.3.42 An AEZ has been constructed for this wreck, based upon an ellipsis covering both seabed objects, with a minor axis diameter of 200m and major axis of 350m, the latter orientated 045°parallel to the debris field between the two large anomalies.

3.4.4 Assessment of known UKHO sites within footprint of geophysical survey

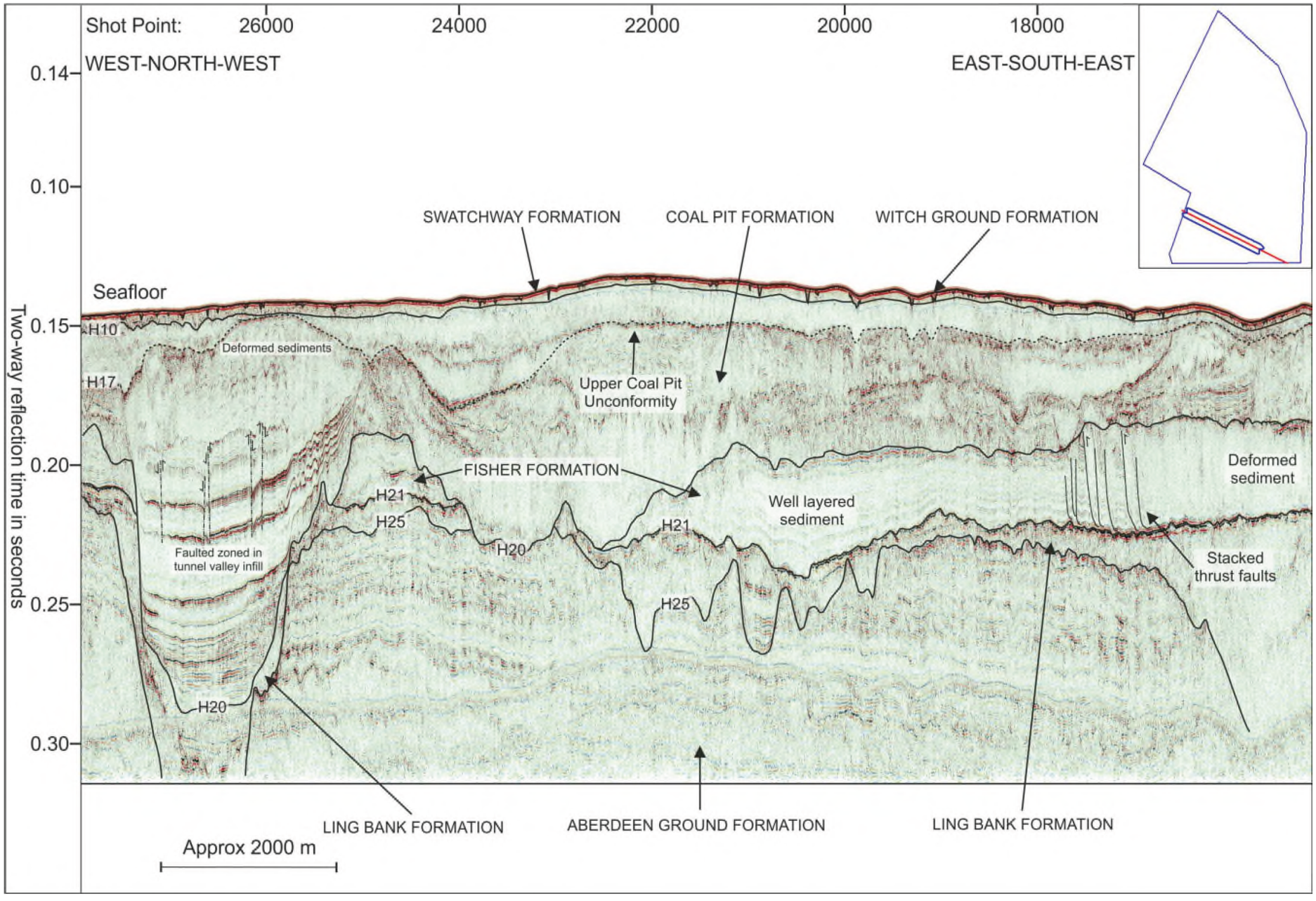
3.4.4.1 In addition to the wreck sites discussed above, there are two additional UKHO records associated with the OAA (**Figure 5**).

3.4.4.2 UKHO 1668, reported as a non-dangerous wreck (live record), is positioned at 632245 6450015. The location has good coverage by all geophysical data types. There are no visible anomalies within either the SSS or MBES within 300m of this position, with the seabed instead being flat and featureless. The closest SSS anomaly is a single boulder approximately 310m east of the UKHO position. There are also no MAG anomalies within 300m of this location, with the closest MAG survey line directly over this position. This UKHO record dates from 1973 and appears to be derived from a Danish chart rather than a seabed discovery. There is no evidence to suggest the presence of a wreck in this location.

3.4.4.3 UKHO 1669, reported as a non-dangerous wreck (live record), is positioned at 646556 6461044. This record is associated with the fishing vessel *Welfare*, which sunk on the 3rd November 1979 after taking in water and sinking during a gale, 60 nautical miles northeast of Peterhead. All crew were rescued. The location has good coverage by all geophysical data types. There are no visible anomalies within either the SSS or MBES within 300m of this position, with the exception of the PL3036 with the PL3036 Golden Eagle to Claymore oil export pipeline, located 140m west of the UKHO location. The only MAG anomalies are those associated with this pipeline, with the nearest MAG survey line being 27m west of the UKHO position. This record, therefore, appears to relate to the approximate sinking position of this fishing vessel rather than an actual known wreck on the seabed.

3.5 Assessment of the submerged palaeolandscape

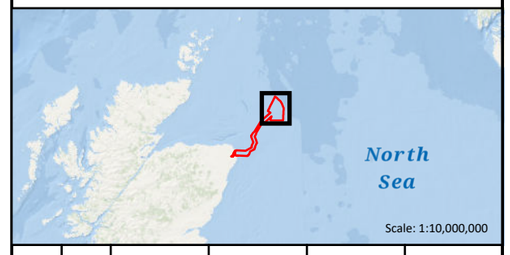
3.5.1.1 The SBP and 2DUHRS datasets from the OAA have permitted the spatial mapping of the Quaternary sedimentary sequence of at least the upper 0.16 seconds TWTT (approximately 120m) beneath the seabed. The combination of these two seismic systems provides the opportunity to image and map sedimentary succession from the Early Middle Pleistocene through to the modern period (**Figure 31**). Deeper Pleistocene Formations, notably the Aberdeen Ground and Ling Bank Formations, are only visible within the 2DUHRS data. The boundary between the Ling Bank Formation and the Fisher Formation is typically marked by a distinctive planar erosion surface. However, differentiation of the seismo-stratigraphic boundary between the Fisher and Ling Bank Formations is not always possible, as they can exhibit similar seismic properties.



Offshore Red Line Boundary

Option Agreement Area

0 10 Kilometres



			--	--	--
2	18/09/2025	MJG	LT	LG	NG
1	21/07/2025	MJG	LT	TG	NG
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-71525
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000138

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:160,000	PAGE SIZE	A3

PROJECT TITLE

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DRAWING TITLE

Figure 31 2DUHRS cross section (line MW-X-031) showing the Pleistocene and Holocene Formations identified within the OAA

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3.5.1.2 Each of these formations has been assigned an age, or approximate age-range, based upon their stratigraphic relationship to each other, their known biostratigraphy, nature of formation, or the direct application of geochronological techniques to assign a date (see Stoker *et al*. 2011). Reporting of these ages is typically by the application of the Marine Isotope Stage (MIS) scheme. MIS provide a subdivision of the Pleistocene, recording the oscillations between glacial and interglacial phases of global climate, with MIS 1 representing the latest post-glacial warm period associated with the Holocene, which begun at 11.7ka. Ages assigned to these MIS are based upon the work of Lisecki and Raymo (2005).

3.5.1.3 The Aberdeen Ground Formation can be divided into a Lower Formation, associated with delta-front to shallow pro-delta / open marine conditions, and an Upper Formation associated with subglacial to proglacial deposition. The Upper Formation will typically consist of heavily over-consolidated, commonly fissured, very high to extremely high strength clays with laminae to beds of dense to very dense silt and sand. Zones of faulting have been observed in the upper part of the Aberdeen Ground Formation (below 75m below sea floor), likely the result of glacial loading and ice movement. Stacked thrust faults have also been previously observed within the Aberdeen Ground Formation in the Central North Sea, caused by repeated ice advance and retreat cycles (Vaughan-Hirsch and Phillips 2015). The Upper Formation appears to be visible across much of the OAA area.

3.5.1.4 There are few chronological controls on the age of this formation, though it is commonly interpreted as being pre- MIS 12 (pre- 478ka). This formation has usually been extensively eroded and dissected prior to the deposition of the overlying glacigenic sediments of the Reaper Glacigenic Group. This results in the base of the Ling Bank and Coal Pit Formations having an unconformable surface resulting partly from sub-glacial channel scouring.

