GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:
Colchester Bus Station

Client:
Colchester Archaeological Trust Ltd

Job ref:
J10650

January 2017

GEOPHYSICAL SURVEY REPORT

Project name: **Colchester Bus Station** Client: **Colchester Archaeological Trust Ltd**	Job ref: **J10650**
Survey date: **7th - 9th 2016**	Report date: **January 2017**
Field team: **Richard Fleming** **Matthew Wetton** MSci	Project Manager: **Simon Haddrell** BEng(Hons) AMBCS PCIfA
Report written by: **Magdalena Udyrysz** MSc	Report approved by: **David Elks** MSc ACIfA
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SUMO Group Member

TABLE OF CONTENTS

LIST OF FIGURES

1 SUMMARY OF RESULTS

A Ground Penetrating Radar (GPR) survey was conducted at the Colchester Bus Station at Queen Street in Colchester to identify Roman structures, and other archaeological remains. The survey identified a number of features that are of possible archaeological potential. This includes a large recti-linear feature adjacent to houses IV and V and a smaller recti-linear response near Trench T5.

The survey also identified modern obstructions, made ground and services.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey at Colchester Bus Station. The purpose of the survey was to detect Roman remains which are known to exist in the area and also any other anomalies of archaeological significance.

2.2 Site Details

NGR / Postcode	TL 999 250/ CO1 2PQ
Location	The site is located at Colchester Bus Station.
HER/SMR	Essex
District	Essex
Topography	Flat
Weather Conditions	Dry
Soils	The overlying soils are unsurveyed – urban or industrial area (Soil Survey of England and Wales, Sheet 4 Eastern England).
Geology	The underlying geology is the Thames Group – clay, silty. Superficial deposits are sand and gravel of the Kesgrave Catchment Subgroup and Gravel Member (British Geological Survey website).
Background information	From The archaeological evaluation at the First Eastern National bus station, Queen Street, Colchester, Essex May-June 2003: *The site is located within the south-east angle of the Roman town wall. During the 20th century, several archaeological excavations have been undertaken in the vicinity of the bus station.* *At the southern end of the evaluation area, a mosaic pavement was uncovered in Lewis's garden in 1923 (the site which is currently occupied by the bus station; Urban Archaeological Database or UAD no 321).*

	During further excavations in 1955 and 1958 (UAD 3069 and 3070; Richardson 1961), evidence of five rubble foundations of Roman buildings were recorded. Two periods of building were represented. The first structure was associated with the first half of the 2nd century; this building was then demolished and replaced at around AD 150, and the later structure appears to have been occupied into the 4th century. Two of the houses had hypocausts. From within the demolition and robbing material, painted wallplaster and red, white and grey tesserae were recovered. Later in 1959, a sewertrench was dug between the 1955 and 1958 sites (UAD 3365; Richardson 1961). The trench showed stretches of wall foundation and a tessellated floor, both on an east-west alignment. *At the northern end of the evaluation area, excavations in 1966 at the rear of no 5 Queen Street by the then Colchester Excavation Committee (now CAT) (UAD 3065; Dunnett 1971) identified a Roman building with rubble foundations that had at least three structural phases. The later of these phases incorporated a hypocaust overlaid with a coloured mosaic floor. The suggested date for the building is 2nd century, and the nature of the building suggests that it was for public rather than private use.* *To the east of the current evaluation area, a watching brief was carried out in 1970 by the Colchester Excavation Committee during the groundworks for the Queen Street multi-storey car park (UAD 3484). Observations were made during the excavation of foundation stanchions. Roman structural remains were recorded and appeared to extend beyond those identified in the excavation in Lewis's garden.* *Most recently, evaluation trenches were dug by CAT in 1990 (UAD 3577; Crossan 1990). Five trenches were excavated to assess the depth, nature and preservation of any archaeological remains. The remains of a Roman house were recorded; one of the wall foundations had been completely robbed out and the associated floor level destroyed. A Roman infant burial in a tile-covered grave, accompanied by a small beaker, was also recorded.*
Survey Methods	Ground Penetrating Radar (GPR) survey.
Study Area	c. 4750m^2

2.3 **Aims and objectives**

The purpose of the survey was to detect Roman remains which are known to exist within the site. Also to identify any other anomalies of archaeological significance.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (2008) and the Chartered Institute for Archaeologists (2002 & 2014).

Stratascan Ltd are a Registered Organisation with the CIfA and are committed to upholding its policies and standards.

