

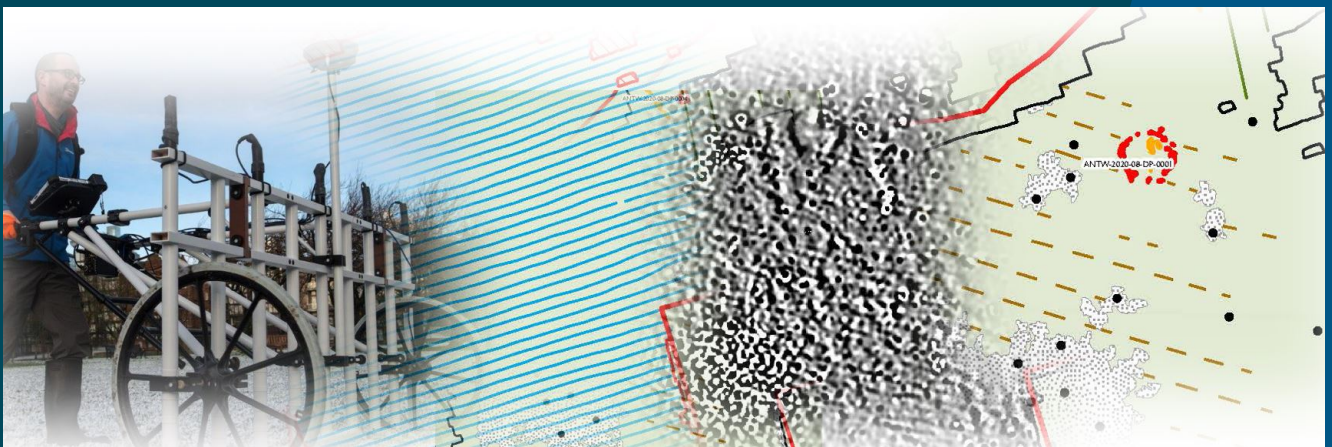


HISTORIC
ENVIRONMENT
SCOTLAND

ÀRAINNEACHD
EACHDRAIDHEIL
ALBA

WORMISTON RINGS

GEOPHYSICAL SURVEY REPORT



HES PROJECT NUMBER: WORM2021
NGR: NT 2345 4548
DATE: JULY 2022
AUTHOR: Hazel Blake

EXECUTIVE SUMMARY

Historic Environment Scotland (HES), Archaeological Survey Team, undertook geophysical (gradiometer) survey at Wormiston Rings fort, The Scottish Borders, Scotland. This project aimed to support investigation into effective methods of integrating multiple datasets for recording earthwork and sub-surface archaeological remains, using geophysical and topographic datasets. Fieldwork was undertaken on 28 April 2021.

In total 0.98ha were surveyed with a Sensys MXPDA gradiometer. The geophysical surveys produced good quality results which give a high level of confidence that the methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

The survey produced the following results:

- Confirmed the location of Wormiston Rings and three associated defensive ditches.
- Identified potential defensive ditch curving to the south.
- Identified six possible roundhouses.
- Identified a palisaded enclosure
- Identification of two potential trackways.
- Identification of an area of burning.
- Identification of three sets of angular features of potential archaeology.

This survey has led to the creation of 1 new entry and the addition of information to 2 entries in the National Record of the Historic Environment.

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

Version:	WORM2021-Report-v1.3		
Author:	Hazel Blake and Nick Hannon	Date:	13/01/2023
Quality Checked by:		Date:	



Contents

EXECUTIVE SUMMARY	i
LIST OF IMAGES.....	iii
LIST OF FIGURES.....	iii
1.0 - INTRODUCTION.....	4
2.0 – PROJECT BACKGROUND & AIMS.....	4
3.0 – SITE LOCATION & DESCRIPTION	4
4.0 – ARCHAEOLOGICAL BACKGROUND	5
5.0 – SURVEY METHODOLOGY	5
5.1 – GRADIOMETER SURVEY	5
6.0 – SURVEY RESULTS & INTERPRETATION.....	6
6.1 – AREA WM01 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES.....	6
6.2 – AREA WM01 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES	7
6.3 – AREA WM01 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES	8
6.4 – AREA WM01 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES	8
6.5 – AREA WR01 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES.....	8
6.6 – AREA WM01 GRADIOMETER SURVEY – MODERN FEATURES.....	8
6.7 – AREA WM01 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS.....	8
7.0 – CONCLUSIONS	8
8.0 – CAVEATS	9
9.0 – ARCHIVE DEPOSITION	9
10.0 – BIBLIOGRAPHY	11
11.0 – IMAGES.....	12
12.0 – FIGURES.....	14
APPENDIX 1 – SURVEY METADATA.....	15
APPENDIX 2 – CALIBRATION CERTIFICATES.....	16
APPENDIX 3 – IDENTIFIED ANOMALIES.....	17
APPENDIX 4 – GLOSSARY OF ANOMALY TYPES.....	18
APPENDIX 5 – DATA PROCESSING METHODOLOGY	20
APPENDIX 6 – DATA PROCESSING STEPS.....	21
APPENDIX 7 – GLOSSARY OF DATA PROCESSING TERMS.....	22
APPENDIX 8 – DISCOVERY AND EXCAVATION IN SCOTLAND TEXT	23
APPENDIX 9 – NATIONAL RECORD OF THE HISTORIC ENVIRONMENT SITE RECORD CREATION OR AMENDMENT	24

LIST OF IMAGES

Image 1	
Image 2	
Image 3	
Image 4	

LIST OF FIGURES

Figure 1	Site location	1:50,000
Figure 2	Survey areas showing photo positions	1:750
Figure 3	Geology solid and Drift	1:750
Figure 4	Pedology	1:750
Figure 5	Environment Agency 0.5m LiDAR DSM for the survey area	1:750
Figure 6	Gradiometer survey area showing GNSS survey swaths & calibration position	1:750
Figure 7	Minimally processed greyscale gradiometer data	1:750
Figure 8	Processed greyscale gradiometer data	1:750
Figure 9	XY trace plot of minimally processed gradiometer data	1:750
Figure 10	Interpretation of gradiometer data	1:750

1.0 - INTRODUCTION

Historic Environment Scotland (HES), Archaeological Survey Team, undertook geophysical (gradiometer) survey at Wormiston Rings fort, The Scottish Borders, Scotland. Fieldwork was undertaken on 28th April 2021.

2.0 – PROJECT BACKGROUND & AIMS

The survey forms part of an ongoing programme of research into remote sensing methods for archaeological survey by the Archaeological Survey Team in Heritage Recording and Archaeology Service at Historic Environment Scotland. The geophysical survey is part of a five-year Historic Scotland Foundation funded project aimed at developing a geophysical survey capability at HES.

Geophysical survey of Wormiston Rings intended to establish the relative effectiveness of gradiometry in identifying sub-surface archaeological features at the site. Beyond this general aim, the survey intended to address the following questions:

- To what extent does the use of multiple methods enhance understanding of the site's archaeology?
- Can the fort's ramparts and ditches be identified in the gradiometer data?
- Can any structures be identified within the fort?
- Can any previously unknown features be identified?

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

Wormiston Rings fort is situated 5km north-northeast of Peebles, The Scottish Borders, Scotland (Figure 1). The site is located at 233m AOD on a promontory between Wormiston Dean to the north and west, and Eddleston Water to the east. The ground to the southwest rises gradually towards the summit of White Meldon 3km away where it reaches an elevation of 427m AOD. The survey area, WM01, (centred on NT 2345 4548) covers a total area of 1ha and lies in an area of pasture 500m southeast of Wormiston (Figure 2). It is bound by dry-stone walls to the north, south and west, and open to the east.

The solid geology is recorded as Portpatrick Formation – Wacke, Sedimentary Rock Cycles. This is overlain with superficial deposits of Glaciofluvial Deposits – Gravel, Sand, and Silt (BGS 2022) (Figure 03). The site's soil is recorded as Brown Earth (Scotland's Soils 2022 (Figure 04).

The survey area comprises of a single land parcel, referred to hereafter as WM01, which contains the remains of Wormiston Ring fort. The area is in private ownership and access was kindly granted on an unconditional basis.

The survey area is not within a Scheduled Monument, so as per The Scheduled Monument Consent Procedure (Scotland) Regulations 2015, a Metal and Mineral Detecting Consent was not required.

The survey area is not within a Site of Special Scientific Interest. It is not protected under the Ramsar Convention or contained within a National or Regional Park and is not a nature reserve (NatureScot 2022). Reference to the National Biodiversity Network's Atlas for the survey area and a 200m buffer surrounding it showed the area contained no sightings of flora or fauna which required the granting of a licence for this survey to be conducted (NBN 2022). Therefore NatureScot were not consulted regarding the survey.

During the survey the weather conditions were cold with occasional snow showers.

A photographic record showing the survey area and ground conditions for both visits can be found in Section 11.0 – IMAGES.

4.0 – ARCHAEOLOGICAL BACKGROUND

Wormiston Rings fort (NRHE ID: [51423](#)) is a prehistoric fort, roughly oval on plan and measuring about 90m from north to south by 70m east to west internally. The site is protected to the north and west by the steep sided Wormiston Burn and to the south and east by ramparts. Soil marks observed by RCAHMS in 1959 suggest that the defences comprised two ramparts and ditches, although these have been heavily ploughed leaving only fragments upstanding. A possible entrance was observed to the west on the lip of the steep slope down to Wormiston Burn, while aerial photography shows a second entrance to the east. More recent aerial photography suggests this entrance may open onto a scooped area measuring around 50m across. This could represent a later settlement.

A second slightly smaller prehistoric fort (NRHE ID: [70105](#)) lies immediately to the south of Wormiston Rings. It is roughly circular on plan and measures about 45m across within a double palisade or ditch. No entrance has been identified. As the two forts lie so close together their defences may intersect.

5.0 – SURVEY METHODOLOGY

All surveys were 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 (Sensys 2019). All sensors had valid in-date calibration certificates which are included in APPENDIX 2 – CALIBRATION CERTIFICATES.

5.1 – GRADIOMETER SURVEY

The gradiometer survey was conducted using a hand propelled Sensys MXPDA system mounted on a Sensys F-type non-magnetic cart, with standard profile wheels. This system utilised five Sensys FGM650/3 sensors operating at 100hz, mounted at a 0.5m sensor separation with bases positioned 0.05m from the surface. The system was balanced prior to the commencement of the survey, with the calibration position shown in Figure 5.

The survey was conducted by walking parallel traverses in a zig-zag pattern, with traverses aligned north-south and positioned 2.5m apart. Navigation was provided by MONMX, the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. The position of the traverses is shown as a "breadcrumb" trail in Figure 5. Data points were recorded every 0.125m along each traverse, with positional accuracy provided by a Leica GS16 GNSS antenna mounted directly on the frame of the cart at a height of 1.5m. 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.

Data was logged using the system's MONMX v.5.01-03/00 software package on a Panasonic FZ-G1 tablet computer in .prm format. Following the completion of the survey the data was then exported from the system in both .asc and .uxo formats. The .uxo file was processed and visualised using DW Consulting's Terrasurveyor v3.0.36.10 and the .asc file retained for archiving purposes. Interpretations of this data were then generated using ESRI ArcGIS Pro v2.8.6.

Data quality was maintained by avoiding ferrous objects within the survey such as fences, gates and inspection covers where possible.

Gradiometer survey can be affected by the site's underlying geology. High levels of background magnetism are often experienced in locations with igneous or metamorphic geologies. This can mask the subtle changes in the magnetic field associated with archaeological remains, making them difficult to detect. The sedimentary bedrock formations (Portpatrick Formation) recorded at the site are expected to exhibit low levels of background magnetism and therefore provide a good response to this methodology (EH 2008: 15).

