GREEN VOLT

Technical Appendix 15.1

Archaeological Assessment of Geophysical and Hydrographic Data

Offshore EIA Report: Volume 2

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Green Volt Offshore Wind Farm

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Produced for Royal Haskoning DHV

MSDS Marine

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Green Volt Offshore Wind Farm

Archaeological Assessment of Geophysical and Hydrographic Data

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1.0 Introduction

1.0.1 MSDS Marine Limited (MSDS Marine) have been contracted Royal Haskoning DHV (RHDHV) to undertake an archaeological assessment of geophysical and hydrographic survey data collected in relation to the Green Volt Offshore Wind Farm (OWF) in the Scottish area of the North Sea.

1.0.2 The array, and cable route data to 12 nm, were collected by Gardline Limited (Gardline) between 7th and 26th September 2021, and landwards from 12 nm by Hydrofix Limited (Hydrofix) on 31st March 2022. The assessment is being undertaken to inform the Environmental Impact Assessment (EIA) process.

1.0.3 This document forms the archaeological assessment of the geophysical and hydrographic survey data, and outlines the specification of the data, the method of archaeological assessment, the presentation of the results and recommendations for mitigation strategies.

2.0 Project location and status

2.0.1 Green Volt OWF is being developed by Green Volt Offshore Windfarm Ltd (Green Volt), a new company formed by Flotation Energy Plc (FE) and CNOOC Petroleum Europe Ltd (CPEL). The project proposes to develop a floating offshore windfarm to facilitate a first of its kind decarbonisation of the Oil and Gas industry through the complete electrification of the Buzzard oil and gas field with the support of a fully connected UK grid connection back to the New Deer substation in Aberdeenshire.

2.0.2 The Offshore Scoping Report[1] was submitted on the 15th November 2021 in support of the request for a formal Scoping Opinion, a response from which was received in April 2022[2]

2.0.3 The location of Green Volt OWF is shown in Figure 1.

[1] RHDHV, 2021. *Green Volt Offshore Windfarm – Offshore Environmental Impact Assessment. Offshore Scoping Report*. Reference: PC2483-RHD-ZZ-XX-RP-Z-0001

[2] Marine Scotland, 2022. *Scoping Opinion for Green Volt Offshore Windfarm*. Available at https://marine.gov.scot/sites/default/files/scoping_opinion_9.pdf

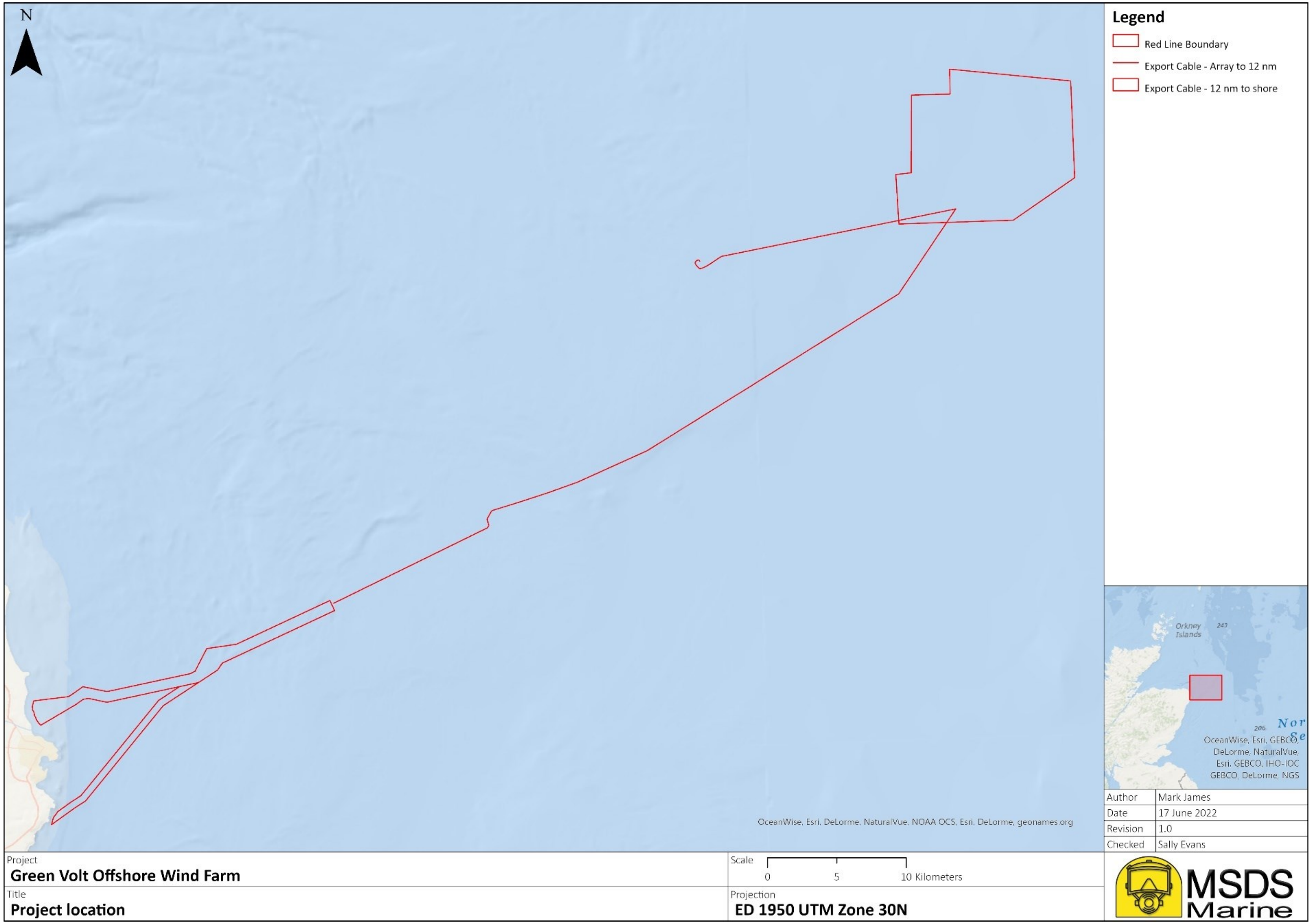

Figure 1: Location of Green Volt Offshore Windfarm

3.0 Aims and objectives

3.1 Archaeological review of geophysical and hydrographic data

3.1.1 The principle aim of the archaeological review of geophysical and hydrographic data is to establish the presence of potentially significant archaeological material on the seabed and the potential for submerged prehistoric remains laid down during different climatic and environmental conditions in the past. The identification of material and geological horizons allows for strategies to be recommended to mitigate against any negative effects that may be caused by the development process.

3.1.2 The objectives of the archaeological interpretation can be summarised as follows;

- To establish the presence of anthropogenic material of archaeological potential;
- To interpret the identified anomalies as to their potential to be of archaeological significance;
- To recommend mitigation strategies for the 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.

4.0 Methodology

4.1 Data collection

4.1.1 All data were collected to a specification that fulfils the requirements of Section 3 of *Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects*[3].

4.1.2 Survey data were collected across the pre-defined Array red line boundary (RLB) area of 116 km^2 and 75 km of cable route for Green Volt OWF by Gardline between 7th and 26th September 2021[4], and c.32 km of cable route from 12 nm landward by Hydrofix on 31st March 2022[5]. The data consisted of full coverage Sidescan Sonar (SSS), Multibeam Bathymetry (MBES), Sub-bottom Profiler (SBP), and Magnetometer data within the array area, and MBES, SSS, and Magnetometer along the cable route to 12 nm. The data collected landwards of 12 nm consisted of MBES. Due to fishing activity, no data was collected from shore to c.8.2 km on the northern cable route, and from shore to 10.4 km on the southern cable route.

4.1.3 Line spacing within the array was planned at 150 m mainlines, and 1.5 km crosslines, single lines were run along the cable routes, centred on the proposed cable location, producing a minimum of 100% SSS coverage, excluding the nadir. MBES data were collected at a line spacing to ensure 100% coverage with sufficient overlap of data, with the exception of the cable route landward of 12 nm where a single pass was undertaken along the two cable routes.

4.1.4 Data coverage is shown in Figure 2 and Figure 3 and the equipment specification shown in Table 1.

Contractor	Gardline	Green Marine
Vessel	MV *Kommandor*	*Green Quest*
Sidescan Sonar	Edgetech 4200FS (120/400 kHz)	None
Multibeam	Simrad EM710	Norbit iWBMS
Magnetometer	Geometrics G882	None
Pinger	GeoAccoustics Geopulse	None
USBL	Kongsberg HIPAP 500	None

Table 1: Mobilised survey equipment

4.1.5 The data were collected to a specification appropriate to achieve the following interpretation requirements

- Sidescan Sonar: ensonification of anomalies > 0.3 m

[3] Wessex Archaeology, 2021. *Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects*. The Crown Estate

[4] Gardline Ltd, 2021. *UKCS Blocks 19/10 to 19/15 and 20/2 to 20/7, Ettrick and Green Volt Site and Export Cable Routes. Debris Clearance, Route, and Environmental Field Survey*. Report for CNOOC International

[5] Hydrofix Ltd, 2022. *Green Volt Export Route, EIA Data Acquisition Survey Report*. Report for Green Marine (UK) Limited

- Multibeam Bathymetry: ensonification of anomalies > 1.0 m
- Sub-bottom Profiler: penetration was achieved up to 5-6 m with a vertical resolution of 1m

4.1.6 With the exception of the cable route landward of 12 nm the data were collected and referenced relative to ED50 UTM Zone 30N. Where data were not provided in ED50 UTM Zone 30N they were transformed in ESRI ArcGIS Pro 2.9.

4.1.7 The SSS and Magnetometer used an Ultra Short Baseline (USBL) positioning system to ensure positional accuracy throughout the survey. USBL ensures the actual position of the sensor is recorded, as opposed to when the position is estimated based upon the direction of the vessel and the amount of cable out (layback).

4.1.8 Although the accuracy of the USBL system is dependent on the angle, and the distance of the beacon from the transceiver, tolerances of between 0.5 m and 2.0 m can be achieved.

4.1.9 Positional accuracy is further increased through the correlation of the SSS dataset with the MBES dataset.

4.2 Data deliverables to MSDS Marine

4.2.1 Following data collection navigation and offsets were applied, and the data Quality Controlled before being delivered to MSDS Marine in the formats presented in Table 2.

Sensor	Deliverables
Sidescan Sonar	Navigation corrected, unprocessed high and low frequency lines (.xtf) Georeferenced mosaic at 2 m resolution (.tif) Seabed features (.csv)
Multibeam Bathymetry	Navigation corrected, unprocessed points (.pts) Georeferenced mosaic at 2 m resolution (.tif) Seabed features (.csv)
Sub-bottom Profiler	Navigation corrected, unprocessed lines (.sgy) Navigation corrected, processed lines (.sgy) Horizon grids and unit interpretations (.grd / .shp)
Magnetometer	Navigation corrected, unprocessed lines (.txt) Magnetic anomalies (.csv)

Table 2: Data deliverables to MSDS Marine

4.2.2 In addition, MSDS Marine were provided with operations and interpretations reports produced by the survey contractors and an SSDM geo-database containing all information, and data, relating to the Gardline survey campaign.

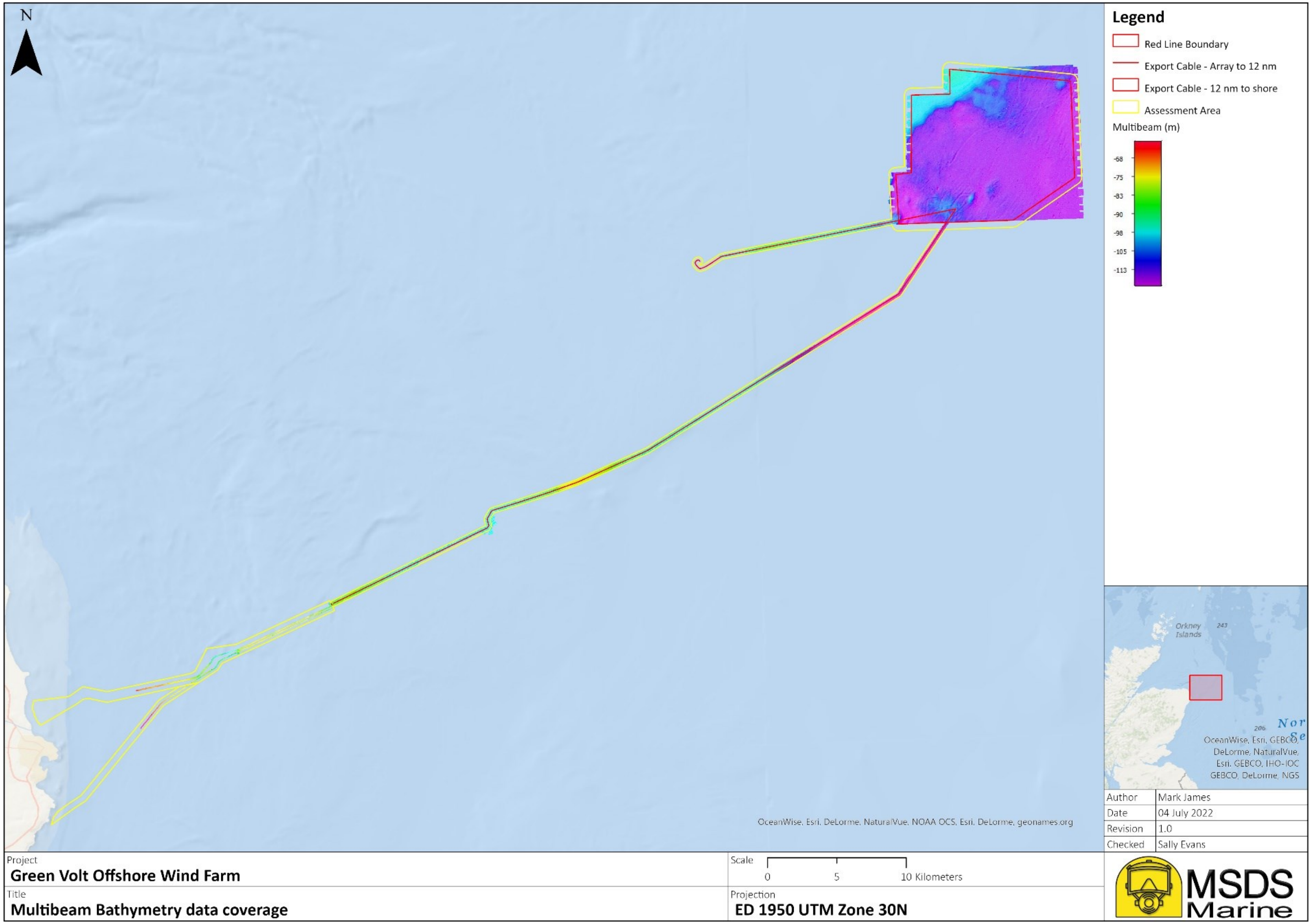

Figure 2: Multibeam Bathymetry data coverage

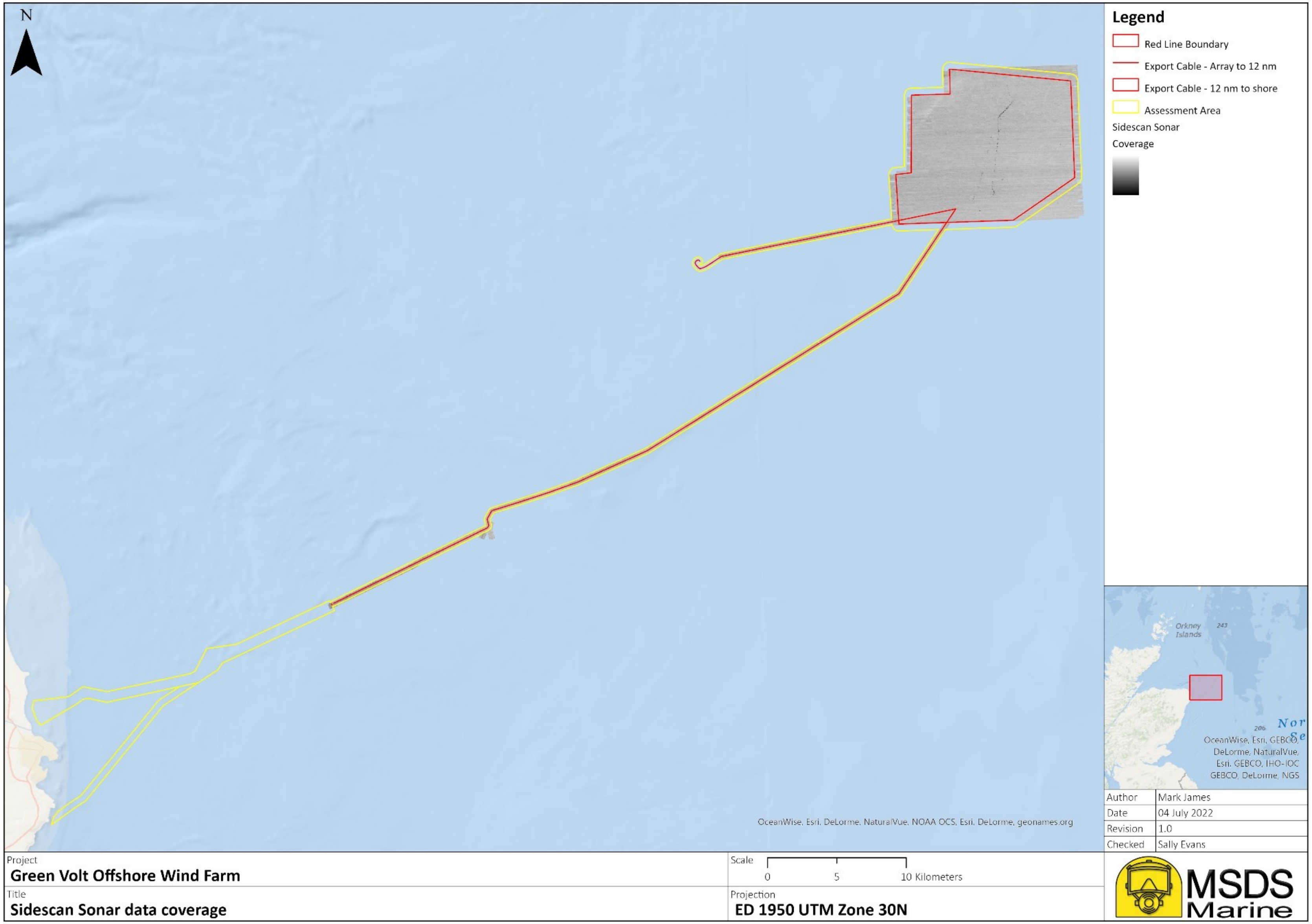

Figure 3: Sidescan Sonar data coverage

4.3 Data quality and limitations

Array to 12 Nautical Miles

4.3.1 The data collected to inform the Green Volt OWF archaeological assessment were generally of good quality, with minimal interference or data degradation caused by environmental factors or the simultaneous use of different sensors.

4.3.2 High and low frequency SSS data were collected simultaneously at a 200 m range. High frequency data collected at this range will degrade towards the outer edges and may mean smaller features are not ensonified. However, the line spacing and the collection of MBES and magnetometer data provides some mitigation for this. It is not considered that this impacted the ability to undertake an effective archaeological assessment.

4.3.3 The MBES data were of good quality and were suitable overall to achieve a resolution of 2.0 m which is sufficient for the correlation of anomalies within the SSS, and to accurately depict seabed topography. Within some areas where there was a greater overlap in data, the density was able to be reduced to less than 1.0 m.

4.3.4 Small offsets were noted in places between the SSS and MBES data, however this is usual and positions for medium and high potential anomalies were always taken from the MBES data.

4.3.5 Undulating seabed topography, particularly in areas of large sandwaves, can obscure the line of sight of the SSS resulting in acoustic shadow hiding anomalies of potential archaeological interest. The seabed in the Green Volt OWF area is largely flat, with changes in topography being gradual which reduces this effect, furthermore the line spacing means that most areas are ensonified from two directions. Outside of extant infrastructure, and seabed scars relating to removed infrastructure, the most notable areas of seabed where anomalies are potentially obscured is within the numerous pock marks across the site. This is mitigated through the assessment of MBES and magnetometer data.

4.3.6 The magnetometer survey line spacing of 150 m is too great for the accurate positioning of small magnetic anomalies but was sufficient to be correlated with features visible on the seabed. Even at a wide line spacing the magnetometer data can indicate areas of archaeological potential.

4.3.7 It was possible to view a range of high, medium, and low potential contacts, alongside the evidence of infrastructure and modern debris, within the survey extents. Overall, the data were deemed suitable for archaeological interpretation. It must be noted that there is always the potential for contacts of archaeological potential to not be visible in the data, this possibility is increased in areas of poor data quality or variable topography.

4.3.8 Sub-bottom Profiler data penetration was achieved up to 6 m with a vertical resolution of 1 m. Data collection covered the north-western part of the array. The extent of data collection is shown in Figure 6. While data was not collected within the remainder of the array or cable routes, the results of previous surveys and in particular deep-penetration seismic and geotechnical data collected in association with oil exploration and well construction provided information for the other areas of the site not covered. Together these datasets were sufficient to characterise the palaeolandscape and sediments within the site and associated potential for submerged prehistoric remains.

Landward of 12 Nautical Miles

4.3.9 The data collected along the cable route landward of 12 nm consisted of only MBES and were collected as a single pass along the potential cable route in advance of grab sampling and Drop-Down Video (DDV) operations. The depth of water (62.6 m to 93.6 m) and the single pass meant that a maximum resolution of c.1.0 m was achieved which is not suitable for the archaeological interpretation of smaller features, at this resolution it is not possible to confidently differentiate between smaller geological features, and potential debris. As such, the data has only been assessed to identify larger anomalies of high potential, and to provide a visual assessment of the locations of UKHO and HER records.

4.4 Archaeological assessment of data

4.4.1 The archaeological assessment of data was undertaken by a qualified and experienced maritime archaeologist with a background in geophysical and hydrographic data acquisition, processing, and interpretation.

4.4.2 Following delivery of the required datasets, an initial review was undertaken to gain an understanding of the geological and topographic make-up of the survey area. Within the extent of the survey area the potential for variations in the seabed are high and can affect the interpretation of anomalies.

