REPORT ON GROUND-PENETRATING RADAR SURVEY

carried out at

FORMER BETHEL CHAPEL, SUNDAY SCHOOL & VAULTS,

12 – 14 VILLIERS STREET, SUNDERLAND SR1 1HA

NGR: NZ 4008 5705

Prepared for

Mario Minchella Architects
3 Front Street
Cleadon Village
Tyne & Wear
SR6 7QE

HER Ref.: MON4241
Planning Application: 06/02541/FUL
OASIS ID: 25678

Contract No: 11010

Date: Apr 2007

Ian Farmer Associates (1998) Limited
Unit 1, Bamburgh Court, Team Valley Trading Estate, Gateshead, Tyne and Wear, NE11 0TX
Tel. 0191 4828500
Fax. 0191 4828520

EXECUTIVE SUMMARY

It is understood that it is proposed to demolish the upstanding buildings on the disused site and develop it with six-storey apartment blocks, including landscaped zones and car parking.

On the instructions of Mario Minchella Architects on behalf of Atlas New Home Ltd, a geotechnical desk study was undertaken by Ian Farmer Associates (Report No. 3953, Jun 06), which recommended the site be subjected to detailed archaeological investigation to enquire into the history of the former Bethel Chapel and Sunday School on site and into the presence of vaults beneath the site.

On further instructions, Ian Farmer Associates *Archaeological Services* carried out the first archaeological phase which comprised a desk-based assessment and a walkover survey (Report No. 11005, Mar 07). These indicated that the former Chapel was demolished, the former Sunday School incorporated into a redundant garage, and the presence of the vaults not proven. The redundant engineering works held no archaeological interest.

Following the conclusion that the proposed development would greatly influence, i.e. destroy, the archaeological remains on site, the second archaeological phase was instigated, which saw the building recording and photographic survey of the upstanding features (Report No. 11008, Apr 07).

During this third archaeological phase on site, the ground was subjected to a ground-penetrating radar (GPR) survey which identified preserved remains of the former Bethel Chapel underneath the car park and located the vaults within the redundant garage.

To clarify access arrangements into the former Sunday School and into the vaults, the plaster board in front of the former was removed while the back wall of the former staff toilet within the protrusion was pulled down. Within the small space under the stairs, the gate to the vaults was found.

It is recommended that targetted archaeological evaluation trenches to proposed foundation depth should result in an understanding of the Chapel's foundations and any underlying archaeology which may be affected by the development. A reconnaissance visit into the vaults should elucidate the state of preservation of the structure as well as the existence of any human remains.

A mitigation strategy should take into consideration the importance of upstanding features and their inclusion into the proposed development as well as the needs of a geotechnical ground investigation.

CONTENTS

1.0 INTRODUCTION

1.1.1 It is understood that it is proposed to demolish the upstanding buildings on the disused site and develop it with six-storey apartment blocks, including landscaped zones and car parking.

1.1.2 On the instructions of Mario Minchella Architects on behalf of Atlas New Home Ltd, a geotechnical desk study was undertaken by Ian Farmer Associates (Report No. 3953, Jun 06), ref. 11.1, which recommended the site be subjected to detailed archaeological investigation to enquire into the history of the former Bethel Chapel and Sunday School on site and into the presence of vaults beneath the site.

1.1.3 On further instructions, Ian Farmer Associates *Archaeological Services* carried out the first archaeological phase which comprised a desk-based assessment and a walkover survey (Report No. 11005, Mar 07), ref 11.2. These indicated that the former Chapel was demolished, the former Sunday School incorporated into a redundant garage, and the presence of the vaults not proven. The redundant engineering works held no archaeological interest.

1.1.4 Following the conclusion that the proposed development would greatly influence, i.e. destroy, the archaeological remains on site, the second archaeological phase was instigated, which saw the building recording and photographic survey of the upstanding features (Report No. 11008, Apr 07), ref. 11.3.

1.1.5 During this third archaeological phase on site, the site was subjected to a ground-penetrating radar (GPR) survey.

2.0 GENERAL STANDARDS

2.1 Compliance

2.1.1 All work is carried out in compliance with the codes of practice of the Institute of Field Archaeologists (IFA), ref. 11.4, and follows the IFA Standards for an archaeological desk-based assessment, ref. 11.5.

2.2 Definition

2.2.1 Ground-penetration radar (GPR) is a remote sensing technique used during building investigation and recording.

2.2.2 *'The definition of archaeological building investigation and recording (ABIR) is a programme of work intended to establish the character, history, dating form and archaeological development of a specified building, structure, or complex and its setting, including buried components, on land, inter-tidal zone or underwater.'* (IFA, ref. 11.5)

2.3 Purpose

2.3.1 *'The purpose of ABIR is to examine a specified building, structure or complex, and its setting, in order to inform:*

- *the formulation of a strategy for the conservation, alteration, demolition, repair or management of a building, or structure, or complex and its setting*

  or

- *to seek a better understanding, compile a lasting record, analyse the findings/record, and then disseminate the results.'* (IFA, ref. 11.5)

2.4 Third Parties

2.4.1 This report has been prepared for the sole use of the Client for the purpose described and no extended duty of care to any third party is implied or offered. Third parties using any information contained within this report do so at their own risk.

2.4.2 It is recommended that a copy of this report be submitted to the relevant authorities to enable them to carry out their own site assessment and provide any comments.

2.4.3 The comments given in this report and the opinions expressed herein are based on the information obtained initially from the desk study and site reconnaissance, and subsequently the desk-based assessment and walkover survey. No intrusive investigation has been carried out to confirm the actual ground or environmental conditions.

2.4.4 Any risks identified in this report are perceived risks based on information reviewed. Actual risks can only be assessed following a physical investigation of the site.

2.4.5 This report has been based, in part, on information supplied by others. The report has been prepared on the basis of that information being accurate.

2.4.6 The conclusions presented in this report are based on the guidance available at the time of preparation of the report. No liability can be accepted for the retrospective effects of any changes or amendments to legislation or guidance.