A total of 0.98 hectares of data were collected during the visit, employing this methodology.

6.0 – SURVEY RESULTS & INTERPRETATION

The following section presents the results obtained using the data collection methodology detailed in Section 5 and the data processing methodologies in Appendices 5, 6, and 7. The results are dealt with by methodology, and anomaly type.

A total of 0.98ha of the planned 1ha for survey were surveyable (Figure 6). As the data was collected along the contours of the hill, this has generated a banding artefact within the processed data.

The figures relating to these results and interpretations can be found in Section 13.

The gradiometer results have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 7) and fully processed data displayed at -3/3nT (Figure 8). XY trace plots have been produced (Figure 9), along with a graphical interpretation of the data (Figure 10). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

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

6.1 – AREA WM01 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area WM01 four anomalies of probable archaeological origin have been identified within the gradiometer data.

The first, **WORM2021-0001**, comprises a band of positive anomalies. It defines a curving feature which originates in the west of the survey area and runs in a south easterly direction to the southern extent of the survey area, before curving to the north and continuing to the northern extent of the survey area. This probably represents part of a circular ditch measuring 80m in diameter and 2m in width

The second group of features is comprised of two diffuse curving bands of positive gradiometer responses, **WORM2022-0011** and **WORM2021-0012**. These range from 1.4 m to 5.5m wide and measure 90m in length. WORM2021-0012 bifurcates 52m from the

northern survey extent. Together they form part of the defensive ditch system. This feature corresponds well with cropmarks recorded on the aerial photographs of the site.

Details of the above have been added to NHRE [51423](#).

A third feature, **WORM2021-0010**, is located in the southwest of the survey area and is formed of a band of positive responses. It measures 2.5m wide and 19.5m in length and curves slightly along its length, curving in the opposite direction to WORM2021-0001. As such, it probably forms part of a larger feature located to the south of WM01 and may represent a section of the ditch of the fort immediately to the south of Wormiston Rings (NRHE ID: [70105](#)).

Details of the above have been added to NRHE [70105](#).

6.2 – AREA WM01 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area WM01 several anomalies of possible archaeological origin have been identified in the gradiometer data.

The first feature, **WORM2021-0002**, is located in the north of the survey area between the two defensive ditches WORM2021-0011 and WORM2021-0012. A series of positive responses form a ring measuring 4.2m in diameter. This feature is possibly a roundhouse and has been added to NHRE [51423](#).

The second anomaly **WORM2021-0003** is a series of positive responses that form three interlocking rings. These are located in the southwest of the survey area and each measures around 10m in diameter. These features may represent roundhouses and, as they overlie one another, may indicate a sequence of roundhouse construction in this location. This feature has been added to NHRE [51423](#).

The next anomaly **WORM2021-0015** is a series of positive responses that form a weak linear trend that intersects WORM2021-0001, WORM2021-0011 and WORM2021-0012. This feature originates in the centre of the survey area and runs from west to southeast. It measures approximately 2m in width and 56m in length. This may represent a track way and therefore could indicate the location of an entrance, though it equally may represent a track of any date. This feature has been added to NHRE [51423](#).

A further anomaly **WORM2021-0005** is a series of positive responses that form two interlocking rings. These are located in the centre of the survey area and measure 12.5m in diameter. These features may represent roundhouses and, as they are overlapping, suggest a sequence of roundhouse construction in this location. This feature has been added to NHRE [51423](#).

On the north edge of WORM2021-0005 is **WORM2021-0013**. This feature is a well-defined but a strong magnetic response and measures 2.9m by 2.1m. The high magnitude nature of this response suggests it is an area of burning.

To the south of WORM2021-0005 and west of WORM2021-0001 is feature **WORM2021-0004**. This feature is formed of a pair of linear trends, set between 4m and 7m apart and running from north to south for a distance of 10m before turning to the west and extending for a further 13m. This feature may relate to settlement activity within the fort. This feature has been added to NHRE [51423](#).

Anomaly **WORM2021-0006** lies in the north of the survey area and is formed of a pair weak linear trends that define a semi-circle measuring 35m in diameter. It originates in the north of the survey area and curves to the southeast. This feature possibly represents a palisaded enclosure inside WORM2021-0001 and has been added to NHRE [51423](#).

Located to the west of WORM2021-0006, is **WORM2021-0014**. This is formed of several weak positive responses, defining a broadly rectangular feature measuring 4m north to south by 3m, open to the east. This feature may relate to settlement activity of the fort and may represent a small enclosure, however a more modern origin cannot be discounted. This feature has been added to NHRE [51423](#).

To the south of WORM2021-0014, is **WORM2021-0007**. This feature is formed of a weak linear trend extended from southwest to northeast, measures 35m in length and 1.60m wide. It bisects WORM2021-0006 and may represent a trackway. This feature has been added to NHRE [51423](#).

To the west of WORM2020-0003 is **WORM2021-0016** and **WORM2021-0017**. Both of these features are formed of a weak positive response. WORM2021-0016 curves slightly along its length and extends from northwest to east for 21.4m. WORM2021-0017 is orientated from southwest to northeast and is 11.7m in length. Both features may relate to settlement activity associated with the fort and have been added to NHRE [51423](#).

The final anomaly of possible archaeology origin is **WORM2021-0009**. This is a pair of weak positive trends located in the southeast of the survey area. Both are L-shaped on plan, possibly representing sections of an enclosure or, as their northern edges are not aligned, sections of two enclosures. The western feature measures 19.5m in length, with the eastern 21m in length. This feature has been added to NHRE.

6.3 – AREA WM01 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

No anomalies of historical agricultural origins have been identified in the gradiometer data.

6.4 – AREA WM01 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

No anomalies of modern agricultural origins have been identified in the gradiometer data.

6.5 – AREA WR01 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

No anomalies of geological and fluvial origins have been identified in the gradiometer data.

6.6 – AREA WM01 GRADIOMETER SURVEY – MODERN FEATURES

No anomalies of modern origins have been identified in the gradiometer data.

6.7 – AREA WM01 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

No anomalies of unknown or uncertain origins have been identified in the gradiometer data.

7.0 – CONCLUSIONS

The geophysical survey has produced good quality gradiometer 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 was appropriate to assess the archaeological potential of the survey area. Unfortunately, additional datasets were not captured using the UAV due to operational reasons, therefore any comparison between datasets was not possible.

The survey has confirmed the eastern and southern extent of the fort's ditches along with several internal features which may be contemporary with the fort. A previously unknown palisaded enclosure has been identified, which is likely to pre-date the construction of the fort's ditches. The survey also positively identified what may be a section of the ditch of the relating to the fort south of the survey area.

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

- *To what extent does the use of multiple methods enhance understanding of the site's archaeology?* Unfortunately, the additional datasets which were due to be collected using a UAV platform could not be captured for operational reasons, therefore a comparison was not possible.
- *Can the fort's ramparts and ditches be identified in the gradiometer data?* The location of the fort's ditches have been confirmed within the gradiometer data.
- *Can internal structures be identified?* Several internal features have been identified within the fort, some of which may be contemporary with the occupation of the site. This includes features interpreted as possible overlapping roundhouses, therefore potentially representing sequences of roundhouse construction within the fort.
- *Can previously unknown features be identified?* The survey has successfully identified several features of archaeological or possible archaeological origins which were previously unknown. This includes the two trackways, a series of roundhouses and a palisaded enclosure.

In summary the survey has confirmed the location and extent of the fort and its defences, along with additional archaeological features, some of which may be contemporary with the fort. This adds significantly to our understanding of the site.

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. As the interpretation of the results has led to the identification and creation of one new site, and two NRHE site records have been amended. A list of these can be found in Appendix 9.

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 a .txt files.
- Processed survey data supplied as a .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

BGS 2021. *British Geological Survey, Geology of Britain Viewer*.

<http://bgs.ac.uk/data/mapviewers/home> [last accessed 31/10/2022]

ClfA 2016. *The Chartered Institute for Archaeologists, Standards and Guidance for Archaeological Survey*.

https://www.archaeologists.net/sites/default/files/ClfAS%26GGeophysics_2.pdf [last accessed 31/10/2022]

Crown copyright Scottish Government, SEPA and Fugro (2020).

DWC 2019. *TerraSurveyor, User Manual, Program Version 3.0.36*. DW Consulting: Barneveld.

EH 2008. *Geophysical Survey in Archaeological Field Evaluation*. English Heritage: Swindon.

HES 2020b. *Geophysical Survey, Standard Operating Procedure*. Edinburgh: HES.

NatureScot 2021. *NatureScot Map Search*. <http://sitelink.nature.scot/map> [last accessed 31/10/2022]

Kokalj, Ž., Somrak, M. 2019. Why Not a Single Image? Combining Visualizations to Facilitate Fieldwork and On-Screen Mapping. *Remote Sensing* 11(7): 747.

NBN 2021. *NBN Atlas Explore Your Area*. <http://nbnatlas.org> [last accessed 31/10/2022]

NLS 2021. *National Library of Scotland Map Viewer*. <http://maps.nls.uk/geo/explore/side-by-side> [last accessed 31/10/2022]

NRHE 2021. *Historic Environment Scotland*. <http://canmore.org.uk> [last accessed 31/10/2022]

Scotland's Soils 2021. *National soil map of Scotland*.

https://map.environment.gov.scot/Soil_maps/?layer=1t [last accessed 31/10/2022]

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. & Fassbinder, J. 2016. *EAC Guidelines for the use of geophysical survey in archaeology: Questions to ask and points to consider*. Archaeolingua: Budapest.

Sensys 2019. *Manual, MAGNETO®MXPDA Measurement System, version 7.1*. Sensys: Bad Saarow.

11.0 – IMAGES



Image 1 – This is taken from the northwest corner looking south at the unsurveyable area (DP####)



Image 2 – Northeast corner of survey area looking south (DP####)



Image 3 – Northeast corner of survey area looking east (DP####)



Image 4- Northwest corner of survey area looking east (DP####)

