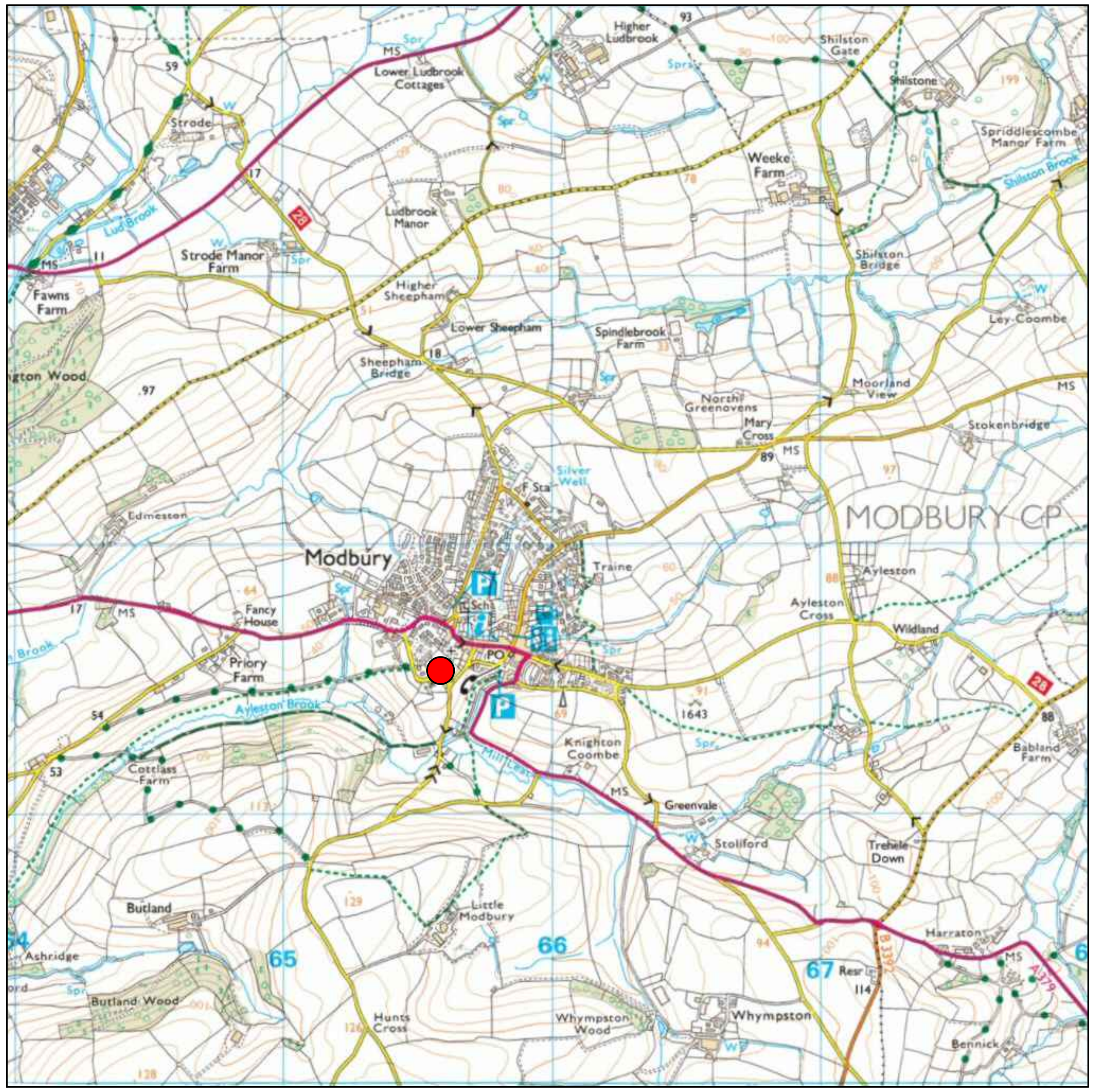


N

	Site Location

SUMO GeoSurveys

Title:
Site Location Diagram

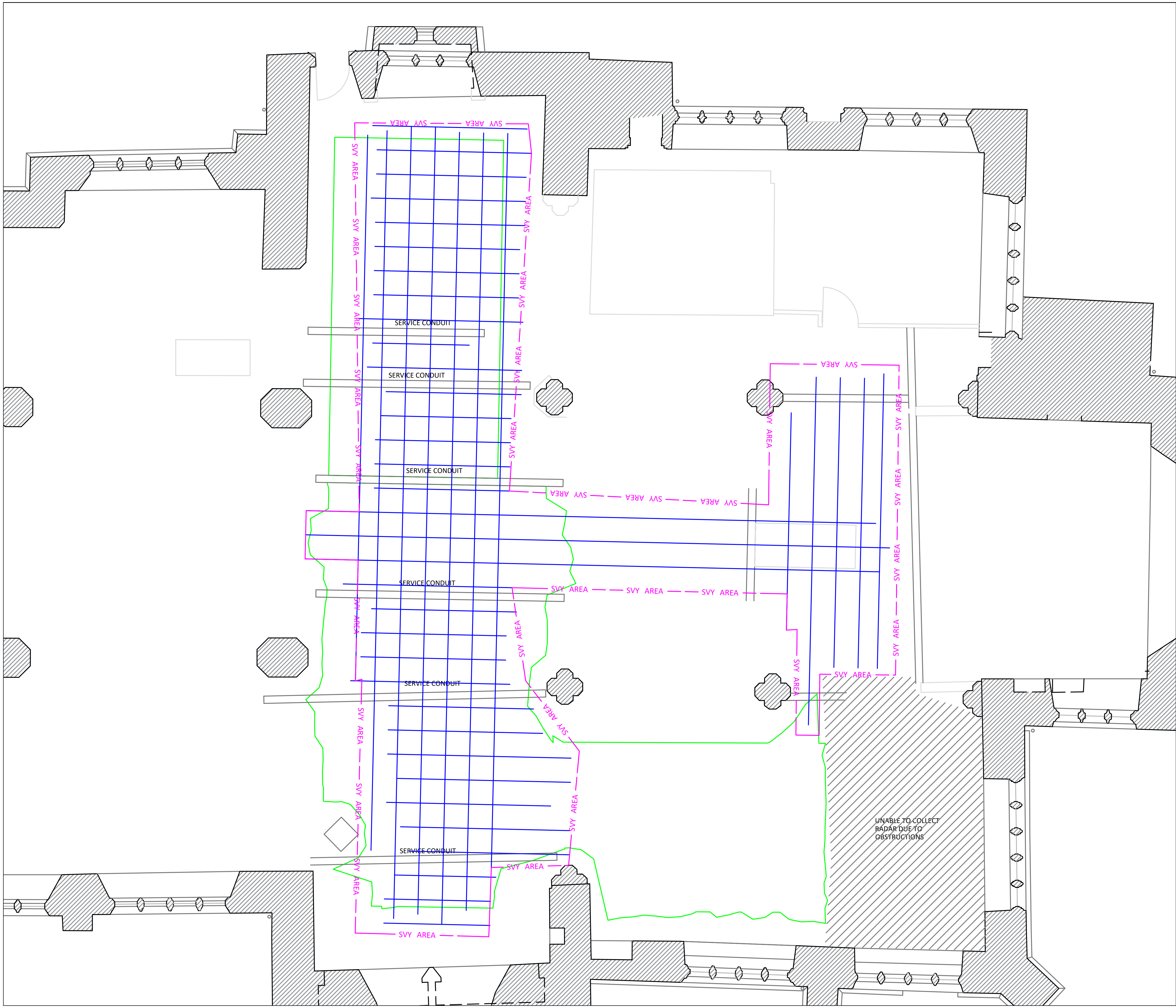
Client:
Parochial Church Council of Modbury

Project:
