TORBEG CURSUS
ARRAN

GEOPHYSICAL SURVEY REPORT

HES PROJECT NUMBER: TORB2021
NGR: NR 89495 29987
DATE: AUGUST 2021
AUTHOR: DR NICK HANNON

EXECUTIVE SUMMARY

Historic Environment Scotland (HES), Archaeological Survey Team, undertook electro-magnetic survey at Torbeg Cursus, Arran, North Ayrshire, Scotland, to investigate the extent and significance of potential sub-surface archaeological features within the survey area. This forms part of five-year project aimed at developing a geophysical survey capacity embedded with the Archaeological Survey Team in the Heritage Recording & Archaeology Service of Historic Environment Scotland.

The survey was conducted on 24th August 2021, in total 0.12 ha were surveyed with a CMD Mini Explorer electro-magnetic device. The geophysical surveys produced good quality results which give a high level of confidence that the methodology and survey strategy were appropriate to assess the archaeological potential of the survey area.

The survey has confirmed the location of the cursus bank and the results correlate well with the visualisations and interpretation derived from the LiDAR data. The methodology was successfully able to sense the bank's rubble core through the peat which blankets the site. This feature was more clearly identifiable in the conductivity data than the magnetic susceptibility data which was in part affected by the igneous bedrock.

The conductivity data also identified three high conductivity anomalies arranged in a row inside the cursus bank, spaced between 10m and 11m apart and running parallel with the bank. These may represent pockets of moisture trapped upslope and behind the cursus bank. Alternatively, they may represent archaeological features within the cursus monument in the form of pits or postholes.

This document has been prepared in accordance with HES' Terrestrial Geophysical Survey Standard Operating Procedures v1.0			
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1.0 - INTRODUCTION

Historic Environment Scotland (HES), Archaeological Survey Team, undertook electro-magnetic survey at Torbeg Cursus, Arran, North Ayrshire, Scotland, to investigate the extent and significance of potential sub-surface archaeological features within the survey area. The survey was conducted on 24th August 2021, and forms part of five-year project aimed at developing a geophysical survey capacity embedded with the Archaeological Survey Team in the Heritage Recording & Archaeology Service of Historic Environment Scotland.

2.0 – PROJECT BACKGROUND & AIMS

Survey at Torbeg cursus was planned to address research questions specific to HES' geophysical survey project. These include testing the use and effectiveness of geophysical survey techniques in areas believed challenging for geophysical survey.

Geophysical survey at Torbeg cursus was primarily intended to establish the effectiveness of electro-magnetic methodologies to identify archaeological features blanketed by peat and in an area with igneous bedrock. This methodological research aim is specific to the project and outside the ScARF recommendations (ScARF 2021: section 5.3), which do not address technical and methodological improvements of geophysical survey techniques.

Torbeg cursus was selected for survey as it was identified recently during assessment of visualisations derived from LiDAR data as a topographic feature. The site was subsequently located on the ground and the interpretation verified. Geophysical survey of the monument provided an opportunity to directly compare the topographic data with that produced through geophysical survey. The survey also aimed to enhance the understanding of the archaeology of Torbeg cursus. Beyond these general aims, the survey intended to address the following questions:

- Is the magnetic susceptibility element of the electro-magnetic survey able to identify the cursus banks within a background of igneous bedrock?
- Is the conductivity element of the electro-magnetic survey able to identify the cursus banks within a background of igneous bedrock?
- Can any ditches running parallel with the cursus banks be identified in the survey data?
- Can any features within the cursus be identified in the survey data?

The survey results could lead to the creation of new entries, or the amendment of existing entries in the National Record of the Historic Environment.

3.0 – SITE LOCATION & DESCRIPTION

Torbeg cursus is situated in an area of moorland 1,400m to the south-southeast of the summit of Torr Righ Mòr and 1,500m north of Blackwaterfoot village, on the west coast of Arran, an island in the Firth of Clyde (Figure 1). The moor contains a concentration of archaeological remains of Bronze Age date, including hut circles, cairns and fragmentary field systems, much of which is protected as scheduled monument SM4414 (Figure 2).

The survey area (centred upon NR 89493 29643) covers a total of 0.13 hectares. It occupies a gentle east facing slope overlooking Torbeg village at a height of 62m AOD (Figures 3 & 4).

The solid geology is recorded as South Arran Sills – Felsite, Igneous Rock. This is overlain with superficial deposits of Devensian Till – Diamicton (BGS 2021). The site's soil is recorded as a peaty podzol (Scotland's Soils 2021).

The survey area is comprised of two discontinuous areas (Figures 3 & 4), they are:

- TB01 – A 0.12 hectare area of open moorland centred upon NR 89498 29732 (Images 1, & 2). The area is rectangular in shape and positioned to straddle the eastern bank of the cursus.
- TB02 – A 0.1 hectare area of open moorland centred upon NR 89494 29572 (Image 3). The area has an irregular shape and is positioned to cover the area excavated by Northlight Heritage and the University of Glasgow in August 2021 (Brophy & MacGregor 2022). Prior to excavation the site was bracken covered but a small area had been cleared to facilitate the excavation.

Prior to conducting the survey, permissions to access the land were obtained from the landowner.

The survey area is within the Arran Moors Site of Special Scientific Interest, but the survey area is not protected under the Ramsar Convention, is not contained within a National or Regional Park, and is not a nature reserve (NatureScot 2021). Reference to the National Biodiversity Network's Atlas for the survey area and a 200m buffer surrounding it, shows the area contains no sightings of flora or fauna which require the granting of a licence for this survey to be conducted (NBN 2021). Due to the survey area's SSSI status, NatureScot were consulted prior to the survey being undertaken. They had no concerns related to the survey.

During the survey the weather conditions were hot and dry, and followed a prolonged period of dry weather.

A photographic record showing the survey areas and ground conditions can be found in Section 11.

4.0 – ARCHAEOLOGICAL BACKGROUND

The NRHE describes the Torbeg Cursus as Follows. The banks of Torbeg Cursus were first identified using visualisations derived from LiDAR data and were investigated subsequently during numerous field visits between late 2017 and 2019. Much of the monument is clad in rank heather or impenetrable gorse such that its extent has been mapped largely from these visualisations. Running N and S, the cursus extends for a distance of at least 1.1km, defined by intermittent stretches of low parallel banks set between 30m and 40m apart. There is nothing to indicate the presence of flanking ditches and neither terminal is visible. The monument is situated towards the east edge of poorly drained open moorland that rises gently to the north offering extensive views inland along the valley of the Black Water. A narrow plantation of dense coniferous trees, established in the 1970s, flanks the north half of the monument and overlies much of its northwest side and possibly also its northern terminal, which may have been situated on a localised rise falling within its northern end.

Both banks are slight in nature and barely visible on the ground, measuring at best 3.3m in thickness and little more than 0.3m in height. They appear discontinuous and to be made up of earth or turf with very few stones visible. It is impossible to say whether any breaks represent original gaps or are simply the result of natural slumping and the differential growth of peat.

To the north and west of the cursus is Scheduled Monument SM4414 which covers a complex of hut circles, associated field systems and areas of field clearance, all dating to the Bronze Age which the scheduled monument description states. This area is one of the best surviving hut circle and field systems of this period on Arran. The area lies on heathery moorland, large parts of which are covered in peat. In a number of cases field banks disappear beneath the peat. Excavations to the north of the scheduled area (Barber 1997) showed that extensive Bronze Age remains lie protected by the peat.

In August 2021, prior to the geophysical survey, a section was excavated through the eastern bank of the cursus towards its southern end. The results of this excavation are awaited (Brophy & MacGregor 2022).

5.0 – SURVEY METHODOLOGY

The survey was conducted on 24th August 2021.

The survey was carried out in accordance with the Chartered Institute for Archaeologists, *Standard and Guidance for archaeological geophysical survey* (CIfA 2020), the *EAC Guideline for the Use of Geophysics in Archaeology* (Schmidt *et al.* 2016), and the Historic Environment Scotland, *Geophysical Survey, Standard Operating Procedures* (HES 2020b).

Survey methods were selected to best deliver the aims detailed in Section 2, in accordance with the recommendations outlined in the EAC guidelines, and in accordance with the manufacturer's guidelines (GF Instruments 2019; Sensys 2019). All sensors had valid in-date calibration certificates which are included in Appendix 2.

5.1 – ELECTRO-MAGNETIC SURVEY

The electro-magnetic survey was conducted using a hand-held GF Instruments CMD Mini Explorer. This system employed a single transmitter coil and three receiver coils spaced at 0.32m, 0.71m and 1.18m from the transmitter. For area TB01 the system was initially set in the Vertical Co-planar configuration and then the survey was repeated with the system set in the Horizontal Coplanar configuration. This allowed measurements to be taken at estimated effective depth penetrations of 0.25m, 0.50m, and 0.90m, and of 0.50m, 1.00m, and 1.80m respectively. For area TB02 the system was set in Horizontal Coplanar configuration only. This allowed measurements to be taken at estimated effective depth penetrations of 0.50m, 1.00m, and 1.80m.

In each configuration both conductivity and magnetic susceptibility readings were recorded simultaneously on the system's integral datalogger, resulting in six readings being recorded at each position in each configuration.

The survey was conducted by walking a series of parallel traverses in a uni-directional pattern, with traverses aligned northeast-southwest and positioned 1m apart. The sensor was carried at approximately 0.2m from the surface to the left-hand side of the operator. Navigation was provided by the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. Data points were recorded every 0.1 seconds along each traverse, with positional accuracy provided by a Leica GS16 mounted on a survey backpack at an antenna height of 1.8m. This provided a constant stream of data in NMEA format allowing each reading to be accurately georeferenced without the need for a pre-determined grid system.

Once the survey was completed the data was later transferred from the system in .bin format. The files were processed and visualised following the process described in Appendices 4, 5 and 6. Interpretations of this data were generated using ESRI ArcGIS Pro v2.8.6.

A total of 0.13ha hectares of data were collected, employing this method.

6.0 – SURVEY RESULTS & INTERPRETATION

The following section presents the results obtained using the data collection method detailed in Section 5 and the data processing methods in Appendices 6, 7, and 8. The figures relating to these results and interpretations can be found in Appendix 10. These figures have a LiDAR hillshade visualisation (Environment Agency data, 0.50m^2 resolution lit with 315° azimuth and 35° altitude) as their background to allow the electro-magnetic and LiDAR results to be directly compared.

In general, only anomalies of archaeological or possible archaeological origins have been assigned an anomaly number.

6.1 – AREA TB01 RESULTS & INTERPRETATION

A total of 0.12 hectares was surveyed for area TB01 in both Vertical and Horizontal Co-planar configurations.

The conductivity results for TB01 have been visualised as processed greyscale plots combined with a graphical interpretation as single figures. The results for the Vertical Co-planar configuration are shown in Figure 5 displayed at -2/2 mS/m. The results for the Horizontal Co-planar configuration are shown in Figure 6 displayed at 0/5 mS/m.

The magnetic susceptibility results for TB01 have been visualised as processed greyscale plots combined with a graphical interpretation as single figures. The results for the Vertical Co-planar configuration are shown in Figure 7 displayed at -1/1 ppt. The results for the Horizontal Co-planar configuration are shown in Figure 8 displayed at -1/1 ppt.