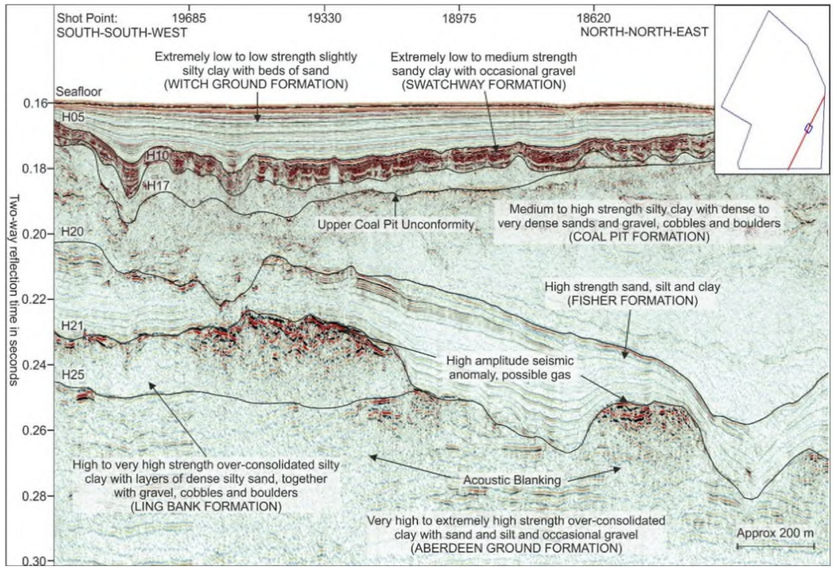
3.5.1.5 The Ling Bank Formation is associated with a Middle to Upper Pleistocene Interglacial, and is expected to contain silts, clays and sands within a channel sequence. It incises into the underlying Aberdeen Ground Formation, with the base of the Ling Bank Formation marked by a regional glacial unconformity and a network of tunnel valleys formed by the action of sub-glacial drainage (Bendixen *et al*. 2017). The base is shallowest in the centre of the survey area, approximately 35m below seabed, but increased below the maximum extent of the 2DUHRS data (approximately 160m or potentially deeper) in other areas, the deepest being within the two tunnel valleys crossing the centre of the survey area (**Figure 32**). The Ling Bank Formation is found across most of the OAA area, except where it pinches out against the base of the Fisher and / or Coal Pit Formations.

630000
645000
660000
6465000
6450000
6435000

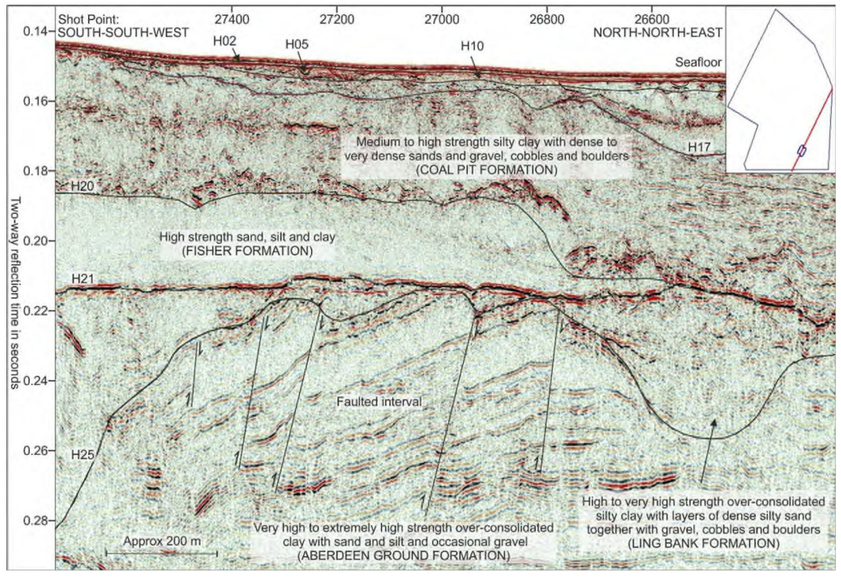
N

Ling Bank Formation
below base of 2DUHRS
dataset

Line MW-Q-292



Line MW-Q-283



Offshore Red Line Boundary

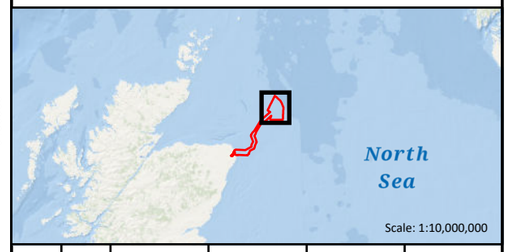
Option Agreement Area

Base of the Ling Bank Formaiton (m below LAT)

251.811

141.073

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	18/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-73113
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000139
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:160,000
PAGE SIZE	A3

PROJECT TITLE
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DRAWING TITLE
Figure 33 Modelled surface for the base of the Ling Bank Formation. Example 2DUHRS cross sections showing the relationship between the underlying Aberdeen Ground Formation and overlying Fisher Bank and Coal Pit Formations in the southeast.
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3.5.1.6 Both the Aberdeen Ground and Ling Bank Formations are present at depths commonly exceeding the proposed maximum depth of impact from the OAA. The overlying younger and shallower Pleistocene and Holocene formations are summarised in **Table 3.3**.

Table 3.3 Pleistocene and Holocene Formations within the OAA

Formation	Depositional environment	Expected lithology	Age
Holocene marine	Holocene reworking of Quaternary sediment in a low- to moderate- energy marine environment.	Expected to comprise of clayey, silty sand and coarse sand with occasional gravel and isolated to scattered cobbles and boulders.	Holocene (MIS 1; post 11.7ka).
Witch Ground	Glaciomarine, sometimes reworked during the mid- to late-Holocene.	Comprise fine sands and silts, often laminated. Unit is often acoustically well-laminated, and characterized by the occurrence of pockmarks.	Late Devensian / Early Holocene (MIS 2/1; post 29ka).
Swatchway	Likely to have been proximal glaciomarine sediments.	Extremely low to medium strength sandy clay with occasional gravel.	Thought to be Middle Devensian (MIS 3/2; approximately 57ka to 26ka.
Coal Pit	Upper Pleistocene (Devensian) Sub-glacial, Post glacial, interglacial to early glacial. Largely exists as infill deposits within tunnel valleys that were eroded during / immediately after Middle Pleistocene glaciation.	Sandy silty clay and interlaminated clay and fine-grained silty sand; clay is generally stiff and over consolidated with some pebbles. Shell fragments and complete valves abundant in places. Boulders are observed within this formation.	Thought to be between MIS 6 and 2 (approximately 191ka and 29ka).
Fisher	Middle to Upper Pleistocene Glaciomarine.	Very stiff over-consolidated silty clay and interlaminated clay and fine-grained silty sand, with some pebbles (of varying clast lithologies). Shell fragments and complete valves abundant in places.	Thought to be between MIS 6 and 2 (approximately 191ka and 29ka).

3.5.1.7 The Fisher Formation contains horizontal contiguous reflectors, occasionally reaching close to the OAA seabed surface, though it is mostly cut into by the younger channelling and / or tunnel valleys associated with the Coal Pit Formation (**Figure 33**). The age of the Fisher Formation is uncertain, with Merritt *et al*. (2003: 62) suggesting that it is no older than MIS 7 (243ka), while Stoker *et al*. (2011) provide a wider date range of MIS 6 to 10 (123ka to 374ka).

630000 645000 660000 675000

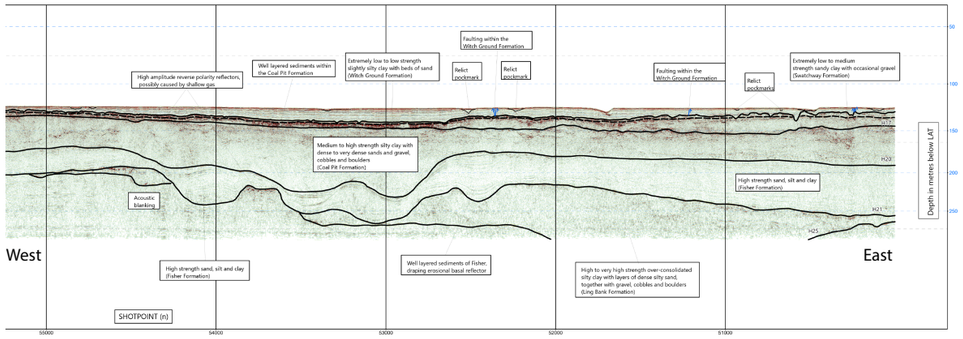
6465000 6450000 6435000

N

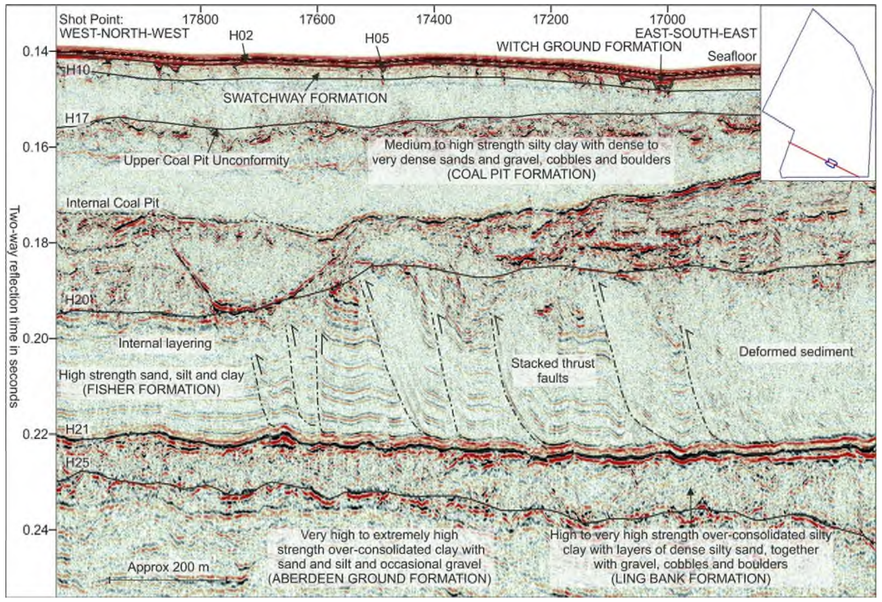
Fisher Formation absent

MW-X-022A

Line MW-X-022A



Line MW-X-031



Offshore Red Line Boundary

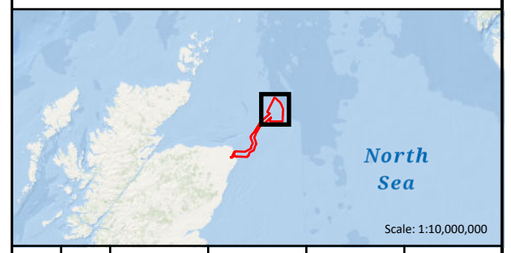
Option Agreement Area

Base of the Fisher Formaiton (m below LAT)

