STRATASCAN

Geophysical Survey Report

West Angle Bay, Pembrokeshire

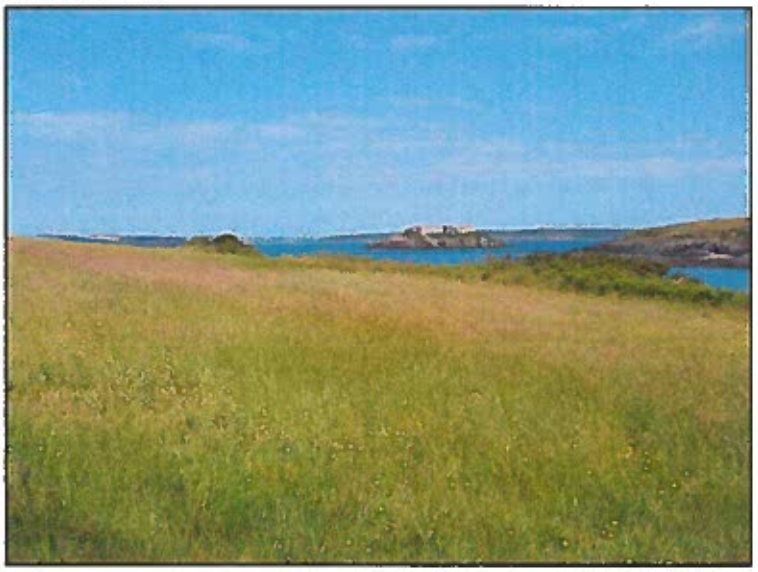
June 2006

J2169

Hannah Heard BSc (Hons)

REGISTERED IFA ORGANISATION

Document Title:	**Geophysical Survey Report** **West Angle Bay, Pembrokeshire**
Client:	**Pembrokeshire Coast National Park Authority**
Stratascan Job No:	**J2169**
Techniques:	**Detailed magnetic survey (gradiometry)** **Detailed resistance survey**
National Grid Ref:	**SM 851 030**



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LIST OF FIGURES

1 SUMMARY OF RESULTS

A gradiometer and resistivity survey was carried out at West Angle Bay at an Early Medieval ecclesiastical site. Both surveys were successful in identifying features of archaeological origin. A large ditch feature has been identified in the northeast corner of the survey, surrounding the oval enclosure associated with the graveyard of St Anthony's Chapel. Within the northeast of the enclosure possible cut features and structural remains have been identified. Weak evidence for a second enclosure has been identified within the resistivity data and appears to be bisected by the ditch feature. Discrete high resistance anomalies identified within the resistivity data may represent possible cist burials, although a number of these anomalies correspond with the 2005 trench and test pit locations.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Pembrokeshire Coast National Park Authority to undertake a geophysical survey of an area of archaeological interest. This survey forms part of an archaeological investigation being undertaken by Pembrokeshire Coast National Park Authority.

2.2 Site location

The site is located at the edge of West Angle Bay in the Pembrokeshire Coast National Park (PCNP) at OS ref. SM 851 030.

2.3 Description of site

The survey area is approximately 2.5ha and is currently under pasture. An oval earthwork is situated in the northeast of the survey area and is thought to represent the churchyard associated with the former St Anthony's Chapel. Two faint linear banks are present within the centre of the survey area. The gradiometer survey covered the entire survey area, whereas the resistivity targeted a 30m strip along the northern coastal edge of the survey (0.5ha), in the attempt to identify coastal cist burials.

The underlying geology is Tournaisian and visean (Carboniferous Limestone Series) (British Geological Survey South Sheet, Fourth Edition Solid, 2001). The overlying soils are known as East Keswick 3 soils which are typical brown earths. These consist of drift over Palaeozoic limestone (Soil Survey of England and Wales, Sheet 2 Wales).

2.4 Site history and archaeological potential

The survey area is known as an Early Medieval ecclesiastical site. The oval earthwork within the survey area is known to be associated with the Late Medieval churchyard of the former St Anthony's Chapel. A number of cist burials have been identified within the survey area and eroding away at the cliff edges.

Evaluation trenching carried out by Cambria Archaeology took place during July 2005. Six definite and three possible cist burials were revealed confined within an area by a substantial stony bank of the oval enclosure. Deeper excavation through the bank revealed an earlier cut feature following a similar alignment to the oval enclosure, possibly suggesting an earlier ditch enclosure (www.cambria.org.uk).

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological significance to enhance the archaeological knowledge and assist in the investigation of the area.

2.6 Survey methods

Detailed magnetometry and resistivity surveys were carried out across the site in order to assess the area with complementary techniques. More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over 5 days from the 12th to the 14th and 21st to the 22nd June when the weather was fine and dry.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information.

3.3 Description of techniques and equipment configurations

3.3.1 Magnetometer

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each sensor has a 1m separation between the sensing elements giving a strong response to deep anomalies.

3.3.2 Resistance Meter

This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current, which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger, which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Magnetometer
Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Resistivity
Readings were taken at 1.0m centres along traverses 1.0m apart. This equates to 900 sampling points in a full 30m x 30m grid. All traverses were surveyed in a "zigzag" mode.

3.4.2 Depth of scan and resolution

Magnetometer
The Grad 601 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an appropriate methodology balancing cost and time with resolution.

Resistivity
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m The collection of data at 1m centres with a 0.5m probe spacing provides an appropriate methodology balancing cost and time with resolution.

3.4.3 Data capture

Magnetometer
The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

Resistivity
The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Magnetometer
Processing is performed using specialist software known as *Geoplot 3.* This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all processed magnetometer data used in this report:

Zero mean grid	*Threshold = 0.25 std. dev.*
Zero mean traverse	*Last mean square fit = off*
Despike	*X radius = 1 Y radius = 1*
	Threshold = 3 std. dev.
	Spike replacement = mean

Resistivity
The processing was carried out using specialist software known as *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

3.5.2 Presentation of results and interpretation

Magnetometer
The presentation of the data for the survey involves a print-out of the raw data both as grey scale (Figure 3) and trace plots (Figure 4 and 5), together with a grey scale plot of the processed data (Figure 6). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 7).

Resistivity
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figure 8), together with a grey scale plot of the processed data (Figure 9). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 10).

4 RESULTS

4.1 Gradiometry

The gradiometer survey has been successful in identifying a large number of anomalies that may relate to archaeological activity. The anomalies have been divided into the following categories:

- Positive area anomalies - possible pits or cut features
- Positive linear anomalies – cut features of possible archaeological origin
- Negative linear anomalies – earthworks or banks of possible archaeological origin
- Positive area anomalies – possible areas of ground disturbance
- Areas of magnetic disturbance – evidence of ground disturbance
- Linear anomalies – possible agricultural marks
- Positive anomalies with associated negative responses – ferrous objects
- Areas of magnetic debris – associated with nearby field boundaries

Positive area anomalies - possible pits or cut features
Ten areas of positive response have been identified in the northwestern corner of the survey area (**1-5**). These anomalies may indicate cut features or ground disturbance of possible archaeological origin and have been identified within an area enclosed by a

possible ditch (7). An isolated positive area anomaly has also been identified in the centre north of the survey (6) and may also represent a possible cut feature of archaeological origin.

