Maes Parcio Penlan

Penlan Car Park

Pwllheli

Geophysical Survey

PN: 4060

March 2023

360 ARCHAEOLOGY

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Project reference	**4060**
On behalf of	**Cyngor Tref Pwllheli / Pwllheli Town Council**
Report prepared by	**Nigel Barker BA, MA, MCIfA**
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1 Contents

CAD Drawings: 4060

Drawing Number	Paper Size	Scale	Title
4060-01	A3	Various	Site Location & Survey Extents
4060-02	A3	1:20	GPR Interpretation

Digital Media: 4082

4060.dwg	Containing Layout 4060-02

Drawings are scaled for ease of use in pdf format. Large scale layouts intended for the production of plotted physical media can be provided upon request.

2 Executive Summary

This report presents the results of a geophysical survey undertaken at Penlan Carpark, Pwllheli, Gwynedd, LL53 5DH.

The ground penetrating radar survey covered approximately 40m x 42m of asphalt covered carpark.

The GPR survey has revealed several sub-surface features, some of which may be of interest. Linear features associated with drainage pipes were located, while shallow horizons observed in the northwest are likely to be modern and associated with drainage pipes or cable ducts. Deeper sub-surface horizons were detected, but it is unclear if they are natural or anthropogenic, especially given the area's historical shoreline location. High amplitude heterogenous responses in the far corners could indicate material or ground composition changes, while hyperbolic responses may reflect buried objects. Further analysis and investigation would be necessary to determine the exact nature and significance of these features.

3 Introduction

A geophysical survey was commissioned by Pwllheli Town Council to be undertaken over a section of Penlan car park located at Pwllheli, Gwynedd, LL53 5DH. The survey extents measured approximately 40m x 42m and encompassed an area of hardstanding asphalt. The location is shown in Figure 1 below.