2.5 Site Archive

2.5.1 The site archive will be deposited in the appropriate local museum within six months of completion of the report.

2.5.2 Tyne and Wear Specialist Conservation Team will require confirmation that the archive has been submitted in a satisfactory form to the relevant museum

before recommending to the local planning authority that the condition should be fully discharged.

3.0 SITE

3.1 Site Location

3.1.1 The site is situated at the former Bethel Chapel, 12-14 Villiers Street, Sunderland, Tyne and Wear, SR1 1HA and may be located by National Grid Reference NZ 4008 5705.

3.1.2 Site location plans are included in Appendix 1, Figures A1.1 and A1.2.

3.2 Geological & Topographic Setting

3.2.1 Details of the geology underlying the site have been obtained from the British Geological Survey map, Sheet No. 21, 'Sunderland', solid and drift edition, 1:50,000 scale, published 1978.

3.2.2 The geological map indicates the site to be underlain by superficial deposits of Devensian undifferentiated glaciofluvial deposits comprising sand and gravel. Immediately to the north of the site, Devensian till is indicated.

3.2.3 The superficial deposits are underlain by Upper Permian dolomite.

3.2.4 The site is within an urban area and, although not indicated as present on the site from the geological maps, the possibility that Made Ground exists on site cannot be discounted.

3.2.5 The walkover showed the site to be covered in concrete.

3.2.6 The junction of Villiers Street and Little Villiers Street to the north of the site lies at approximately 27m OD while the junction of Villiers Street with Coronation Street to the south of the site lies at approximately 28m OD.

3.2.7 The geological report is included in Appendix 2.

4.0 AIMS AND OBJECTIVES

4.1.1 Acting on the recommendations of earlier phases of work (reports 3953, 11005 & 11008), GPR was employed as the only non-intrusive technique to potentially work on this site due to the concrete floor.

4.1.2 This technique should ascertain the extent and form of the vaults, the location of the entrance and potentially whether human remains are still in-situ. This suggestion has been supported by Neil Linford, geophysicist for English Heritage.

4.1.3 Furthermore, the GPR should delineate potential archaeological remains beneath the concrete car park.

4.1.4 Once the vaults were identified, the search for the vault entrance would intensify.

5.0 METHODOLOGY

5.1.1 The GPR survey was undertaken by Utsi Electronics Ltd on October 17th, 2006.

5.1.2 A series of parallel transects were carried out, covering the whole area. Each transect produced evidence of the depth of signals returned against the distance travelled by radar. These transects were then combined into a 3-dimentsional data block from which horizontal time slices could be taken, effectively providing a plan view which changed with depth. Patterning in both 2-dimentional and horizontal time slices was examined.

5.1.3 The full GPR report is included in Appendix 3.

6.0 ANALYSIS AND INTERPRETATION

6.1.1 As explained extensively within the report included in Appendix 3, the GPR survey has identified a complex series of interconnecting tunnels and vaults with extensive coverage beneath the north of the site as well as significant building footprints to the south of the site.

6.1.2 To compare the findings of the survey with known features, an overlay of the current ground floor plan with the GPR results as well as a Victorian sketch of the former Chapel has been included in Appendix 4.

6.1.3 As stated in the desk-based assessment (ref. 11.2), the vaults had a single entrance so that any reference to further entrances in the GPR report will have to be investigated.

6.1.4 Furthermore, it is known that there were three ranges to the vaults, the complexity of which were identified by the survey.

6.1.5 The location of the former Chapel is known from early maps, and it ties in comfortably with the building footprints and the Victorian sketch at the same scale.

6.1.6 In the light of the GPR results, the search for possible entrances was intensified with particular emphasis on the inaccessible space behind the former staff toilet within the protrusion at one end of the substantial east to west feature identified by the GPR survey.

6.1.7 A cast-iron gate was discovered by removing internal plaster boards within the protrusion, along with which the bricked-up archway in the protrusion's western exterior wall was cleared.

6.1.8 While removing modern plaster boards, the eastern front door to the former Sunday School was also uncovered.

6.1.9 Photographs of these undertakings have been included in the photographic archive in conjunction with Report No. 11008, and to reiterate the findings digital prints have been incorporated into Appendix 5.

6.1.10 The cast-iron gate was not opened. Discounting the breach through the inspection pit, no other entrances into the vaults were found.

7.0 IMPACT OF PROPOSED DEVELOPMENT

7.1.1 A proposed site plan has been made available by the client.

7.1.2 It indicates an L-shaped building footprint to the east of the site, the length of which reaches from the northern site boundary all the way to the junction of Villiers Street with Coronation Street, while the width of it runs parallel to Coronation Street to the lane. In addition to the proposed building, the plan shows landscaped zones and car parking spaces parallel to the lane.

7.1.3 The proposed building would cover the eastern halves of the former Bethel Chapel, the former Sunday School, the redundant engineering works and the underlying vaults.

7.1.4 The landscapes zones and car parking spaces would cover the western halves of the former Bethel Chapel, the former Sunday School, the redundant engineering works and the underlying vaults.

7.1.5 It is intended to demolish any structures on site. In addition, groundworks related to the building footprint would have a profound effect not only on the foundations of the Bethel Chapel and the Sunday School, but would most certainly unearth the vaults.

7.1.6 At this stage, it is not possible to know if landscaping and the construction of a car park would touch on any sub-surface deposits.

8.0 RECOMMENDATIONS

8.1.1 In the light of the complexity of the site, the proposed demolition of all structures, and detrimental effects of any groundworks during the construction of the proposed developments, it is suggested to employ a phased approach to further archaeological work.

8.1.2 If it is thought that the remains of the former Sunday School are of local or regional interest than a mitigation strategy to preserve these should be contemplated early on.

8.1.3 In the light of building remains surviving beneath the site's concrete car park, targeted archaeological evaluation trenches prior to and/or an archaeological watching brief during any groundworks should clarify the nature of the Chapel foundations as well as potential archaeology beneath these.