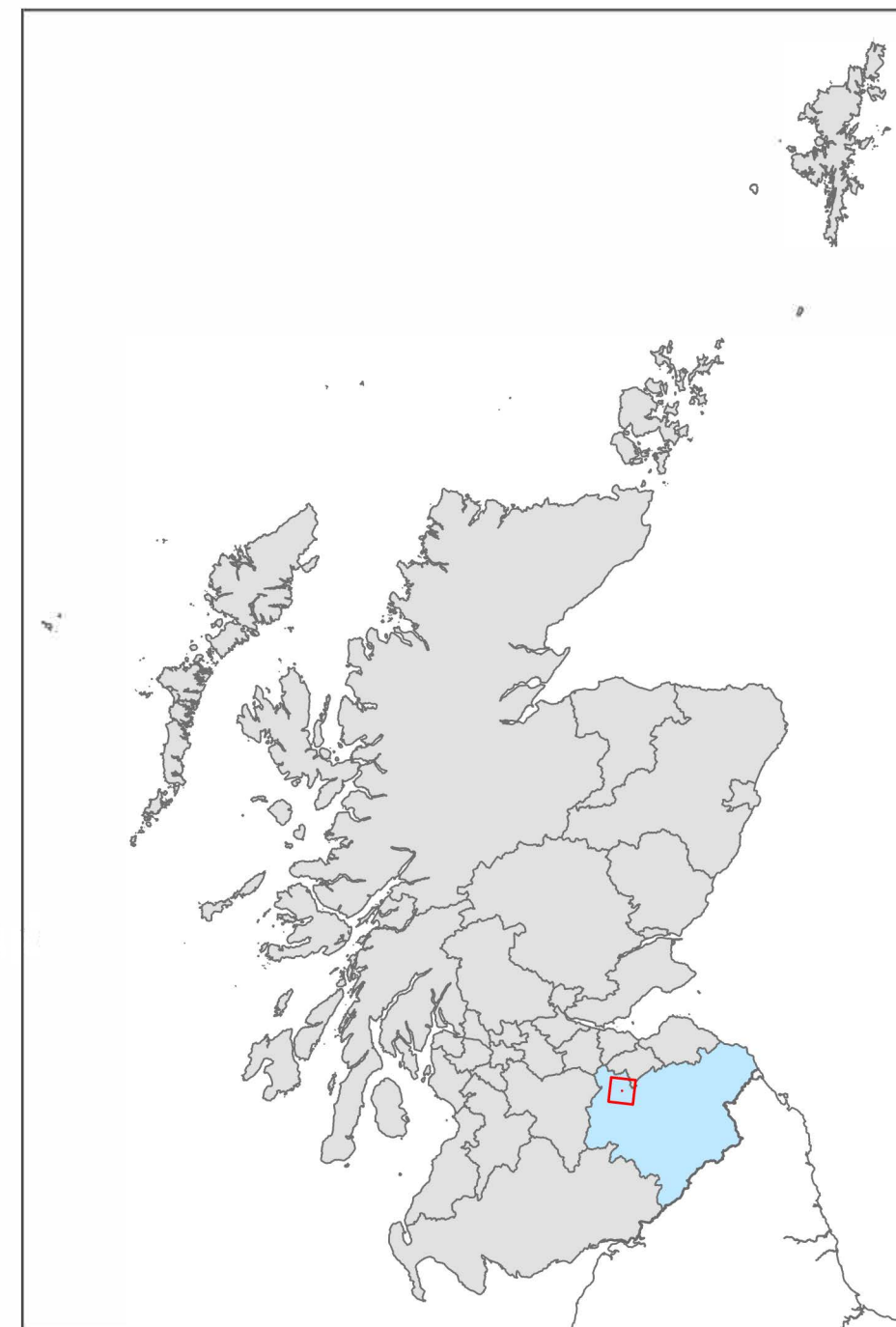
12.0 – FIGURES



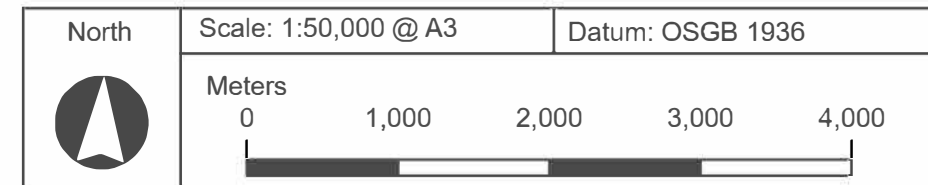
Figure 01

Survey Location

Project Name	Wormiston Rings
Project Code	WORM2021
Prepared By	Hazel Blake
Prepared On	24/10/2022



- Survey Area
- Scottish Borders



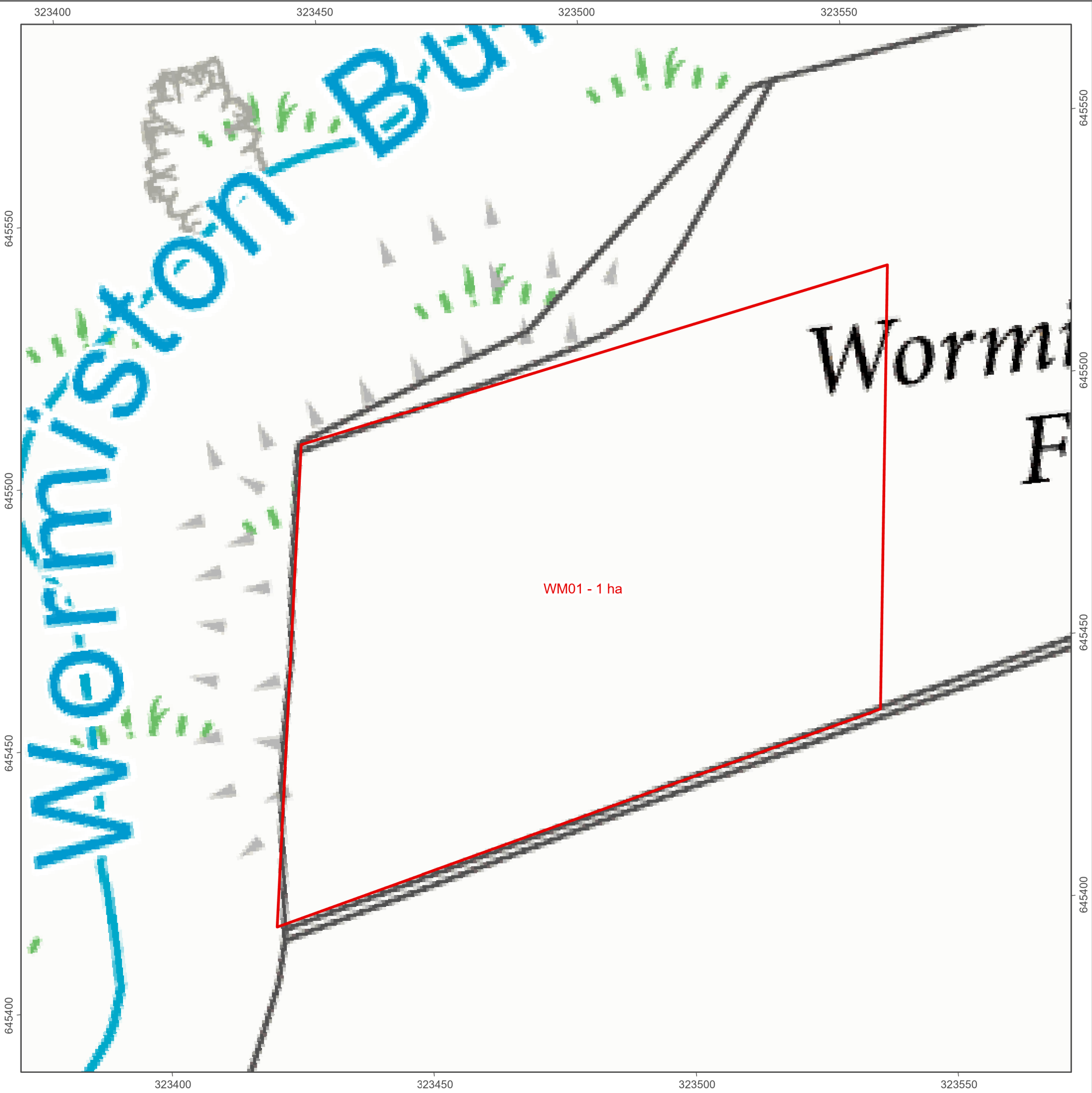

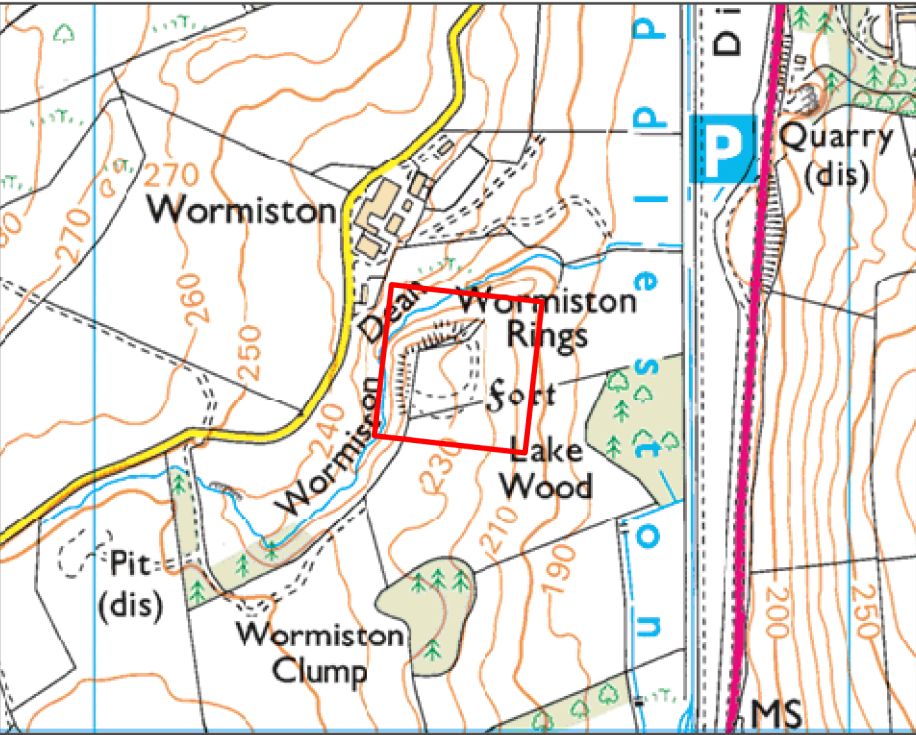


Figure 02		Survey Area	
Project Name	Wormiston Rings	 HISTORIC ENVIRONMENT SCOTLAND ÀRAINNEACHD EACHDRAIDHEIL ALBA	
Project Code	WORM2021		
Prepared By	Hazel Blake		
Prepared On	02/11/2022		



