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Sheffield General Cemetery
Sheffield

Ground Penetrating Radar Survey Report

Ref: 113880.02
August 2016

geoservices

Sheffield General Cemetery
Sheffield

Ground Penetrating Radar Survey Report

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August 2016

WA Report Ref. 113880.02

Quality Assurance

Project Code	113880	**Accession Code**		**Client Ref.**	
Planning Application Ref.		**Ordnance Survey (OS) national grid reference (NGR)**	NGR 434152, 385876		

Version	Status*	Prepared by	Checked and Approved By	Approver's Signature	Date
v01	I	*NLC*	*TR*		09/08/2016
File:	S:\PROJECTS\113880_Reports\Terrestrial_Geophysics\113880_SGC_LJL_TR.docx				
	E	*NLC*	*PAB*		07/09/2016
File:	S:\PROJECTS\113880_Reports\Terrestrial_Geophysics\113880_SGC.docx				
	F				
File:					

* I = Internal Draft; E = External Draft; F = Final

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Ground Penetrating Radar Survey

Summary

A ground penetrating radar survey was conducted over land at Sheffield General Cemetery (centred on NGR 434152, 385876). The project was commissioned by Sheffield City Council with the specific aims of determining the extent of the original designed landscape and ground levels. More specifically it is hoped the GPR survey will determine the extent of the stone quarry face and extent of below ground remains of original structures.

The Site covers just over 5 ha and is made up of areas of dense standing monuments, patchy woodland and open parkland. SGC is a Grade II* registered Park and Garden on the Heritage at Risk Register. The Site contains ten listed structures and is a Local Nature Reserve. The ground penetrating radar survey was undertaken on 30th June 2016 and included a total of 12 transects (divided into 65 sub-transects). The ground penetrating radar survey has demonstrated the presence of a number of high amplitude features of potential archaeological interest and has revealed several details regarding the original designed landscaped and the pre-design ground formation.

The use of a 200 MHz and 100 MHz Bi-static antennae has provided two differing, but largely complimentary datasets, which resulted in a good level of detail for near surface deposits. The features of archaeological interest are primarily those associated with the construction of the cemetery itself and are generally located within the first 4 m below the current ground surface. Evidence for former surfaces has been identified, in addition to high amplitude features which may represent walls or structural remains relating to former or below ground structures. The attenuation of the GPR was generally much poorer after a depth of 4 m and this prevented the detection of further features or trends.

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Acknowledgements

Wessex Archaeology would like to thank Sheffield City Council for commissioning the geophysical survey. The assistance of Amanda Cosgrove is gratefully acknowledged in this regard.

The fieldwork was undertaken by Nicholas Crabb, Chris Breeden, Chris Hirst and Matt Tooke. Nicholas Crabb processed and interpreted the geophysical data and also wrote this report. The geophysical work was quality controlled by Tom Richardson and Lucy Learmonth. Illustrations were prepared by Nancy Dixon. The project was managed on behalf of Wessex Archaeology by Chris Swales.

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Ground Penetrating Radar Survey

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Sheffield City Council to carry out a geophysical survey at Sheffield General Cemetery (hereafter "the Site", centred on NGR 434152, 385876) (**Figure 1**). The survey forms part of Round 1 of the Parks for People Project within Sheffield General Cemetery (SGC) which is intended to conserve the SGC and ultimately better connect the local population with the Site and allow a coherent management plan for its future.

1.1.2 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 Aims and objectives

1.2.1 The general aims of the ground penetrating radar (GPR) survey comprise the following:

- to conduct a survey covering as much of the specified transects as possible, allowing for obstructions;
- to clarify the presence/absence and extent of any buried archaeological remains within the site;
- to determine the general nature of the remains present.

More specifically, it is hoped the GPR survey will;

- determine the extent of the original designed landscape ground levels;
- determine the extent of the stone quarry face and pre-design ground formation.

1.3 The Site

1.3.1 The Site is located in the district of Sharrow, just over 1.6 km to the south-west of Sheffield city centre in the county of South Yorkshire. It is bounded by Cemetery Road to the south-east and the Porter Brook, which runs along the north-west edge of the cemetery.

1.3.2 The Site covers approximately 5.8 ha and consists of areas of dense standing monuments, patchy woodland and open parkland. The western half of the cemetery contains grave markers and memorials whilst the eastern half was cleared of monuments in the latter half of the 20th century SGC is a Grade II* registered Park and Garden on the Heritage at Risk Register.

1.3.3 The Site is situated on land sloping down towards the Porter Brook. The southern corner of the Site is at an elevation of approximately 115 m above Ordnance Datum (aOD) and falls to the north and north-west to an elevation of approximately 90 m aOD.

1.3.4 The solid geology comprises Mudstone, Siltstone and Sandstone of the Pennine Lower Coal Measures Formation with a band of Sandstone of the Pennine Lower Coal Formation at the north-west corner of the site, and at the south-east boundary. There are recorded superficial deposits of alluvium along the route of the Porter Brook (British Geological Survey 2016)

1.3.5 There is no information regarding the underlying soils as the area is not surveyed due to the location within a large urban area (SSEW SE Sheet 1-2 1983). However, the soils are likely to be acceptable for the detection of archaeological remains through GPR survey.

2 ARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 An Archaeological Desk-Based Assessment (DBA) will be undertaken by Wessex Archaeology (2016) which will examine the potential for the survival of buried archaeological remains within the development area and a 500 m Study Area. It is not the intention of this report to repeat this work and therefore the following background is a summary of information relevant to the interpretation of the geophysical survey from the Heritage Gateway (www.heritagegateway.org.uk), a publically available online resource.

2.1.2 Sheffield General Cemetery is registered under the Historic Buildings and Ancient Monuments Act 1953 within the Register of Historic Parks and Gardens by English Heritage for its special historic interest (List entry no. 10001391). The Site also contains ten listed structures and is a Local Nature Reserve.

2.1.3 The cemetery was designed by Sheffield architect Samuel Worth in 1836 with a chapel, catacombs and a cemetery office. The layout of the cemetery makes use of a quarried hillside that took advantage of the site through infilling the excavated areas with vaults. Contemporary plans show an additional catacomb structure attached to the rear of the Non-Conformist chapel although documentary evidence indicates the catacomb structure was not completed to its initial plan (WA 2016: 16). The catacombs beneath the Non-Conformist Chapel (WA 4) have been inspected which suggested that the area behind the Non-Conformist Chapel was some 3.5 m lower than it is today (Taylor 2013: 12)

2.1.4 The Sheffield General Cemetery Company was set up in response to overcrowding and poor conditions in Sheffield churchyards, exacerbated by a cholera epidemic in 1832. The company bought the site for use by Nonconformists in 1836 and stone for the chapel, offices and gateways was quarried from the site. In 1846 the Anglicans negotiated with the Company to extend the cemetery and in 1850 c. 3 ha attached to the east side of the existing site was consecrated by the Archbishop of York. Leading figures from Sheffield's 19th century industrial, political, religious and business circles are buried in the Cemetery and by the mid. 20th century more than 77,000 interments had taken place.

2.1.5 In 1963 the Company sold a majority of the shares to a development company and the ite subsequently passed to Sheffield City Council. The Cemetery was closed as a burial ground by Act of Parliament in 1979. In the early 1980s the Anglican part of the site was largely cleared of gravestones and the area dedicated as a public park.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team on 30th June 2016. Field and weather conditions at the time of the survey were generally good throughout the period of survey and the majority of the transect areas were cleared. A total of 10 transects, of the anticipated 12, were achieved with both antennae. Transect 8 was not completed due to a particularly high level of grave markers, which prevented good surface contact. Transect 3 was also not possible as it could not be cleared prior to the survey. In order to account for this several transects were extended, or additional shorter transects undertaken in order to provide further detail where possible.

3.1.2 GPR requires the collection of data in linear transects, and therefore it was necessary to divide each transect into a series of straight lines. This was kept to a minimum wherever possible, but in order to account for changes in orientation each line was given a suffix according to the location within each transect. For example, GPR transect 2 was divided into 4 lines and these are henceforth referred to as GPR 2.1 – 2.4.

3.1.3 Many GPR investigations require the detection of interfaces which are not sharp or clean cut, but natural interfaces are often blurred by the natural depositional sequence involved in the creation of stratigraphy. Furthermore, many man made interfaces can also be indistinct as construction practice may lead to mixing of materials. Therefore, whilst the results of this survey have identified several features likely associated with the development and construction of the Site, this may not be exhaustive.

3.2 Fieldwork methodology

3.2.1 The position of the transects was recorded using a Leica TCR307 Total Station Theodolite across the Site in order to accurately locate the GPR lines. Topographic information was also recorded for each transect in order to account for any changes in height across the transect. This is precise to approximately 0.02 m and therefore exceeds Historic England recommendations (English Heritage 2008).

