HOP
CONSULTING CIVIL AND STRUCTURAL ENGINEERS

VICTORIA GARDENS, OLD STEINE, BRIGHTON

ASSESSMENT OF SHALLOW SUBSURFACE GEOLOGICAL ANOMALIES

13 MAY 2022

Ref: 15707/03/HOP/RPT/01A

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APPENDIX C 40Seven Subsurface Scan Report

Client : Brighton & Hove City Council
Hove Town Hall
Norton Road
HOVE
East Sussex BN3 3BQ

Prepared by	Checked by	Approved by	Revision
J W Orrell	**XXXXX**	**XXXXX**	**Rev A**

1.0 INTRODUCTION

1.1 Instructions were received from Brighton & Hove City Council to review the occurrence of a shallow surface void in a grassed area of Victoria Gardens, The Old Steine, Brighton.

1.2 The purpose of this report was to consider the likely cause of this void and consequently what risks there might be of similar voids occurring.

1.3 It is understood the void was revealed following the removal of a Christmas Market in late 2021, where some large amusement rides were installed (see Photographs 1 and 2 in Appendix A). On removal of these rides, some depressions were found looking like the rides' heavy baseplates had borne down on the ground and a void had appeared (see Photographs 2 and 3).

1.4 This void appeared in the northeast part of the garden (see Photograph 1 in Appendix A and Site Plan SK7 in Appendix B).

2.0 RECENT HISTORY, APPEARANCE OF VOID & SITE WORKS

2.1 It is understood that around November 2021 a large amusement ride was placed in the vicinity of the subsequent cavity.

We were sent Photographs 2 and 3 (see Appendix A), showing this amusement ride in place.

2.2 On removal of the ride, a cavity appeared almost directly beneath where one of the large 'feet' of the amusement ride had been placed.

2.3 HOP attended site in January 2021 and took a confirming photograph. (See Appendix A – Photograph 4, shows a void and Photograph 5, a very similar shaped depression close by).

The ground was probed with 6mm steel probes and the void and very loose material was assessed at being about 2m deep on the subsequent visit (see Sketch 15707-3-SK7 in Appendix B).

2.4 Due to the possibility of there being other, similar, voids, as yet undetected, a subsurface scan was commissioned from Specialist Surveyors, 40Seven.

Initial results were inconclusive and only part of Victoria Gardens were assessed. A subsequent survey in early April 2022 recorded possible anomalies in a number of locations (see Appendix B and C).

2.5 Arrangements were made to excavate a trial pit to physically inspect the void and, at the same time, other areas where potential anomalies had been recorded marked B and C on Sketch SK9 were also assessed.

2.6 The trial excavation and further assessment of these areas was undertaken on 27 April 2022. Interestingly, the void which had appeared visually was not recorded on the 40Seven survey. All anomalies were at quite shallow depth and were generally, but not always, quite close to underground services. Apart from in the southeast corner of Victoria Gardens, all anomalies were recorded as shallow and it is though that the deeper anomalies relate to some subterranean structure understood to be sited below the trees in the vicinity of Area C in the southeast corner. However, no evidence could be found of other evident holes appearing.

2.7 The trail pit excavated all the loose material around the void forming a trench about 4.7m long, 1.5m wide and 2.1m deep – see Photograph 6.

2.8 The trial pit was subsequently backfilled, compacted and made good.

2.9 As a separate exercise, HOP have, in conjunction with Brighton & Hove City Council Officers, been assessing the nearby Victoria Gardens 'Dolphin Statue' Fountain. However, the issue here is with the superstructure of the statue (corroding bolts and services above ground). These are not related to the site geology or nearby void.

3.0 BACKGROUND & GEOLOGY

3.1 An extract from the British Geological Survey (31833 - Brighton & Worthing) Solid & Drift Geology is attached here, in Appendix B.

In the area of the Old Steine including Victoria Gardens, the area is dominated by chalk at considerable depth, overlain by older 'head' material. Closer to the sea, there are also raised beach deposits.

3.2 The map gives the appearance that there might be a system of rivers and tributaries throughout Brighton and the downlands behind. These are marked as 'older head' on the map. In fact, the vast majority of these are 'dry' valleys formed in periods when the glaciers melted and there was extensive flooding. Consequently, a lot of these dry valleys and the Old Steine itself, (which still has some underground water), are filled with the products of solifluction and the parent material, which was washed over to form these early valleys.

Surface and drift geology, therefore comprises often a brown silty loam, with a highly variable content of clays, flint and occasional sandstone fragments. Predominantly, in this area, the head on the chalk outcrop, often known as 'coombe' deposits, comprises a chalky loam or chalk rubble.

3.3 Additionally, as Brighton developed, the shallow surface geology can be dominated by development work. For example, areas around Brighton Station have large areas of chalk fill deposited when the railways were constructed, with excavations forming large cuttings at the entrance to Brighton itself and tunnels linking Hove and stations to the north on the main London line.

3.4 The word 'Steine' is thought to relate to large stones that were often found in the area historically.

Before surface water drainage was introduced in the 17th Century, the Steine area was quite marshy and used only for things like Fishermen drying their nets and, as today, was never built on, probably a reflection of the poor marshy ground, which dominated it.

3.5 The Wellesbourne stream runs at depth down the London Road and under the Old Steine.

3.6 Both the head and chalk materials are susceptible to outwash of fine fractions in these soils under the action of water. Additionally, a weak carbonic acid forms when rainwater falls through the air, which can, over time, dissolve chalk in solution. These are often responsible for deep chalk 'swallow holes' or 'pipes', as once a cavity forms this tends to be a low spot into which more water will enter. The local swallow holes or pipes can be many metres deep and the geological contact between surface head materials and chalk is rarely regular due, in part, to the surface weathering of the chalk in this way.

These surface deposits are also particularly susceptible to the action of water, which may remain undetected (i.e. no evidence on the surface), while material, particularly fine material is carried away in solution below.

Such solution cavities that form may sometimes lead to very large cavities and subsequent collapse of the overburden when this is unable to arch over the top of the cavity. An example of this was the collapse at Percival Terrace in the late 1980's, although various historic manmade features (tunnels and cellars), subsequently filled, contributing greatly to this, it is understood.

