St Cybi's Church
Holyhead

Geophysical Survey

PN: ACC-19-STC

December 2019

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December 2019

Project reference	**ACC-19-STC**
On behalf of	**Isle of Anglesey County Council**
Report prepared by	**Nigel Barker BA, MA**

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2 Summary

This report presents the results of a geophysical survey undertaken at St Cybi's Church, Holyhead, Anglesey.

The combined ground penetrating radar and electromagnetic conductivity survey covered approximately 0.45ha and included the interior of Caer Gybi Roman Fort, the lower churchyard to the east of the fort and a section of car park that was external to the fort's north wall.

The survey detected several possible structural features that may be of interest amongst the multi-layered interments within the upper and lower churchyards. Several broad anomalies were identified within the lower churchyard that could be possible structural elements, however it is feasible that they might be attributed to natural features that were present as part of the original shoreline before the land was reclaimed.

Linear features likely to be associated with buried utilities were also identified.

3 Introduction

A geophysical survey was commissioned at St Cybi’s Church, Holyhead, Anglesey by the Isle of Anglesey County Council. The survey area measured approximately 0.45ha and encompassed the church and associated graveyards that stand within the walls of a former Roman shore fort (NGR SH 2472 8262). A lower churchyard to the east of the fort and a section of car park, exterior to the north wall of the fort was surveyed. The purpose of the survey was to identify the presence and extent of any buried archaeological remains that could be associated with the Roman fort as well as a former monastery that pre-dated the current church. The presence of a possible well within the survey area was also of interest. The car park area was investigated to determine if a ditch had been in place as part of the fort’s defences.

3.1 Location and land use

The location and survey areas are shown in drawing ACC-19-STC.01. The walled area comprised an upper churchyard with an additional lower churchyard to the east of the fort walls. The elevation difference between the upper and lower churchyards is approximately 6m. The upper area slopes gently to the east and contains the church, Eglwys y Bedd and the three walls that comprised the Roman shore fort. The eastern wall has a central opening with steps that lead to the lower churchyard and is of a later date to the fort which was originally open to the shoreline. A low wall with metallic railings is in place adjacent to the church along with stone footpaths. The upper churchyard is grassed and the remaining headstones are flattened. The lower churchyard is walled and is part of the reclaimed former shoreline. Evidence of an arched wharf entrance is present within the western retaining wall. The lower churchyard is grassed, relatively level and contains numerous flattened headstones. The external car park area is relatively level and comprises hardstanding asphalt and paving slabs with associated street furniture. A compound delineated with metal fencing was present in the northwest of the car park and the south face of the church was heavily scaffolded at the time of the survey therefore data could not be collected within these areas. For the purpose of this survey, the upper churchyard is split into four segments labelled Areas 1 to 4 on the drawing. The lower churchyard is area 5 and the car park area 6.

3.2 Site history

The site comprised several protected structures including:

- Caer Gybi Roman Fort - a Scheduled Ancient Monument (AN031) and Grade I Listed Building (ID 5415);
- St Cybi’s Church - a Grade I Listed Building (ID 5413);
- Eglwys y Bedd - a Grade II Listed Building (ID 5414); and
- the lower churchyard wall - Grade II Listed.

A comprehensive history of the site is provided in the archaeological assessment: *St Cybi’s Churchyards and Environs – PN- CR143-22017* (C.Rees & M. Jones: 2017).

Limited excavations had been undertaken within the survey area. Of note, in 1952 works took place to determine whether a defensive ditch was present beyond the north wall of the fort. The excavations were undertaken by W.E Griffiths on behalf of the Ministry of Works but no evidence of a former ditch was found.

3.3 Geology and soils

The underlying geology of the survey area comprises New Harbour Group metamorphic bedrock overlain with Devensian Till.

3.4 Dates and additional information

The geophysical survey was undertaken on 2nd to 7th December 2019, under mixed weather conditions.

4 Field Methodology

4.1 Geomatic referencing

The data was collected over six survey grids that were initially drafted in CAD software then overlain onto topographic detail prior to the commencement of the geophysical survey. The grids are shown in drawing ACC_19_STC_01 and were categorised as Grids 1-6. The grids were uploaded to a Leica TS16 R500 total station to enable the accurate setting out of the co-ordinates in the field using the ground control established for the topographic survey. Measuring tapes were used for heading and positional markers.

4.2 Techniques

Ground penetrating radar (GPR) and electromagnetic ground conductivity (EM) surveys were selected to undertake the survey. The use of earth resistance was not considered to be viable due to the number of flattened headstones within the churchyard and burial ground. Both the selected techniques could be used over hard standing areas, the GPR offering a reasonable depth of penetration as well as approximate depth information whilst the electromagnetic ground conductivity would be able to detect deeper anomalies beyond the detection of the GPR such as the possible well and external defensive ditch.

4.2.1 Ground penetrating radar

Ground penetrating radar surveys are undertaken for the location of buried archaeological features such as structural remains, former roads and trackways as well as graves and ditches under favourable ground conditions. The survey was practiced in accordance with Historic England (2008) Guideline No 1, *Geophysical survey in archaeological field evaluation*, and the Charted Institute for Archaeologists (2014), *Standard and guidance for archaeological geophysical survey*.

4.2.1.1 Instrumentation

A dual frequency (700MHz – 250MHz) IDS ground penetrating radar system was used for the detailed area GPR survey. The system had the capability of detecting anomalies approximately 3.5m in depth over suitable ground conditions.

4.2.1.2 Data Collection

The ground penetrating radar data was collected over an orthogonal survey grid with 0.5m traverse spacings. The profiles are shown in drawing ACC-19-STC_01. The radar was calibrated for distance and first wave correction prior to data collection.

4.2.1.3 Post-processing

The data collected by the GPR was imported into IDS GRED HD software. Each individual radargram was analysed to identify and reference anomalies that were present in the data. Horizontal timeslices were also produced to aid interpretation and to validate anomalies detected from the traversal radargrams. The categorised anomalies were then exported into AutoCAD software for interpretation.