3.2 Survey methods

Due to the urban environment ground penetrating radar (GPR) was selected as the most suitable methodology for this survey. More information regarding this technique is included in Appendix A.

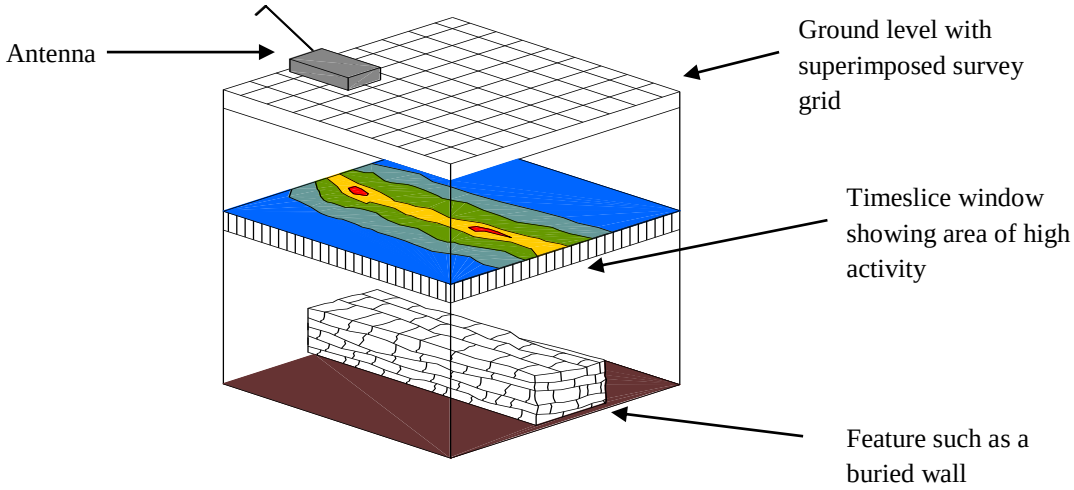
3.3 Processing, presentation and interpretation of results

Processing is performed using specialist software (Mala Rslicer). There are a wide range of filters available, the application of which will vary depending on the project. The below table shows the processes used for this data:

Gain	Amplification to correct for weakening of signal with depth.
DC-Shift	Re-establishes oscillation of the radar pulse around the zero point)
Dewow / Ringdown Removal	Removes low frequency, down-trace instrument noise
Bandpass Filtering	Suppresses frequencies outside of the antenna's peak bandwidth thus reducing noise
Background Removal	Can remove ringing, instrument noise and minimize the near-surface 'coupling' effect
Migration	Collapses hyperbolic tails (also known as 'diffractions') back towards the reflection source
Amplitude Envelope	Simplifies pulses for production of time-slice maps by summing peak values, regardless of polarity, over a given time-window.

Timeslice plots

A computer analysis was 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 light grey colour. The stronger reflections are represented by colours such black and dark grey.

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.

Several timeslices were chosen as representative examples of the data.

4 RESULTS

The Ground Penetrating Radar survey conducted at Colchester Bus Station, has identified a number of anomalies which may be of archaeological interest. It has also identified anomalies that may relate to possible obstructions, made ground and services.

A number of complex, discrete and linear responses were found across the survey area, most of them are located to the east of site. They were identified at a range of depths from 0.7 to 2.4m.

Anomalies identified in the area of previous excavation – Roman House IV and V can be interpreted as Roman structural remains. To the south of the Roman house IV and V there is a recti-linear response similar in size (27mx8m) and orientation to these houses. It is also similar in size and orientation to modern buildings on the site, however no building is shown here on recent maps. As a result, this has tentatively been interpreted as archaeology, potentially further Roman buildings, but this is far from certain.

Further anomalies have been identified which correlate in location with remains found during excavations. These include responses in the south eastern corner of the site and a response in the centre of the site where a Roman house was found.

Recti-linear anomalies found in the north of the study area lie close to excavation T5 and so could be of archaeological interest. As with the recti-linear structure seen close to houses IV and V there is no known modern building recorded in this area. This suggests that these are more likely to be archaeological in origin but this remains uncertain. A further linear anomaly to the west of the survey area could be related to previous building remains. However, there was no evidence of it on available recent maps.

A number of possible obstructions were found along the projected route of the Roman Road in the north of the site. Despite this evidence these anomalies are more characteristic of modern obstructions due to their relatively shallow depth.