3.7 Underground streams, which previously ran freely in the Old Steine are through to have been largely contained by the construction of large diameter (often brick) surface water sewers.

3.8 However, it is entirely possible that not all underground watercourses are 'trained' in this way and further, particularly older sewers can leak. If subsoil comprises filling, perhaps not fully compacted, particularly when it has a high volume of fines which might be carried away in solution, then these areas are also more susceptible to outwash of fines, subsequent cavities forming and those cavities then becoming a course for more water and the process accelerates.

Such voids can largely remain undetected, particularly if they are small and at depth. However, the deeper the ground the denser it will be, with less likelihood of looser filling. Water will therefore tend to run over the top of deeper material making it often more likely that any voids will form at shallow level rather than deeper.

4.0 ASSESSMENT

4.1 Subsurface voids or anomalies, sometimes referred to as 'swallow' or 'sink' holes cannot always be easily identified from the surface.

However, a combination of historical evidence, subsurface surveying and visual assessment can establish the likelihood, or future risk, of further such voids occurring.

4.2 The Victoria Gardens swallow hole appears to have occurred by surface and subterranean water flow dissolving finer material and carrying this away in solution, forming a cavity.

4.3 This may be related to the large brick sewer running down the east side of Victoria Gardens; during the trial pit excavations evidence of chalk filling was found, which could be from the original construction of the sewer.

4.4 However, although we have not seen confirming reports, it is understood that the brick sewer has been inspected and that there are no significant collapses or leaks, this should be doublechecked with the relevant Authorities.

4.5 When considering failure of soil strata due to loads above, it may be helpful to the reader to understand the concept of Safe Ground Bearing Pressures (SGBP). This measured in Kilo Newtons force per square metre of area (kN/m^2). For guidance purposes, normal domestic foundations might initially be designed to a notional 100kN/m^2 SGBP, but even a medium dense sand or gravel will achieve a SGBP in excess of 200kN/m^2. Virgin chalk, depending on the grade, would be significantly higher than this and 'Northern' rocks such as granite would have a SGBP in the 1,000s.

4.6 General loads imposed on the ground from, say, public assembly is unlikely to exceed 5kN/m^2 and an allowance for vehicular traffic could be lower than this. However, the wheels of vehicles present a concentrated or point load over a very small area, so locally the ground bearing pressures could peak at much higher values. For example, a 2.5 tonne van with most of the load on the back axle could exert, immediately under one tyre, a pressure of over 500kN/m^2 locally only. However, this local intensity will rapidly decay from the ground

surface as loads spreads in all directions and at just 0.5m below this point pressures would reduce to below 20kN/m^2.

4.7 If there is insufficient depth of material to arch over any void and dissipate the load then failure of the thinner surface 'crust' can occur.

The situation can be made very much worse when there are exceptionally high point loads. The intensity of a point load from a hydraulic stabilizing and supporting jack from a lorry, crane or amusement ride does, of course, depend on the weight of that ride and the loads in operation.

High amusement rides, fully loaded, under some wind can often generate very significant high point loads under their jacks or feet, often in the 100's of kN and if the jack feet or baseplates are quite small then the local bearing pressure could be several hundred kN/m^2. The soil could fail locally, which if solid ground exists beneath might just lead to an indentation, but if voids exist below, then any soil arched over the void could be 'punched through'.

4.8 This can be counteracted by a degree with the use of suitable sized spreader plates. It is common practice, for example, for even relatively small cranes to carry large spreader plates to avoid ground damage underneath their baseplates when lifting heavy loads.

5.0 CONCLUSIONS & RECOMMENDATIONS

5.1 From our surface visible observations, it would appear that a high load from a jack has 'punched through' surface layers in an area where a void probably already existed below, as the load imposed by that jack, locally, was far greater than any general use would have generated before.

5.2 Provided any exceptional future points loads, such as heavy lorry wheels or stabilising jacks are appropriately dealt with by means of suitably sized spreaders and the situation properly monitored, then we do not believe there is cause for immediate concern in respect of additional swallow holes appearing.

5.3 However, it should be confirmed that the nearby large diameter surface water sewers are in good condition; that they are free from leaks and that there is no material leaching into them from the filled ground around.

5.4 It would also be helpful to develop a simple check system, Code of Practice or permission requirement to ensure that heavy loads on any surface likely to be used by heavy machinery, particularly those with high load outriggers are properly assessed in advance. HOP are now developing a simple system in conjunction with Council Officers to facilitate this.

5.5 If you would like any assistance in this regard, please contact the undersigned. In the meantime, if there are any queries, again, please contact us.

For HOP CONSULTING LIMITED

J W ORRELL BSc (Hons) CEng, FICE, FCIOB, FIStructE
Director
jono@hop.uk.com

APPENDIX A – PHOTOGRAPHS

Photograph 1: Victoria Fountain looking southwest, swallow hole in foreground

Photographs 2 & 3: (Credit unknown – received from Brighton & Hove City Council 24 January 2022). Understood to show large amusement ride in position (bottom photo) and situation without ride in place taken from a similar location. November 2021 or January 2022?

Photograph 4: Close up of swallow hole 31 January 2022.
(Note almost 'square' shape).

Photograph 5: Similar ‘foot’ depression close by, probably another square ‘foot’ from the amusement ride.

Photograph 6: Trial hole excavated 27 April 2022 (looking north) showing filled nature of ground and chalk filling on the side of the nearby sewer.

APPENDIX B – DRAWINGS / PLANS


'OLDER HEAD'
VICTORIA GARDENS
CHALK
SOLID & DRIFT
GEOLOGY
RAISED BEACH DEPOSITS EXPOSED
BENEATH 14m OF SOLIFLUXION MATERIAL
UMCk
BRIGHTON
HOVE
Palace Pier
West Pier
Aquarium
Electric rly
Kemp Town
Patcham
Withdean
Hollingbury
Hollingbury Castle
Coldean
Stanmer
Stanmer Park
University of Sussex
North Moulsecoomb
Falmer Hill
Bevendean
Upper Bevendean
Woodingdean
Mount Pleasant
Race Course
Tegdown Hill
Heathy Brow
High Park Fm
Stanmer Down
Lower Standean
New Barn
The Kennels
Scare Hill
Patcham Place
Great Wood
4 Miles
6 Kilometres

AT 1:1000

APPROX. "SWALLOW HOLE POSITION IMP

Topsoil

Backfill?