4.2.1.4 Data presentation

The GPR data results are presented as a 1:200 interpretation plot in drawing ACC-19-STC.05.

4.2.2 Electromagnetic ground conductivity

Ground conductivity surveys may be used to detect large archaeological features at depth such as ditches, wells and structural remains over suitable ground conditions. The instrument can also identify accumulations of buried metal. The survey was practiced in accordance with Historic England (2008) Guideline No 1*, Geophysical survey in archaeological field evaluation*, and the Charted Institute for Archaeologists (2014), *Standard and guidance for archaeological geophysical survey*.

4.2.2.1 Instrumentation

A Geonics EM31 (frequency domain) instrument with associated Allegro field computer was used to undertake the EM survey.

4.2.2.2 Data Collection

The EM data was collected over pre-determined grids using measuring tapes for heading and positional markers. Readings were taken at 0.5m increments spaced on 1m traverses. The instrument was balanced external to the survey area with several readings taken from this origin prior to and after the data collection. The readings could later be checked for instrument drift with corrections made to the data if necessary.

Readings were taken in vertical dipole position, providing an effective depth of exploration of approximately 2-5m over suitable ground conditions.

4.2.2.3 Post-processing

Data collected by the instrument was downloaded into DAT31W software for conversion into a spreadsheet format. The data was then loaded into viewshed software where graphic datasets were produced for the quadrature-phase (conductivity) and in-phase (magnetic susceptibility) readings.

4.2.2.4 Data presentation

The quadrature-phase data is shown in drawing ACC-19-STC.02. The in-phase data is shown in drawing ACC-19-STC.03. The results of both data sets are presented as a 1:200 interpretation plot in drawing ACC-19-STC.04.

5 Results

The composite archaeological interpretation of the ground penetrating radar and electromagnetic ground conductivity survey are shown in drawing ACC-19-STC.06.

5.1 Ground penetrating radar data

The effective average depth penetration of the ground penetrating radar within the survey areas was approximately 2.7 metres below ground level before signal attenuation.

5.1.1 Grave Locations

GPR data within the upper and lower churchyards was dominated by anomalies likely to be associated with burials. Each radargram was analysed to record the position of individual responses. Some were better defined than others, possibly due to the ground conditions and/or the materials used for the interments. When burials are of a uniform depth, the production of horizontal timeslices from the GPR data can identify the position of individual graves. The timeslice data from St Cybi's churchyards showed that interments were sporadic in depth, some beyond 2 metres below ground level, whilst others were within the top 1 metre. It is very likely that some of the burials have been stacked vertically, potentially for example in the case of family plots. It is likely the churchyards were 'made-up' with supplemental material, to enable further burials, which may explain the varied range in anomaly depths.

Figure 1 is a section of a radargram taken from Area 1 and shows multiple interments at approximately 0.9 and 1.9 metres below ground level.

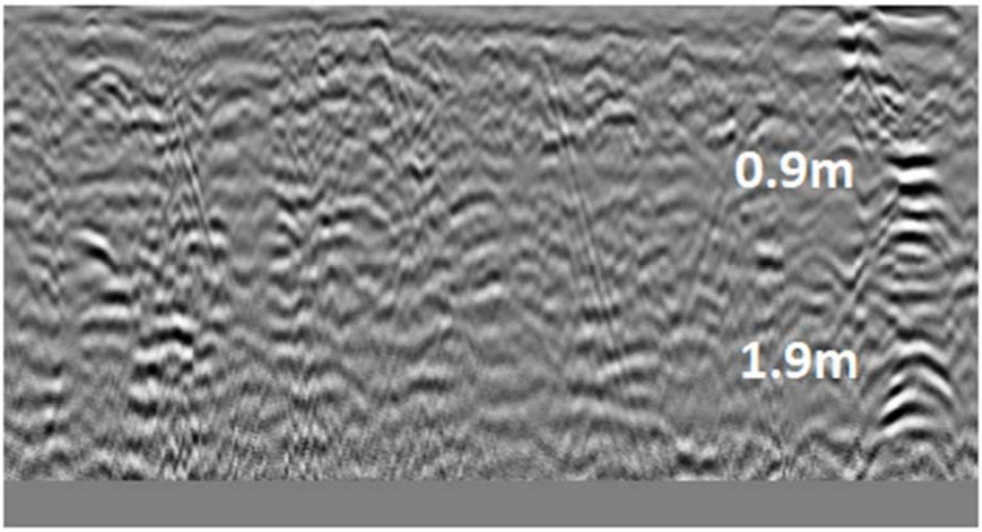


Figure 1

In the GPR interpretation drawing, assemblages of higher amplitude anomalies are depicted as areas, some possibly including parallel burials that were cut in close proximity to each other, therefore each area does not correspond to a single defined plot. Other, isolated high amplitude responses are also included on the drawing and are likely to be associated with burials. Only the higher amplitude anomalies are included in the interpretation drawing and it is likely that additional burials will be present, given the number of weaker, sporadic responses that peppered the churchyards.

It is noteworthy that Areas 2 and 4 of the upper churchyard yielded significantly fewer possible interments with high amplitude responses. The GPR data for parts of Area 4 proved to be very homogenous, whereas Area 2 demonstrated a more disturbed response that made it difficult to identify defined anomalies. It is possible that a high moisture content may have attenuated the radar signal in Area 4, however it may also be possible that removal of graves and subsequent reinstatement could have caused the disturbance and homogenous conditions. If this were the case, it would have been unusual not to have removed all the burials within the given areas, unless legal restrictions were in place.