Further shallower responses were interpreted of being related to possible obstructions or made ground depending on the signal strength. These were found at the depths between 0.25m and 0.90m. The difference being that obstructions give a more 'solid' appearing response with clear edges and a finite shape, whereas made ground has a fragmented anomaly which is more diffuse and irregular in shape.

A number of modern services have been identified at a range of depths from 0.35 to 1.0m.

Further shallow linear anomalies across the site were interpreted as being of unknown origin. While an archaeological origin cannot be entirely ruled out it is more likely they are related to the modern road surface given their relatively shallow depths of 0.2 to 0.35m.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Urban sites tend to be complex due to the various phases of construction throughout their history and occurrence of services as well as their different surface materials – tarmac and reinforced concrete. All of that together with the clayey and silty geology has limited the depth of penetration and can mask weaker anomalies. However, the results seem to correlate well with previous findings and show several locations of archaeological potential.

6 CONCLUSION

The GPR survey has identified a number of anomalies which are of possible archaeological origin and correspond with the previous excavations findings. Further potential Roman buildings have been identified in the east of the site adjacent to houses IV and V, and in the north close to Trench T5. The survey has also identified modern obstructions, made ground and services across the site.

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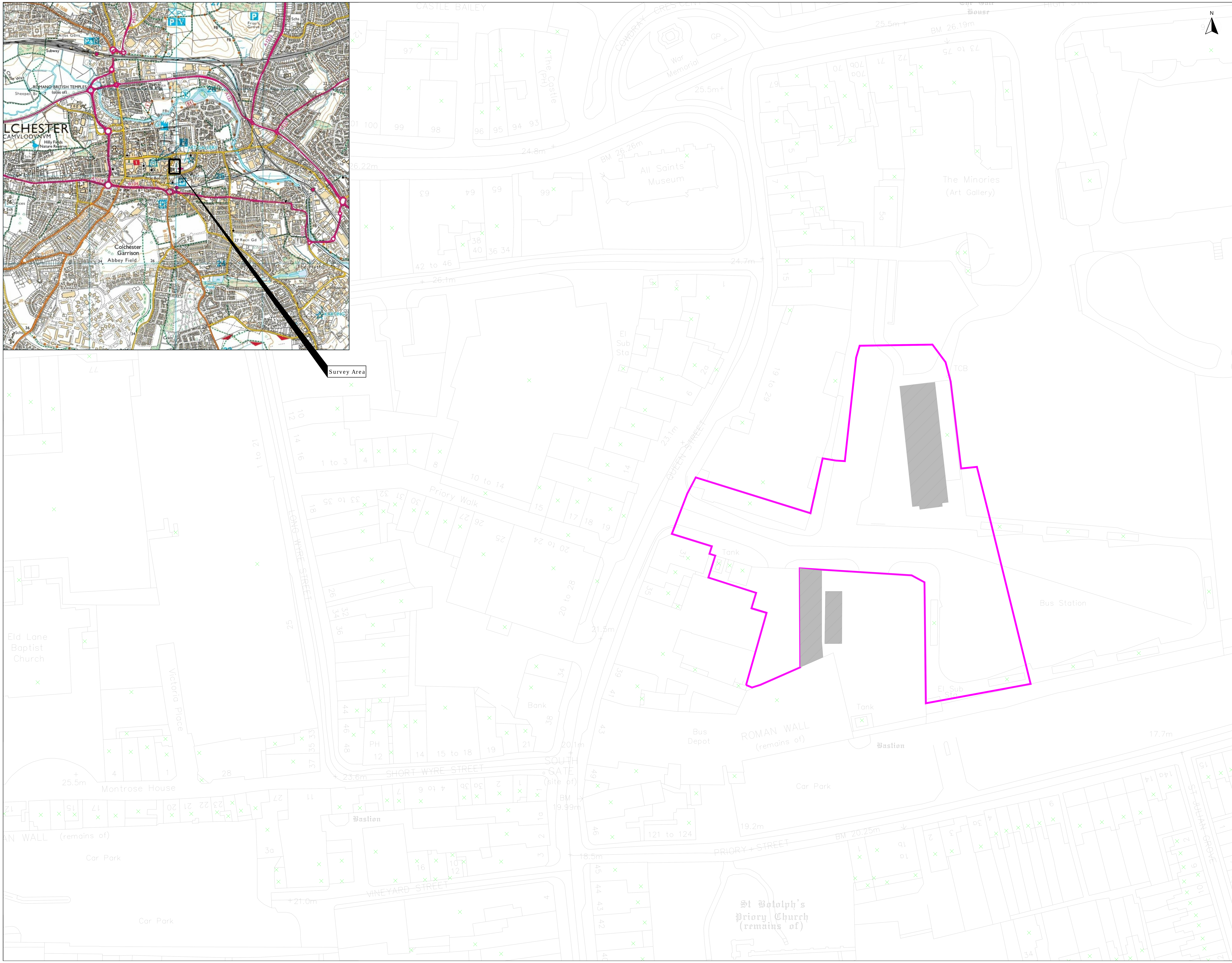