Survey Area

 Survey Area

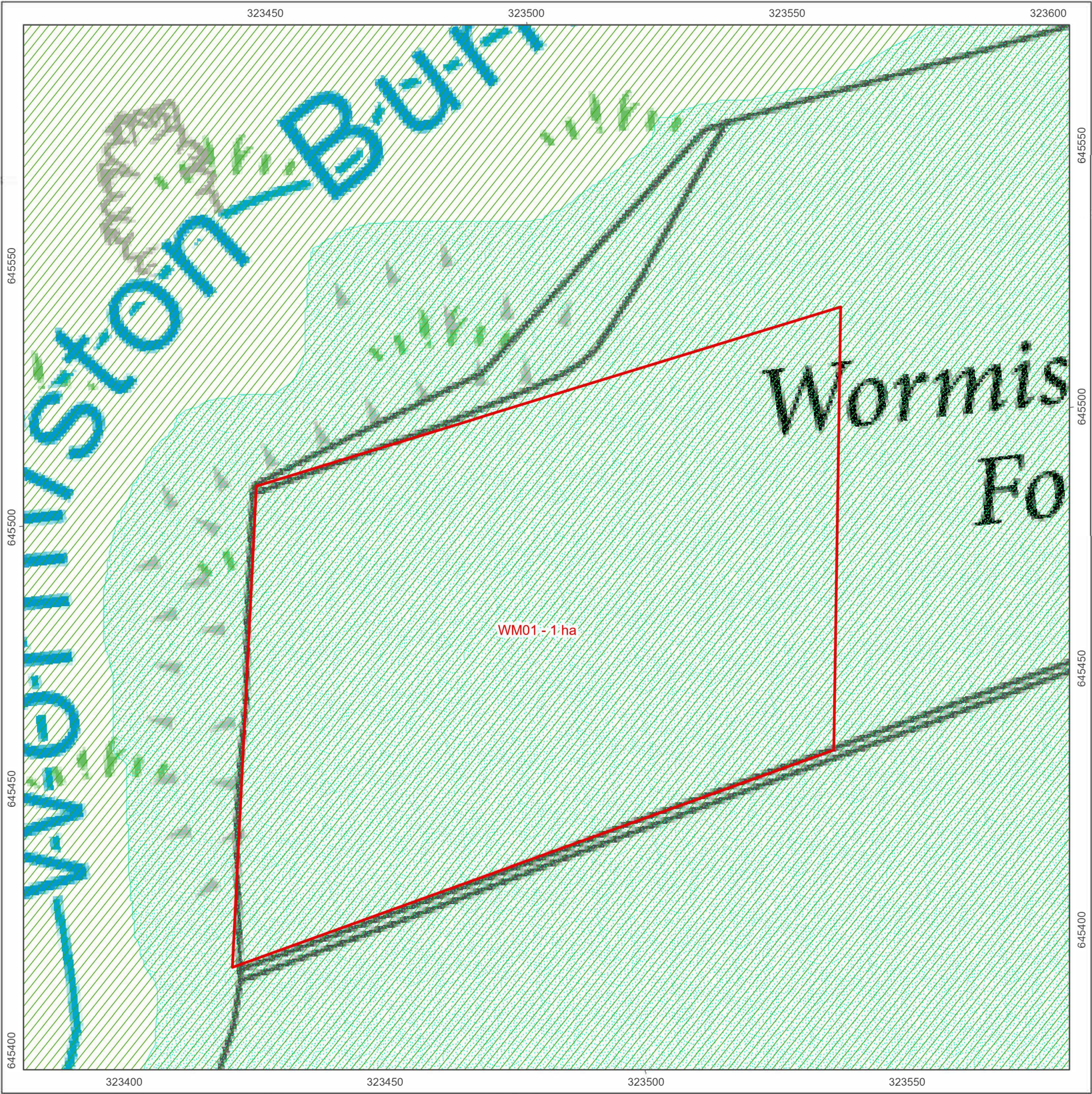
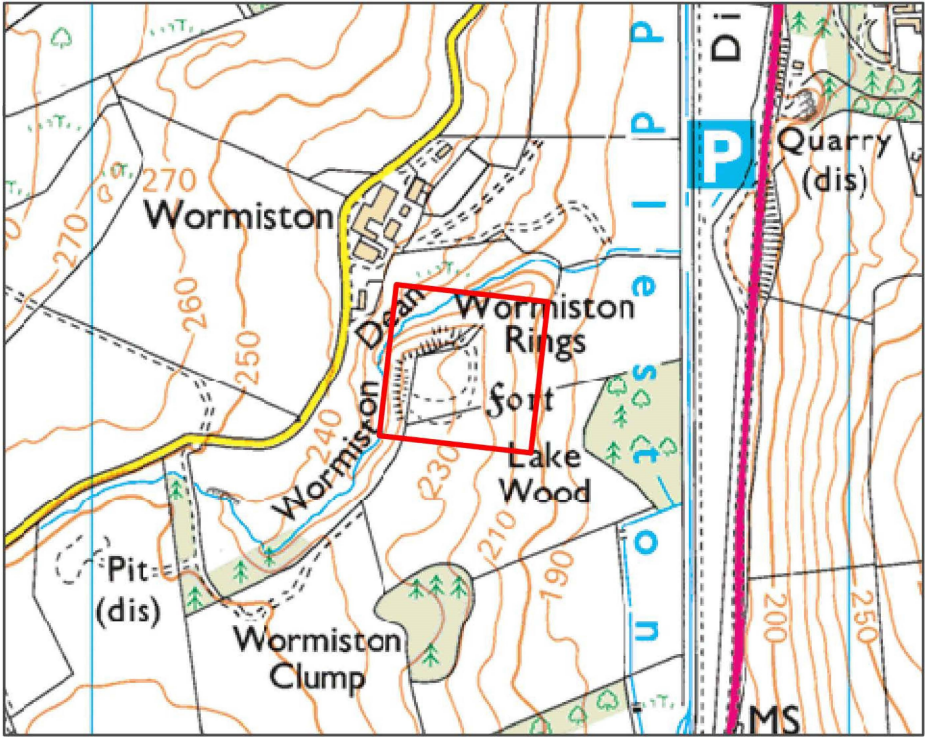





Figure 03		Geology Solid (BGS 2022)	
Project Name	Wormiston Rings	 <div>HISTORIC ENVIRONMENT SCOTLAND ÀRAINNEACHD EACHDRAIDHEIL ALBA</div>	
Project Code	WORM2021		
Prepared By	Hazel Blake		
Prepared On	04/11/2022		



Survey Area
 Survey Area

GEOLOGY - SOLID
 Portpatrick Formation - Wacke

GEOLOGY - DRIFT
 Glaciofluvial Deposit- Grave, Sand and Silt

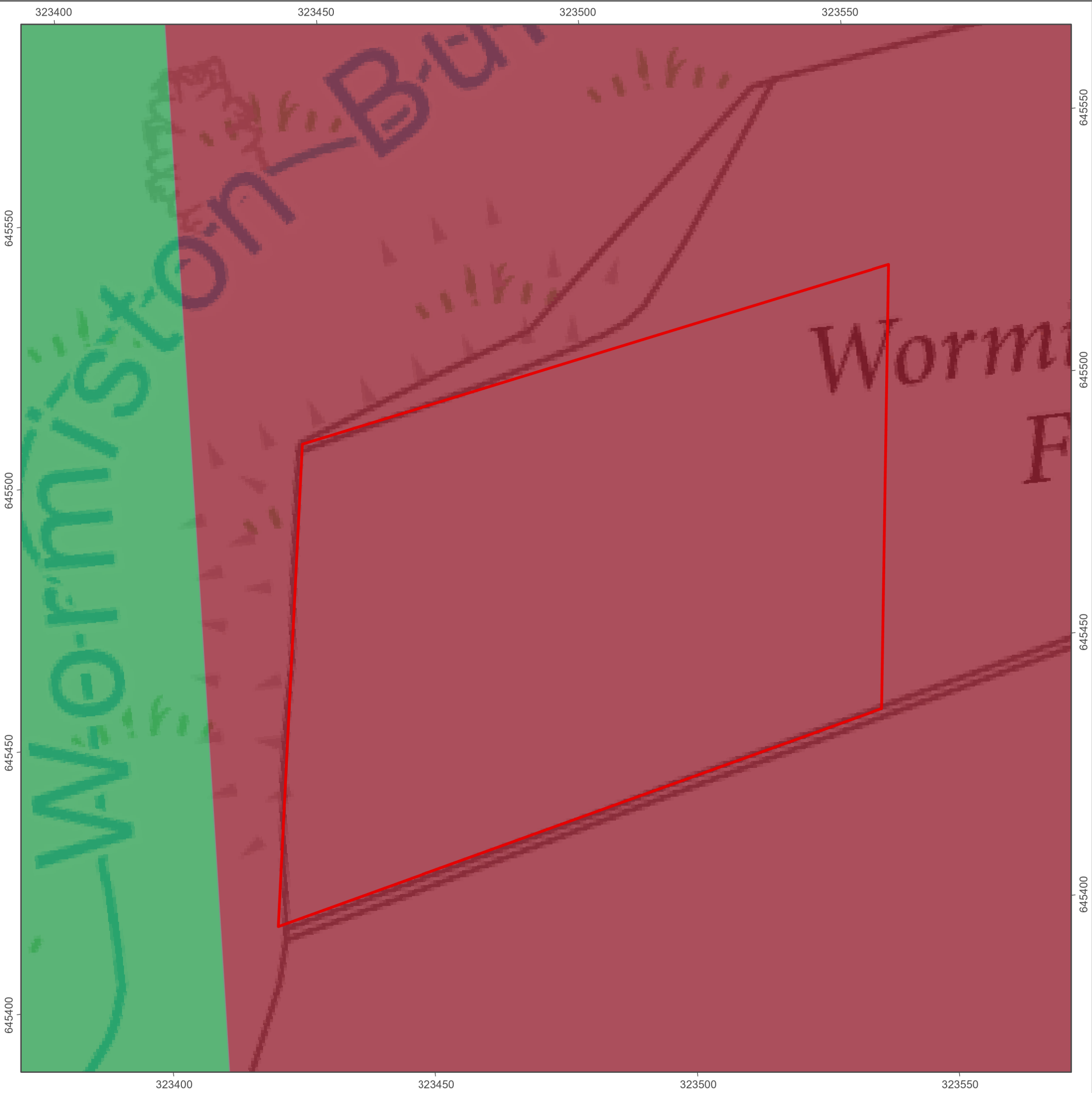

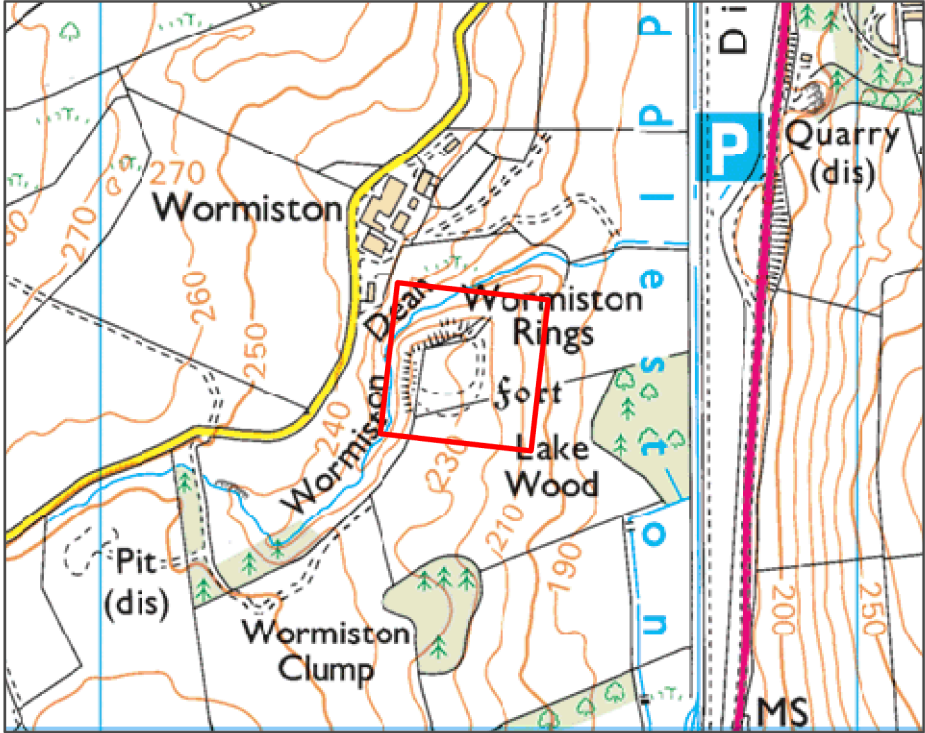





Figure 04		Pedology (Scotland's Soils 2022)	
Project Name	Wormiston Rings	 <div>HISTORIC ENVIRONMENT SCOTLAND ÀRAINNEACHD EACHDRAIDHEIL ALBA</div>	
Project Code	WORM2021		
Prepared By	Hazel Blake		
Prepared On	02/11/2022		




PEDOLOGY

-  Brown forest soils
-  Brown forest soils; some brown forest soils with gleying