236.93

131.08

0 10 Kilometres



2	27/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NG
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-81088
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000140

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:160,000	PAGE SIZE	A3

PROJECT TITLE

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DRAWING TITLE

Figure 33 Modelled surface for the base of the Fisher Formation. Example 2DUHRS cross sections showing channel infill and faulting within the formation

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3.5.1.8 Thermoluminescence dates from the base and centre of the Fisher Formation in British Geology Survey (BGS) Borehole 81/29 from Devil's Hole provided ages of 210±20ka and 182±18ka (Jensen and Knudsen 1988), placing this within the MIS 7/6 period (around 191ka). While the broad interpretation of this deposit is glaciomarine (Gatliff *et al*. 1994: 89; Merritt *et al*. 2003: 62), samples from BGS Borehole 81/26 in the Fladen area demonstrated that the Fisher Formation was characterised by sediments deposited in a sub glacial environment, including diamicton, during MIS 6 (191ka to 123ka) (Sejrup *et al*., 1987; Ekman and Scourse 1993).

3.5.1.9 The Fisher Formation is present throughout most of the area, underlying the Coal Pit Formation. Where absent, this is largely due to the Coal Pit Formation, and associated tunnel valleys, having eroded through the Fisher Formation into the underlying Ling Bank Formation (Figure 33). The Fisher Formation predominantly consists of a lower amplitude semi-transparent parallel to subparallel layer, though in some areas these have been deformed by glacial activity to produce a more homogenous and featureless seismic character. The division between these two units often coincided with a series of stacked thrust faults, interpreted to be the result of glacial drag and associated deformation, separating the well-laminated parallel bedding in the west from the homogenous deformed sediments in the east. The base of the Fisher Formation varies in depth between approximately 28m below the seabed in the west and approximately 125m in the east (**Figure 33**).

3.5.1.10 The Aberdeen Ground, Ling Bank and Fisher Formation are all cut by large and deep tunnel valleys associated with fills of the Coal Pit Formation (**Figure 34**). These deep valleys are expected to be the result of Middle Pleistocene glaciation. Channelling is complex and discontinuous within the Coal Pit Formation but overall seems to suggest two main channel patterns. The first phase related to two main large tunnel valleys orientated approximately northeast to southwest, running through the centre of the OAA area. These two tunnel valleys have reused existing Ling Bank Formation tunnel valleys and contain a significant infill of Coal Pit Formation, some extending down beyond approximately 160m below the seabed. Zones of faulting have been identified within the mid to upper sequence of Coal Pit tunnel valley infills. They are interpreted as de-watering structures, attributed to the rapid sedimentation rates of the channel infill sequence. These two tunnel valleys cut across a series of shallower early Coal Pit Formation channels that are predominantly orientated north-south, though with east-west flow in the south.

630000 645000 660000 675000

6465000

6450000

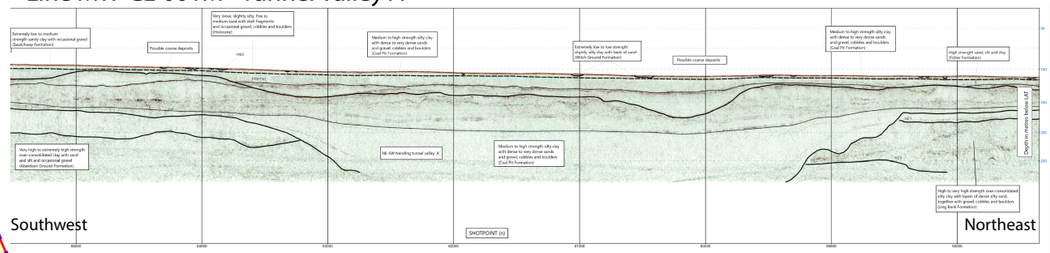
6435000

N

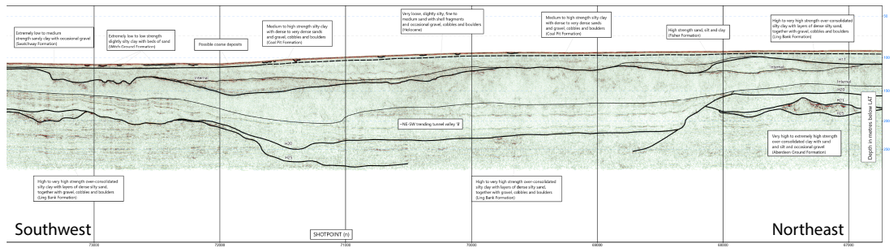
Coal Pit Formation below base of 2DUHRS dataset

Tunnel Valley A

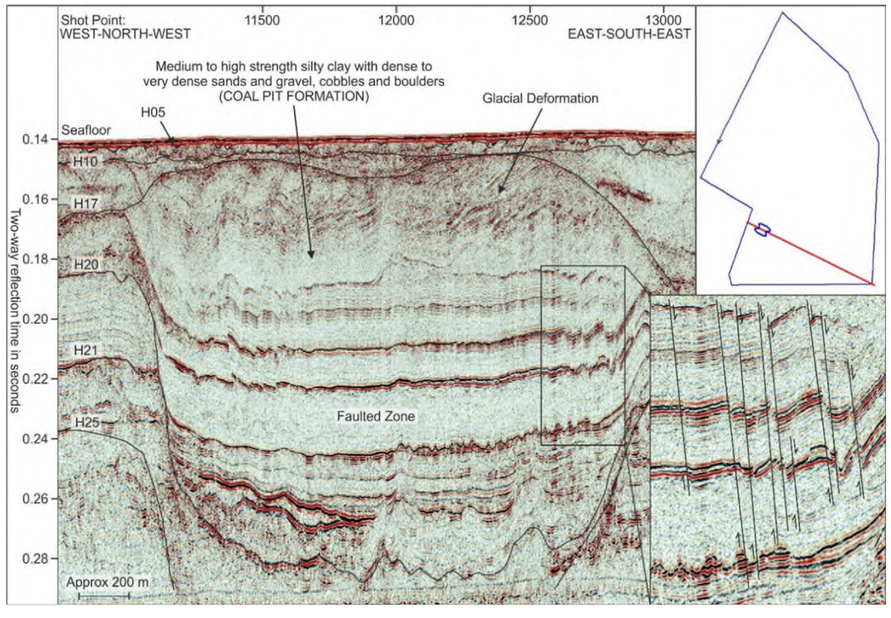
Line MW-CL-001M - Tunnel Valley A



Line MW-CL-001M - Tunnel Valley B



Line MW-X-030



Offshore Red Line Boundary

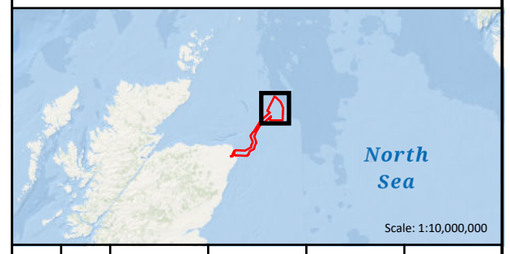
Option Agreement Area

Base of the Coal Pit Formaiton (m below LAT)

260.15

119.13

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	27/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-21853
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000141

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:160,000	PAGE SIZE	A3

PROJECT TITLE
MarramWind Offshore Wind Farm

DRAWING TITLE
Figure 34 Modelled surface for the base of the Coal Pit Formation Example 2DUHRS cross sections showing Tunnel Valleys A and B and faulting within the formation

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3.5.1.11 A later phase of channelling is associated with an unconformity, marking a division between the relatively acoustically semi-transparent facies above and acoustically variable (chaotic to well layered) moderate to high amplitude facies beneath. This Upper Coal Pit Formation contains one main channel crossing the north of the OAA, orientated north-west to south-east, with a maximum depth of 65m below seabed, and two smaller channels crossing the south of the survey area, orientated east-west (**Figure 35**).