SUMO - 00895 St Georges Church,Modbury

Scale: 0 metres 1000
1:25000 @ A3

Fig No: 01

Survey date	Drawn by	Checked by
17 June 2023	CEF	SH



KEY

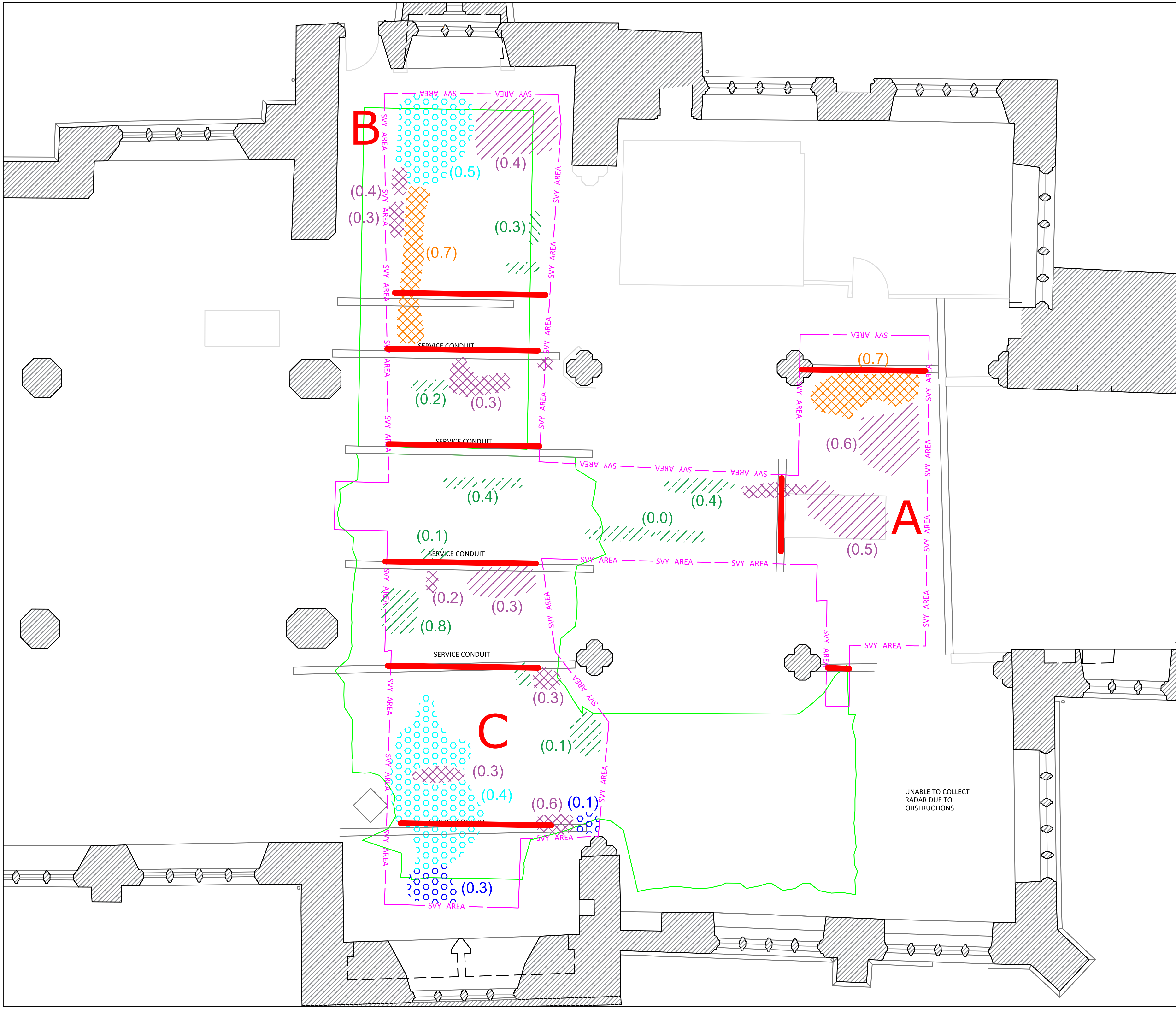
	Survey area
	Radar traverse
	Unsurveyable