5.1.2 Structural Anomalies

Several anomalies were detected by the GPR that could be associated with buried structural remains. Anomaly A and Anomaly B are located in Area 3. Anomaly A is a semi-circular apse-like response, approximately 0.8m below ground level and is shown in the horizontal timeslice of Figure 2. Anomaly B is shown in the horizontal timeslice of Figure 3 and comprises a curvilinear feature at a depth of approximately 1.0m below ground level directly beneath Anomaly A. It is difficult to interpret whether Anomalies A and B are part of the same feature or separate entities as Anomaly B extends to 1.2m in depth within footprint of the lower section of Anomaly A. The two anomalies were not detected as continuations within the data of the adjoining Area 4.

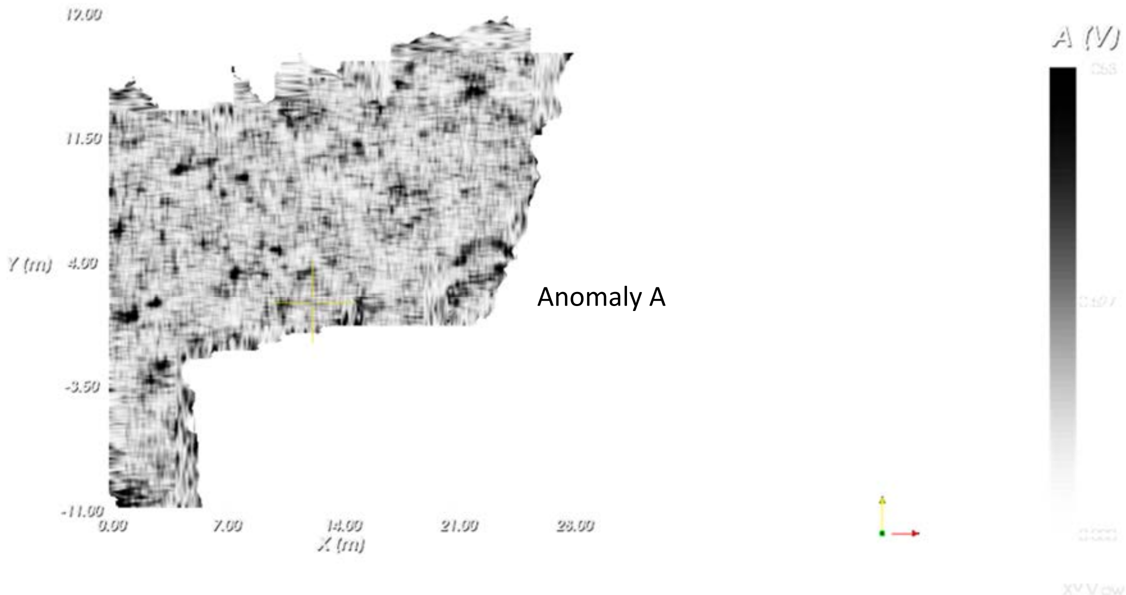


Figure 2

Anomaly C was identified within the lower churchyard, Area 5 and comprises a rectangular structure approximately 0.7m below ground surface. Given its position outside the confines of the Roman Fort and relatively shallow depth, it may be presumed that Anomaly C could be associated with an interment or former grave architecture.

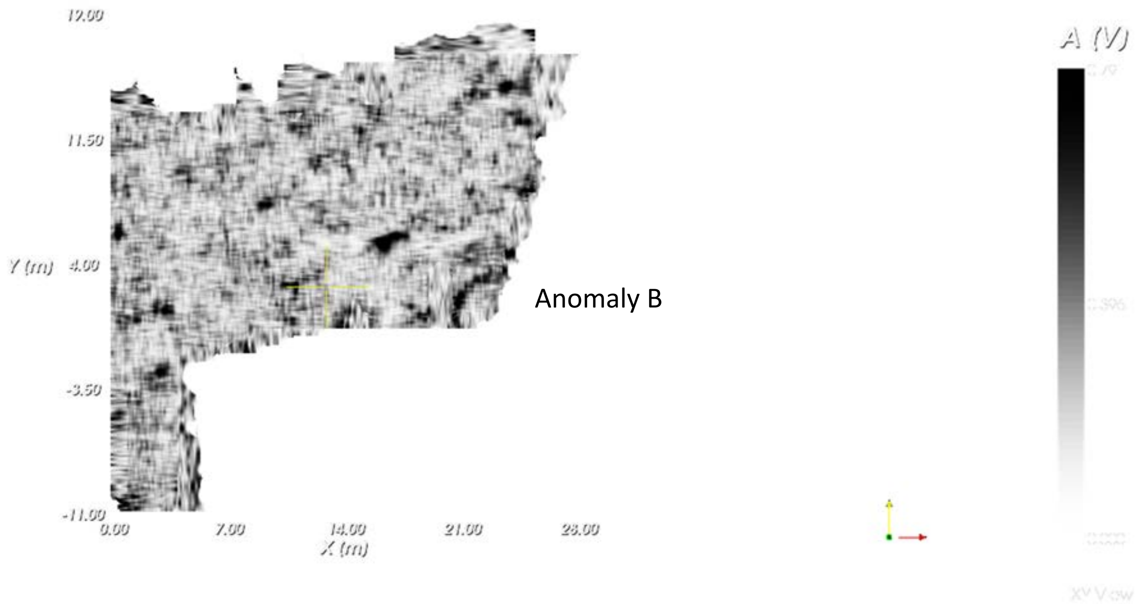


Figure 3

Anomaly D is located adjacent to the church wall in Area 3. It has a high amplitude and is roughly linear in shape, at a depth of approximately 2.5m below ground level. The south face of the church was clad in scaffolding at the time of the survey therefore it is possible that anomaly D could extend further north towards the church wall.