8.1.4 The GPR has delineated the location of the vaults, and these should be investigated further. The entrance to the vaults has been found, and removal of the original cast-iron gate would grant access to the sub-surface structure. If the entrance cannot be made safe, the next best place would be the inspection pit in the floor of the former Sunday School.

8.1.5 A visit into the vaults would elucidate the state of preservation of the vaults as well as the existence of any human remains. With those questions answered, a strategy on how to proceed must be sought.

8.1.6 In addition to being of archaeological interest, the vaults represent a void over which geotechnical ground investigation paramount to foundation design cannot be carried out. Any archaeological mitigation strategy should be scrutinised by a geotechnical engineer to allow for the ground investigation to proceed satisfactorily.

8.1.7 The burial registers have been requested from the National Archives. They should be examined by a historian, and if necessary, living relatives should be notified of the proposed scheme.

8.1.8 Due to increased interest in this type of project (see 10.1.1) and the importance to local and regional archaeology, the developer may be able to seek additional funding for the archaeological work from local authorities.

9.0 OASIS

9.1.1 Ian Farmer Associates *Archaeological Services* support the Online Access to Index of Archaeological Investigation (OASIS) Project. The overall aim of the OASIS Project is to provide an online index to the mass of archaeological grey literature that has been produced as a result of the advent of large-scale developer-funded fieldwork.

9.1.2 *Archaeological Services* therefore completed the online OASIS form at http://ads.ahds.ac.uj/project/oasis. Submission and validation of a completed OASS form places the information into the public domain on the OASIS website.

9.1.3 A copy of the form submitted for validation has been included in Appendix 6.

10.0 PUBLICATION

10.1.1 While the specification foresees the publication of the results in a suitable archaeological journal, Cox (ref. 11.6) suggests,

'Whichever mode is selected from the dissemination of results to other archaeologists and interested academics, it should not be forgotten that such high profile projects with immediate human relevance will attract a wider range of interested parties than may normally occur with archaeological projects. Dissemination of information at a more popular level should also be considered. Public interest in such projects may merit the production of a popular account of any future crypt excavation as it has in the past.'

10.1.2 The mode of publication will be considered as a phased approach progresses and will be discussed with the client. The creation of a website should be beneficial.

11.0 REFERENCES

11.1 Ian Farmer Associates, unpubl., *Geotechnical Desk Study for 12 – 14 Villiers Street, Sunderland*, IFA Report No. 3953, Ian Farmer Associates, Gateshead

11.2 Ian Farmer Associates, unpubl., *Former Bethel Chapel, Sunday School and Vaults – Report on Archaeological Desk-based Assessment and Walkover Survey*, IFA Report No. 11005, Ian Farmer Associates, Gateshead

11.3 Ian Farmer Associates, unpubl., *Former Sunday School – Report on Building Recording and Photographic Survey*, IFA Report No. 11008, Ian Farmer Associates, Gateshead

11.4 Institute of Field Archaeologists, 2000, *Code of Conduct*, IFA, Reading

11.5 Institute of Field Archaeologists, 1999, *Standard and Guidance for Archaeological Desk-Based Assessment*, IFA, Reading

11.6 Cox, M. Crypt Archaeology: an approach, IFA, Reading

For and on behalf of Ian Farmer Associates (1998) Limited

Frigga Kruse
BSc, MSc, PIFA
Archaeologist & Engineer Geologist

APPENDIX 1

DRAWINGS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Villiers Street Sunderland
Contract No. 11008
Site Location Plans

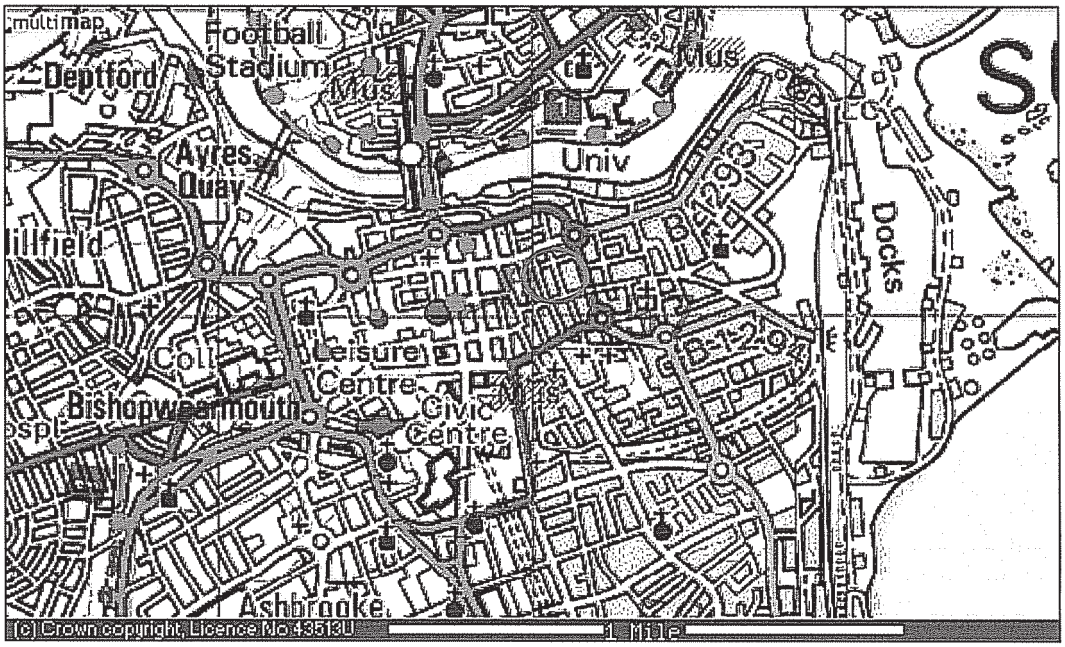
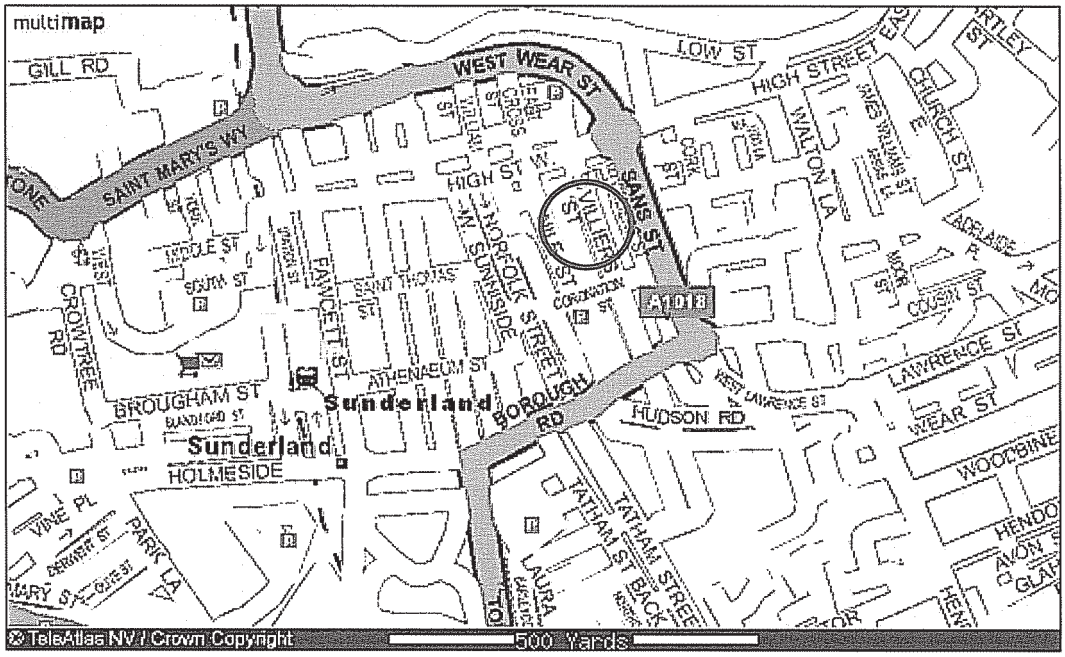