Title:
Location of Survey Area and GPR Profiles

Client:
Parochial Church Council of Modbury

Project:
SUMO - 00895 St Georges Church,Modbury

Scale: 0m 1 metres 2 3m, 1:75 @ A3		Fig No: 02
Survey date 17 June 2023	Drawn by CEF	Checked by SH



The performance of the technologies employed in non-invasive surveys can be adversely affected by factors outside of Sumo's control. Whilst Sumo uses all due diligence and reasonable endeavours it does not warrant that 100% detection can be achieved. Irrespective of the information provided by a geophysical survey, any ground works should be undertaken with extreme caution.

KEY

	Possible void - burial / foundation
	Possible high void ratio ground - vault / foundation
	Possible structure - undefined
	Possible structure - burial
	Disturbed ground
	Anomalous layer
	Service conduit
0.6	Depth to the top of the feature (in m)
A	Anomaly Label

SUMO GeoSurveys

Title: GPR Survey Plan Interpretation

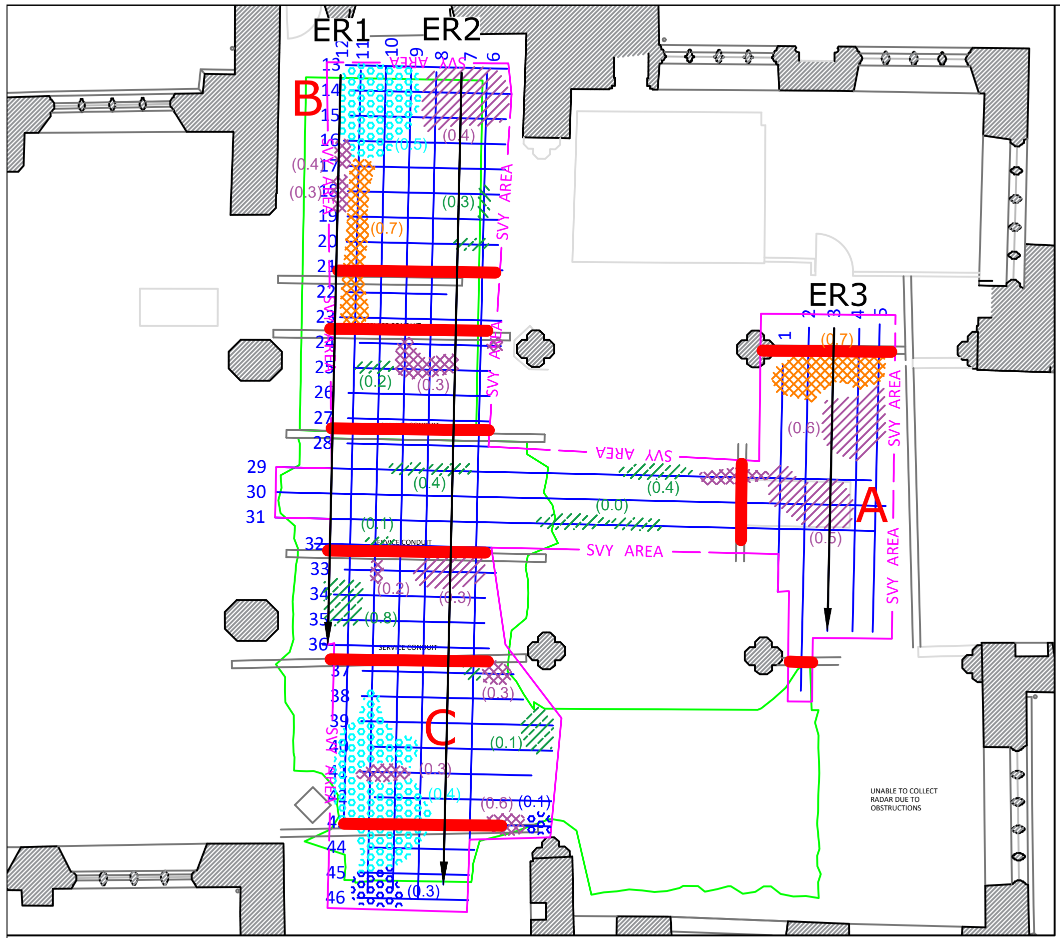
Client: Parochial Church Council of Modbury