3.2.2 The GPR survey was conducted using a GSSI SIR 3000 control unit with both a 200 MHz and 100 MHz Bi-static antenna with an attached survey wheel to record the horizontal distance. Both antennae were deployed across the Site with data collected along each transect. Several shorter additional transects were undertaken with the 200 MHz where it was felt an extra level of detail could be achieved.

3.2.3 Data with the 200 MHz antenna were collected at 60 scans per unit (1 unit = 1 m) with an effective time window of 100 ns. Data with the 100 MHz antenna were collected at 20 scans per unit with an effective time window of 300 ns. The GPR survey was undertaken in accordance with Historic England guidelines (English Heritage 2008). The data were collected by continuously dragging along straight transects.

3.3 Data processing

3.3.1 Data from the survey were subject to common radar signal correction processes. These comprise applying a gain and wobble correction of the radar profile to correct for variance in temperature and soil moisture content as well as background and bandpass filtering to remove noise in the data from the surrounding area. These steps were applied on both datasets collected at the Site. As both datasets produced an increased level of high frequency random noise, an additional boxcar smoothing was applied.

3.3.2 In order to estimate the depth of the GPR data it is important to understand how fast the GPR pulse travels in the material under investigation. It is possible to determine more precisely the average velocity of the signals through the ground if excavated features at a known depth can be identified in the data. However, this is rarely achievable and instead a velocity analysis was undertaken on the radargrams whereby suitable hyperbolic reflections were identified and used to determine the velocity of the GPR pulse through the subsurface deposit. The relative velocity to depth conversion for the 200 MHz antenna was based on a dielectric constant of 7.6 and suggested a maximum depth penetration of 5.4 m. For the 100 MHz Bi-Static antenna the relative velocity to depth calculation was based on a dielectric constant of 7.4 and suggested a maximum depth penetration of 10.5 these are typical values of conductivity associated with sandy material, however this can be varying in wet or dry conditions.

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 The ground penetrating radar survey has identified a number of high amplitude point source reflectors and planar returns across the Site, along with some complex areas of high and low amplitude reflections. Results are presented as a series of greyscale radargrams and archaeological interpretations (**Figures 2** to **5)**, with black representing high amplitude responses and white relating to low amplitude responses.

4.1.2 The interpretation of the datasets highlights the presence of features of possible archaeological interest and several anomalous and high and low amplitude responses (**Figures 2** to **5**). Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.

4.1.3 It should be noted that small features and waterlogged features may produce responses that are below the detection threshold of the GPR antennae. Excessive disturbance in the form of excavation and demolition can also impede the ability of geophysical techniques to detect archaeology. It may therefore be the case that more archaeological features may be present than have been identified through geophysical survey.

4.1.4 The combination of two frequencies of GPR antenna has provided differing information that requires some qualification. The 200 MHz GPR survey is intended to provide detail from 0 to 5 m below the current ground surface. The 100 MHz Bi-Static antenna was deployed in order to provide more detail for any deposits below this depth (up to approximately 10 to 12 m), at the expense of detail and near surface targets. The results of the 200 MHz antenna data will therefore be discussed first, followed by any additional details provided by the 100 MHz Bi-Static dataset.

4.1.5 Consideration of the impact of ground surface conditions and topography will also be referred to in order to explain any anomalous high amplitude reflections that may be present throughout the datasets.

4.2 Ground penetrating radar survey results

4.2.1 A total of 35 transects of GPR were collected using the 200 MHz antenna, and a further 30 were collected using the 100 MHz Bi-Static antenna. This yielded generally good results and identified a number of high and low amplitude features to a depth of approximately 10.54 m.

Transect 1

4.2.2 GPR Transect 1 was completed in one continuous 17.9 m long traverse from north-west to south-east. It is located on a slightly different orientation than was predetermined in order to account for obstacles and impassable ground. The radar antennae were dragged over a variety of terrain, ranging from concreted pathway in the north-west, grass, grave markers and finally a gravelled pathway in the south-east. There is also a significant, but steady incline from north-west (94.14 aOD) - south-east (96.87 aOD).

4.2.3 Aspects of the varying terrain and can be seen within the uppermost part of the 200 MHz radargram as a series of high amplitude undulations. Approximately between 8 and 10 m there is also a short high amplitude planar reflection at **4000** which is most likely associated with a large stone grave marker which was visible on the surface during the time of survey.

4.2.4 From 3 m into GPR Transect 1.1, at a depth of approximately 4.4 m (80 ns) there is a moderate amplitude planar reflection which rises gradually to approximately 3.6 m (67 ns) at 15 m along the transect. In the south-eastern part of this transect there are also several small point source hyperbolae, which might be representative of an area of complex geology.

4.2.5 Aside from this, there are few identifiable reflections of note within the radargram for the 200 MHz antenna and few additional details are provided in the 100 MHz Bi-Static dataset for GPR transect 1. However, many of the features mentioned can also be seen within the 100 MHz radargram, albeit with less clarity. The consistency of the radargram throughout the remaining may suggest that there is little change beyond 3 to 4 m.

Transect 2

4.2.6 This is the most northerly of transects collected at the Site. It was divided into four shorter sub-transects (2.1 to 2.4) and measures 152 m in total length. It follows the line of the path from the Gatehouse in the north-west corner of the Site along the northern edge of the catacombs, to approximately 20 m south of the main junction of paths within the centre of the cemetery. The terrain was consistently concreted footpaths throughout each sub-transect, only being interrupted by occasional drains to the south of the catacombs.

4.2.7 Transect 2.1 measures 24.4 m in length and was relatively flat, measuring 92.11 aOD in the west and 91.92 aOD in the east. There was a drain noticeable on the surface at the eastern end of the transect and this can be seen within the 200 MHz dataset at approximately 22.5 m as a narrow planar return (**4001**)**.**

4.2.8 In the west of the transect, between 0 and 1 m, there is a convex reflector, which is visible from 1.6 m to approximately 3 m (30 - 67 ns) (**4002**). This is suggestive of resistant material, perhaps associated with an additional buried drain or service.

4.2.9 Between 16 and 20 m, there is a small area with several high amplitude hyperbolic point reflections, which may be suggestive of an area of complexity, or simply the presence of particularly hard objects such as large rocks (**4003**). Beyond approximately 4 m deep, there are very few responses which indicate any change. This is also mirrored in the 100 MHz Bi-Static dataset, which displays very few signs of change with only minor diffractions. This suggests that a natural bedrock is reached and remains generally consistent between 4 to 10 m.

4.2.10 Transect 2.2 measures 48.7 m in length and there is a gradual and regular incline from south-west (91.92 aOD) to north-east (93.52 aOD). Within the 200 MHz dataset for the transect there are a number of reflections within the radargram for the 200 MHz dataset which are of interest. Perhaps the clearest of these are the series of hyperbolae or point diffractions visible within the south-west of the transect between 0 m and 7.5 m (**4004**). These are visible from 1.6 m to approximately 4 m (30-72 ns) in depth and represent an area of strong complex reflections which may indicate an area of artificial disturbance or made ground.

4.2.11 Immediately to the north-west of the reflections identified at **4004** there are some broad planar returns visible from 7 -17 m and 24-31 m along the transect and between 1.1 m and 3.5 m deep (20 – 65 ns). These are harder to interpret, and may simply represent a variation in water content within the ground or a change in the material used for construction of the path.

4.2.12 At **4005**, between 33 m and 36 m there are several moderate amplitude point source hyperbolae at a depth of 2 – 3.5m (37 – 65 ns). These are again likely to present an area of complexity, possibly associated with made ground or artificial disturbance.

4.2.13 Transect 2.3 measured 21.8 m in length and is orientated west-north-west to east-south-east. It has a gradual incline from 93.52 aOD to 95.42 aOD and continues to follow the route of the pathway as it curves round towards the south-east. There is only one area of complexity where there is a mix of high amplitude point source hyperbolae and convex reflectors (**4006**). This is present between 12 m and 16 m along the transect between 1.5 m and 3.2m (27 – 59 ns) and is suggestive of an area of artificial disturbance. This could take the form of made ground or perhaps some buried structural material associated with the construction of the pathway.

4.2.14 Transect 2.4 is the longest of the 4 sub-transects that comprise GPR Transect 2. It measures 56.6 m in length and has a gradual incline from 95.42 aOD in the north-west to 99.83 aOD in the south-east. There are six moderate amplitude point source reflection hyperbola between 19 m and 32 m along the transect (**4007**). Though these are not as strongly reflected within the radargram as previous features, such as **4005** and **4006**, it is possible these could represent some artificial disturbance at 2 – 3 m below the current ground surface (37 – 57 ns). This feature is also visible as a planar return within the 100 MHz Bi-Static dataset, which does not provide further detail of the feature, but does confirm that objects or material causing high amplitude reflections are present within this part of the Site.