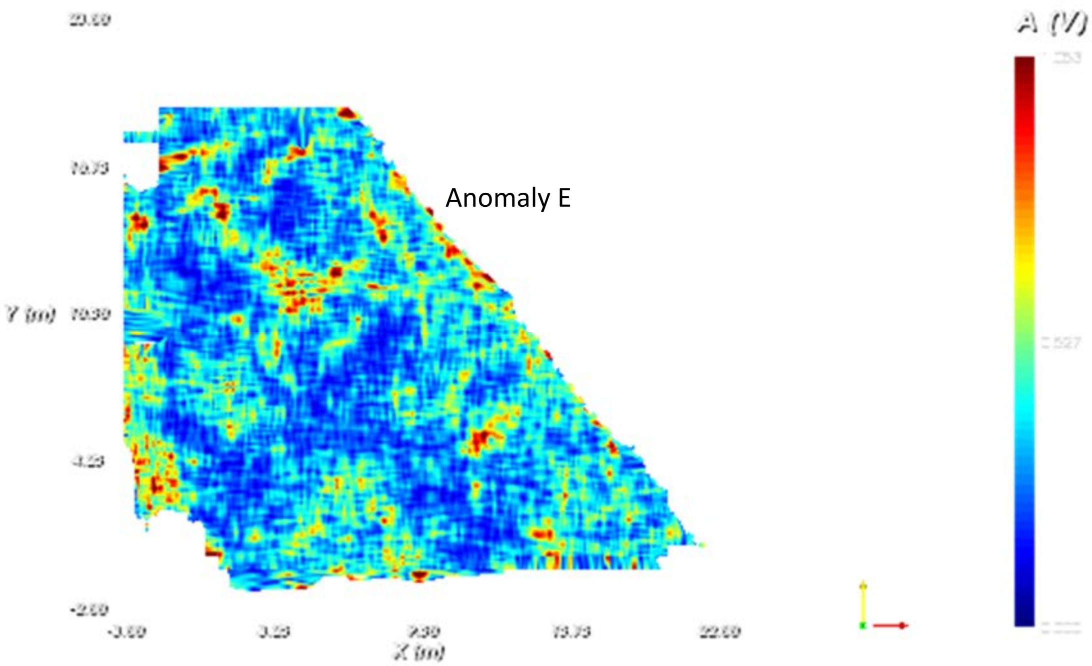


Figure 4

Anomaly E is in Area 2 and is less well defined than the previous examples, shown in the horizontal timeslice of Figure 4, taken at a depth of approximately 1m below ground level

Anomaly E is a fragmented square shape and is comprised of small high amplitude responses. The anomalies are consistent in the radargrams within a disturbed background; however, it is difficult to conclude if they are from an underlying structure and if the shape is coincidental.

A small but deep structural feature was also identified adjacent to the western stone retaining wall of Eglwys Y Bedd. It is of high amplitude and approximately 2.3m in depth.

5.1.3 High Amplitude Anomalies (of uncertain origin)

Several areas of high amplitude anomalies were identified within the data. They occur beneath the stone path of Area 3 leading to the church entrance, beneath the path of the Area 4 and the path of the Area 5. The anomalies beneath the paths of Areas 3 and 5 are characteristically very similar to the anomalies associated with burials, however there are no recorded burials under the paths and as such they have been categorised as of uncertain origin.

The anomalies within Area 4 as well as others located to the west of Eglwys Y Bedd occur at depth and could be structural although they lack any defined shape to positively identify them as such. The high amplitude anomaly associated between anomalies A and B could be an interment or a separate associated structural element.

Additional high amplitude anomalies were detected north of the church building within Area 1 at a depth of approximately 0.6m below ground level as well as a deeper response in Area 2 approximately 1.5m below ground level. It is uncertain if they are structural remains or associated with interments, however the anomaly in Area 2 is a deeper but similar response to Anomaly E.

5.1.4 Broad anomalies

A series of broad Anomalies were identified in the data from Area 5, the lower churchyard. Anomaly F runs adjacent to the southern stone wall, close towards the arched wharf entrance at a depth of approximately 2.3m to 2.6m below ground level. Anomaly G is a 'U' shape and is approximately 2.3m to 2.4m in depth. The remaining anomalies as a collective, along with anomaly G, form a broad linear shape approximately 2.3m to 2.6m in depth that become curvilinear in the north as it bends slightly to the east. Unfortunately, it cannot be readily determined from the data whether the anomalies are associated with human agency such as a wall, or in the case of Anomaly F, a possible slipway associated with the arched wharf entrance, or whether they are a natural feature of the former shoreline.

5.1.5 Linear Anomalies

Several linear anomalies were located during the survey. The most prominent are within the car park of Area 6 and are probably associated with buried utilities. Similarly, fragments of linear features were detected beneath the stone paving in Areas 2 and 4 as well as along the south wall of Area 4, parallel with Stanley House. Although incomplete, it is probable that they are likely to be responses from buried utility plant. The results of this survey should not be used as an assessment of the buried utilities.

Two short linear features were also detected in Areas 1 and 3. They are both comprised of a string of hyperbola anomalies running at a consistent depth, however, given their context it is unclear what they could be.

5.2 *Electromagnetic ground conductivity data*

The EM31 instrument comprises a large 3.7m long boom that is held by a harness by the operator. The length of the instrument restricts how close the operator can be in relation to surface obstructions and therefore limits how much data can be collected.

All the quadrature-phase data and in-phase data shows strong positive and negative values around the perimeter of the grids that are likely to be caused by buildings, walls, railings and the metallic fencing from the compound located within the car park.

5.2.1 Quadrature-phase data

The quadrature indicates the bulk apparent conductivity of the volume of ground sampled and is measured in milliSeimens per metre (MS/m). The quadrature-phase data identified four broad linear features within the survey area. Usually the breadth of the electromagnetic anomaly does not necessarily indicate the breadth of the underlying features which are usually located central to the response. It is likely that the linear features detected in the car park are associated with buried utilities and support the findings of the ground penetrating radar data. The linear feature in Area 3 is likely to be a product of the stone path whilst the one present in Area 1 could also be a former path that has been grassed over or the location of a buried utility that is feeding the church from the car park area.

In Area 5, four circular anomalies (Anomaly H) are present with a strong electromagnetic response possibly derived from buried stone or concrete. The anomalies are not evident in the ground penetrating radar data and it is unclear what they may be, but they are very well defined and worthy of note.