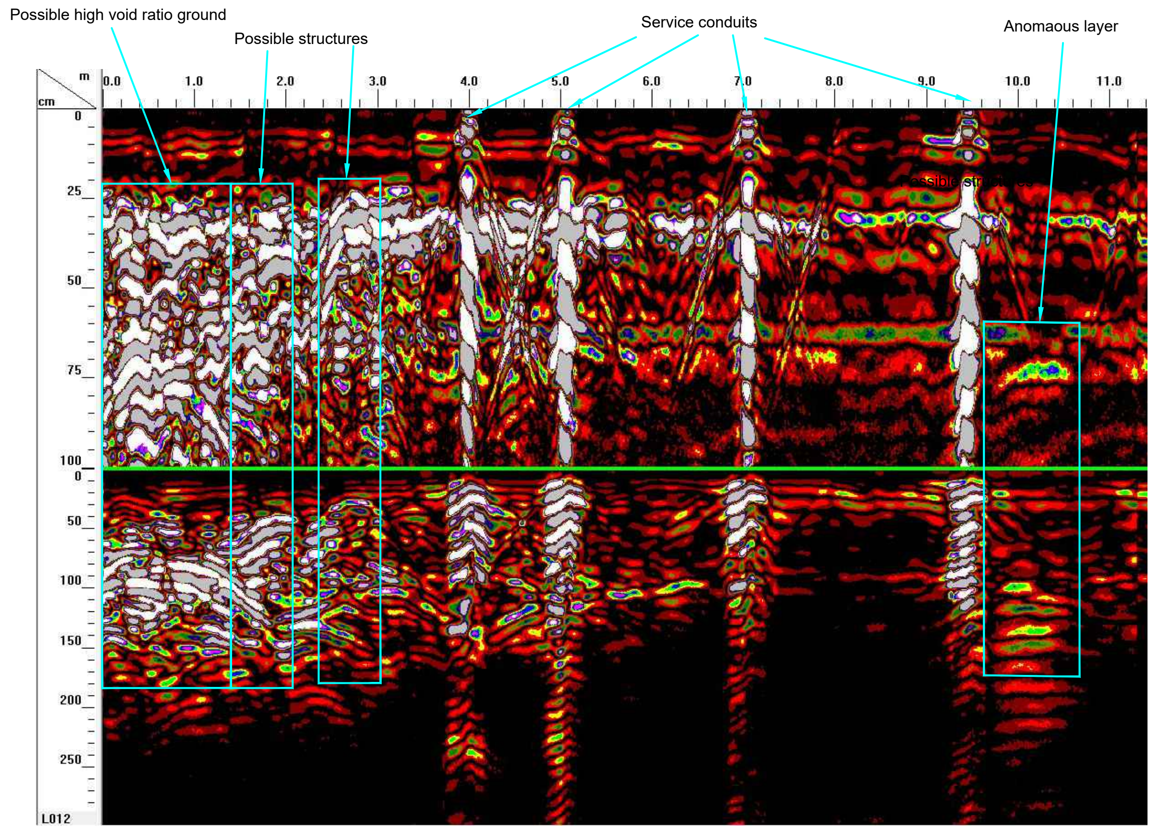
Project: SUMO - 00895 St Georges Church,Modbury