630000 645000 660000 675000

6465000

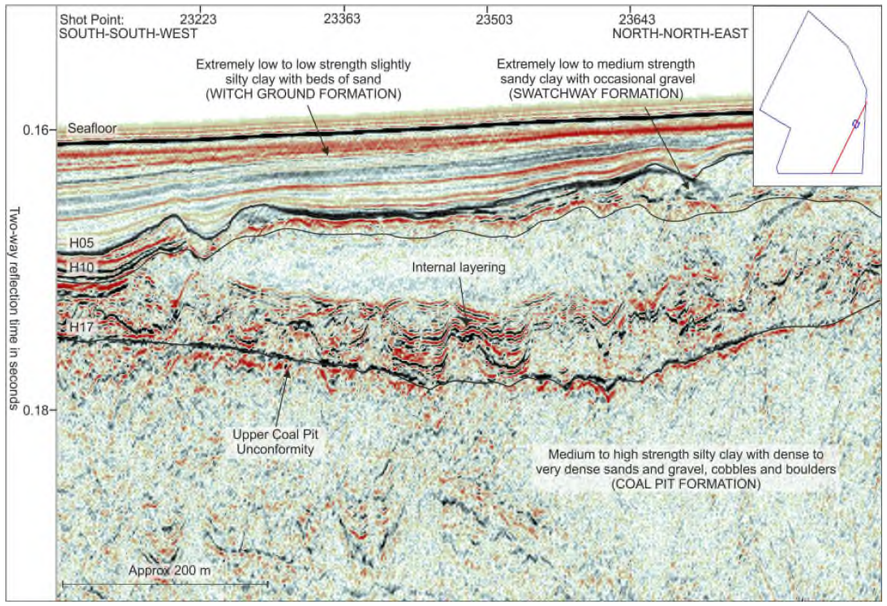
6450000

6435000

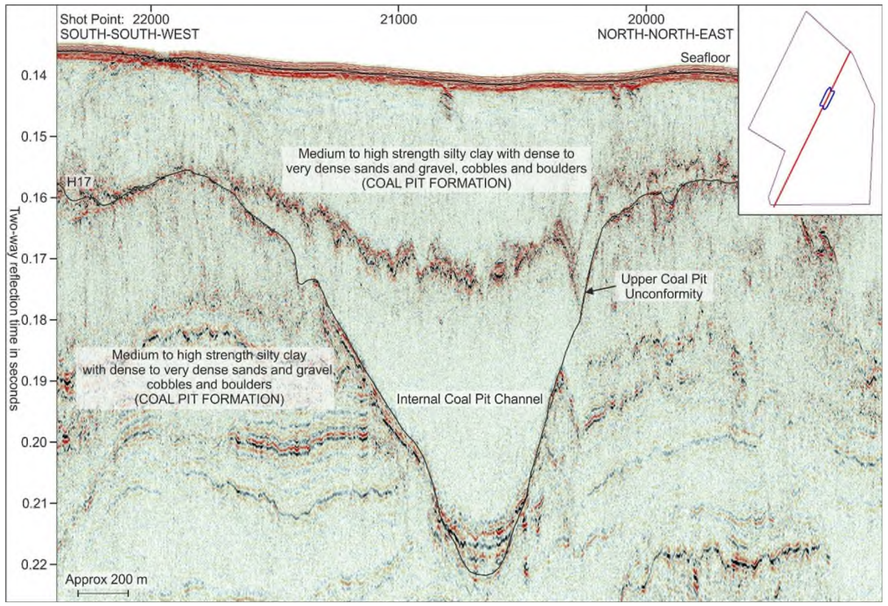
N

Primary channel

Line MW-R-299



Line MW-R-157



Offshore Red Line Boundary

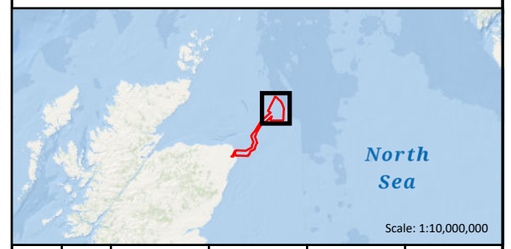
Option Agreement Area

Base of the Upper Coal Pit Formaiton 'unconformity' (m below LAT)

169.63

88.86

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
2	27/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-3718		
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000142		
DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:160,000	PAGE SIZE	A3

PROJECT TITLE
MarramWind Offshore Wind Farm

DRAWING TITLE
Figure 35 Modelled surface for the base of the Upper Coal Pit Formation 'Unconformity' Example 2DUHRS cross sections showing the unconformity and primary channel cut

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3.5.1.12 The expected sediments to be encountered within the Coal Pit Formation are firm to stiff clays with dense layers of sand and occasional gravel, cobbles and boulders. Shell fragments and complete valves are also commonly reported to be abundant in places.

3.5.1.13 Within the Witch Ground basin, Graham *et al* (2007) identified, in 3D seismic datasets, localised patches of sub-ice-stream bedforms, termed mega scale glacial lineation's (MSGLs), at the base of the Coal Pit Formation. These lineation's were interpreted as the buried signature of a palaeo-ice-stream from the later Middle Pleistocene. Further MSGLs were also mapped within the Coal Pit Formation itself, which are tentatively correlated with MIS 2 (29ka to 11.7ka; Graham *et al*. 2007; Graham *et al*. 2011). This means that the Coal Pit Formation covers the transition from the Middle to Late Pleistocene, with both MIS 5e Ipswichian interglacial (123ka to 109ka) and Late Saalian and Devensian glacial phases (post 191ka) contained within it, and their associated environments which may range from glaciomarine within the deeper parts, possible extending up to shallow inner shelf or intertidal towards land (Merritt *et al.,* 2003; Stoker *et al*. 1985). Indeed, studies of the upper marine sediments have revealed foraminiferal assemblages' representative of the MIS 5e Ipswichian interglacial (Cameron *et al*. 1987), underlying a horizon that has been correlated, using palaeomagnetisim, with the MIS 5e/d boundary, showing a transition from glaciomarine to marine sediments. The Coal Pit Formation also includes a sequence of shelly glaciomarine clays that have been placed tentatively in MIS 3 (57ka to 29ka) on palaeomagnetic evidence (Stoker *et al*.,1985) indicating that this area was free of glacier ice during this stage. This may indicate that part of the Coal Pit Formation might immediately precede the Late Devensian glaciation of the North Sea.

3.5.1.14 The Swatchway Formation occurs throughout the OAA area, underlying the Holocene and, where present, Witch Ground Formation. The base of this formation is often poorly resolved (Andrews *et al*. 1990; Graham *et al*. 2010), especially when a clear basal reflector is absent, and is therefore taken as being below laterally discontinuous reflectors. This results in low confidence in the spatial mapping of this formation and its thickness (**Figure 36**). Where observed, however, it appears to range in depth from just below the seabed to approximately 25m below seabed. The formation is variable in acoustic nature, ranging from seismically opaque with scattered point reflectors. Locally it can be chaotic and where the unit is thicker, and in particular where it underlies the Witch Ground, discontinuous patches of acoustically high amplitude, well-layered reflectors are observed, which too in places show evidence of iceberg scouring and deformation. The lack of an acoustic contrast at the base of the Swatchway is attributed to the idea that the Swatchway is comprised of re-worked underlying Coal Pit Formation (BGS, 1988) (Fugro, 2024b). The Swatchway Formation is thought to possibly be a proximal glaciomarine sediment deposited during MIS 2–3.

630000 645000 660000 675000

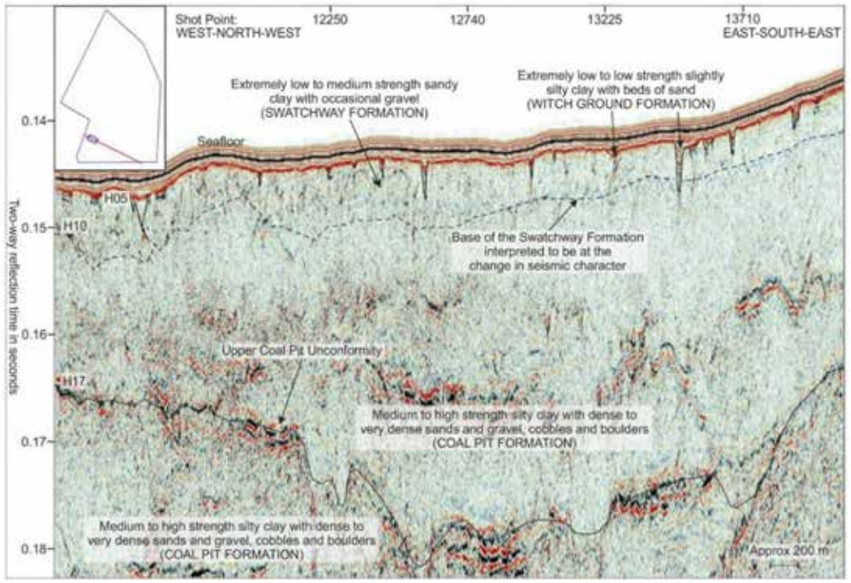
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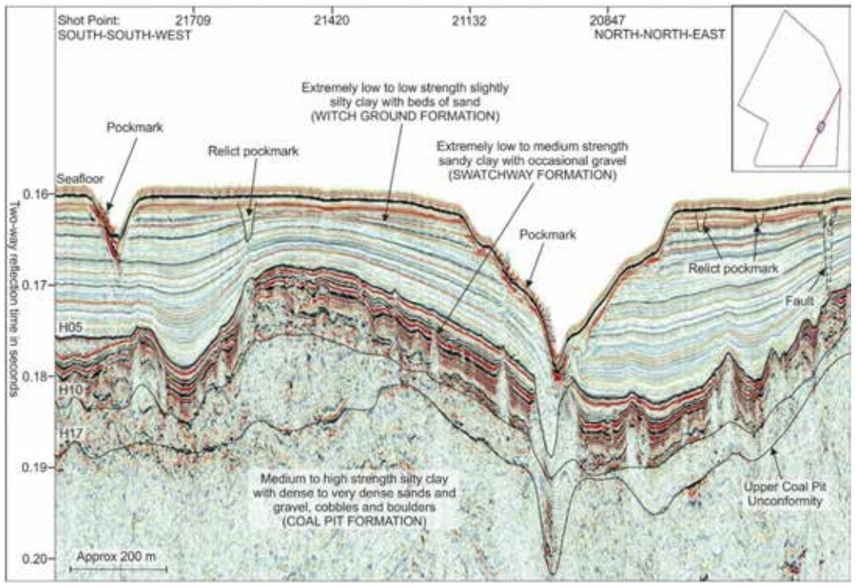
6435000