5.2.2 In-phase data

The in-phase component of the data is the magnetic susceptibility of materials present within the sub-surface. The in-phase is measured in parts per thousand (ppt) and is useful for detecting buried metal.

A linear feature was detected in Area 3 that matches the position of that which was identified in the quadrature-phase data. This low electromagnetic response is likely to be a product of the stone pathway.

Anomaly I was detected in Area 1 and is comprised of two strong electromagnetic responses which are central and clear of any external interferences such as walls or fencing. The origin of the responses is not clear, but they could be structural entities or responses from metallic materials.

6 **Conclusions**

The combined ground penetrating radar and electromagnetic ground conductivity survey identified several anomalies within a challenging sub-surface that was dominated by the presence of multiple layers of graves.

The GPR identified several possible structural features that may be of note, however the estimated depths of some of the more well defined anomalies are relatively shallow (0.8m to 1.0m) and it would therefore be assumed that they may have been noted during the period of time that the graveyard was active as the graves exceed the depth of the anomalies. Four circular anomalies were identified in the lower churchyard by the EM survey that could be of note. The responses are strong although their immediate purpose is unclear. Two areas of enhanced electromagnetic response were detected in the upper churchyard and could be structural remains or contain materials that are metallic.

The radar also identified a series of broad anomalies within the lower burial ground. It is possible that the response in the far south of the area could be associated with a possible slipway as it corresponds with the position of the arched wharf entrance present in the southwest corner. The remaining anomalies form a broken linear shape that curves slightly to the east. It is unclear from the data if the anomalies are of archaeological potential or if they are natural features from the former shoreline. The anomalies did not appear within the electromagnetic data which would be expected if they were large accumulations of built stone.

Several high amplitude anomalies were identified within the GPR data. Some of the anomalies are characteristically very similar to the anomalies associated with burials, however there are no recorded burials within the churchyard paths, therefore it is uncertain what they could be associated with. If these anomalies were interments, then they may precede the burial records held by the church. Additional high amplitude responses were detected throughout the upper churchyard at varying depths that could be structural entities, however their context amongst the burial responses makes that difficult to determine.

Numerous linear anomalies were detected by the GPR and EM that are probably associated with buried utilities. The most prominent were within the car park area. Fragmented linear features were also detected beneath the stone paving in the upper churchyards and parallel with Stanley House. Although incomplete, it is probable that they are likely to be responses from buried utility plant.

The presence of an external defensive ditch was not supported by the geophysical data from the car park.

As with all geophysical investigations, the results presented are not infallible and are derived from data that is representative of the ground conditions at the time of the survey. Caution should always be exercised when excavating.

7 References

Historic England (English Heritage 2008) Geophysical Survey in Archaeological Field Evaluation. Research and Professional Services Guideline #1.

Institute of Field Archaeologists (2002) IFA Paper No 6, The use of geophysical techniques in archaeological evaluations.

Charted Institute of Archaeologists (2014) Standard and Guidance for Archaeological Geophysical Survey.

Rees. C & Jones. M (2017): St Cybi's Churchyards and Environs. C.R Archaeology: PN CR143-2017

8 Appendix 1

8.1 Ground Penetrating Radar: technical information

Ground penetrating radar (GPR), involves the use of an antenna which houses a transmitter and receiver. The transmitter propagates electromagnetic energy pulses into the sub-surface using specific frequencies. The strength and time required for the signal to be reflected back to the surface is then recorded by the receiver and logged using an external data console. Reflections occur when the pulse passes through a material with different electrical conduction properties or dielectric permittivity from the 'background material' that the GPR was calibrated over.

The strength or amplitude of the reflection is determined by the level of dielectric constants between the two materials, for example a pulse that moves from dry sand (diel 5), to wet sand (diel 30) will produce a strong, high amplitude reflection. By measuring the time and amplitude strength of the reflections it is possible to obtain approximate depths to the detected anomaly. The success of a GPR survey will commonly be determined by the level of contrast between the buried target and its surrounding matrix.

Ground with a high dielectric value can be very conductive and often has a high-water content that will disperse or attenuate the signal very quickly. Therefore, if the ground is water saturated or the soil is high in dissolved salts or comprises heavy wet clays, the effective penetration of the signal will be significantly reduced. Heterogenous materials that are varied in composition (such as made ground), can also reduce depth penetration and produce false artefacts within the data as the signal is scattered within the medium.

The GPR identifies anomalies or variations within the background response. Given the size, shape or nature of the response it is possible to provide an interpretation of the anomaly, however this can be sometimes subjective and difficult under poor ground conditions.

The centre frequency of the antenna selected for the survey will be largely dependent upon the proposed depth of the target. High frequency antennas (1GHz or higher), are used for high resolution, shallow scans, with medium (400MHz to 700MHz) and low frequency antennas (150MHz or lower) used to find deeper targets or geological features respectively at the compromise of near surface resolution.

8.1.1 Survey Method

The traverse interval used for a data collection will be dependent upon the purpose of the survey and the size of the buried target (if known). The following are commonly used:

- High frequency – 20cm to 50cm traverse intervals
- Medium frequency – 50cm to 1m traverse intervals
- Low frequency - 1m to 5m traverse intervals

The velocity of the radar pulse and the number of scans taken per metre will be set and will be dependent upon the frequency of the antenna used. The survey wheel will be calibrated to ensure accuracy and the first wave adjustment made to adjust the value that the system sets as 'time zero'. For some instruments, the gain will be adjusted to a suitable constant if the system records the gain values.

Digital distance markers will be inserted onto the data as the machine passes over the pre-determined grid if a global positioning system (GPS) is not in use, so that the data can be geo-referenced onto a base map.

For some high frequency structural surveys, anomalies can be marked out on the wall or floor surface using chalk or wax crayon. The anomalies are then surveyed using a total station or GPS.

The data is displayed on a console and is also recorded onto an internal storage card.