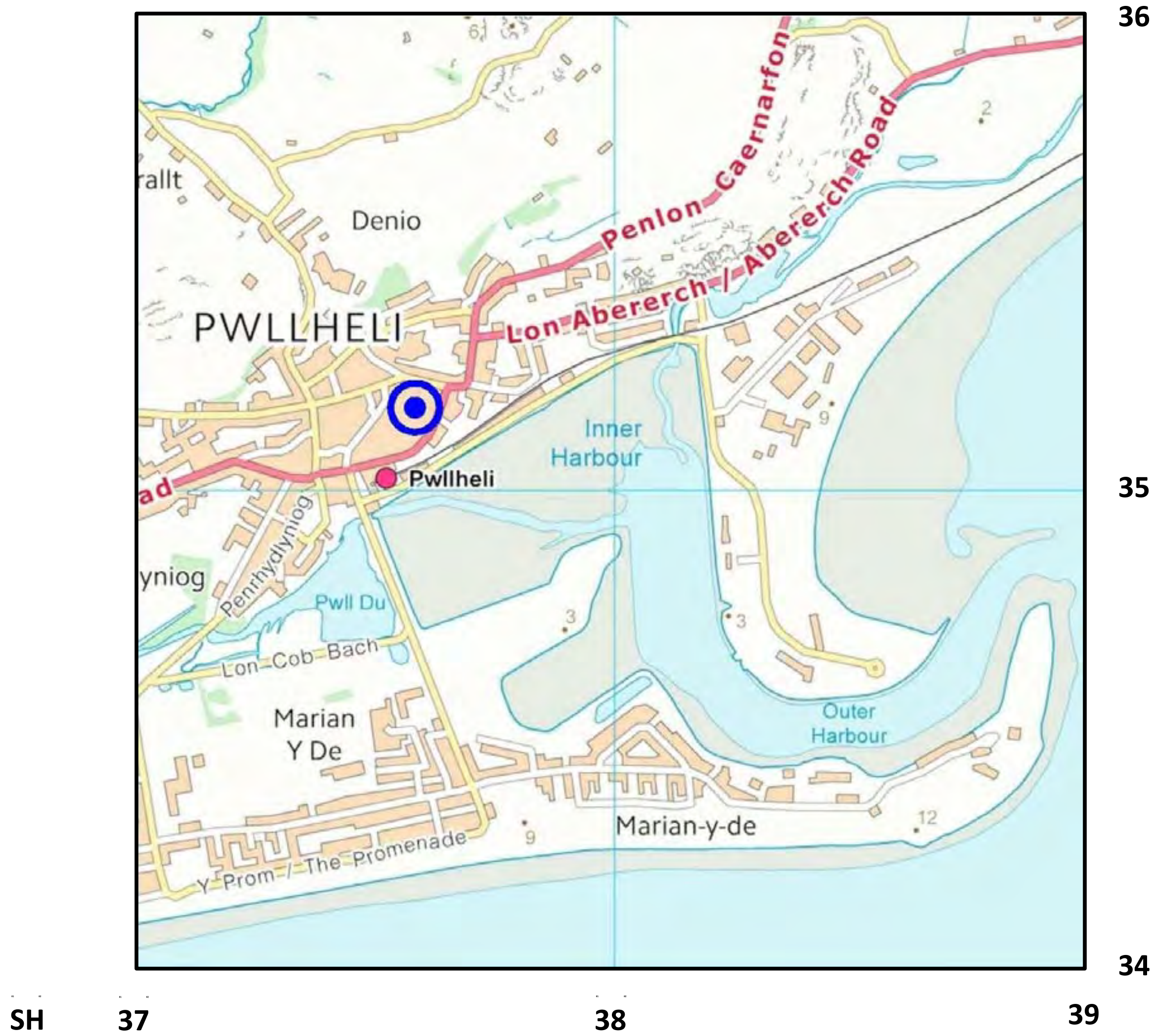

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Figure 1

3.1 *Location and land use*

The location and scaled survey areas are shown in drawing 4060-01.

NGR Centre	SH 37588 35171
Postcode	LL53 5DH
HER/SMR	Archwillio Gwynedd
HER Number	N/A
Period	Possible medieval

District	Caernarfon
Parish	Deneio

Area	Hectares	Topography & Notes	Land Use
1	0.15	The area encompasses the northern half of Penlan car park. The surface is asphalt with kerbing segmenting the area into two parts. A public convenience is located in the northwest corner, and lampposts and manhole covers suggest that buried utilities are present. The works were undertaken during the night as the carpark was fully operational. However, some vehicles belonging to permit holders were still parked within the required area at the start of the survey, limiting the available coverage.	Carpark

3.2 *Aims and objectives*

The key aim and objective of the geophysical survey was to establish whether potential archaeological remains survive within the survey area.

It was proposed that ground penetrating radar (GPR) would be used as the primary reconnaissance technique to locate any buried archaeological features. This technique has the advantage that it can be used over hardstanding ground and any anomalies likely to be anthropomorphic could then be targeted intrusively if necessary.

The GPR identifies anomalies or variations within the background signal. Given the size, shape, or nature of the response it is possible to provide an interpretation of the anomaly, however this can be subjective at times and difficult under poor ground conditions. By measuring the time and amplitude strength of the reflections it is also possible to obtain depth estimates of 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.

3.3 *Site history*

An Urban Characterisation report was available at the time of the fieldwork, undertaken by Gwynedd Archaeological Trust (GAT:2008). It is certain that in the 12th century Pwllheli became an administrative centre of the commote of Afloegion and subsequently developed into a town and port. Historical post conquest surveys and taxation documents confirms the existence of a court which was maintained by the tenants and a home farm. The report suggests that the potential for medieval archaeology is high in the area within the old town as a mound to the east of the carpark may be a medieval motte, and the placename 'gadlys' which is applied to the carpark indicates the site of the 12th century llys or court hall. It has been called Gadlys from at least the 17th century and is thought to refer to the location of medieval buildings enclosed within a ditched enclosure and adjacent to the motte. The junction of the High Street with Penlan Street and Kingshead

Street was the centre of the Medieval Borough, and the location of the marketplace. Medieval development is likely along Kingshead Street, to the north of the carpark and possibly North Street, that would have lined the former Medieval harbour. The carpark is shown as an open garden on Wood's map of 1834, with no development beyond encroachment of the buildings of New Street and St Tudwal's Terrace.