Positive linear anomalies – cut features of possible archaeological origin
A large number of positive linear anomalies have been identified across the survey area. The most substantial can be seen in the northeast corner of the survey area and is likely to represent a ditch enclosing an area around the present oval earthwork (7).

An oval positive linear anomaly has been identified in a similar position to the earthwork (**8a**). This feature may represent a ditch associated with the earthwork or possibly relate to the cut feature identified within trench 13 during the 2005 evaluations, possibly predating the earthwork. A curvilinear positive anomaly has also been identified to the south of **8a**, and may represent an additional cut feature (**8b**).

A series of strong positive linear anomalies have been identified in an approximate northwest to southeast orientation (**9a** and **9b**). These anomalies may represent a set of parallel ditches associated with the remains of the visible earthwork. These ditches and bank may represent a previous boundary of possible agricultural origin.

A series of faint parallel positive linear anomalies situated in the centre of the survey area (**10**) can be seen in an approximate north to south orientation. These linear anomalies may represent cut features of archaeological or agricultural origin, but may also be of geological origin.

A series of stronger linear anomalies situated to the south of the bank and ditch boundary have also been identified in a north to south orientation (**11-13**). These anomalies may represent cut features of archaeological origin, possibly relating to a previous field system.

Faint linear anomalies can be seen along the north of the survey area (**14**). These anomalies may represent weak evidence for cut features of possible archaeological origin.

Negative linear anomalies – earthworks or banks of possible archaeological origin
A negative linear anomaly has been identified in the centre of the survey area and is likely to be associated with the visible linear earthwork (**15**). This anomaly may represent a bank of a previous field boundary, with ditches either side (**9a** and **9b**).

Faint negative linear anomalies can be seen in the north of the survey area (**16** and **17**). These anomalies may represent compacted ground or agricultural marks.

Two parallel negative linear anomalies have been identified in the south of the survey area in an approximate east to west orientation (**18**). These anomalies may represent a double bank earthwork, possibly relating to a previous boundary.

Positive area anomalies – possible areas of ground disturbance
A series of positive area anomalies have been identified to the south of the earthen bank (**15**). These anomalies may indicate areas of ground disturbance of possible archaeological origin (**19 - 21**).

Areas of magnetic disturbance – evidence of ground disturbance
Areas of magnetic disturbance have been mainly identified within and around the oval enclosure in the northeast of the survey area (**22-27**). Theses anomalies may represent areas of ground disturbance possibly associated with archaeological activity.

Linear anomalies – possible agricultural marks
Two groups of parallel linear anomalies have been identified towards the north and southern extents of the survey area. These parallel linear anomalies may represent agricultural marks but may also be related to the local geology.

Positive anomalies with associated negative responses – ferrous objects
A series of discrete positive anomalies with associated negative returns can be seen across the entire survey area. These anomalies often represent near surface ferrous objects.

Areas of magnetic debris – associated with nearby field boundaries
Areas of magnetic debris have been identified around the perimeter of the survey area. These anomalies are often associated with nearby field boundaries. The strong magnetic responses may obscure the presence of faint anomalies of possible archaeological origin.

4.2 Resistivity

The resistivity survey was carried out along the northern boundary of the survey area. The main objective of the survey was to identify further cist burials that may exist along the coastline. The resistivity survey has identified comparable features identified within the gradiometer survey with additional features that may be of archaeological origin. The anomalies have been divided into the following categories:

- High resistance area anomalies – possible structural remains or compacted ground
- Moderate resistance linear anomalies – possible structural remains or compacted ground
- Low resistance area anomaly – cut feature or ditch of possible archaeological origin
- Low resistance linear anomalies – cut features of possible archaeological origin
- Moderate high resistance area anomaly – unknown origin
- Low resistance area anomaly – possible cut feature of archaeological origin
- High resistance area anomaly – possible area of disturbed ground or debris
- High resistance area anomaly – coastal path

High resistance area anomalies – possible structural remains or compacted ground

A rectilinear area of high resistance has been identified within the northeast area of the oval enclosure (**a**). This area anomaly may represent structural remains, burials or ground disturbance associated with St Anthony's Chapel. A large high resistance area anomaly can be seen surrounding the present earthwork (**b**). This area anomaly may represent structural debris possibly associated with the stone bank uncovered in trench 13 during the 2005 evaluation.

Area anomalies **c**, **e**, **i** and **l** may represent areas of disturbed ground associated with the 2005 evaluation trenches. Discrete high resistance area anomalies **f**, **h**, **j** and **k** may indicate possible areas of structural remains (possible cist burials) or areas of compacted ground. High resistance anomaly **d** may represent a possible cist burial and appears to be situated in a ditch feature (gradiometer anomaly **7** and **n**).

A faint high resistance area anomaly can be seen to the west of the oval earthwork (**g**). This anomaly may represent weak evidence for earthen bank or structural remains, possibly suggesting the presence of an earlier earthwork. The anomaly appears to be cut by the ditch feature **7**.

Moderate resistance linear anomalies – possible structural remains or compacted ground
A number of moderate resistance linear anomalies have been identified mainly in the east of the survey area. These anomalies may represent possible structural remains or debris of archaeological origin. Linear anomalies **m** may represent weak evidence for the western extent of the possible enclosure feature.

Low resistance area anomaly – cut feature or ditch of possible archaeological origin
A substantial low resistance area anomaly has been identified running in an approximate north to south orientation (**n**). This anomaly is likely to represent the ditch feature that has also been identified within the gradiometer survey (**7**).

Low resistance linear anomalies – cut features of possible archaeological origin
A faint low resistance linear anomaly (**o**) can be seen running parallel with the high resistance anomaly **g**. This anomaly may represent a cut feature along the outer edge of the possible bank. A further low resistance linear anomaly has been identified towards the eastern edge of the survey area. This anomaly may represent a cut feature of possible agricultural or archaeological origin.

Moderate high resistance area anomaly – unknown origin
A series of parallel moderate high resistance area anomalies can be seen across the survey in a northeast to southwest orientation. These anomalies may relate to ploughing, but some don't appear 'regimented' enough for agricultural marks and therefore may be of geological origin. However, these anomalies could still be of agricultural origin, having been destroyed by subsequent ploughing in an east-west direction.

Low resistance area anomaly – possible cut feature of archaeological origin
Two low resistance area anomalies have been identified in the centre of the survey area. Anomaly **p** may represent weak evidence for a cut feature positioned on the inner side

of anomaly **g**. Anomaly **q** may represent a further cut feature of possible archaeological or agricultural origin.