N

Line MW-X-032



Line MW-Q-283



Offshore Red Line Boundary

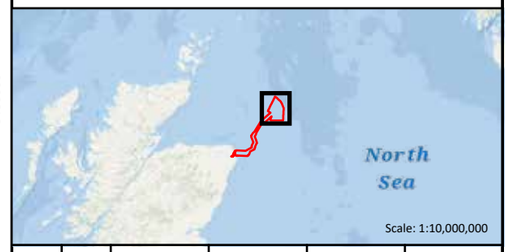
Option Agreement Area

Base of Swatchway Formation (m below LAT)

144.7

90.39

0 10 Kilometres



REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
			--	--	--
2	27/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-31810
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000143
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:160,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 36 Modelled surface for the base of the Swatchway Formation. Example 2DUHRS cross sections showing the complexity of interpreting the presence and position of the base of this formation

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wsp

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3.5.1.15 The Witch Ground Formation is present intermittently throughout the survey area but most prevalent in two depo-centres: one in the northwest and the other in the southeast of the survey area where it reaches a maximum depth of 23.4m below seafloor. In their processing and interpretation of the 2DUHRS data, Fugro (2024b) have demonstrated that the base of the Witch Ground Formation, when mapped across the whole OAA area, demonstrate an intricate network of relict iceberg ploughmarks and their infill. Infills are typically < 3m below the seabed and geotechnical data shows they are comprised of similar sediments to that of the thicker deposits of Witch Ground Formation (Fugro, 2024b), which is typically highly plastic, poorly sorted, slightly sandy mud or clay. The orientation of these ploughmarks seems to show a predominantly northeast-southwest orientation.

3.5.1.16 The Witch Ground Formation is also characterised by the presence of pockmarks, both at seafloor and buried, which is a common trait of this formation (for example, Böttner *et al*. 2019). Isolated normal faults are also present within the thickest part of the Witch Ground Formation, in the southeast of the survey area. These faults have variable vertical extent, the longest being approximately 12m. The majority are constrained to the Witch Ground Formation; however occasional faults extend a short distance into the Swatchway Formation below. These faults are likely caused by dewatering and settlement of sediments (Fugro, 2024b). This Witch Ground Formation is a late to post-glacial glaciomarine and marine deposit, dating to MIS 2–1.

3.5.1.17 Finally, a thin capping of Holocene clayey, silty sand and coarse sand is found across the area where outcropping of the earlier Witch Ground Formation occurs. Thicknesses range from <0.5m or absent, especially around pockmarks, to a maximum of approximately 3m in the south and east of the OAA. Where Holocene sediments thicken locally, these can be seen within the 2DUHRS to have infilled the underlying relict iceberg ploughmarks. These Holocene deposits are all attributed to marine deposition.

3.5.2 Geoarchaeological potential of the submerged palaeolandscape

3.5.2.1 The interpretation of the available SBP and 2DUHRS datasets from the OAA indicate the presence of thick Middle to Late Quaternary deposits across the area. The formations identified include the Aberdeen Ground Formation at the base, overlain by the Ling Bank Formation, Fisher Formation, Coal Pit Formation, Swatchway Formation, Witch Ground Formation and Holocene (including modern) seabed deposits. The majority of the formations mapped within the area were likely deposited in marine to glaciomarine environments, with the presence of deep channels observed within the Ling Bank and Coal Pit Formations indicating multiple phases of sub-glacial channelling due to Pleistocene glaciations over the OAA during the Saalian and Devensian periods. Glacial and glaciomarine environments are not conducive to archaeological activity, therefore the archaeological potential of many of these formations is low to non-existent.

3.5.2.2 For the late Devensian and Holocene period, this is in agreement with the sea level history and current glacial isostatic adjustment models for the region. Prior to the advance of the Late Devensian ice sheet over the area, Clark *et al*. (2022: Figure 6) suggest that the OAA might have been close to a coastline, with the area to the south dry land and to the north marine. However, this would have had a palaeoclimate non-conducive to human occupation, with the ice sheet positioned on the present Scottish coast around 30ka, extending over the OAA by 28ka, where it would remain until ice retreat after 19ka. When the ice did retreat, the OAA would have been submerged, leading to glaciomarine sediment depositiduring the Late Glacial and Early Holocene periods (Shennan *et al*. 2018; Sturt *et al*. 2013; Bradley *et al*. 2023). Any Late Glacial to Early Holocene shorelines and submerged palaeolandscapes would only be found, if present and preserved, in shallower waters west of the OAA towards the Scottish coast. Consequently, there is no potential to locate, within the OAA, any submerged terrestrial palaeolandscapes within which Late Upper Palaeolithic, Mesolithic or subsequent human activity took place.

3.5.2.3 The OAA lies within an area where the mapping of glacial landforms is lacking (Clark *et al*. 2018). The later phase of channelling present in the upper Coal Pit Formation may relate to an earlier phase of MIS 2 glaciation, though the overlying glaciomarine deposits associated with the Swatchway and Witch Ground Formations imply the presence of glaciomarine deposits throughout much of MIS 2. Of particular note are the extensive iceberg ploughmarks which not only support a glaciomarine environment at this time but also indicate the palaeo-direction of iceberg movement at this time. This high-resolution data generated through the 2DUHRS dataset provides a valuable contribution to increasing our understanding of the extent and timing of the Devensian glaciation in the wider North Sea region.

3.5.2.4 The multiple phases of subglacial channelisation present within the Coal Pit Formation provide a valuable opportunity for better understanding the timing of these Middle Pleistocene events, especially as the different channel phases are stratigraphically superimposed on each other. The dating of subglacial deposits is challenging due to the inability to use standard dating techniques, such as Luminescence dating (see Grant and Marshall 2025) due to the lack of sunlight to permit bleaching, but other techniques might be possible, such as amino acid racemisation (AAR) of any shell-rich horizons. This approach may permit new opportunities to better understand the age of these channels and therefore provide a chronological constraint on their formation and Middle Pleistocene glaciation in the wider region. Of note, currently the shelly glaciomarine clays from within the Coal Pit Formation have been tentatively correlated to MIS 3 using palaeomagnetic evidence (Stoker *et al*. 1985), indicating a period free from glacial ice, which correlates with the current mapping of the ice sheet by Clark *et al*. (2022). However, AAR provides the opportunity to test and better constrain these ages and the palaeogeography of this area at that time. The Coal Pit Formation is also known to contain shallow marine to intertidal deposits and therefore has the potential to provide some information on these coastal Middle to Late Pleistocene deposits.

3.5.2.5 While these might have the potential to support hominins, there is no evidence for such activity in Scotland at the time these deposits might have been deposited, with prevailing palaeoclimate conditions also unlikely to make habitation conducive. The archaeological potential of these deposits is therefore considered to be limited, though these still contain significant interest from a Quaternary Science and palaeogeography perspective.

4. Proposed Archaeological Mitigation

4.1.1.1 Low potential anomalies have been identified as potentially anthropogenic in origin but with a low likelihood to be of archaeological significance. Should material of potential archaeological significance be identified during the course of pre-development and development works, it should be reported under an appropriate PAD.

4.2 Archaeological exclusion zones

4.2.1.1 AEZs have been recommended (**Table 4.1**) based on the available evidence as interpreted by an experienced and qualified maritime archaeologist (Figure 37). They are to be agreed between the project, the archaeological curator, and the regulator. AEZs are implemented to protect, in situ, potentially archaeologically significant material. Where an exclusion zone has been implemented, no development work impacting the seabed is to take place within the prescribed area.