4.2.15 In the south-eastern part of Transect 2.4 there is a high amplitude planar return from approximately 45 m to 55 m along the transect (**4008**). This begins to slope down from 1.8 m (3 ns) below the current ground surface to 2.5 m (47 ns) from the south-east to the north-west. It is likely that this represents an interface or marked change in material or moisture content.

4.2.16 The 100 MHz Bi-Static dataset for Transects 2.2, 2.3 and 2.4 do not show the areas of complexity identified within the 200 MHz results with any clarity. They also do not provide any further details for near surface deposits. However, the 100 MHz bi-static results do show that beyond approximately 4 m (70 ns) the ground is likely to remain of a similar character. From this point throughout the remainder of the profile to a depth of 10.53 m (190 ns) there are no notable high or low amplitude responses, suggesting that perhaps a natural bedrock has been reached and remains consistent beyond this depth. The weak or moderate planar returns that can be seen are likely only representative of subtle changes to the material and/or water content.

Transect 4

4.2.17 Transect 4 is the longest transect undertaken at the Site and measures a total distance of 216.9 m. It begins at the eastern side of the main junction of pathways at the centre of the cemetery grounds and continues on a south-westerly trajectory along the pathway that runs in front of the non-conformist chapel. The pathway then begins to arch in a semi-circle back up towards the Registrar's house in the south of the cemetery. The variation in orientation across this transect necessitated that it was broken up into 15 sub-transects (GPR 4.1 – 4.15). 4.1 – 4.14 were covered with both the 200 MHz and 100 MHz Bi-Static antennae, but GPR 15 was only possible to complete with the 200 MHz due to spatial restrictions.

4.2.18 Transect 4.1 is relatively flat, but generally declines from north-east (97.95 aOD) to south west (101.47 aOD) and measures 58.6 m in length. This provided some of the most interesting results from the 200 MHz dataset in the form of a series of high amplitude point

source reflection hyperbolae which can be seen in the north-eastern part of the radargram from 2 m to 25 m along the transect (**4009**). These are present between 1.6 m and 3 m below the current ground surface (30 – 60 ns) and are located in between two dense areas of graves within the cemetery. This type of complex reflection is often associated with disturbed or made up ground. Given the location of these high amplitude reflection on a levelled terrace it is most likely related to landscaping and the construction of the pathway located in this area. Moreover, as some of these hyperbolae appear to be at relatively regular intervals, and approximately at the same depth, it is possible that there may be some regularity to this arrangement. However, further investigation would be required to better understand this.

4.2.19 The 100 MHz Bi-static radargram for Transect 4.1, also shows some planar returns at the same level and position. This confirms the presence of material of a higher amplitude within this area, but provides little further detail regarding its composition. Deeper within this radargram at an approximate depth of 8.5 m (150 ns), there is a distinctive undulating high amplitude planar return. At such depth, this is difficult to provide any precise details for, but the high amplitude nature of the response may suggest that there is an interface between differing materials. -

4.2.20 GPR Transect 4.2, is the following radargram and is located at the start of where the path begins to rise at the western extent of the cemetery, and has a gradual incline from the south-east (101.41 aOD) to north-west (103.29 aOD). It is 25.5 m long and within the 200 MHz dataset there are no high amplitude point source reflections of interest. In the 200 MHz dataset a moderate amplitude planar return is present at an approximate depth of 1.5 m below the current ground surface which is most clearly identifiable between 3 m and 21 m along the transect (**4010**). In the centre of the radargram, this planar return appears to form a very broad convex form. It is likely that this denotes a possible change between materials or water content at this level, but is likely related to the construction of the path rather than being archaeological.

4.2.21 The topography between GPR Transect 4.3 and 4.10 rises steadily from 103.29 aOD in the south to 112.13 aOD in the north at the north-eastern end of Transect 4.10. As GPR requires the collection of data in straight lines, the curved pathway had to be divided into several sub-transects, but the results of these are likely to be associated and most relevant when considered together.

4.2.22 Within the 200 MHz antenna radargram for GPR Transect 4.3 measures 10.1 m in length and has relatively few significant high amplitude reflections. Between 1 m and 2.5 m there are two moderate amplitude convex crested reflectors. These may relate to drains or insignificant buried obstructions, such as rocks. There is also a moderate amplitude sloping planar return which could represent an interface between materials. This does not continue further south-west into GPR Transect 4.4.

4.2.23 GPR transects 4.4 – 4.10 display no high or low amplitude reflections likely to be archaeological within the 100 MHz Bi-Static antennae dataset. Within the 200 MHz radargams, there are some isolated moderate amplitude point source reflection hyperbolae, but these are unlikely to relate to the development of the cemetery. It is possible that the may relate to anomalous rocks or interfaces, but these are not clearly defined. For example, within GPR Transect 4.7 there is an example of this 5 m into the transect at approximately 1.6 – 4m deep (30 – 75 ns). There is also a slightly higher amplitude point source reflection hyperbolae at approximately 10 m along GPR Transect 4.8 at a similar depth.

4.2.24 As the path continues on a more south-west to north-east trajectory, to the north-west of the Registrar's building within Sheffield general cemetery, there are similarly few high amplitude reflections. There are several sparsely distributed moderate amplitude point source hyperbolae, but none of the these are considered to relate to any archaeological features. Equally, there are no planar returns considered to be clearly representative of any interfaces or changes in material or water content.

Transect 5

4.2.25 Transect 5 was completed in a single continuous line from east to west and measured a total of 13.9 m in length. It is located behind the non-conformist chapel, over a relatively flat area at approximately 101.7 aOD. The land rises steeply directly to the south of the transect and it is likely that the ground has been levelled in this area in order to facilitate the construction of the chapel. There were no surface obstacles or terrain changes of note along the transect, but a small amount of damp grass over the south-western part of the transect may have had a limited impact upon the attenuation of the radar wave.

4.2.26 Within the radargram for the 200 MHz antenna, there is a broad crested refraction at the eastern extent, between 1 and 2.5 m, at an approximate depth of 1.2 – 2.7 m (22- 49 ns) (**4011**). This type of refraction can be caused by structural remains, though the exact nature of these remains is not clear from the results of the GPR alone. Despite this, the width and arched nature of the refraction could potentially be representative of a vaulted ceiling associated with a catacomb. However, this is by no means conclusive and there is limited clear evidence of a void below this refraction. To the west of **4013** there are also several planar high amplitude reflections which are not easy to provide precise interpretation for. The strength of the reponse is also suggestive of structural remains, but there is no clear indication of the layout of this. Nonetheless, at the very least these refractions relate to some form of structural remains to the south of the chapel and the it is likely that this is attributable to the catacombs which are known to exist to the south of the non-conformist chapel.

4.2.27 Within the radargram for the 100 MHz Bi-Static antenna the previous higher amplitude features are not well represented. There are also few significant further moderate or high amplitude reflections below 4m within this transect.

Transect 6

4.2.28 This transect was also completed in one continuous line and did not require sub-division. It is orientated on a south-south-east to north-north-west alignment and measures 20.7 m in length. It is situated to the north-east of the non-conformist chapel and traverse from the wide pathway in the north, close to the south-west corner of the chapel itself. Further continuation of the transect was not possible due to the high number of grave markers and surface obstacles within south-eastern part of this transect. The topography is relatively flat at around 101.2 aOD.

4.2.29 At approximately 2.8 m into the radargram there is a high amplitude point source hyperbola (**4012**) at a depth of 1.1 m (20 ns) and is present throughout the remainder of the radargram to a depth of 5.4 m (100 ns). This type of response is often associated with a small diameter pipe or wall and may be associated with the with a drain or similar adjacent to the pathway in front of the non-conformist chapel.

4.2.30 Elsewhere within the 200 MHz dataset for GPR Transect 6.1, there is a moderate amplitude planar return between 12 and 16 m along the radargram, at a depth of 2.2 m (40 ns), but this is not suggestive of any specific below ground change.

4.2.31 The 100 MHz Bi-Static radargram also identifies the high amplitude point source diffraction (**4012**), as well as an area of increased complexity at around 15 m into the transect, however these are again poorly defined. Below, this no further features or high amplitude responses of note are recorded.

Transect 7

4.2.32 Transect 7 was undertaken as a single continuous traverse located to the west of the non-conformist chapel. It is orientated south-east – north-west and measures 25.5 m in length. The terrain changes from wet grass, in the south-east to tarmac in the north-west, but there were no surface obstacles or any other factors that could affect the data. The topography is relatively flat at around 101.7 aOD.