8.1.2 Data Processing

The data from the instrument will be downloaded into bespoke software specific to the system used. Commonly, a background removal process will be applied, and a simple gain function added to enhance the presence of any anomalies.

Each individual radargram will be reviewed and the different anomalies highlighted. The anomalies are then interpreted in CAD software and geo-referenced onto a base map.

Horizontal timeslices will also be produced to validate the anomalies detected in the radargrams and aid interpretation but will not be used solely for interpretation.

8.1.3 Limitations

The success of a GPR survey is largely dependent upon the ground conditions and the prospective target. The instrumentation detects measurable differences of materials within the sub-surface rather than locating specific objects, therefore if the target is too small or does not have a variable conductivity to the surrounding matrix then it is unlikely to be detected. It is not possible to guarantee that a GPR survey will comprehensively identify all sub-surface features.

Depth information can be produced by the instrumentation; however, this is determined by the average wave velocities within a given medium and are therefore approximate. Depth accuracy will also lessen under poor or heterogenous ground conditions.

It is important that the survey area is clear of dense vegetation and surface obstructions so that antenna has adequate contact with the ground to enable suitable penetration. Areas of standing water or waterlogged ground will attenuate the signal and prevent the location of possible anomalies. Buried metal objects are very good reflectors, however if the survey area is covered with reinforcement, then the signal will in most cases fail to travel beyond the reinforcement layer. GPR is not infallible therefore it is always important to exercise caution when excavating.

9 Appendix 2

9.1 Fixed Frequency Electromagnetic Conductivity: technical information

The use of electromagnetic techniques to measure the sub-surface is a time-tested technique that has a wide variety of geological, environmental, hydrological and archaeological applications.

Electromagnetic surveying is based upon induction and does not involve inserting probes into the ground. The instruments comprise of a transmitter coil and a receiver coil, the distance between them determining the depth of penetration, for example a 1m coil separation will provide an approximate penetration depth of 4m in good ground conditions whilst a non-fixed coil instrument can penetrate up to 60m in good ground conditions.

The transmitter coil emits a time varying magnetic or primary field into the ground that will generate eddy currents in conductive materials that in turn produce a secondary magnetic field that is measurable by the receiver together with the original primary field.

The measured secondary field has two components referred to as the 'quad-phase' or quadrature and the 'in-phase'. The quadrature is the apparent conductivity of materials present in the sub-surface and is measured in milliSiemens per metre (mS/m), the apparent conductivity inversely proportionate to apparent resistivity. The in-phase component is the magnetic susceptibility of materials present in the sub-surface, measured in parts per thousand (ppt), and is useful for detecting accumulations of buried metal.

Measurements can be recorded with the dipole orientation positioned horizontally, vertically or in both orientations. The two orientations will measure different sub-surface volumes, the vertical orientation having a greater depth penetration than the horizontal.

The instruments are calibrated to read the conductivity of a uniform sub-surface. If the ground is composed of layers having different conductivities, then the instrument will determine an intermediate value.

9.1.1 Instrumentation

Karta Geo LTD use three different instruments dependent upon the type of target to be detected and the required depth of location.

The Geonics EM38 has a fixed intercoil spacing of 0.5 m offering an effective depth penetration of 0.7 m to 1.5 m when used in horizontal and vertical dipole orientations. This instrument is useful for shallow engineering, environmental and archaeological investigations.

The Geonics EM31 has a fixed intercoil spacing of 3.66 m offering an effective depth penetration of approximately 3 m to 6 m when used in horizontal and vertical dipole orientations. This instrument is useful for general site characterisation surveys as well as the extent of shallow contaminant plumes.

The Geonics EM34 is a non-fixed coil that can be adjusted dependent upon the required depth of penetration. An intercoil spacing of 10m will achieve an approximate depth of 7.5m to 15m in respective horizontal and vertical dipole orientations. An intercoil spacing of 40m will achieve an approximate depth of 30m to 60m in respective horizontal and vertical dipole orientations. This instrument is primarily used for geological applications and the detection of contaminant plumes.

9.1.2 Survey Method

The surveys are usually undertaken using a grid system with readings taken on 1 m centres. In some instances, the increments may change dependent upon the size of the target required for location.

The instrumentation will be balanced in a uniformly 'quiet' area that will be located away from the survey area if balancing proves problematical.

9.1.3 Data Processing

The data is downloaded and archived at the end of each days surveying. The data is compiled into a 'X, Y, Z' spreadsheet format and imported into viewshed software.

Data sets are processed and exported from the viewshed software usually in bitmap format and imported into AutoCAD for interpretation drawings to be produced.

9.1.4 Limitations

It should be noted that electromagnetic measurements, in some instances, due to interference or other geophysical limitations, may not detect anomalies present in the sub-surface.

The success of a fixed frequency electromagnetic survey is largely dependent upon the ground conditions and the prospective target. The instrumentation detects measurable differences of materials within the sub-surface rather than locating specific objects so if the target is too small or does not vary in conductivity to the background matrix then it is unlikely to be detected. The instrumentation is also susceptible to surface interference caused by power lines, cars, metallic street furniture and fencing that can create a response that will mask any potential sub-surface features.

The results of any geophysical survey are not infallible as the character and extent of an anomaly are determined remotely so a definite interpretation cannot be made or presumed. The 'ground-truth' of measurable responses can only concluded by intrusive means; therefore, caution should always be exercised during excavation.