2M

15707-3-SK7

(c) Crown copyright and database rights 2022 Ordnance Survey 100031673

Data updated: 17/01/22

Scale: 1:1000

Map Centre: 531299,104006

Date: 24/01/22

Our Ref: 764011 - 2

Wastewater Plan A3

Powered by digdat

andyk@hop.uk.com

15707-02

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2022 Ordnance Survey 100031673 .This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

WATER MAINS

4" C.I.

2440/1650 BRICK SEWER

0.50-0.60

0.35-0.6

0.8-1.0

"ANOMALIES" UP TO 2.5 deep

0.35-0.6 1+1.5

0.35-0.6

0.52

0.63

0.33-0.55

TRIAL PIT 26.04.22

VISUAL 'SWALLOW HOLE'

0.4-0.2

0.2-1.1

0.6-1.0

0.3<+0.8

1.50-2.60

1.5-2.6

15-20 ELEC(?) CABLE

60ø PLASTIC DUCT

1.5< 4.7 >

TOP SOIL 0.6m

ANCIENT FILL

CHALK FILL

2.1

A-A B-B

TRIAL PIT SECTIONS

(TO BE COMPACT FILLED)

HOP 15707-3-SK9

JUNE 270422

SITE NOTES

20m

	Survey Type	Quality Level	Post-Processing	Location Accuracy		Supporting Data
				Horizontal	Vertical	
D	Desktop utility Records Search	QL-D	-	Undefined	Undefined	
C	Site Reconnaissance	QL-C	-	Undefined	Undefined	A segment of utility whose location is demonstrated by visual reference to street furniture, topographical features or evidence of previous street works (reinstatement scar).
B	Detection	QL-B4	No	Undefined	Undefined	A utility segment which is suspected to exist but has not been detected and is therefore shown as an assumed route.
		QL-B3	No	±500mm	Undefined (No reliable depth measurement possible)	Horizontal location only of the utility detected by one of the geophysical techniques used.
		QL-B3P	Yes			
		QL-B2	No	±250mm or 40% of detected depth whichever is greater	±40% of detected depth	Horizontal and vertical location of the utility detected by one of the geophysical techniques used.
		QL-B2P	Yes			
		QL-B1	No	±150mm or 15% of detected depth whichever is greater	±15% of detected depth	Horizontal and vertical location of the utility detected by multiple geophysical techniques used.
		QL-B1P	Yes			
A	Verification	QL-A	-	±50mm	±25mm	Horizontal and vertical location of the top and/or bottom of the utility.

SHEET LAYOUT

GPR LEGEND

Unknown Route Located by GPR

GPR Ground Anomaly

GPR Geological Movement

GPR Reinforcement

GPR Underground Structure

GPR Underground Void

Survey Extents

GPR Image Position

*Warning: Linetypes do not display when represented by 3D Polylines in AutoCAD. To view or plot linetypes use 2D CAD file.

ABBREVIATIONS

ABC	Abbeyline Convent	FH	Fire Hydrant	RW	Retaining Wall
AC	Air Conditioning Unit	FO	Fibre Optic Cover	S	Stump
AD	Assumed Direction	FP	Flag Pole	SA	Surveyor Abandoned
AR	Assumed Route	G	Gully	SB	Spotelevation
AS	Air Valve	GI/MH	Ground Penetrating Radar (inconclusive)	SB	Battery Booster
B	Barking Beacon	GPL	Grade Change	SC	Speed Camera
BC	Back Drop	GV	Ground Light	SF	Battery Fence
BL	Bad Level	HV	Gas Valve	SI	Spot Iron
BR	Boreholes	HY	Hand Rail	SL	Traffic Level
BRK	Brick	IC	High Voltage (Electric)	SL	Street Lighting (Electric)
BW	Basement Light	IL	Inspection Cover	SP	Right Post
C	Bollard	IN	Invert Level	SW	Spring
CB	Bollard Illuminated	IR	Iron Rail Fence	SR	Glass Railings
CH	Bottom of Chamber	KO	Kerb Outlet	SS	Sandy Slope
CL	Brick	LB	Letter Box	ST	Strip Tap
CP	Box Step	LC	Lighting Column	STC	Structural Support
CT	British Telecom Cover	LH	Lamp Hole	SV	Survey Station
CW	British Telecom Box	LOR	Line Of Reflection	SV	Sluice Valve
D	Brick Wall	LOS	Line Of Sight	SVP	Soil Vent Pipe
DM	Barbed Wire Fence	LV	Low Voltage (Electric)	SW	Stone Wall
DR	Camera	M	Masting Bollard	TB	Tactile Paving
E	Catenary Level	MC	Multiple Cables	TBM	Temporary Bench Mark
EB	Close Boarded Fence	MH	Manhole Cover	TC	Telephone Cover
EC	Control Cabinet	MP	Marker Post	TCB	Telephone Cat Box
ECTV	Close Circuit TV Cover	NA	No Access/Obstruction	TCP	Telephone Cat Post
EL	Drainage	NBN	No Bollard/Illumination	TP	Temporary Pipes
EM	Channel Level	NC	Node Marker	TPR	Telsan Point Records
F	Cast Iron	NF	Heras Fence	TR	Trial Hole / Pit
FA	Corrugated Iron Fence	NPV	No Pipes Visible	TVL	Threshold Level
FC	Cover Level	OBA	Off Survey Area	TX	Tank
FE	Chain Link Fence	P	Pole	TOW	Top Of Wall
FH	Concrete	PBH	Permanent Bench Mark	TP	Telegraph Pole
FL	Concrete Kerb	PE	Polyethylene	TR	Traffic Signals
FLR	Gabion Level	PGN	Permanent Ground Marker	TSC	Traffic Signals Cover
FM	Cable TV Cover	PL	Plastic	UG	Unknown
FN	Culvert	PLA	Palisade Fence	UGA	Unable to Gain Access
FO	Concrete Wall	PM	Parking Meter	UTL	Unable to Locate
FP	Ductile Iron	PR	Post and Rail Fence	UTR	Unable to Survey
FR	Dilapidated	PS	Post Signal	UTT	Unable to TRaCe
FS	Dilapidated	PUG	Pump	VCO	Verified Clay
FW	Downpipers	PVC	Polyvinylchloride	VDP	Vehicle Detector Pad
G	Dry Stone Wall	PW	Post and Wire Fence	VP	Vent Pipe
GB	Electricity Box	PWB	Power	VR	Vibrator Recovery
GC	Electricity Cover	PZ	Piezometer	VTP	Vertical Pipe
GD	Empty Duct	R	Radio	W	Water Cover
GF	Electricity Fence	RE	Existing Rye	WL	Water Level
GP	Electricity Feeder Pillar	RL	Floor	WM	Water Meter
GR	End of Track	RL	Roof Level	WN	Wire Mesh Fence
GT	Electricity Pole	RP	Reflector Post	WO	Wash Out
GV	Earth Rod	RS	Road Sign	WS	Window Sample
HC	Fuel Cover	RWP	Rain Water Pipe	WV	Wheel Valve
HL	Finished Floor Level				