6.1.1 – AREA TB01 ELECTRO-MAGNETIC SURVEY – CONDUCTIVITY – VERTICAL CO-PLANAR

The results in Figure 5 shows the conductivity data at three separate depth penetrations and the interpretation of this data.

At all three depths a band of low to very low conductivity (TORB2021-0001) runs roughly through the centre of the survey area on a broadly north to south orientation. When compared with the LiDAR base mapping it is apparent that this aligns with the slight earthwork previously identified as the eastern bank of the cursus and is of a similar width. Therefore, TORB2021-0001 has been interpreted as representing the bank's rubble core.

At all three depths a small area of very low conductivity (TORB2021-0002) is located at the southeast of the survey area. This is slightly downslope from the bank represented by TORB2021-001 and may represent bank material which has tumbled downslope as the bank has eroded.

A further area of low conductivity (TORB2021-0003) is located in the northwest corner of the survey area. This corresponds with a small gully identifiable in the LiDAR data and is only visible up to a depth of 0.50m. This has been interpreted as representing a small gully within the peat.

An irregular area of high conductivity (TORB2021-0004) is located adjacent to the west of TORB2021-0001 and measures around 4m across. This anomaly has two possible interpretations: it may represent a large posthole or small pit located within the cursus or an area where moisture has collected and been trapped upslope behind the cursus' bank, causing elevated conductivity readings. This has been interpreted as a large posthole or small pit, although moisture collection cannot be ruled out.

In the southwest of the survey area is an area of high conductivity caused by an area of waterlogged ground which was observed during survey.

6.1.2 – AREA TB01 ELECTRO-MAGNETIC SURVEY – CONDUCTIVITY – HORIZONTAL CO-PLANAR

The results in Figure 6 shows the conductivity data at three separate depth penetrations and the interpretation of this data.

Again, at all three depths a band of low to very low conductivity (TORB2021-0001) runs roughly through the centre of the survey area on a broadly north to south orientation. When compared with the LiDAR base mapping it is apparent that this both aligns with and, at c.5m, is similar in width to cursus monument's slight bank. Therefore, this has been interpreted as representing the bank's rubble core.

A small area of very low conductivity (TORB2021-0002) is again located at the southeast corner of the survey area. This anomaly is apparent at depths 1 and 2 but is not visible at depth 3. As this anomaly is not visible as deeply as TORB2021-0001 it helps support the theory that this anomaly may represent bank material which has tumbled downslope as the bank has eroded and so lies at the original ground level.

Similar to the Conductivity Vertical Co-planar data a further area of low conductivity (TORB2021-0003) is located in the northwest corner of the survey area. This corresponds with a small gully identifiable in the LiDAR data and has been interpreted as representing a small gully within the peat.

Three subcircular areas of high conductivity (TORB2021-0005, TORB2021-0006, & TORB2021-0007) are located adjacent and to the west of TORB2021-0001. TORB2021-0005 corresponds with the position of TORB2021-0004 but is noticeably smaller in this dataset at around 2m in diameter. These anomalies are most visible in the 1.00m depth visualisation and least visible at the 1.80m depth visualisation, possibly indicating the depth of the features. The full extent of TORB2021-0007 is hard to establish as it extends outside the survey area on the north. The three anomalies appear to be arranged in a row and spaced between 10m and 11m apart. This group of anomalies have two possible interpretations. They may represent three small pits or postholes arranged in a row, or they may represent areas where moisture has collected and been trapped upslope behind the cursus' bank, causing elevated conductivity readings. These anomalies have been interpreted as a large posthole or small pit, although moisture collection cannot be ruled out.

In the southwest of the survey area is an area of high conductivity, caused by an area of waterlogged ground which was observed during survey.

6.1.3 – AREA TB01 ELECTRO-MAGNETIC SURVEY – MAGNETIC SUSCEPTIBILITY - VERTICAL CO-PLANAR

The results in Figure 7 shows the magnetic susceptibility data at three separate depth penetrations and the interpretation of this data.

This dataset is not as well defined as the conductivity dataset for TB01. Depth 1 is especially ill defined and of little archaeological use, while Depth 3 is quite noisy. This may be fully or partially caused by the igneous bedrock. However, two broad groups of anomalies can be seen in the data.

Firstly, a band of low magnetic readings (TORB2021-0008) runs roughly through the centre of the survey area on a broadly north to south orientation. When compared with the LiDAR base mapping it is apparent that this aligns with the cursus monument's slight bank. Therefore, this has been interpreted as representing the bank's rubble core, corresponding with TORB2021-0001.

A second area of low magnetic readings (TORB2021-0009) is located in the southeast corner of the survey area. This appears to correspond with TORB2021-0002 and may represent an area of tumble from the cursus bank.

Running along the southern edge of the survey area to the west of TORB2021-0008 is a band of high magnetic readings. This follows the traverse lines so appears to be a data collection artefact of unknown cause.

6.1.4 – AREA TB01 ELECTRO-MAGNETIC SURVEY – MAGNETIC SUSCEPTIBILITY - HORIZONTAL CO-PLANAR

The results in Figure 8 shows the magnetic susceptibility data at three separate depth penetrations and the interpretation of this data.

Again, this dataset is not as well defined as the conductivity dataset for TB01. Depth 1 is especially ill defined and of little archaeological use. This may be fully or partially caused by the igneous bedrock. However, two broad groups of anomalies can be seen in the data.

Firstly, a weak band of low magnetic readings (TORB2021-0008) run roughly through the centre of the survey area on a broadly north to south orientation. The low magnetic readings are only apparent at Depths 1 and 2, at Depth 3 this feature appears as an extremely weak band of high magnetic readings. Again, when compared with the LiDAR base mapping it is apparent that this aligns with the cursus monument's slight bank. Therefore, this has been interpreted as representing the bank's rubble core and analogous with TORB2021-0001.

A second area of low magnetic readings (TORB2021-0009) is located in the southeast corner of the survey area. This appears to be analogous with TORB2021-0002 and may represent an area of tumble from the cursus bank.

Running along the southern and northern edges of the survey area west of TORB2021-0008 are two bands of high magnetic readings. These follow the traverse lines so appears to be a data collection artefact of unknown cause.

6.2 – AREA TB02 RESULTS & INTERPRETATION

A total of 0.01 hectares was surveyed for area TB02 in Horizontal Co-planar configuration. This was not repeated in Vertical Co-planar configuration due to time constraints. Survey of this area was intended to compare the methodology's results with those obtained during the recent excavation. Due to the height of the vegetation, only the area which had been cleared for the excavation could be surveyed.

The conductivity results for TB02 have been visualised as processed greyscale plots combined with a graphical interpretation as a single figure. The results for the Horizontal Co-planar configuration are shown in Figure 9 displayed at -2/12 mS/m.

The magnetic susceptibility) results for TB02 have been visualised as processed greyscale plots combined with a graphical interpretation as a single figure. The results for the Horizontal Co-planar configuration are shown in Figure 10 displayed at 0/1 ppt.

6.2.1 – AREA TB01 ELECTRO-MAGNETIC SURVEY – CONDUCTIVITY – HORIZONTAL CO-PLANAR

The results in Figure 9 shows the conductivity data at three separate depth penetrations and the interpretation of this data.

Due to the limited space available for survey it is difficult to interpret the data in any great detail, however, when compared with the LiDAR base mapping, a band of very low conductivity (TORB2021-0010) correlates with the position of the bank. This is consistent with the results from TB01. At the centre of this anomaly is a spike of high conductivity, caused by a metal ranging rod placed on the cursus' bank (Image 3).

To the west of TORB2021-0010 is an area of high conductivity which may run parallel with TORB2021-0010. However, as such a small area is available for interpretation and this area has been excavated and backfilled, it is difficult to draw any firm conclusions; it could simply represent the position of an excavation slot.

6.2.2 – AREA TB02 ELECTRO-MAGNETIC SURVEY – MAGNETIC SUSCEPTIBILITY - HORIZONTAL CO-PLANAR

The results in Figure 10 shows the magnetic susceptibility data at three separate depth penetrations and the interpretation of this data.

Again, due to the limited space available for survey, it is difficult to interpret the data in any great detail. However, when compared with the LiDAR base mapping, an area of reduced magnetic susceptibility (TORB2021-0011) coincides with the position of the cursus bank, corresponding with TORB2021-0010 in the conductivity data.

The area to the west of TORB2021-0011 appears to have been affected by the excavation and backfilling and is visible as an area of magnetic disturbance.

7.0 – CONCLUSIONS

The geophysical survey has produced good quality electro-magnetic results which have successfully contributed to the aims detailed in Section 2. There is a high level of confidence that the chosen methodology and survey strategy were appropriate to assess the archaeological potential of the survey area.

The survey has confirmed the location of the cursus bank and the results correlate well with the visualisations and interpretation derived from the LiDAR data. The methodology was successfully able to sense the bank's rubble core through the peat which blankets the site. This feature was more clearly identifiable in the conductivity data than the magnetic susceptibility data which was in part affected by the igneous bedrock.

The conductivity data also identified three high conductivity anomalies arranged in a row inside the cursus bank, spaced between 10m and 11m apart and running parallel with the bank. These may represent pockets of moisture trapped upslope and behind the cursus bank. Alternatively, they may represent archaeological features within the cursus monument in the form of pits or postholes.

Pits are not uncommon features within cursus monuments and so, if these are archaeological features, the presence of pits would not be unusual. A row of postholes, though, would be of considerable interest as cursus monuments shown to combine both timber and earthwork elements are not common (Brophy and Millican 2015; Brophy 2016). At present, Holywood North is the only known example. Here a timber cursus was later replaced by the bank and ditch of an earthwork cursus (Thomas 2007). The possibility of postholes within the interior and running parallel to the cursus bank is therefore intriguing and may suggest that the Torbeg cursus had a timber component or perhaps an earlier timber phase. The area surveyed, though, is too small to draw any definitive conclusions and only further survey and excavation could resolve the interpretation of these features.

In assessing these results against the specific aims listed in Section 2.

- *Is the magnetic susceptibility element of the electro-magnetic survey able to identify the cursus banks within a background of igneous bedrock?* Yes, in the small areas sampled the magnetic susceptibility element of the electro-magnetic identified the cursus bank as a band of reduced magnetic susceptibility. However, this was in partly affected by the area's igneous bedrock.

- *Is the conductivity element of the electro-magnetic survey able to identify the cursus banks within a background of igneous bedrock?* Yes, in the small areas sampled the conductivity element of the electro-magnetic was able to identify the cursus bank as a band of low to very low conductivity. This provided clearer results than the magnetic-susceptibility data.

- *Can any ditches running parallel with the cursus banks be identified in the survey data?* No ditches were identified running parallel with the cursus bank.

- *Can any features be identified within the cursus in the survey data?* In the conductivity data, three anomalies of high conductivity arranged in a row and running parallel with the line of the bank have been identified. These may represent internal features such as pits or postholes. The small survey area, though, means this interpretation is not certain and alternative interpretations are equally plausible.

In summary the survey has confirmed that electro-magnetic survey is able to identify archaeological features in a peatland environment and so is suitable for use in similar circumstances elsewhere.

8.0 – CAVEATS

Geophysical survey relies upon the detection of anomalous values and patterns in the physical properties of the ground and uses these as a proxy for anthropogenic activity; it does not directly detect archaeological features. Therefore, the results from this method of survey will not be a direct indicator of the absence or presence of archaeological features.