Scale: 0m 1 metres 2 3m — 1:75 @ A3

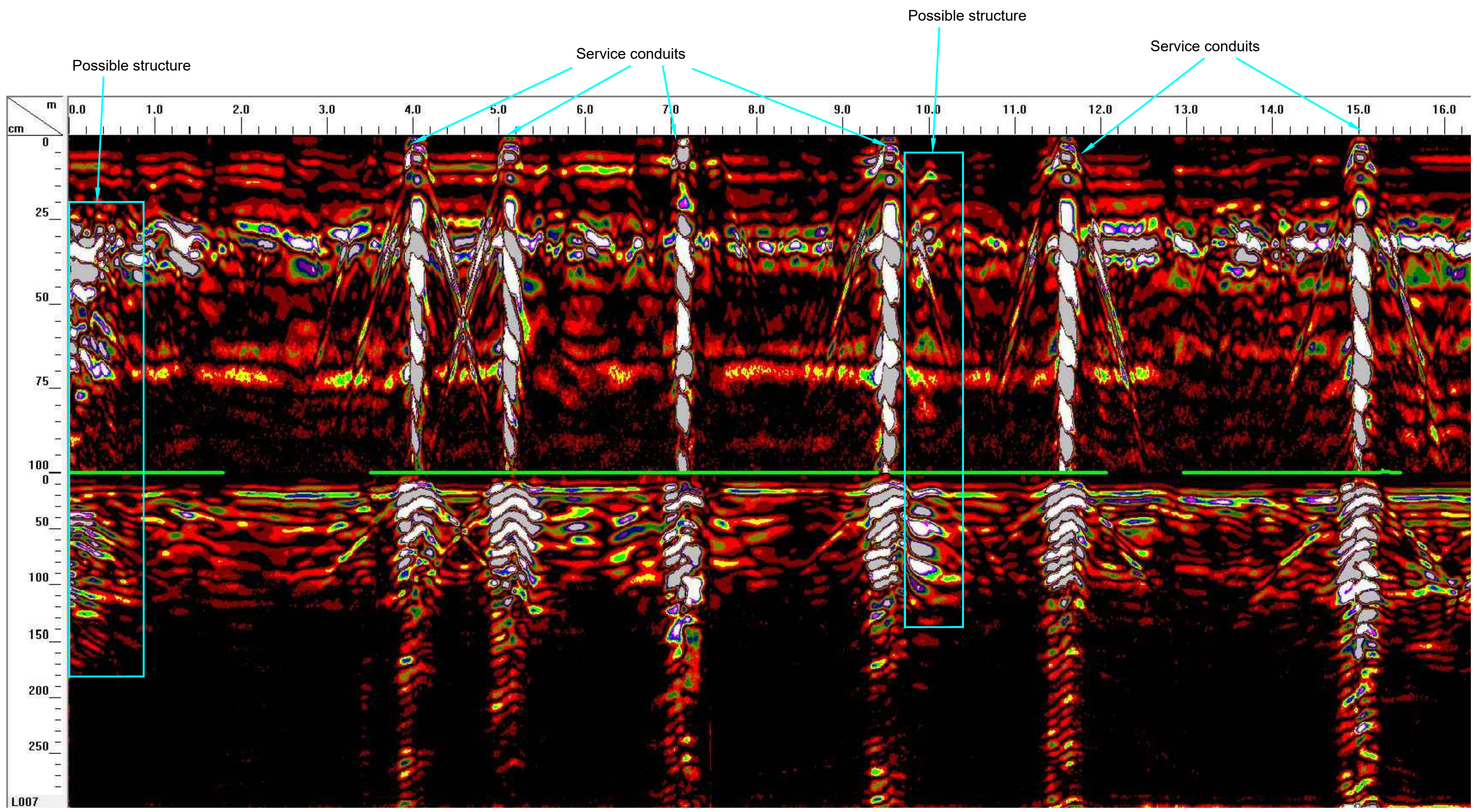
Fig No: 03

Survey date	Drawn by	Checked by
17 June 2023	CEF	SH

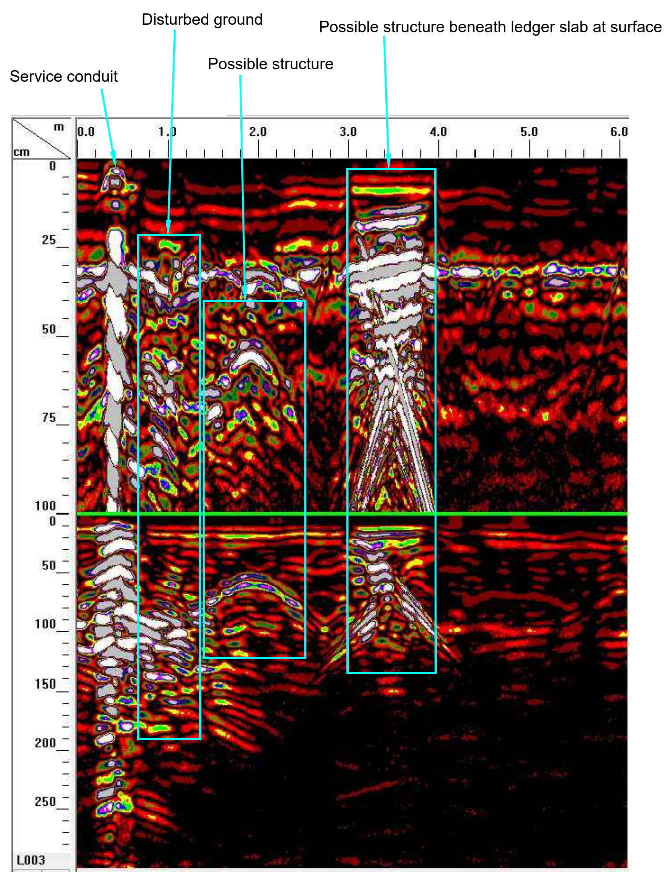




Example Radargram 1.
Possible high void ratio ground, structures, anomalous layer and service conduits.



Example Radargram 2.
Possible structures and service conduits.



Example Radargram 3.
Possible structures, disturbed ground and service conduit.

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Dual Frequency GSSI radar is collected with 300MHz and 800MHz antennae simultaneously. The example radargrams show data from both frequencies. The top section shows the high frequency (800MHz) data, while the bottom section shows the low frequency (300MHz) data.

KEY

	Possible void - burial / foundation
	Possible high void ratio ground - vault / foundation
	Possible structure - undefined
	Possible structure - burial
	Disturbed ground
	Anomalous layer
	Service conduit
0.6	Depth to the top of the feature (in m)
A	Anomaly Label
	Example radargram

SUMO GeoSurveys

Title: GPR Survey Plan Interpretation with Example Radargrams

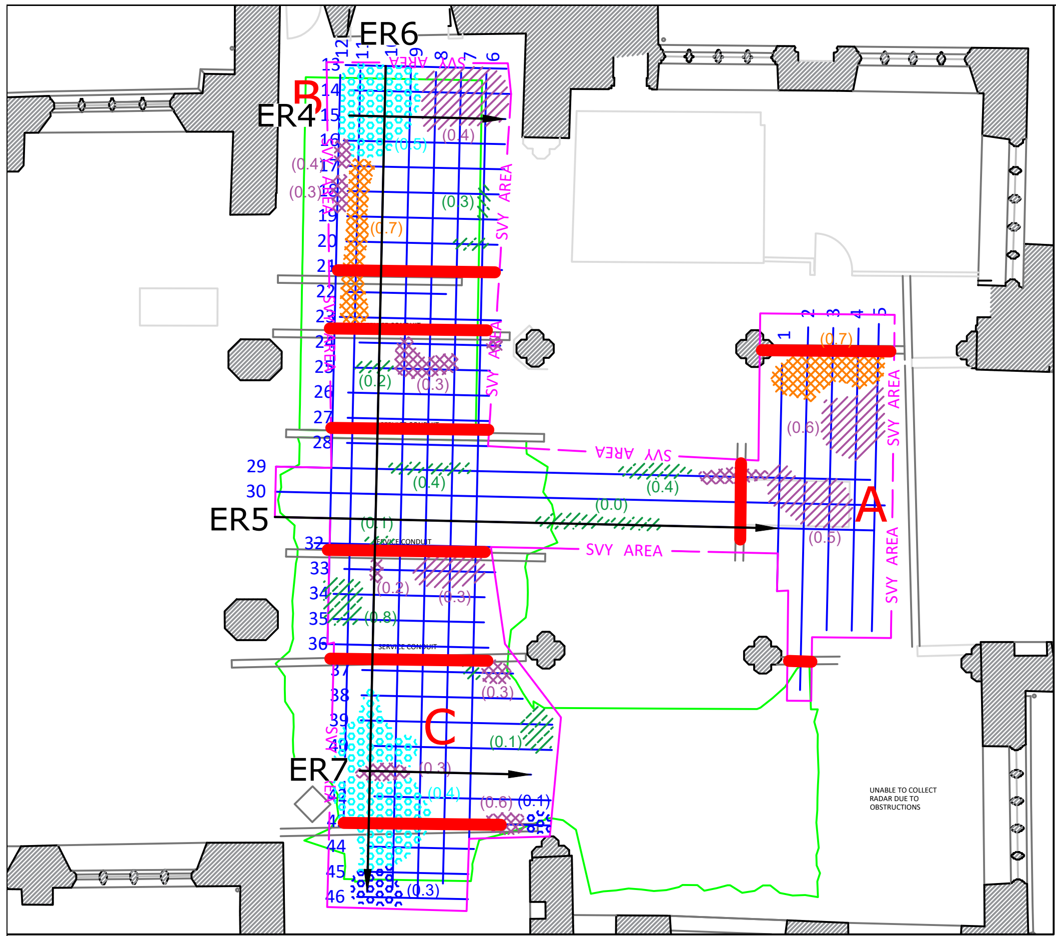
Client: Parochial Church Council of Modbury