Fig. A1.1 Location plans



Licence No. 100031101

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Villiers Street, Sunderland
Contract No. 11010
Site Location Plan

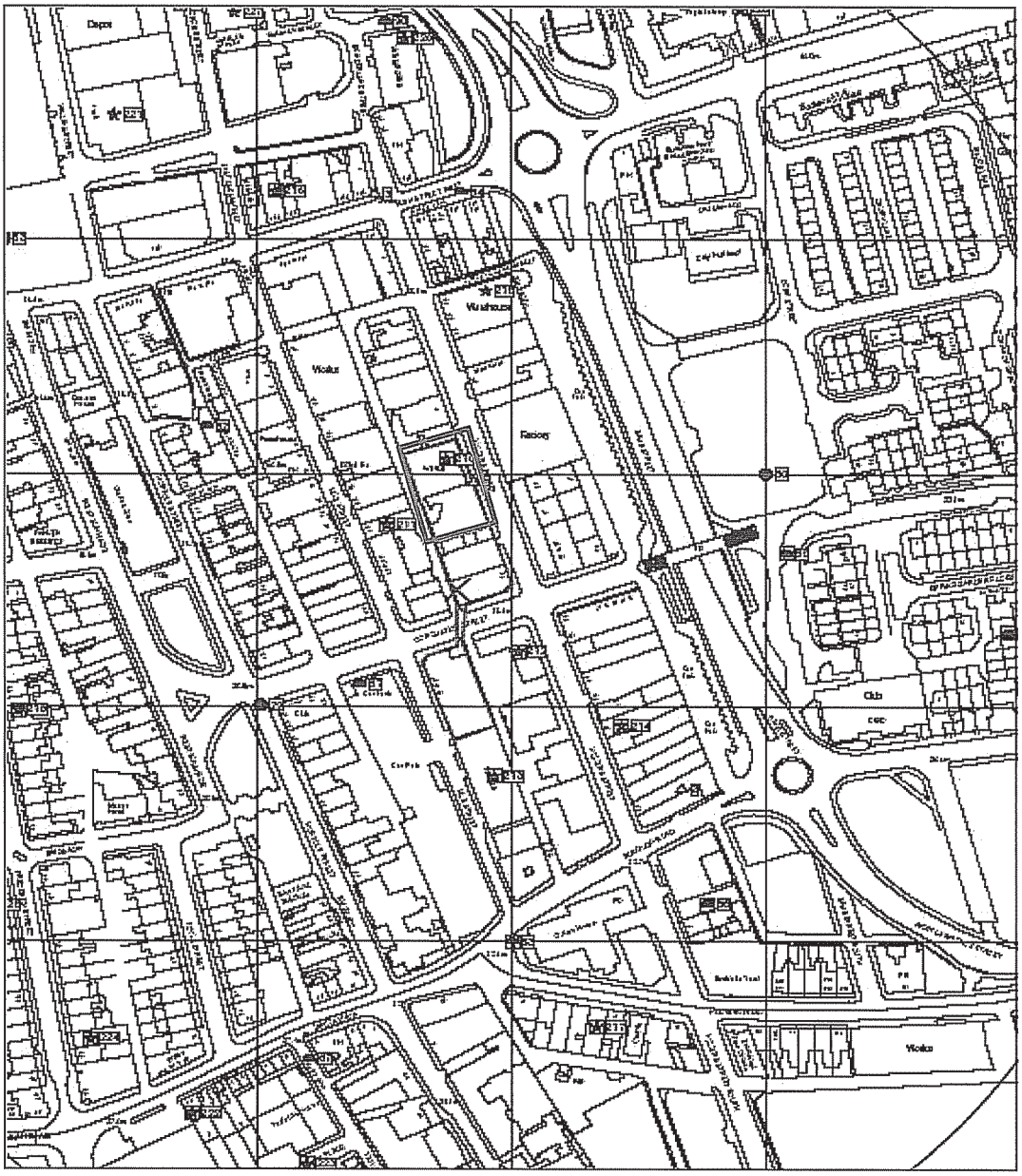


Fig. A1.2 Site Location Plan

APPENDIX 2

GEOLOGY REPORT

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Envirocheck® Report

Geology Report

Report on:
New Residential Development
Villiers Street and Nile Street
Sunderland
SR1 1HA