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OS 100km square = TL

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Title: LOCATION PLAN OF SURVEY AREA

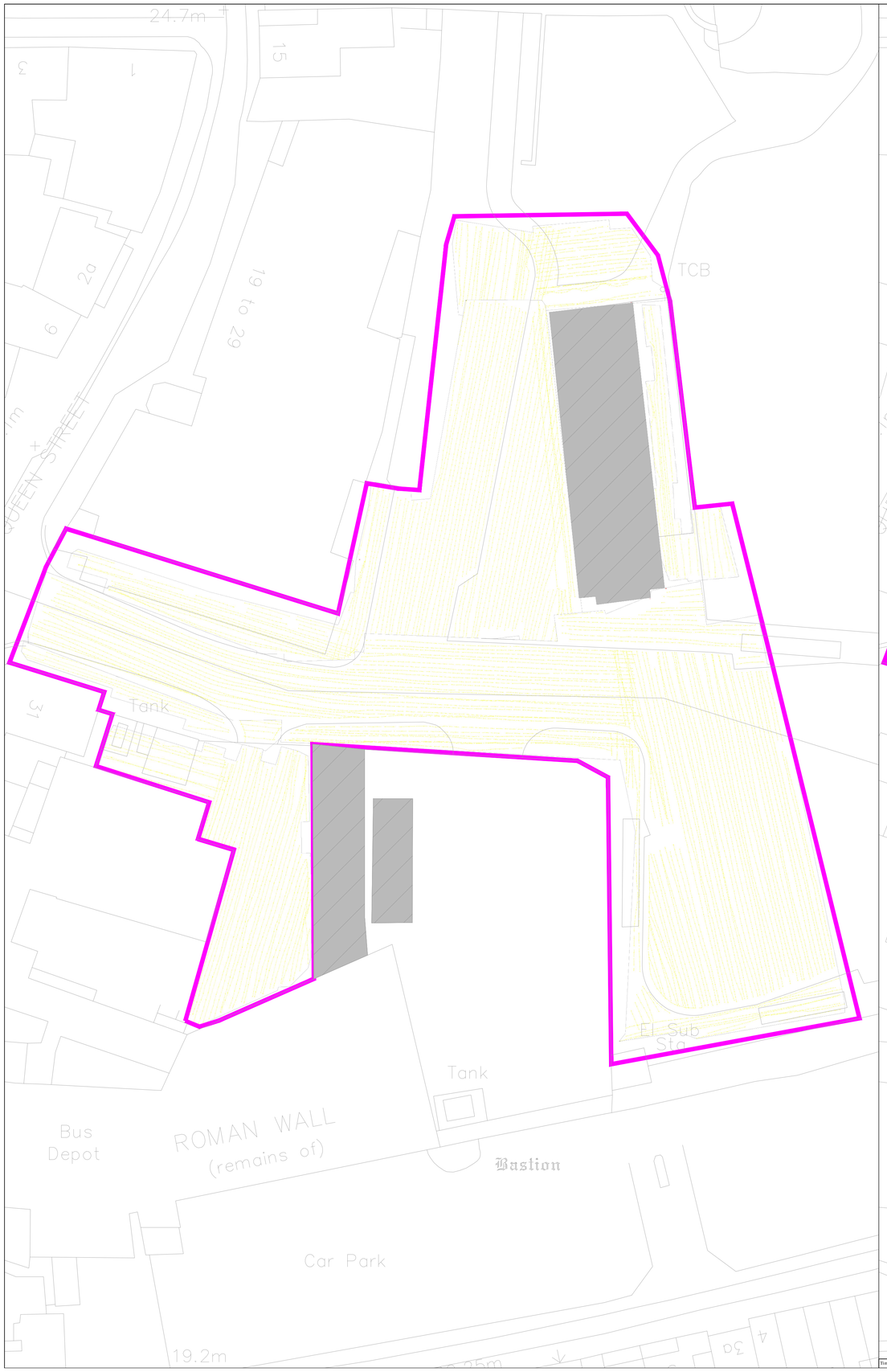
Client: COLCHESTER ARCHAEOLOGICAL TRUST LTD