DISCLAIMER

Unless otherwise stated, all services shown on this plan have been surveyed using approved detectors and the connections between manholes, if not fixed, are assumed to be direct.
No guarantee can be given that all services have been shown.
In clear conditions the depth accuracies for the underground utilities located is +/- 10% of depth.
Where services are shown as 'Taken from Records' on the drawing we are not liable for any loss that may arise due to a lack of accuracy in that quoted information.
Reference should be made to the methodology used on site as detailed within the latest version of HSE/HSG Site Procedures for Utility Location Surveys.
Excavations in the vicinity of services shown are to be carried out with due diligence (Ref. HSG47).
The following 'text' is an extract from Surveys of Land, Buildings and Utility Surveys at scales of 1:500 and Larger issued by the Royal Institute of Chartered Surveyors December 2014.
"Electronic tracing is a reliable method of locating buried services, however, less than one 80% completeness is probably all that can be expected.
"Ten accuracies of the order of +/- 150mm may be achieved but this figure will depend on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.
"Existing record information showing underground services is often incomplete and of doubtful accuracy. It should be regarded only as an indication and cannot be guaranteed.

NOTES

Base plan provided by client. Read in conjunction with existing records.
For copies contact 40SEVEN.
Services plotted outside survey extents should not be considered to be exhaustive.

REV.	DETAILS	BY	DATE

GRID: ORDNANCE SURVEY RELATED TO THE OS ACTIVE STATIONS BY GPS OBSERVATIONS

DATUM: ORDNANCE SURVEY RELATED TO THE OS ACTIVE STATIONS BY GPS OBSERVATIONS

40SEVEN

LEEDS 0113 201 8768 LONDON 01702 74994
E-mail: info@40seven.com Web site: www.40seven.com