4.4.3 The interpretation report considers extents up to 0.5 km from the Array RLB, 0.2 km from the Array to 12 nm cable route, and the full extents of the provided area for landward of 12 nm (St Fergus South and North Connect Parallel) – termed throughout as the assessment area. Whilst some of the data extends beyond the Array RLB, the purpose of the assessment is to characterise the historic environment and therefore data from the wider area were considered. The focus of the mitigation measures is however on anomalies within the Array RLB and cable route, or where mitigation measures would impact within the Array RLB or cable route. The assessment area is presented in Figure 2 and Figure 3.

Sidescan Sonar

4.4.4 SSS is considered the best tool for the identification of anthropogenic anomalies on the seabed due to the ability to ensonify small features and as such forms the basis of any archaeological assessment of data. SSS data in .xtf format were imported into Chesapeake SonarWiz 7.9 software, navigation and positioning were checked and corrected where required, and optimal gains were applied to ensure the consistent presentation of data.

4.4.5 Data were reviewed on a line-by-line basis, and all anomalies of potential anthropogenic origin identified and recorded. Records include at a minimum an image of the anomaly, dimensions, and a description. An archaeological potential was assigned to the anomaly following the criteria outlined in Table 3 below.

4.4.6 Following assessment of the individual lines, a mosaic was created and a Geotiff exported to allow for the checking of positional accuracy against the MBES data and to identify the extents of any anomalies that may have extended past the limits of individual lines.

Magnetometer

4.4.7 Magnetometer data indicates the presence of ferrous, and thus usually anthropogenic, material both on, and under the seabed. Where line spacing allows, typically to a specification for the detection of UXO, magnetometer data can provide accurate positions of buried ferrous anomalies. The survey line spacing for Green Volt OWF is c.150 m which is too great for the accurate positioning of magnetic anomalies but can indicate areas of archaeological potential. Where possible, magnetic anomalies were correlated with anomalies visible on the seabed.

4.4.8 Magnetometry data were provided as .xyz files and as a gazetteer detailing all anomalies greater than 3 nT. An assessment was made by MSDS Marine as to the suitability of the gazetteer for archaeological interpretation. Where required the .xyz magnetometer data was imported into either Geometrics MagPick or Chesapeake SonarWiz 7.9 software where the data was smoothed, and a 'baseline' identified and removed from the data to highlight ferrous anomalies whilst taking into account geological variations in the data.

4.4.9 Magnetic anomalies identified within the data had the position, intensity and dimensions recorded. An archaeological potential was assigned to the anomaly following the criteria outlined in Table 3 below. The data were gridded to visually identify areas where the distribution of anomalies may represent a wider feature such a buried but dispersed wreck, or modern features such as buried cable or chain.

Multibeam Bathymetry

4.4.10 Due to the minimum anomaly detection size of MBES data being larger than that of SSS data, the primary use during archaeological assessment, outside of seabed characterisation, is the corroboration of anomalies identified within other datasets and the visualisation of anomalies that may otherwise be obscured by shadow.

4.4.11 Navigation corrected, but unprocessed, MBES data were provide to MSDS Marine as .xyz files, the data were imported into QPS Fledermaus where it was gridded and a hill-shaded surface applied, shading was adjusted to ensure the optimal presentation of data. The resulting 3-Dimensional image was viewed on a block-by-block basis, and all anomalies of potential anthropogenic origin identified and recorded.

4.4.12 Records include, at a minimum, an image of the anomaly, dimensions, and a description. An archaeological potential was assigned to the anomaly following the criteria outlined in Table 3 below. Where the interpretation of an anomaly was unclear, the data were imported into point cloud visualisation software such as Cloud Compare, in order to view the un-gridded data. The gridded surface image was exported as a Geotiff to allow further assessment alongside other datasets.

Potential	Criteria
Low	An anomaly potentially of anthropogenic origin but that is unlikely to be of archaeological significance – Examples may include discarded modern debris such as rope, cable, chain, or fishing gear; small, isolated anomalies with no wider context; or small boulder-like features with associated magnetometer readings.
Medium	An anomaly believed to be of anthropogenic origin but that would require further investigation to establish its archaeological significance – Examples may include larger unidentifiable debris or clusters of debris, unidentifiable structures, or significant magnetic anomalies.
High	An anomaly almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential

	anomalies tend to be the remains of wrecks, the suspected remains of wrecks, or known structures of archaeological significance.

Table 3: Criteria for the assessment of archaeological potential

Combined assessment

4.4.13 Following the assessment of all datasets the results were loaded into ESRI ArcGIS Pro 2.9, a Geographical Information System (GIS), and reviewed alongside each other, along with Geotiffs of the SSS and MBES. The concurrent review allows the amalgamation of duplicate anomalies, the assessment of the wider context, and an understanding of the extents of a feature that may be partially buried, or span across two or more lines of data.

4.4.14 Data from the United Kingdom Hydrographic Office (UKHO), including the positions of wrecks and obstructions, and the relevant Historic Environment Records (HER) as well as all other relevant data such as third party assets were assessed to ensure that any additional information is drawn upon, but also that anomalies are not unnecessarily identified as having archaeological potential when the origination can be identified. The resultant remaining anomalies assessed as having archaeological potential were compiled into a gazetteer and a shapefile.

4.4.15 The interpretation of geophysical and hydrographic data is, by its very nature, subjective. However, with experience and by analysing the form, size, and characteristics of an anomaly, a reasonable degree of certainty as to the origin of an anomaly can be achieved.

4.4.16 Measurements can be taken in most data processing software, and whilst largely accurate, discrepancies can be noted due to a number of factors. Where there is uncertainty as to the potential of an anomaly, or its origin, a precautionary approach is always taken to ensure the most appropriate mitigation for the historic environment.

4.4.17 It should be noted that there may be instances where an anomaly may exist on the seabed but not be visible in the geophysical data. This may be due to being covered by sediment or being obscured from the line of sight of the sonar. The use of both SSS and MBES data mitigates this by visualising anomalies from multiples angles, including from above. Anomalies were named following the standard MSDS Marine convention, [PROJECT_YEAR_ID], e.g., GV22_XXX.

4.5 Existing infrastructure

4.5.1 The Green Volt Array RLB encompasses the Ettrick oil field to the North, and the Blackbird oil field to the south. Both oil fields ceased production in 2016, with subsea infrastructure removal commencing in 2017, and well plug and abandonment commencing 2018, although as noted in the Offshore Scoping Report[6] decommissioning was still ongoing in 2021. An initial review of the geophysical data identified a significant amount of relict infrastructure (or the remains of, including rock dumps, seabed disturbance, etc.) on, or under, the seabed. Data was obtained from the North Sea Transition Authority[7] (NSTA) to identify the locations of infrastructure to ensure that it was not unnecessarily identified as of archaeological potential.

[6] RHDHV, 2021. *Green Volt Offshore Windfarm – Offshore Environmental Impact Assessment. Offshore Scoping Report*. Reference: PC2483-RHD-ZZ-XX-RP-Z-0001

[7] https://www.nstauthority.co.uk/

4.5.2 Infrastructure (or the remains of) is noted across much of the Array RLB, although it is predominantly clustered around, and between, the Ettrick and Blackbird oil fields. The locations are shown in Figure 4 and the type classified in Table 4 below.

Infrastructure Type	Count	Notes
Pipeline	17	Two still active, ten trenched and buried
Well location	25	Associated with 26 well bottom locations and 26 well paths

Table 4: Infrastructure within the Green Volt OWF Array RLB

4.5.3 In addition to the physical remaining infrastructure, or evidence of, on the seabed, the seabed is also heavily scarred from operation and decommissioning activities including anchor scars, anchor pull-out pits, and mooring piles. These seabed scars were mapped by Gardline, including cross referencing with known positions, and are also presented in Figure 4.

4.5.4 Seabed infrastructure within the cable routes is limited to three pipe crossings between Green Volt OWF and the shore. Along the Green Volt OWF to Buzzard oil field cable route are a number of anchor scars, one sub-surface well bottom, and two well paths. The remaining infrastructure associated with the Buzzard oil field is outside the extents of the data used within this assessment. Cable route infrastructure is shown in Figure 5.

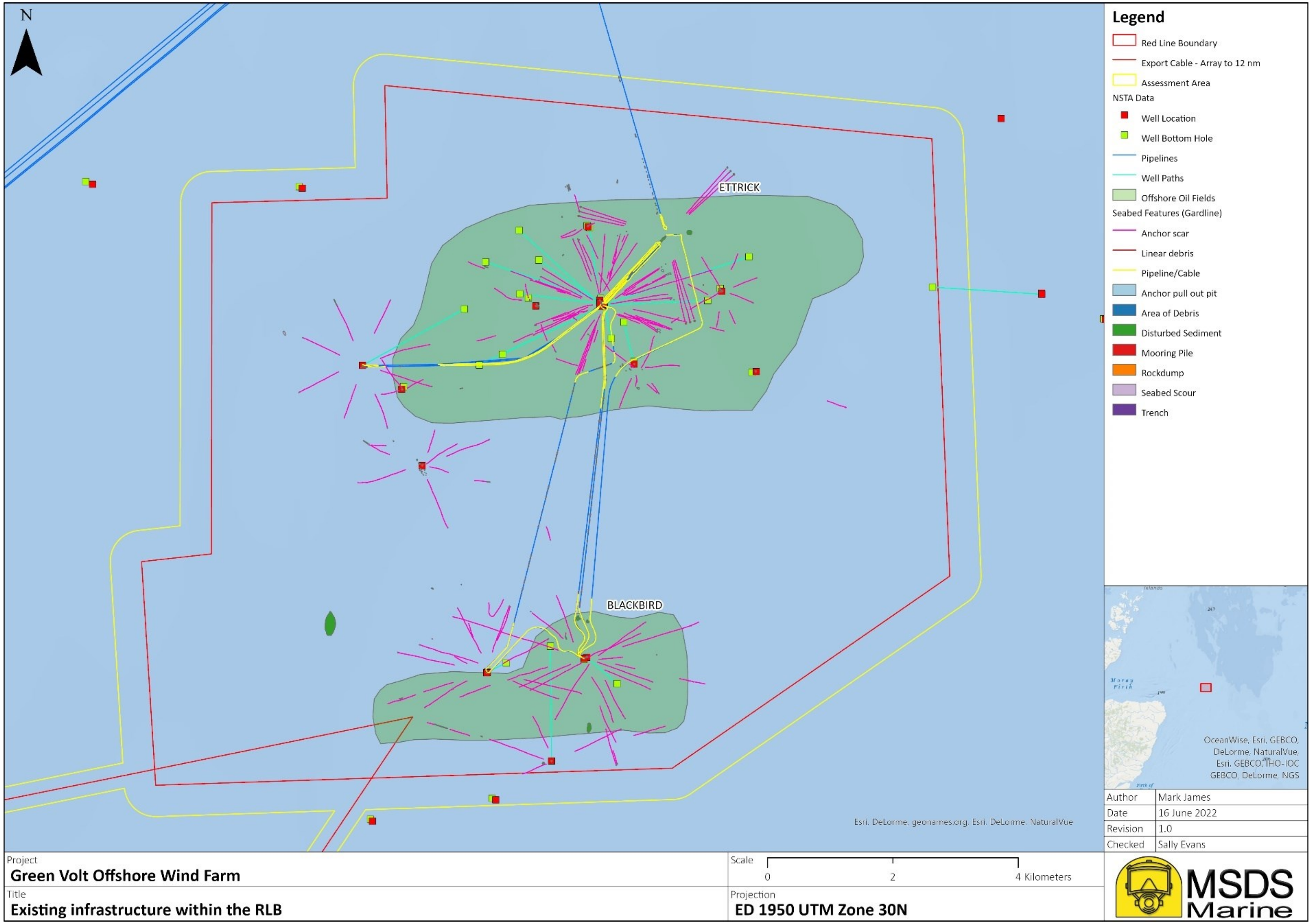

Figure 4: Existing infrastructure within the Array RLB

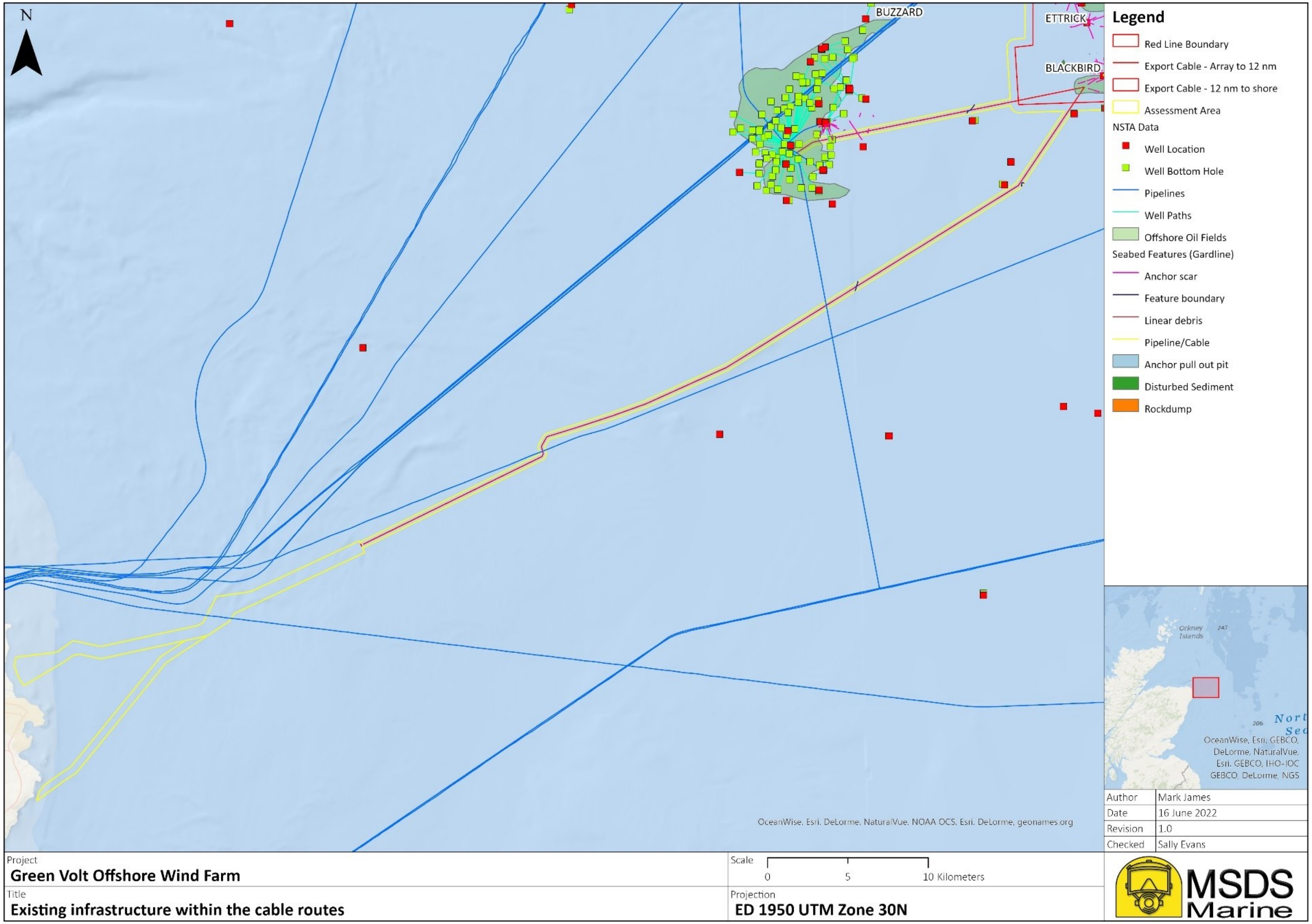

Figure 5: Existing infrastructure within the cable routes

4.6 Palaeolandscape and Sub-bottom Profiler interpretation

4.6.1 Whilst the interpretation of the palaeolandscape is based upon the archaeological review of geophysical and hydrographic data, the method of assessment, the assessment criteria and the best practise mitigation strategies differ from those presented in the preceding sections and thus it is detailed separately for clarity.

4.6.2 Sub-surface data acquired from sub bottom profile and seismic surveys are key to understanding the palaeolandscape potential of the site. These data are available (see below for data sources) and have been assessed to identify ground conditions within the site. The interpretations of the data feed into the ground model, which incorporates both geological modelling and engineering conditions, knowledge of which is necessary for development design. Sedimentary units have been identified within the seismic data based on their seismic character and likely depositional environment, and tentatively correlated with known geological formations in the area based on the available data (Gardline, 2022). The base of each sedimentary unit has been mapped to feed into the ground model, and grids have been exported from the ground model for this assessment. From an archaeological perspective, this preliminary ground model provides insight into the potential geological formations within the site, and their likely depositional environment. This feeds into the assessment of the palaeolandscape through time, and corresponding archaeological potential.

4.6.3 Sedimentary unit grids and geological maps derived from the interpretation of sub-surface data and the current seabed derived from MBES data were assessed alongside existing studies which contribute to the understanding of the palaeolandscape and prehistoric archaeological potential within the area. An archaeological review of the geophysical survey assessments and ground model covering the site was conducted by MSDS Marine. This included a review of geophysical survey data reports and ground model outputs including mapped horizons and grids. These sources were reviewed in order to establish an understanding of the geological make-up of the site, formations present and their palaeoenvironmental and archaeological potential. Information about the wider area has also been used to better contextualise the various environments experienced in the area during the Pleistocene and Holocene.

4.6.4 Geological formations and their archaeological potential have been discussed within this report.

4.7 Palaeolandscape and Sub-bottom Profiler sources

4.7.1 New surveys of the site have been conducted as part of the current applications (Gardline 2022). In addition to these surveys, previous works associated with the Ettrick and Blackbird oil fields, lying within the northern and southern part of the proposed array area provide detailed baseline evidence from within the site. Others situated within the wider area also provide background information. Figure 7 shows the locations of the oil fields within the site and those further afield, and the areas of associated data collection. Together these sources allow a detailed characterisation of site conditions which enable understanding of the archaeological resource. Further details of these surveys are given below.

Primary sources

4.7.2 Geophysical surveys have been undertaken within the site and provide the key source of primary information on the archaeological potential of the area. In regard to the palaeolandscape the SBP data and MBES data provide key information. Gardline Limited conducted a survey campaign for CNOOC International in United Kingdom Continental Shelf (UKCS) Blocks 20/02 and 20/03 (Gardline 2022). The work included an environmental survey at the proposed Green Volt site and associated routes from the Buzzard Platform and offshore end of the Export Cable Route (ECR) and a debris clearance survey at the Ettrick field. The data acquisition was concurrent as the Ettrick field lies within the Green Volt site. Sub-bottom profiler data was collected from within the area of the Ettrick field only. MBES, sidescan sonar (SSS) and magnetometer data were also collected across the Ettrick and Green Volt sites.

4.7.3 Sub-bottom profiler data was collected at 150 m line spacing with 1.5 km cross lines (Figure 6). Penetration was between 5-6 m and has been processed to form grids which map the base of sedimentary units identified within the site. The grids are shown as figures in this report.

4.7.4 Site-specific data is also available from the work of previous studies, associated with the oil and gas fields within the area. The decommissioned Ettrick and Blackbird oil fields are located within the site and have been associated with survey works covering the site. There are 25 wells within the site, and accompanying site investigations provide detailed information which support understanding of the palaeolandscape (Figure 7 shows well locations within the array area) (Calesurvey 2013). Previous investigations within these areas are summarised within Table 5, and have formed key primary sources referred to within this assessment.

Secondary sources

4.7.5 The site lies within the area of BGS Sheet 57°N-02°W, and charts showing the solid geology (BGS 1982), Quaternary deposits (BGS 1986) and seabed sediments (BGS 1984) are available for this area. The BGS publications, The Geology of the Central North Sea (Gatliff et al. 1994) and Cainozoic geology and landscape evolution of North-East Scotland (Merritt et al. 2003) are both also relevant to understanding the offshore geology of this area. Other studies which have focused on the Quaternary sediments of the North Sea are also of relevance to this assessment, including Stoker et al. (2008), Davies et al. (2011). These, and other sources, are referred to within the text.