Project: J10650 - COLCHESTER BUS STATION

Scale: 1:500 @ A1

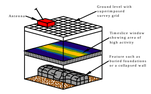
0m 5 10 15 20 25 30m

Fig No: 01



TIMESLICE PLOTS

A computer analysis was 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.



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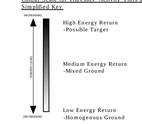
The weaker reflections in the time slice windows are shown as light grey. The stronger reflections are represented by dark grey and black.

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 buried foundations or surfaces within the soil matrix.

Colour Scale for Timeslice 'Activity' Plots and Simplified Key



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Title: GRIDS LOCATION AND TIMESLICE AT 0.20m DEPTH

Client: COLCHESTER ARCHAEOLOGICAL TRUST LTD

Project: J10650 - COLCHESTER BUS STATION

Scale: 1:300 @ A1

0m 3 6 9 12 15 18

Fig No: 02

TIMESLICE PLOTS

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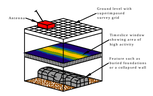

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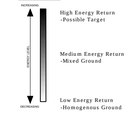

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Title:
TIMESLICE AT 0.35m AND 0.50m DEPTH

Client:
COLCHESTER ARCHAEOLOGICAL TRUST LTD

Project:
J10650 - COLCHESTER BUS STATION

Scale: 1:300 @ A1
0m 3 6 9 12 15 18

Fig No:
03

TIMESLICE PLOTS

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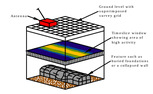

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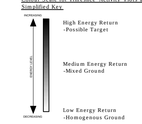

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Title:
TIMESLICE AT 0.65m AND 0.80m DEPTH

Client:
COLCHESTER ARCHAEOLOGICAL TRUST LTD

Project:
J10650 - COLCHESTER BUS STATION

Scale: 1:300 @ A1
0m 3 6 9 12 15 18

Fig No:
04

TIMESLICE PLOTS

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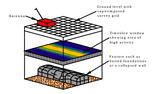

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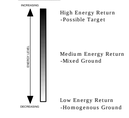
Colour Scale for Timeslice 'Activity' Plots and Simplified Key



High Energy Return
-Possible Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

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Title:
TIMESLICE AT 0.95m AND 1.10m DEPTH

Client:
COLCHESTER ARCHAEOLOGICAL TRUST LTD

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J10650 - COLCHESTER BUS STATION

Scale: 1:300 @ A1
0m 3 6 9 12 15 18

Fig No:
05

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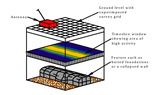

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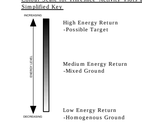

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Title:
TIMESLICE AT 1.25m AND 1.55m DEPTH

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Scale: 1:300 @ A1
0m 3 6 9 12 15 18

Fig No:
06

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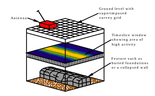

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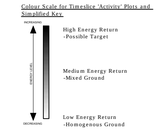

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Title:
TIMESLICE AT 1.75m AND 2.40m DEPTH