Survey Area

-  Survey Area

	Scale: 1:750 @ A3	Datum: OSGB 1936
		

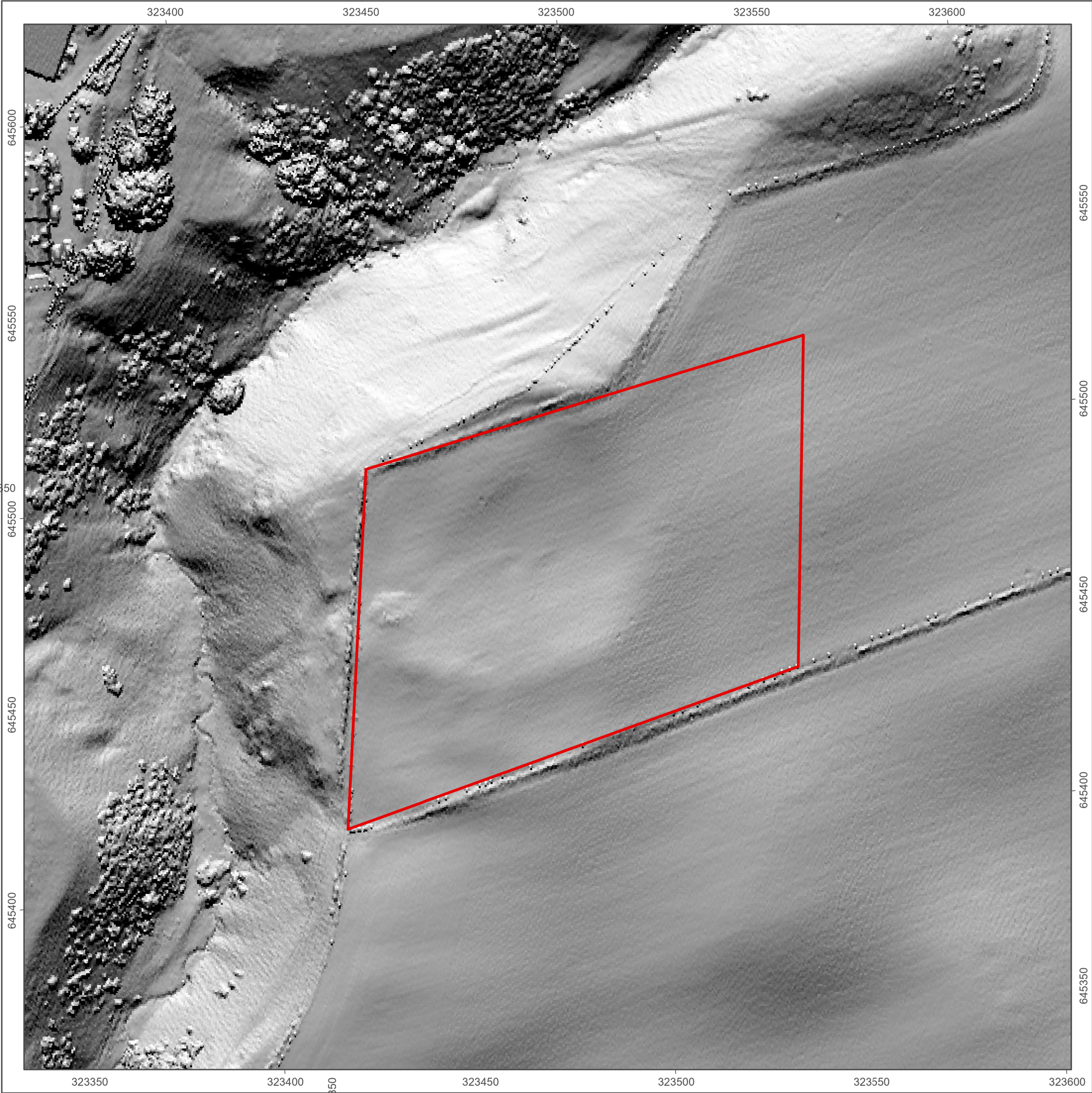


Figure 05

Environment Agency 0.5m LiDAR DSM for the survey area

Project Name	Wormiston Rings
Project Code	WORM2021
Prepared By	Hazel Blake
Prepared On	01/11/2022



HISTORIC
ENVIRONMENT
SCOTLAND

ÀRAINNEACHD
EACHDRAIDHEIL
ALBA

 Survey Area

Resolution (metres)	0.50
Visualisation	Multi Direction Hillshade
Directions	16
Altitude (degrees)	35
Azimuth (degrees)	315
Stretch	Standard Deviation
Standard Deviations	1
Gamma	1
Z-Factor	1

North



Scale: 1:1,003 @ A3

Datum: OSGB 1936

Metres

0

20

40

60

80



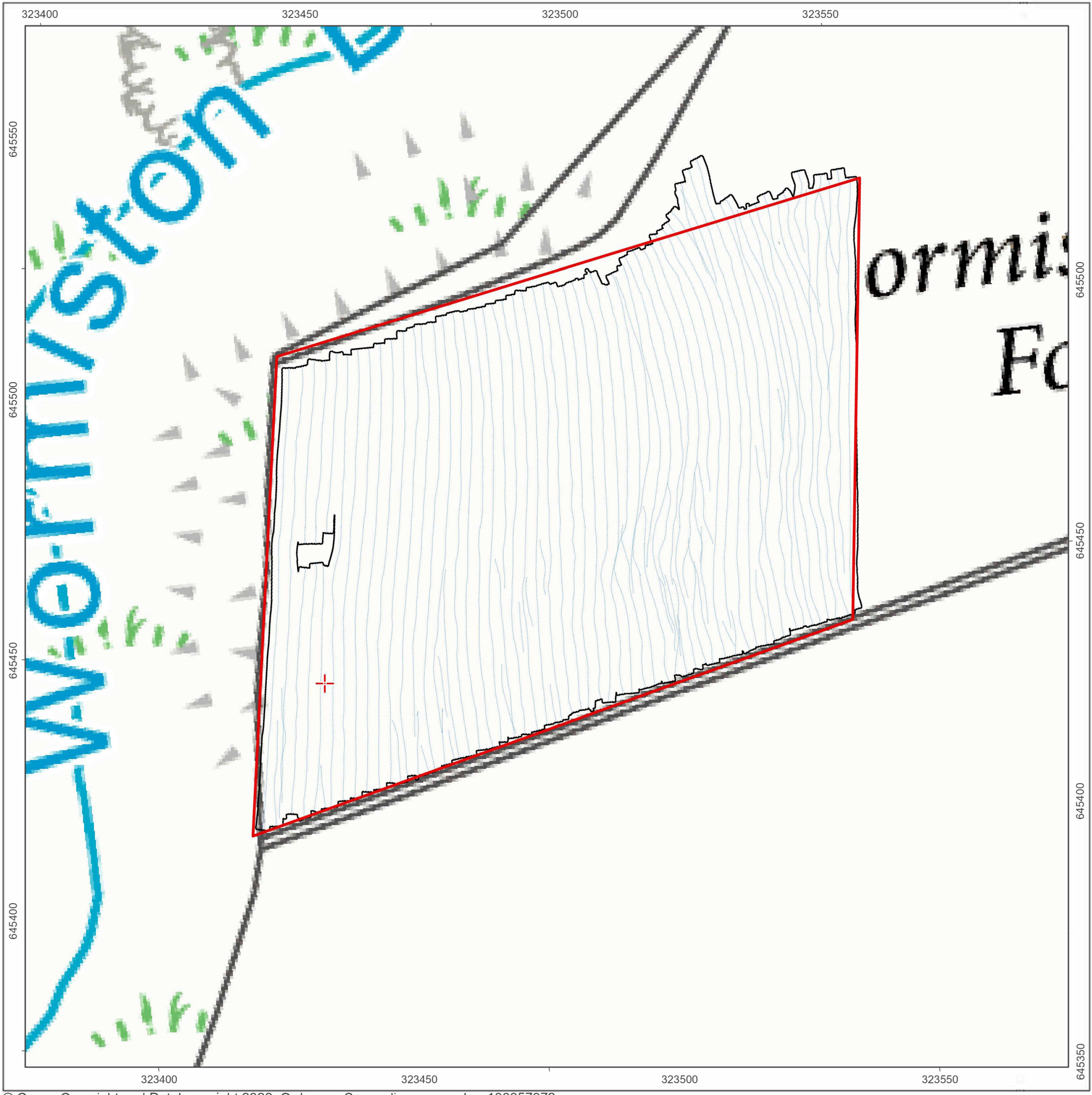

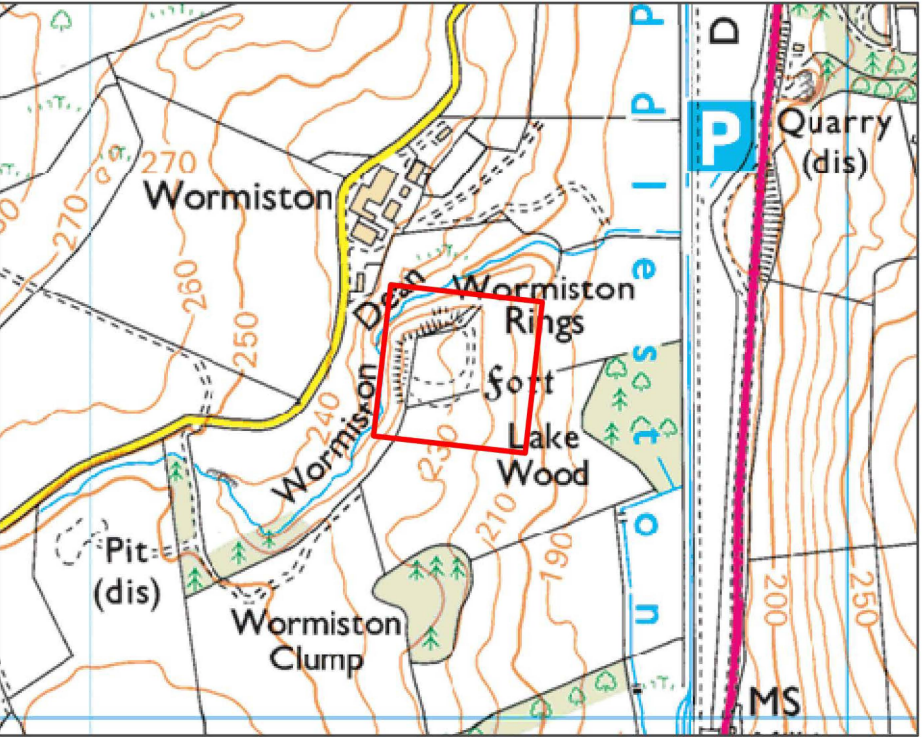


Figure 06		Gradiometer Survey GNSS Swaths & Calibration Position	
Project Name	Wormiston Rings	 HISTORIC ENVIRONMENT SCOTLAND ÀRAINNEACHD EACHDRAIDHEIL ALBA	
Project Code	WORM2021		
Prepared By	Hazel Blake		
Prepared On	01/11/2022		