Figure 6: Seismic survey lines

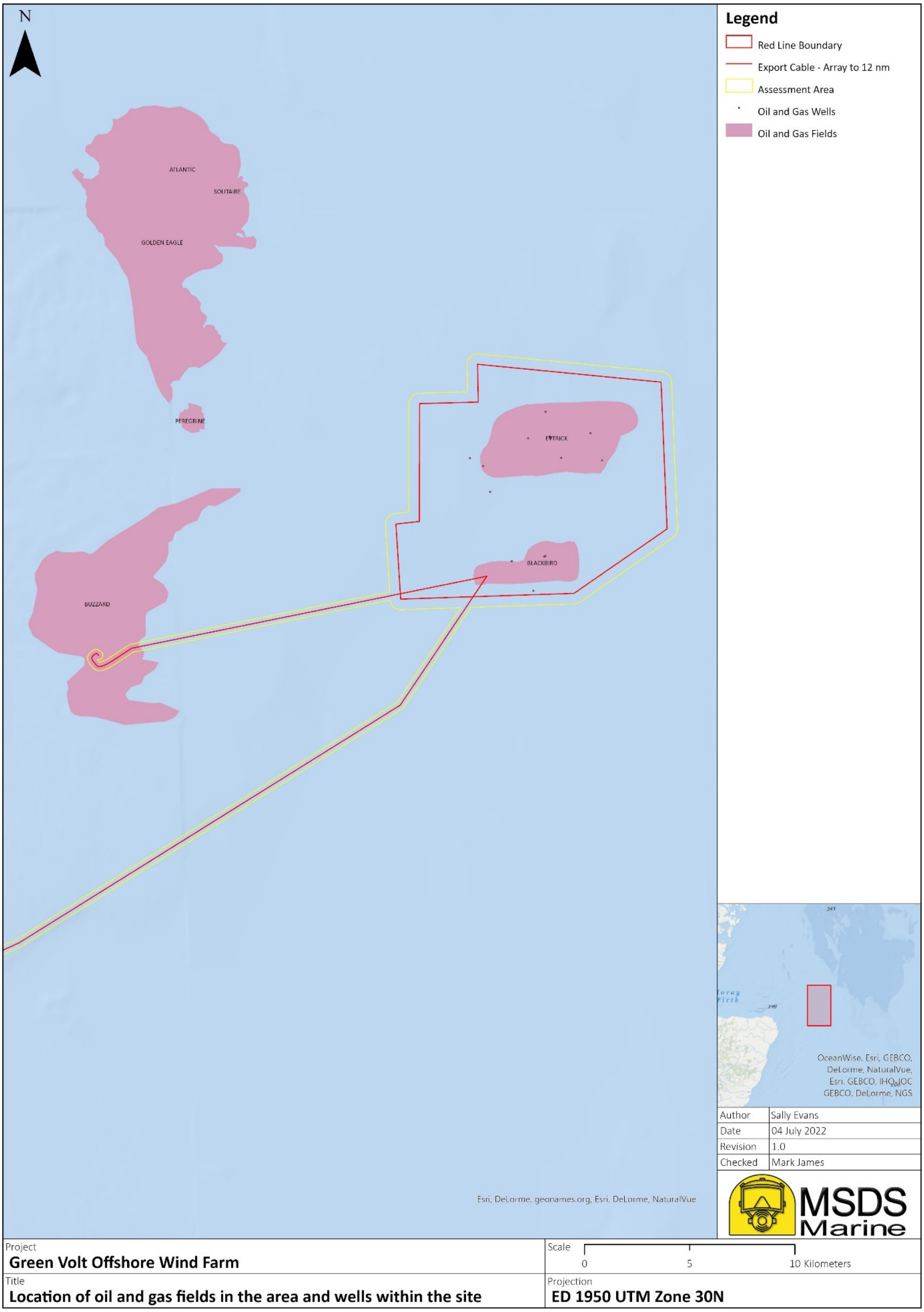

Figure 7: Location of oil and gas fields in the area and wells within the site

Report title	Site	Survey details	Reference
Debris Clearance Survey UKCS Block 20/2a Proposed Locations at Blackbird	Blackbird	Debris clearance accompanied by geophysical survey including single and MBES, SSS and pinger SBP.	Fugro 2010
Rig Site Survey UKCS Block 20/02 Proposed Location 20/02 Blackbird	Blackbird	Including collection of single beam echo sounder, MBES, pinger SBP, SSS, magnetometer 2DHR multichannel seismic data, seabed sampling.	Fugro 2011
Nexen Petroleum UK Ltd UKCS Block 20/2a Blackbird Site Survey	Blackbird	Rig site survey involving the collection of singlebeam and MBES, SSS, pinger and boomer (SBP) data, high resolution seismic, environmental camera, and grab data.	Gardline 2009
Nexen Petroleum U.K. Ltd Site Survey UKCS 20/2a (Blackbird) January 2007 Survey Report	Blackbird	Survey to identify obstructions, geology, geohazards and environmental conditions, including collection of camera footage, grab sampling and coring. Geophysical survey data were also collected including SBP, echo sounder, MBES, SSS, 2D High Resolution Seismic (HRS) data.	Gardline 2007
Pipeline Route Survey UKCS Block 20/2a Ettrick to Blackbird	Ettrick To Blackbird (pipeline)	Geophysical and environmental survey including SSS, MBES, pinger SBP, magnetometer data.	Fugro 2008
Independent Geohazard Assessment: Ettrick DCM Revised Well Location UKCS, BLOCK 20/2a & 20/3a	Ettrick	Surveys associated with revised DCM location and including the collection of 2DHR infill lines and reporting on extensive 2DHR collected in 2005 and 2011, 3D seismic data, and collection of four CPTs.	RPS 2013
Ettrick Site Survey UKCS Blocks 20/2a & 20/3a Results Report	Ettrick	Environmental survey of proposed well locations including collection of 2DHR data, pinger SBP, single beam echosounder, MBES, SSS and Chirp and magnetometer data.	Calesurvey 2013b
Habitat Assessment for Ettrick, UKCS Blocks 20/2a and 20/3a (BSL Project 1233.2)	Ettrick	Habitat survey involving geophysical survey (SSS, MBES, SBP), grab samples and seabed photography.	Calesurvey 2013a
Debris Box-In Survey, UKCS 20/02 Ettrick Wi Debris Memo	Ettrick	SSS data collection of debris identified within Ettrick site.	Fugro 2011
Rig Site Survey UKCS 20/2a & 20/3a Ettrick Drill Sites Report No.: 68 - 8713.2 Volume II: Environmental Baseline Survey	Ettrick	Environmental and geophysical data collection and included grab sampling, seabed photography and the collection of vibrocores, in addition to SSS, MBES and SBP data.	Fugro 2006
Ettrick Debris and Route Survey UKCS Block 20, AML Report No. 0456540-1(02)	Ettrick	Report not available at the time of writing.	Alluvial Mining Ltd, 2006

Table 5: Summary of previous investigations with the Green Volt OWF Array RLB

4.8 Mitigation

Surface anomalies

4.8.1 To ensure the most appropriate and robust mitigation for the historic environment, whilst being proportional to the requirements of the development, mitigation recommendations are determined on an anomaly-by-anomaly basis, and consider all available data including;

- Potential significance;
- Size;
- Seabed type;
- Seabed dynamics;
- Development type; and
- Potential negative impacts.

4.8.2 Mitigation strategies have been based on the criteria in Table 6 below.

Potential	Criteria
Low	No archaeological significance interpreted. Maintain an operational awareness of the anomaly's location and reporting through the agreed protocol should material of potential archaeological significance be encountered.
Medium	Avoidance of the anomaly's position and where appropriate an archaeological exclusion zone may be recommended. Ground truthing of the anomaly through the use of divers or an ROV would establish the archaeological potential.
High	Archaeological exclusion zones will be recommended based on the size of the anomaly, any outlying debris and the seabed dynamics as interpreted from the SSS and MBES data.

Table 6: Mitigation criteria for archaeological anomalies

4.8.3 Where an anomaly is visible in the MBES data, that position will generally be used for the implementation of mitigation recommendations. The position obtained from the MBES data is generally more accurate due to the sensor and the GPS receiver being fixed to the vessel in known planes. SSS and magnetometer sensors are towed, and thus the margin for error is greater even with USBL, as the positional tolerance can be between 0.5 m and 2.0 m.

4.8.4 A phased approach to mitigation is proposed for Green Volt OWF, corresponding with the planned future survey strategy. The survey specification was designed for the purposes of consenting and Front End Engineering Design (FEED) to determine the most appropriate area for development, and as part of debris clearance and environmental obligations for Ettrick and Blackbird oil fields. Future surveys will likely combine an increase in resolution, and the addition of magnetometer data with tighter line spacing (as determined by the pUXO risk), 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. Following the archaeological assessment, recommendations have made as to the coverage and specification of future surveys to ensure a robust archaeological assessment of the development area.

4.8.5 At this phase, differentiation has made between anomalies that are visible and identifiable in the survey data (e.g., SSS and MBES anomalies), and potential anomalies that have not been identified in the survey data but are likely to exist on the seabed (e.g., Live UKHO records).

4.8.6 The mitigation strategies detailed in Table 7 have been used.

Strategy	Description
Archaeological Exclusion Zones (AEZs)	For archaeologically significant anomalies that are clearly identifiable in the survey data and where the extents are largely known, Archaeological Exclusion Zones (AEZs) will be recommended. AEZs will remain for the life of the project or until ground truthing or higher resolution data determines a reduction in potential, significance, or extents.
Temporary Archaeological Exclusion Zones (TAEZs)	Where an anomaly is not visible in the survey data but likely to exist on the seabed at a known position or where the extents of an anomaly are not fully identifiable, Temporary Archaeological Exclusion Zones (TAEZs) will be recommended. TAEZs have been identified as highly likely to be altered following higher resolution or full coverage data assessment, however, they will remain in place until alterations have been formally agreed.
Areas of Archaeological Potential (AAP)	Areas of Archaeological Potential (AAP) are primarily reserved for magnetic anomalies where, due to line spacing, positions are not accurately known. AAPs demonstrate that there is potentially an anomaly of archaeological significance around the given position. The anomaly is likely to be identified following higher resolution or full coverage data assessment but as the nature and position is not precisely known, no formal exclusion zone is recommended but instead a general awareness of the position is considered appropriate at this phase.

Table 7: Archaeological mitigation strategies

Palaeolandscape

4.8.7 Dependant on the assessed potential, the process of mitigation in relation to the palaeolandscape and palaeoenvironmental remains typically follows a more staged approach of continued assessment aligning with the engineering requirement to undertake geotechnical works.

4.8.8 Archaeological input into geotechnical core locations can allow for the greatest insights into the palaeolandscape, such as through the sampling of stratified channel deposits, deposits likely to contain organic remains or un-eroded surfaces.

4.8.9 Typically, this process involves close collaboration with the Site Investigation team. Round-table discussions and the review of seismic profiles tends to be a conducive method of allowing engineering and archaeological requirements to be taken into consideration when micro-siting geotechnical cores.

4.8.10 Following the collection of geotechnical cores, they will undergo a staged program of geoarchaeological assessment and analysis. In brief the process is as follows;

- Stage 1: Geoarchaeological review of core logs;

- Stage 2: Geoarchaeological recording;
- Stage 3: Geoarchaeological assessment;
- Stage 4: Geoarchaeological analysis, and;
- Stage 5: Final reporting.

5.0 Results

5.0.1 For the avoidance of confusion, the results of the palaeolandscape assessment are presented separately in Section 9.0.

5.0.2 A total of 32 anomalies of potential archaeological interest were identified within the extents of the survey data, 23 of which fall within the Array RLB, two within the cable route corridor, and the remaining seven within the Array RLB 500 m buffer. The anomalies are categorised by potential in Table 8.

Potential	RLB	RLB + 500 m buffer	Array to shore	Array to Blackbird	Total
Low	22	7	1	1	31
Medium	0	0	0	0	0
High	1	0	0	0	1
Total	23	7	1	1	32

Table 8: Distribution of archaeological anomalies by potential

5.0.3 The distribution of anomalies is shown in Figure 8, as can be noted the distribution is fairly uniform across the surveyed area. The ratios of high, medium, and low potential anomalies are relatively consistent with a typical archaeological assessment of data, especially where the development area has been previously developed, thus having already avoided potential archaeological features previously identified. It is however notable that no medium potential anomalies were identified within the data.

5.0.4 The distribution of anomalies within the geophysical data shows a consistent approach to the assessment. The low, and high potential anomalies are discussed below according to their assessed potential.

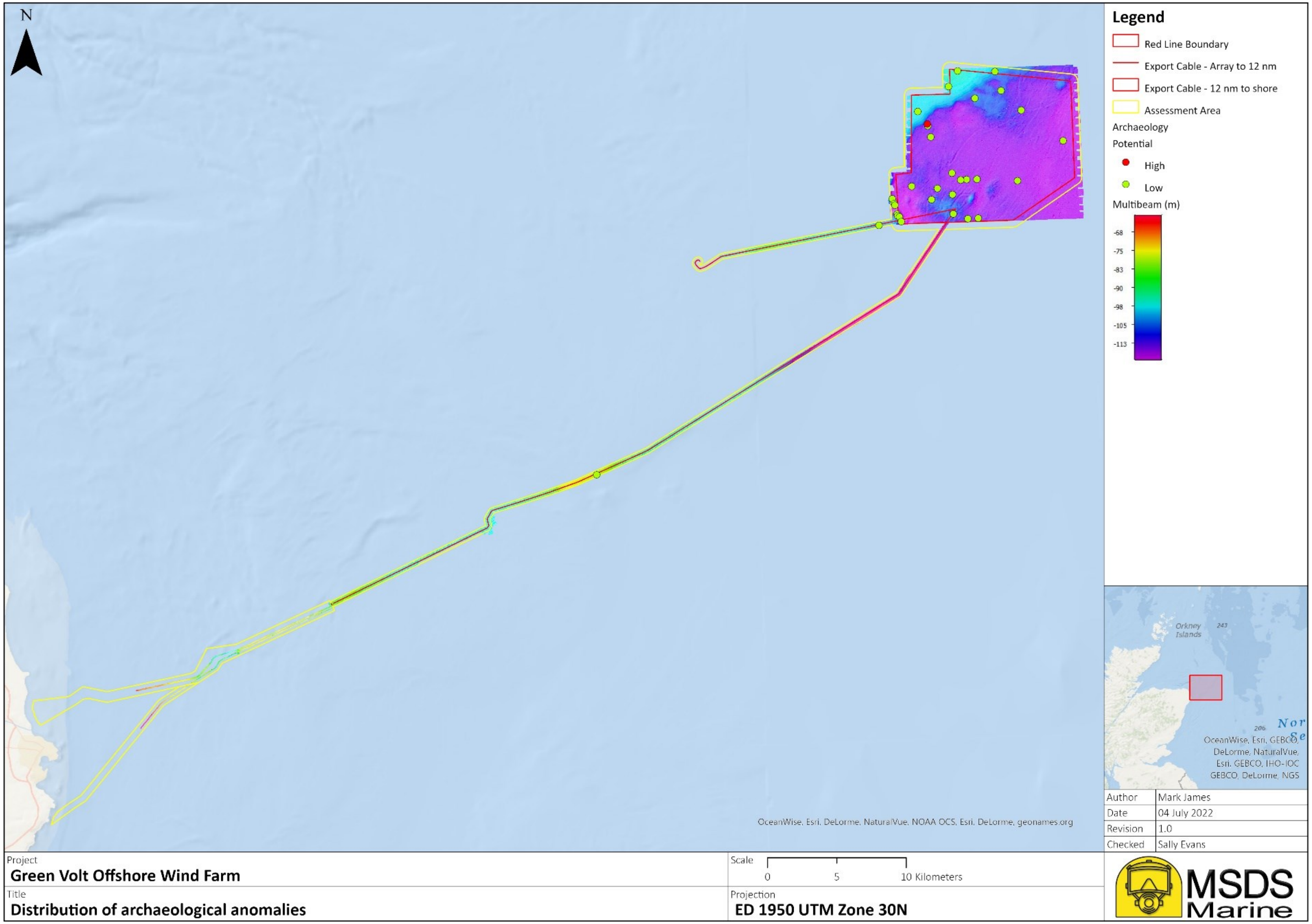

Figure 8: Distribution of Archaeological Anomalies

5.1 Low potential anomalies

5.1.1 31 anomalies interpreted as of low archaeological potential were identified within the Green Volt OWF survey extents, 22 of which fall within the Array RLB, seven within the 500 m buffer, and the remaining two along the cable routes. The anomalies can be categorised as follows in Table 9.

Anomaly category	Count
Chain, cable, or rope	2[8]
Likely geological	1[9]
Possible mine sinker	8[10]
Potential debris	11[11]
Unidentified debris	9[12]
Total	31

Table 9: Low potential anomaly categories

5.1.2 The anomalies interpreted as of low archaeological potential (see Table 3) are a mixture of small features, often boulder like, or likely to represent modern debris such as chain, cable, or rope or linear features with no features indicating archaeological potential. Each anomaly was reviewed and interpreted to be of low archaeological potential. A further review was undertaken following the assessment of the survey area extents.

5.1.3 Eight anomalies were identified in the south-west corner of the Array RLB and the 500 m buffer, seven of which are arranged along a line extending c.1.8 km and orientated approximately north-north-west, south-south-east. The features have been interpreted by Gardline as possible World War Two (WWII) mine sinker weights based on similar evidence from other surveys they have undertaken in the area[13]. However, the features identified in the geophysical data have not been ground truthed and are similar in form to modern debris and geological features noted in the wider area.

5.1.4 Whilst remnants of WWII activity can be considered to be of archaeological interest, it is the location of the mine sinker weights that potentially hold the most information. The identification of the anomalies as mine sinker weight would confirm the presence of historic

[8] GV22_0006, GV22_0023
[9] GV22_0004
[10] GV22_0025, GV22_0026, GV22_0027, GV22_0028, GV22_0029, GV22_0030, GV22_0031, GV22_0032
[11] GV22_0002, GV22_0003, GV22_0009, GV22_0010, GV22_0011, GV22_0014, GV22_0015, GV22_0017, GV22_0019, GV22_0022, GV22_0024
[12] GV22_0001, GV22_0005, GV22_0007, GV22_0012, GV22_0013, GV22_0016, GV22_0018, GV22_0020, GV22_0021
[13] Gardline Ltd, 2021. *UKCS Blocks 19/10 to 19/15 and 20/2 to 20/7, Ettrick and Green Volt Site and Export Cable Routes. Debris Clearance, Route, and Environmental Field Survey*. Report for CNOOC International

mine fields. Due to limited evidence, or confirmation, of their identity a low potential rating was assigned to the anomalies due to the appropriateness of the mitigation for this category - *Maintain an operational awareness of the anomaly's location and reporting through the agreed protocol should material of potential archaeological significance be encountered*.

5.1.5 The remaining low potential anomalies have been assessed against all available evidence and are deemed unlikely to be of archaeological significance and as such are not discussed further within the results section of this report. The distribution of low potential anomalies is shown in Figure 9.

5.1.6 Further information regarding mitigation can be found in Section 10.0, and a gazetteer of low potential anomalies, including positions and dimensions, can be found in Annex A – *Anomalies of archaeological potential*.

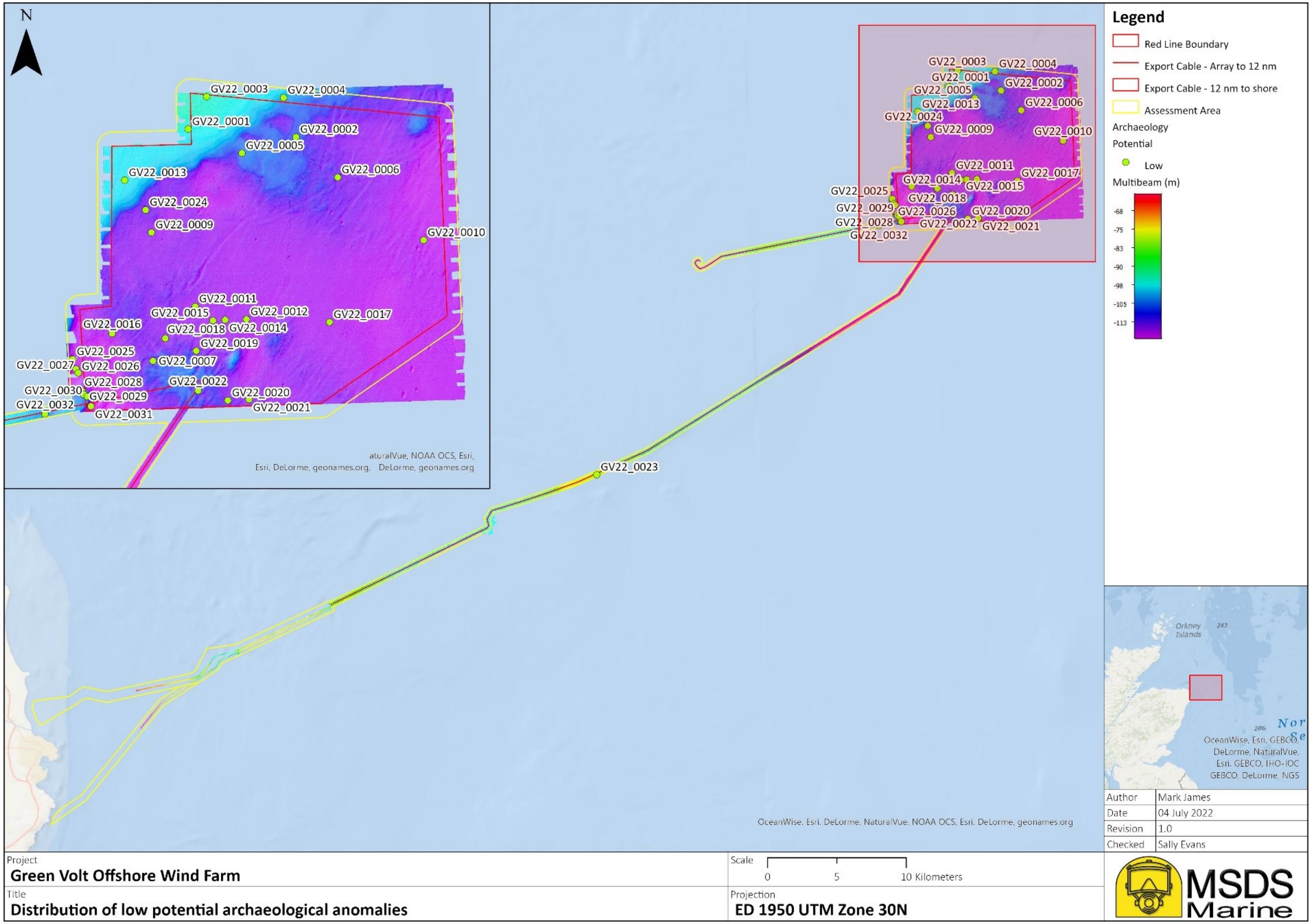

Figure 9: Distribution of Low Potential Archaeological Anomalies

5.2 Medium potential anomalies

5.2.1 No anomalies interpreted as of medium archaeological potential were identified within the Green Volt OWF survey data extents.

5.3 High potential anomalies

5.3.1 One anomaly interpreted as of high archaeological potential was identified within the Green Volt OWF survey extents, and which falls within the Array RLB. The anomaly can be categorised as follows in Table 10, the location is presented in Figure 10.

Anomaly category	Count
Wreck	1
Total	1

Table 10: High potential anomaly categories

5.3.2 The anomaly (GV22_0008) interpreted as of high archaeological potential relates to a wrecked vessel. The wreck is not recorded at the identified position by the UKHO or Canmore and is therefore not definitively named.

5.3.3 The high potential anomaly is discussed, along with an image, within Section 5.3 of this report. Further information regarding mitigation can be found in Section 10.0, and a gazetteer of high potential anomalies, including positions and dimensions can be found in Annex A – *Anomalies of archaeological potential*.