3.4 *Geology and soils*

The underlying geology of the survey area comprises Cwm Elgiau Formation, which consists of siltstone (purple in Figure 2). This is a Sedimentary bedrock formed between 455.25 and 452.75 million years ago during the Ordovician Period. The superficial geology is Alluvium. These are sedimentary superficial deposits of clay, silt, sand and gravel formed between 11.8 thousand years ago and the present during the Quaternary period (British Geological Survey: 2023).

Figure 2 (www.bgs.ac.uk)

3.5 *Dates and additional information*

The geophysical survey was undertaken during the evening of the 25th March 2023, under mixed weather conditions. Not all the parking bays were clear of vehicles during the time of the survey, therefore the coverage by the GPR was not comprehensive.

4 Field Methodology

4.1 *Technique*

A ground penetrating radar (GPR) survey was selected as the primary technique to undertake the survey. This method can be used over both hard standing and grassed areas and will offer approximate depth information of potential targets. Under favourable ground conditions, a GPR survey can identify the location of buried archaeological features such as structural remains, former roads/ trackways, and graves and ditches. The survey was practiced in accordance with the 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 *Geomatic referencing*

The data was collected over an orthogonal survey grid that was initially drafted in CAD software, then overlain onto OS Mastermap digital data, prior to the commencement of the geophysical survey. The grid was uploaded to a Trimble R10 GPS instrument to enable the accurate setting out of the co-ordinates in the carpark. Measuring tapes were used for heading and positional markers.

4.3 *Instrumentation*

A Proceq GS8000 ground penetrating radar system was used for the survey. The system has the capability of detecting anomalies approximately 4.0m in depth over suitable ground conditions.

4.4 *Data Collection*

The GPR data was collected over an orthogonal survey grid with 0.5m traverse spacings using a standard resolution with a repetition rate of 0.4 scans per cm. The data was stored on a field tablet mounted on the GPR platform and prior to collection, the radar was calibrated for distance with the dielectric constant, gain and time window adjustments, all made specific to the site conditions. The dielectric constant was set at by hyperbola correction, using strong, high amplitude drainage pipe anomalies that were evident close to manholes. Access to the drainage system was not possible during the survey but the calibration can be checked by obtaining the invert level of the drains from manhole chambers, then adjusting the depth information accordingly if they differ.

4.5 *Post-processing*

The completed data set was imported into Screening Eagle Insights GPR software. Each individual radargram was analysed to identify and reference anomalies evident within the data. Horizontal timeslices were produced to aid interpretation and to validate anomalies detected from the traversal radargrams. The categorised anomalies were then exported into AutoCAD software as a .dxf file for interpretation.

4.6 *Data presentation*

The magnetic data results are presented as a 1:20 interpretation plot in drawing 4060-02.

4.7 Archive

360 Archaeology & Heritage LTD hold a full in-house digital archive resulting from the project including all raw and processed data, geomatics, plans, documents, and written material.

5 Results

The effective average depth penetration of the GPR within the survey area was approximately 2.8m below ground level, with a general horizon occurring approximately 2.0m below ground level that may be indicative of a change in material or moisture levels. The signal can be seen to attenuate beyond 2,8m although some deeper anomalies were detected in places.

5.1 Discussion

5.1.1 Linear Features

Numerous linear features were detected within the data that are comprised of hyperbolic anomalies that occur in adjacent traverses forming chains of responses. From their position within the carpark, the majority of the linear features are associated with drainage pipes, as they link to, or from the position of manhole covers.

5.1.2 Sub-surface Horizon – High Amplitude

Anomalies [A1] and [A2] are shallow, well-defined horizons located in the northwest of the survey area, shown in Figure 1. They occur approximately 0.5m below ground level and are roughly square in shape with sides of just over 1m in length. Both have linear features associated with them running west that are likely to be from drainage pipes or cable ducts. It is therefore probable that Anomalies [A] are modern.