4.2.33 Within the 200 MHz radargram for Transect 7.1 there are several high amplitude features, particularly in the south-east between 0 m to 7 m (**4013**). This denotes an area of complexity across the majority of the transect, but particularly between 1.1 and 3.5 m deep (21 – 63 ns). This complexity is difficult to interpret but most likely represents a possible below ground structural remains with some indication of voids. This is most likely associated with the construction of the chapel and catacombs within this area, but as the radargram for the 100 MHz Bi-Static antenna also displays little to no high amplitude reflections, it is impossible to provide any exact details regarding the nature of this feature.

Transect 9

4.2.34 This transect was divided into two sub-transects (9.1 and 9.2) and is located to the east of the Registrar's building in the south of the Site. Both transects are orientated on a south-east to north-west alignment and are divided by a pathway and railings associated with the grounds of this building.

4.2.35 The topography of Transect 9.1 is generally flat with a very slight decline from south-east to north-west (112.35 – 111.96 aOD) and the ground surface was comprised of a gravel surface. It extends for approximately 10.9 m and there are several high amplitude features identifiable within the radargram. These are again not necessarily indicative of a particular type of feature, but may be related with artificial ground disturbance associated with the construction of the Registrar's building. For example, in the south-east of the radargram between 0 m and 2 m, there are some strong reflectors at an approximate depth of 1 m to 3.5 m (20 – 65 ns) (**4014**). To the north-west of this there are also some moderate amplitude planar returns at a depth of 1.5 m (27 ns) from the current ground surface between 4 m and 10 m along the transect.

4.2.36 Within the 100 MHz Bi-Static radargram for Transect 9.1 many of the reflections witnessed within the 200 MHz dataset are visible. In addition, there is also a weak, but clear planar reflection at approximately 4 m (70 ns) below the current ground surface at **4015**. This is difficult to interpret, but it is likely to denote a subtle interface between two materials, the implication of which is not readily apparent. Beyond this depth there are no further significant high or low amplitude features within the 100 MHz Bi-Static dataset.

4.2.37 The topography is slightly steeper across Transect 9.2 and there is a decline from 111.85 aOD on the pathway in the south-east to 110.59 aOD in the north-west. The terrain was relatively rough across this transect and was constricted by the presence of grave markers on each site of the cleared area. This prevented the collection of data with the 100 MHz Bi-Static antenna, but a transect of 8.7 m length was achieved with the 200 MHz antenna.

4.2.38 Within the uppermost part of Transect 9.2 there is a great deal of variation, most likely associated with the rough terrain over which the antenna was dragged over. Aside from this, between 2.5 and 4.5 m there is an area of complexity with some moderate amplitude point source reflections between 1.6 m – 3.8 m deep (30 – 70 ns) (**4016**). These are not strong enough to suggest any made ground within this area, but may suggest that there has been some light artificial disturbance, prior to placement of graves within the area.

Transect 10

4.2.39 Transect 10 is located on a north-east orientation and was divided into three sub-transects (10.1 -10.3). Transect 10.1 and 10.2 are only divided by the presence of iron railings associated with the grounds of the Registrar's building. Transect 10.3 was undertaken parallel and 1 m to the south-east of GPR 10.2 in order to attempt further clarity in this area. However, this was only achieved with the 200 MHz antenna, the 100 MHz Bi-Static antenna only covered Transects 10.1 and 10.2.

4.2.40 The topography of the area is relatively flat, and was probably levelled or landscaped prior to the construction of the Registrar's building. However, there is a gradual incline from 110.71 aOD in the north-east to 112.26 aOD in the south-west. The terrain is variable with a woodchip pathway at Transect 10.1 and gravel at Transect 10.2 and 10.3.

4.2.41 GPR Transect 10.1 measured 14.3 m in length and identified two distinctive high amplitude slightly convex diffractions at 2.7 m (**4017**) and 8 m (**4018**) along the transect. These both become visible at approximately 0.7 m (15 ns) below the current ground surface and are most likely to represent pipes or a narrow wall generating a hybrid of a point diffraction and convex reflectors. However, it is difficult to provide a more specific interpretation of these features in isolation.

4.2.42 Further to the south-west GPR Transect 10.2 was undertaken from south-west to north-east, but represents a continuation of Transect 10.1. Throughout the majority of the transect there is a complex of high amplitude planar returns. These are strongest between 1 m and 6.5 m along the transect (**4019**) at an approximate depth of 1.6 m and 3 m below the current ground surface (30 – 57 ns). At the base of this there are also several high amplitude point source reflectors. This correlates well with the additional Transect 10.3 which displays a similar area of complexity in the same depth and range of the radargram (**4020**).

4.2.43 The 100 MHz Bi-Static dataset for Transect 10.1 and 10.2 identify many of these near surface features, but with the anticipated lower level of clarity. For example, within the radargram for Transect 10.2, there is a strong high amplitude planar return that corresponds with **4019** in the 200MHz data. This strongly suggests that a degree of artificial disturbances has occurred within the area immediately to the north-east of the Registrar's building. This is most likely associated with the landscaping of the area, prior to the construction of the building.

Transect 11

4.2.44 Transect 11 runs from the entrance way at the southern gate of the cemetery along the path in an easterly direction towards the Anglican chapel. It comprises three sub-divisions (Transects 11.1 – 11.3) and extends for a total length of 72.3 m. It follows the path and both the 200 MHz and the 100 MHz Bi-Static antennae were dragged over a consistent hard pathway surface.

4.2.45 Transect 11.1 is orientated south-west to north-east and has a slight decline from 111.70 aOD to 110.84 aOD. It measures 20 m in length and displays a number of moderate amplitude point source reflection hyperbolae that are difficult to interpret. They occur fairly regularly at a depth of 1.6 m (30 ns) below the current ground surface, but are not indicative of a particular type of feature. Also at this depth at 15 m along the transect there is a very strong convex diffraction which may represent a drain or small diameter pipe at this location (**4021**).

4.2.46 Within the 200 MHz radargram for GPR Transect 11.2, there is a similar range of features. The transect measures 19.9 m and declines from the south-west (110.84 aOD) to the north-east (108.71 aOD). At the south-western extent there is a cluster of complex reflections of indeterminate origin. These are visible between 0 m and 2.5 m along the transect at a depth of approximately 1.6 m -3.8 m (30 – 70 ns) (**4022**).

4.2.47 Between 3 m and 15 m there is a moderate amplitude broad convex diffraction at a depth of 2.7 m – 3.8 m (50 – 70 ns). This is most likely related to a subtle interface between differing materials or water content and is not considered likely to be of archaeological significance.

4.2.48 GPR Transect 11.3 is the longest of the three sub divisions that comprise transect 11 and measures 32.3 m. The topography gradually declines from 108.43 aOD in the south-west to 106.5 aOD in the north-east. There are relatively few high or low amplitude reflections within the 200 MHz dataset. The only identifiable features of note are located between 22 m – 33 m along the transect, directly to the south-west of the Anglican chapel (**4023**). These take the form of undulating high amplitude planar returns at a depth of 0.5 m – 2.7 m (10 – 50 ns) and are most likely associated with landscaping or levelling of the area in order to facilitate the construction of the chapel.

4.2.49 The 100 MHz radargrams for Transects 11.1 – 11.3 provide little further detail. Many of the features identified in the 200 MHz are also present within the uppermost part of the radargrams. There is also a notable lack of high or low amplitude reflection beyond the features already discussed, which may suggest that there has been little artificial disturbance to the natural ground within this area of the Site.

Transect 12

4.2.50 This transect is located close to the entrance to the Anglican church area from Cemetery Road. It was subdivided into Transect 12.1 and 12.2 as the presence of a large grave monument prevented the collection of the transect in a consecutive line.

4.2.51 Transect 12.1 measured 11.7 m and steadily declines from south-east (108.03 aOD) to north-west (106.8 aOD). The 200 MHz radargram displayed no moderate or high amplitude reflections likely to be of archaeological significance. The 100 MHz Bi-Static antenna also failed to reveal any further features at deeper levels.

4.2.52 For Transect 12.2 it was not possible to collect a complete transect with the 200 MHz antenna as the topography became too steep and prevented the odometer wheel from running freely beyond the length 23.7 m. With the 100 MHz Bi-static antenna it was possible to undertake a transect measuring 38.3 m in length. The topography is relatively flat in the south-eastern extent, with a slight decline from 106.59 aOD to 105.43 aOD. At the north-western end of 200 MHz radargram, the topography begins to decline more sharply to a height of 102.58 aOD on the pathway.

4.2.53 Within the 200 MHz data there is a high amplitude planar return between 0 and 21 m along the traverse, at a depth or 0-5 m – 1.1 m (10 -20 ns). This is likely to relate to a preparation for the tarmac surface which is present in this area. In the north-western extent of the radargram there is a broad crested hyperbole response which corresponds with where the topography begins to drop off more steadily. This can be clearly identified between 19 m and 22 m at a depth of 3.3 m – 4.9 m (60 – 90 ns) (**4024**). This may relate to the topographic change in the area, but is more indicative of a large obstruction, such as a rock or large pipe. However, this anomaly cannot be interpreted in any further detail in isolation. Within the 100 MHz Bi-Static radargram for Transect 12.2 there is also an interface at this location, but this is much less clear.