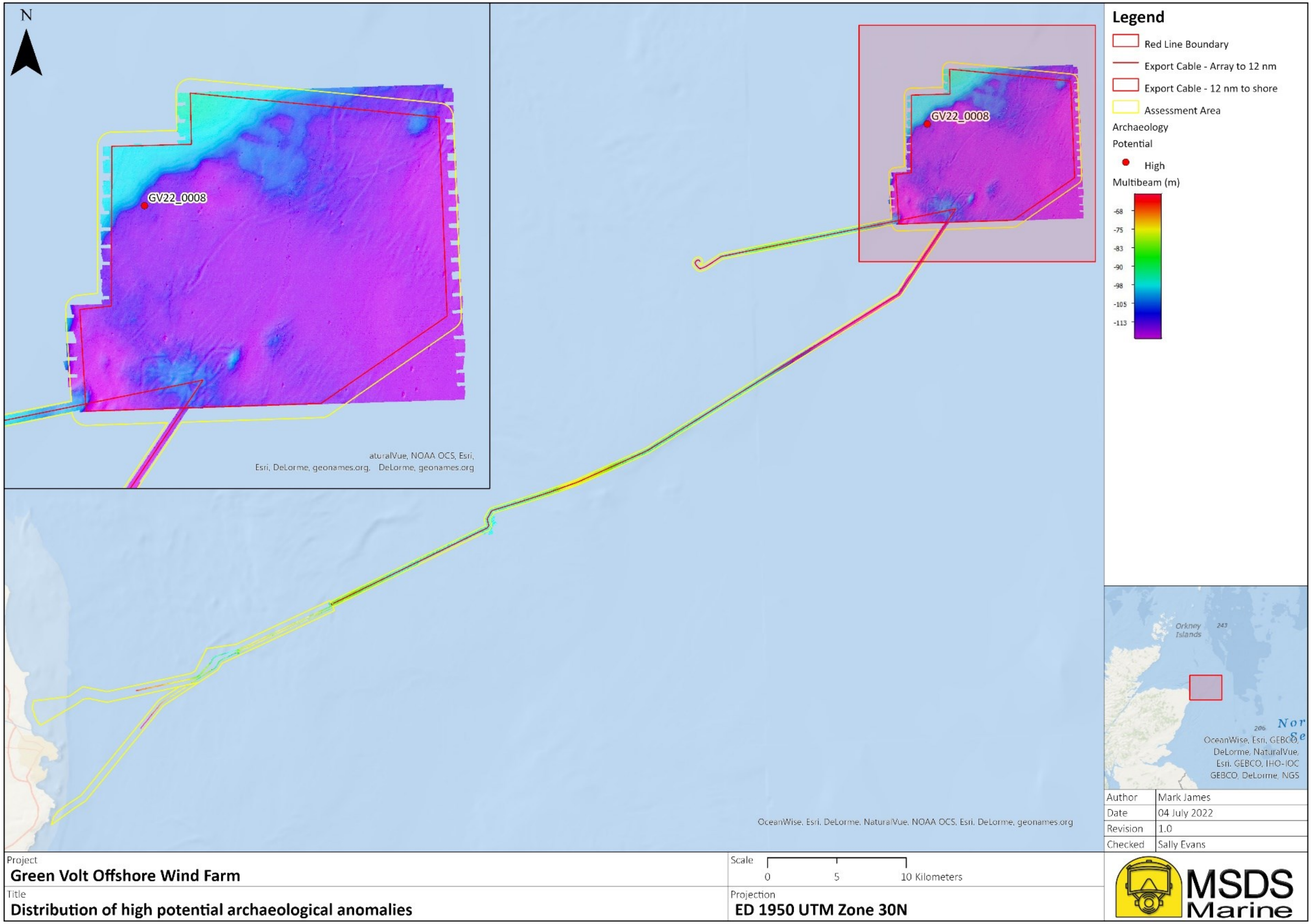

Figure 10: Distribution of High Potential Archaeological Anomalies

GV22_0008

5.3.4 GV22_0008 (Figure 13) lies in the north-east of the Green Volt OWF Array RLB, approximately 2.4 km south-south-east of the north-western corner. The anomaly is visible in both the SSS and MBES data and has an associated magnetic anomaly of 125 nT. The anomaly is not recorded at the identified location by either the UKHO or Canmore.

5.3.5 The anomaly is visible in the data as a prominent feature measuring 52.1 m x 8.9 m with an overall measurable height of 3.2 m, raising to nearly 6.0 m towards the south. The form of the anomaly is characteristic of a wrecked vessel. Due to the depth of water, and thus the density of the point cloud achieved, the form of the wreck is clearer in the SSS data which appears to show an upright, largely intact wreck with the bow approximately to the south. Regularly spaced linear features run port to starboard, potentially indicative of deck beams or frames viewed through open hatches. The MBES data also shows a wreck appearing upright. Prominent and upstanding features, potentially representing the wheelhouse, ship's structure and potentially winches are visible towards the bow and the stern although this is not clear in the data (Figure 11). The form of the wreck would likely suggest steel or iron construction.

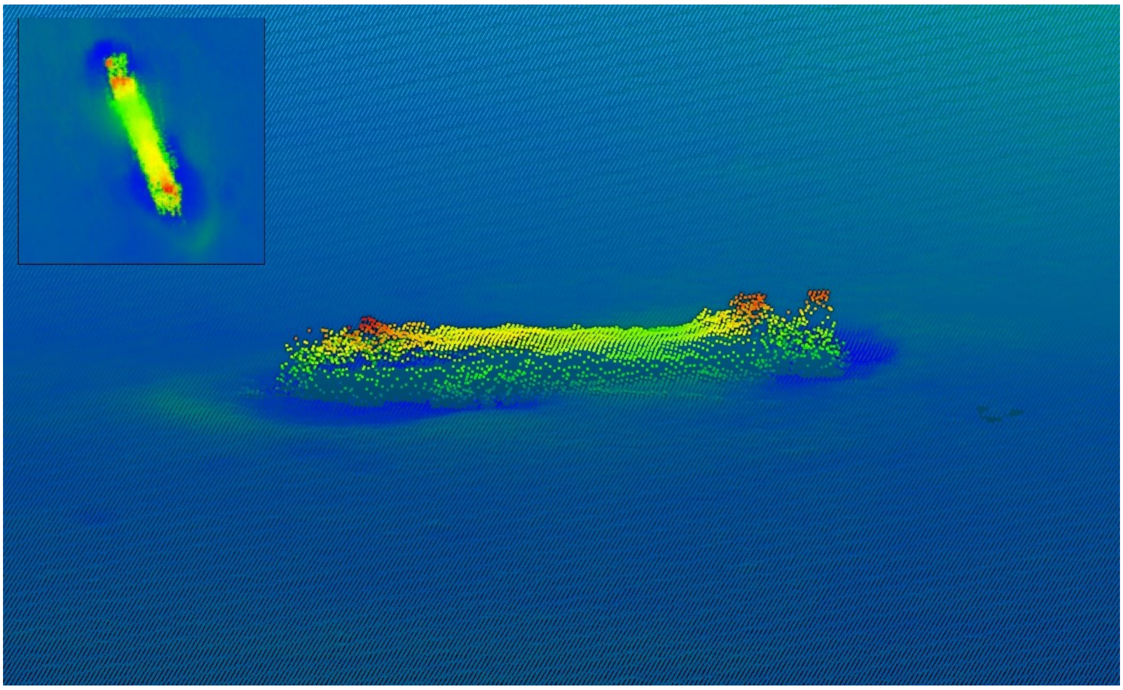

Figure 11: MBES image from the east (portside). Inset image is plan view, north up.

5.3.6 Scour is visible around most of the wreck, extending up to 0.5 m below seabed level, and 6.0 m from the wreck, the most prominent of which is around the bow to the south. Some accumulation, although minimal, is noted amidships. The debris field is limited, with the only discernible debris being an incoherent feature lying 10 m to the east of the stern, and what is interpreted as the mast lying along the port side. However, there is the potential for debris to lie within the scour which is obscured from the line of site of the SSS.

5.3.7 As noted, the wreck is not recorded in the position by the UKHO, which given the level of seabed activity within the vicinity is unusual. The closest UKHO record is 2402, the wreck of the *Ernst Friesecke*, a German cargo vessel built in 1955[14] and sunk on the 4th March 1972 with a cargo

[14] https://www.shipspotting.com/photos/3154095

of coal. The record originates from an observed sinking; thus, it is not considered an accurate position. The *Ernst Friesecke* developed a heavy list after developing engine trouble whilst on passage from Gdansk to Buckie, the vessel was abandoned and sunk whilst under tow by HMS *Keppel*.

5.3.8 The as-built dimensions of 56.1 m x 8.5 m as listed by the UKHO are slightly longer in length than those observed on the seabed (52.1 m). Should the wreck be that of the *Ernst Friesecke* this could be explained by either partial burial, or collapse, at the bow, or inaccuracies in the as built length reported by the UKHO. Similarities can be observed between contemporary images of the *Ernst Friesecke* and the wreck identified in the data (Figure 12). Given the proximity to the observed sinking position, the similarity in as-built and observed measurements, the similarities in both construction and form, it is likely the wreck observed on the seabed is that of the *Ernst Friesecke.*

Figure 12: The Ernst Friesecke *- taken by Charlie Hill*

5.3.9 The *Ernst Friesecke* is referenced in two Canmore records (309175 and 321988), neither of which are at the location of the wreck identified on the seabed. Canmore records are discussed further in Section 8.1

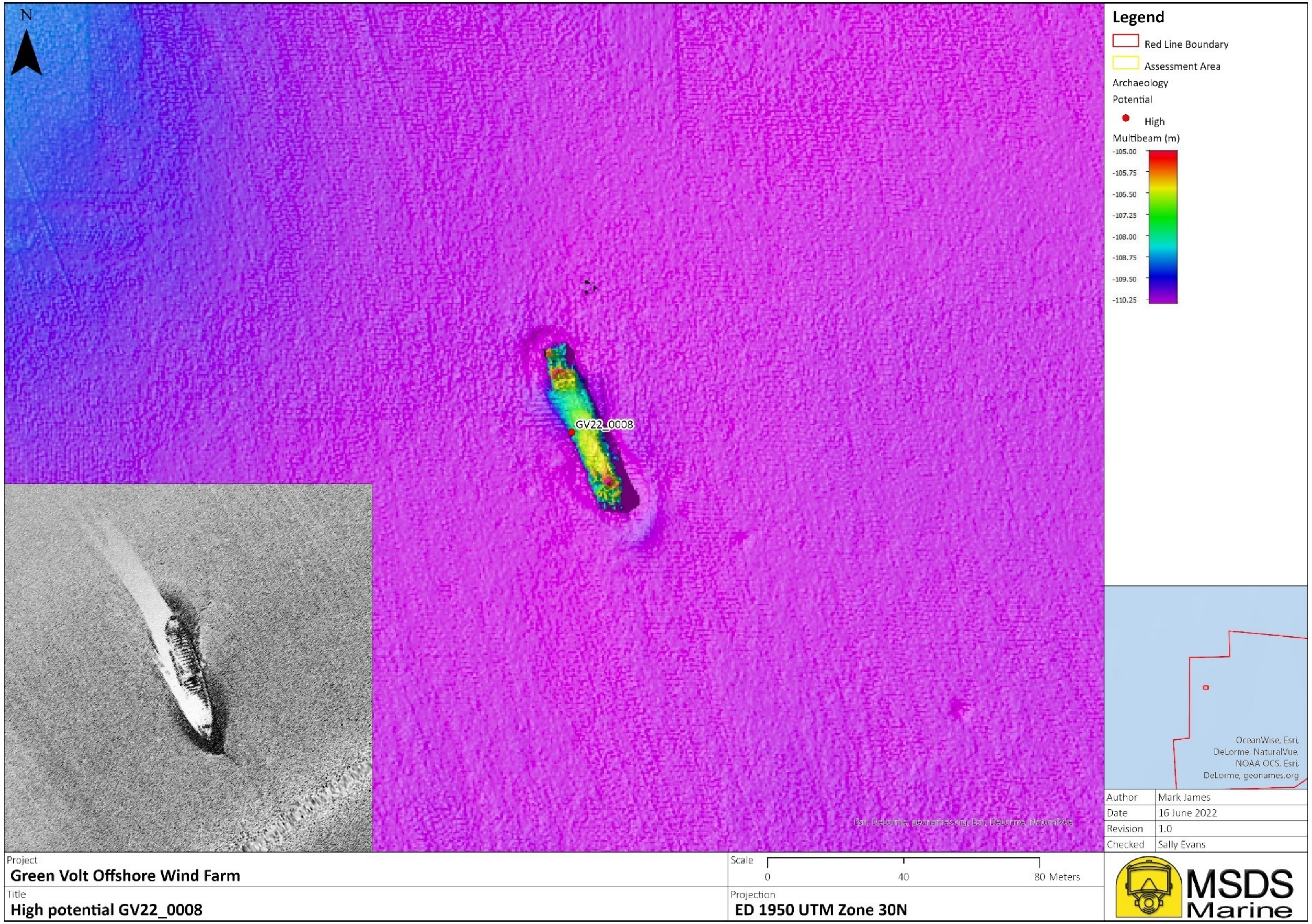

Figure 13: High potential GV22_0008

6.0 Magnetic anomalies

6.0.1 115 magnetic anomalies ranging between 3 nT and 4,213 nT were identified within the data extents, of these six do not correlate with known features, infrastructure, or surface anomalies identified as of archaeological potential. All six fall with the Green Volt OWF Array RLB. The distribution of intensities is shown below in Table 11 and the distribution of anomalies presented in Figure 14.

Intensity (nT)	Count
5 to 50	6
50 to 100	0
100 to 200	0
200 +	0
Total	6

Table 11: Magnetic anomalies

6.0.2 Anomalies identified from the magnetometer data are ferrous and thus generally anthropogenic in origin although they can be associated with geological features, however there is no visual interpretation as with other geophysical data.

6.0.3 The magnetometer data collection methodology across the Green Volt OWF survey area was to run lines concurrently with the SSS and MBES, thus the line spacing is not sufficient for the detailed assessment of small, ferrous features on or below the seabed. The position for a magnetic anomaly can only be determined from directly below a single sensor, or where lines are run close enough together to be able to confidently position an anomaly seen on two, or more, lines. However, in combination with SSS and MBES data the magnetometer specification is considered sufficient to develop a broad understanding of the potential of the survey area, and to identify larger features of potential archaeological significance.

6.0.4 The positions of magnetic anomalies were viewed in the available datasets and where there was a strong correlation with a seabed anomaly, they were assessed for archaeological potential. All remaining anomalies have been included within this section.

6.0.5 All isolated magnetic anomalies of 50 nT or less are considered to be of limited potential to be of archaeological significance.

6.1 Large magnetic anomalies

6.1.1 No magnetic anomalies considered large (>100nT) have been identified within the data extents.

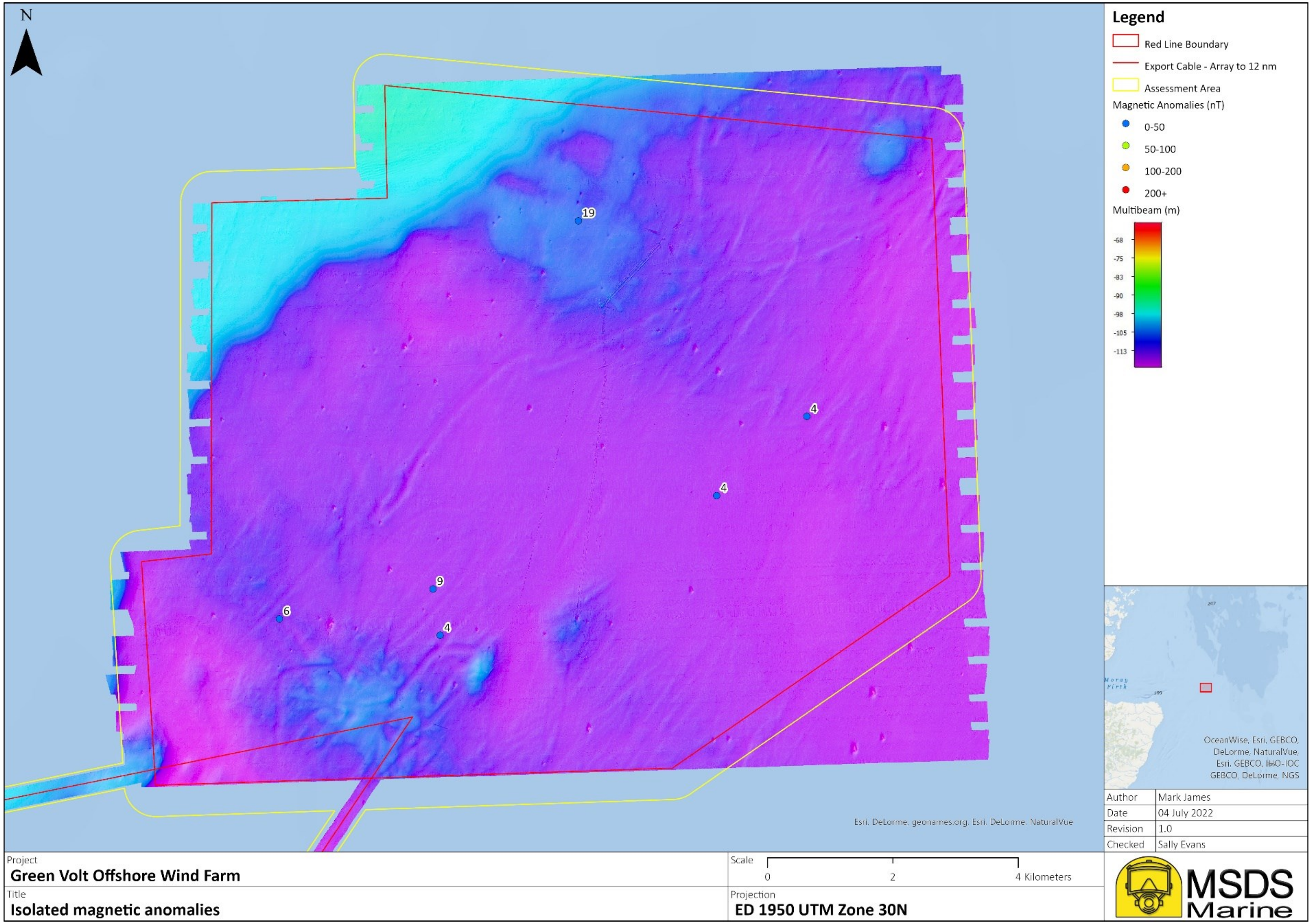

Figure 14: Distribution of isolated magnetic anomalies

7.0 United Kingdom Hydrographic Office (UKHO) Data

7.0.1 United Kingdom Hydrographic Office (UKHO) data from 2022 was obtained for the assessment area for correlation with anomalies identified within the geophysical data, and the establishment of TAEZs.

7.0.2 A total of two UKHO records were identified within the assessment area, both of which are located within the Green Volt OWF Array RLB, and within the extents of the geophysical data.

7.0.3 The categories of records, along with record counts, are detailed in Table 12, and the distribution presented in Figure 15.

Record type	Count
FPSO (Floating, Production, Storage, and Offloading)	1
Wreck	1
Total	2

Table 12: UKHO records by type within the Green Volt OWF scoping boundary

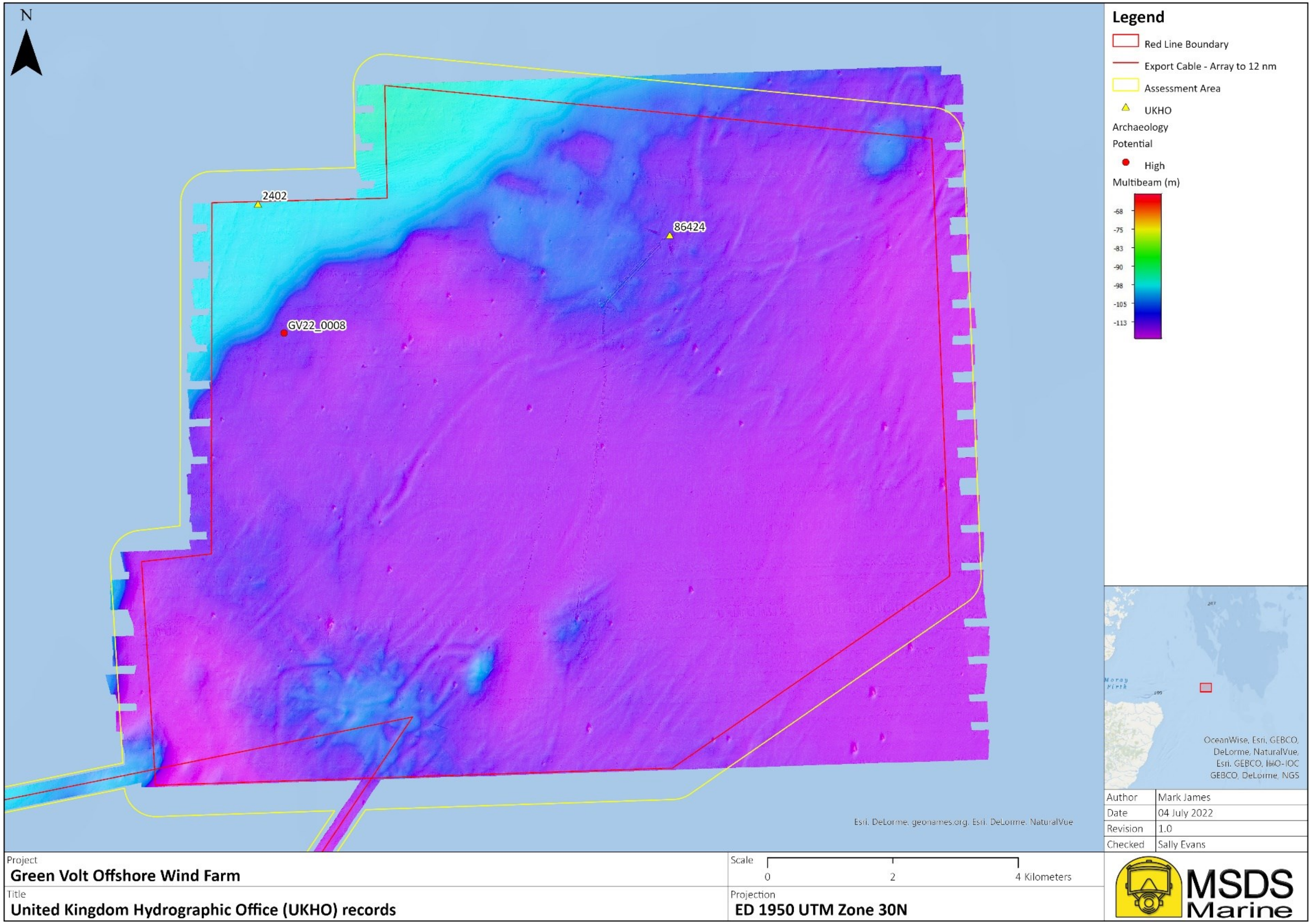

Figure 15: Distribution of United Kingdom Hydrographic Office Records

7.1 UKHO Records of Wreck

7.1.1 Of the two UKHO records identified, one is the record of a wreck. The record lies within the Green Volt OWF Array RLB, approximately 733 m east of the north-eastern corner and within the extents of the geophysical data

7.1.2 UKHO data typically, where known, lists information about the wreck, the circumstances of its loss, surveying details, and whether the record is considered live or dead. A dead record is one which has *not been detected by repeated surveys, therefore considered not to exist*[15]. Whilst the decision to amend a wreck to dead is based on data available from repeat surveys, records can be amended for a number of reasons including,

- Deterioration of the wreck to such a degree that it no longer exists on the seabed;
- Continual burial of the wreck so that the presence is not detected over repeat surveys;
- The identification of the wreck as a natural feature; or perhaps most commonly,
- The wreck not existing at the listed location due to inaccurate reporting or positioning at the period of identification.