Survey Area

Calibration Position

GNSS Breascumb

Survey Area Outline

North



Scale: 1:750 @ A3

Datum: OSGB 1936

Metres

0

10

20

30

40



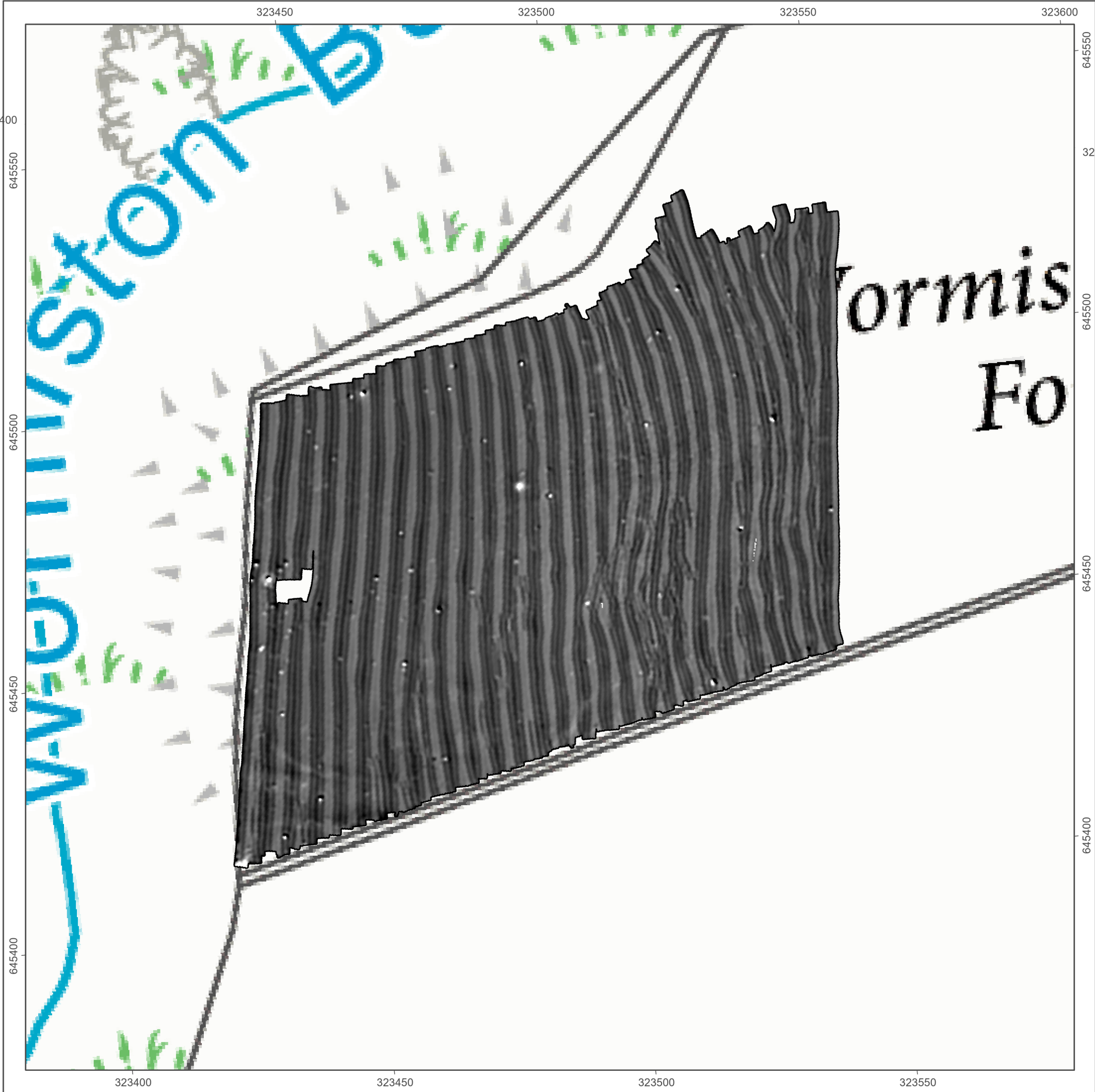

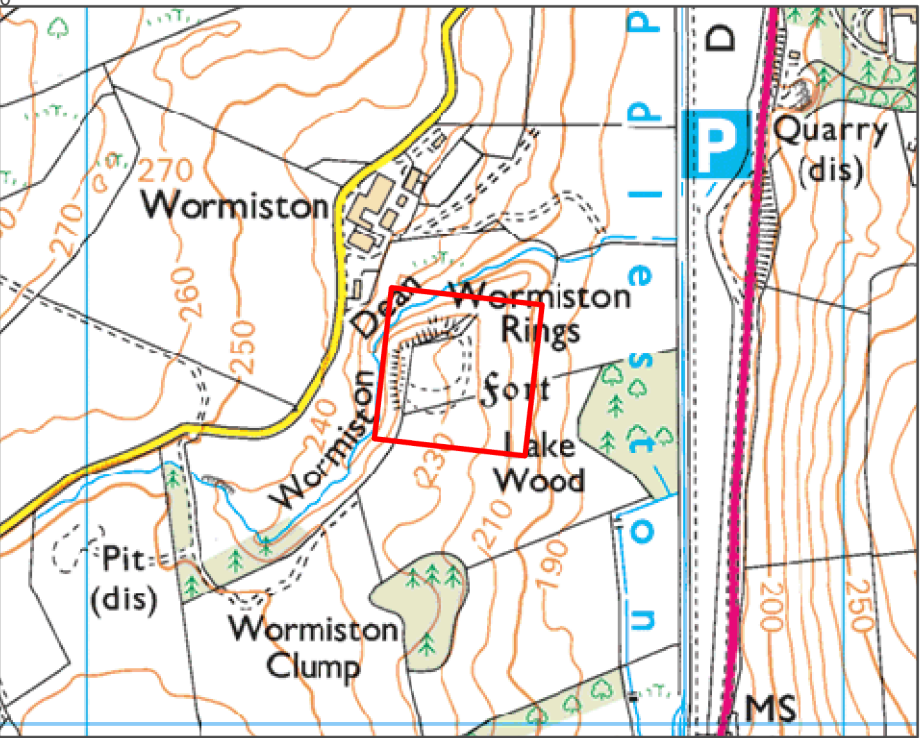


Figure 07		Minimally Processed Gradiometer Data - Greyscale Plot	
Project Name	Wormiston Rings	 HISTORIC ENVIRONMENT SCOTLAND ÀRAINNEACHD EACHDRAIDHEIL ALBA	
Project Code	WORM021		
Prepared By	Hazel Blake		
Prepared On	01/11/2022		





GREYSCALE PLOT

Value



Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1
Gamma	1

North	Scale: 1:750 @ A3	Datum: OSGB 1936
	<p>Metres</p> <p>0 10 20 30 40</p> 	

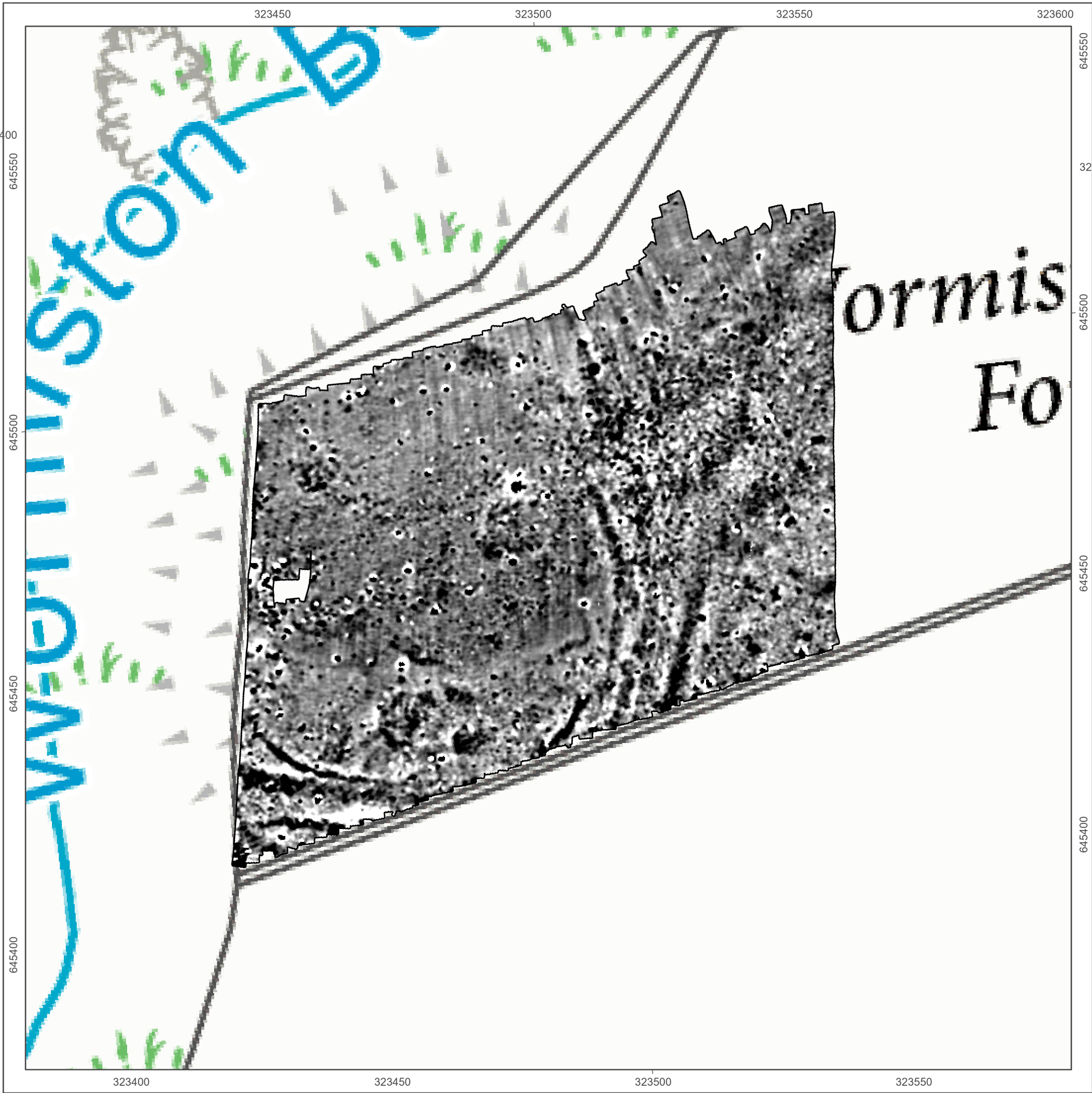



Figure 8

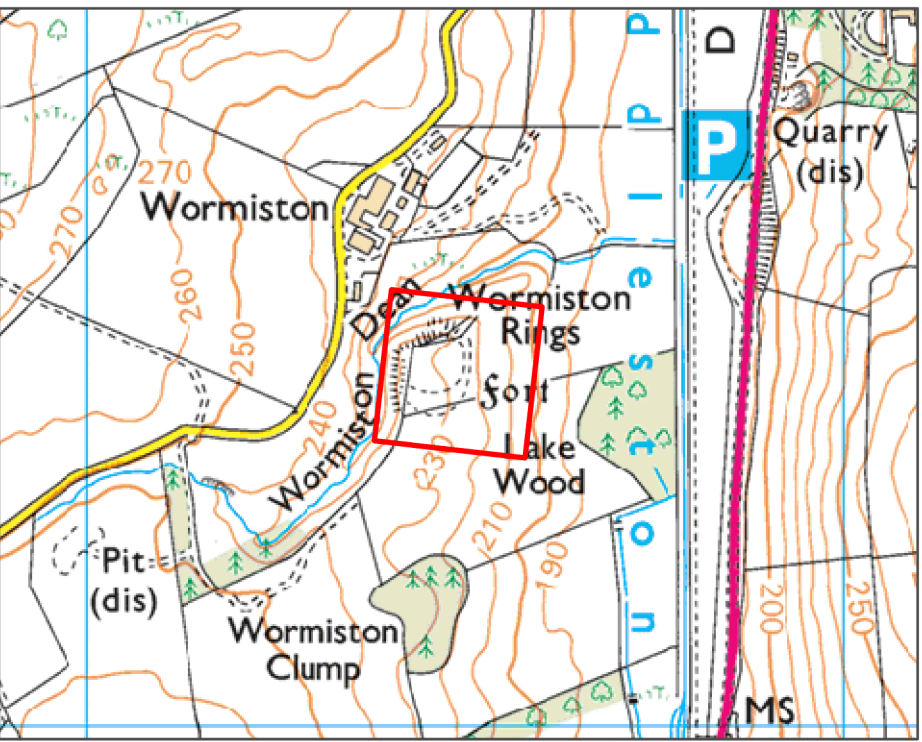
Processed Gradiometer Data - Greyscale Plot

Project Name	Wormiston
Project Code	WORM2021
Prepared By	Hazel Blake
Prepared On	01/11/2022