National Grid Reference:
440080 557050

Prepared For:
Ian Farmer Associates
Unit 1 Bamburgh Court
Team Valley Trading Estate
Gateshead
Tyne & Wear
NE11 0TX

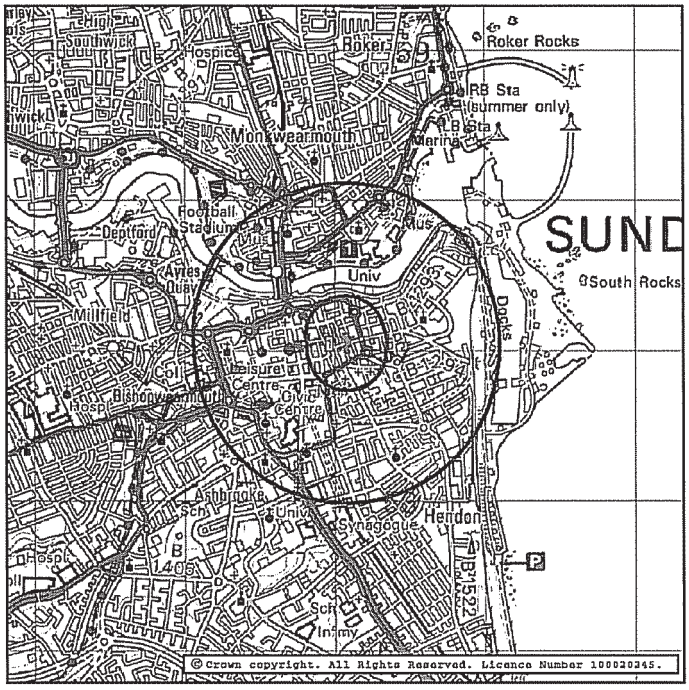
Your Reference:
S Corrigan, 3953_EC

Geological Coverage

This report is designed for users carrying out preliminary site assessments who require geological maps for the area around a site. The report contains geological map extracts taken from the BGS Digital Geological map of Great Britain at 1:50,000 scale. This mapping may be more up to date than previously published paper maps.

The various geological layers - artificial (man-made) and landslip deposits, superficial geology and solid (bedrock) geology are displayed in separate maps. The final map, that of 'Combined Surface Geology', superimposes all these distinct layers into one, producing a map that shows the rocks that occur at the surface just beneath the soil. NOTE: All the legends only report information contained within the 250m and 1000m search buffers that are displayed on the maps.

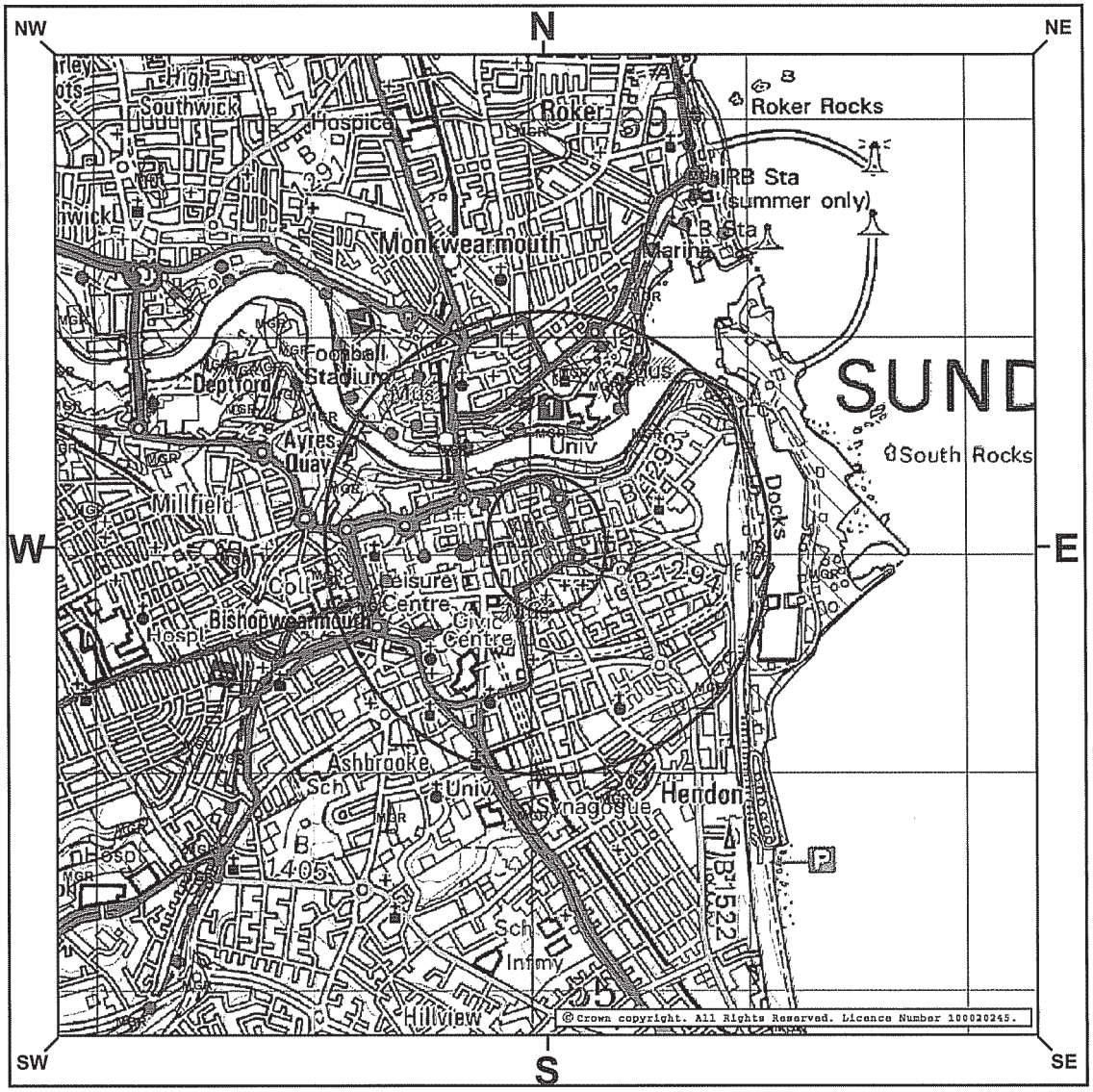
Not all of the layers have complete nationwide coverage, so availability of data for relevant map sheets is indicated below.