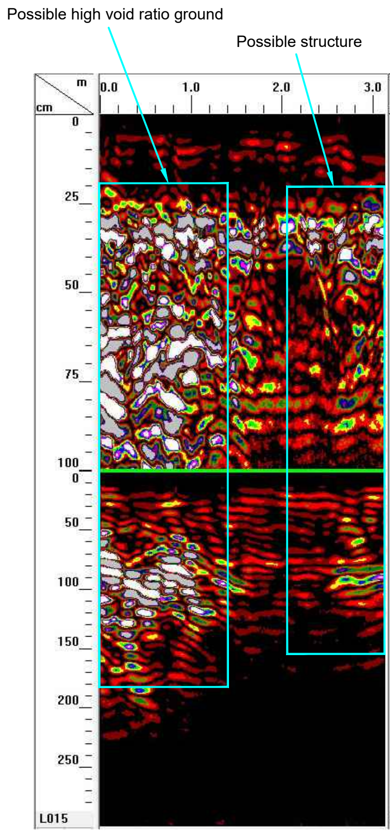
Project: SUMO - 00895 St Georges Church,Modbury

Scale: metres 0m 1 2 3 4 5m 1:150 @ A3

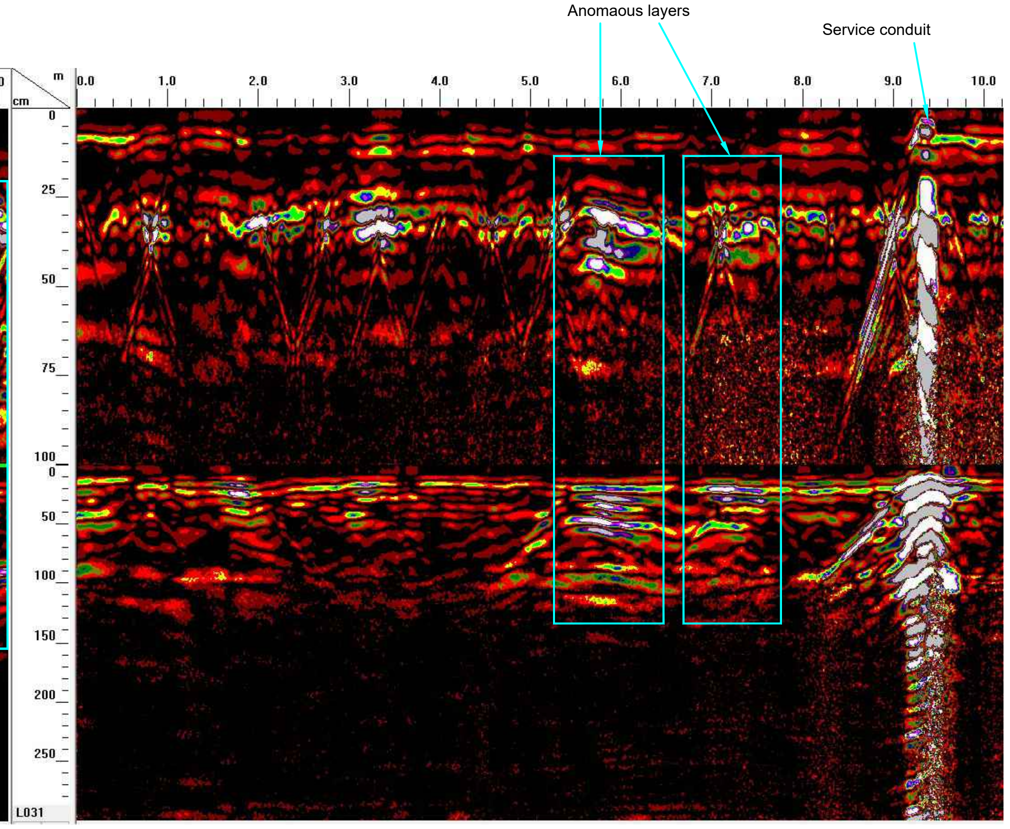
Fig No: 04

Survey date	Drawn by	Checked by
17 June 2023	CEF	SH





Example Radargram 4.
Possible high void ratio ground, and possible structure.



Example Radargram 5.
Anomalous layers and service conduit.