CLIENT: Brighton & Hove City Council

PROJECT TITLE: VICTORIA GARDENS GROUND PENETRATING RADAR SURVEY

DRAWING TITLE: VICTORIA GARDENS

SURVEYED BY:	DRAWN BY:	APPROVED BY:
GC / ST	NC	LP

SCALE: 1:200 @ A1

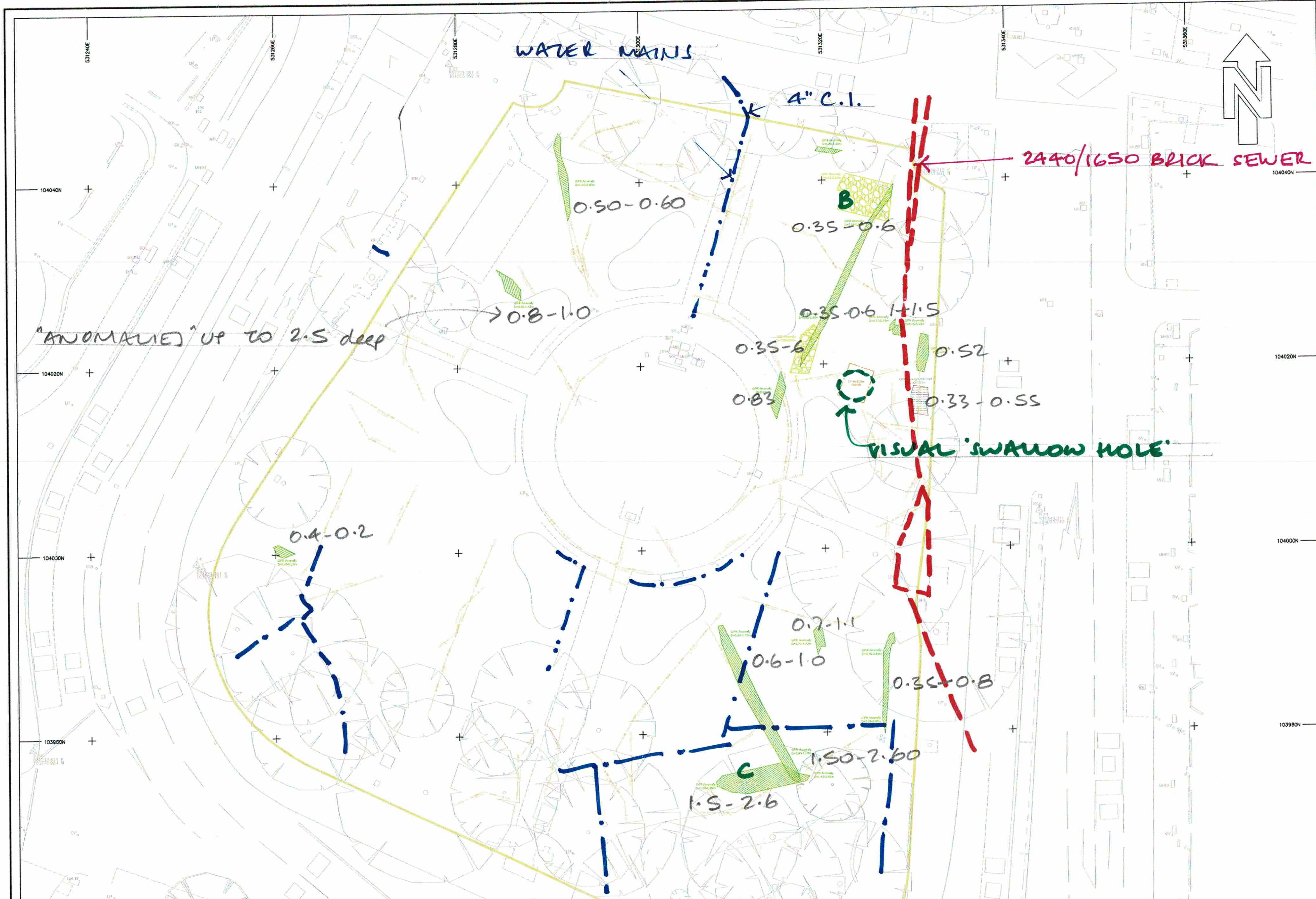
SURVEY DATE: 04/2022

DRAWING NUMBER: 2554_P

SHEET NUMBER: 1 of 1 A1

REV.

119



Survey Type		Quality Level	Post-Processing	Location Accuracy: Horizontal	Location Accuracy: Vertical	Supporting Data
D	Desktop utility Records Search	QL-D	-	Undefined	Undefined	-
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SHEET LAYOUT

GPR LEGEND

ABBREVIATIONS

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The following text* is an extract from Surveys of Land, Buildings and Utility Surveys at scales of 1:500 and Larger issued by the Royal Institute of Chartered Surveyors December 2014.
*Electronic tracing is a reliable method of locating buried services. On heavy, built up sites 85% completeness is probably all that can be expected.
*Plan accuracies of the order of + or - 150mm may be achieved but this figure will depend on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.
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DATUM: ORDNANCE SURVEY RELATED TO THE OS ACTIVE STATIONS BY GPS OBSERVATIONS

40SEVEN

LEEDS 0113 201 9700 LONDON 01732 740696
E-Mail: info@40seven.com Web site: www.40seven.com

CLIENT: Brighton & Hove City Council

PROJECT TITLE: VICTORIA GARDENS GROUND PENETRATING RADAR SURVEY

DRAWING TITLE: VICTORIA GARDENS

SURVEYED BY: GC / ST DRAWN BY: NC APPROVED BY: LP

SCALE: 1:200 @ A1 SURVEY DATE: 04/2022

DRAWING NUMBER: 2554_P

SHEET NUMBER: 1 of 1 A1 REV:

Victoria Gardens
Brighton

GPR Survey
Site Report
Project No. 2554

Prepared by:
Guy Collis
40SEVEN Limited

Unit E
Great Hollanden Business Centre
Underriver
Sevenoaks
Kent
TN15 0SQ
Tel: 08450 179 300

Commissioned by: Mike Bayton

Facilities and Building Services
Brighton & Hove City Council
Town Hall
Norton Road
Hove
BN3 3 BQ

Table Of Contents

Utility Surveyor: Guy Collis, Steve Taylor
Date of Survey: April 2022
Drawings Number Issued to the Client: 2554_P
Type of Survey: GPR Survey.
Accuracies: Depth by GPR: +/- 10% of depth (in Normal Ground Conditions)
Specification Notes: 1. All survey works carried out in the area defined by Brighton & Hove City Council. 2. All drawings must be read in conjunction with record information.

Field Equipment

Type	Make	Model	Company I.D No.	Operator(s) Initials
Ground Penetrating Radar	**Mala**	**Wide Range**	**ELP013**	**GC**

Equipment Introduction

A Mala GeoScience EL Pro Wide Range Ground Penetrating Radar (GPR), effective bandwidth 80MHz - 950MHz antenna, was utilized for this survey.

GPR is a technique that employs high-frequency pulsed radio waves, usually between 25MHz – 2.3GHz, to map metallic/non-metallic structures/features buried in the ground or in man-made structures.

Pulsed radio waves (signals) are emitted into the ground and propagate through the surface layers. Buried objects or boundaries with an abrupt change in electrical properties reflect the received signal, which then scatters back to the surface. Data is received by the receiver antenna and is displayed digitally on the computer as a radargram, data is then be stored for post processing.

Aim of the Survey

The Mala EL Pro Wide Range all terrain cart was deployed on the site at Victoria for the purposes of identifying anomalies and voids which are possibly associated with a sink hole that has appeared in the northeast of.
The radar reflects changes in the electrical properties of materials in the sub-surface. The data prevents definition of unknown targets. A PAS128 M4P GPR survey has been carried out across the sites where possible. GPR images shown within this report are not necessarily indicative of actual routes / anomalies detected. Several unknown targets detected within the survey extents although only partially in several areas due to losses of reflection. Unable to GPR some areas due to vegetation, water features, and flower beds. Please see photos.

Site Location

Figure 1 – Aerial image

Methodology

Working within the survey extents provided by Brighton & Hove City Council, scans were taken over all accessible areas utilising the following methodology:

Data collection

- Collect Survey data at a maximum 0.5m transects as shown below.
- Start and stop the scan before turning around at the edges of the survey area.
- Monitor the total station lock, and radargram on each scan to check that data is being captured correctly and that there are no problems.
- Set up further survey stations if necessary.
- If satellite signal permits, use GPS to survey GPR survey baselines.
- Finish site work

