GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services SUMO Group Member

Project name:

St. Michael's Without, Bath

Client:

Benjamin + Beauchamp Architects Ltd

July 2014

Job ref:

J7123

Report author:

Magdalena Udyrysz MSc

GEOPHYSICAL SURVEY REPORT

Project name:
St. Michael's Without, Bath
Client:
Benjamin + Beauchamp Architects Ltd.

Job ref:
J7123

Techniques:
Ground Penetrating Radar

Survey date:
15th July 2014

Site centred at:
ST 750 650

Post code:
BA1 1AJ

Field team:
Joshua Jones
Stephen Weston

Project manager:
Simon Haddrell BEng(Hons) AMBCS PIFA

Report written by:
Magdalena Udyrysz MSc

CAD illustrations by:
Magdalena Udyrysz MSc

Checked by:
David Elks MSc AIFA

TABLE OF CONTENTS

LIST OF FIGURES 1
1 SUMMARY OF RESULTS 2
2 INTRODUCTION 2
2.1 Background synopsis 2
2.2 Site location 2
2.3 Description of site 2
2.4 Geology and soils 2
2.5 Site history. 3
2.6 Survey objectives 3
2.7 Survey methods 3
2.8 Processing, presentation and interpretation of results 3
2.8.1 Processing 3
3 RESULTS 6
4 CONCLUSION 6
REFERENCES 7
APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT 8

LIST OF FIGURES

Figure 01	1:25000	Location plan of survey area
Figure 02	1:125	Location of survey grids and referencing
Figure 03	1:200	GPR survey – Timeslices
Figure 04	1:150	GPR interpretation and example radargrams

1 SUMMARY OF RESULTS

A Ground Probing Radar survey at St. Michael's Without Church in Bath was carried out to determine the location of vaults.

The survey used GSSI Dual Frequency radar with 300MHz and 800MHz antennas giving a depth of penetration of approximately 3.00m and 1.10m respectively.

The survey did not identify any anomalous areas relating to the location of possible vaults. The features next to the church are likely related to its foundations. Two probable and two possible obstructions were found, but there is not enough information to determine their origin with any degree of confidence. The survey also identified known services and one additional service.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey at St. Michael's Without Church in Bath, Somerset with the aim of identifying the location of vaults prior to the erection of scaffolding.

2.2 *Site location*

The site is located in Bath, Somerset, in the central part of the city, on the crossroads between Broad Street and Walcot Street, at OS ref. ST 750 650.

2.3 *Description of site*

The survey covered the footway around St. Michael's Without Church and is constructed with a mixture of tarmac, paving slabs and flagstones. The church is surrounded by fences, restricting access in places.

2.4 *Geology and soils*

The underlying geology of the survey area is Charmouth Mudstone Formation – Mudstone. Sedimentary Bedrock formed approximately 183 to 197 million years ago in the Jurassic Period. Local environment previously dominated by shallow seas (British Geological Survey website).

The site is urban and industrial area – unsurveyed in terms of the soil type (Soil Survey of England and Wales, Sheet 5, South West England).

2.5 *Site history.*

The following is taken from the St. Michael's Without Church website (accessed 24/07/2014) and refers to the church around which the survey has been carried out:

"The Church of St. Michael with St. Paul was designed in the Early English style of Gothic architecture by the city architect C.P. Manners. (…) Construction of the present church (the fourth on the site) began on 21 April 1835.

(…) Religious worship has been carried on this site for many centuries. Walcot Street follows the course of the ancient Roman road, the Fosse way, and there are many traces of Roman settlement in the area. However, the first definite record that a church existed on the site is an entry, dated about 1180 (…). The first church on the site appears to have fallen into decay, and the second was built between 1370 and 1400. The wealth which made its construction possible may have come from the wool trade which was making England prosperous at the time. (…) Structural defects, and the fact that it had, like the previous church, become too small to cater for the growing population of the parish, led to the demolition of the building in 1835. The new church was consecrated on 4 January, 1837 at a ceremony attended by the City's Mayor".

2.6 *Survey objectives*

The objective of the survey was to locate the putative vaults beneath and next to St. Michael's Without Church in Bath prior to the erection of scaffolding.

2.7 *Survey methods*

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

Ground penetrating radar (GPR) was selected as the most suitable methodology for this survey. The survey used Dual Frequency radar with 300MHz and 800MHz antennas manufactured by Geophysical Survey Systems Inc. (GSSI). This range of frequencies gives a depth of penetration of approximately 3.00m and 1.10m respectively.

Data was gathered on an orthogonal grid with spacing of 1.0m.

2.8 *Processing, presentation and interpretation of results*

2.8.1 Processing

Manual abstraction

Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams. This abstraction is then employed as the primary source for producing the interpretation plot (Figure 4), but is not itself reproduced in the report.

i. Strong and weak discrete reflector.

These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

ii. Complex reflectors.

These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

iii. Point diffractions.