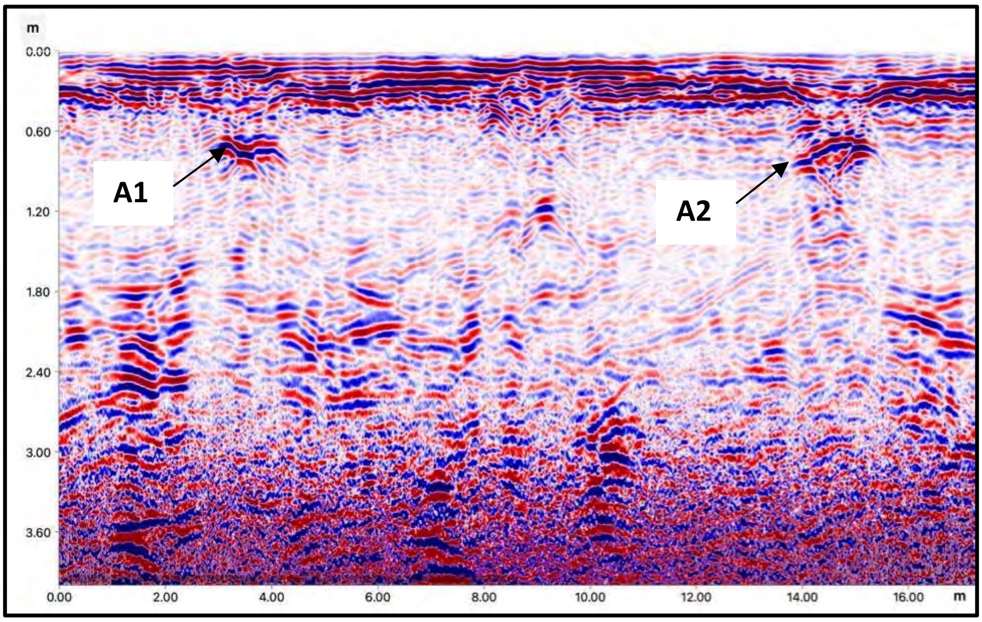

Figure 1(Anomalies A1 & A2 Radargram)

Deeper sub-surface horizons were detected elsewhere in the carpark that may be of interest. Anomaly [B] is in the east of the survey area and comprises a high amplitude interface at approximately 1.1m below ground level that slopes down to the north and south to a depth of approximately 2.1m below ground level, shown in Figure 2. This anomaly is flanked by pipes to the east and west that create disturbance in the data, making it difficult to determine if they extend further. Anomaly [C] is deeper than Anomaly [B] but has a similar sloping characteristic. Additional high amplitude horizons occur to the southwest of Anomaly B and could be a extension of it (also shown on the timeslice of Figure 3), although they do not have the sloping characteristics of Anomaly [B]. In all cases, the responses below the initial horizon are heterogenous and extend at depth perhaps implying an accumulation of materials. A similar high amplitude accumulation was identified in the far south of the survey area.

It is unclear if these responses are anthropogenic and representative of buried earthworks or a previous ground surface, or if they are natural variations within the sub-surface especially as this area could have been a historical shoreline.