High resistance area anomaly – possible area of disturbed ground or debris
Areas of high resistance can be seen in the west of the survey area. These area anomalies may indicate areas of ground disturbance or debris.

High resistance area anomaly – coastal path
The Pembrokeshire coastal path has been identified within the survey as an area of high resistance in the southeast corner of the survey area.

5 CONCLUSION

The gradiometer and resistivity survey have both been successful in identifying features of archaeological origin. A curvilinear ditch has been identified surrounding the oval earthwork in the northeast corner of the survey area. In the area of the oval earthwork, structural remains have been identified by the resistivity, possibly relating to the stone bank uncovered during excavation. The gradiometer survey has highlighted a ditch around the earthwork which may relate to the cut feature identified underneath the bank in the 2005 evaluation trench.

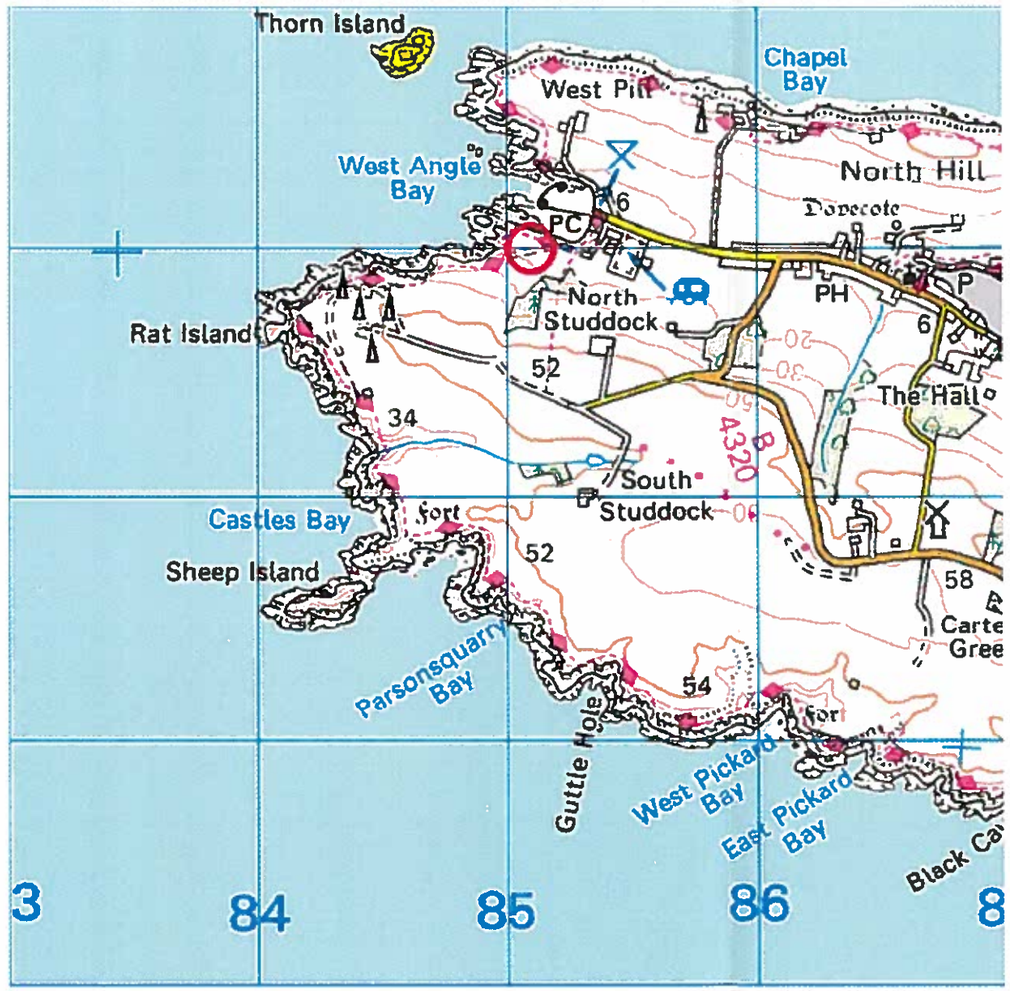
Faint evidence for a second enclosure may be identified in a series of high and low resistance linear and area resistance anomalies (representing a possible bank and ditch enclosure). This enclosure appears to be bisected by the ditch identified in both the survey techniques (**7** and **n**). However, little evidence of this possible enclosure can be seen within the gradiometer survey, although the western extent of the magnetic disturbance may relate to the western edge of the possible enclosure.

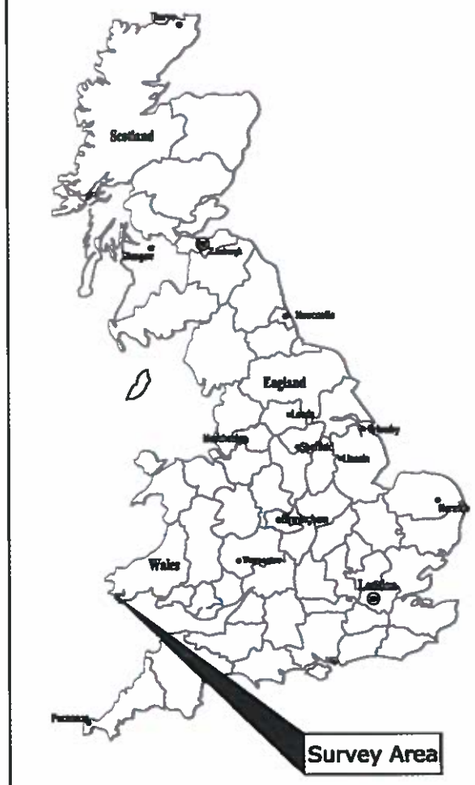
Discrete high resistance anomalies identified within the resistivity data may represent possible cist burials, although a number of these anomalies correspond with the 2005 trench and test pit locations. The high resistance area anomaly along with the positive area anomalies situated in the northwest corner of the oval enclosure may represent structural remains and cut features relating to cist burials or structural remains.

Positive area anomalies situated outside the oval earthwork but within the ditch enclosure may represent cut features and areas of activity of archaeological origin. A series of parallel linear anomalies and linear bank features situated across the southwest of the survey area may represent a previous field system and could be of archaeological origin.