The ability of geophysical survey to identify the potential for archaeological remains is impacted by several interconnecting factors, including geological and fluvial processes, weather conditions, ground conditions, and the taphonomic processes involved in the archaeological site's formation. Therefore, the survey results may not provide a complete plan of the site's archaeology.

Nonetheless Historic Environment Scotland have endeavoured to produce interpretations of the data as accurately as possible. However, it should be noted that these interpretations and the conclusions contained within this report are a subjective assessment of the data.

9.0 – ARCHIVE DEPOSITION

A digital copy of this report has been supplied to both Historic Environment Scotland and the local Historic Environment Record for archive purposes. An event record has been generated for the National Record of the Historic Environment (NRHE) summarising the methodology and results of the project. No existing site records have been amended.

In accordance with standard industry practice an Online Access to the Index of Archaeological Investigations (OASIS) record has been generated and submitted to the Historic Environment Record (HER) and the Archaeological Data Service (ADS).

As the survey was conducted in Scotland an entry has been generated for inclusion in "Discovery and Excavation in Scotland". This text can be found in Appendix 8.

The digital elements of the project have been supplied to the NRHE for archive in the following formats.

- Unprocessed survey data supplied as .txt files.
- Processed survey data supplied as .tif files.
- A .zip containing the following .shp files.
    - Polygons showing the survey area extents and containing the survey's metadata.
    - Interpretation polygons.
    - Interpretation polylines.
    - Interpretation points.

10.0 – BIBLIOGRAPHY

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11.0 – IMAGES

Image 1 – TB01 looking northeast (DP378814)

Image 2 – TB01 looking east (DP378815)


Image 3 – TB02 looking north (DP394593)

APPENDIX 1 – SURVEY METADATA

The following table details the survey's metadata.

Field	Description
Data Collection Organisation	Historic Environment Scotland
Site Name	Torbeg Cursus, Arran
Project ID	TORB2021
OASIS ID	historic14-412624
Report Title	Torbeg Cursus, Arran, Archaeological Geophysical Survey Report
Report Author	Dr Nick Hannon
Report QC	Dr Kirsty Millican/Dr Dave Cowley
National Grid Reference (centre)	NR 89495 29987
Coordinate System	OSGB1936
Transformation	OSTN15
Geoid	OSGM15
County	North Ayrshire
Scheduled Ancient Monument/s	N/A
Known Archaeology on site	360276
Survey Personnel	Dr Nick Hannon, Dr Łukasz Banaszek
Survey Dates	24/08/2021
Weather Conditions	Hot and Sunny
Land Use	Peat Moorland
Ground Conditions	Boggy
Solid Geology	South Arran Sills – Felsite, Igneous Rock (BGS 2021)
Drift Geology	Till, Devensian – Diamicton (BGS 2021)
Soil	Peaty Podzol (Scotland's Soils 2021)
Survey Type	Electro-magnetic
EMI Equipment	CMD Mini Explorer
Sensor Separation/s (m)	0.2/0.5/0.7
Sensor Configuration	Low (Vertical Co-planar) & High (Horizontal Co-planar)
Traverse Separation (m)	0.5
Reading Interval (sec)	0.1
Data Collection Software	On-board hardware
Data Processing Software	TerraSurveyor v3.0.37.0
Data Visualisation Software	ArcGIS Pro v2.8.6
Area Covered (ha)	0.13ha
Positional Accuracy	Leica GS16 GNSS +/- 0.02m

APPENDIX 3 – IDENTIFIED ANOMALIES

The following table lists each named anomaly identified in the survey.

Anomaly ID	Location	Classification	Interpretation
TORB2021-0001	TB01	Low/Very Low Conductivity	Cursus bank
TORB2021-0002	TB01	Very Low Conductivity	Tumble from cursus bank
TORB2021-0003	TB01	Low Conductivity	Small gulley
TORB2021-0004	TB01	High Conductivity	Possible large posthole/small pit
TORB2021-0005	TB01	High Conductivity	Possible posthole
TORB2021-0006	TB01	High Conductivity	Possible posthole
TORB2021-0007	TB01	High Conductivity	Possible posthole
TORB2021-0008	TB01	Low magnetism	Cursus bank
TORB2021-0009	TB01	Low magnetism	Tumble from cursus bank
TORB2021-0010	TB02	Very Low Conductivity	Cursus bank
TORB2021-0011	TB02	Low magnetism	Cursus bank

APPENDIX 4 – GLOSSARY OF ANOMALY TYPES

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Magnetic Susceptibility) survey within this report.

	Anomaly Type	Description
Area	High Magnetism	An area displaying particularly high magnetic properties, possibly of anthropogenic origins.
	Low Magnetism	An area displaying particularly low magnetic properties, possibly of anthropogenic origins.

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Conductivity) survey within this report.

	Anomaly Type	Description
Area	Very Low Conductivity	An area displaying very low conductivity, possibly of anthropogenic origins.
	Low Conductivity	An area displaying low conductivity, possibly of anthropogenic origins.
	High Conductivity	An area displaying low high conductivity, possibly of anthropogenic origins.

APPENDIX 5 – DATA PROCESSING METHODOLOGY

The following section details the data processing methodology used for this survey; the specific process parameters used for each datafile are detailed in Appendix 6.

ELECTRO-MAGNETIC DATA PROCESSING

Following the collection of data following the methodology detailed in section 5.2, all datafiles were exported from the CMD Mini Explorer's datalogger via a USB memory stick in .bin format. These files were then transferred to the processing computer and opened with the CMD Data Transfer application; each file was then exported as an interpolated .dat file. Each data file was opened in Microsoft Excel and the trailing "W" and "N" removed from the data in columns A and B; column B also had the leading "-" removed. The data was saved in .csv format.

Data processing was conducted using Terrasurveyor (DW Consulting: 2019). The GPS Geoid was set to "WGS-84" and the coordinate system set to "UTM Zone 30" prior to data import, to match the GNSS used during data collection. The .csv files were imported using the pre-defined TerraSurveyor import template appropriate for the CMD Mini Explorer system, and converted into .xcp format composite. This process was repeated six times, each time changing the "Val posn" value on the "Source Settings" screen to produce a composite for each of the six sets of readings taken during survey.

The .xcp files were opened and a .grd exported to allow visualisation of the minimally processed data. The data was despiked, destriped and had a high-pass filter applied. The data was interpolated to values appropriate for the display requirements for the processed results; these processed results were exported in .grd format. An image boarder was generated and exported as a .dxf. The data was clipped and an XY trace plot generated and exported as a .dxf.

The .grd's were imported to the project's ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the "Project Raster" tool, with the input coordinate system set as "ETRS_1989_UTM_Zone_30N", the output coordinate system as "British National Grid", using the "OSGB_1936_To_ETRS_1989_1" geographic transformation, resampled as "Nearest neighbour".

Once the reprojection was complete the data was manually interpreted.

APPENDIX 6 – DATA PROCESSING STEPS

The following table details the processing steps each data file has undergone and the order these processes were applied before the data was transferred to the data visualisation software.

Filename	Process	Values
TORB202TB01_EM_LO_COND1.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_LO_COND2.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_LO_COND3.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_LO_MSUS1.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Mean Standard Deviation 1.5
TORB202TB01_EM_LO_MSUS2.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Mean Standard Deviation 1.5
TORB202TB01_EM_LO_MSUS3.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Median Standard Deviation 1.5
TORB202TB01_EM_HI_COND1.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_HI_COND2.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_HI_COND3.xcp	Base Settings	Interval 0.20m, Track Radius 1.59m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB01_EM_HI_MSUS1.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Mean Standard Deviation 1
TORB202TB01_EM_HI_MSUS2.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Mean Standard Deviation 1
TORB202TB01_EM_HI_MSUS3.xcp	Base Settings	Interval 0.20m, Track Radius 1.55m
	Remove Turns	Manually Identified
	Destripe	Mean Standard Deviation 1
TORB202TB02_EM_HI_COND1.xcp	Base Settings	Interval 0.20m, Track Radius 1.30m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB02_EM_HI_COND2.xcp	Base Settings	Interval 0.20m, Track Radius 1.30m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB02_EM_HI_COND3.xcp	Base Settings	Interval 0.20m, Track Radius 1.30m
	Remove Turns	Manually Identified
	High Pass Filter	Uniform (median) Diameter 301
TORB202TB02_EM_HI_MSUS1.xcp	Base Settings	Interval 0.25m, Track Radius 1.30m
	Remove Turns	Manually Identified
	Destripe	Median Standard Deviation 1.5
TORB202TB02_EM_HI_MSUS2.xcp	Base Settings	Interval 0.25m, Track Radius 1.30m
	Remove Turns	Manually Identified
	Destripe	Median Standard Deviation 1.5

TORB202TB02_EM_HI_MSUS3.xcp	Base Settings	Interval 0.25m, Track Radius 1.30m
	Remove Turns	Manually Identified
	Destripe	Median Standard Deviation 1.5

APPENDIX 7 – GLOSSARY OF DATA PROCESSING TERMS

The following table contains a glossary of the technical terminology used during sections 4 and 5 of this report.

Process	Definition
Break on Jump	This process calculates the distance between each data point along a traverse and if this distance exceeds the set threshold the traverse will be split into individual traverses. This process is used when there is a large gap in the collected data points caused by GNSS signal drop-out.
Clip	This process removes values outside of the defined upper and lower limits and replaces them with the upper and lower limits. It can be applied as absolute values, or as a standard deviation. The process is used to remove the skewing effect of areas of unusually high or low values in the data.
De-spike	This process identifies data points which are unusually high or low compared with those around it and replaces the values with an average value based on the surrounding points. This process is used to remove the skewing effect of spikes in the data due to ferrous objects in the topsoil.
De-stagger	This process corrects mechanical errors which occur during data collection when a traverse is started too early or too late. It shifts the traverse backwards or forwards to compensate for the error. This process is used when data is collected on steep terrain when it is difficult to keep the cart parallel with the surface.
De-stripe	This process calculates the average (Mean, Mode or Median) of each individual traverse and then deducts this value from the readings along that traverse. This transforms the values into the difference from the average instead of an absolute value. This process is used to remove the striping effect caused by neighbouring traverses being surveyed in opposite directions (heading errors). This process is sometimes referred to as a 'Zero Mean Traverse'.
Discard Overlap	This process is used to remove data points when they have been collected too close to other data points. This process is used to remove the distorting effect caused by traverses overlapping due to operator error.
High Pass Filter	This process uses either a Gaussian or uniformly weighted window to remove low-frequency noise from the data to highlight the high-frequency trends.
Interval	This process sets the size of the cells in the greyscale image of the data and thus the level of interpolation applied to the data
Low Pass Filter	This process uses either a Gaussian or uniformly weighted window to remove high-frequency trends from the data resulting in a smoothing effect.
Reduce Points	This process uses an algorithm to reduce the number of data points passed to subsequent processing step. This process is used to reduce processing time for large data sets.
Remove Turns	This process is used to separate a track of data into individual traverses when data collection was not manually stopped by the surveyor at the end of each traverse. A turn is detected by a change in direction of travel and set in degrees. This is commonly used when data is collected using a mechanical towing device.
Straighten	This process corrects sudden changes in direction along a traverse. This process is used to correct errors caused by the GNSS changing between satellite constellations which cause a slight jump in position.
Track Radius	This process sets the size of area around each data point which is included in the interpolated calculation.