HISTORIC
ENVIRONMENT
SCOTLAND

ÀRAINNEACHD
EACHDRAIDHEIL
ALBA



GREYSCALE PLOT


Value

3

-3

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	3.4
Gamma	1

North



Scale: 1:750 @ A3

Datum: OSGB 1936

Metres


0

10

20

30

40



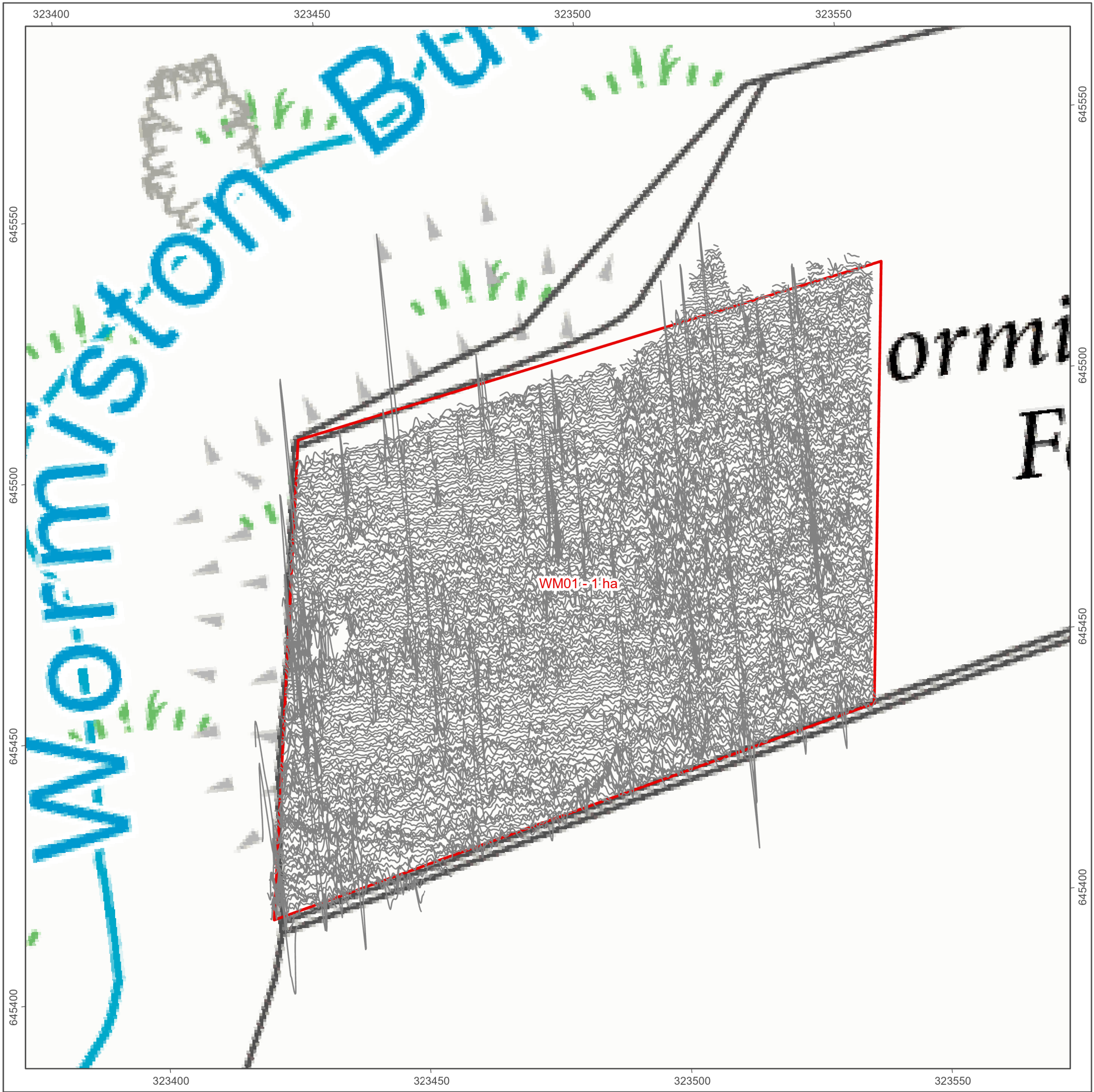




Figure 09

XY Trace Plot of Gradiometer Data

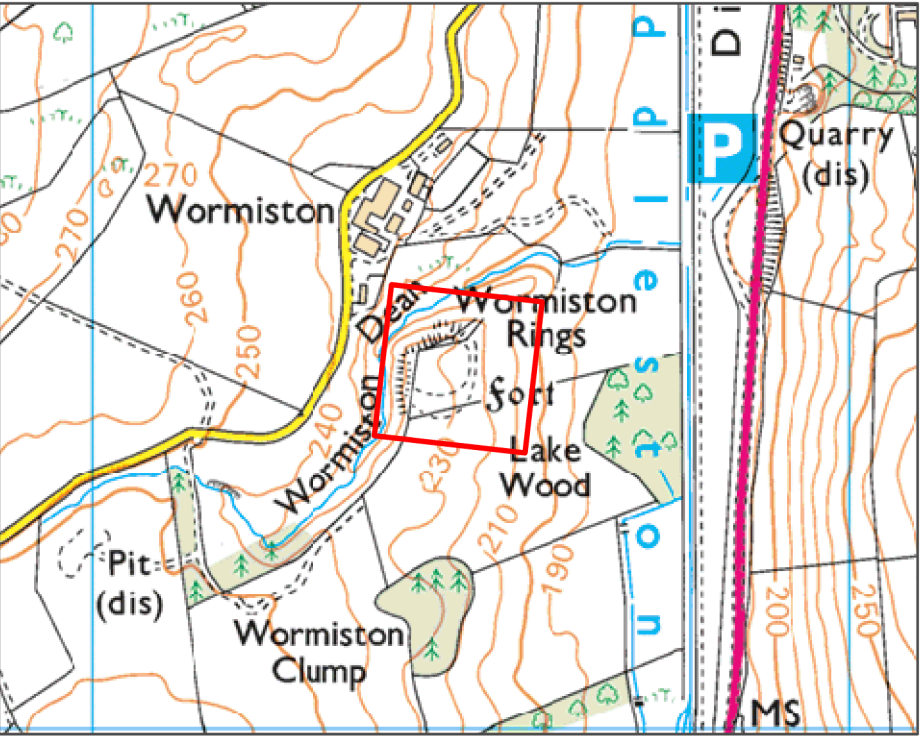
Project Name	Wormiston Rings
Project Code	WORM2021
Prepared By	Hazel Blake
Prepared On	09/11/2022




HISTORIC
ENVIRONMENT
SCOTLAND




ÀRAINNEACHD
EACHDRAIDHEIL
ALBA



Survey Area

 Survey Area

 XY Trace Plot

330 nT

165 nT

0 nT

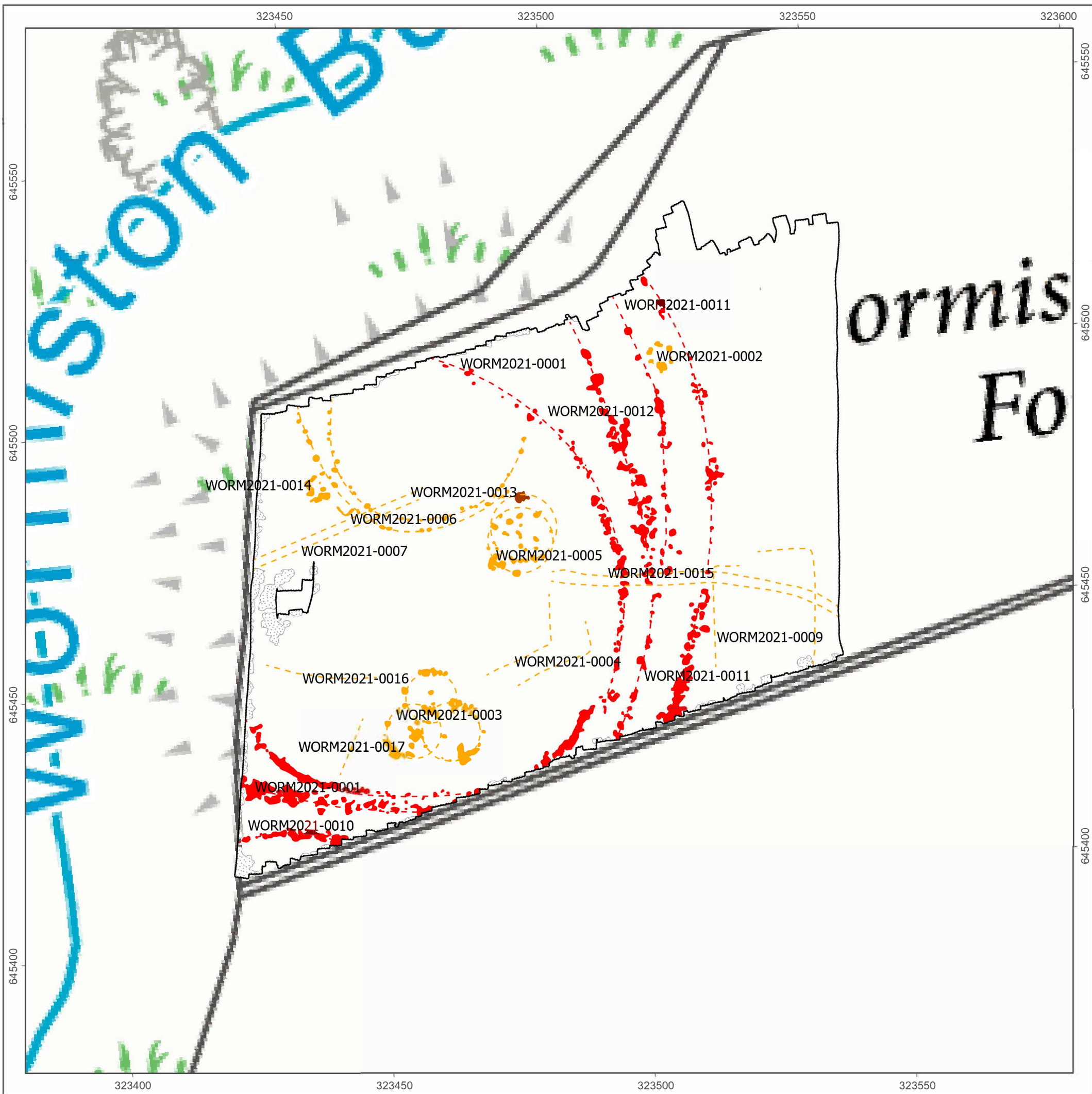
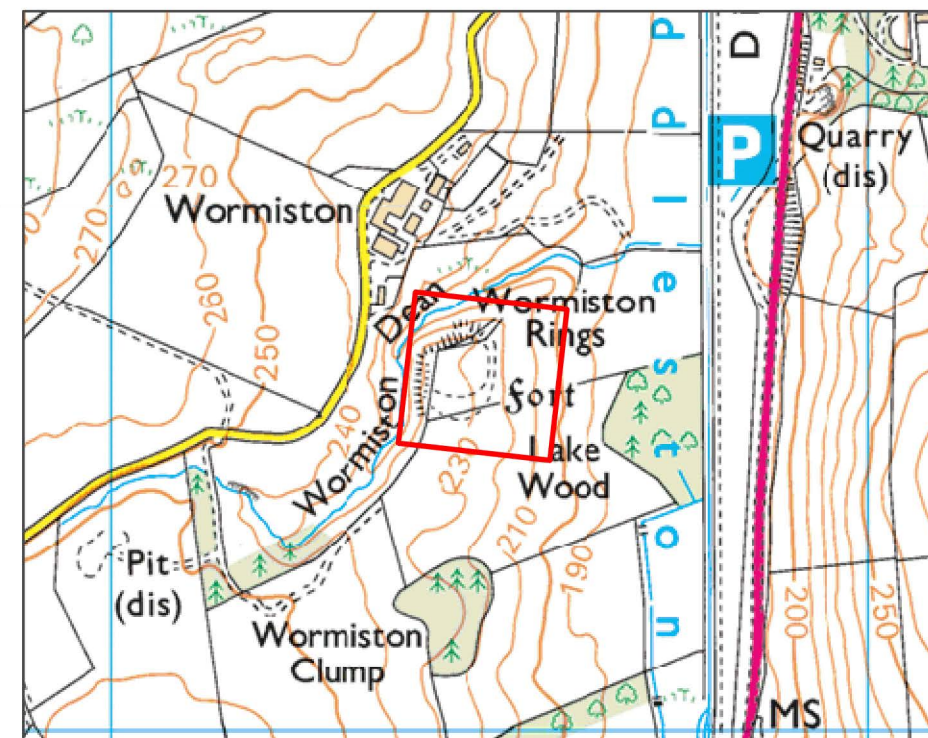


Figure 10

Interpretation of Gradiometer Data

Project Name	Wormiston Rings
Project Code	WORM2021
Prepared By	Hazel Blake
Prepared On	16/01/2023



Survey Area Outline

Survey Area Outline

Gradiometer Polyline

- Linear Trend (Archaeology)
- Linear Trend (Possible Archaeology)

Gradiometer Polygon

- Area of Disturbance (Modern)
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

North



Scale: 1:750 @ A3

Datum: OSGB 1936

Metres



APPENDIX 1 – SURVEY METADATA

The following table details the survey's metadata.