Bibliography

Early Medieval Cemeteries in Pembrokeshire 2005. www.cambira.org.uk. Accessed 21-06-2006





Amendments

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Site centred on NGR SM 851 030

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
LOCATION PLAN OF SURVEY AREA

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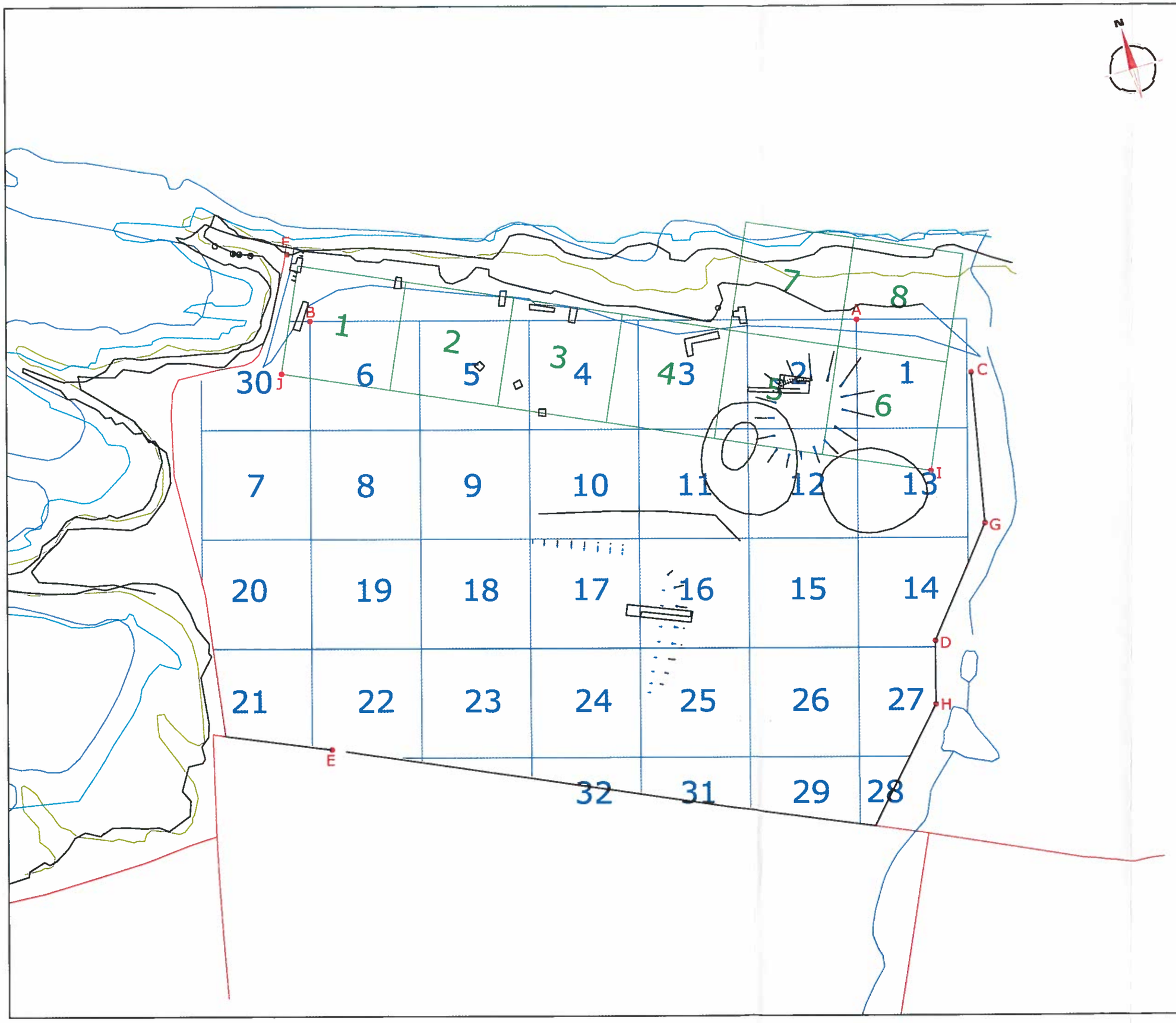

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REFERENCING INFORMATION

A-B	150m	A-C	34.45m	A-D	90.62m
A-E	187.67m	A-F	157.27m	B-C	181.67m
B-D	192.28m	B-E	119.63m	B-F	19.35m
I-C	29.19m	I-D	46.55m	I-G	20.54m
J-C	189.07m	J-D	193.44m	J-H	200.74m

A-B I-J	Base line
C,D,E F,G,H	Referencing points
2	Grid number
2	Gradiometer survey
2	Resistivity survey

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
SITE PLAN SHOWING LOCATION OF SURVEY GRIDS AND REFERENCING

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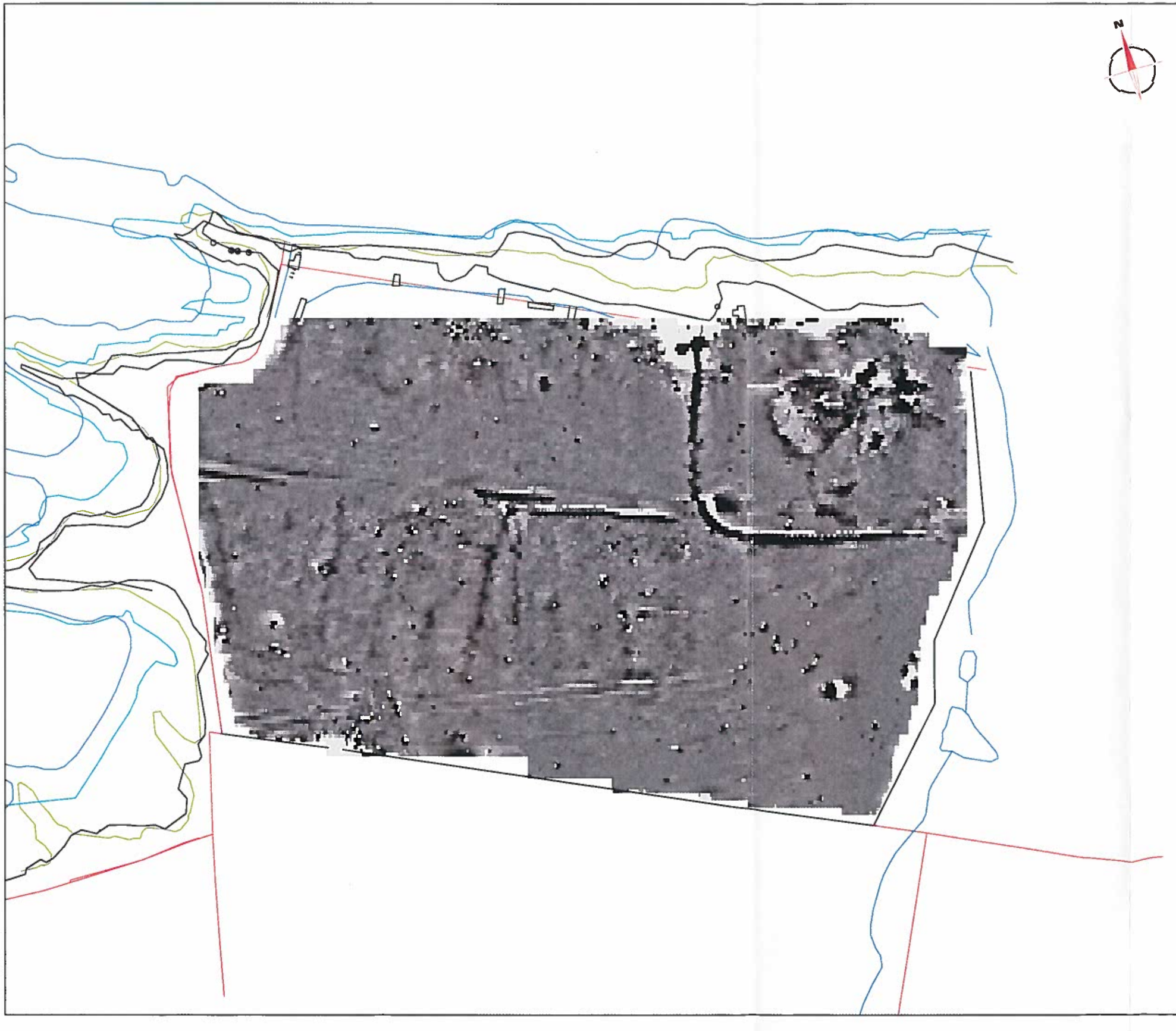