BGS 1:50,000 Geological Mapping Coverage

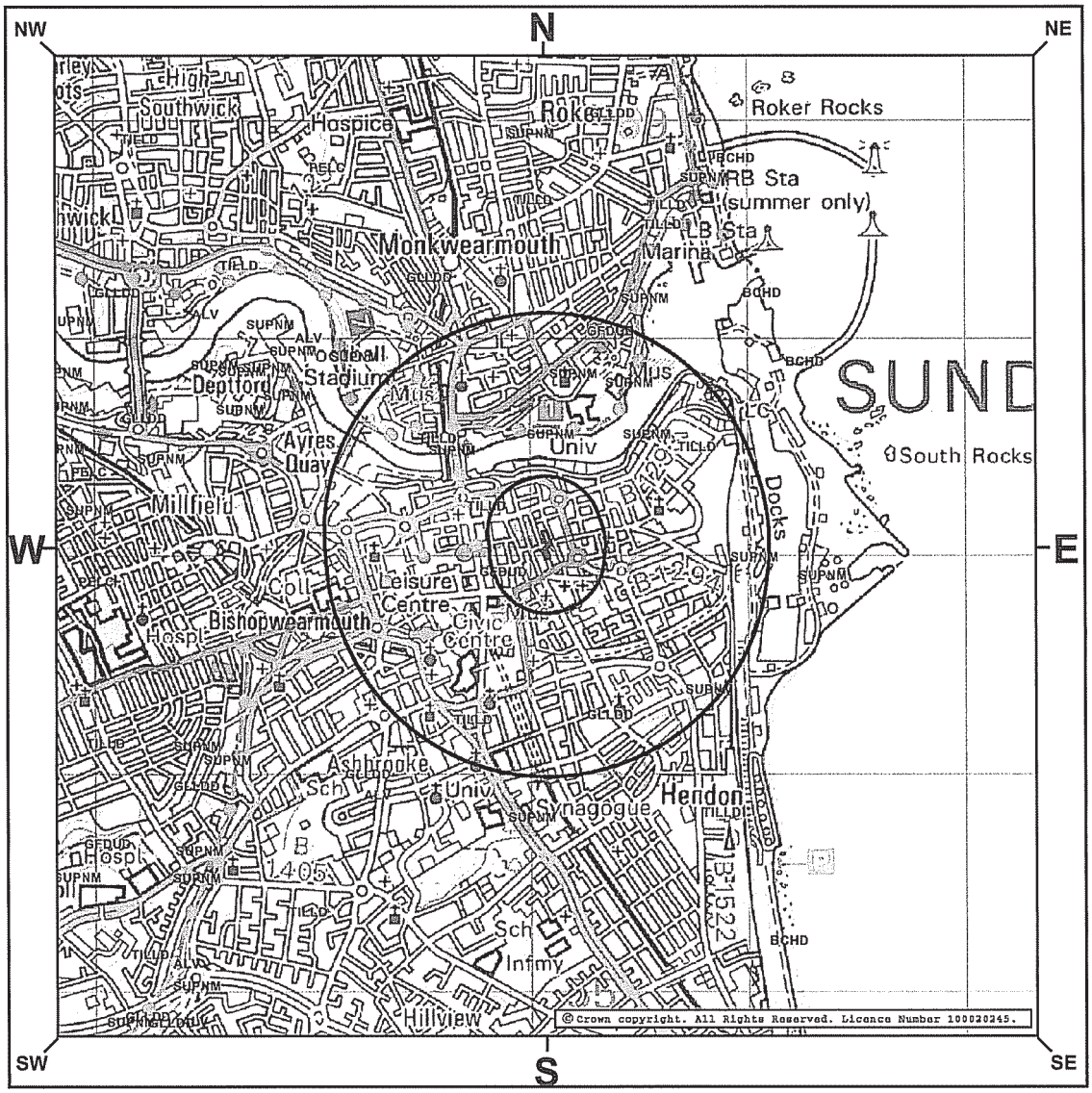
Map ID:	1
Map Sheet No:	021
Map Name:	Sunderland
Map Date:	1978
Bedrock Geology:	Available
Superficial Geology:	Available
Artificial Geology:	Available
Faults:	Available
Landslip:	Available
Rock Segments:	Available