Table 4.1 Archaeological exclusion zones recommended for the OAA

Anomaly ID	Description	Archaeological potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_002	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 48m and major axis of 75m, the latter orientated 114°parallel to the direction of the linear anomaly and scour extension.	Medium	627469	6449503
MW_Arr_Arch_004	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 90m and major axis of 130m, the latter orientated 118°parallel to the direction of the linear anomaly and scour extension.	Medium	629235	6454131
MW_Arr_Arch_005	An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 310m and major axis of 400m, the latter orientated 112°parallel to the wreck and scour alignment.	High	629080	6454442
MW_Arr_Arch_011	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 140m and major axis of 210m, the latter orientated 051°parallel to the direction of the bathymetric high.	Medium	637255	6469455

Anomaly ID	Description	Archaeological potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_012	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 90m and major axis of 110m, the latter orientated 059°parallel to the direction of the SSS anomaly.	Medium	633818	6456643
MW_Arr_Arch_013	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 205m and major axis of 270m, the latter orientated 165° parallel to the direction of the seabed scour.	Medium	636088	6462684
MW_Arr_Arch_014	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 240m and major axis of 270m, the latter orientated 016°parallel to the direction SSS reflectors.	Medium	638208	6465283
MW_Arr_Arch_015	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 80m.	Medium	632237	6451437
MW_Arr_Arch_016	An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 280m and major axis of 325m, the latter orientated 120°parallel to the wreck alignment and also includes the likely deployed gear from the stern of the vessel.	High	634649	6454890
MW_Arr_Arch_017	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 100m.	Medium	638157	6461785
MW_Arr_Arch_019	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 125m and major axis of 205m, the latter orientated 117°parallel to the MAG anomaly alignment.	Medium	636176	6456490
MW_Arr_Arch_021	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 280m and major axis of 390m, the latter orientated 140° parallel to the scour and anomaly alignment.	Medium	640475	6458516

Anomaly ID	Description	Archaeological potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_023	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 150m.	Medium	638505	6453786
MW_Arr_Arch_026	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 100m and major axis of 140m, the latter orientated 160°parallel to the scour and anomaly alignment.	Medium	638499	6451827
MW_Arr_Arch_028	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 235m and major axis of 290m, the latter orientated 40°parallel to the scour and anomaly alignment.	Medium	634781	6443155
MW_Arr_Arch_034	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 150m.	Medium	639124	6441472
MW_Arr_Arch_037	An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 125m and major axis of 172m, the latter orientated 018° parallel to the wreck alignment.	High	647198	6452499
MW_Arr_Arch_040	An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 160m and major axis of 210m, the latter orientated 172°parallel to the north-south scour alignment.	High	641755	6441804
MW_Arr_Arch_041	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 120m.	Medium	639556	6439450
MW_Arr_Arch_048	An AEZ has been constructed for this anomaly, based upon an ellipsis, with a minor axis diameter of 210m and major axis of 260m, the latter orientated 20°parallel to the area of increased seabed roughness.	Medium	643176	6432896
MW_Arr_Arch_052	An AEZ has been constructed for this wreck, based upon an ellipsis, with a minor axis diameter of 155m and major axis of 250m, the latter	High	648480	6433407

Anomaly ID	Description	Archaeological potential	Easting UTM31N	Northing UTM31N
	orientated 180°parallel to the north-south scour alignment.			
MW_Arr_Arch_053	An AEZ has been constructed for this wreck, based upon an ellipsis covering both seabed objects, with a minor axis diameter of 200m and major axis of 350m, the latter orientated 045°parallel to the debris field between the two large anomalies.	High	643890	6447761
MW_Arr_Arch_057	An AEZ has been constructed for this anomaly, based upon a circle, with a diameter of 100m.	Medium	633434	6435350

615000 630000 645000 660000

6465000 6450000 6435000

N

MW_Arr_Arch_011
MW_Arr_Arch_014
MW_Arr_Arch_013
MW_Arr_Arch_017
MW_Arr_Arch_021
MW_Arr_Arch_012
MW_Arr_Arch_019
MW_Arr_Arch_005
MW_Arr_Arch_016
MW_Arr_Arch_004
MW_Arr_Arch_023
MW_Arr_Arch_037
MW_Arr_Arch_015
MW_Arr_Arch_026
MW_Arr_Arch_002
MW_Arr_Arch_053
MW_Arr_Arch_028
MW_Arr_Arch_040
MW_Arr_Arch_034
MW_Arr_Arch_041
MW_Arr_Arch_057
MW_Arr_Arch_052
MW_Arr_Arch_048

Offshore Red Line Boundary

Option Agreement Area

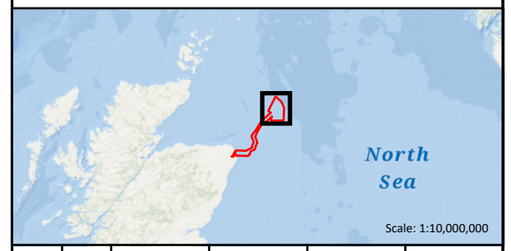
Bathymetry (m LAT)

-87.76

-133.66

Archaeological Exclusion Zones

0 10 Kilometres



2	27/09/2025	MJG	LT	LG	NC
1	21/07/2025	MJG	LT	TG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-M2-12509
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000144

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:160,000	PAGE SIZE	A3

PROJECT TITLE
MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 37 Distribution of recommended Archaeological Exclusion Zones within the OAA

Environmental Impact Assessment Report
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4.2.1.2 For sites identified as having high archaeological potential (wreck sites), an additional vertical dimension should be added to the AEZ to account for upstanding features observed upon each wreck. This should be set at 20m above the seabed where the wreck is present to ensure that no survey equipment, such as a geophysical towfish or pelagic trawl, can entangle with, or impact upon the upstanding superstructure observed at these wreck sites.

4.2.1.3 Should an AEZ impact the development program it is recommended that a program of ground truthing be undertaken to establish the identity of an anomaly in order that the potential archaeological significance can be assessed by a qualified and experienced archaeologist. Following identification and assessment, the AEZ can be reassessed to ensure mitigation is appropriate to the archaeological significance of the anomaly.

4.2.1.4 Should an AEZ impact upon the Project works, it is recommended that a program of site investigation of the identified anomalies be undertaken to establish their identification and further assess their archaeological potential. Such investigations could take the form of a remotely operated vehicle or drop-down camera / video surveys. Such investigations would be subject to a separate method statement. These site investigations should also be considered for the identified wreck sites with high archaeological potential, as such an investigation may result in a positive identification of the ship and its state of preservation.

4.3 Prehistoric archaeology and paleoenvironmental remains

4.3.1.1 The assessment of prehistoric archaeological and palaeoenvironmental potential has identified that there is low potential for the former, though opportunities exist to enhance our understanding of the Middle to Late Pleistocene and Early Holocene palaeoenvironment of the area. Archaeological input into geotechnical core locations would permit the targeting of key features, such as channel fills or non-eroded surfaces, leading to the recovery of optimal samples for further investigation. Mitigation in relation to the palaeolandscape and palaeoenvironmental remains would utilise geotechnical samples (vibrocores and boreholes) to permit a geoarchaeological assessment of these deposits, including the provision for geochronological dating. This sampling can be aligned with the engineering requirement to undertake geotechnical works. Typically, this process involves close collaboration with the Site Investigation team. Archaeological input into geotechnical core locations would permit the targeting of key features, such as channel fills or non-eroded surfaces, leading to the recovery of optimal samples for further investigation. Such an approach can also enhance the interpretation of the evolving OAA ground models. Any such works should be accompanied by a method statement outlining how core material is to be handled to enable geoarchaeological assessment, including the provision for luminescence dating, if required.

4.3.1.2 Following the collection of geotechnical cores, it is recommended that they undergo a staged program of geoarchaeological assessment and analysis as the primary means of ground truthing the potential identified in this Appendix and of mitigating impacts to remains. This approach would follow the guidelines of COWRIE (2011), using the following staged approach:

- Stage 1: Geoarchaeological review of core logs;
- Stage 2: Geoarchaeological recording of recovered deposits;
- Stage 3: Geoarchaeological assessment;
- Stage 4: Geoarchaeological analysis, and
- Stage 5: final reporting.

4.3.1.3 This geoarchaeological assessment and analysis should aim to deliver conclusions on the prehistoric archaeological and palaeoenvironmental remains within the area.

4.4 Recommendations for future work

4.4.1.1 The archaeological interpretation of the geophysical data collected at the pre-application stage, outlined in this Appendix, fits within a wider framework of planned geophysical survey for the Project. This survey specification was designed for the purposes of consenting and FEED to determine the most appropriate area for development. Future surveys will likely combine an increase in resolution, and the addition of MAG data with tighter line spacing within the development area. With the data resolution and coverage set to increase, the confidence in interpretation and appropriateness of mitigation strategies will also increase.

4.4.1.2 All geophysical data collected as part of the project will require assessment for archaeological potential by a qualified and experienced maritime archaeologist where relevant to the development. The archaeological review of data at these stages is considered necessary, not only for the robust assessment of the historic environment and archaeological potential but also for development planning.

4.4.1.3 An archaeological review of video footage obtained over identified wreck sites should be undertaken to aid the identification of these vessels and better understand their condition.

4.4.1.4 The methodology for the archaeological interpretation of data will follow those on which this review is based but will be subject to the preparation and agreement of a separate method statement to take into account any changes in survey methodology.