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Plotting parameters

Maximum +4nT (black)
Minimum -4nT (white)

-3SD +3SD

+4nT

-4nT

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
PLOT OF RAW GRADIOMETER DATA

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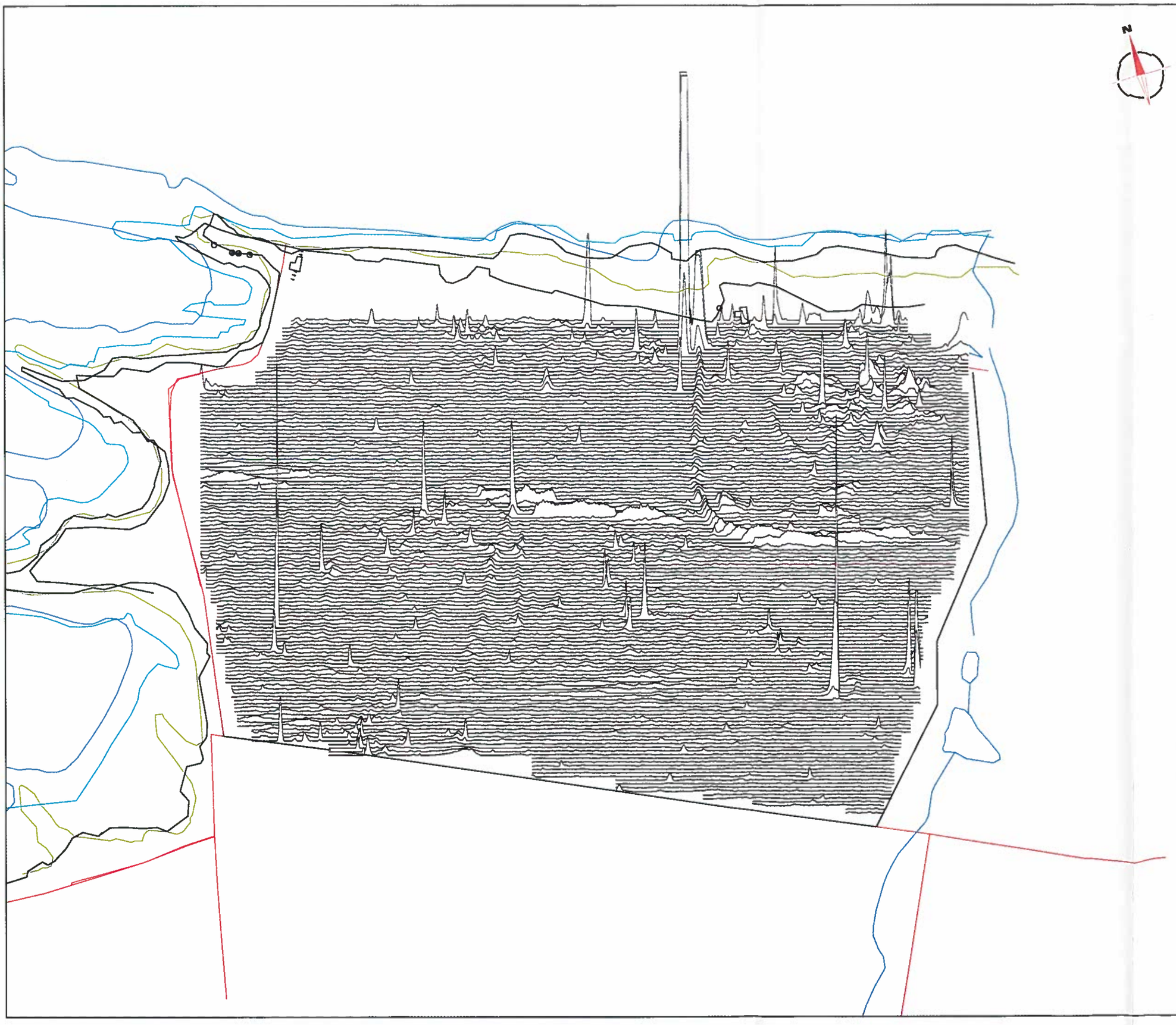

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Plotting parameters

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160nT
120nT
80nT
40nT
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Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
TRACE PLOT OF GRADIOMETER DATA SHOWING POSITIVE VALUES