SITE LOCATION

SCALE 1:25000

0M 500M 1000M

SCALE 1:500 @ A3

0 20

SURVEY EXTENTS

EM31 EXTENTS

GPR PROFILES

SITE LOCATION

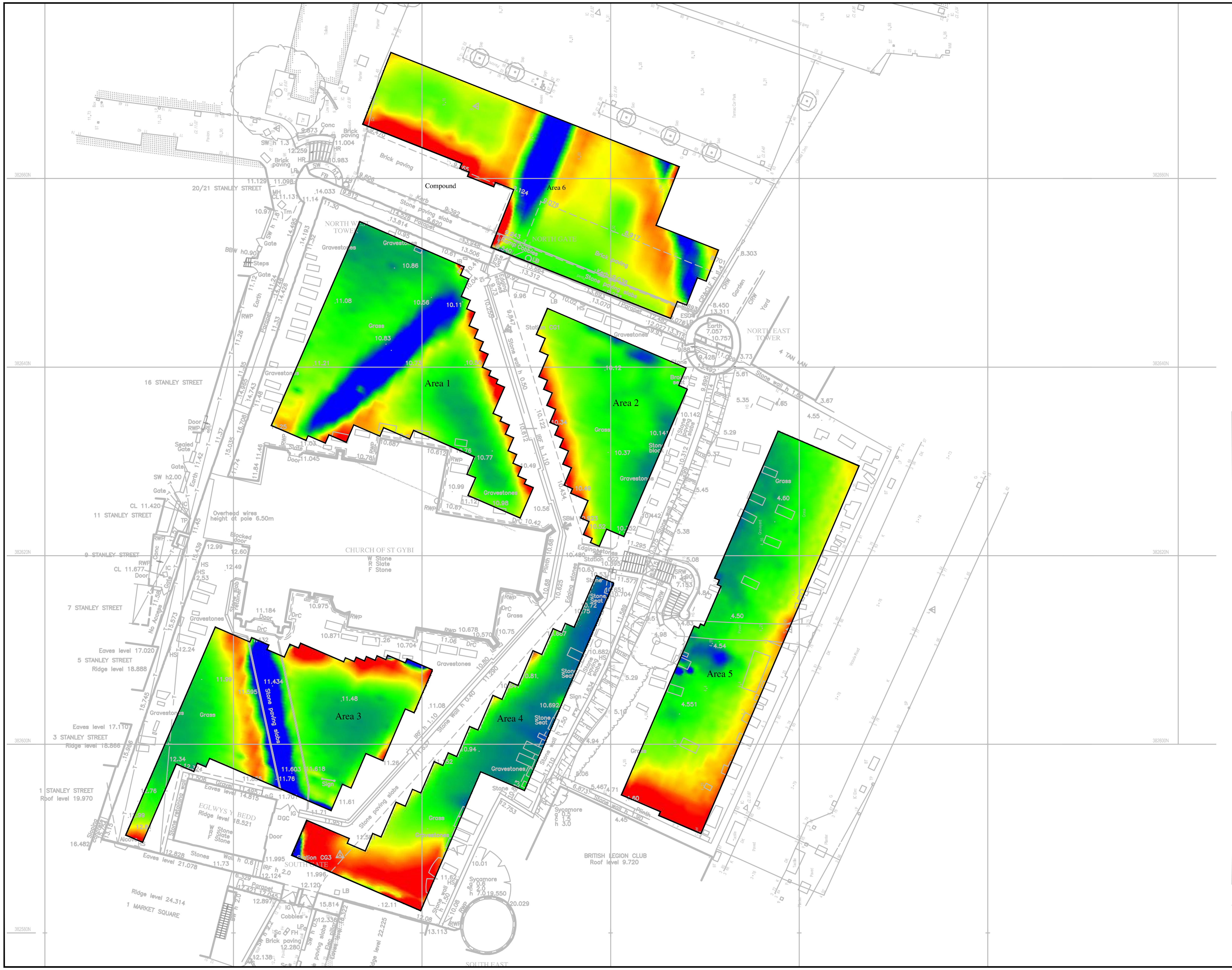
Karta

St Peter's Gate
Sunderland Science Park
Charles Street
Sunderland
SR6 0AN
E: admin@eden-mapping.co.uk
W: www.eden-mapping.co.uk

Client Name	Isle of Anglesey County Council
Job Title	St Cybi's Church Anglesey
Drawing Title	Site Location & Survey Extents
Scale	As Shown
Drawn	NB
Date	14/12/19
Approved	AP

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
ACC-19-STC	01	-	Final



Direction of North taken from topographical drawing 15569-1-1

Apparent Conductivity

+

-

mS/m

Karta

St Peter's Gate
Sunderland Science Park
Charles Street
Sunderland
SR6 0AN
E: admin@eden-mapping.co.uk
W: www.eden-mapping.co.uk