Artificial Ground and Landslip



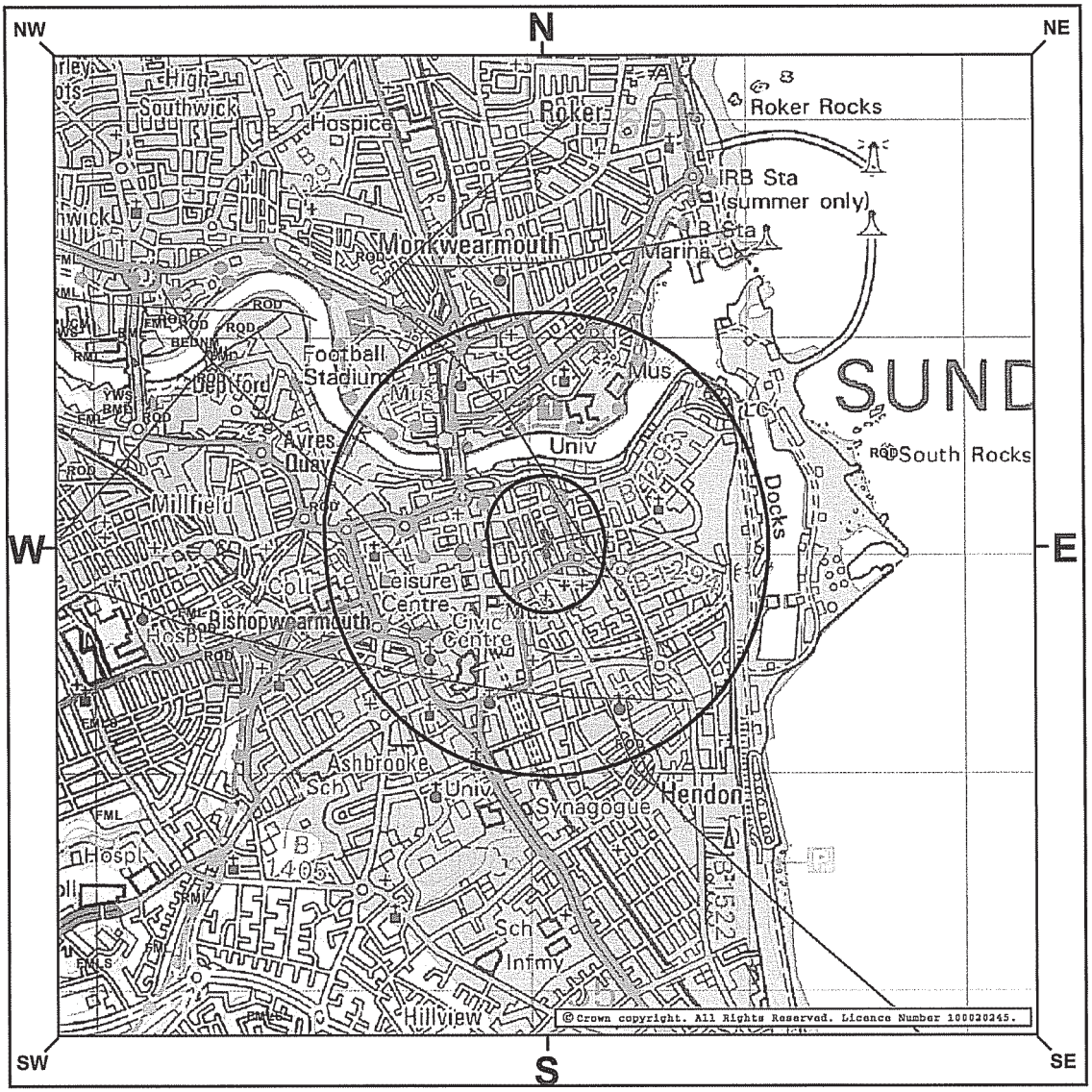
Map Colour	LEX Code	Rock Name	Rock Type	Min and Max Age
	MGR	Made Ground (Undivided)	Made Ground(ex MGR), Fill, Rubbish, Ash, Slag, Forced Ground,etc.	Flandrian - Flandrian

Superficial Geology



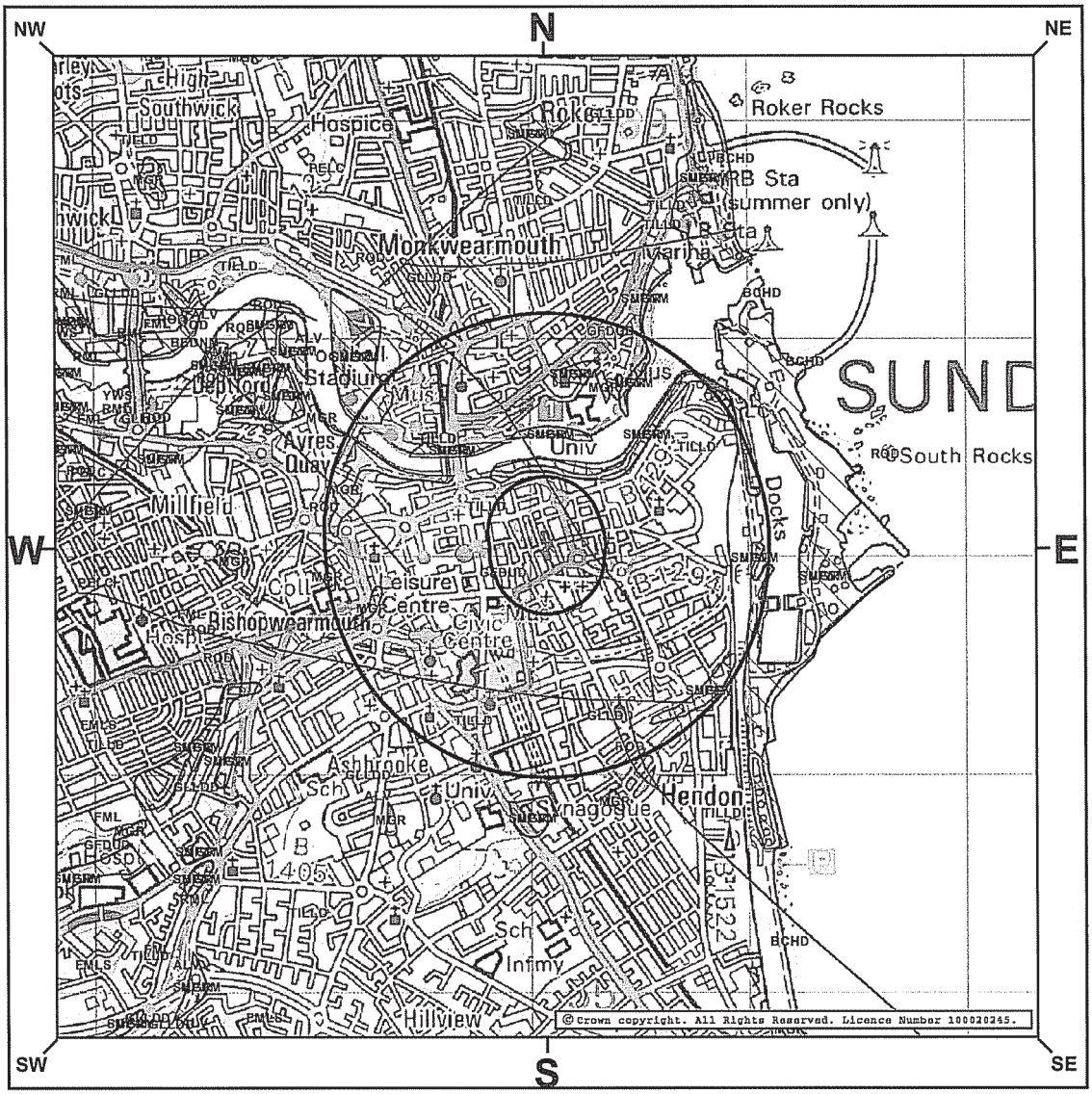
Map Colour	LEX Code	Rock Name	Rock Type	Min and Max Age
	GFDUD	Glaciofluvial Deposits, Undifferentiated, Devensian	Sand and Gravel	Devensian - Devensian
	TILLD	Till, Devensian	Diamicton	Devensian - Devensian
	GLLDD	Glaciolacustrine Deposits, Devensian	Clay and Silt	Devensian - Devensian
	ALV	Alluvium	Clay, Silt, Sand and Gravel	Quaternary - Quaternary
	SUPNM	Superficial Deposits Not Mapped [For Digital Map Use Only]	Unknown Lithology	No Data Entered - No Data Entered