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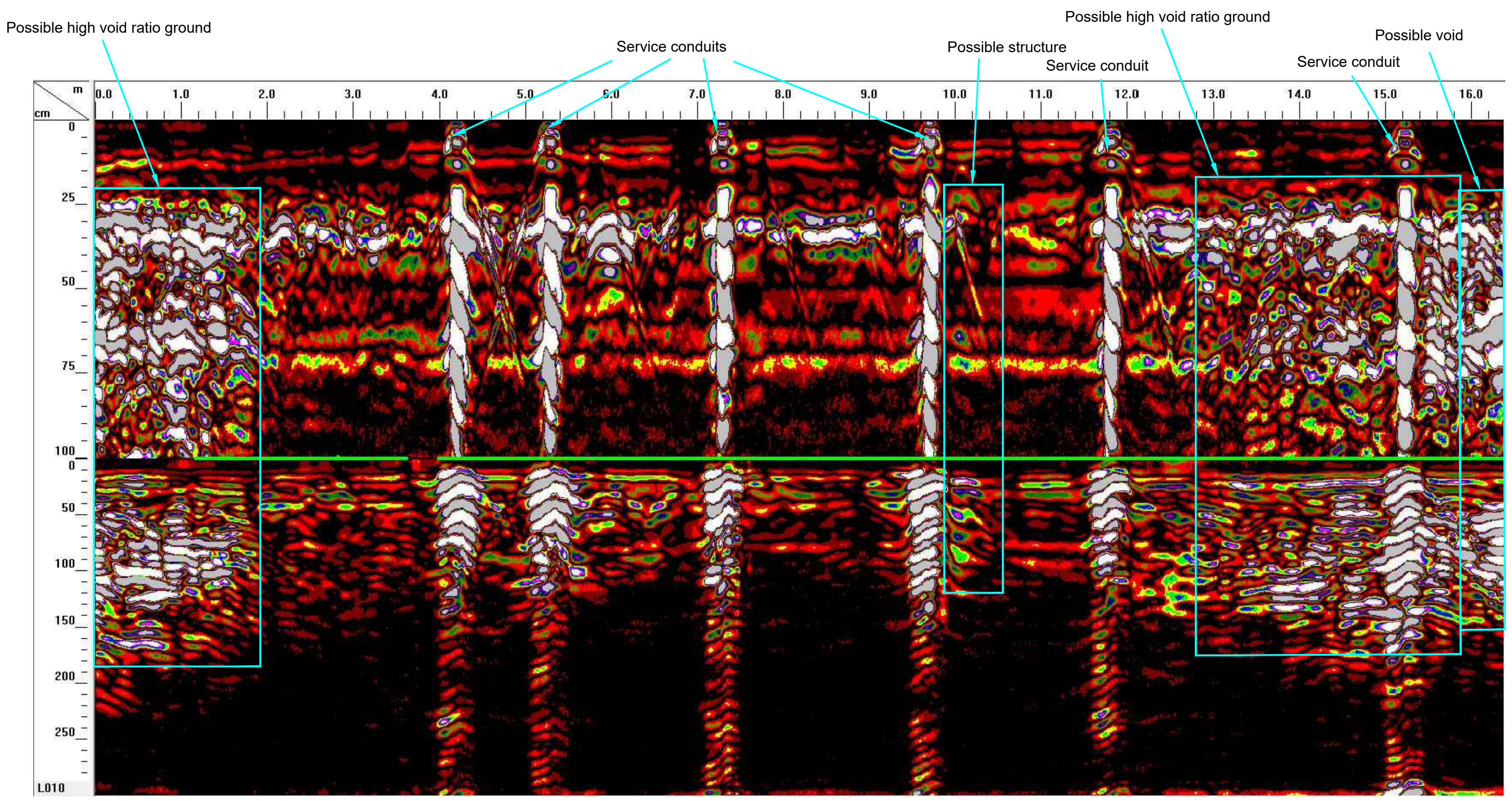
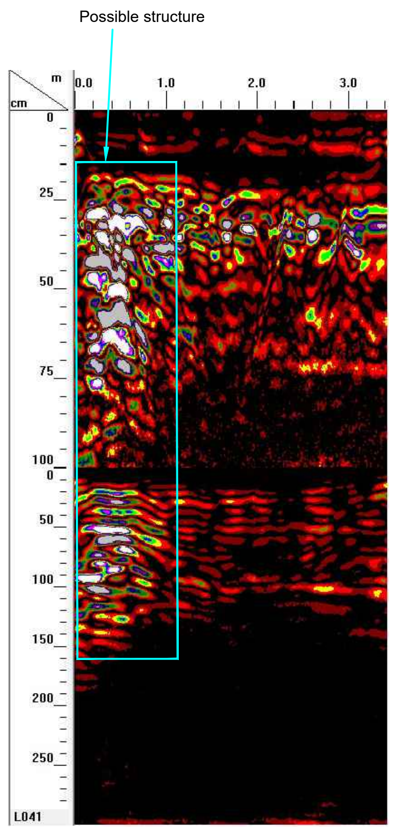
Dual Frequency GSSI radar is collected with 300MHz and 800MHz antennae simultaneously. The example radargrams show data from both frequencies. The top section shows the high frequency (800MHz) data, while the bottom section shows the low frequency (300MHz) data.



Example Radargram 6.
Possible high void ratio ground, possible structures, possible void and service conduits.



Example Radargram 7.
Possible structure.

KEY

	Possible void - burial / foundation
	Possible high void ratio ground - vault / foundation
	Possible structure - undefined
	Possible structure - burial
	Disturbed ground
	Anomalous layer
	Service conduit
0.6	Depth to the top of the feature (in m)
A	Anomaly Label
	Example radargram

Title: GPR Survey Plan Interpretation with Example Radargrams

Client: Parochial Church Council of Modbury

Project: SUMO - 00895 St Georges Church,Modbury

Scale: 1:150 @ A3 (metres: 0m 1 2 3 4 5m)

Fig No: 05

Survey date	Drawn by	Checked by
17 June 2023	CEF	SH

A Ground Penetrating Radar (GPR) survey was carried out inside St Georges Church Modbury, Devon. St George's Parish Church is predominantly 700 years old, although parts of it pre-date the Doomsday Book of the year 1086. It was largely a cruciform building with a central tower and was completed in around 1250. In 1943 it was almost destroyed in a raid by a group of German fighter bombers. The church was rebuilt by 1957 but subsequent structural problems led to the tower being reduced to two thirds of its original height. However the two-story porch survived, along with its richly moulded thirteenth-century doorways. The aim of the GPR survey was to search for evidence of voids, burials and obstructions in conjunction with Time Team.

A survey grid was established over the two area by GPS, as a reference for the site work. A GSSI Dual Frequency (DF) Radar system was used for the survey in conjunction with 300MHz and 800MHz antennae. The DF GPR system provides higher resolution, shallower depth penetration profiles with the 800 MHz antenna and greater depth penetration but lower resolution data with the 300 MHz antenna. An orthogonal grid of GPR profiles was carried out over area with a nominal spacing of 0.5 X 0.5 metres, subject to available access (Figure 2).