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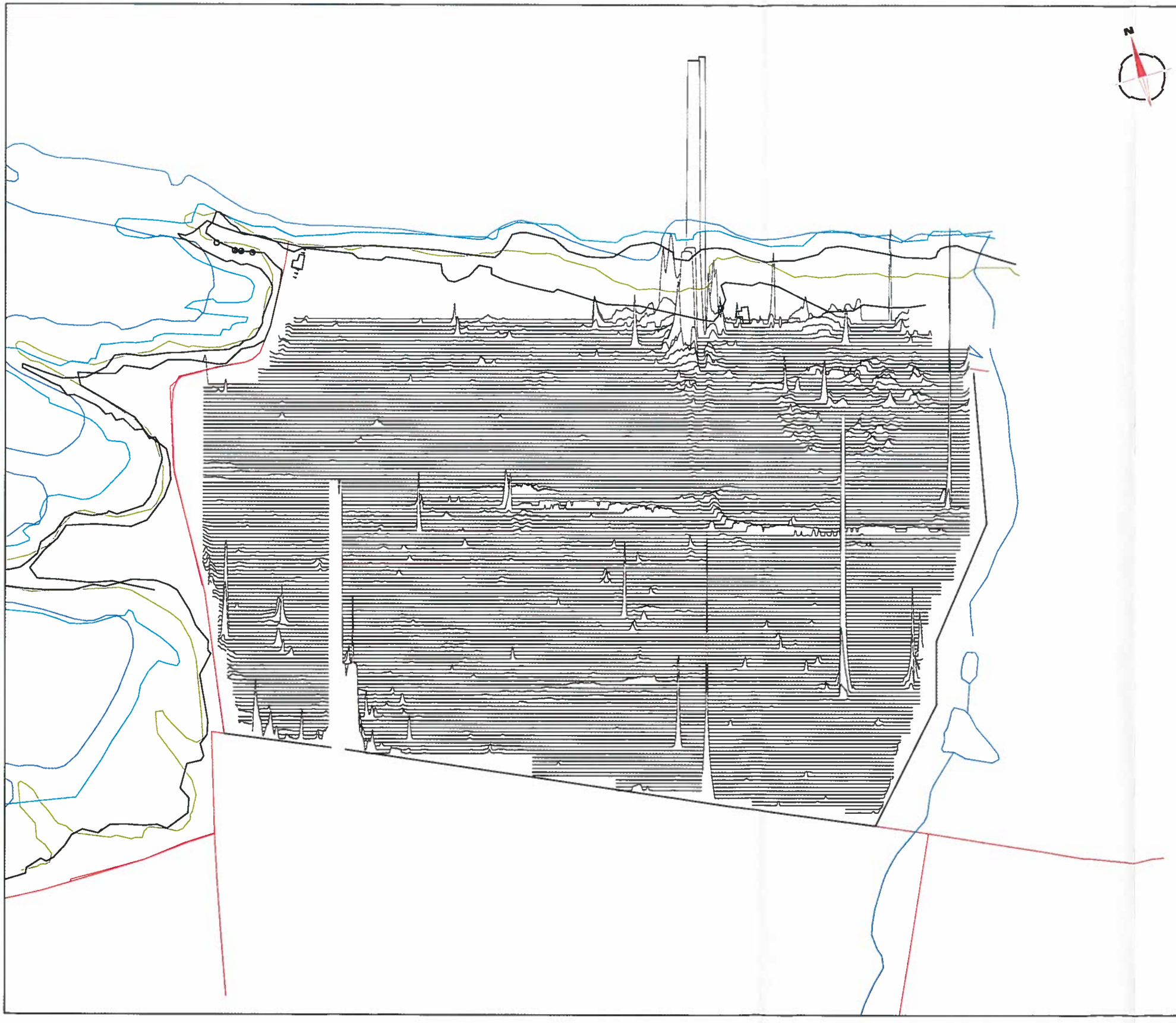

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Plotting parameters

-40nT

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-200nT
-160nT
-120nT
-80nT
-40nT
0nT

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
TRACE PLOT OF GRADIOMETER DATA SHOWING NEGATIVE VALUES

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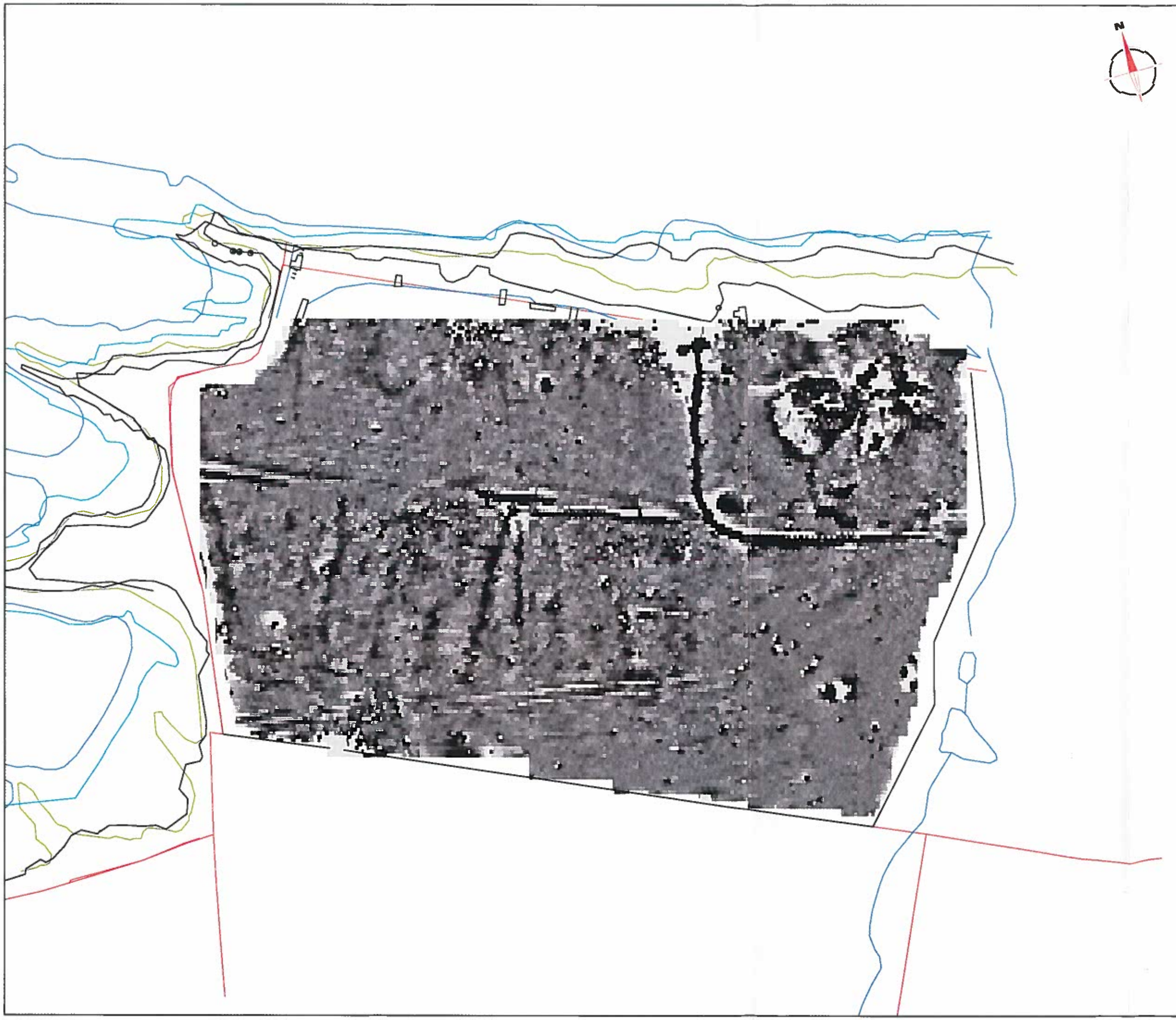

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Plotting parameters

Maximum +2nT (black)
Minimum -2nT (white)

-3SD +3SD

+2nT

-2nT

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
PLOT OF PROCESSED GRADIOMETER DATA