Transects 13 and 14

4.2.54 GPR Transect 13.1 and 14.1 were undertaken in order to provide extra detail for the path way which forms the route of GPR Transect 2. It was only undertaken using the 200 MHz antenna and data were collected across two short transects, 3.5 and 3 m respectively. Both transects were relatively flat and undertaken over a concrete pathway about the catacombs.

4.2.55 Within Transect 13.1, there is a single high amplitude point source hyperbola which most likely relates to a drain visible on the surface. Transect 14.1 identified an area of complexity with several convex reflectors and crested diffractions. This is probably related to made ground associated with the construction of the terrace above the catacombs and helps to confirm the interpretations discussed for GPR Transect 2.2.

5 DISCUSSION

5.1 Introduction

5.1.1 The GPR survey has been successful in detecting anomalies with archaeological potential. It has revealed several details regarding the original designed landscaped and the pre-design ground formation.

5.1.2 The use of a 200 MHz and 100 MHz Bi-static antennae has provided two differing but largely complimentary datasets which resulted in a good level of detail for near surface deposits and a depth penetration of up to 10.5 m. The features of potential interest are primarily those associated with the construction of the cemetery itself and are generally located within the first 4 m below the current ground surface. However, after this point the attenuation of the GPR is generally poor across the entire site.

5.2 Conclusion

5.2.1 Transect 2 revealed several high amplitude responses which may relate to the design of the landscape located to the south of the catacombs. These features are likely caused by areas of made ground, possibly related to landscaping or the quarrying activity in the area. Further possible evidence for quarrying activity at **4008**, where a sloped feature suggests a change in former ground levels. This may indicate an area that has been previously excavated, such as the edge of the quarry. However, it is difficult to determine the cause of the anomalies in isolation, and bore-holing or excavation would improve the interpretation of the data.

5.2.2 Evidence of the development of the designed landscape can also be identified within Transect 4, most clearly at the north-eastern extent of Transect 4.1 displays this most clearly with a very wide area of high amplitude responses located at **4009**. This is again likely to be related to the building up of ground that may once have been quarried, in order to create the terraced pathway that runs in front of the non-conformist chapel.

5.2.3 To the South of the non-conformist church at Transect 5 it was anticipated that divisions between catacombs, and the voids that one might expect to be able to detect with GPR would be clearly identifiable within the dataset, yet this is not the case. There is certainly evidence for structural remains at **4011**, but there is no clear indication of an exact layout of the catacombs. There are a number of possibilities that can be suggested for why this might be the case and this dataset is unfortunately not detailed enough to provide a precise conclusion. However, as an inspection of the catacombs has suggested that they are not likely to be backfilled with material and still survive as voids (Taylor 2012) it is surprising that they are not visible within the radargram for Transect 5. It may be that that part of the catacombs, not accessed during this inspection, may have been backfilled and therefore no voids have been clearly detected.

5.2.4 Within Transects 6 and 7, which surround the non-conformist chapel at the centre of Sheffield General Cemetery there is evidence for ground disturbance which is probably associated with levelling of the ground prior to the construction of the building. More interestingly, planar responses are seen in close proximity to the chapel in Transect 7, possibly providing evidence of structural features relating to the catacombs (**4013**). Although by no means conclusive, it is possible that this feature could relate to a vaulted structure, with the roof of the vault arching on an alignment parallel to the southern wall of the chapel (south-west – north-east). This may also account for the planar reflections that are encountered at the western extent of Transect 5 between 4 and 13.9 m and would also provide a possible explanation for why there are not more discernible vaults within the

Transect 5. If the roof of the catacomb vaults are aligned in this fashion it is possible that the radar wave is refracted to such an extent that the internal divisions of the catacombs is was not detectable. However, further investigation, perhaps in the form of excavation, would is required to confirm this.

5.2.5 To the north-east of the Registrar's building in the south-west of the Site, Transects 9 and 10 revealed several strong high amplitude reflectors (**4014** to **4020**). **4014** to **4018** are probably largely associated with the development or levelling of the ground prior to the construction of the Registrar's Building itself. Whereas the stronger planar responses of **4019** and **4020**, which are in closer proximity to the Registrar's building, suggest a buried surface possibly related to the building's construction.

5.2.6 Further to the west, Transect 11 showed few clearly high and low amplitude reflections. The only clear features were located close to the Anglican chapel (**4023**). However, Transect 12 revealed a high amplitude broad crested return which may relate to a topographic change identified at the same location or a buried obstruction (**4024**). The exact origin of this response is not clear from the GPR results alone.

5.2.7 In general, there appears to be a greater concentration of made-ground and landscaping features across Transect 2 and the start of Transect 4 between depths of 1.5 m and 3.8 m. This may indicate that quarrying activity was concentrated in these areas, over the north-west of the Site. There is little evidence for unknown structures on the Site. However, there is evidence for structural features around the chapels and Registrar's building, all of which are largely related to the construction of these buildings.

5.2.8 The detection of the original ground surface features has not been readily apparent within either GPR dataset. The data seems generally quieter below levels of 4 m across the majority of the Site and 3.5 m in the south-east. One possibility is that a high soil conductivity has resulted in poor attenuation of the radar wave below this depth and as a result few reflections of note have been identified below 4 m. It is unlikely that this subtle change is related to a consistent level of bedrock across the entire site between 3.5 m and 4 m, though it could suggest that any levelling of the site could have taken place using a material similar to that of the natural geology.

5.3 Recommendations

5.3.1 Following the results of the geophysical survey, it is considered that further archaeological investigations are required to fully understand the development of the site. These works could take the form of an archaeological borehole survey or trial trenching. In particular, it is recommended that trial trenching would be the best method to establish the exact layout of the catacombs located to the south of the non-conformist chapel.

5.3.2 Additionally, further data should be collected via bore hole survey or trial trenching from the areas identified as superficial archaeology / potential spreads to ensure that these responses are not masking weaker and potentially archaeological responses. Trenches should also be planned to investigate areas where no anomalies of potential archaeological interest have been identified within the Site.

5.3.3

6 REFERENCES

6.1 Bibliography

English Heritage 2008 *Geophysical Survey in Archaeological Field Evaluation. Research and Professional Service Guideline No 1.* Swindon (2nd Edition)

Taylor, R., 2013. *The Under World of Sheffield's General Cemetery: Understanding General Cemetery's Subterranean Landscape*. Unpublished Masters' Dissertation

Wessex Archaeology 2016 *Sheffield General Cemetery, Sheffield: Historic Environment Desk-Based Assessment.* WA Doc. Ref. 113880.01

6.2 Cartographic and documentary sources

Ordnance Survey 1983 *Soil Survey of England and Wales Sheet 3, Soils of Midland and Western England.* Southampton.

6.3 Online resources

British Geological Survey Geology of Britain Viewer [accessed July 2016] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Heritage Gateway, http://www.heritagegateway.org.uk [accessed August 2016]

Historic England https://historicengland.org.uk/listing/the-list/list-entry/1001391 [accessed August 2016]

7 APPENDICES

7.1 Appendix 1: Survey Equipment and Data Processing

Survey Methods and Equipment

The ground penetrating radar (GPR) data were collected using shielded antennae with central frequencies suitable for the types of target being investigated. Lower frequency antennae are able to acquire data from deeper below the surface, whereas higher frequencies allow high resolution imaging of near-surface targets at the expense of deep penetration. The exact make and model of equipment varies.

The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivity (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration c. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

The GPR beam is conical in shape, however, and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

The vertical resolution is similarly dependent upon the central frequency; for the 300MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

GPR data for detailed surveys are collected along traverses of varying length separated by 0.5m with cross lines collected running perpendicular to these traverses at wider separations. The data sampling resolution is governed by the data logger and a minimum separation of 0.05m between traces is collected for all surveys.

Post-Processing

The radar data collected during the detail survey are downloaded from the GPR system for processing and analysis using commercial software (GPR Slice). This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background. A wobble correction is also applied during this step;
- Background Filter - is used to remove banding noises that are seen across the radargrams
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.
- Boxcar Smoothing – Smooths radargrams that have high frequency random noise.

Typical displays of the data used during processing and analysis:

- Timeslice – Presents the data as a series of successive plan views of the variation of reflector energy from the surface to the deepest recorded response. The variation in amplitude is

represented using a colour scale with red indicating high amplitude and blue indicating low amplitude responses.

- Radargram – Presents each radar profile in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. The amplitude variation is expressed using a greyscale.