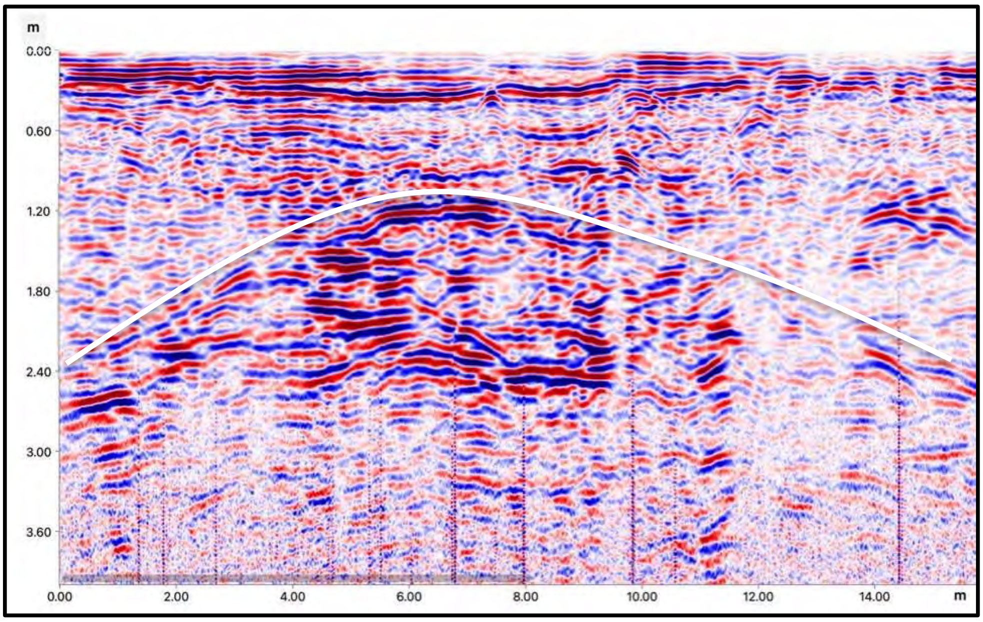

Figure 2 (Anomaly B Radargram)

5.1.3 *High Amplitude Heterogenous Responses*

Two areas that show high amplitude heterogenous responses in the data were identified in the far northwest corner and southeast corner of the survey area. This disturbance is caused by multiple reflectors and short high amplitude horizons present within the sub-surface that scatter the GPR signal as it propagates down through the ground. This response could be indicative of a change of material or ground composition and it is unclear if they are natural or anthropogenic features.

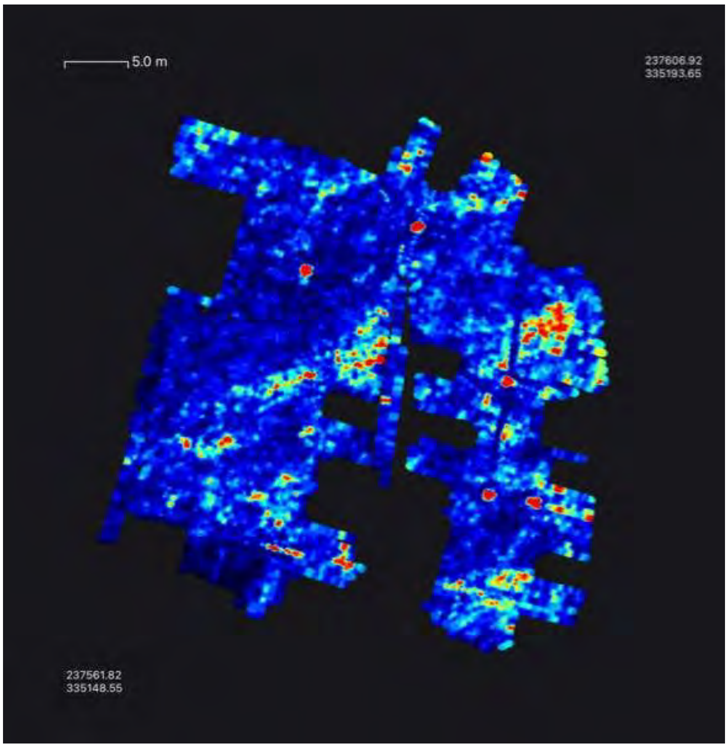

Figure 3 (Timeslice – 1.57m-1.67m)

5.1.4 *High Amplitude Hyperbolic Responses*

Numerous large, high amplitude hyperbolic responses were detected within the data. Some could be part of linear configurations but were not consistent enough to form a coherent chain of responses. Others were isolated and could be possible reflections from a buried object within the sub-surface. Only the largest hyperbola have been represented on the drawing and the selection was not intended to be exhaustive.

6 Conclusions

In conclusion, the GPR survey of the carpark has identified a range of interesting sub-surface features that can be targeted to determine if they are of archaeological interest.