Field	Description
Data Collection Organisation	Historic Environment Scotland
Site Name	Wormiston Rings
Project ID	WORM2021
OASIS ID	historic14-412624
Report Title	Wormiston, Archaeological Geophysical Survey Report
Report Author	Dr Nick Hannon
Report QC	Dr Kirsty Millican/Dr Dave Cowley
National Grid Reference (centre)	NT 2345 4548
Coordinate System	OSGB1936
Transformation	OSTN15
Geoid	OSGM15
County	Scottish Borders
Scheduled Ancient Monument/s	None
Known Archaeology on site	NT24NW 3 (51423), NT24NW 42 (70105)
Survey Personnel	Dr Nick Hannon & Alison McCaig
Survey Dates	28/04/2021
Weather Conditions	Cold and snowy
Land Use	Pasture
Ground Conditions	Cold and dry
Solid Geology	Portpatrick Formation – Wacke, Sedimentary Rock Cycles (BGS 2021)
Drift Geology	Glaciofluvial Deposits – Gravel, Sand, and Silt (BGS 2021)
Soil	Brown Earth (Scotland's Soils 2021)
Survey Type	Gradiometer
Gradiometer Equipment	Sensys MXPDA
Sensors Type	FGM650/3
Sample Rate (hz)	100
Number of Sensors	5
Sensor Serial Numbers	1519/1520/1521/1522/1523
Sensor Separation (m)	0.5
Reading Interval (m)	0.125
Data Collection Software	MONMX v5.01-03/00
Data Processing Software	TerraSurveyor v3.0.36.10
Data Visualisation Software	ArcGIS Pro v2.8.6
Area Covered (ha)	0.98
Positional Accuracy	Leica GS16 GNSS +/- 0.02m

APPENDIX 2 – CALIBRATION CERTIFICATES

SENSYS[®]

Magnetometers & Survey Solutions

SENSYS Sensorik & Systemtechnologie GmbH • Rabenfelde 5 • 15526 Bad Saarow

Technologiezentrum
Rabenfelde

Inspection and Calibration Certificate

We hereby confirm that the device below:

MAGNETO[®] MXPDA 5channel system

(S/N: 000144)

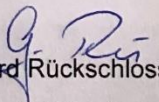
with sensor probes FGM650/3


(S/N: 1519, 1520, 1521, 1522, 1523)

has been inspected and calibrated on **17.09.2020** by SENSYS - Sensorik und Systemtechnologie GmbH according to manufacturer's instructions and according to in-house inspection requirements. All inspections and maintenance procedures are carried out according to the quality management systems ISO 9001:2015 of SENSYS GmbH. No technical defects have been detected on the device. Thus the device can be used without any restrictions.

The next inspection is due in **September 2021** if no other damages or malfunction occurs in the meantime.

Bad Saarow, 17.09.2020


Gerd Rückschloss
Head of Customer Service

SENSYS Sensorik & Systemtechnologie GmbH Rabenfelde 5 15526 Bad Saarow • GERMANY	Telefon +49 33631 59650 Fax +49 33631 59652 E-Mail info@sensys.de Internet www.sensys.de	Hauptgeschäftsführer: Dr.-Ing. A. Fischer Geschäftsführer: W. SöB, F. Meier, K. Lutter Ust.-IdNr. DE 178430879 Amtsgericht Frankfurt (Oder) • HRB 5419	Bankverbindung Sparkasse Oder-Spree BLZ 170 550 50 • Kto.-Nr. 3000003060 BIC: WELADED1105 IBAN: DE 24 1705 5050 3000 0030 60	 Management System ISO 9001:2015
--	--	---	---	--

APPENDIX 3 – IDENTIFIED ANOMALIES

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

Anomaly ID	Location	Classification	Interpretation
WORM2021-0001	WM01	Enhanced Magnetism (Archaeology)	Defensive ditches
WORM2021-0002	WM01	Enhanced Magnetism (Possible Archaeology)	Roundhouse
WORM2021-0003	WM01	Enhanced Magnetism (Possible Archaeology)	Roundhouse
WORM2021-0004	WM01	Linear Trend (Possible Archaeology)	Settlement activity
WORM2021-0005	WM01	Enhanced Magnetism (Possible Archaeology)	Roundhouse
WORM2021-0006	WM01	Linear Trend (Possible Archaeology)	Enclosure
WORM2021-0007	WM01	Linear Trend (Possible Archaeology)	Trackway
WORM2021-0009	WM01	Linear Trend (Possible Archaeology)	Settlement activity
WORM2021-0010	WM01	Enhanced Magnetism (Archaeology)	Defensive ditches
WORM2021-0011	WM01	Enhanced Magnetism (Archaeology)	Defensive ditches
WORM2021-0012	WM01	Enhanced Magnetism (Archaeology)	Defensive ditches
WORM2021-0013	WM01	Enhanced Magnetism (Area of Burning)	Area of Burning
WORM2021-0014	WM01	Enhanced Magnetism (Possible Archaeology)	Settlement activity
WORM2021-0015	WM01	Linear Trend (Possible Archaeology)	Trackway
WORM2021-0016	WM01	Linear Trend (Possible Archaeology)	Settlement activity
WORM2021-0017	WM01	Linear Trend (Possible Archaeology)	Settlement activity

APPENDIX 4 – GLOSSARY OF ANOMALY TYPES

The following table contains a glossary of the technical terminology used for gradiometer survey anomalies within this report.

	Anomaly Type	Description
Area	Area of Disturbance (Modern)	An area of magnetic disturbance caused by modern activity such as metallic fences, gates, inspection covers, green waste, or modern refuse.
	Enhanced Magnetism (Area of Burning)	An anomaly with a distinct pattern in the XY trace plot which indicates burning has taken place, suggesting the location of a hearth or kiln.
	Enhanced Magnetism (Historic Agriculture)	An anomaly caused by historic agricultural activity such as rig & furrow, or a headland.
	Enhanced Magnetism (Archaeology)	An anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly.
	Enhanced Magnetism (Historic Feature)	An anomaly caused by an historic feature. This will appear on a documentary record such as an old map but the feature is no longer extant on the surface, such as a demolished building, or a former field boundary.
	Enhanced Magnetism (Possible Archaeology)	An anomaly of possible archaeological origin; this interpretation will have no other supporting evidence.
	Enhanced Magnetism (Unclear Origin)	An anomaly for which it is not possible to assign an interpretation.
	Enhanced Magnetism (Utility)	An area of magnetic disturbance caused by the magnetic field of a utility, such as the halo around a gas pipe.
	Geology/Natural	An anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels.
Trend	Linear Trend (Archaeology)	A linear anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly.
	Linear Trend (Drainage)	A linear anomaly caused by modern drainage such as a field drain.
	Linear Trend (Historic Agriculture)	A linear anomaly caused by historic agricultural activity such as rig & furrow, or a headland.
	Linear Trend (Historic Feature)	A linear anomaly caused by a historic feature. This will appear on a documentary record such as an old map but the feature is no longer visible on the ground, such as an old pathway.
	Linear Trend (Modern Agriculture)	A linear anomaly caused by modern agricultural activity such as ploughing.
	Linear Trend (Possible Archaeology)	A linear anomaly of possible archaeological origin; this interpretation will have no other supporting evidence.
	Linear Trend (Unclear Origin)	A linear anomaly for which it is not possible to assign an interpretation.
	Linear Trend (Utility)	A linear anomaly caused by the presence of a modern utility, such as a gas pipe.
	Geology/Natural	A linear anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels.
Point	Ferrous Spike	An anomaly caused by a ferrous object in the topsoil which causes a spike in the XY trace plot of the data.

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. Data files suffixed with “V1” relate to the first site visit. Data suffixed with “V2” related to the second site visit.

GRADIOMETER DATA PROCESSING

Following the collection of data using the methodology detailed in section 5.1, all datafiles were exported from the Sensys system’s MONMX in .asc, and .uxo formats. These files were then transferred to the processing computer.

Data processing was conducted using TerraSurveyor v3.0.36.10 (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 .uxo files were imported using the pre-defined TerraSurveyor import template appropriate for the Sensys system and converted into .xcp format composites. The .asc format file was retained for archiving.

The .xcp file was opened and a .grd exported to allow visualisation of the minimally processed data. The data was destriped and clipped. The data was interpolated to values appropriate to 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 minimally processed data was clipped to -10/100 nT and an XY trace plot generated and exported as a .dxf.

The .grd and .dxf files were imported to the project’s ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the “Project” and “Project Raster” tools, 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
WORM2021WM01-MAG-V1.xcp	Destripe	Median / SD 1.5
	Base Settings	Interval 0.125m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m

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

The text below was submitted for inclusion in the next Discovery and Excavation in Scotland.

NT 23466 45463 The HES Archaeological Survey Team undertook geophysical (gradiometer) survey at Wormiston Rings. The fieldwork was conducted on 28 April 2021. In total 0.99ha were surveyed using a Sensys MXPDA gradiometer covering the location of a Late Iron Age site previously identified through cropmark evidence. The geophysical survey has produced good quality gradiometer results, which have successfully contributed to the aims of the survey. There is a high level of confidence that the chosen methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

The geophysical survey confirmed the presence of roundhouses enclosed within two defensive ditches.

(Project ID: WORM2021)

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
51423	WORM2021-0001, WORM2021-0002, WORM2021-0003, WORM2021-0004, WORM2021-0005, WORM2021-0006, WORM2021-0007, WORM2021-0008, WORM2021-0009, WORM2021-0011, WORM2021-0012, WORM2021-0013, WORM2021-0014, WORM2021-0015, WORM2021-0016, WORM2021-0017	Addition	
	WORM2021-0009	Creation	
70150	WORM2021-0010	Addition	

Historic Environment Scotland is the lead public body established to investigate, care for and promote Scotland's historic environment.

We are committed to ensuring this publication is accessible to everyone. If you need it supplied in a different format or language including Gaelic, please get in touch.



HISTORIC
ENVIRONMENT
SCOTLAND

ÀRAINNEACHD
EACHDRAIDHEIL
ALBA

Historic Environment Scotland
16 Bernard Terrace
Edinburgh EH9 1SH

0131 668 8600
historicenvironment.scot

Historic Environment Scotland – Scottish Charity No. SC045925
Registered Address: Longmore House, Salisbury Place, Edinburgh EH9 1SH