APPENDIX 8 – DISCOVERY AND EXCAVATION IN SCOTLAND TEXT

Historic Environment Scotland (HES), Archaeological Survey Team, undertook electro-magnetic survey at Torbeg Cursus, Arran, North Ayrshire, Scotland, to investigate the extent and significance of potential sub-surface archaeological features within the survey area. This forms part of five-year project aimed at developing a geophysical survey capacity embedded with the Archaeological Survey Team in the Heritage Recording & Archaeology Service of Historic Environment Scotland.

The survey was conducted on 24th August 2021, in total 0.13 ha were surveyed with a CMD Mini Explorer electro-magnetic device. The geophysical surveys produced good quality results which give a high level of confidence that the methodology and survey strategy were appropriate to assess the archaeological potential of the survey area.

The survey has confirmed the location of the cursus bank and the results correlate well with the visualisations and interpretation derived from the LiDAR data. The methodology was successfully able to sense the bank's rubble core through the peat which blankets the site. This feature was more clearly identifiable in the conductivity data than the magnetic susceptibility data which was in part affected by the igneous bedrock.

The conductivity data also identified three high conductivity anomalies arranged in a row inside the cursus bank, spaced between 10m and 11m apart and running parallel with the bank. These may represent pockets of moisture trapped upslope and behind the cursus bank. Alternatively, they may represent archaeological features within the cursus monument in the form of pits or postholes.

Funder: Historic Scotland Foundation

(Project ID: TORB2021)

APPENDIX 9 – NATIONAL RECORD OF THE HISTORIC ENVIRONMENT SITE RECORD CREATION OR AMENDMENT

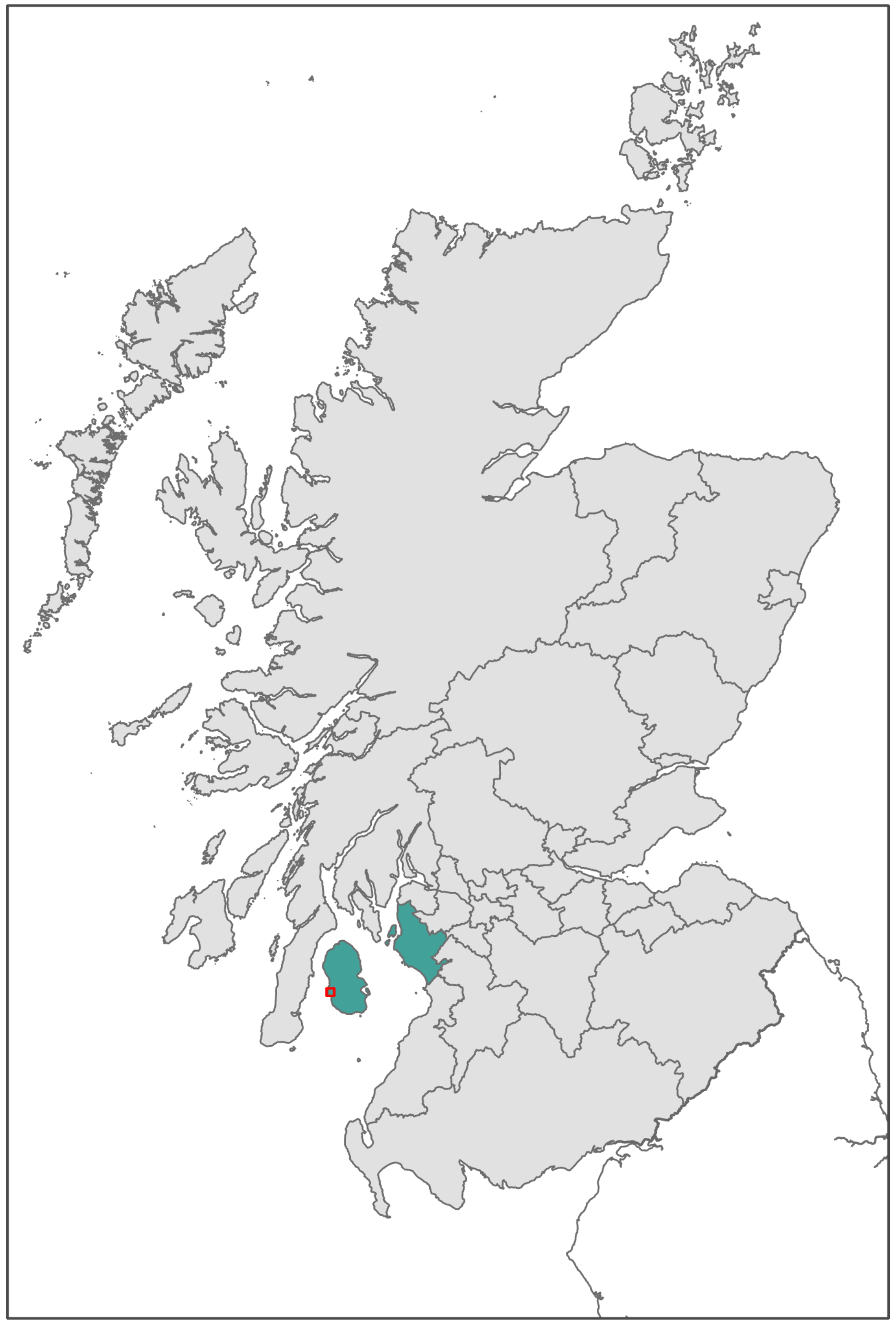
The following table details the National Record of the Historic Environment entries which have been amended or created as a result of this survey.

NRHE ID	Anomaly ID	Change	Notes
360276	TORB2021-0001	Amendment	Details of Survey added to record

APPENDIX 10 – FIGURES

Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	19/04/2022
Figure 01	Survey Location

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



Survey Area
North Ayrshire
Cursus Banks

North

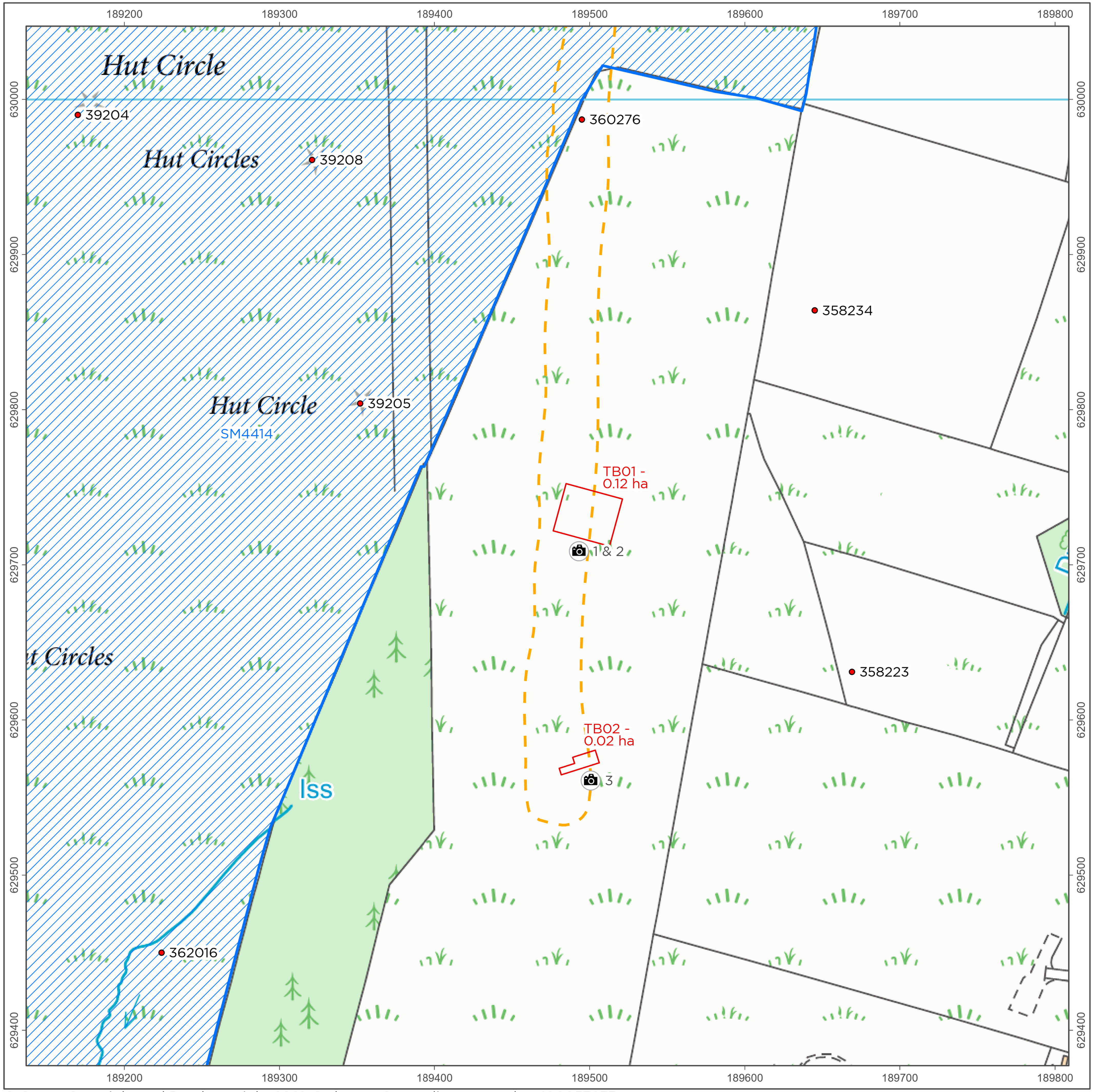
Scale: 1:12,500 @ A3

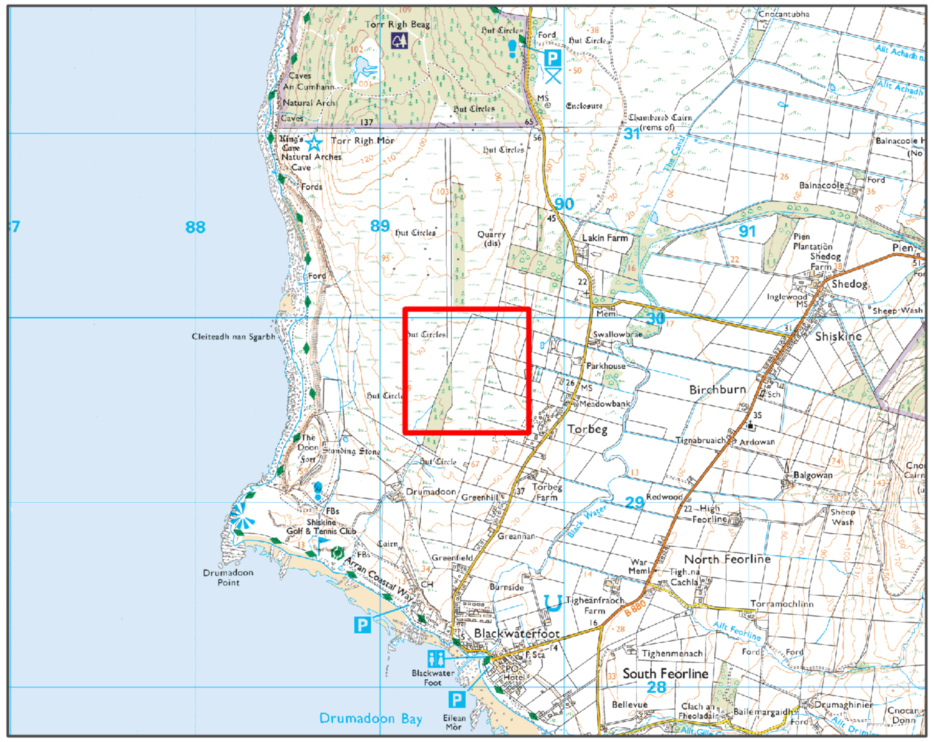
Datum: OSGB 1936

Meters: 0, 250, 500, 750, 1,000

Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	21/04/2022
Figure 02	Survey Area Showing Historic Environment & Photograph Positions