7.1.3 As detailed in Section 5.3 the wreck identified within the geophysical data does not correspond with a UKHO record. The position of the UKHO records were reviewed in the data and an assessment made as to whether they were visible, or likely to exist on the seabed.

7.1.4 The UKHO records relating to wreck are presented in Table 13 below, and a description of each wreck follows where not previously described in Section 5.3.

Record	Status	Name	Date sank	Date recorded	Last detected	Visible in data
2402	Live	*Ernst Friesecke*	1972	1972 Observed	Not detected	Not visible

Table 13: UKHO records of wreck within the Green Volt OWF assessment area

UKHO record 2402

7.1.5 UKHO record 2402 is the wreck of the *Ernst Friesecke*, a German cargo vessel built in 1955 and sunk on the 4th of March 1972 with a cargo of coal. The *Ernst Friesecke* developed a heavy list after developing engine trouble whilst on passage from Gdansk to Buckie, the vessel was abandoned and sunk whilst under tow by HMS *Keppel*. The UKHO record the record as live. The UKHO record the as-built dimensions as 56.1 m x 8.5 m, with a draught of 3.4 m and a gross tonnage of 498.

7.1.6 No wreck, or evidence of wreck, is visible within the geophysical datasets within 2.0 km east and south, and 733 m west of the record location. It should be noted that the geophysical data extends 40 m north of the record position and thus no assessment can be made northward of this point.

7.1.7 The record originates from an observed sinking, thus is not considered an accurate position. It can be inferred that the observed sinking position was reported by HMS *Keppel*. The record potentially relates to the high potential anomaly GV22_0008, a wrecked vessel of similar

[15] https://www.wrecksite.eu/ukhoAbbrev.aspx

proportions and form to the *Ernst Friesecke* and lying approximately 2.1 km to the south. The discrepancy in positions is feasible for an observed position from 1972 taken whilst a vessel is sinking under tow, and in a water depth of over 100 m. It is therefore considered likely that the GV22_0008 and UKHO record 2402 relate to the same wreck, and that no remains are likely to exist on the seabed at the record location.

7.1.8 Further information can be found in Section 5.3.

7.2 UKHO Records of Modern Features

7.2.1 Of the two UKHO records identified, one is recorded by the UKHO as relating to a modern feature. The record lies to the north of the Green Volt OWF Array RLB approximately 4.5 km south-west of the north-east corner. The record is within the extents of the geophysical data. The locations of records potentially relating to modern features were reviewed in the geophysical data to ensure the correct interpretation, and to ensure they do not represent material of potential archaeological interest.

UKHO record 86424

7.2.2 UKHO record 86424 was created in 2016 and originated from a Notice to Mariners (NtM) (NM 4646/16). The NtM was submitted for the replacement of a lighted FPSO (Floating, Production, Storage, and Offloading), with a 45 m obstruction at the record location. A further NtM was submitted in 2018 (NM 3946/18) presumably for the removal of the obstruction as the record was subsequently amended to dead. No material of potential archaeological interest is visible in the geophysical data, and the record lies over a heavily disturbed area of seabed relating to infrastructure.

7.3 UKHO Records of Non Submarine Contacts (NSC)

7.3.1 No records of Non Submarine Contacts (NSC) were identified within the assessment area.

7.4 UKHO Records of Obstructions and Foul Ground

7.4.1 No records of Obstruction and Foul Ground were identified with the assessment area.

8.0 Historic Environment Records

8.0.1 Historic Environment Records (HERs) were obtained from Canmore (The National Record of the Historic Environment in Scotland) and the Aberdeenshire HER for the Green Volt OWF assessment area. HER records were used for correlation with anomalies identified within the geophysical data, in particular where the identity of an anomaly may be subject to uncertainty.

8.0.2 HER records are generally discussed after the UKHO records due to a large number of the records in the offshore area being comparable to, or informed by, the UKHO records.

8.1 Canmore

8.1.1 Eight Canmore records were returned, two of which are within the Green Volt OWF, four within the cable route, and two within the wider assessment area around the Array RLB. Of the eight records returned, all relate to wrecks, or records of wreck. The distribution of records is shown in Figure 16 and Figure 17.

8.1.2 With the exception of Canmore ID 321988, none of the records correspond with the positions of UKHO records. The eight Canmore records, with their corresponding UKHO records, are detailed below in Table 14. It should be noted that records from Canmore make no differentiation between live records and dead records. UKHO records are discussed in Section 7.0.

Canmore record	UKHO record	Canmore description
202106		Craft; Unknown
207841		Steam Trawler; *Japonica*
208451		Steamship; *St Fergus*
291434		Barge; Unknown
309175		Motor Vessel; *Ernst Friesecke*
309176		Trawler; Shamrock
321988	2402	Motor Vessel; *Ernst Friesecke* (same location)
324755		Craft (possible); Unknown

Table 14: Canmore records and corresponding UKHO records

Canmore records 309175 and 321988

8.1.3 Canmore records 309175[16] and 321988[17] both relate to the wreck of the *Ernst Friesecke*, with record 321988 lying in the same position as UKHO record 2402 approximately 2.1 km north of the wreck identified on the seabed, the information is taken directly from the UKHO record. Record 309175 lies approximately 1.4 km north of the wreck identified on the seabed and the record states the wreck is unlocated. No wreck, or the remains of wreck, were identified in the

[16] https://canmore.org.uk/site/309175/ernst-freisecke-north-sea
[17] https://canmore.org.uk/site/321988/ernst-friesecke

geophysical data at the locations of the records. The *Ernst Friesecke* has been discussed in detail in Section 5.3 and Section 7.1 and requires no further discussion here.

Canmore record 202106

8.1.4 Canmore record 202106[18] lies along the cable route, approximately 15.3 km seaward of landfall. The record is a named location (NLO) relating to Peterhead, but no further information is available, the Canmore record states that *the significance of this record remains unclear*. The record falls outside of the geophysical data so it is not possible to determine whether remains are present on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position.

Canmore record 207841

8.1.5 Canmore record 207841[19] lies along the cable route, approximately 75.5 km seaward of landfall and 0.4 km south of the RLB. The record is of the steel steam trawler *Japonica*, built in 1896 and sunk by gunfire from a submarine on 5th June 1915. The recorded location of the sinking was 45 miles east of Kinnaird Head. The record falls outside of the geophysical data so it is not possible to determine whether remains are present on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position, the wreck is stated as being unlocated with the position (NGR) given to the nearest 1 km.

Canmore record 208451

8.1.6 Canmore record 208451[20] lies along the cable route, approximately 10.5 km seaward of landfall. The record is of the steel steamship *St Fergus*, built in 1913 and sunk following a collision on 31st December 1940. The recorded location of the sinking was off Rattray Head. The record falls outside of the geophysical data so it is not possible to determine whether remains are present on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position, the wreck is stated as being unlocated with the position (NGR) given to the nearest 1 km. To note, the UKHO record physical remains of a wreck, believed to be the *St Fergus*, 8.4 km north of Canmore record.

Canmore record 291434

8.1.7 Canmore record 291434[21] lies along the cable route, approximately 18.0 km seaward of landfall. The record is of an unknown wreck seen adrift on 11th December 1919. The vessel noted as adrift at Buchan Ness bearing south-west, and at Rattray Head bearing west-north-west. The record falls within the geophysical data but no remains have been identified on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position, the wreck is stated as being unlocated with the position (NGR) given to the nearest 1 km.

Canmore record 309176

8.1.8 Canmore record 309176[22] approximately 175 m, outside the north-east of the Green Volt OWF Array RLB. The record is of the iron trawler *Shamrock*, built in 1900 and sunk by submarine on 29th January 1917. The recorded location of the sinking was 115 miles north-north-east of Longstone. No wreck, or the remains of wreck, were identified in the geophysical data at the

[18] https://canmore.org.uk/site/202106/unknown-north-sea
[19] https://canmore.org.uk/site/207841/japonica-north-sea
[20] https://canmore.org.uk/site/208451/st-fergus-north-sea
[21] https://canmore.org.uk/site/291434/unknown-north-sea
[22] https://canmore.org.uk/site/309176/shamrock-north-sea

locations of the record. The wreck is stated as being unlocated, and it is therefore believed that no remains are present at the location of the record.

Canmore record 324755

8.1.9 Canmore record 324755[23] lies along the cable route, approximately 15.3 km seaward of landfall. The record is of a possible pre-1945 craft originating from documentary evidence, no further information is given. The record falls outside of the geophysical data so it is not possible to determine whether remains are present on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position, the position is stated as being approximate with the position (NGR) given to the nearest 1 km

[23] https://canmore.org.uk/site/324755/unknown

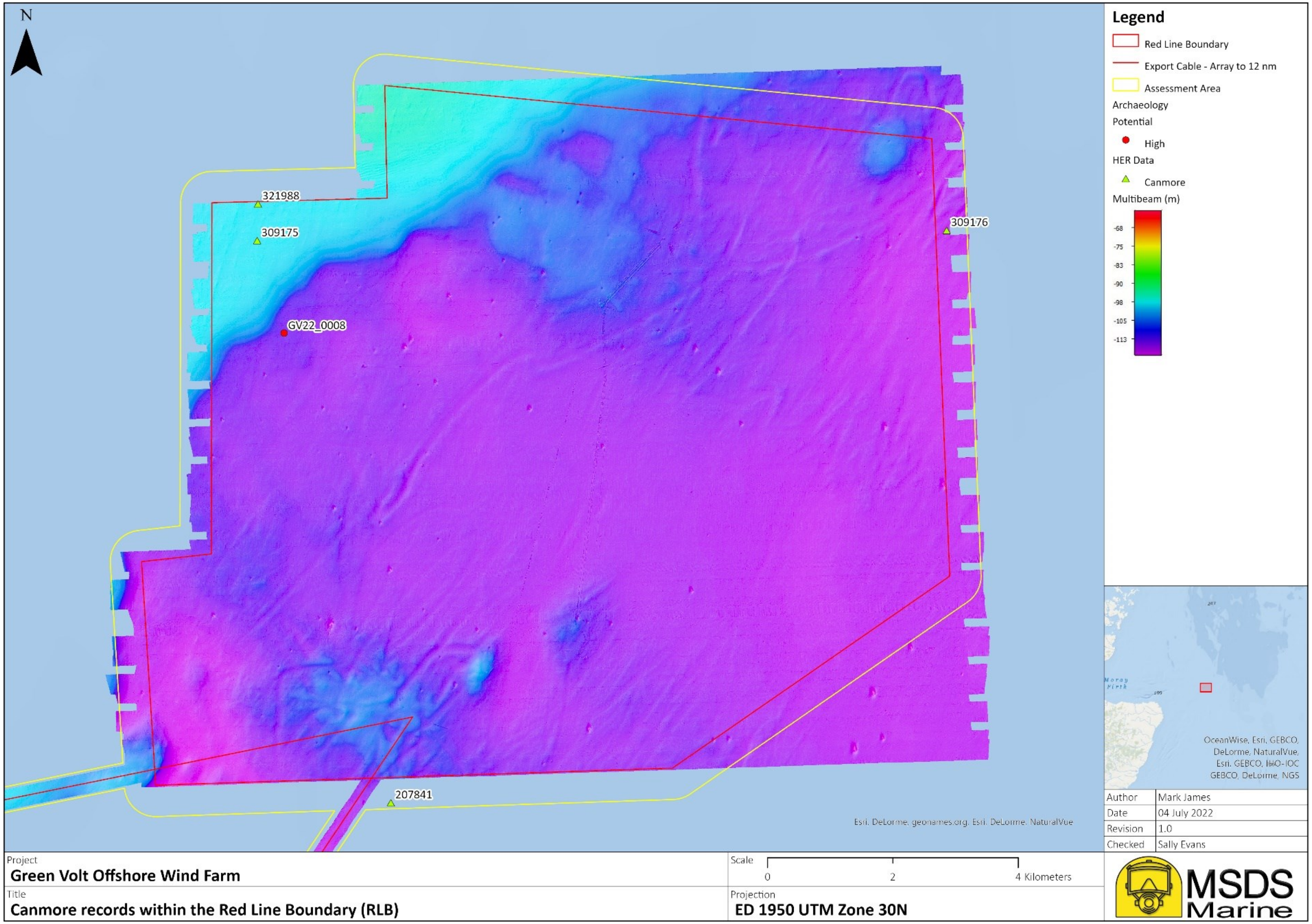

Figure 16: Distribution of Canmore records within the Red Line Boundary (RLB)

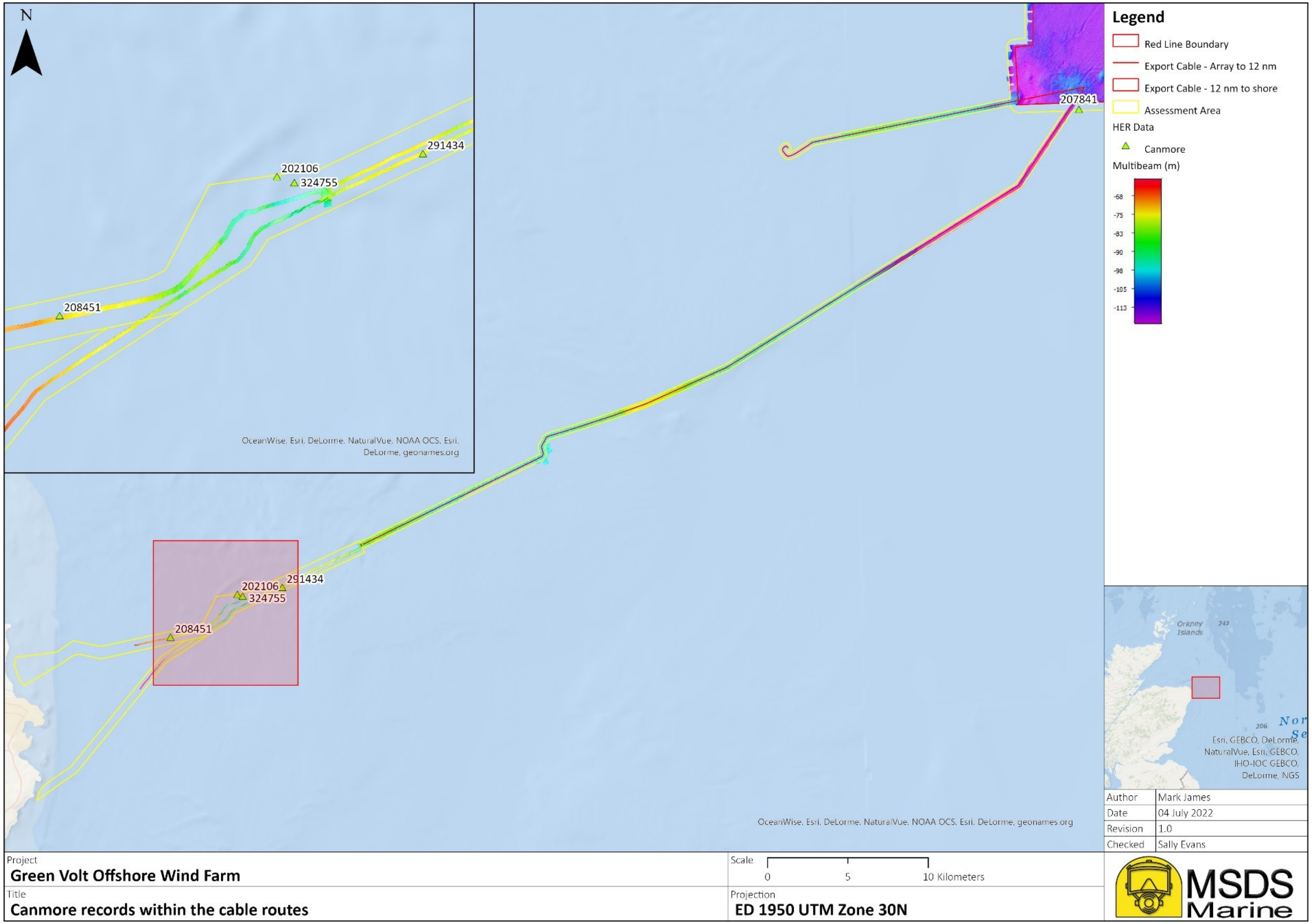

Figure 17: Distribution of Canmore records within the cable routes

8.2 Aberdeenshire Historic Environment Record

8.2.1 One record was returned within the assessment area, the record lies within the cable route. The distribution of records is shown in Figure 18.

8.2.2 The record does not correlate with any UKHO records but does correlate with a Canmore record. The correlated record is detailed below in Table 15.

HER record	Canmore record	HER description
NK25SE0004	291434	Unnamed barge

Table 15: Aberdeenshire HER records and corresponding Canmore records

Aberdeenshire HER record NK25SE0004

8.2.3 Record NK25SE0004[24]lies along the cable route, approximately 18.0 km seaward of landfall. The record is of an unknown barge seen adrift on 11th December 1919. The vessel noted as adrift at Buchan Ness bearing south-west, and at Rattray Head bearing west-north-west. The record falls within the geophysical data but no remains have been identified on the seabed. However, it is not believed that the record relates to physical remains on the seabed at the given position. The data of compilation of the record is after the creation of the corresponding Canmore record and it can be assumed the information was taken directly from it.

[24] https://online.aberdeenshire.gov.uk/smrpub/master/detail.aspx?tab=main&refno=NK25SE0004

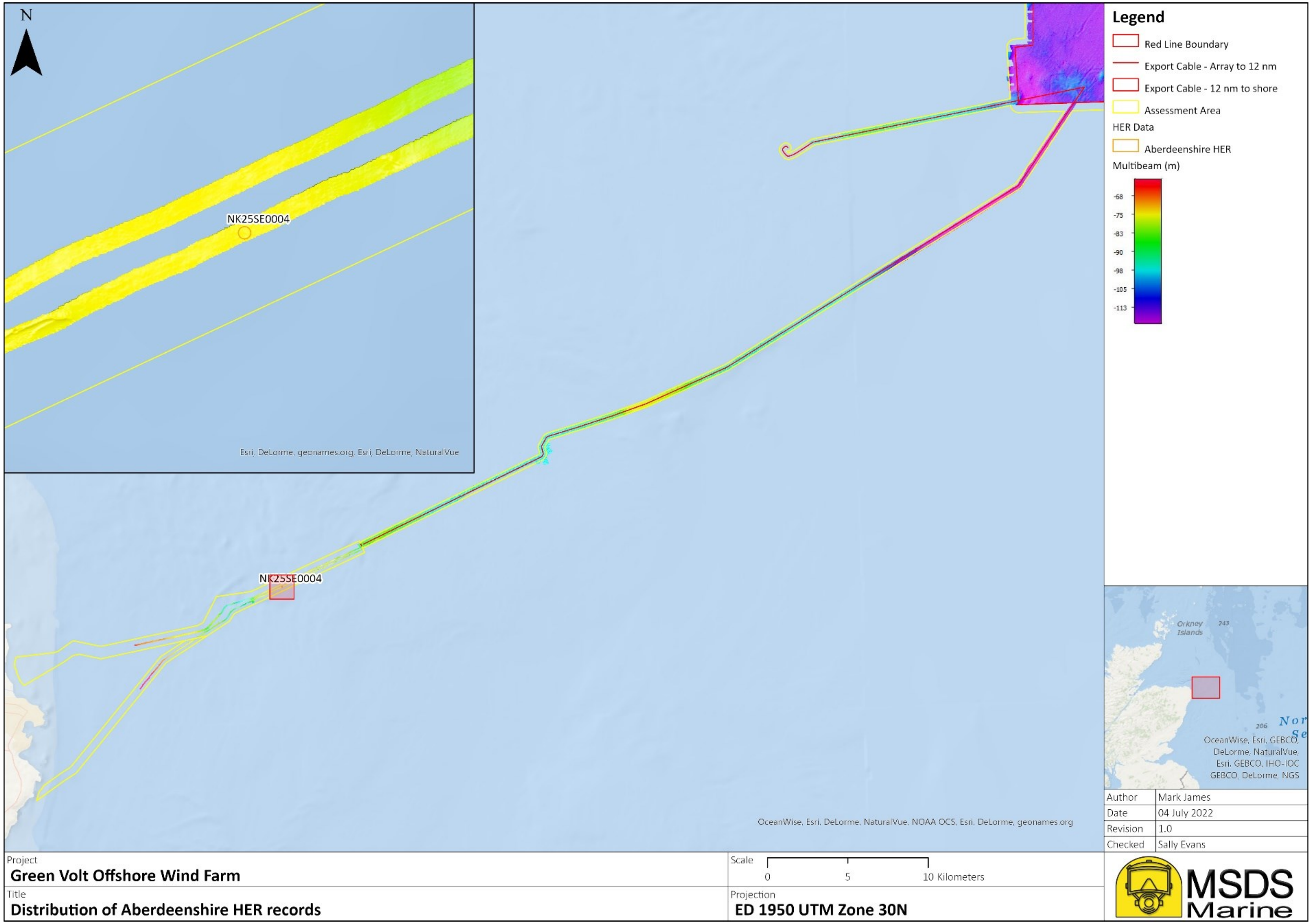

Figure 18: Distribution of Aberdeenshire HER records

9.0 Palaeolandscapes

9.0.1 This section provides a geological summary and assessment of the prehistoric archaeological potential of the site, taking into account the depositional environment, date, nature, and post-depositional processes which may have influenced archaeological potential.

9.1 Bedrock

9.1.1 Previous studies have identified Tertiary deposits underlying the Quaternary sequence within the array area, including undifferentiated Tertiary deposits laying atop the Tertiary Beauly Formation of the Palaeocene period. The Lignite Horizon occurs within the Beauly Formation (Calesurvey 2013b). Beneath this is the Dornoch Formation, also from the Tertiary Palaeocene period (Calesurvey 2013b). Beneath this the BGS have mapped bedrock of the Cretaceous, Jurassic, Triassic, and Permian periods (BGS 1982).

9.1.2 The bedrock sequence seen within the array area is broadly reflected along the cable route, though the later deposits are not extant closer inshore, and instead the earlier underlying Palaeocene, Cretaceous, Jurassic, Permian, and Triassic geology outcrop beneath the Quaternary formations, with the earliest formations outcropping closest to the coast (BGS 1982).