Client Name

Isle of Anglesey County Council

Job Title

St Cybi's Church
Anglesey

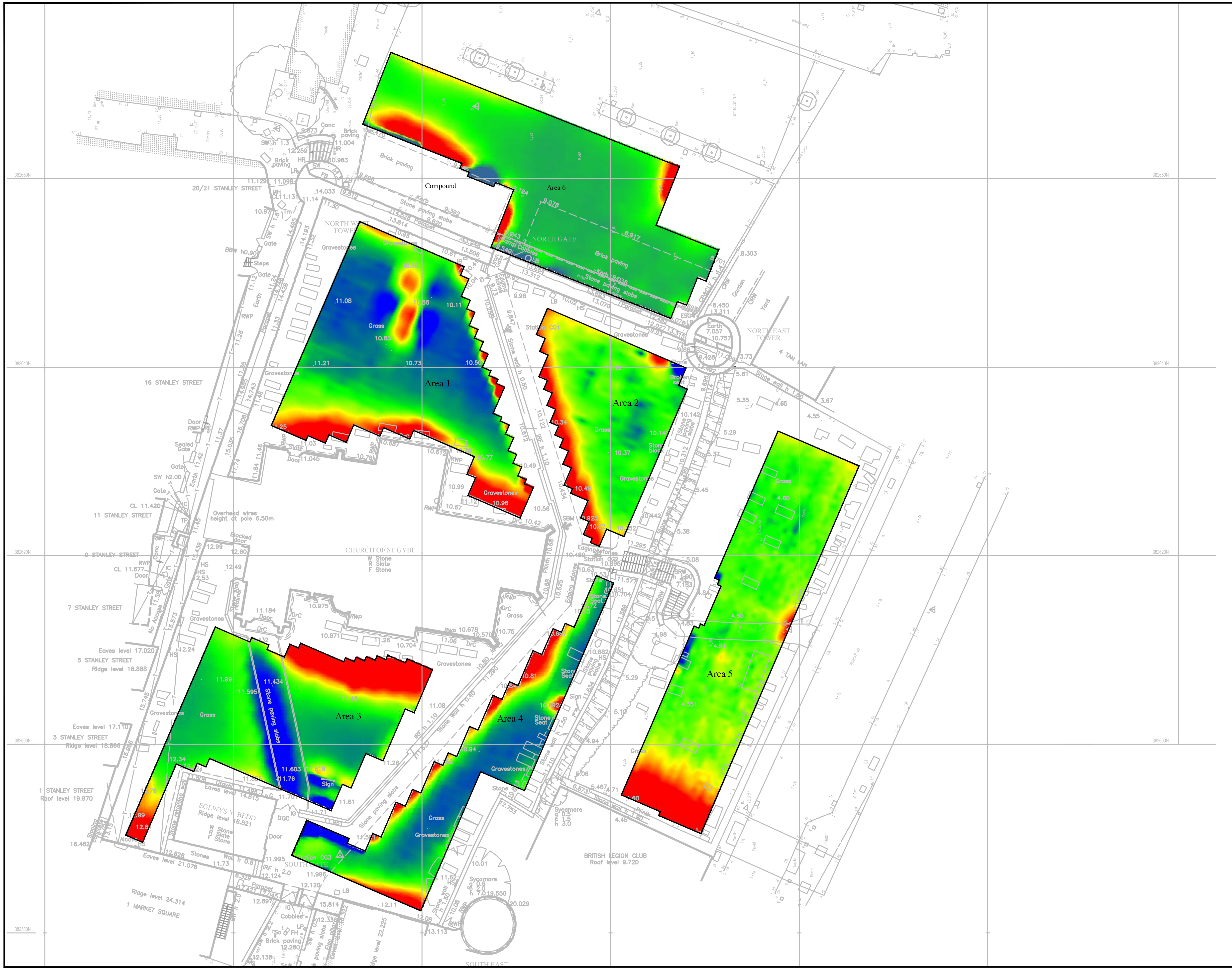
Drawing Title

Electromagnetic Quadrature-Phase Data

Scale	1:400 @ A3	Drawn	NB
Date	14/12/19	Approved	AP

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
ACC-19-STC	02	-	Final



Direction of North taken from topographical drawing 15569-1-1

In-Phase

+

-

ppt

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Client Name	Isle of Anglesey County Council
Job Title	St Cybi's Church Anglesey
Drawing Title	Electromagnetic In-Phase Data
Scale	1:400 @ A3
Drawn	NB
Date	14/12/19
Approved	AP

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
ACC-19-STC	03	-	Final

Direction of North taken from topographical drawing 15569-1-1

Key

Electromagnetic Ground Conductivity (EM)

- Area of low electromagnetic response. Probably associated with stone paving or buried utilities.
- Area of low electromagnetic in-phase response. Probably associated with stone paving.
- Area of high electromagnetic in-phase response. Possible associated with buried structural feature or metallic materials.
- Area of presumed quadrature-phase data disturbance. Probably caused by buildings, railings, metallic fencing, cars and street furniture.
- Area of presumed in-phase data disturbance. Probably caused by buildings, railings, metallic fencing, cars and street furniture.
- EM31 survry extents

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Client Name: Isle of Anglesey County Council

Job Title: St Cybi's Church Anglesey

Drawing Title: Electromagnetic Data Interpretation Drawing

Scale: 1:200 @ A1	Drawn: NB
Date: 14/12/19	Approved: AP

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
ACC-19-STC	04	-	Final

Direction of North taken from topographical drawing 15569-1-1

Key

Ground Penetrating Radar (GPR)

- Areas of high amplitude GPR anomalies. Probably associated with graves.
- Isolated magnetic enhancement. Possibly associated with a grave.
- Areas of high amplitude GPR anomalies. Associated with a buried feature of unknown origin / possible grave.
- High amplitude GPR anomaly. Possibly associated with buried structural feature.
- Area of broad higher amplitude anomalies. Possibly associated with deep structural remains or natural geological feature from the original shoreline.
- Linear anomalies. Possibly associated with buried utilities.
- Survey extents

(All GPR depths values are metres below ground level. Only the higher amplitude anomalies were included for the grave locations. It is likely that additional interments will be present, given that weaker, sporadic responses that peppered the churchyard areas.)

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Client Name	Isle of Anglesey County Council
Job Title	St Cybi's Church Anglesey
Drawing Title	Ground Penetrating Radar Data Interpretation Drawing
Scale	1:200 @ A1
Drawn	NB
Date	14/12/19
Approved	AP

Revision	Amendments	By	Checked

Project Number	Drawing No	Revision	Status
ACC-19-STC	05	-	Final

Direction of North taken from topographical drawing 15569-1-1

Key

- Probable location of grave(s)
- Strong, isolated anomaly. Possible location of a grave.
- Anomaly of uncertain origin. Possibly associated with graves or sub-surface structural feature.
- Possible buried structural feature.
- Broad anomalies, possibly associated with deep structural remains or natural geological feature from the original shoreline.
- Linear anomalies. Possibly associated with buried utilities.
- Possible buried structural features or metallic materials.
- Survey extents

(All GPR depths values are metres below ground level. Only the higher amplitude anomalies were included for the grave locations. It is likely that additional interments will be present, given that weaker, sporadic responses that peppered the churchyard areas.)

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Client Name	Isle of Anglesey County Council
Job Title	St Cybi's Church Anglesey
Drawing Title	Archaeological Interpretation Drawing
Scale	1:200 @ A1
Drawn	NB
Date	14/12/19
Approved	AP

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
ACC-19-STC	06	-	Final