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





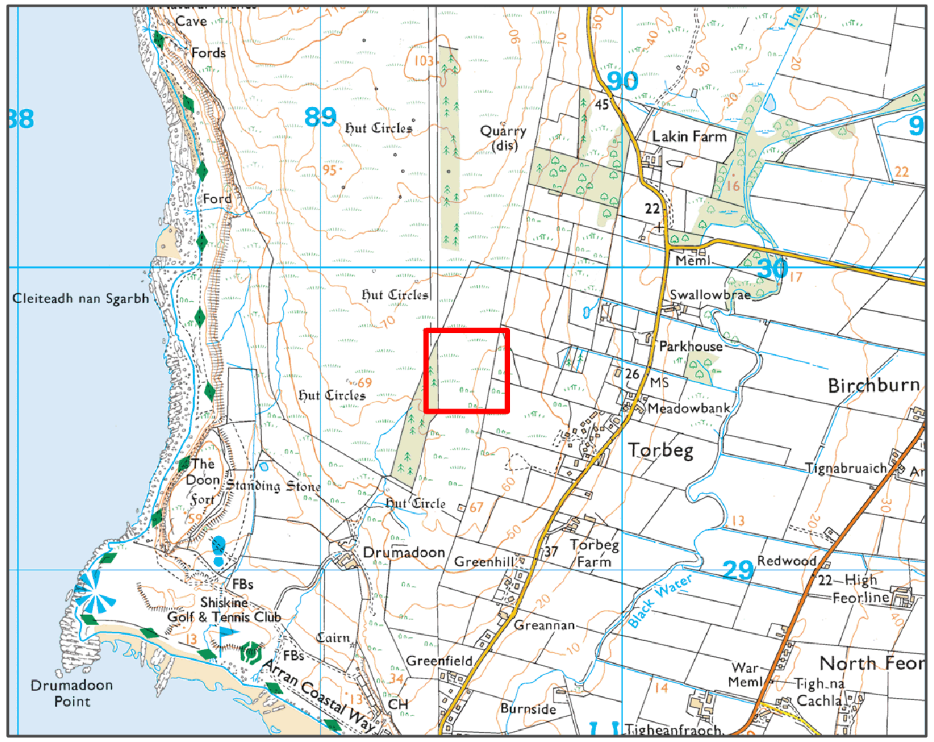
GEOPHYSICAL SURVEY
- Survey Area
- Photograph Position

HISTORIC ENVIRONMENT
- Scheduled Monument
- Cursus Banks
- NRHE Entry

North	Scale: 1:2,500 @ A3	Datum: OSGB 1936
	Metres 0 50 100 150 200	

Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	19/04/2022
Figure 03	Survey Area Showing Historic Environment & Aerial Photograph

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

- Survey Area

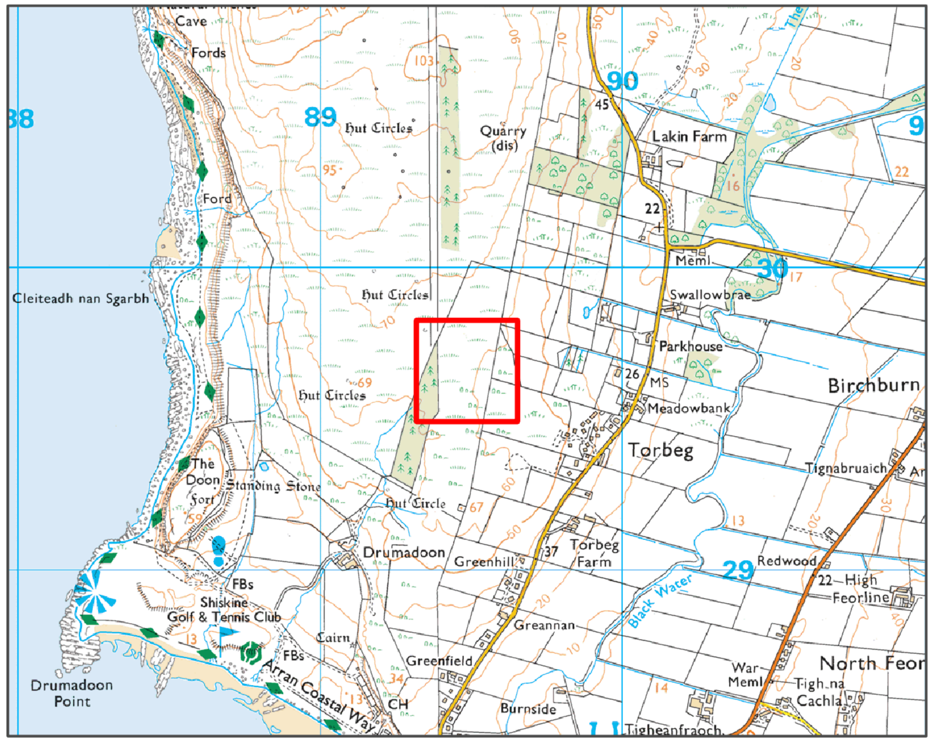
HISTORIC ENVIRONMENT

- Scheduled Monument
- Cursus Banks

North	Scale: 1:1,000 @ A3	Datum: OSGB 1936
	Metres 0 20 40 60 80	

Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	19/04/2022
Figure 04	Survey Area Showing Historic Environment & LiDAR Data

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY
- Survey Area

HISTORIC ENVIRONMENT
- Scheduled Monument

North

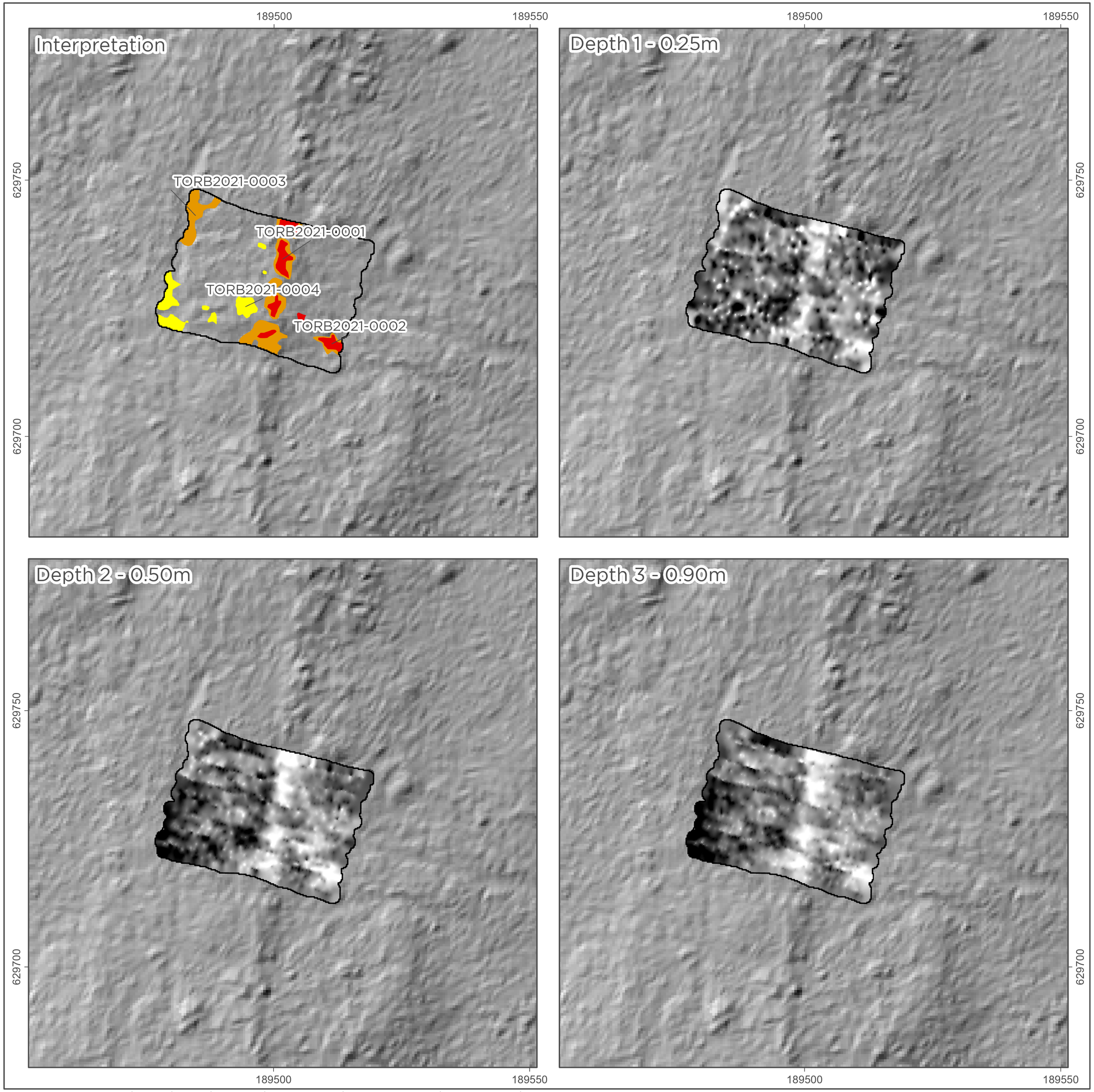
Scale: 1:1,250 @ A3

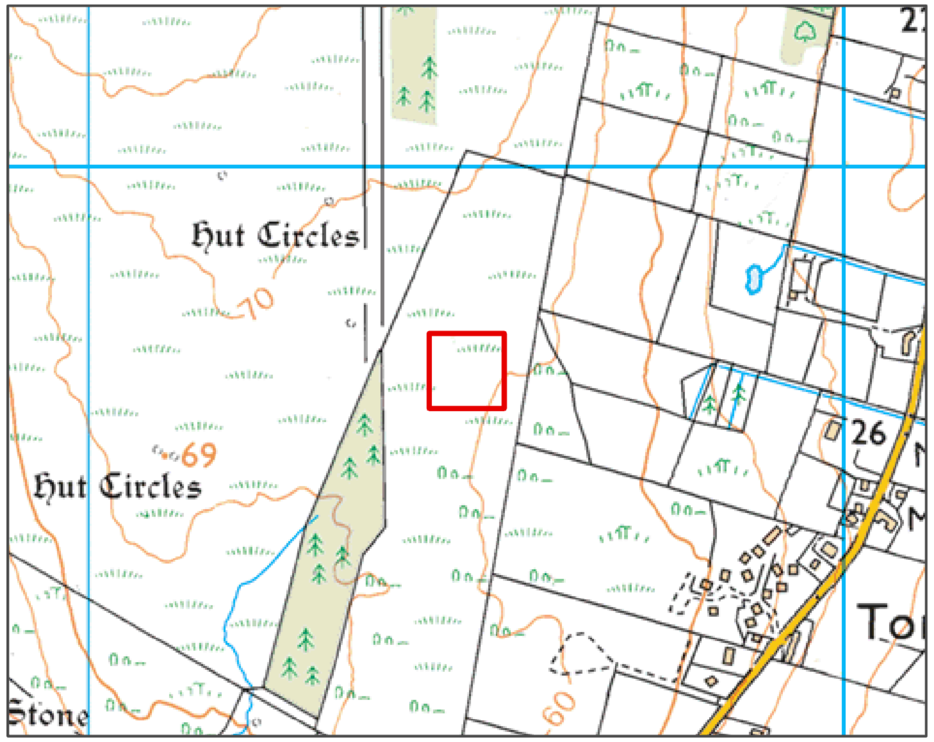
Datum: OSGB 1936

Metres 0 25 50 75 100

Figure 05	Processed Electro-magnetic Data & Interpretation Vertical Co-planar Conductivity - Area TB01
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	26/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT
Value
2 mS/m
-2 mS/m