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6. Glossary of terms and abbreviations

6.1 Abbreviations

Acronym	Definition
2DUHRS	2D Ultra High Resolution seismic
AAR	Amino Acid Racemisation
AEZ	Archaeological Exclusion Zone
EIA	Environmental Impact Assessment
GW	gigawatt
ka	kilo annum
kHz	kilo hertz
km	kilometre
LAT	Lowest Astronomical Tide
MAG	magnetometer
MBES	Multibeam echo sounder
MIS	Marine Isotope Stage
ms	milli second
MSGL	mega scale glacial lineation
NE7	Northeast 7
NSTA	North Sea Transition Authority
NNE	North-northeast
NNW	North-northwest
OAA	Option Area Agreement
OLA	Option to Lease Agreement
PAD	Protocol for Archaeological Discoveries
SBP	sub-bottom profiler
SSE	South-southeast
SSS	sidescan sonar
TWTT	two-way travel time

Acronym	Definition
UK	United Kingdom
UKHO	UK Hydrographic Office
UNESCO	United Nations Educational, Scientific and Cultural Organization
UTM	Universal Transverse Mercator
WTG	Wind turbine generators

6.2 Glossary of terms

Term	Definition
Anthropogenic	Man-made.
Archaeology	The study of the material remains of the past.
Biostratigraphy	Branch of stratigraphical analysis concerned with fossils and their use in dating sedimentary deposits.
Chronology	The science of arranging events in their order of occurrence in time.
Geoarchaeology	A multi-disciplinary approach that uses the techniques and subject matter of geography, geology, geophysics and other earth sciences to examine and inform archaeological knowledge and thought.
Geophysical survey	Activities to obtain data on the distribution and nature of geophysical properties of the seabed (for example. bathymetry, surficial sediment type and bedforms, sub surface geology). Geophysical survey outputs typically include multibeam bathymetry, sidescan sonar, magnetometer and sub-bottom profiler data.
Glacial	Interval of cold climate associated with larger glaciers and expansion of continental ice-sheets, coupled with lower global sea level.
Glacial Maximum	Period within a glacial when global ice sheets reach their greatest extent.
Glaciation	The process or state of being covered by glaciers or ice sheets.
Heritage	The historic environment and especially valued assets and qualities such as historic buildings and cultural traditions.
Heritage Asset	An element of the historic environment that has value in policy.
Historic Environment	The physical evidence of past human activity.
Holocene	The second (and present) epoch within the Quaternary Period, starting c. 11.7 ka.
Ice Sheet	A layer of ice covering an extensive tract of land for a long period of time.

Term	Definition
Interglacial	An interval of warmer global average temperature lasting thousands of years that separates consecutive glacial periods.
Ipswichian	The last Pleistocene warm interglacial period, equivalent to MIS 5e (c. 124–119 ka).
Last Glacial Maximum	The most recent time during the Devensian glaciation when ice sheets reached their greatest extent in Britain, c. 26–20 ka.
Magnetometer	An instrument which measures the strength of a magnetic field.
Marine Oxygen Isotope Stage	Alternating warm and cool periods in the past climate of the Earth, deduced from oxygen isotope data from deep sea core samples.
Multibeam Echosounder	An instrument that uses sound to create a three-dimensional map of the seabed bathymetry.
Moraine	A large mass of rocks and dirt that is carried along with a glacier and is left behind when the glacier melt.
Palaeolandscape	Palaeolandscape refers to an ancient / relict landscape that has been preserved in the geological record.
Palaeolithic	The cultural period once referred to as the Old Stone Age. It is defined by the practice of hunting and gathering and the use of chipped flint tools.
Pleistocene	The first epoch within the Quaternary Period, between c. 2.58 Ma and 11.7 ka.
Post-glacial	Relating to or occurring during the time following a glacial period, usually referring to the time after the Last Glacial Maximum.
Quaternary	The most recent period of the Cenozoic Era, starting c. 2.6 Ma. It follows the Tertiary Period and is subdivided into the Pleistocene and Holocene Epochs.
Sidecan sonar	An instrument that used sound to create a two-dimensional representation of the seabed.
Stratigraphy	Study of the order and relative position of strata / archaeological deposits.
Sub-bottom Profiler	An instrument that uses sound to create a representation of the sub-seabed stratigraphy.

Appendix A Geophysical Anomalies with Archaeological Potential within the Project OAA

Table A1 Geophysical anomalies with archaeological potential within the MarramWind OAA

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_001	MAG anomaly Anom_A_014 (47nT). No associated anomaly on SSS or MBES.	Low	626575	6449486
MW_Arr_Arch_002	Light angular SSS reflector 5.6m x 5.3m x 9m associated with scour on MBES surrounding linear feature 15.1m x 2.25m x0.27m, and MAG anomaly Anom_A_014 (5nT).	Medium	627469	6449503
MW_Arr_Arch_003	SSS anomaly SSS_A_0108, 0.8m x 0.7m x0.1m, associated with MAG anomaly Anom_A_001 (38nT). No MBES anomaly visible.	Low	627845	6450975
MW_Arr_Arch_004	SSS anomaly SSS_A_0172, 0.5m x 0.2m, associated with MBES depression, 6.2m x 2.0m x 0.2m, and MAG anomaly Anom_A_002 (36nT).	Medium	629235	6454131
MW_Arr_Arch_005	Wreck, possibly the *Tobol*, fully visible in MBES, 100.8m x 19.5m x 9.2m, and SSS anomaly SSS_A_0158, associated with Anom_A_003 (310nT), Anom_A_004 (2233nT) and Anom_A_005 (188nT). Scour NNW-SSE, up to 75m. SSS anomaly SSS_A_0157, possible debris, 54m north of wreck.	High	629080	6454442
MW_Arr_Arch_006	MAG anomaly Anom_A_038 (32 nT). No visible anomalies in SSS or MBES.	Low	631063	6456577
MW_Arr_Arch_007	Angular dark SSS reflection, 1.5m x 0.9m x 0.2m, associated with small anomaly on MBES and MAG anomaly Anom_A_024 (6nT).	Low	631260	6458578
MW_Arr_Arch_008	MAG anomaly Anom_A_017 (75nT). No anomalies present within the MBES or SSS.	Low	632561	6460791

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_009	SSS light angular reflector, 11.2m x 4.0m, consisting of depression with possible linear extension to NW. With MBES depression and MAG anomaly Anom_A_009 (81nT).	Low	633359	6461799
MW_Arr_Arch_010	Linear dark angular SSS reflector (SSS_A_1033), 3m x 0.4m x 0.1m, with MBES depression, 9.0m x 7.0m x 0.5m, associated with MAG anomaly Anom_A_033 (6nT)	Low	635833	6467113
MW_Arr_Arch_011	MAG anomaly Anom_A_012 (42nT) within area of slightly elevated seabed. No SSS or MBES features in this position, but a depression is on the SW edge of the raised seabed 65m SW, measuring 17m x 11m x 0.3m.	Medium	637255	6469455
MW_Arr_Arch_012	Linear dark SSS reflector (SSS_C_1463), 7.8m x 1.2m x 0.4m, within area of increased seabed roughness and likely debris, also visible in MBES.	Medium	633818	6456643
MW_Arr_Arch_013	Area of increased seabed roughness, 67 x 38m, coinciding with upstanding central feature in MBES, 38m x 21m x 1.5m, with scour to the north and south. Seabed feature is very different to nearby boulders which are in depressions.	Medium	636088	6462684
MW_Arr_Arch_014	MAG anomaly ANOM_C_022 (78nT) in area with a series of small (<0.5m) light angular reflectors in the wider area, with further MAG anomalies 63m (ANOM_C_020; 26nT) and 97m (Anom_C_027; 19nT) further north. Likely to be debris.	Medium	638208	6465283
MW_Arr_Arch_015	Series of linear dark angular SSS reflectors (SSS_D_0386), covering an area 17.3m x 10.9m x 0.5m, coincidig with an area of increased roughness in MBES, 24m x 21m	Medium	632237	6451437
MW_Arr_Arch_016	Wreck, *Ocean Challenge*, associated with SSS anomaly SSS_D_1072 and MBES, 21m x 6m x 5.2m. Wreck sitting upright, aligned NW-SW. Mag Anomalies ANOM_D_021 (396nT) and ANOM_D_015 (366nT). Linear anomalies (SSS_D_1111 and	High	634649	6454890

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
	SSS_D_1110), up to 150m, extend E and SE."			
MW_Arr_Arch_017	Group of linear dark angular SSS reflectors (SSS_D_0950), up to 5.4m long, within area 14.5m x 10.1m, coinciding with area of raised seabed, 10.7m x 10.4m x 0.3m.	Medium	638157	6461785
MW_Arr_Arch_018	Dark angular SSS reflector (SSS_E_0493), 1.5m x 0.6m x 0.4m, associated with MBES depression, 4.7m x 3.6m x 0.4m, and MAG anomaly Anom_E_022 (10nT).	Low	639206	6460738
MW_Arr_Arch_019	MAG anomaly Anom_E_001 (52nT) within area of flat seabed with no anomalies in SSS or MBES, but with MAG anomalies 36m west (Anom_E_005; 5nT) and 40m east (Anom_E_020; 44nT) confirming buried ferrous material.	Medium	636176	6456490
MW_Arr_Arch_020	MAG anomaly Anom_F_009 (62nT) within an area with no anomalies in SSS or MBES.	Low	637392	6455015
MW_Arr_Arch_021	Dark angular SSS reflector (SSS_G_0048), 4m x 3.1m x 2.2m, on the SE corner of an area of scour seen in MBES, 120m x 114m x 1.2m, with elevated mound to SE, 65m x 52m x 0.6m.	Medium	640475	6458516
MW_Arr_Arch_022	Linear dark SSS reflector (SSS_G_0231), 5.6m x 0.9m, associated with small depression in MBES, 8.7m x 3.6m x 0.15m, and MAG anomaly Anom_G_026 (24nT).	Low	638801	6454105
MW_Arr_Arch_023	MAG anomaly Anom_G_004 (79nT). No visible anomalies in SSS or MBES.	Medium	638505	6453786
MW_Arr_Arch_024	Dark angular SSS reflector (SSS_G_1462), 2.4m x 0.4m x 0.6m, in MBES depression, 8.6m x 7.9 x 0.3m, with MAG anomaly Anom_G_025 (8nT).	Low	635110	6446695
MW_Arr_Arch_025	MAG anomaly Anom_H_013 (36nT). No anomalies in SSS or MBES.	Low	639516	6452674
MW_Arr_Arch_026	Cluster of dark angular SSS anomalies (SSS_H_0260, SSS_H_0261 and SSS_H_0262), up to 2.6m, associated with an area of scour extending 40m	Medium	638499	6451827