Client:
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Project:
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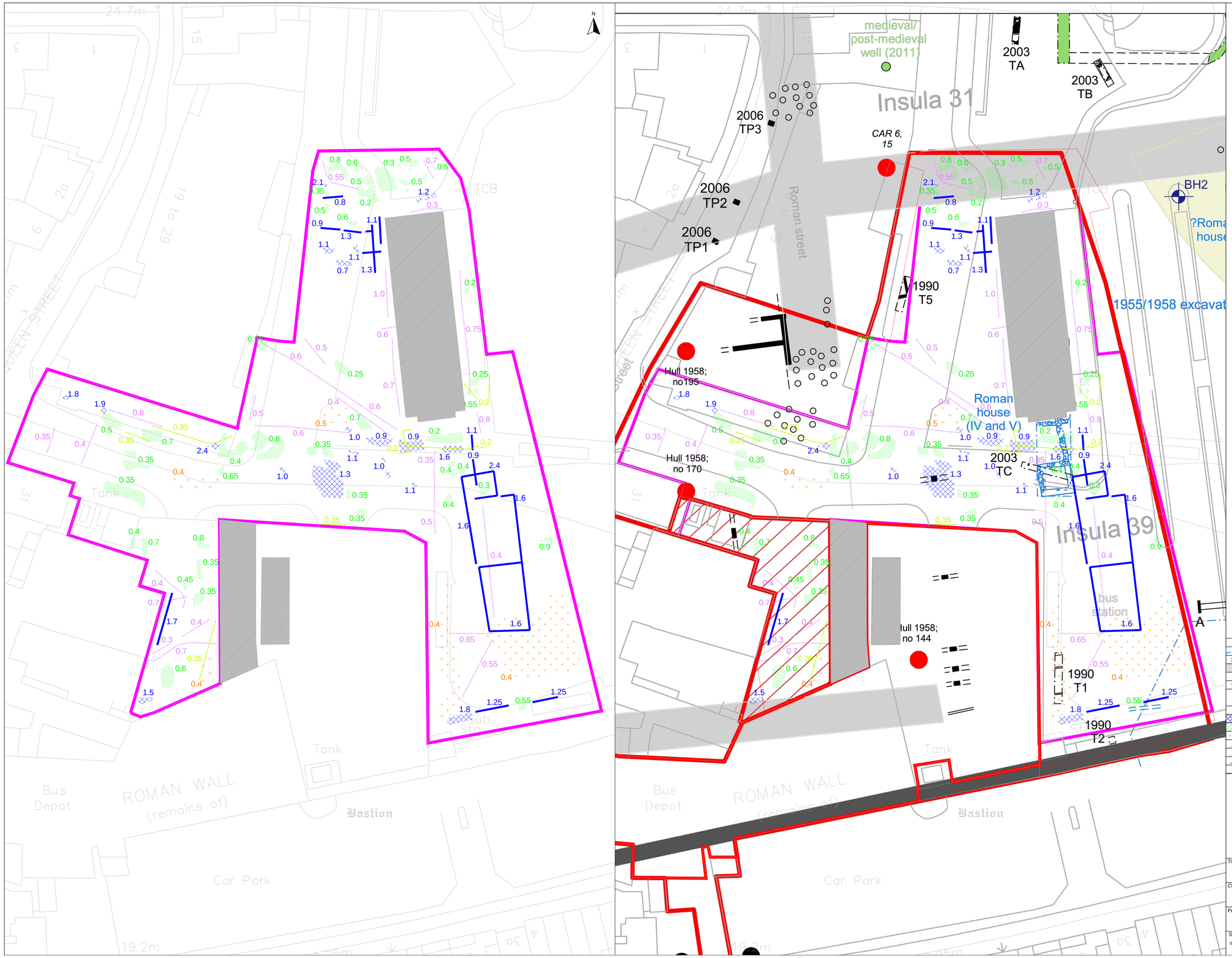
Scale: 1:300 @ A1
0m 3 6 9 12 15 18

Fig No:
07



Information provided by the client

	Roman structures
	Roman houses
	Projected Roman streets
	Tessellated floors or mosaics
	Observed metalling

KEY

	Feature of possible archaeological interest
	Possible obstruction
	Madeground
	Possible service
	Linear feature of unknown origin
	Survey area
0.65	Depth to top of the feature (in m)

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING

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Title:
GPR INTERPRETATION WITH KNOWN ARCHAEOLOGY

Client:
COLCHESTER ARCHAEOLOGICAL TRUST LTD

Project:
J10650 - COLCHESTER BUS STATION

Scale: 1:300 @ A1

0m 3 6 9 12 15 18

Fig No:
08

Appendix A - Technical Information: Ground Penetrating Radar

Ground Penetrating Radar
Traverses were carried out on a 0.08m parallel grid.

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.

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.

The Ground Penetrating Impulse Radars used was MALA MIRA High Density Array Radar with antennae frequency 400MHz. 0.08m parallel traverses were used to record the data in the area.

Sampling interval
Readings were taken at 0.05m intervals with traverse intervals of 0.08m. All survey traverse positioning was carried out using a Trimble S6 Robotic Total Station.

Depth of scan and resolution

The average velocity of the radar pulse is calculated to be 0.1m/nsec which is typical for the type of sub-soils on the site. With a range setting of 100nsec this equates to a maximum depth of scan of 2m but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

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