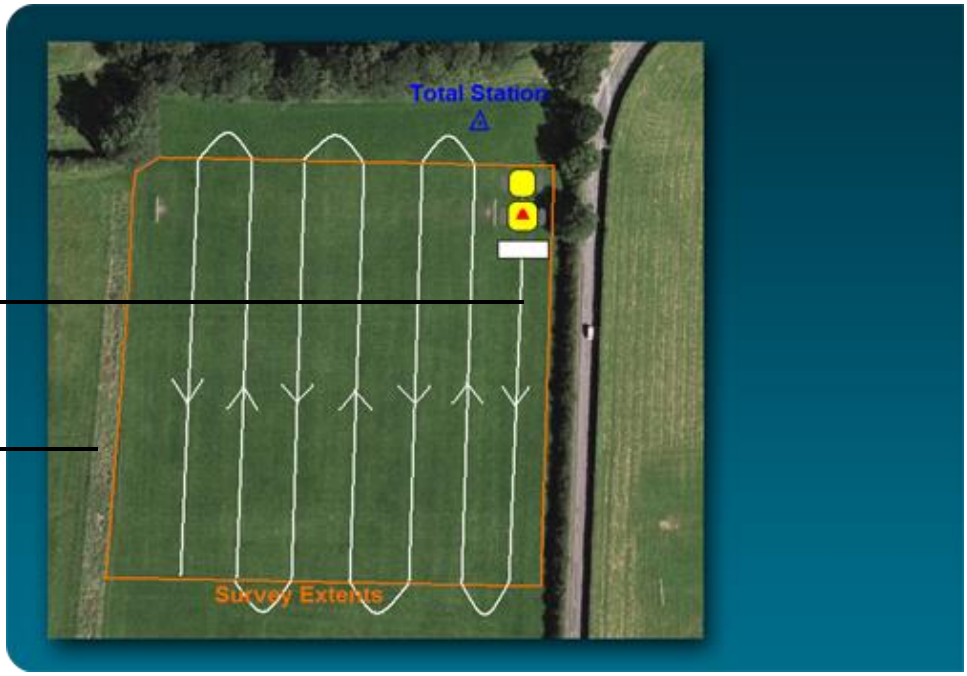


Figure 2 – Capturing data

Post Processing data

- Import Objectmapper files into Objectmapper
  - These files contain both the radar data and topographical (above ground) data.
- Pre-process the data – Apply filters to aid interpretation.
- Interpolate the data – Fill in any gaps between scans due to poor overlap and merge each separate swath into one mass of radar data.
- Migration – Set the velocity of the ground so that correct size and depth of targets can be obtained.

- Interpret the data – Digitise polylines/plates over the position of utilities/geophysical features on the radargram.
- Export the data as appropriate, for GIS and design software, export as a .dxf and import into the 3rd party software for plan creation and analysis of results

Results

Figure 3 shows the results exported into AutoCAD. The Wide Range results are the beige, green and grey polylines and the base plan has been put into grayscale to make the results easier to visualise.

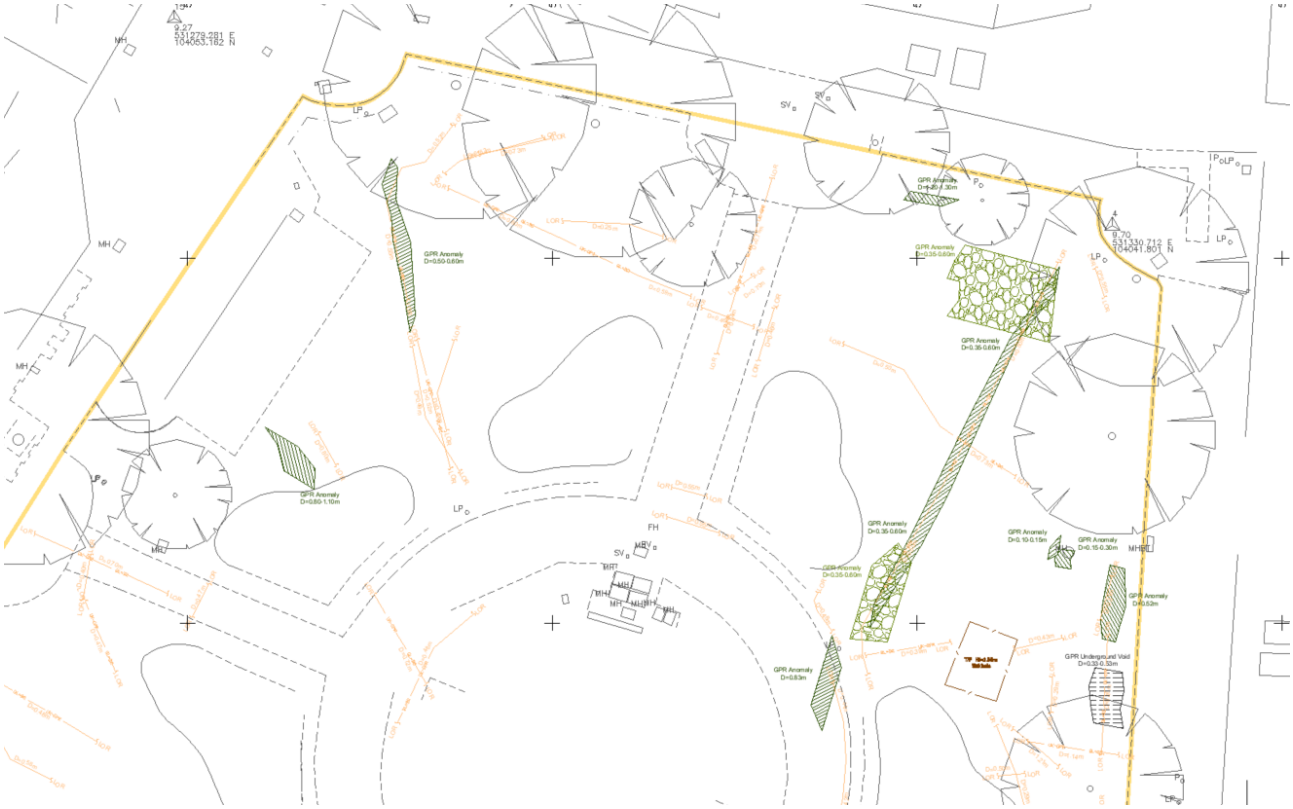


Figure 3 – Exported Wide Range data

The coloured polylines/hatches take the form of reflectors, which are classed as linear features (beige), anomalies (green) and voids (grey) within the radar data set. The beige shown on the section surveyed is representing geological signatures related to unknown linear features (possible utilities).

Unknown Route – Where a clear hyperbola is seen and is consistent across the data for at least a few meters in a linear fashion.