The majority of the linear features detected are associated with drainage pipes, linking to or from manhole covers. Shallow, well-defined horizons located in the northwest of the survey area are likely to be modern and associated with drainage pipes or cable ducts.

Deeper sub-surface horizons were detected in the carpark, that contrast well with homogenous background seen elsewhere in the data, but it is unclear if they are anthropogenic or natural variations within the sub-surface, especially as the area could have been the location of a historical shoreline. The high amplitude heterogenous responses in the far northwest and southeast corners could be indicative of a change of material or ground composition, and it is also unclear if they are natural or anthropogenic features. Lastly, numerous large, high amplitude hyperbolic responses were identified within the data, possibly reflections from a buried object within the sub-surface. Further investigation and analysis may be necessary to determine the exact nature and significance of these features.

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. Where possible, the magnetic data should be used in conjunction with supporting evidence and resources to corroborate or eliminate these findings.

7 References

- Historic England (English Heritage 2008) *Geophysical Survey in Archaeological Field Evaluation. Research and Professional Services #1.*
- Institute of Field Archaeologists (2002) IFA Paper No 6, *The use of geophysical techniques in archaeological evaluations.*
- European Archaeological Council - EAC Guidelines 2 (2015) *Guidelines for the use of Geophysics in Archaeology: Questions to Ask and Points to Consider*
- Charted Institute of Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*
- British Geological Survey – Geology of Britain Viewer - www.bgs.ac.uk
- Gwynedd Archaeological Trust (GAT) – (Project# 1913 - Report# 730) *Urban Characterisation: Pwllheli.*
- Cover: Ordnance Survey – OS One-Inch Revised New Series - Pwllheli (Hills) – Scale one inch to the mile: 1899.

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 at specific frequencies. The amplitude and time required for the signal to be reflected to the surface is then recorded by the receiver and logged using an external data console. Reflections occur when the pulses encounter a material with different electrical conductivity or dielectric permittivity than the 'background material' that the GPR was calibrated over.

The strength or amplitude of the reflection is determined by the difference in 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 from the detected anomaly. The success of a GPR survey will commonly be determined by the level of contrast of 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. Water saturated ground, soils high in dissolved salts, or heavy wet clays can significantly reduce the effective penetration of the signal. Heterogeneous materials with varying composition, such as made ground, can reduce depth penetration and produce false artefacts due to signal scattering within the sub-surface.

The GPR identifies anomalies or variations in sub-surface materials within the background response. Based on 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 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: 0.2m to 0.5m traverse intervals
- Medium frequency: 0.5m to 1.0m traverse intervals
- Low frequency: 1.0m to 5.0m traverse intervals

The velocity of the radar pulse and the number of scans taken per metre will be set and is 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 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 be produced to validate the anomalies detected in the radargrams and aid understanding of the data 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 variations in material properties within the sub-surface, rather than locating specific objects. Therefore, if the target is too small or does not have a significant contrast in electrical properties compared to the surrounding matrix, it may not 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 is therefore approximate. Depth accuracy will lessen under poor or heterogenous ground conditions.

It is important that the survey area is clear of dense vegetation and surface obstructions so that the 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.