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
	north of a small mound, 7m x 4m x 0.5m.			
MW_Arr_Arch_027	MAG anomaly Anom_I_037 (36nT). No anomalies in SSS or MBES.	Low	636559	6446063
MW_Arr_Arch_028	Dark angular SSS reflectors (SSS_H_0867 and SSS_H_0869) associated with an MBES depression, 96m x 86m x 1.5m, with upstanding feature in the centre, 22m x 17m x 1.1m, with MAG anomaly Anom_H_015 15nT).	Medium	634781	6443155
MW_Arr_Arch_029	Dark angular SSS reflector (SSS_H_0901), 3.5m x 2m x 0.8m, associated with MBES depression, 12m x 7m x 0.5m.	Low	631870	6438319
MW_Arr_Arch_030	Dark angular SSS reflector (SSS_J_0313), 0.9m x 0.4m x 0.1m, associated with MBES depression, 8m x 4m x 0.2m, and MAG anomaly Anom_J_019 (12nT).	Low	634057	6436835
MW_Arr_Arch_031	MAG anomaly Anom_J_013 (19nT) associated with small depression in SSS and MBES, 5.5m x 4.4m x 0.3m.	Low	632002	6433941
MW_Arr_Arch_032	MAG anomaly Anom_K_033 (31nT).	Low	633568	6434130
MW_Arr_Arch_033	Light angular SSS reflector (SSS_K_0156), 12.9m x 0.3m x 0.6m, associated with MBES depression, 22.2m x 14.7m x 0.5m, with MAG anomaly Anom_K_002 (34nT). Probably 40ft pipe, reported through PAD.	Low	633100	6432664
MW_Arr_Arch_034	Light angular SSS reflector (SSS_M_0063), 3.7m x 1.8m x 0.9m, within MBES depression, 72m x 63m x 2.1m, with MAG anomaly Anom_M_016 (24nT).	Medium	639124	6441472
MW_Arr_Arch_035	MAG anomaly ANOM_L_005 (32nT), associated with MBES depression, 10.4m x 9.4m x 0.2m.	Low	638015	6440563
MW_Arr_Arch_036	MAG anomaly Anom_M_006 (36nT).	Low	636000	6432869
MW_Arr_Arch_037	Wreck, possibly *Emma Jayne*. Associated with light angular SSS reflector SSS_N_0172, 24m x 7m x 7.7m, Wreck is upstanding with little	High	647198	6452499

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
	scour. Associated with MAG anomalies ANOM_N_0030 (238nT) and ANOM_N_0031 (5386nT).			
MW_Arr_Arch_038	MAG anomaly Anom_N_025 (40nT).	Low	644253	6446896
MW_Arr_Arch_039	Light angular SSS reflector, 4.7m x 0.8m x 0.3m, visible in MBES and associated with MAG anomaly Anom_N_034 (42nT).	Low	641410	6443011
MW_Arr_Arch_040	Wreck, possibly the *Compass Rose 3*. Deck layout clearly visible in SSS (SSS_N_0148), 41.5m x 7.8m x 5.5m, with scour at western end, up to 10m from stern, and extending 70m south and north. Associated with MAG anomalies ANOM_N_0023 (6252nT) and ANOM_N_0024 (596nT).	High	641755	6441804
MW_Arr_Arch_041	MAG anomaly Anom_N_003 (78nT) associated with small cluster of light angular SSS reflectors, over area 5.3m x 4.2m, with small MBES depression, 7m x 4.4m x 0.2m.	Medium	639556	6439450
MW_Arr_Arch_042	MAG anomaly Anom_O_022 (32nT).	Low	642062	6439112
MW_Arr_Arch_043	Light angular SSS reflector (SSS_P_0198), 2.3m x 1m x 0.1m, with MAG anomaly Anom_P_013 (9nT).	Low	650401	6452589
MW_Arr_Arch_044	Dark angular SSS reflector (SSS_P_0197), 3m x 1.6m x 0.1m, with MAG anomaly Anom_P_006 (10nT).	Low	648325	6449168
MW_Arr_Arch_045	MAG anomaly Anom_P_019 (37nT).	Low	641862	6437170
MW_Arr_Arch_046	Group of dark angular SSS reflectors (SSS_P_0201), up to 1.9m x 0.3m x 0.1m, associated with MAG anomaly Anom_P_022 (26nT).	Low	640555	6434167
MW_Arr_Arch_047	MAG anomaly Anom_Q_008 (48nT).	Low	647370	6443349
MW_Arr_Arch_048	Area of increased seabed roughness in SSS and MBES, covering 66m x 43m, associated with MAG anomalies Anom_R_008 (1270nT) and Anom_R_001 (19nT).	Medium	643176	6432896

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_049	MAG anomaly Anom_R_001 (21nT).	Low	644639	6434546
MW_Arr_Arch_050	SSS and MBES round depression, 21m diameter, with raised margins and MAG anomalies Anom_S_014 (22nT) and Anom_S_015 (5nT).	Low	650404	6436635
MW_Arr_Arch_051	SSS and MBES round depression, 12m diameter, with raised margins and MAG anomaly Anom_S_021 (38nT).	Low	649282	6435209
MW_Arr_Arch_052	Wreck, possibly the *FV Lucerne*. SSS anomaly SSS_S_0227, 34.5m x 7m x 3.2m, clearly visible in MBES, with scour north and south up to 100m. Associated with MAG anomalies Anom_S_012 (641nT) and Anom_S_013 (526nT).	High	648480	6433407
MW_Arr_Arch_053	Wreck, vessel unknown but possibly a trawler, at 641755 6441804. SSS reflector SSS_N_0141 coinciding with upstanding MBES feature, 5.4m x 2.2m x 1.8m, with limited scour extending up to 40m from the site. Wreck confirmed by Environmental Video Transect (NTR04). Second object 160m south (643768 6447651), measures 12m x 4m x 1m and associated with MAG anomaly ANOM_N_0017 (11nT). Line of debris and linear SSS anomaly SSS_N_0281 between the two large anomalies.	High	643890	6447761
MW_Arr_Arch_054	MAG anomaly Anom_N_035 (107nT), with Anom_N_020 (6nT) 14m east.	Low	638001	6435673
MW_Arr_Arch_055	MAG anomaly Anom_F_018 (140nT).	Low	637873	6454455
MW_Arr_Arch_056	MAG anomaly Anom_F_017 (113nT) associated with depression in MBES, 8.1m x 4.5m x 0.3m.	Low	638986	6456678
MW_Arr_Arch_057	MAG anomaly Anom_J_047 (402nT), possibly associated with linear or dispersed debris on the seabed over an area c.14m x 10m.	Medium	633434	6435350
MW_Arr_Arch_058	SSS and MBES depression with central upstanding feature, 15.6m x 8.8m x 0.3m, associated with MAG anomaly Anom_N_026 (71nT).	Low	643813	6447188

Anomaly ID	Description	Archaeological Potential	Easting UTM31N	Northing UTM31N
MW_Arr_Arch_059	MAG anomaly Anom_N_027 (71nT) associated with shallow depression in MBES, 3.8m x 3.4m x 0.1m.	Low	643843	6447538
MW_Arr_Arch_060	MAG anomaly Anom_S_019 (161nT) associated with shallow depression in MBES, 5.1m x 4.2m x 0.2m.	Low	647023	6433696
MW_Arr_Arch_061	MAG anomaly Anom_O_010 (54nT) associated with shallow depression in MBES, 8.9m x 2.6m x 0.2m.	Low	641144	6438520
MW_Arr_Arch_062	MAG anomaly Anom_I_014 (108nT) associated with a pair of shallow depression in MBES, approximately 18m x 18m x 0.3m.	Low	635484	6443871
MW_Arr_Arch_063	Pair of shallow circular depression in MBES and SSS, 4m x 4m x 0.2m, associated with MAG anomaly Anom_N_033 (69nT).	Low	648508	6455522
MW_Arr_Arch_064	MAG anomaly Anom_L_001 (45nT) associated with depression in MBES, 3m x 3m x 0.1m.	Low	647605	6459425
MW_Arr_Arch_065	MAG anomaly Anom_B_005 (77nT).	Low	636041	6465849
MW_Arr_Arch_066	MAG anomaly Anom_A_015 (41nT) with Anom_A_032 (6nT) 14m NW.	Low	631850	6459360
MW_Arr_Arch_067	MAG anomaly Anom_D_012 (78nT).	Low	635116	6457260
MW_Arr_Arch_068	MAG anomaly Anom_D_004 (64nT).	Low	635580	6456979
MW_Arr_Arch_069	MAG Anomaly Anom_E_006 (59nT).	Low	636749	6455912
MW_Arr_Arch_070	MAG Anomaly Anom_B_001 (38nT).	Low	630420	6452321
MW_Arr_Arch_071	MAG anomalies ANOM_C_001 (42nT) and Anom_B_008 (11nT).	Low	628840	6448697

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