Most ground conditions contain electrically contrasting layers, which produce reflection events on the GPR profiles. Features such as soil or constructional boundaries provide the background signals around unusual features such as graves or foundations. Processing and interpretation procedures are designed to separate the reflections into various target categories, and then map the different reflection types on to a plan diagram. This process involves the interpretation of each individual radar profile, followed by an areal interpretation of all the radar profiles. Features identified across several profiles are interpolated in areas where the data is well constrained.

The confidence levels placed on a plan interpretation depend on the spacing of the survey grid. A target must be intersected by at least one radar profile to be detected. Ideally, the profile spacing should allow any target to be intersected by several profiles. Consequently, the survey line spacing is selected to provide optimum coverage balancing data density and cost.

In a typical church, unmarked burial features could be either individual graves or larger vaults. Radar reflections produced by such features will be dependent on whether the coffin or vault is intact and has an internal void, or if it has collapsed internally (structure). The method used to detect voids depends on identifying the strong electrical changes associated with void targets. The large electrical contrast between solid material and air generates a high amplitude response, which should stand out clearly against the background reflections. Void reflections may also be associated with ringing, caused by reverberation of the radar pulse within the void. In some cases, strong diffractions are generated from the corners at the base of the grave, to produce a characteristic crossover reflection pattern. Older graves and vaults may have collapsed internally, causing the reflection amplitude to diminish significantly and the reflection characteristics to change laterally, displaying structures, high void ratio or disturbed ground f large enough. Closely spaced burial areas are likely to produce zones of composite, heterogeneous reflections, which in some cases may prevent individual graves from being detected.

Individual data profiles are divided into upper and lower halves shown at the same horizontal distance scale for comparison purposes. The top half of the profile presents the higher resolution, lower depth penetration 800 MHz data and the lower half has the lower resolution but greater depth penetration 300 MHz data. The GPR profiles were calibrated using a propagation velocity of 0.106 m/ns. A maximum depth penetration of 2.0 metres was achieved by the survey. This velocity was obtained using a routine in RADAN to make a 'best fit' of point diffraction tails from which a velocity can be established. Data interpretation identified six significant categories of reflection targets, which are described below. Examples of the different reflection categories are presented as a series of Example Radargrams (ER) in Figures 4 & 5.

i) Possible void
ii) Possible structure
iii) Possible high void ratio ground
iv) Disturbed ground
v) Anomalous layer
vi) Service conduit

Possible Void

Voids appear as discrete, high amplitude reflections, with a flat or upwardly convex top surface, showing a marked contrast against the background. The void reflections are often associated with reverberations, producing characteristic ringing on the GPR record. ER6 presents an example of the possible void reflection category. It is important to note that GPR is able to identify the presence and cover depth of a void, but normally cannot determine the internal vertical dimension. Pulse ringing usually masks any reflections from the base of the void. It is suggested that the possible voids may correspond to burial features. Larger voids could be vaults or other types of constructed voids.

Possible Structure

The possible structure reflection category consists of moderate to high amplitude, well defined reflections, typically with a planar, curved or sometimes more irregular top surface and clearly defined margins characterized by edge scattering. Some typical examples are shown in ER1 to 4, 6 and ER7. Several of the structures marked on the interpretation plan have been interpreted as burials, displaying a characteristic curved top, which correspond with adjacent radar profiles to produce an east to west structure.

Title: Report		
Client: Parochial Church Council of Modbury		
Project: SUMO - 00895 St Georges Church,Modbury		
Survey date 17 June 2023	Written by CEF	Checked by SH

Possible High Void Ratio Ground

Possible high void ratio ground appears on the GPR data as dense zones of high amplitude reflections, in some cases displaying evidence of pulse ringing. The high void ratio ground areas display both curved and more irregularly shaped top surfaces. A characteristic chaotic structure is evident caused by complex interference between numerous small, high amplitude reflections. An example of possible high void ratio ground reflections is shown in ER's 1, 4 and 6.

Disturbed Ground

Areas identified as disturbed ground generally appear as zones of moderate to high amplitude, irregular, reflections with broken layering. In some cases, there is evidence of a slightly chaotic internal structure, resulting from interaction between individual reflections. An example of the disturbed ground reflection category is given in ER3. Disturbed ground can be caused by localised disturbance of the ground associated with a reasonably compacted burial or a discrete change in ground composition.

Anomalous Layer

Anomalous layer occurs as well defined, moderate to high amplitude, planar or sub-planar reflections, with little evidence of edge scattering. ER1 and ER5 present some examples of this reflection category. Anomalous layers are distinct compositional layers within the subsurface that may correspond to constructed planar features or discrete ground layers. These features may alternatively be burial related.

Service Conduits

Nine service conduits are present across the survey area (Figure 3). The high amplitude response showing ringing to depth is shown in ER's 1 to 3, ER5 and ER6.

Summary of Results

The positions of all the anomalies detected by the GPR survey are presented on the plan interpretation (Figure 3), together with example radargrams (Figures 4 & 5).

Three structures are interpreted to represent burials as shown on the plan. This interpretation is based on the shape and characteristics both in plan view and on GPR profiles as described above. Additional unidentified structures may also represent burials or relate to features such as foundations or other types of buried structures. The burial labelled A on the plans furthermore shows evidence for both an internal structure and also a ledger slab at surface (ER2, Figure 4).

Two areas of high void ratio ground are presented on the plan interpretation (labelled B and C). Both could represent either vaults or foundations relating to rebuilding of the church in 1957, following the German bombing. The anomalies B and C however form composites, being adjacent or surrounding additional structures, voids, and disturbed ground. This favours the interpretation of the composites forming vaults.

References

https://www.modburyteam.org/st-andrews-church