Unknown Anomaly/Void – Where a clear hyperbola/transition reflector is seen in the data indicative of a buried object etc. but is not linear/does not possess characteristics of a utility route.

The depth penetration over the site varied slightly but on average this was 2.0-2.5m at best, items below an area's maximum penetration cannot be located.

It is important to also note that GPR will not locate 100% of underground utilities/ anomalies/voids, due to many variables such as ground conditions and the dependency GPR has on electromagnetic property variations.

The benefit of using the Wide Range is that we can see the shape of the item and that it is positioned accurately and referenced to your topographical survey on site.

Site Photos:

Photo 1

Description: General view of survey extents.

Photo 2

Description: General view of survey extents.

Photo 3

Description: General view of survey extents.

Photo 4

Description: General view of survey extents.

Photo 5

Description: General view of survey extents.

Photo 6

Description: General view of survey extents.

Photo 7

Description: General view of survey extents.

Photo 8

Description: General view of survey extents.

Photo 9

Description: General view of survey extents.

Photo 10

Description: General view of survey extents.

Photo 11

Description: General view of survey extents.

Photo 12

Description: General view of survey extents.

Photo 13

Description: General view of survey extents.

Photo 14

Description: General view of survey extents.

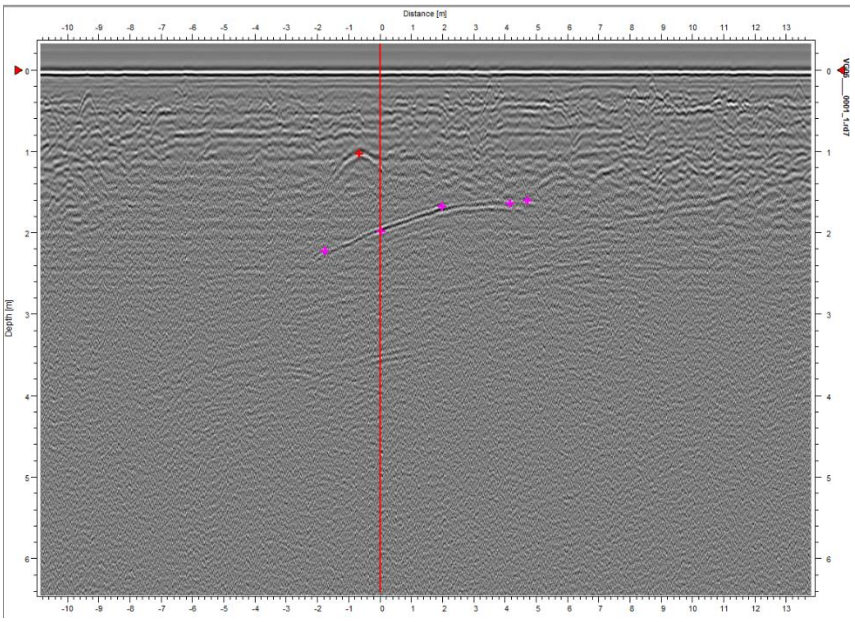
Photo 15

Description: General view of survey extents.

Photo 16

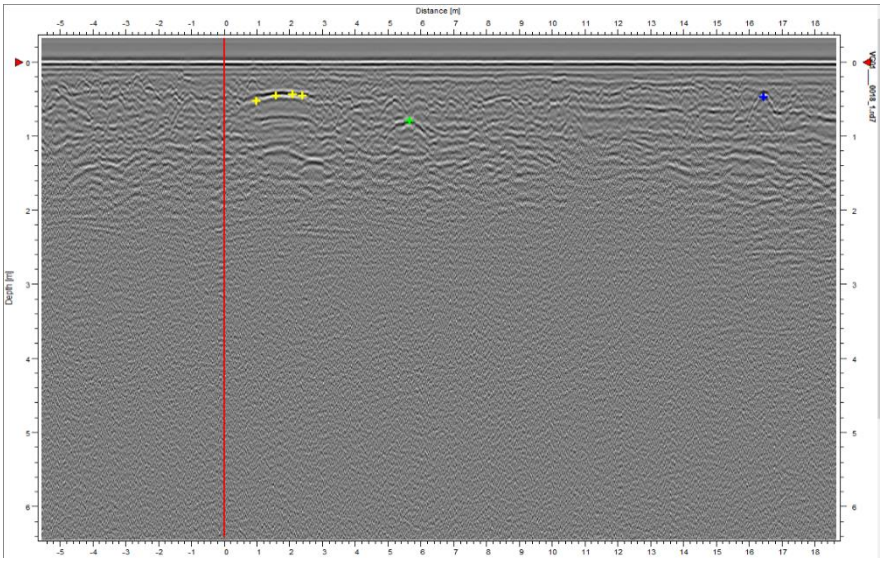
Description: General view of survey extents.

GPR Image 1



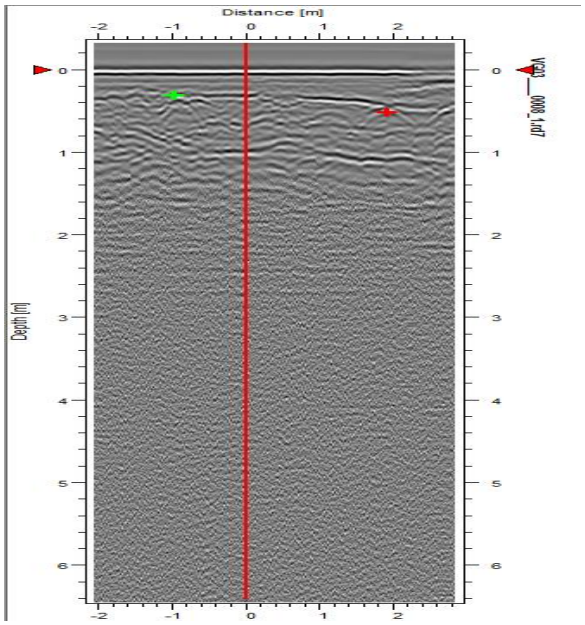
Description: Ground Penetrating Radar Image.