9.2 Thickness of Quaternary deposits

9.2.1 Quaternary deposits overly the bedrock within both the array and cable route areas. The previous investigations within the array area demonstrate that the Quaternary deposits extend to a depth of c. 250 m below seabed level within the northern part of the array (Calesurvey 2013b; RPS 2013), and c. 300 m below seabed level within the southern part of the array area (Gardline 2007: 47).

9.2.2 The Quaternary sequence decreases in thickness toward the shoreline, with c. 5 – 20 m of Quaternary deposits mapped within the 12 nm boundary. Close inshore the thickness is further decreased to under 5 m of deposits (BGS Offshore GeoIndex).

9.3 Seabed sediments

9.3.1 Gardline (2022) record seabed sediments within the Ettrick survey area predominantly silty sand with shell fragments. In localised patches there may be accumulations of shell fragments or other coarse material, or exposures of underlying clay deposits. These sediments have also been recorded by previous surveys within the site (Calesurvey 2013; Gardline 2007). Although the seabed sediments have been found to blanket the site in areas where previous investigations have been focused, in isolated areas the underlying quaternary sediments (mainly the Witch Ground Formation) have been found to outcrop within the Blackbird field, reflecting localised absences of seabed sediments (Gardline 2007).

9.4 Seabed features

9.4.1 The seabed in the array area is largely flat, with gentle undulations. Pockmarks are evident throughout the site (formed as a result of methane venting from deeper marine sediments), and irregular depressions thought to be associated with glacial boulders have been identified.

Buried ploughmarks have also been observed within the bathymetry data, again likely associated with glaciation (Gardline 2021). The bathymetry and these features can be seen in Figure 14. No other features associated with palaeolandscapes have been identified within the site.

9.4.2 Other seabed features are of modern origin and include scarring associated with former drilling, pipe laying and anchoring. These seabed scars were mapped by Gardline and are also presented in Figure 4 and Figure 5.

9.5 Quaternary sequence

9.5.1 The BGS map the Quaternary sequence within the array and cable route, providing a broad indication of the deposits within the region (BGS 1986). The BGS depict the Aberdeen Ground Formation, overlain by the Ling Bank Formation, Fisher Formation, Coal Pit Formation, Swatchway Formation (offshore), and Wee Bankie Formation (inshore), and with the upper deposits formed by the Witch Ground Formation (offshore) and the Forth Formation (inshore). The Swatchway and Wee Bankie Formations are laterally equivalent, as are the Witch Ground and Forth Formations. Sections 1 and 2 in Figure 20 show this sequence and represent the offshore area (eastern end) to the inshore area (western end), to the north and south of the site (BGS 1986). While these deposits are all depicted within the sections, not all are laterally continuous and as such there are likely to be differences in the deposits encountered across the cable route and array area.

9.5.2 Figure 19 shows the location of these sections. The approximate location of the array and cable route relative to sections 1 and 4 (which pass closest to the array site) is shown in this figure. The sections demonstrate that, based on the BGS data, the sequence within the array can be expected to include the Aberdeen Ground Formation at the base, overlain by the Ling Bank Formation, Fisher Formation, Coal Pit Formation, Swatchway Formation and Witch Ground Formation.

9.5.3 Sections 1 and 2 (Figure 20) also give an indication of the likely sediment sequence along the cable route. They demonstrate that the Quaternary deposits become thinner closer to the coastline and the Aberdeen Ground Formation in particular thins from west to east and may be absent in some areas approaching the coast. This is also the case for the Ling Bank Formation, which may be absent on the inshore portion of the cable route, including from the 12 nm limit. The Fisher Formation may also be absent inshore. The sequence in the nearshore area is instead characterised by the discontinuous presence of the Aberdeen Ground Formation, overlain by the Coal Pit Formation (also discontinuous). Section 2 indicates that it is overlain to the south of the site by the Wee Bankie Formation and Forth Formation, while to the north Section 1 demonstrates that the Forth Formation directly overlies the Coal Pit Formation.

9.5.4 The geophysical surveys within the Ettrick survey area and previous investigations which cover the wider Green Volt site provide information on the Quaternary sequence. Gardlines (2022) survey of the Ettrick field identified the presence of modern marine sediments, overlying a sandy, silty clay interbedded with sands, which in turn overlays a clay deposit interbedded with sand. The silty clay has been interpreted as the Witch Ground and Swatchway Formations, and the underlying clay deposit as the Coal Pit Formation. Earlier work (summarised in Table 5) has provided information on the deeper deposits. The anticipated Quaternary sequence within the array and cable route is summarised in Table 16.

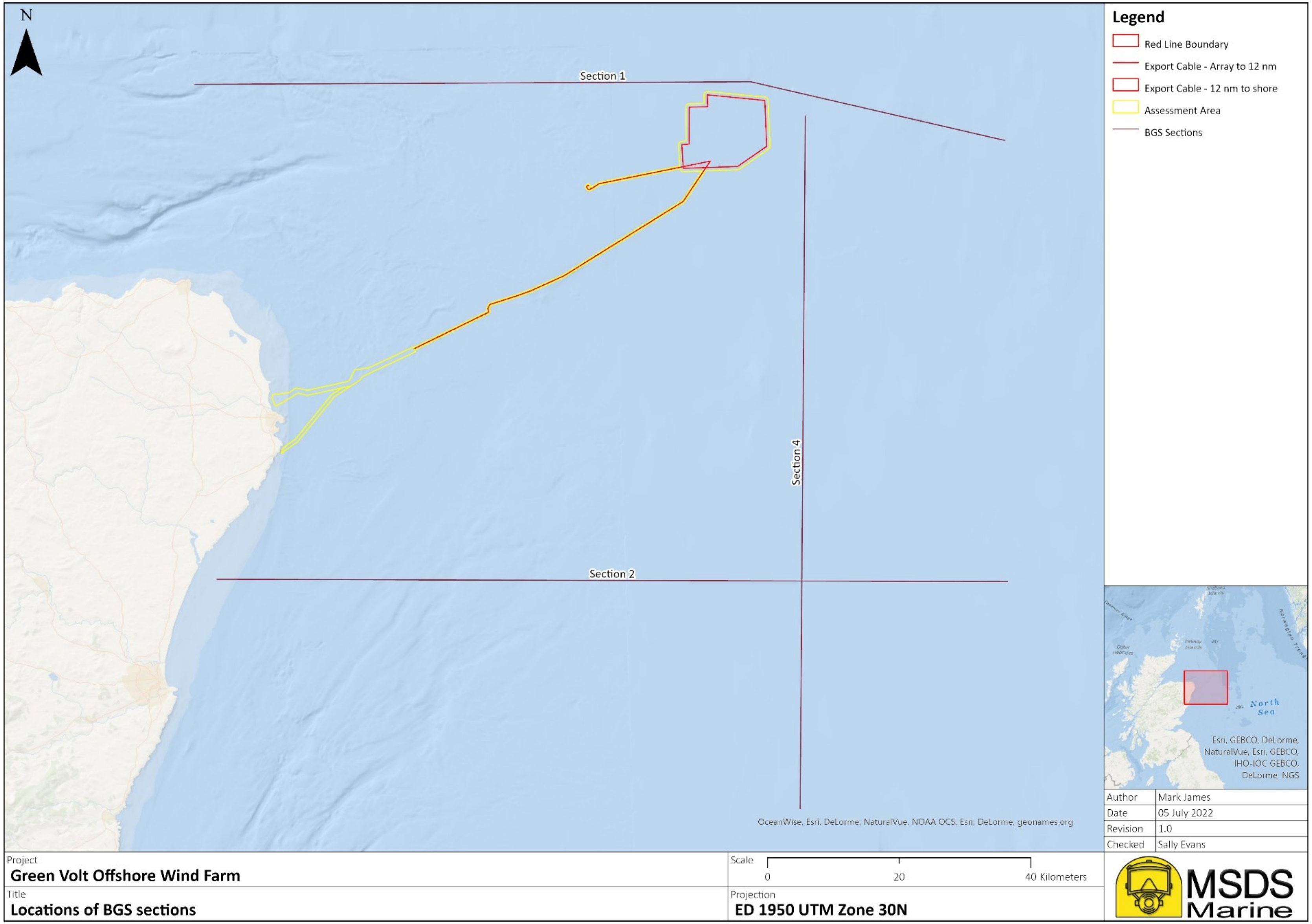

Figure 19: Locations of BGS sections

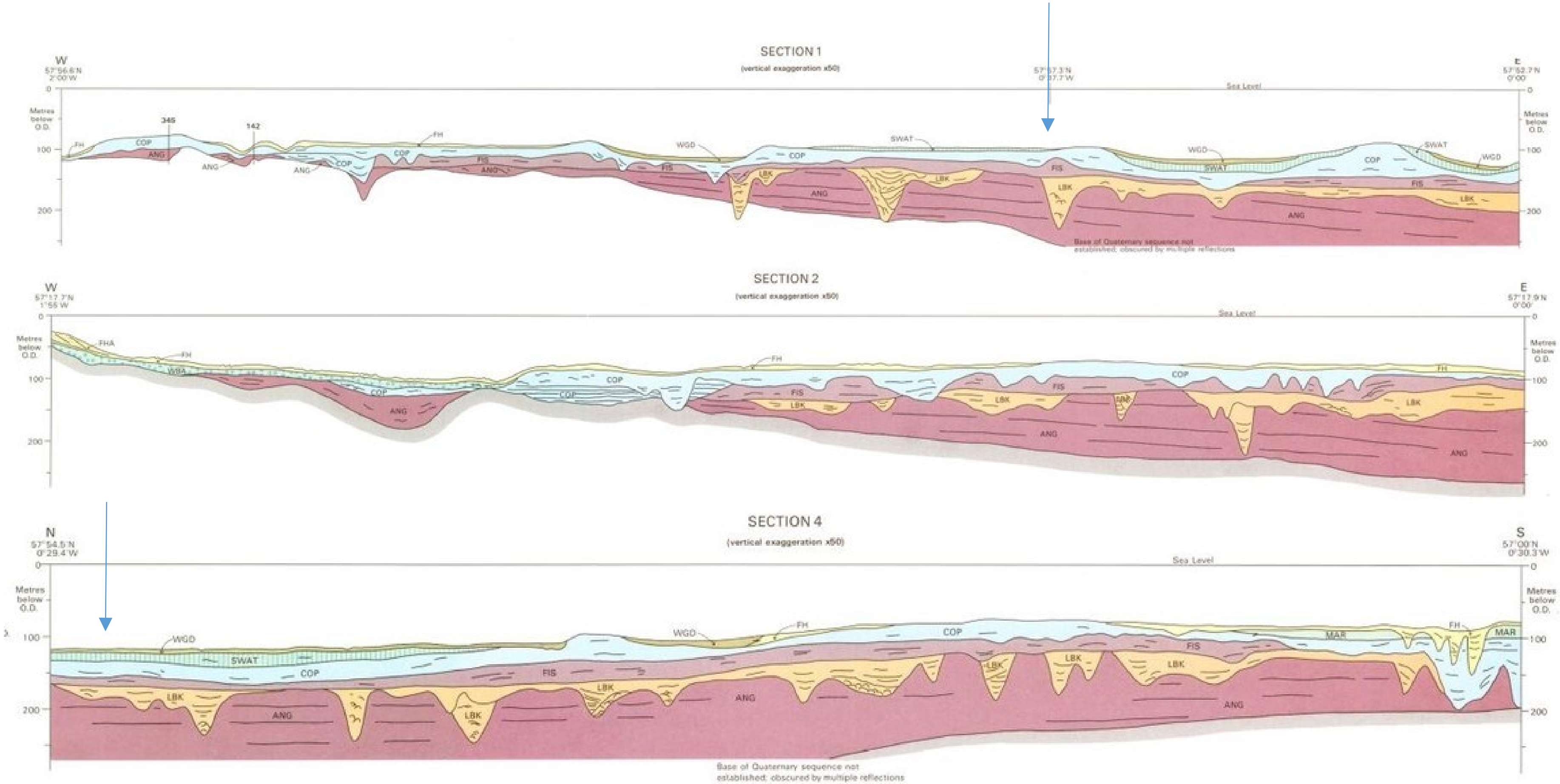

Figure 20: Sections extracted from the BGS (1986) Quaternary Sheet 57°N-02°W with the approximate location of the array shown with the blue arrow

Formation	Lithology	Environment	Age	Archaeological potential	Depth bsb (m)	Source
Modern seabed sediments	Veneer of fine silty sand with occasional shell fragments	Marine	Holocene	Limited	At surface	Calesurvey 2013; Gardline 2007; 2022
Forth Formation (partially laterally equivalent to the Witch Ground Formation)	Sands resting on marine to glaciomarine muds	Glaciomarine, marine, estuarine, intertidal?	Late Devensian to early Holocene (MIS 2-1)	Archaeological and paleoenvironmental potential within some members	At surface	BGS 1986; Stoker et al. 2008;
Witch Ground Formation	Very soft to soft silty clay with interbedded very loose silty sand silty sand toward the base (confirmed by vibrocores and CPTs). Highly irregular and erosive base.	Glaciomarine to marine	Late Devensian to early Holocene (MIS 2-1)?	Very limited	0-1.7m to 9m	Calesurvey 2013a, b; RPS 2013; Gardline 2007
Wee Bankie Formation (laterally contemporary with the Swatchway Formation)	Diamicton with some interbeds of sand, pebbly sand, and silty clay.	Sub glacial	Late Devensian (MIS 3-2)	Limited/ no potential for in situ remains	Extends up to 40m in thickness	BGS 1986; Merritt et al. 2003: 63
Swatchway Formation	Soft to firm silty clay and silty sand with occasional gravel, cobbles, and boulders	Glaciomarine to sub glacial?	Late Devensian (MIS 3-2)	Very limited	1.7/7m-18/19m	Calesurvey 2013b; Fugro 2011; Gardline 2007; RPS 2013
Coal Pit Formation	Firm to stiff clay with dense layers of sand and occasional gravel, cobbles, and boulders	Glaciomarine, marine, intertidal	Late to Middle Pleistocene (MIS 6-3)	Limited	18/19m-30/32m to 70m within Blackbird area	Calesurvey 2013b; RPS 2013; Gardline 2007
Fisher Formation	Firm to very stiff sandy clay, with sand layers.	Glaciomarine to sub glacial	Middle Pleistocene Wolstonian Complex (MIS 10 – 6)	Very limited	43 – 122m	Fugro 2011; Gardline 2007; BGS 2022
Ling Bank Formation	Stiff to very stiff clay, silt and sand with gravel, cobbles, and boulders	Glaciomarine to marine	Middle Pleistocene	Very limited	30/33m-60/70m to 127m within Blackbird area	Calesurvey 2013b; RPS 2013
Aberdeen Ground Formation/ Near Base Quaternary	Very stiff to very hard clay with occasional sandy and silty layers	Deltaic, marine, glacial and terrestrial	Middle to Early Pleistocene	Limited	60/70-241/250m to 393m within Blackbird area	Calesurvey 2013b; RPS 2013; Gardline 2007
Tertiary formation, with Beauly Formation beneath and Lignite Horizon and Dornoch Formation beneath	Bedrock		Pre-Quaternary	None	241/249m+	Calesurvey 2013b; RPS 2013

Table 16: Quaternary formations identified within the array and cable routes

Aberdeen Ground Formation

9.5.5 The Aberdeen Ground Formation forms the lowest of the Quaternary deposits and has been identified across the Array area (reaching thicknesses of over 250m) and is present along much of the cable route, thinning toward the shore and absent near to the coast (Gatliff et al. 1994). The formation has limited archaeological potential, as demonstrated below.

9.5.6 The Aberdeen Ground Formation is characterised by generally parallel and laterally continuous reflectors. The base of the formation is poorly defined, lacking a clear reflector, however, a 'near base' reflector has been identified and is recorded as the Near Base Quaternary Marker (Calesurvey 2013b: 35). The formation is composed of very stiff to very hard clay with occasional sandy and silty layers.

9.5.7 The Aberdeen Ground Formation was laid down over a prolonged period during the early to middle Pleistocene (MIS 100-MIS 13). Although dating of the formation is not fully resolved the base of the formation itself is correlated with a distinctive acoustic reflector considered to correlate in age with the base of the Quaternary deposits in the central North Sea (Stoker et al., 2011: 9). The upper parts of the deposit in this region are thought to date to the middle Pleistocene, and the Brunhes–Matuyama (B–M) magnetic boundary, dated to c. 780 000 +/- 5000 years BP (and considered to represent the transition between the early and middle Pleistocene by some authors e.g. Merritt et al. (2003: 59)), has been identified within the formation in a series of boreholes collected from the central North Sea area (Stewart et al., 2012; Stoker et al., 1983).

9.5.8 The date range of the formation suggests some contemporaneity with some of the earliest deposits associated with hominid activity identified within the UK, at Happisburgh. The remains from Happisburgh were found within the onshore Cromer Forest Bed formation. Offshore the Cromer Forest Beds are correlated (in part) with the Yarmouth Roads Formation, which is partially equivalent to the Aberdeen Ground Formation and associated with the large delta system which characterised the North Sea area during the early and middle Pleistocene.

9.5.9 The formation is extremely long-lived and covers a period of fluctuating climatic cycles including warmer and cooler periods (Hall et al., 2018). In warmer periods the North Sea area was characterised by the presence of a large delta system (the Eridanos delta), which was disrupted by the large glaciations of the later Quaternary period (e.g., the Anglian). Analysis of the Aberdeen Ground Formation has demonstrated that the formation was deposited in a variety of environments, including deltaic, marine, glacial and terrestrial (Buckley 2014) though off the north-eastern coast of Scotland the formation is primarily characterised by pro-delta deposits laid down in shallow marine environments (Merritt et al. 2003: 60). In the region of the site the muds, pebbles and sandy sediments of the upper Aberdeen Ground Formation are thought to have been deposited in cold environments (Vaughan-Hirsch and Phillips 2017).

9.5.10 Although the Yarmouth Roads and Cromer Forest beds hold archaeological potential it is likely that the Aberdeen Ground Formation was, at least in part, characterised by a colder environment than the delta system further south (Vaughan-Hirsch and Phillips 2017) and is likely to have been largely glacial or marine in the region of the site. Such deposits are not associated with environments which are conducive to hominid activity. Archaeological potential associated with the Aberdeen Ground Formation within the site is therefore limited, though as the deposit is a long-lived one, likely reflecting a variety of different environments there may be some potential. However, there is a lack of any secure evidence of Lower Palaeolithic or Middle Palaeolithic activity in a Scottish context and potential for in situ archaeological remains is therefore extremely limited. Redeposited remains could occur, where eroded from formations present in other areas. However, no such evidence has been found in Scottish contexts to date and as such the potential for redeposited remains from these periods is also extremely limited, though palaeoenvironmental evidence may survive within the formation (e.g., Holmes 1977).

Ling Bank Formation

9.5.11 The Ling Bank Formation overlies the Aberdeen Ground Formation. The deposit infills deep channels incised into the underlying Aberdeen Ground Formation (Calesurvey 2013b: 35). The formation is over 100 m thick in places, where it fills channels, but in other areas is much thinner. In the Blackbird oil field (within the southern part of the array area) the Ling Bank Formation is thin (only a few meters thick in places), and subcrops the Fisher Formation (Gardline 2007: 45). The formation is primarily present in the offshore area. Near to the coast it is absent (Gatliff et al. 1994). The formation has very limited archaeological potential, as demonstrated below.

9.5.12 The Ling Bank Formation has been identified with a complex seismic character, thought to reflect several phases of channel erosion and infilling (Calesurvey 213b: 35). High amplitude reflectors have been identified within the base of some of these channels within the Ettrick field and are thought to represent lithological variations (coarse basal lags at the channel bases) rather than gas pockets. Internal erosional surfaces and channelling has been noted within the formation (RPS 2013: 17). The unit is composed of stiff to very stiff clay, silt and sand with gravel, cobbles, and boulders.

9.5.13 The Ling Bank Formation is broadly thought to originate in MIS 12- 10 (Stoker et al. 2011), though there is debate over the precise dating of the formation (Gatliff et al. 1994: 89) and some suggest that the basal parts of the unit originate in the late Cromerian during an interglacial phase (Merritt et al. 2003: 62). Overlying the lowest parts of the unit are arctic glaciomarine deposits dating to MIS 12 (Merritt et al. 2003: 62). The upper parts of the Ling Bank formation have been correlated with marine sediments originating in the Hoxnian (Holstein) interglacial. Palaeoenvironmental assessments have demonstrated that the formation was largely laid down under arctic conditions, with the upper parts of the unit deposited during an interglacial phase.

9.5.14 The formation pre-dates the earliest evidence of hominid activity in Scotland and the arctic conditions and marine origin of aspects of the formation further demonstrates its limited archaeological potential.

Fisher Formation

9.5.15 The Fisher Formation has been identified within the southern part of the site, in the Blackbird oil field (Gardline 2007). It overlies the Ling Bank Formation and is present from c. 70 m below seabed level (Gardline 2007: 47). The top of the deposit is eroded by multi-phased channels and fills (Fugro 2011: 21). The base of the formation is encountered at varied depths ranging from c. 43 m to c. 122 m below seabed level (Fugro 2011: 21; Gardline 2007). As with the Aberdeen Ground and Ling Bank Formations, this formation is primarily present offshore including within the array area. The formation is absent from the nearshore area (Gatliff et al. 1994) and has very limited archaeological potential.

9.5.16 The deposit is transparent to chaotic, and its base lies on an unconformity thought to represent an eroded surface associated with a phase of marine transgression (Merritt et al. 2003: 62). The unit is thought to comprise firm to very stiff sandy clay within the site and is well layered (Gardline 2007).

9.5.17 The Fisher Formation is thought to be no older than MIS 7 (Merritt et al. 2003: 62), though Stoker et al. (2011) give a wider date range of MIS 6 - 10. It has been interpreted as a deposit laid in a transitional glaciomarine environment during the Wolstonian stage, which included a series of glaciations and associated sea level change. While the broad character of the deposit is glaciomarine (Gatliff et al. 1994: 89; Merritt et al. 2003: 62) BGS Borehole 81/26, taken c. 30 km to the north-east of the array area demonstrated that in this area the Fisher Formation is characterised by sediments deposited in a sub glacial environment during MIS 6 (Sejrup et al., 1987), while further south, in the outer Moray Firth, the formation is characterised by glaciomarine sands (Andrews et al. 1990; Davies et al. 2011: 60). Such environments are not conducive to human activity and the deposit therefore has very limited archaeological potential. Additionally, the formation predates the earliest evidence for hominid activity in Scotland, further limiting potential.