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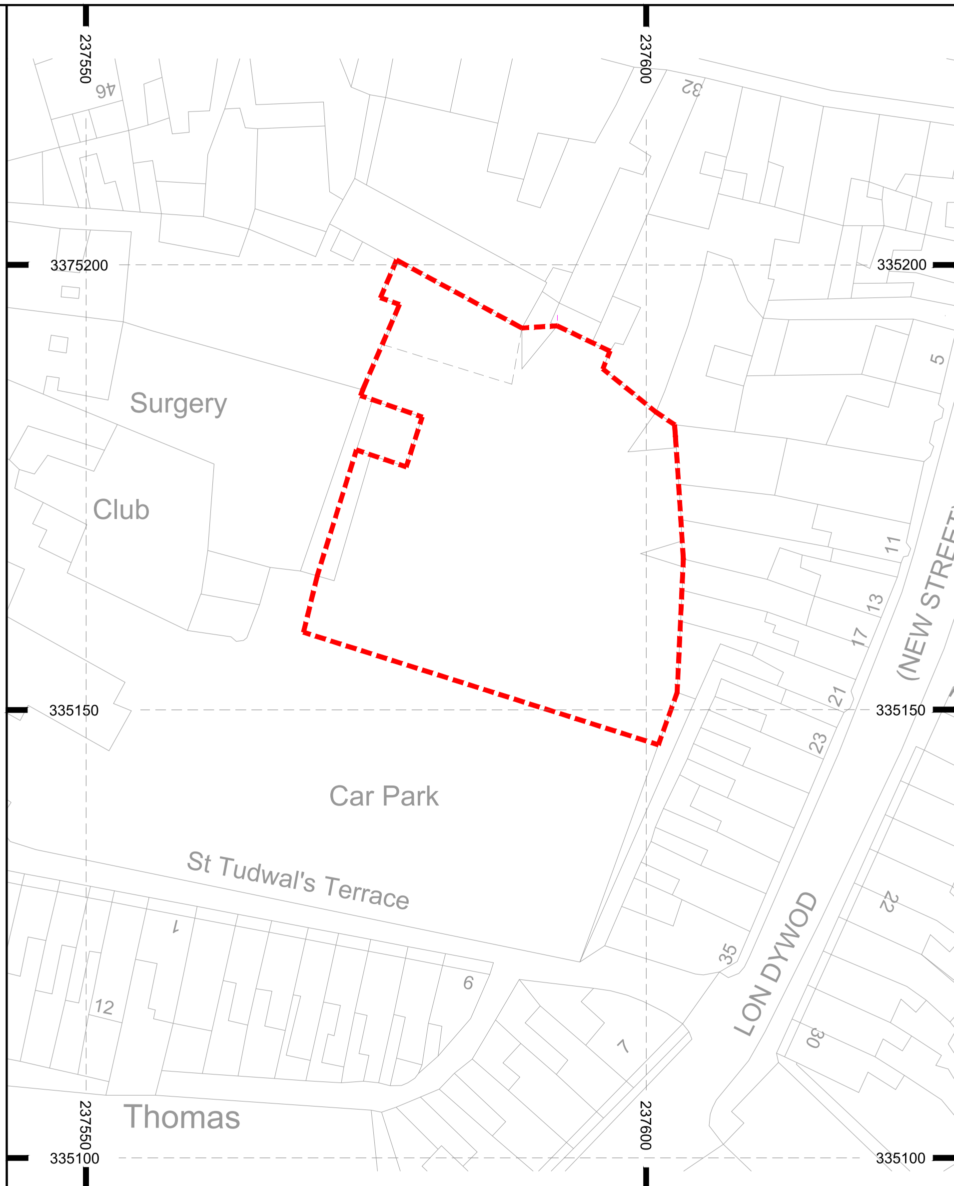
SH 36 37 38 39

SITE LOCATION

SCALE 1:25000

0M 500M 1000M



SURVEY AREA

SCALE 1:600 @ A3

0 25M

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Client Name: Cyngor Tref Pwllheli / Pwllheli Town Council

Job Title: Maes Parcio Penlan / Penlan Car Park

Drawing Title: Site Location & Survey Extents

Scale	As Shown	Drawn	NB
Date	24/01/23	Approved	PH

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
4060	01	-	Final

Approximate Direction of North

Key

- Sub-surface Horizon - high amplitude
- High amplitude heterogeneous response. Possible sub-surface disturbance / change of material
- High amplitude hyperbolic response. Possibly associated with an isolated sub-surface object or possible linear feature when occurring as a string
- Linear feature. Probable buried utility
- Linear feature. Possible buried utility
- GPR survey extents
- 0.2-1.7 Approximate depth of GPR anomaly (meters below ground level)

Drawing to be used in conjunction with report 4060

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Job Title	Maes Parcio Penlan Penlan Car Park
Drawing Title	GPR Interpretation
Scale	1:20 @ A3
Drawn	NB
Date	26/03/23
Approved	PH

Revision	Amendments	By	Checked

Project Number	Drawing No.	Revision	Status
4060	02	-	Final