GPR Image 2



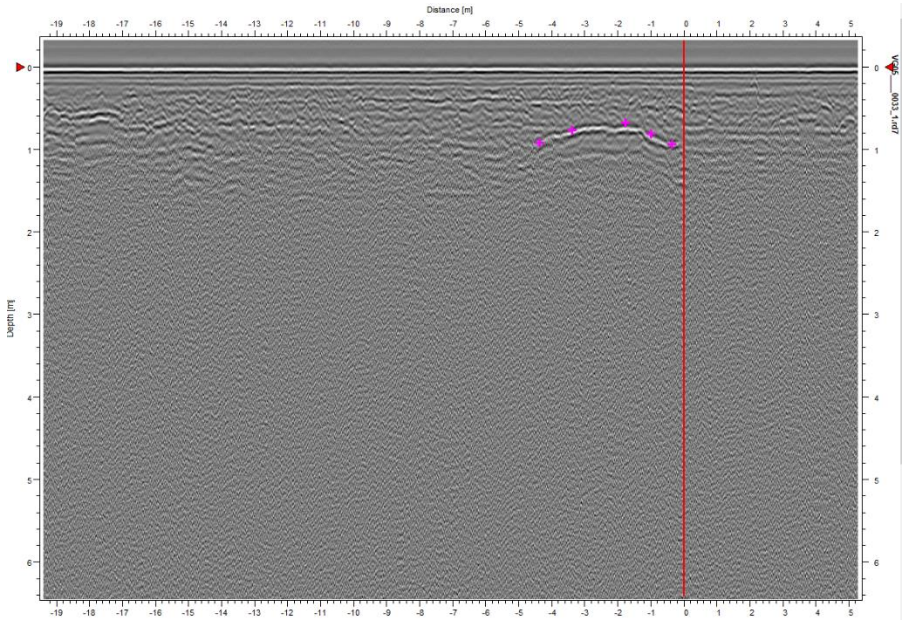
Description: Ground Penetrating Radar Image.

GPR Image 3



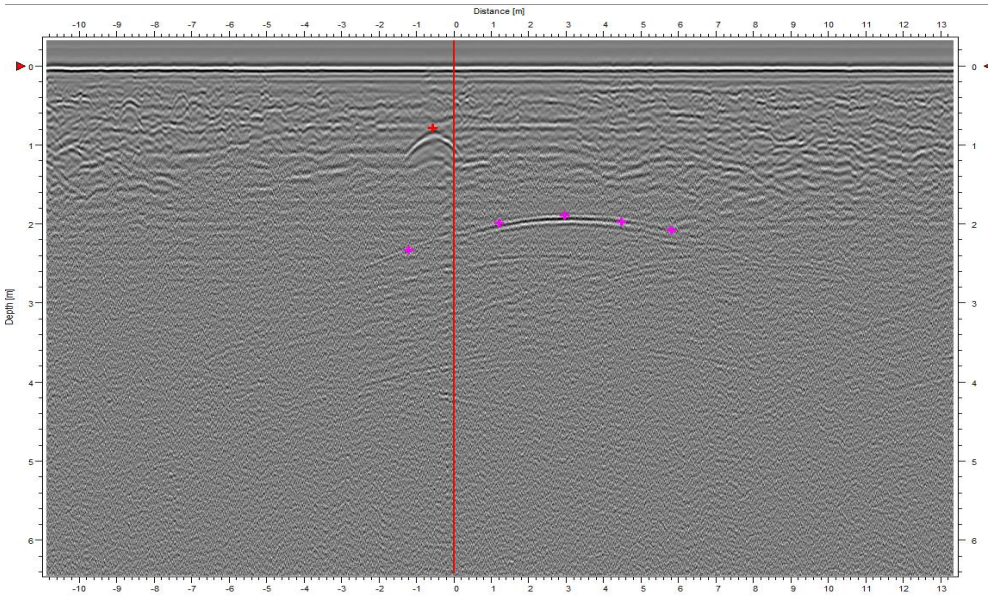
Description: Ground Penetrating Radar Image.

GPR Image 4



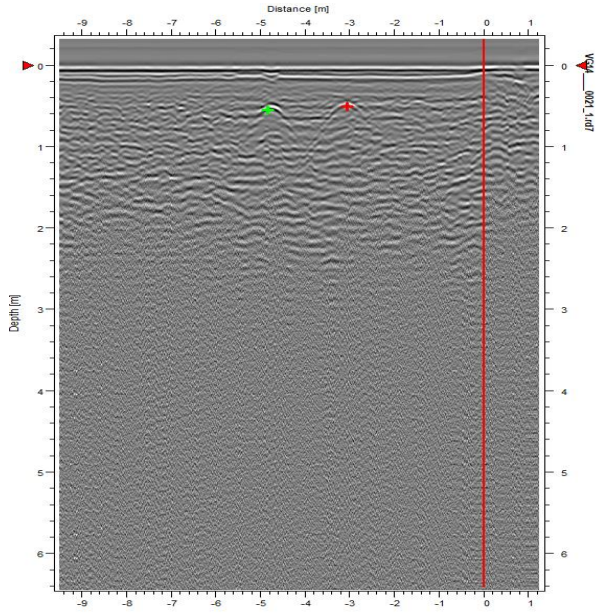
Description: Ground Penetrating Radar Image.

GPR Image 5



Description: Ground Penetrating Radar Image.

GPR Image 6



Description: Ground Penetrating Radar Image.

QA Managers Comments:

1. All procedures have been followed.

Project Managers Comments:

1. All statutory authority records should be checked prior to commencing any work.
2. An electromagnetic survey was not undertaken.
3. GPR survey carried out across the site where possible.
4. GPR works by emitting electromagnetic signals into the ground and analysing signal returns. The use of GPR is strongly dependent upon local soil properties. Depth of penetration is limited by the presence of clays of other highly conductive materials. There must be a significant electrical contrast between the target and the host materials.
5. Unknowns/Anomalies detected by GPR, although it was not possible to decipher function. Future intrusive works (eg: trial pits) are recommended to gather further information.
6. It is recommended that statutory authority records are acquired and read in conjunction with this information, as no guarantee can be made for the completeness of this drawing.

APPENDIX C – 40SEVEN SUBSURFACE SCAN REPORT