7.2 Appendix 2: Geophysical Interpretation

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

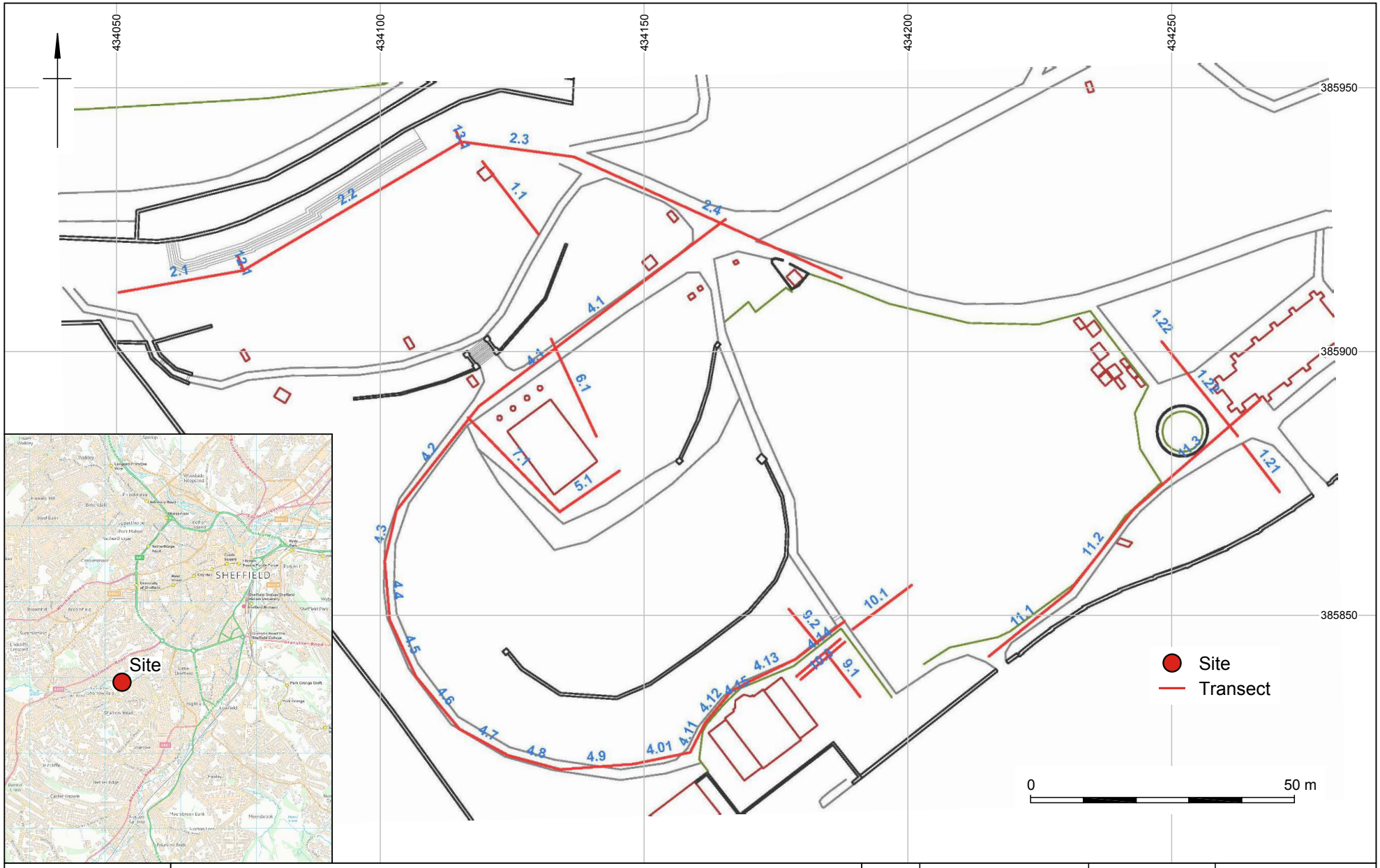
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative or broad bipolar (positive and negative) anomalies.



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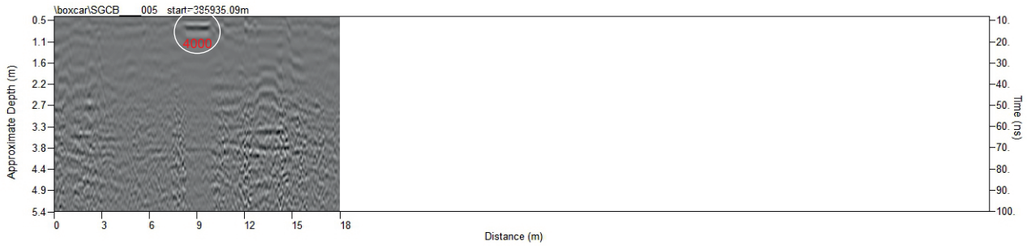
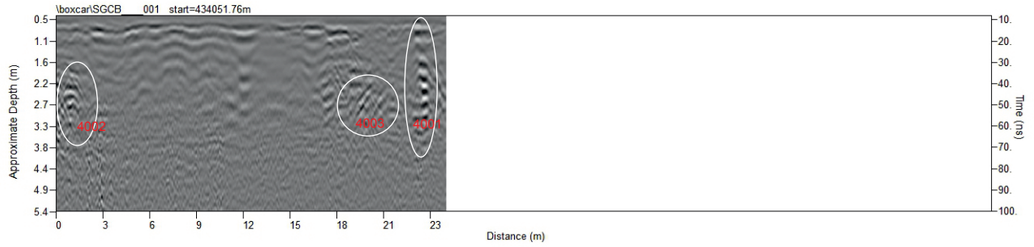
Site location plan