Coal Pit Formation

9.5.18 This formation overlies the Fisher Formation, the top of which is marked by a crenulate unconformity thought to reflect the erosive effects of a Wolstonian glaciation (Gatliff et al. 1994; Merritt et al. 2003: 62). The formation fills these channels and as such has a varied thickness (see Table 16). The deposit may be present across the array area and much of the cable route, though thinning or absent near the coast (Gatliff et al. 1994). The formation has generally limited archaeological potential.

9.5.19 The formation has a chaotic character on seismic data, thought to be due to the multiple phases of successive channel erosion which incise the underlying Fisher, Ling Bank and Aberdeen Ground Formations (Calesurvey 2013b: 34-35; Fugro 2011: 21). The deposit also has evidence of internal erosion (Stoker 1985), and the base of the formation has a clear sub horizonal reflector visible within 2DHR data (Calesurvey 2013b). Minor amplitude reflectors have been identified in channel bases within this formation, interpreted as representing coarse material in the channel bases (Calesurvey 2013b: 44). The unit is formed of firm to stiff clay with dense layers of sand and occasional gravel, cobbles, and boulders.

9.5.20 The stratigraphic position of the deposit indicates that it was laid down after the Aberdeen Ground Formation (MIS 100-13) and before the Marr Bank Formation (MIS 2). Stoker et al., (2011) have narrowed this range and date the deposit to between MIS 6-3. This range spans the late Wolstonian glacial stage (MIS 6), the Ipswitchian interglacial (MIS 5e) and early to mid-Devensian glacial phases (MIS 5d-3), which included a number of warmer interstadials (e.g., MIS 5c, a). The deposit is therefore long-lived, and potentially spans a series of vastly different environmental conditions, ranging from glacial to interglacial. The nature of the deposit identified within the site has been interpreted as representing an intertidal to shallow inner shelf environment in its upper parts, and glaciomarine environment in its lower parts (Merritt et al. 2003: 62; Stoker 1985). The upper marine sediments contain foraminiferal assemblages' representative of the Ipswichian interglacial (MIS 5e) (Merritt et al. 2003: 63).

9.5.21 The deposit as a whole pre-dates the period of known human activity in Scotland. In addition, glaciomarine environments are not conducive to hominid activity and archaeological potential is therefore very limited within the lower parts of the deposit. Shelf areas represent marine environments which would also be uninhabitable. While intertidal areas may have been exploited by early human communities in Scotland there is currently no secure evidence of activity in date range of this formation and archaeological potential is therefore considered to be limited.

Swatchway Formation

9.5.22 The Wee Bankie and Swatchway Formations overlie the Coal Pit Formation. The latter extends to c. 19 m below seabed level and is a blanket deposit present offshore (Calesurvey 2013b: 34), while the Wee Bankie Formation is present inshore (Gatliff et al. 1994). The formation has very limited archaeological potential.

9.5.23 The Swatchway Formation is characterised by semi-transparent and poorly layered seismic reflectors. The deposit is composed of soft to firm silty clay and silty sand with occasional gravel, cobbles, and boulders. Within the Blackbird field in particular frequent boulders were identified within the deposit and at its surface (Gardline 2007: 40)

9.5.24 This formation has been attributed to the late Devensian, in MIS 3-2, and was laid in harsh climatic conditions related to the LGM (Last Glacial Maximum), although dinoflagellate evidence indicates that there was no significant sea-ice cover (Gatliff et al. 1994; Stoker et al. 1985). The top of the unit is marked by an erosion surface created by ice scouring, supporting the glaciomarine character of the site during the late Devensian. Dating of the glaciomarine elements of the formation has been undertaken on samples from borehole 77/2, collected c. 100 km north-east of the array area. The analyses, which focused on mollusc and foraminiferids, returned dates of 22.7, 20.9 and 19.7k BP demonstrating that glaciomarine conditions were present during that period (Merritt et al 2003: 6; Serjup et al. 1994). However, underlying deposits within the formation may represent subglacial till which may be associated with an early phase of the LGM (prior to 22k BP) suggesting sub-glacial conditions may have characterised the site at this time (Merritt et al 2003: 6; Serjup et al. 1994) though the complete extents of ice cover during the Devensian are under debate. Later glacial cover is also thought to have been extensive and likely covered the nearshore portion of the cable route, its extents in this area represented by the sub-glacially deposited Wee Bankie Formation, discussed below (Merritt et al. 2003: 63).

9.5.25 Within the array the Swatchway Formation primarily represents glaciomarine muds deposited during this period (Gardline 2007: 40), with potential for sub glacial till in its lower parts based on evidence from borehole 77/2 (Merritt et al. 2003: 64). Wider evidence shows that the formation comprises well sorted, medium, dense, muddy sands in the southern part of the Witch Ground Basin, and further north clayey silts and silty clays with thin layers of sand become more common (Stoker et al. 1985), as are found within the site. The distribution of geology within this formation indicates deposition in shallower waters to the south and deepening waters to the north.

9.5.26 Glaciomarine and sub-glacial environments are not conducive to hominid activity and the formation therefore has very limited archaeological potential, though palaeoenvironmental remains may occur.

Wee Bankie Formation

9.5.27 The Wee Bankie Formation consists of gravelly and sandy clay, with a sheet-like geometry that has been interpreted as subglacial till (Merritt et al. 2003: 63). The deposit is formed of a diamicton with some interbedded sand, pebbly sand, and silty clay. The formation is present off the east coast of Scotland including in parts of the cable route (extending to c. 40 km offshore) and is thought to represent the eastern extent of the late Devensian glaciation (MIS 2) (Merritt et al. 2003: 63). Deglaciation of the majority of the North Sea area is thought to have occurred by 16 – 14 k BP (ibid).

9.5.28 The formation is subglacial, and therefore has no potential to contain in situ prehistoric remains.

Witch Ground Formation

9.5.29 The Witch Ground Formation has been identified across the site, in the Ettrick, Blackbird and Panda Bear fields. Geotechnical data collected from within the Ettrick field (Alluvial Mining Limited 2006) suggests that the thickness of the formation increases toward the west of the site (RPS 2013: 14). However, the deposit is discontinuous and closer inshore it may be absent (Gatliff et al. 1994). Where present within the array, the depth of the base of the formation varies between c. 0.5 m and c. 9 m below sea level. In places the formation fills iceberg plough marks in the underlying formation and investigations have also demonstrated that the unit has an erosive base (Fugro 2011; Gardline 2007). Dropstones may be present at the base of this deposit (RPS 2013). The formation has very limited archaeological potential.

9.5.30 Seismically this unit is characterised by sub-parallel, continuous reflectors lying on an irregular poorly defined erosional surface (Calesurvey 2013b). The unit is classified as a very soft to soft silty clay with interbedded very loose silty sand silty sand toward the base. The lithology has been confirmed by vibrocores and CPTs (Alluvial Mining Limited 2006).

9.5.31 In some areas difficulties in distinguishing between the Witch Ground Formation and the underlying Swatchway Formation have been noted, reflecting the fact that the transition is from very soft clay (Witch Ground Formation) to soft clay (Swatchway Formation) and the change is gradual (Gardline 2007: 40). This is the case for the SBP data from within the array area, where it has not been possible to distinguish the Witch Ground and Swatchway Formations. The bases of these formations are therefore mapped together, and the depths of the bases below seabed level (within the area of data coverage) are shown in Figure 21.

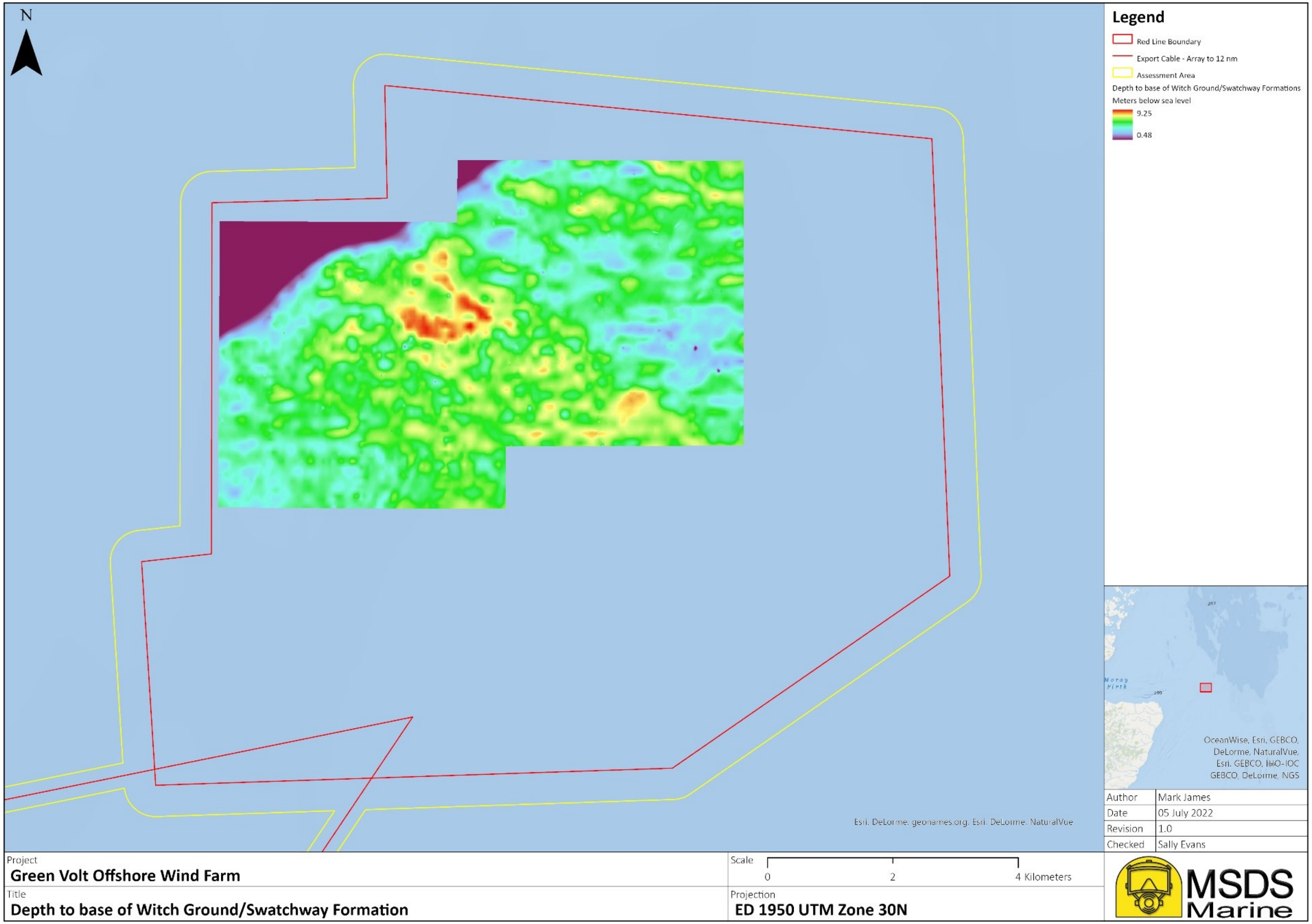

Figure 21: Depth to the base of the Witch Ground/Swatchway Formation

9.5.32 This deposit was laid down during the shift from glaciomarine to temperate marine environment in the late glacial to Holocene period (Stoker et al. 1985). It is situated in the Witch Ground Basin, in which the majority of the array lies. The BGS has sub-divided the Witch Ground Formation into three distinct units: the Fladen, Witch, and Glenn members. These members reflect the transition of the site from glaciomarine conditions during the late Devensian (represented by the Fladen Member), to a shallow cold-water environment lacking sea ice, in the late Devensian to early Holocene (the Witch Member), and to deeper temperate seas (up to 100 m in depth) in the Holocene period (Glenn Member) (Gatliff et al. 1994; Stoker et al 1985). The earliest deposits are grouped as the Fladen Member (18,000 – 15,000 BP; Jansen et al. 1979). A study by Bottner et al. (2019) investigating pockmarks in the Witch Ground Formation subdivided the deposit into two seismically distinct units, S5.1 and S5.2. This study determined that S5.1 was deposited after 26,595 ± 387 BP and comprises laterally continuous, very well laminated strata, and that S5.2 was deposited after 13,165 ± 55 BP and comprises well laminated and lateral coherent stratigraphy.

9.5.33 A series of small and large ovoid pockmarks are present within the Witch Ground Formation deposit, formed as a result of methane venting from deeper marine sediments; smaller pockmarks are 20-40 m in diameter and are generally less than 3 m deep, larger pockmarks are up to 200 m in diameter and up to 10 m deep (Gatliff et al. 1994; Bottner et al. 2019). These pockmarks are present in the surface of the Witch Ground Formation, but buried pockmarks are also present within the deposit, likely formed as a result of environmental changes following deglaciation of the Devensian ice (Bottner et al. 2019).

9.5.34 The top of this deposit is the seabed, although in some areas it is covered by a thin veneer of superficial seabed sediments.

9.5.35 The glaciomarine to marine character of this formation renders archaeological potential very limited.

Forth Formation

9.5.36 The Witch Ground Formation is partially laterally equivalent to the Forth Formation, which has been identified by the BGS (1986) within nearshore areas and is likely to be present along the nearshore half of the cable route, including within the 12 nm limit and may be present beyond this area. Archaeological and paleoenvironmental potential is associated with some parts of this formation.

9.5.37 The Forth Formation originated in the late glacial and Holocene periods and can be divided into two members spanning this period: The Largo Bay Member and the St Andrew's Bay Member (BGS 1986). During the late glacial period, the St Fergus Silt Formation was also laid down, though the exact dating is uncertain (Peacock 1999). While this Formation has been identified onshore c. 3 km to the north of the northern cable route landfall it demonstrates that sea levels around the site were higher than those of today in the late glacial period (at 7- 16m OD), indicating very limited archaeological potential for this period (Peacock 1999).

9.5.38 The Largo Bay member of the Forth Formation is thought to have been deposited during the late glacial interstadial (Merritt et al 2003: 64). Although sea levels were likely regressing on the east coast during this period following the high stand during the late glacial period (Stoker et al. 2008) deposits within the inner estuaries in eastern Scotland provide evidence of raised marine deposits in the Windemere Interstadial (Holloway et al. 2002; Peacock 1999), (c. 15,000

– 13,000 BP) demonstrating the likelihood that the site, including the array and entire cable route, experienced marine to glaciomarine conditions and was therefore uninhabited during this period.

9.5.39 Given the likely submerged nature of the site during this period, the Largo Bay member is considered to have generally limited potential for in situ archaeological remains. However, toward the end of the interstadial relative sea level may have lowered sufficiently to reach present day levels suggesting the potential for exploitation of intertidal resources in the upper parts of the Largo Bay member, within the general area of the current intertidal or nearshore zone. Erosion from subsequent marine action is likely to have affected any such remains.

9.5.40 During the Loch Lomond Stadial (c. 13,000 – 12,000 BP) colder conditions were re-established, and there was a short-lived period of ice sheet expansion between c. 13,000 – 12,000 BP during which sea levels fell (Stoker et al. 2008: 294). Around the east coast, evidence of this now-submerged shoreline, termed the Main Lateglacial Shoreline, has been encountered. Deposition of the St. Andrews Bay Member of the Forth Formation is thought to have begun during this cold period and continued throughout the Holocene (Merritt et al 2003; Stoker et al. 2008). Evidence of the St Andrew's Member has been identified in the nearshore area by the BGS (marked as FHA on Figure 20, Section 2, a representative section from c. 20 km south of the southern landfall site) and may be present within the nearshore parts of the cable route. The deposit represents shallow marine or estuarine environments (Gatliff et al. 1994). The estuarine nature of the deposit indicates broad archaeological and palaeoenvironmental potential associated with the Forth Formation, spanning the Late Upper Palaeolithic and Mesolithic. This can be further refined by considering changes in relative sea level.

9.5.41 Stoker et al. (2008) divided the St Andrews Member into four separate lithozones, representing seaward-prograding clinoforms. Lithozone 1 was found to represent a fluvio-delta deposit dated to the Loch Lomond Stadial (Younger Dryas) and is thus thought to represent deposition during the lowstand. Stoker et al. (2008) found that the seaward edge of the delta may have been around -20 to -30 m OD. At Berwick, the submerged shoreline is evident in the form of a 600m-wide rock-cut platform at between -27 m OD and -18 m OD, correlating with the Main Lateglacial Shoreline (Stoker et al. 2008). These depths are greater than those estimated by previous studies, which suggested that the Main Late Glacial Shoreline was around -10 m OD (Shennan et al. 2006). During this period areas of the cable route are likely to have been exposed as dry land, and evidence of this shoreline may survive within the site. Within the site the 30 m contour lies up to 500 m to the east of the current coastline on the southern cable route option, and up to 2.5 km further eastward on the more gently sloping nearshore area of the northern landfall option. This suggests the potential for a large previously inhabitable area within the nearshore part of the cable route, particularly in the northern landfall option area. This indicates that there is potential for this area to have been exposed and potentially habitable during the Late Upper Palaeolithic. However, despite evidence for human activity in the previous period, and while sub-aerial exposure of the intertidal and nearshore zone is likely to have occurred during the Loch Lomond Stadial, the glacial conditions within the region are likely to have rendered the area largely unfavourable for human habitation, though a human presence cannot be ruled out. Potential for in situ archaeological remains is focused on the nearshore areas and is dependent on the survival of the Forth Formation in this area. This potential is also dependent upon the nature of the Forth Formation, which may represent St

Andrews Bay Member or seabed sediments and geotechnical investigations have the potential to investigate this potential further.

9.5.42 Climatic amelioration occurred in the subsequent Holocene period was coupled with a renewed phase of marine transgression. Stoker's study also identified further lithozones within the St. Andrews Bay Member relating to this period. Lithozone 2 and 3 were found to be of mid Holocene origin, and Lithozone 4 late Holocene (modern marine sediments). AMS C14 dating indicated that the sequence of lithozones (1-4) spans the last c. 12,500 years BP (i.e., from the Loch Lomond Stadial to the late Holocene) (Stoker et al. 2008: 307).

9.5.43 While Stoker's study was focused to the south of the site, in areas around the Firth of Tay estuary and Montrose, and adjacent offshore waters, it has clear implications for the interpretation of the St Andrews Member deposits which may lie within the site. These different lithozones have not been mapped by the BGS and the extent of the different lithozones within the Forth Formation occurring within the cable route are therefore unknown. Geotechnical investigations may provide further evidence and analysis by Stoker has demonstrated the high palaeoenvironmental potential of these deposits, including potential for dateable remains and remains which can inform relative sea level.

9.5.44 Relative sea level in the post-glacial period is not currently understood in detail, with different models and data presenting differing scenarios, and sea level over the late Pleistocene and Holocene (and in particular over the last 2000 years) has been identified as an area of future research (Smith et al. 2019). In general, the eastern coast of Scotland is agreed to be an area which saw variations in relative sea level, with episodes of regression and transgression occurring during the Late glacial and Holocene periods (Stoker et al. 2008). Current models suggest that relative sea level within the area of the site may have been lower than current levels at around 10,000 BP following the regression associated with the Loch Lomond Stadial, though sea levels began to rise either toward the end of this period or during the early Holocene (Stoker et al. 2008). This phase of marine transgression is thought to have resulted in an eventual high-stand during the mid to late-Holocene and the formation of the Main Postglacial Shoreline occurred, up to +9m OD (Bradley et al. 2001; Kuchar et al. 2013; Stoker et al. 2008). Lithozones 2-4 identified by Stoker et al. (2008) may derive from this period, and their character supports formation in a highstand environment. Data from the Farne Islands suggests sea level at current levels +/-2m OD were achieved by around 5000 BP (Shennan et al. 2006) following a reversal to marine regression during the mid-Holocene which may have continued to the present day (Stoker et al. 2008).

9.5.45 Deposits within the site, and in particular the Forth Formation, may have the potential to contribute to understanding of relative sea levels during these periods. Though uncertainties in relative sea level exist, on the basis of current evidence it is likely that the site was inundated for much of the Holocene, though areas may have been exposed during the Loch Lomond Stadial and Early Holocene. During periods of sea level change areas of the site may have been exposed as intertidal and terrestrial areas, and the current intertidal zone may have been characterised as such potentially from the mid Holocene. Remains from Mesolithic sites indicate a strong focus on marine resources during this period, and evidence such as extensive shell middens suggest that exploitation of intertidal and nearshore areas formed a key part of life during the Mesolithic (Cramp et al. 2014; Mellars 1987). The intertidal and nearshore areas of the site may have formed an attractive environment for exploitation during this period and remains relating to exploitation may have been laid down. There is therefore potential for archaeological remains to occur within these areas situated within the Forth Formation deposits dating to the Mesolithic. However, erosion and reworking of the deposits associated with any potential remains may also have occurred over the Holocene period, suggesting a greater potential for redeposited remains (Kuchar et al. 2012).

9.6 Summary

9.6.1 Evidence indicates that deposits spanning the Quaternary may be present within the site, with the deepest and most complete sequences present in the array area and offshore parts of the cable route. The formations identified include the Aberdeen Ground Formation, Ling Bank Formation, Fisher Formation, Coal Pit Formation, Swatchway Formation, Wee Bankie Formation, Witch Ground Formation, Forth Formation and modern seabed sediment. The vast majority of the formations mapped within the area were likely deposited in marine to glaciomarine environments, representing the fluctuations in Quaternary glaciations that have shaped the area. The Aberdeen Ground Formation and Coal Pit formation may hold evidence of deltaic, intertidal, and terrestrial landscapes which may have characterised the site for part of the Cromerian and Wolstonian to Devensian periods, incorporating the Ipswitchian interglacial. However, while hominid activity is known elsewhere in the UK from as early as 780,000 – 970,000 BP (Parfitt et al. 2010), during the Cromerian, there is no known evidence for human activity in Scottish contexts dating to these periods and as such the archaeological potential is very limited, though palaeoenvironmental evidence may survive.

9.6.2 The Forth Formation represents the uppermost deposit, laid down in the late glacial to Holocene periods within the nearshore area and potentially beyond. The site is likely to have been submerged during the late glacial period and at the time of the formation of the Largo Bay member of the Forth Formation during the Windemere Interstadial, though at the end of the interstadial sea levels may have been around their current level and areas of the Largo Bay member may therefore have been exposed during this period. Evidence of the Main Lateglacial Shoreline, established during the lowstand of the subsequent Loch Lomond Stadial, may survive within the site and previous studies indicate that it may be found at -20 to -30 m OD. The St Andrews Bay Member of the Forth Formation was laid down from this period and has some potential for Late Upper Palaeolithic and Mesolithic remains, when sea levels were at current or lower levels during the Late Pleistocene and early Holocene. Following the subsequent marine high stand sea levels lowered and the intertidal zone may have been accessible to prehistoric communities from the mid Holocene.