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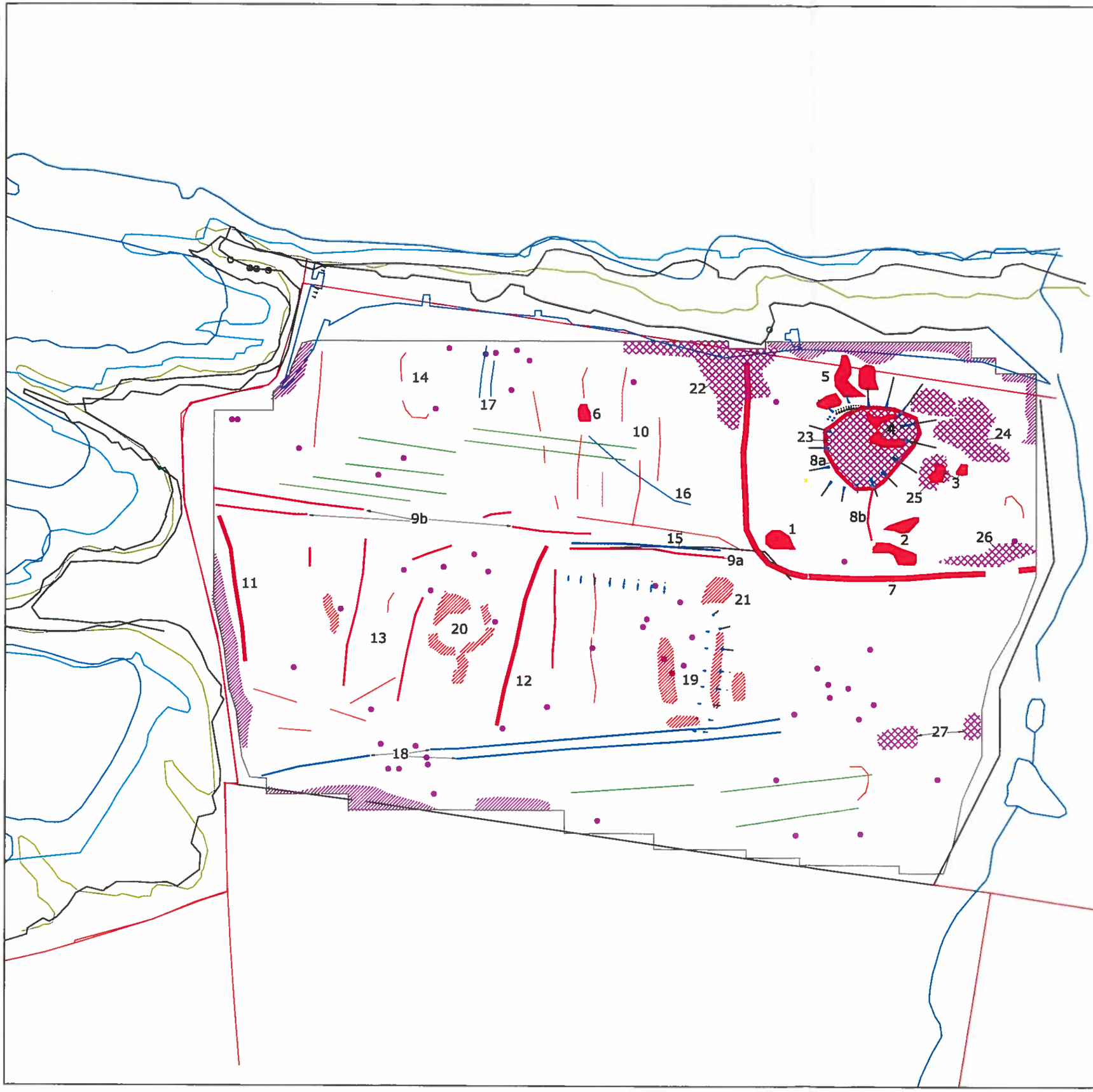

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KEY

	Positive anomaly with associated negative response - ferrous object
	Linear anomaly - possible agricultural mark
	Positive area anomaly - possible pit or cut feature
	Positive linear anomaly - cut feature of possible archaeological origin
	Negative linear anomaly - earthwork or bank of possible archaeological origin
	Positive area anomaly - possible area of ground disturbance
	Area of magnetic disturbance - evidence of ground disturbance
	Area of magnetic debris - associated with nearby field boundaries

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2196
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

STRATASCAN™
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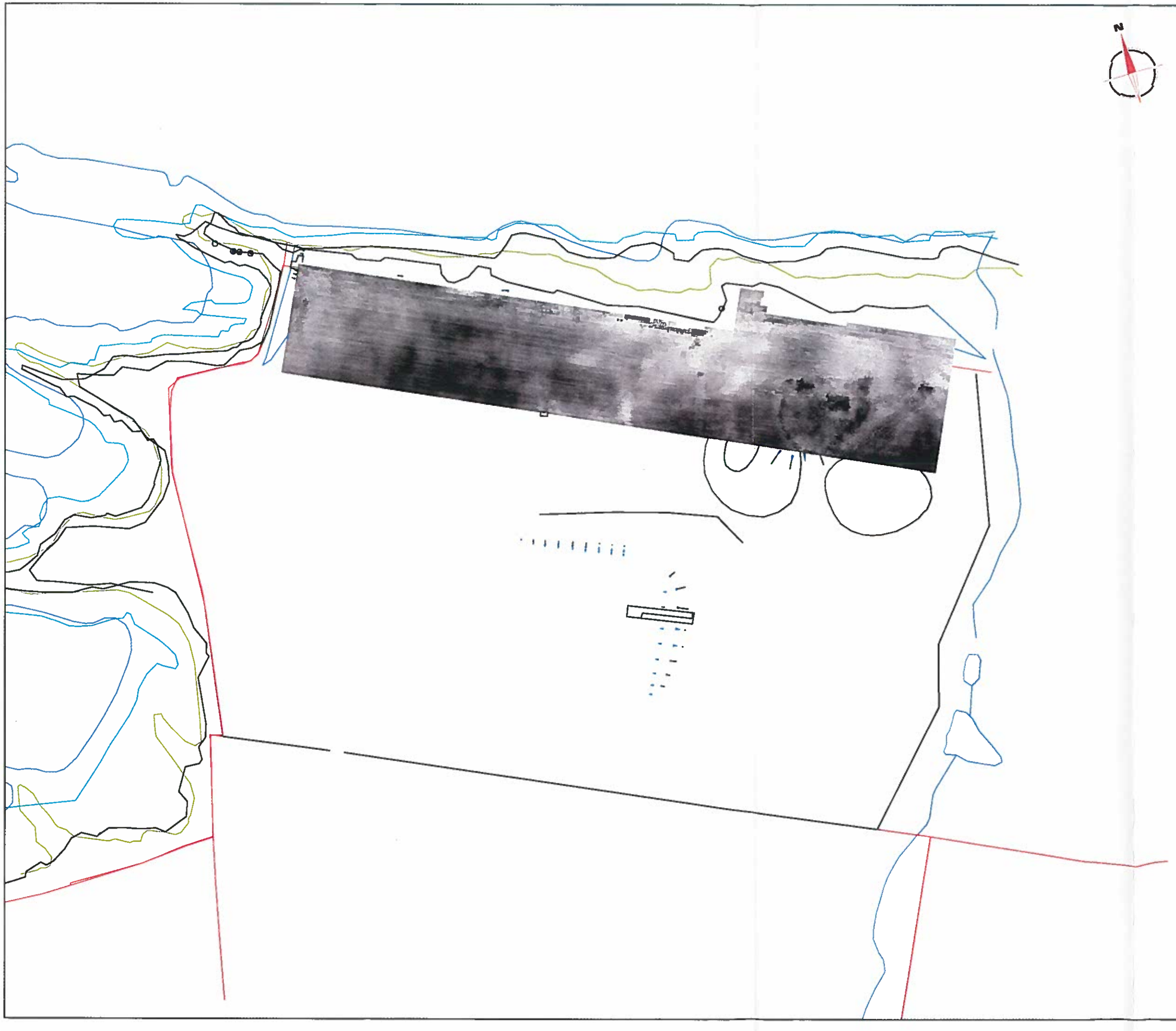
Scale 1:1000 — 0m 10 20 30 40 50