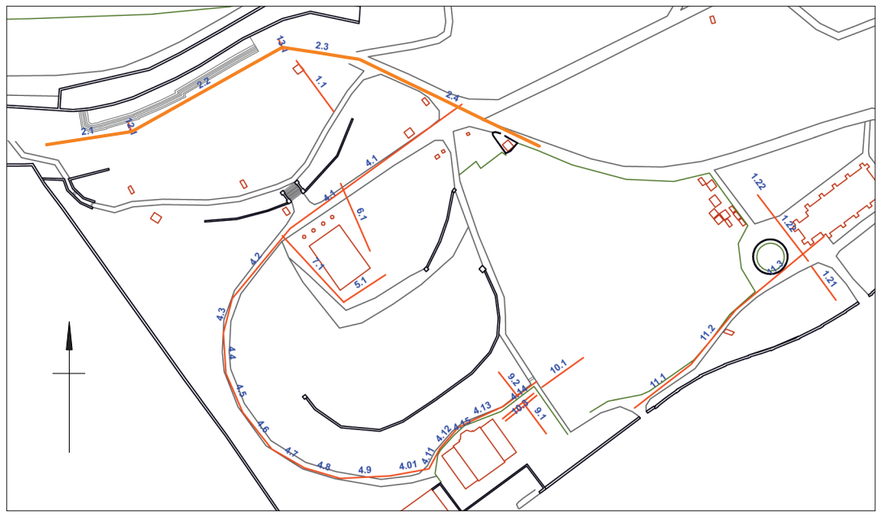
Figure 1

Transect 1.1, 200 MHz



Transect 2.1, 200 MHz

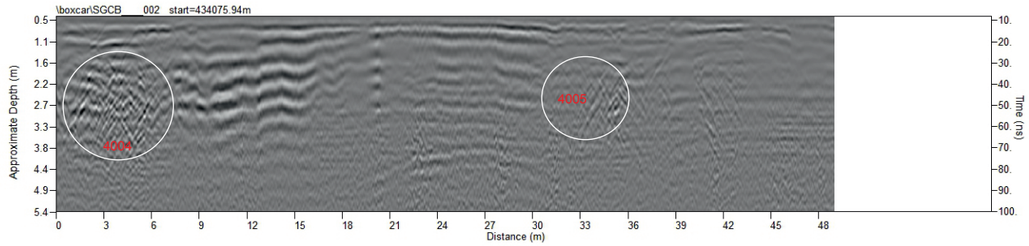




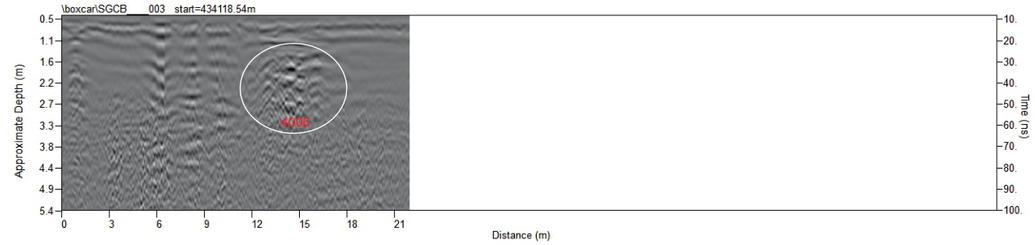
Transect

Transect with radargram shown

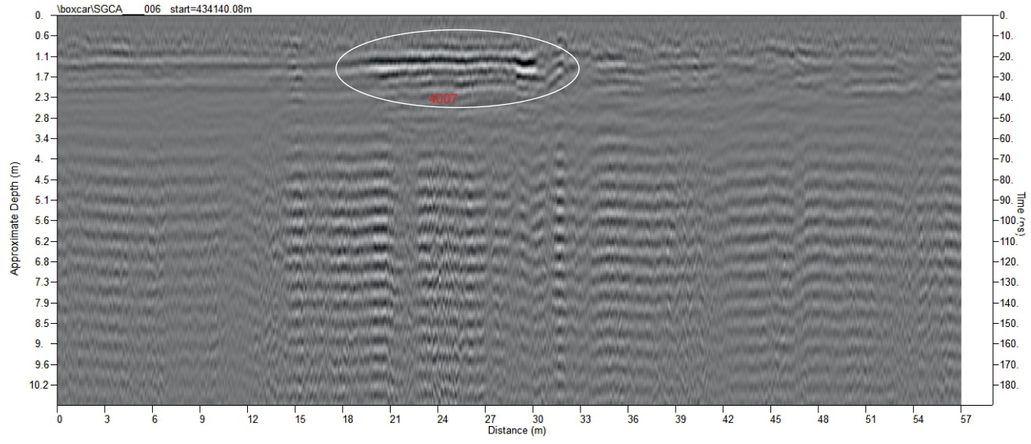
Transect 2.2, 200 MHz



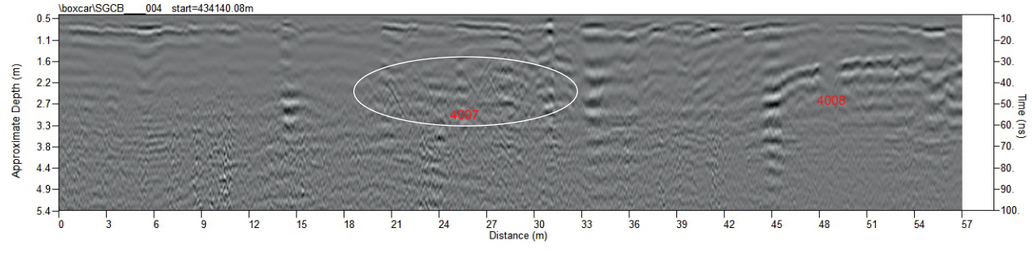
Transect 2.3, 200 MHz



Transect 2.4, 100 MHz



Transect 2.4, 200 MHz



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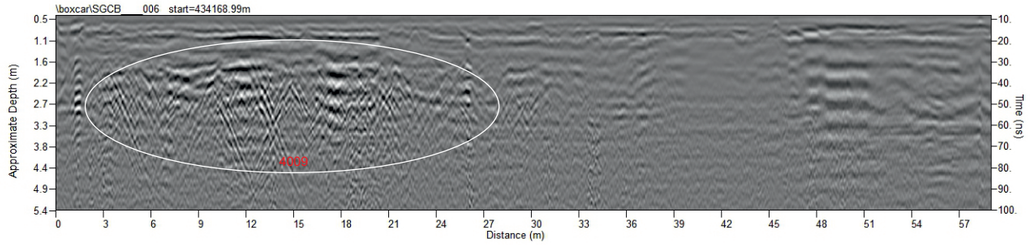
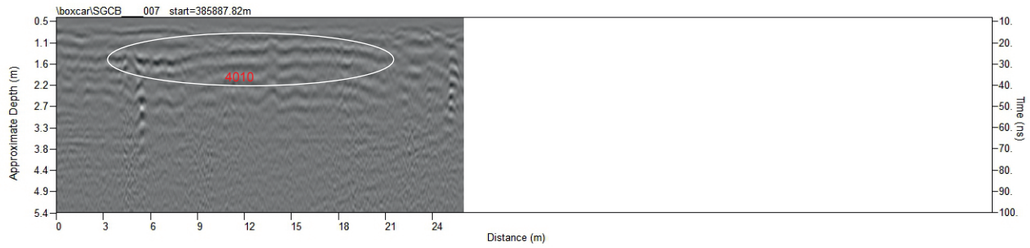
Transects 2.1, 2.2, 2.3 and 2.4