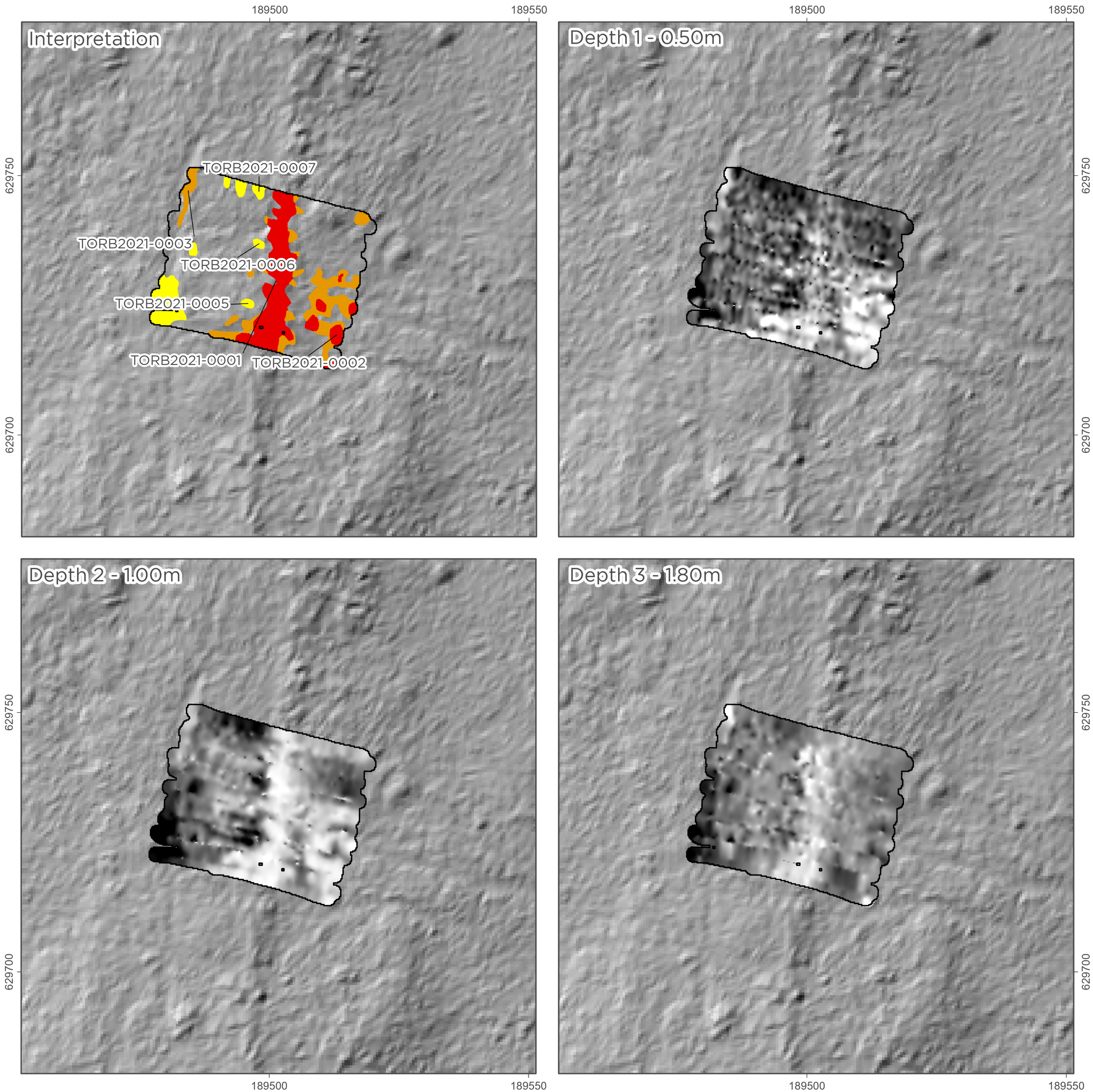
Conductivity Polygon (Low)
- Very Low Conductivity
- Low Conductivity
- High Conductivity

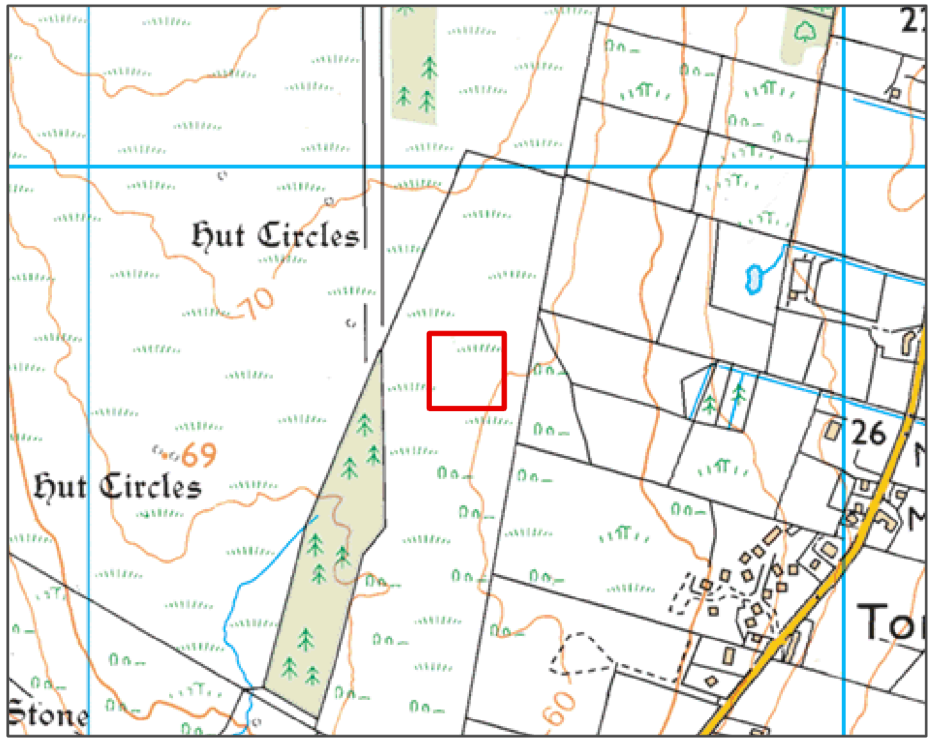
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40 50

Figure 06	Processed Electro-magnetic Data & Interpretation Horizontal Co-planar Conductivity - Area TB01
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	26/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

5 mS/m

0 mS/m

Conductivity Polygon (High)

- High Conductivity
- Low Conductivity
- Very Low Conductivity

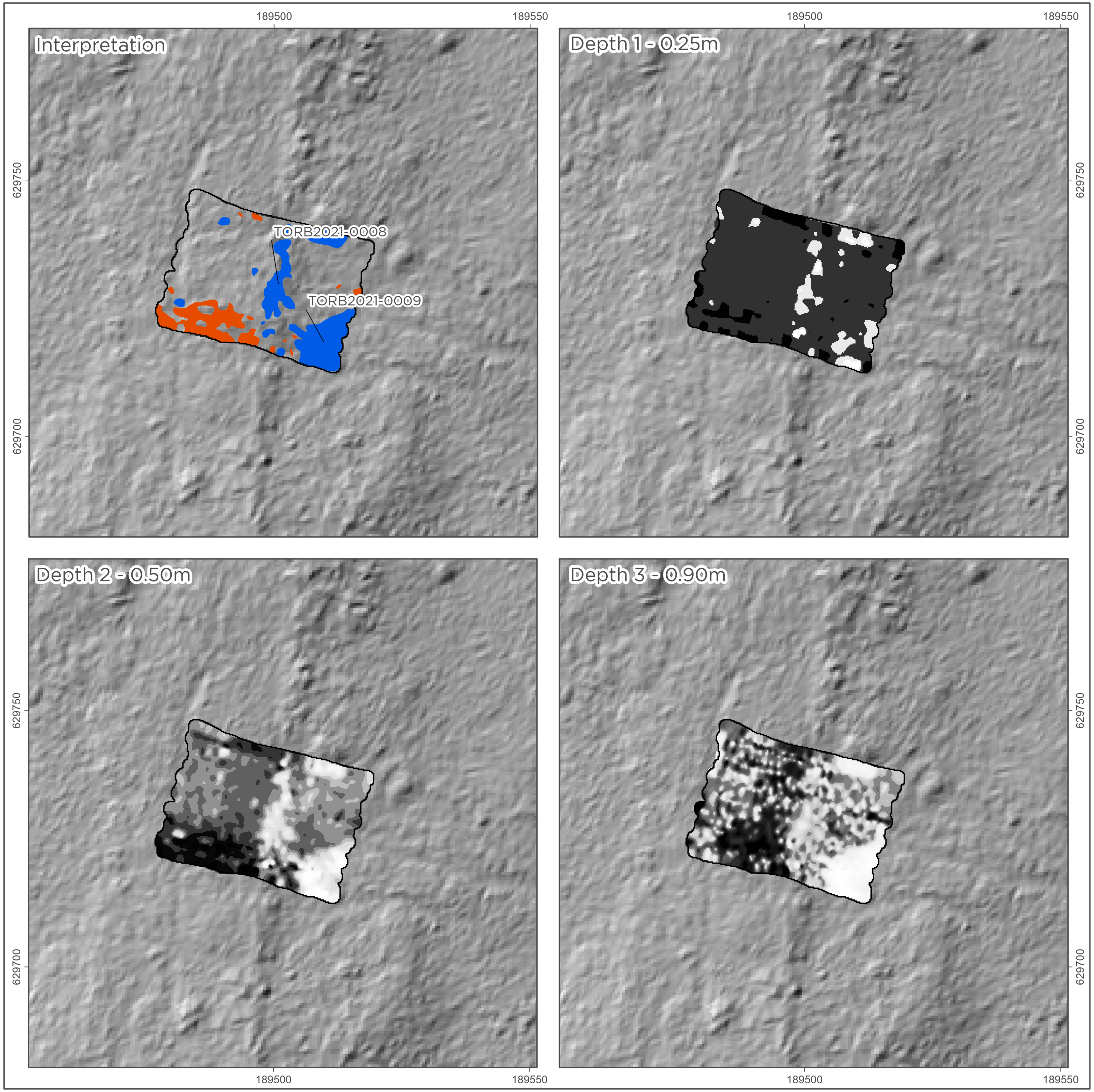
North	Scale: 1:750 @ A3	Datum: OSGB 1936