These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in iv. below)

iv. Convex reflectors and broad crested diffractions.

A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.

These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

vi. Inclined events.

These may be a planar feature but not parallel with the survey surface. However, similar responses can be caused by extraneous reflections. For example, an "air-wave" caused by a strong reflection from an above ground object would produce a linear dipping anomaly and does not relate to any sub-surface feature. Normally this is not a problem as the antennae used are shielded, but under some circumstances these effects can become noticeable.

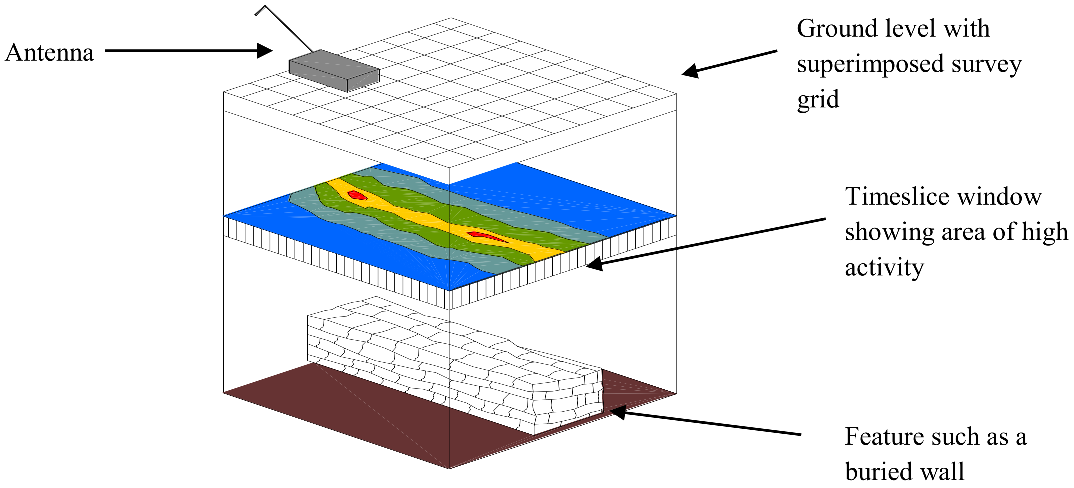
vii. Conductive surface.

The radiowave transmitted from the antenna has its waveform modulated by the ground surface. If this ground surface or layers close to the surface are particularly conductive a 'ground coupled wavetrain' is generated which can produce a complex wave pattern affecting part or all of the scan and so can obscure the weaker returns from targets lower down in the ground.

viii. A category for *"focused ringing"* has been included as this type of anomaly can indicate the presence of an air void. This is created by the signal resonating within the void, but with a characteristic domed shape due to the "velocity pull-up effect".

Timeslice plots

In addition to a manual abstraction from the radargrams, a computer analysis was also carried out. The radar data is interrogated for areas of high activity and the results presented in a plan format known as timeslice plots. In this way it is easy to see if the high activity areas form recognisable patterns.



The GPR data is compiled to create a 3D file. This 3D file can be manipulated to view the data from any angle and at any depth within a range. The 3D file can be sampled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report. Based on an average velocity calculations have been made to show the equivalent depth into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white.

Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

3 RESULTS

The ground penetrating radar survey conducted at St. Michael's Without Church in Bath, has identified several anomalies.

The survey identified anomalies next to the church walls, relating to the location of the foundations at a depth of 0.8 – 1.2m from the surface. Two probable and two possible obstructions have been detected at the depths of 1.20, 1.10m, 0.20m and 0.86m from the surface respectively. These anomalies may be related to buried objects, but there is not enough information to indicate their origin with conviction. The survey also identified known services and one additional service at the depth of 0.25m which connects with thedrainage in the south of the survey area.

4 CONCLUSION

A Ground Probing Radar survey at St. Michael's Without Church in Bath was carried out to determine the location of vaults.

The survey has identified several anomalies. Complex anomalies found next to the walls of the church are interpreted as foundations. The remaining features are interpreted as probable and possible obstructions as well as a possible service. There is no evidence for the presence of vaults.

REFERENCES

British Geological Survey, n.d., *website*:
(http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps) Geology of Britain viewer.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England*.

St. Michael's Without Church Website (Accessed 24/07/2014):
(http://www.stmichaelsbath.org.uk/)

Institute For Archaeologists. *Standard and Guidance for Archaeological Geophysical Survey.*
http://www.archaeologists.net/sites/default/files/nodefiles/Geophysics2010.pdf

APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site.

Survey equipment and configuration

Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

Data capture

Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

Processing

The radar plots included in this report have been produced from the recorded data using Radan software. Filters were applied to the data to remove background noise.

STRATASCAN LTD
Vineyard House Upper Hook Road Upton upon Severn
Worcestershire WR8 0SA United Kingdom

T: 0 1684 592266 F: 01684 594142
info@stratascan.co.uk www.stratascan.co.u