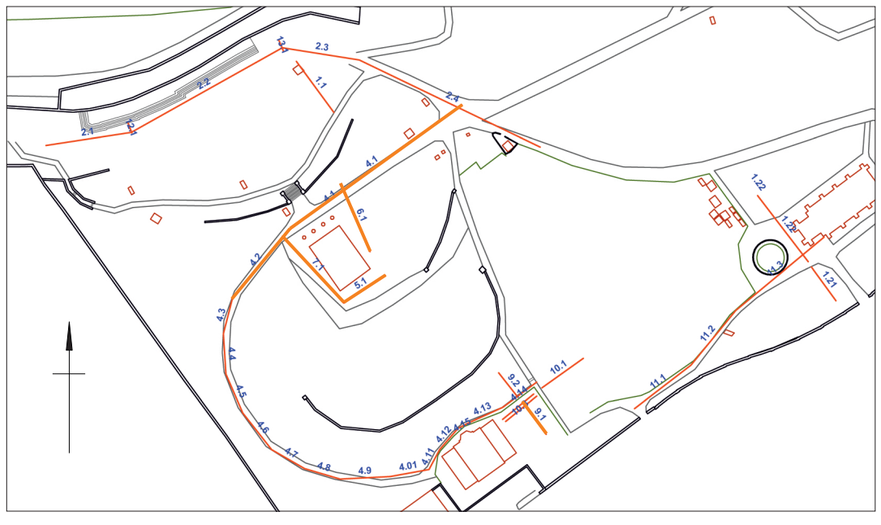
Figure 2

Transect 4.1, 200 MHz

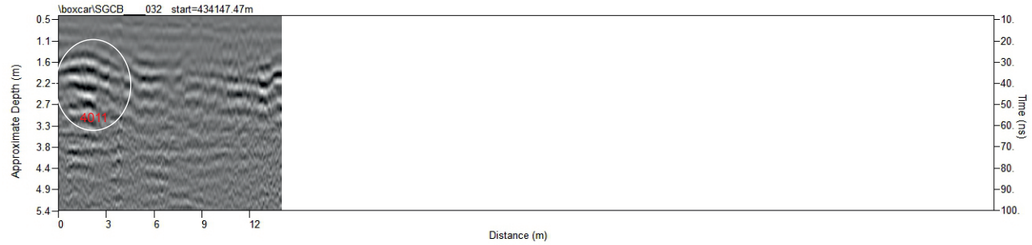


Transect 4.2, 100 MHz

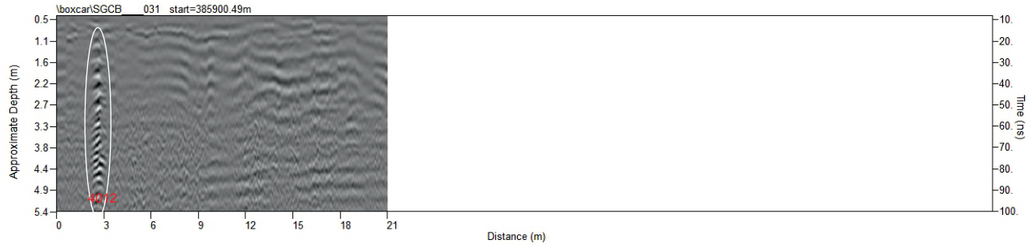




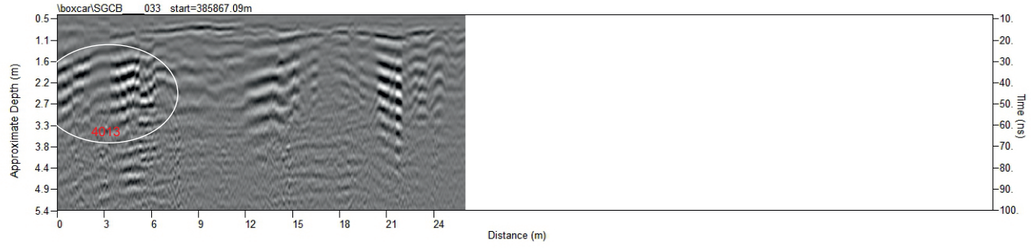
Transect 5.1, 200 MHz



Transect 6.1, 200 MHz



Transect 7.1, 200 MHz



Transect 9.1, 100 MHz

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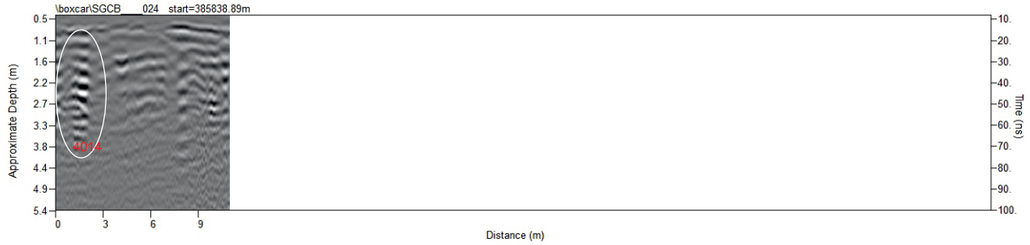
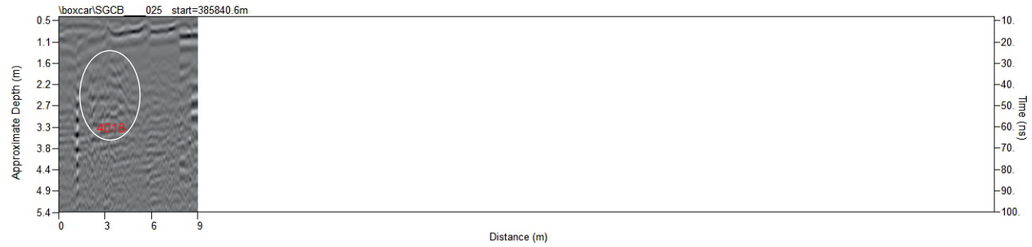
Transects 4.1, 4.2, 5.1, 6.1, 7.1 and 9.1

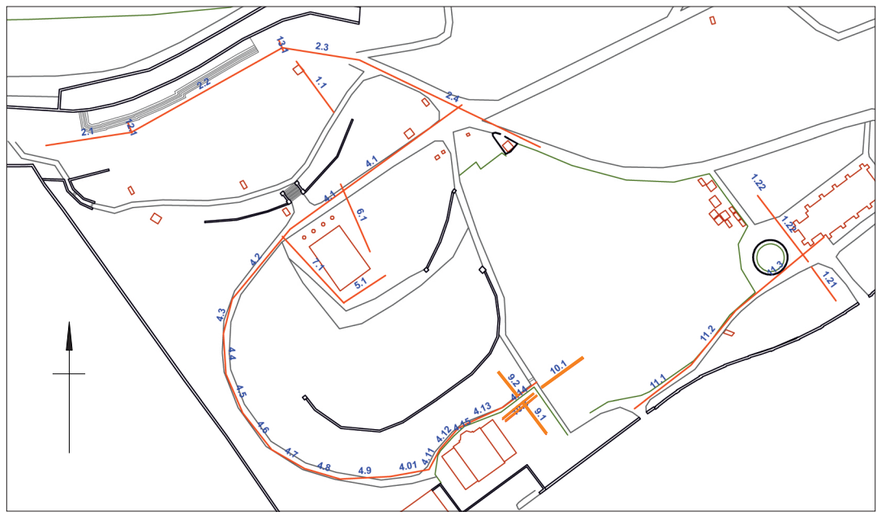
Figure 3

Transect 9.1, 200 MHz



Transect 9.2, 200 MHz

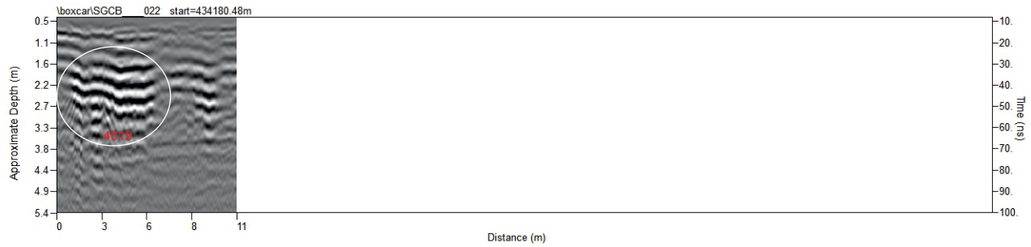




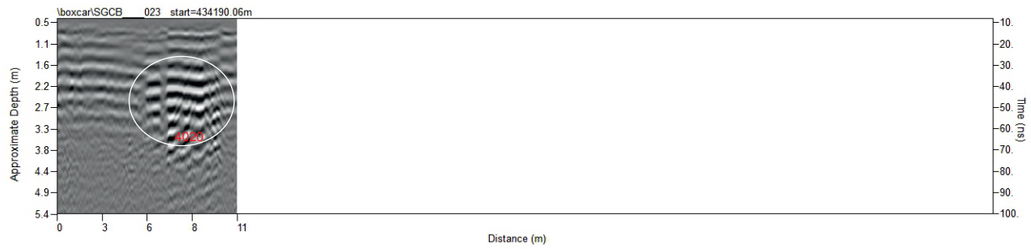
Transect 10.1, 200 MHz

Transect 10.2, 100 MHz

Transect 10.2, 200 MHz



Transect 10.3, 200 MHz



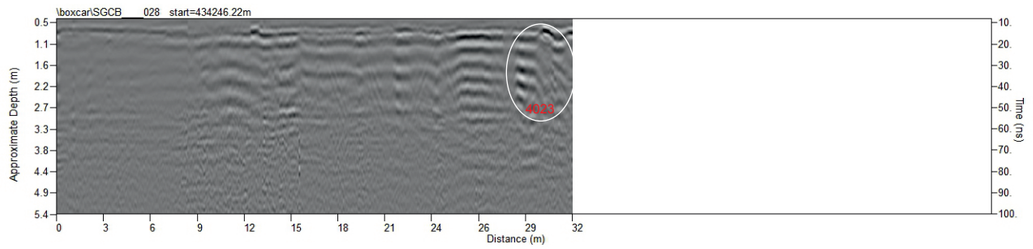
Date:	15/08/2016	Revision Number:	0
Scale:	NTS	Illustrator:	ND
Path:	Y:\PROJECTS\113880\Graphics_Office\Rep figs\GPR\2016_08_08		

Transects 9.1, 9.2, 10.1, 10.2 and 10.3

Figure 4

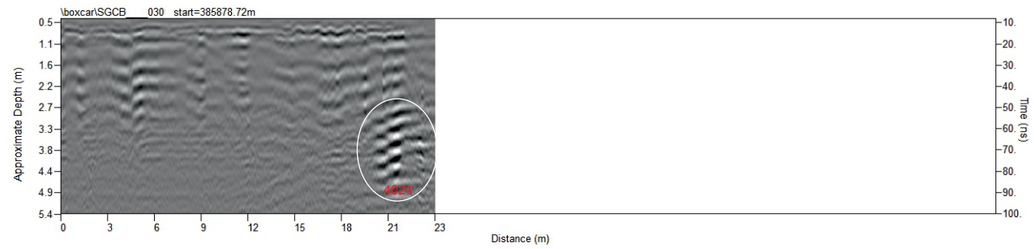
Transect 11.1, 200 MHz

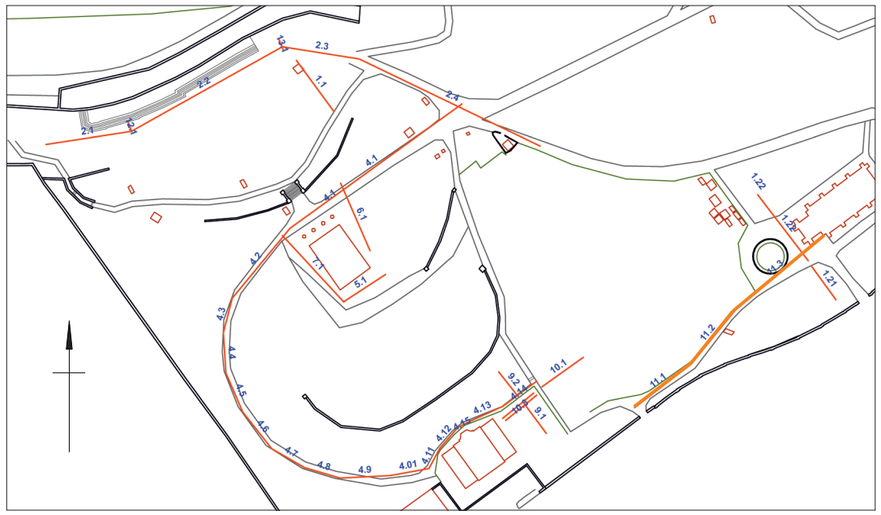
Transect 11.3, 200 MHz



Transect 11.2, 200 MHz

Transect 12.2, 200 MHz





Transect

Transect with radargram shown

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Transects 11.1, 11.2, 11.3 and 12.2

Figure 5

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