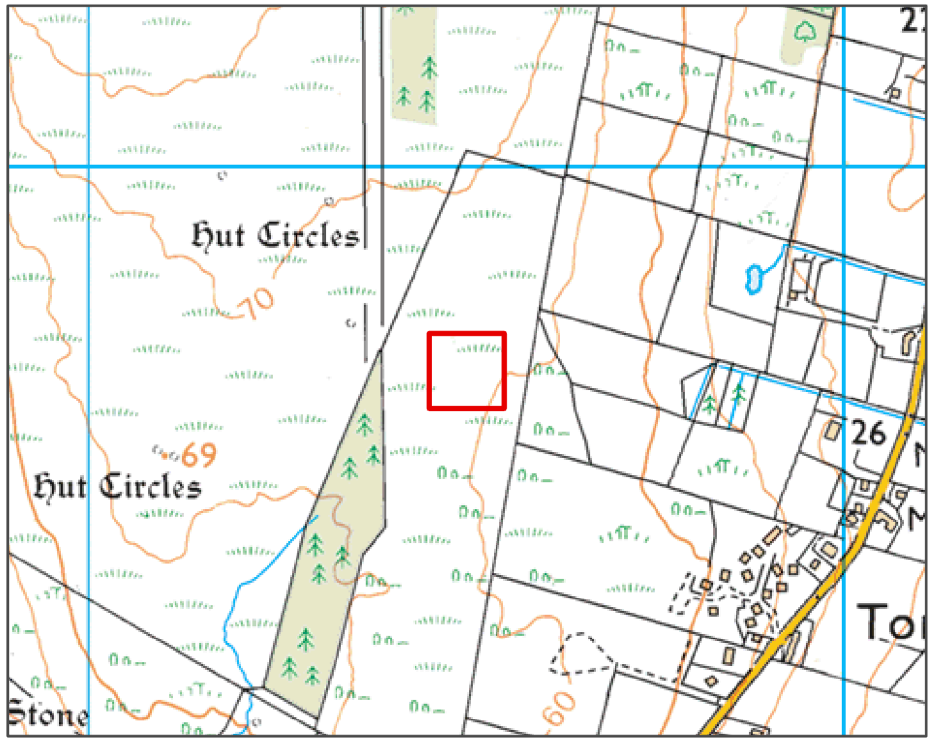
Metres

0 10 20 30 40 50

Figure 07	Processed Electro-magnetic Data & Interpretation Vertical Co-planar Magnetic Susceptibility- Area TB01
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	28/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

1 ppt

-1 ppt

Magnetic Susceptibility Polygon (Low)

- High Magnetism
- Low Magnetism

North

Scale: 1:750 @ A3

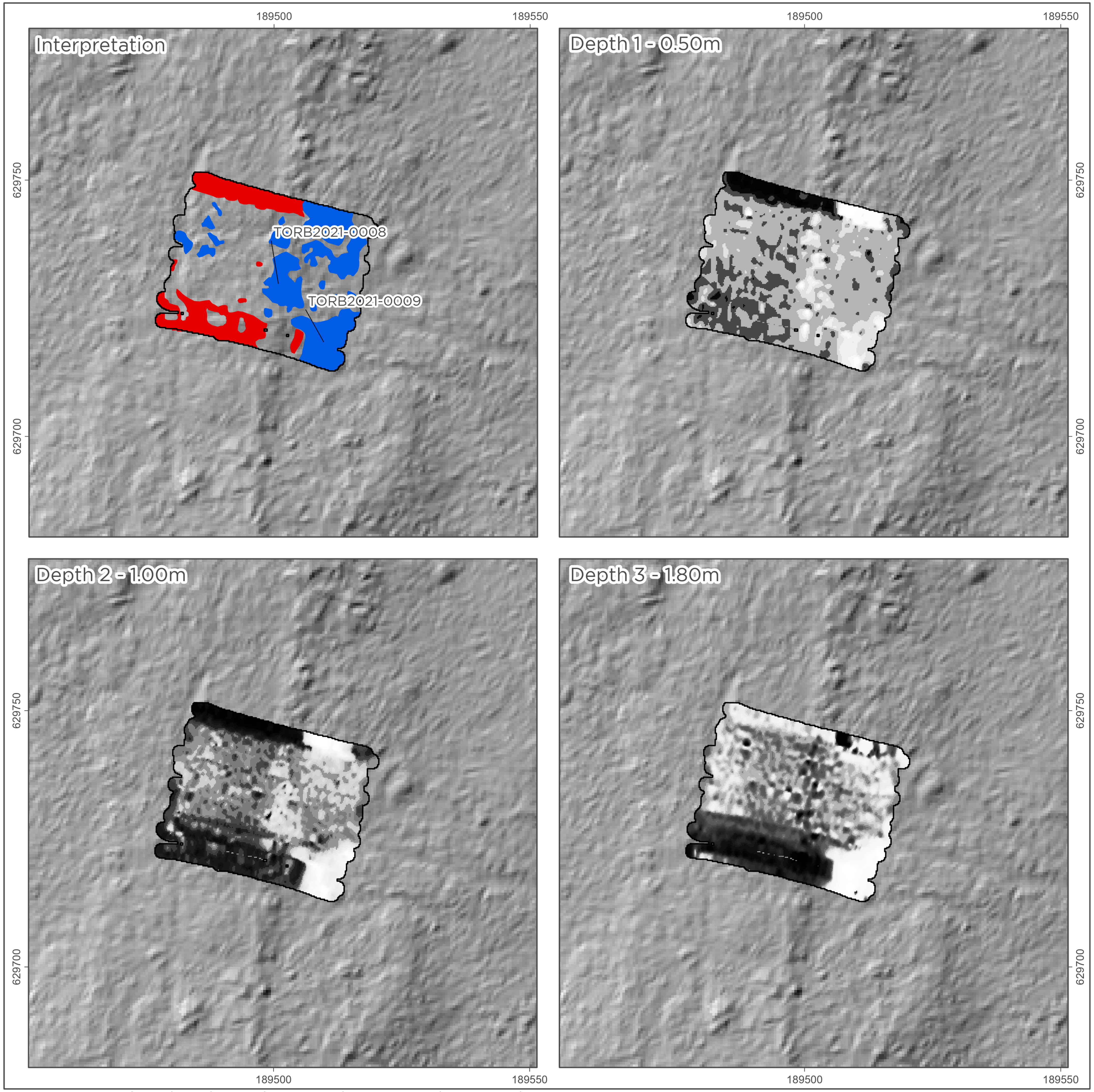
Datum: OSGB 1936

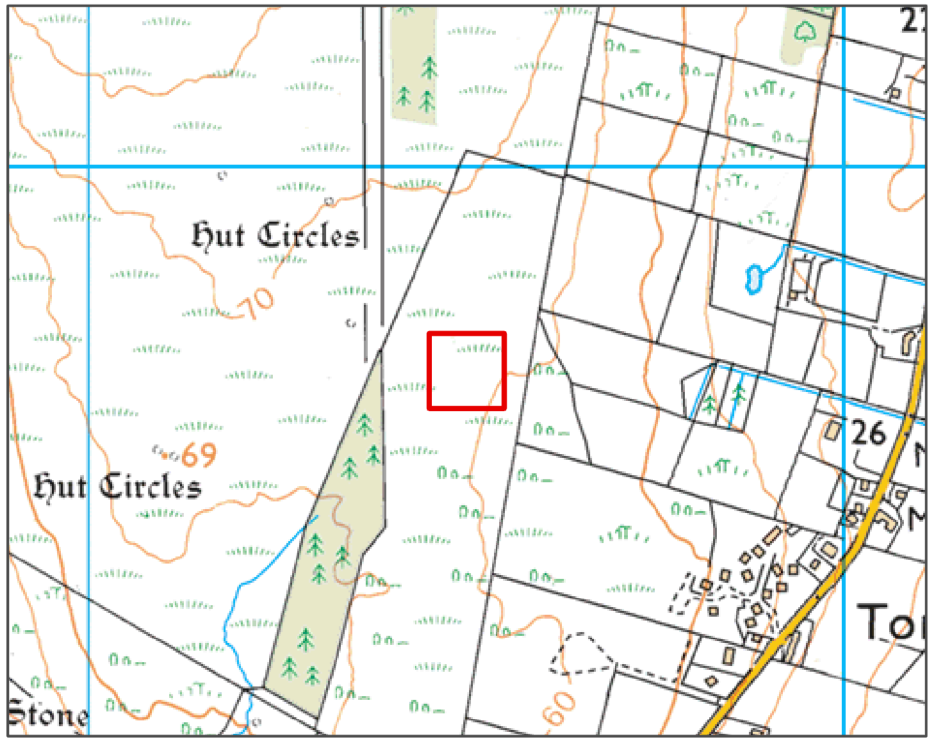
Metres

0 10 20 30 40 50

Figure 08	Processed Electro-magnetic Data & Interpretation Horizonal Co-planar Magnetic Susceptibility - Area TB01
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	26/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT
Value
1 ppt
-1 ppt