10.0 Mitigation

10.0.1 This section provides recommendations for the robust, but proportional, mitigation of impacts to the historic environment for low, medium, and high potential anomalies identified within the geophysical dataset. As outlined in Section 4.8 recommended mitigation for these anomalies will be through the implementation of AEZs, TAEZs and AAPs.

10.0.2 The mitigation strategies recommended within this report are based on the available data, which is limited to full coverage MBES and full coverage (with the exception of the nadir in places) high frequency SSS. Magnetometer data was collected at the same line spacing as the SSS and MBES which means there is potential for smaller items of buried material of archaeological interest to be present within the assessment area that is not visible within the current dataset.

10.0.3 However, the data serve to characterise the potential of the area with respect to the requirement for exclusion zones. Mitigation will be developed through each phase of survey works as detailed within Section 11.0.

10.0.4 The data extents do not fully cover the assessment area, they do however cover the Array RLB, and the majority of the cable route assessment area to 12 nm. Whilst UKHO and HER records have been identified outside of the Array RLB, only those records falling within, or close to, the Array RLB have been assessed for mitigation as no development, and thus impact, is planned outside this area.

10.1 Low Potential Anomalies

10.1.1 Low potential anomalies have been identified as potentially anthropogenic in origin but unlikely to be of archaeological significance and no exclusion zones are recommended for these anomalies. Should material of potential archaeological significance be identified during the course of pre-development and development works they should be reported under an appropriate protocol for archaeological discoveries such as the *Crown Estates Protocol for Archaeological Discoveries: Offshore Renewables Projects*[25] or a project specific protocol that considers the individual requirements of the project.

10.2 Archaeological Exclusion Zones (AEZ)

10.2.1 Medium and high potential anomalies have been identified as likely to be of anthropogenic origin and potentially of archaeological significance, within the dataset one anomaly was interpreted as of high potential and no anomalies were interpreted as medium potential. The anomaly has been recommended an AEZ based on the size of the anomaly, the extents of any debris, the potential significance of the anomaly, the potential impact of the development and the seabed dynamics within the area.

10.2.2 Dependant on the form of anomalies, AEZs will either be recommended as a radius from the centre point of the anomaly or as a distance from the extents. Particularly in the case of shipwrecks, which tend to be longer in length than width, the use of a circle provides unequal

[25] The Crown Estate, 2014. *Protocol for Archaeological Discoveries: Offshore Renewables Projects*. Wessex Archaeology on behalf of the Crown Estate.

protection around the extents. This not only impacts the protection afforded but does not represent proportional mitigation.

10.2.3 Anomalies and their recommended exclusion zones are detailed in Table 17 and the distribution presented in Figure 22. Note, where discrepancies exist between the position within different datasets, the position deemed to be most accurate has been used.

10.2.4 In total one AEZ relating to a high potential anomaly has been recommended within the Green Volt OWF assessment area. The AEZ lies within the Array RLB (Figure 23). To note: should the high potential anomaly to which the AEZ relates be definitively identified as the wreck of the *Ernst Friesecke* the archaeological potential, and mitigation, could be reassessed in line with the archaeological significance.

Geophysical ID	Description	Potential	ETRS89 Z30N		AEZ (m)
			X	Y	
GV22_0008	Wreck	High	636672.5	6419826.0	50 extents

Table 17: Archaeological Exclusion Zones within the Green Volt OWF assessment area

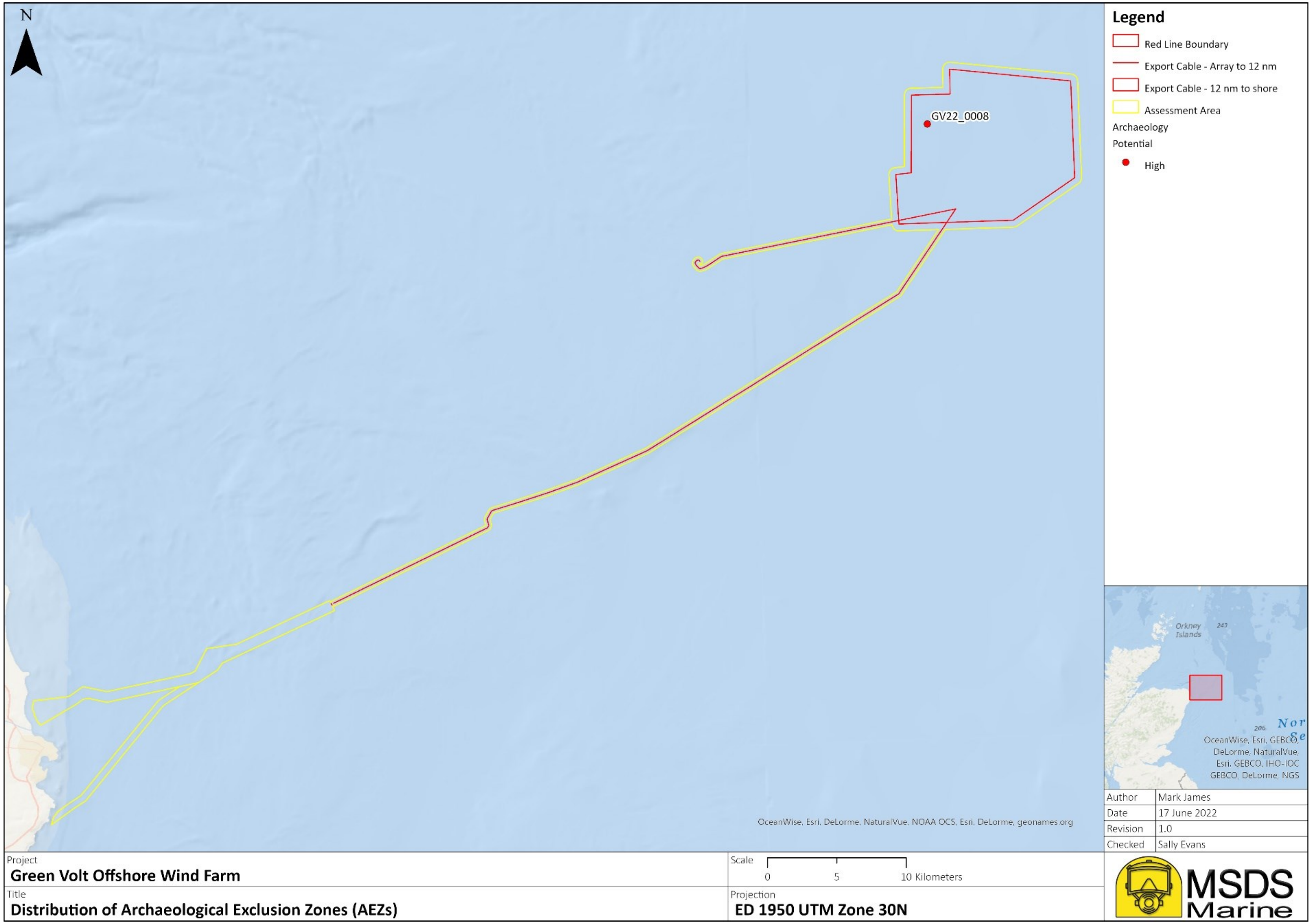

Figure 22: Distribution of Archaeological Exclusion Zones

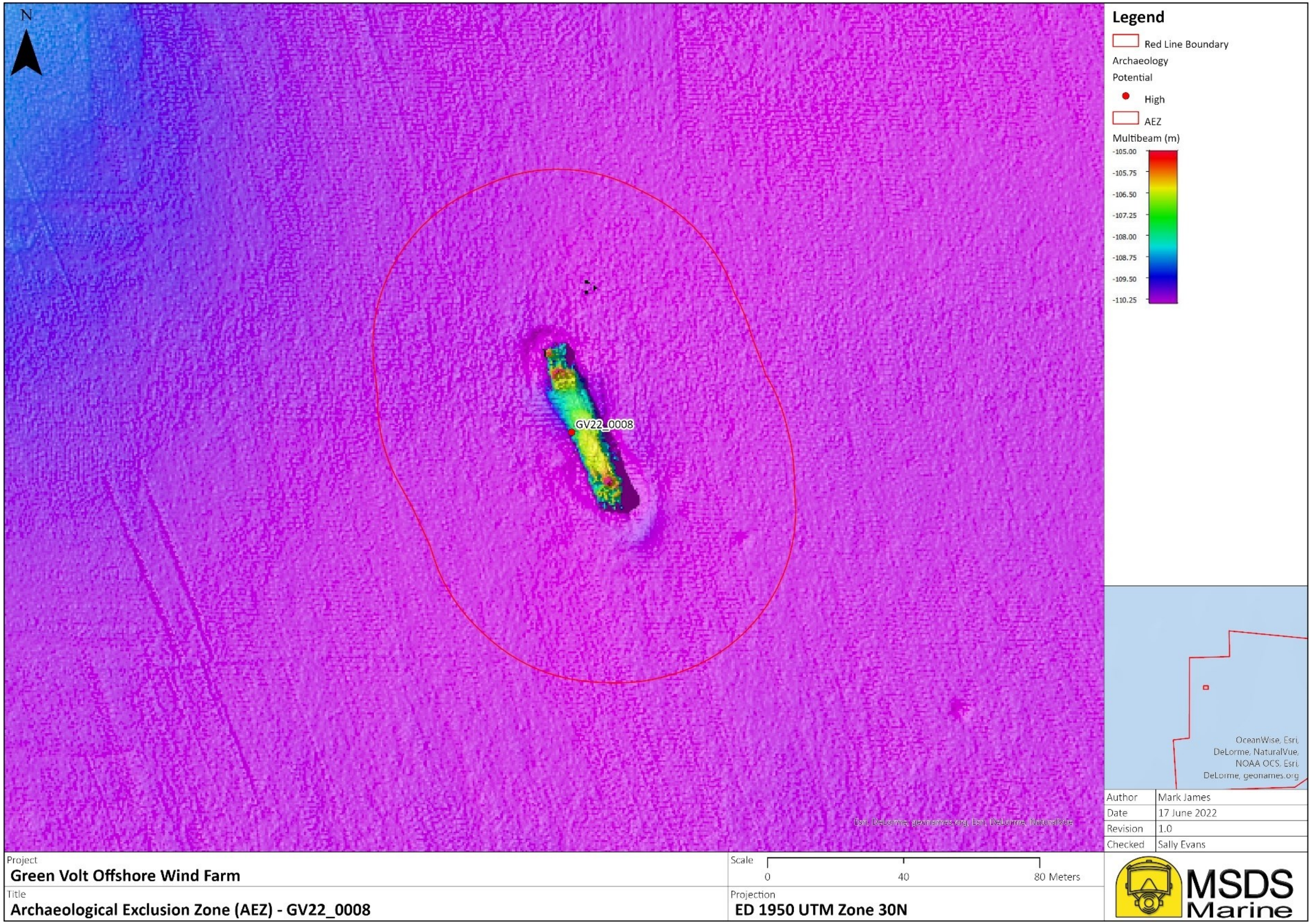

Figure 23: Archaeological Exclusion Zone (AEZ) - GV22_0008

10.3 Temporary Archaeological Exclusion Zones (TAEZ)

10.3.1 No TAEZs are recommended within the Green Volt OWF assessment area.

10.4 Area of Archaeological Potential (AAP)

10.4.1 No AAPs have been identified within the Green Volt OWF assessment area.

10.5 Notes on Exclusion Zones

10.5.1 Exclusion zones have been recommended based on the available evidence as interpreted by an experienced and qualified maritime archaeologist, they are to be agreed between the project, the archaeological curator, and the regulator. Exclusion zones are implemented to protect, in-situ, potentially archaeologically significant material.

10.5.2 Where an exclusion zone has been implemented, no development work impacting the seabed is to take place within the prescribed area. Should an exclusion zone 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 exclusion zone can be re-assessed to ensure mitigation is appropriate to the archaeological significance of the anomaly.

10.6 Prehistoric Archaeology and Palaeoenvironmental Remains

10.6.1 This report has outlined areas of prehistoric archaeological and palaeoenvironmental potential. The key mitigation in relation to the palaeolandscape and palaeoenvironmental remains follows a staged approach of geoarchaeological assessment 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 can allow for the greatest insights into the palaeolandscape, such as through the sampling of stratified channel deposits, deposits likely to contain organic remains or un-eroded surfaces. Round-table discussions and the review of seismic profiles tends to be a conducive method of allowing engineering and archaeological requirements to be taken into consideration when micro-siting geotechnical cores.

10.6.2 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 report, and of mitigating impacts to remains. In brief the process is as follows;

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

10.6.3 This geoarchaeological assessment and analysis should aim to deliver conclusions on the prehistoric archaeological and palaeoenvironmental remains within the area. Further mitigation may be required based on the results of this assessment. Use an appropriate protocol for archaeological discoveries such as the *Crown Estates Protocol for Archaeological Discoveries: Offshore Renewables Projects*[26] also provides mitigation for prehistoric and palaeoenvironmental remains

[26] The Crown Estate, 2014. *Protocol for Archaeological Discoveries: Offshore Renewables Projects*. Wessex Archaeology on behalf of the Crown Estate.

11.0 Recommendations for Future Work

11.1 Archaeological Assessment of Geophysical Data

11.1.1 The archaeological interpretation of the geophysical data collected at the pre-application stage, to which this assessment pertains, fits within a wider framework of planned geophysical survey for Green Volt OWF. The survey specification was designed for the purposes of consenting and Front End Engineering Design (FEED) to determine the most appropriate area for development, and as part of debris clearance and environmental obligations for Ettrick and Blackbird oil fields. Future surveys will likely combine an increase in resolution, and the addition of magnetometer data with tighter line spacing (as determined by the pUXO risk), 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.

11.1.2 All geophysical data collected as part of the project will be assessed for archaeological potential by a qualified and experienced maritime archaeologist where relevant to the development. It is recommended that the archaeologist have a demonstrable background in both the collection and processing of geophysical data as well as the archaeological review of data.

11.1.3 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. As the planned surveys increase in coverage and resolution but decrease in area, it is beneficial to be aware of any potential archaeological mitigation that may be required to ensure minimal re-planning.

11.1.4 Prior to any impact on the seabed pUXO specification data will be made available to, and reviewed by, the archaeologist. This includes, but is not limited to, cable laying operations, WTG installations, jack up barge positioning, anchor positions, UXO and boulder clearance and geotechnical works.

11.1.5 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. Whilst it is anticipated that methodologies will not vary a great deal between phases of work it is important to draw upon previous results to ensure the method proposed is both robust but practical.

11.1.6 A particular requirement is the collection of an appropriate dataset landward of 12 nm. The current dataset is limited in coverage due to the avoidance of fishing activity, and appropriateness for archaeological interpretation.

Survey Specification

11.1.7 Survey specifications will vary dependent on a number of factors including, water depth, vessel and equipment, however certain recommendations can be made such as coverage, size of anomaly to be ensonified and positional accuracy.

11.1.8 Of particular relevance is the specification for pUXO surveys which are undertaken to a specification suitable to reduce the UXO risk to As Low As Reasonably Practical (ALARP). In almost all instances' data collected for UXO assessment is highly suitable for archaeological assessment. General specifications are detailed below;

- Sidescan Sonar: data should be high frequency (at least 400-600 kHz), collected with a minimum of 200% coverage and the fish should be flown at an optimal altitude (typically c.10% of range). The fish should be positioned with a correctly calibrated USBL system and layback recorded as a backup. The data should be of a quality and resolution to identify seabed anomalies >0.3 m.
- Sub-bottom Profiler: data should be collected at a frequency and power appropriate to the seabed type and the required penetration, vertical resolution should be <0.3m where possible and the data should be heave corrected. Sub-bottom data are only collected below the sensor; therefore, data should be collected on all magnetometer lines as these are generally the tightest spacing.
- Multibeam Echo Sounder: for archaeological interpretation multibeam data are used for general seabed characterisation and quality control for the positioning of anomalies identified in the sidescan data. Data should be high resolution (typically 300-400 kHz) and acquired within IHO Special Order specifications , this includes full coverage data and a requirement to detect features >1.0 m on the seabed.
- Magnetometer: the method for magnetometer surveys will vary between multiple close survey lines or multiple magnetometers in an Array and wider survey lines. Magnetometer surveys for UXO identification should aim for full coverage with a blanking distance of 2.5 m, a target positioning accuracy of +/-2.5 m and an absolute accuracy of <2 nT. The fish should be flown between 2.0 m and 4.0 m and positioned with a correctly calibrated USBL system and layback recorded as a backup.

Reporting

11.1.9 Reporting following each phase of survey and archaeological assessment will be submitted to the curator and the regulator no later than three months following the end of the survey campaign and no later than one month prior to the start of construction works or any pre-construction impacts to the seabed.

11.2 Geoarchaeological Assessment

11.2.1 This report has outlined areas of prehistoric archaeological and palaeoenvironmental potential (summarised in Section 9.6). While the majority of the deposits within the site are unlikely to hold archaeological potential, some areas of potential have been identified and it is recommended that geoarchaeological assessment should accompany any geotechnical work undertaken within the site to investigate this potential further, and provide an opportunity to mitigate impacts to the palaeolandscape. The assessment should follow the staged process outlined in Section 10.6 of this report.

11.3 Protocol for Archaeological Discoveries (PAD)

11.3.1 A suitable protocol for archaeological discoveries is a key element of the mitigation procedures, particularly for anomalies identified as low archaeological potential. A suitable protocol should also be implemented during any works that may visually inspect the seabed or recover material to deck.

11.3.2 The protocol will take the form of the Crown Estates *Protocol for Archaeological Discoveries: Offshore Renewables Projects*[27] or a project specific protocol that considers the individual

[27] The Crown Estate, 2014. *Protocol for Archaeological Discoveries: Offshore Renewables Projects*. Wessex Archaeology on behalf of the Crown Estate.

requirements of the project. The protocol will be agreed with the curator and the regulator prior to any impact on the seabed.

11.4 Ground Truthing

11.4.1 Should archaeological exclusion zones impact on the proposed development works it is recommended that a program of ground truthing is undertaken to establish the identity of the anomalies so that further archaeological assessment can be undertaken, and interpretations revised as appropriate.

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13.0 Annex A – Anomalies of Archaeological Potential

Name	Potential	Description	Mag (nT)	Name	UKHO	Canmore	Length (m)	Width (m)	Height (m)	AEZ (m)	AEZ Type	X	Y
GV22_0001	Low	Unidentified debris	-	-	-	-	6.3	0.4	0.0	-	-	638204.4	6422512.5
GV22_0002	Low	Potential debris	-	-	-	-	18.8	1.6	1.6	-	-	641992.4	6422237.7
GV22_0003	Low	Potential debris	-	-	-	-	3.2	3.5	1.9	-	-	638849.7	6423650.9
GV22_0004	Low	Likely geological	-	-	-	-	3.6	0.7	0.8	-	-	641553.7	6423616.5
GV22_0005	Low	Unidentified debris	-	-	-	-	19.8	0.4	0.0	-	-	640090.4	6421671.5
GV22_0006	Low	Chain, cable, or rope	-	-	-	-	20.3	0.6	0.0	-	-	643449.2	6420820.4
GV22_0008	High	Wreck	125	*Ernst Friesecke*	2402	309175, 321988	52.1	8.9	3.2	50	Extents	636672.5	6419826.0
GV22_0009	Low	Potential debris	-	-	-	-	5.3	3.0	1.7	-	-	636917.8	6418884.0
GV22_0010	Low	Potential debris	-	-	-	-	1.7	0.8	0.5	-	-	646466.6	6418615.9
GV22_0011	Low	Potential debris	-	-	-	-	3.7	1.4	0.7	-	-	638447.9	6416285.9
GV22_0012	Low	Unidentified debris	-	-	-	-	7.2	5.7	0.9	-	-	640248.4	6415840.5
GV22_0014	Low	Potential debris	-	-	-	-	4.8	3.0	1.1	-	-	639503.5	6415817.5
GV22_0015	Low	Potential debris	9	-	-	-	3.3	2.0	0.0	-	-	639072.3	6415790.3
GV22_0016	Low	Unidentified debris	-	-	-	-	4.0	0.5	0.0	-	-	635533.7	6415333.1
GV22_0017	Low	Potential debris	-	-	-	-	2.0	3.2	0.6	-	-	643167.7	6415736.9
GV22_0018	Low	Unidentified debris	-	-	-	-	5.0	0.7	0.0	-	-	637401.9	6415170.3

GV22_0019	Low	Potential debris	-	-	-	-	5.0	2.4	1.3	-	-	638491.6	6414731.9
GV22_0020	Low	Unidentified debris	-	-	-	-	3.8	2.6	0.0	-	-	639599.0	6412991.2
GV22_0021	Low	Unidentified debris	-	-	-	-	3.9	1.6	0.0	-	-	640338.8	6413022.8
GV22_0022	Low	Potential debris	-	-	-	-	2.3	1.6	0.0	-	-	638553.4	6413331.4
GV22_0023	Low	Chain, cable, or rope	-	-	-	-	50.3	0.2	0.1	-	-	612830.7	6394537.7
GV22_0024	Low	Potential wreck debris	6	-	-	-	2.5	1.9	0.3	-	-	636714.8	6419680.0
GV22_0013	Low	Unidentified debris	3	-	-	-	1.6	0.5	0.9	-	-	635977.5	6420717.8
GV22_0007	Low	Unidentified debris	7	-	-	-	0.9	0.2	0.3	-	-	636967.3	6414374.5
GV22_0025	Low	Possible mine sinker	-	-	-	-	1.4	1.3	0.3	-	-	634150.7	6414433.8
GV22_0026	Low	Possible mine sinker	-	-	-	-	1.9	1.3	0.3	-	-	634271.9	6414092.0
GV22_0027	Low	Possible mine sinker	-	-	-	-	1.5	1.5	0.3	-	-	634342.5	6413961.0
GV22_0028	Low	Possible mine sinker	-	-	-	-	0.8	0.6	0.3	-	-	634486.4	6413316.3
GV22_0029	Low	Possible mine sinker	-	-	-	-	1.2	1.1	0.3	-	-	634535.6	6413204.3
GV22_0030	Low	Possible mine sinker	-	-	-	-	1.4	1.3	0.3	-	-	634664.8	6413128.6
GV22_0031	Low	Possible mine sinker	-	-	-	-	1.4	1.3	0.3	-	-	634795.4	6412784.7
GV22_0032	Low	Possible mine sinker	-	-	-	-	1.3	1.5	0.3	-	-	633181.5	6412509.7

GREEN VOLT

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