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	Drawn by	Figure No.
JUNE 06	HH	07



Amendments		
Issue No.	Date	Description
-	-	
		-

Plotting parameters

Maximum +86Ω (black)
Minimum +52Ω (white)

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
PLOT OF RAW RESISTANCE DATA

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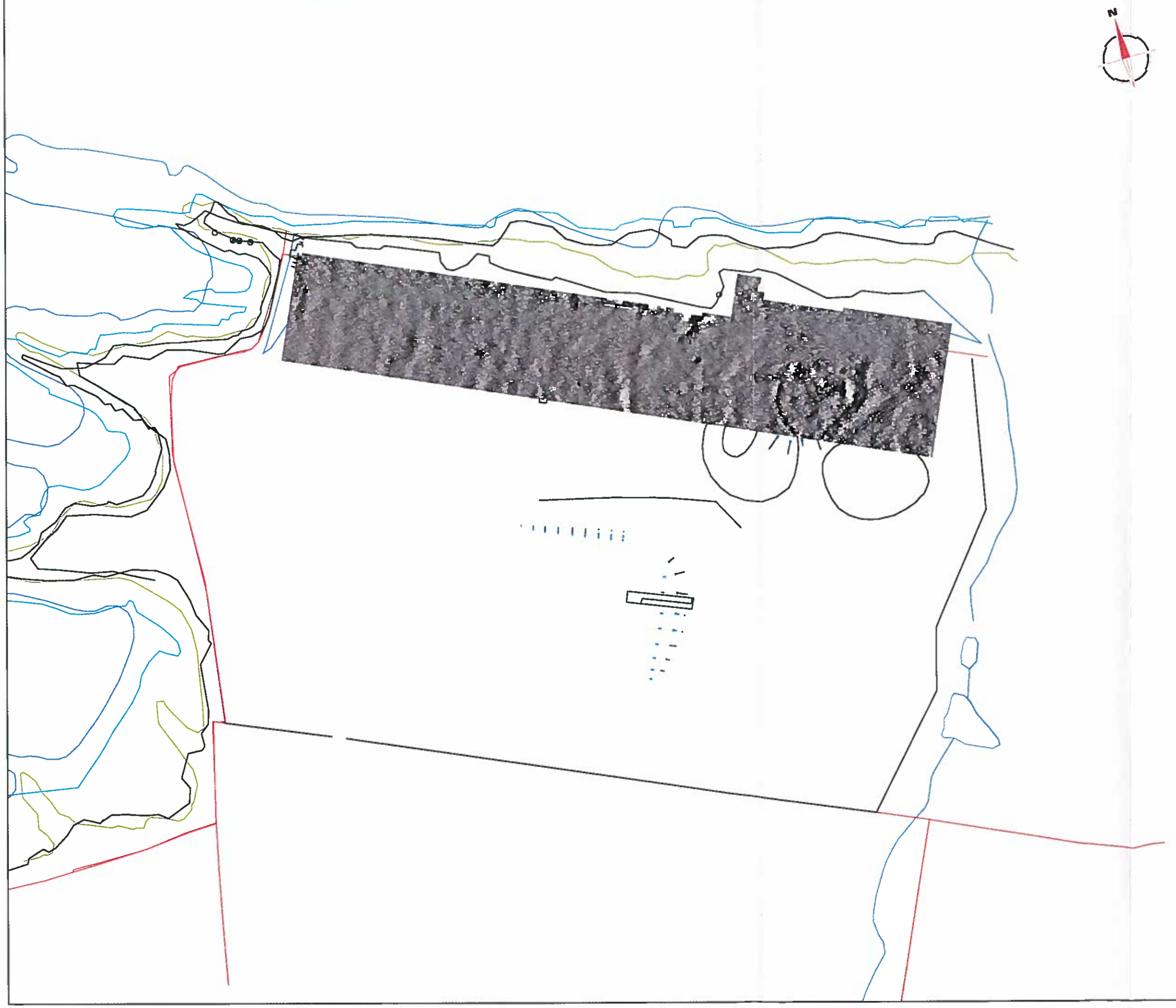
Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	Drawn by	Figure No.
JUNE 06	HH	08



Amendments		
Issue No.	Date	Description
-	-	-
		-

Plotting parameters

Maximum +6Ω (black)
Minimum -2Ω (white)

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
PLOT OF PROCESSED RESISTANCE DATA

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Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	Drawn by	Figure No.
JUNE 06	HH	09

Amendments		
Issue No.	Date	Description
-	-	
		-

KEY

	Moderate resistance linear anomaly - possible structural remains or compacted ground
	High resistance area anomaly - possible structural remains or compacted ground
	Low resistance linear anomaly - cut feature of possible archaeological origin
	Low resistance area anomaly - cut feature or ditch of possible archaeological origin
	Moderately high resistance area anomaly - unknown origin
	Low resistance area anomaly - possible cut feature of archaeological origin
	High resitance area anomaly - possible area of disturbed ground or debris
	High resitance area anomaly - coastal path

Client
PEMBROKESHIRE COAST NATIONAL PARK AUTHORITY

Project Title — Job No. 2169
GEOPHYSICAL SURVEY - WEST ANGLE BAY

Subject
ABSTRACTION AND INTERPRETATION OF RESISTANCE ANOMALIES

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Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	Drawn by	Figure No.
JUNE 06	HH	10