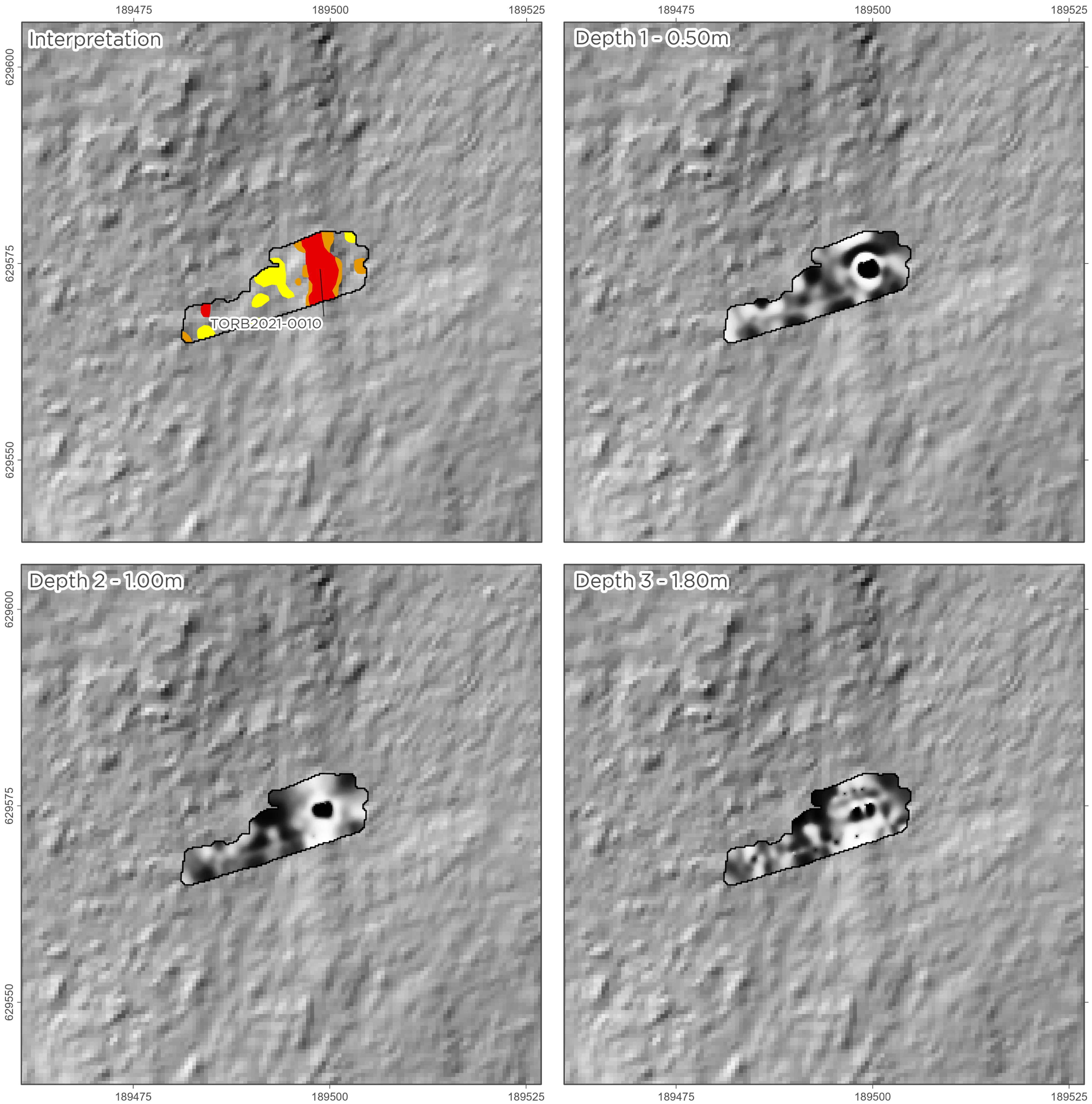
Magnetic Susceptibility Polygon (High)
High Magnetism
Low Magnetism

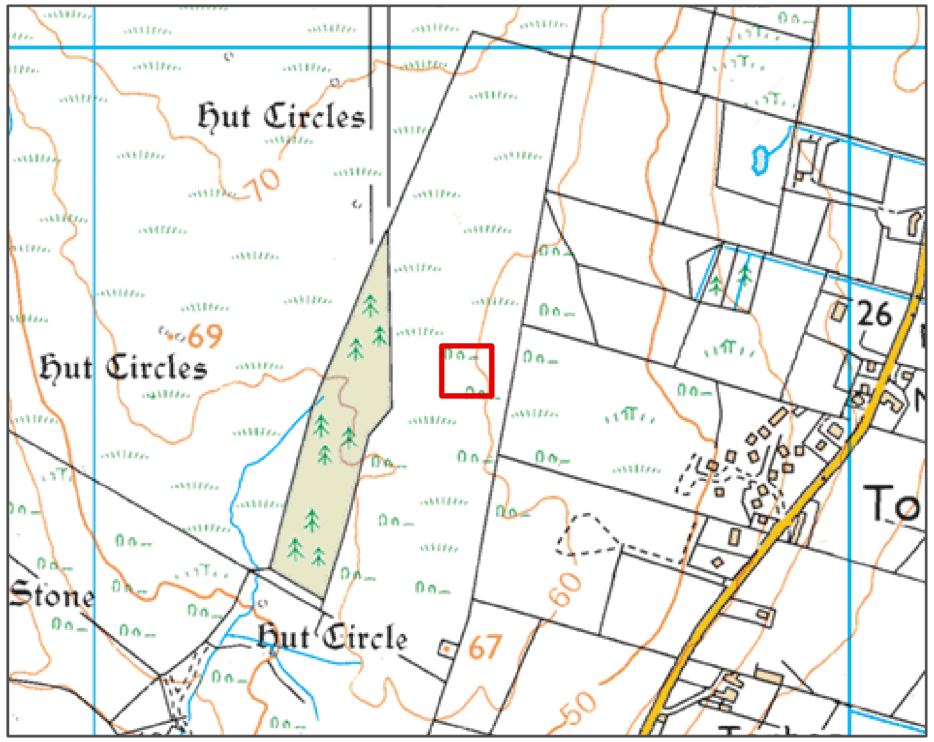
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres
0 10 20 30 40 50

Figure 09	Processed Electro-magnetic Data & Interpretation Horizontal Co-planar Conductivity - Area TB02
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	26/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

12 mS/m

-2 mS/m

Conductivity Polygon (High)

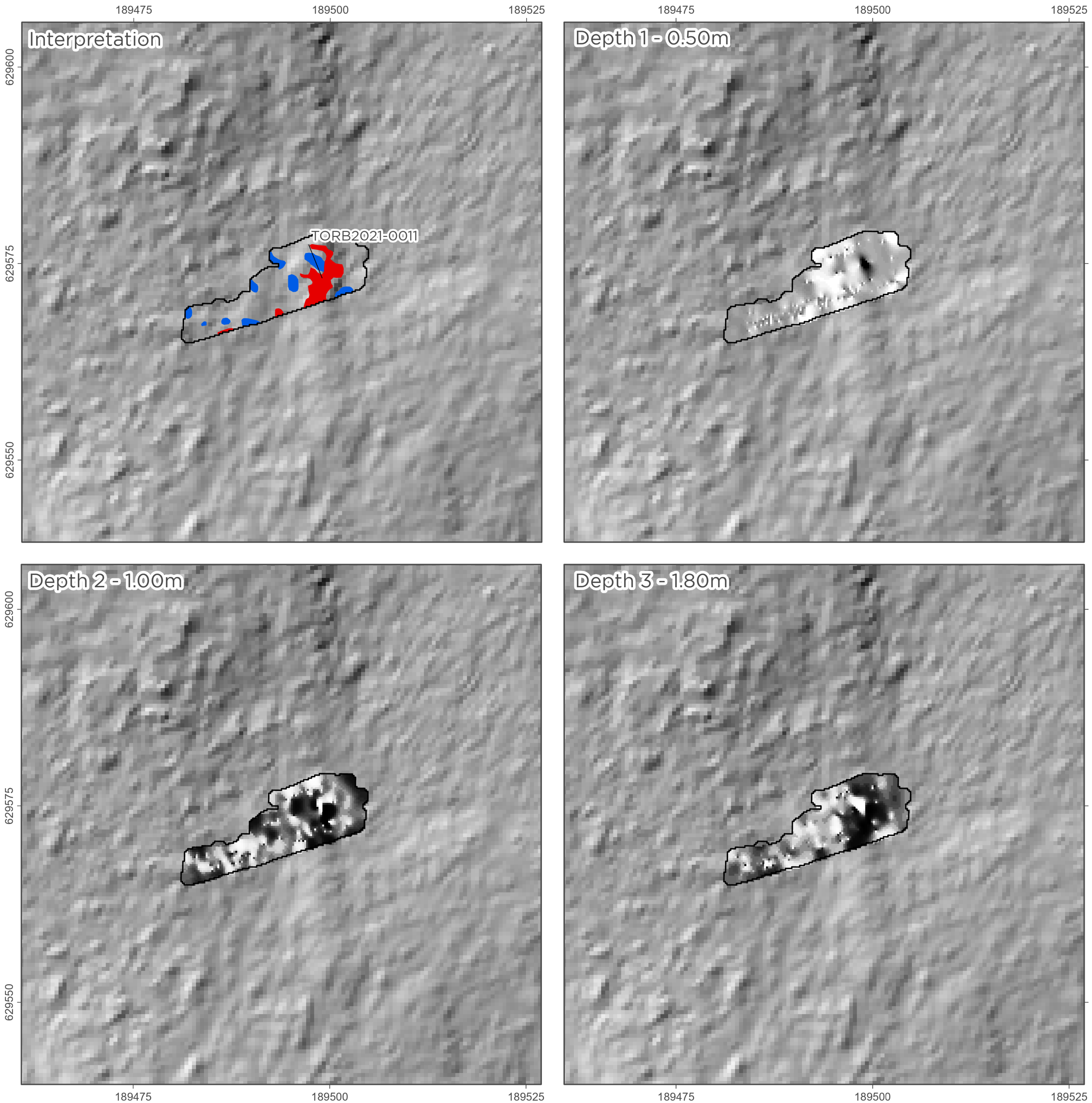
- High Conductivity
- Low Conductivity
- Very Low Conductivity

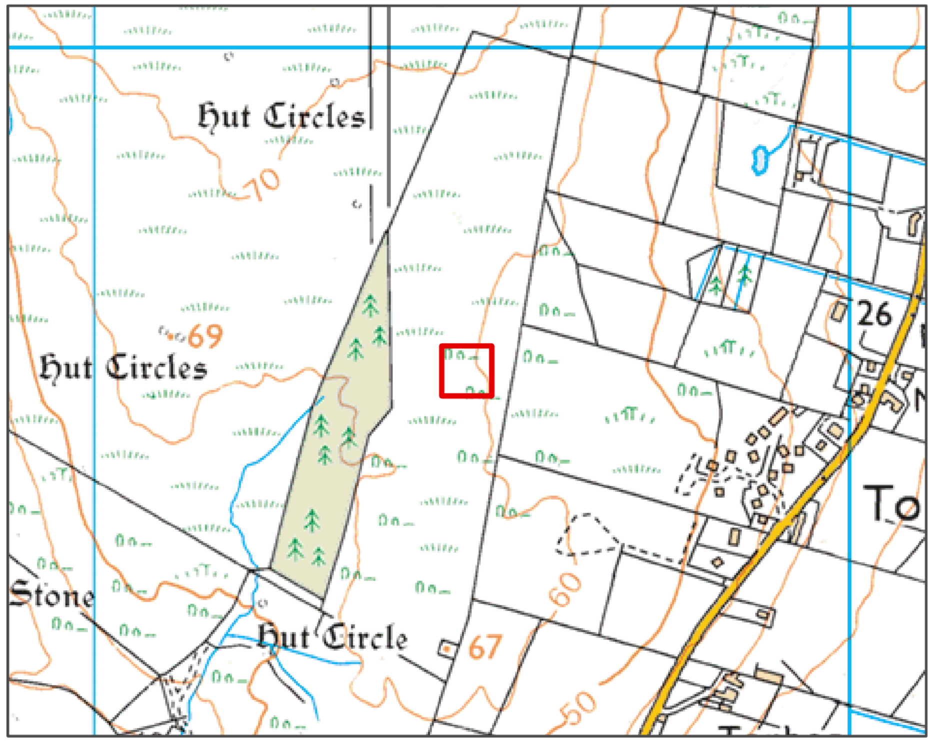
North	Scale: 1:500 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Figure 10	Processed Electro-magnetic Data & Interpretation Horizontal Co-planar Magnetic Susceptibility - Area TB02
Project Name	Torbeg Cursus
Project Code	TORB2021
Prepared By	Nick Hannon
Prepared On	26/04/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT
Value
1 ppt
0 ppt

Magnetic Susceptibility Polygon (High)
- High Magnetism
- Low Magnetism

North	Scale: 1:500 @ A3	Datum: OSGB 1936

Metres
0 10 20 30 40

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