Bedrock and Faults



Map Colour	LEX Code	Rock Name	Rock Type	Min and Max Age
	ROD	Roker Formation	Dolomite Rock (Synonymous with Dolostone)	Upper Permian - Upper Permian
		Faults		

Combined "Surface Geology"



Please see the legends to the previous maps to interpret the Combined "Surface Geology" map.

Additional Information

More information on 1:50,000 Geological mapping and explanations of rock classifications can be found on the BGS website. Using the LEX Codes in this report, further descriptions of rock types can be obtained by interrogating the 'BGS Lexicon of Named Rock Units'. This database can be accessed by following the 'Information and Data' link on the BGS website.

Contact

British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
Nottinghamshire
NG12 5GG
Telephone: 0115 936 3143
Fax: 0115 936 3276
email: enquiries@bgs.ac.uk
website www.bgs.ac.uk

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

APPENDIX 3

GPR SURVEY

Utsi Electronics Ltd

Ground Penetrating Radar Survey of the site of a former Dissenters' Chapel in Villiers St, Sunderland

for

Ian Farmer Associates

26th October 2006

CONTENTS

SURVEY OBJECTIVE

The former Dissenters' Chapel in Villiers St is known to be associated with brick burial vaults. There is an existing metal door, fitted at current ground level, to deter body snatchers from entering the vaults. The building fell into disuse as a chapel and has subsequently been used as a garage and workshop which itself is no longer in use. The metal door is situated at the back of the former main workshop i.e. to the East of this area. Figure 1 shows the layout of the survey area.

The purpose of the Ground Penetrating Radar (GPR) survey was to provide as much information as possible about the foundations of the original chapel and its associated school house; the location of the brick vaults used for burial; and any other related material. This information will be used to plan future investigations.

SURVEY STRATEGY

Use of Ground Penetrating Radar

GPR operates on the same principles as conventional radar except that it uses a wider frequency range, a shorter pulse, and a much shorter range of detection. The radar generates a short pulse which is transmitted into the ground via an antenna. The return signal is received by another antenna. The amplitude of the returning signal provides information about changing ground characteristics with depth. The use of the radar does not affect underlying deposits: it is non-destructive.

The expected targets for this survey are all substantial in nature: building footings, brick vaults and air voids within the vaults. The identification of these features depends upon the detection of anomalous material relative to the surrounding environment, measured on the basis of the electromagnetic response of the materials involved. Although the radar always identifies changes in materials the nature of the change and/or the reason for the change are not always either evident or easy to interpret.

Since the interpretation of GPR results is dependent on recognising and understanding patterning in the data, both the traditional 2-dimensional data and horizontal time slices were generated in order to maximise this possibility. Two-dimensional data depicts signal returns from depth against the distance travelled by the radar, effectively a vertical section in GPR format. Combining a series of parallel 2-dimensional traces at a regular spacing allows a 3-dimensional data block to be generated. From this, horizontal plans or time slices can be extracted.

Note that the time slices extracted from this data block will only represent a horizontal view where the materials crossed by the electromagnetic pulses are identical. The speed of transmission of radio waves varies with the electromagnetic properties of the materials through which the pulses pass. Where the dielectric properties of these materials are similar, transmission speeds will not vary significantly. As an example, the speed of transmission through concrete, brick structures and dry soil will not differ materially from each other. Where an air gap is encountered, the speed of transmission increases from c. 0.1m/ns to 0.3m/ns (i.e. the speed of light). Wherever voids exist alongside soil or building materials, the time slices will be representative

of the same time frame but the depths in metres will be distorted, the signal having travelled three times faster through any air gaps.

Three further caveats on the use of GPR require a mention. Firstly since similar patterns may be generated by more than one type of buried feature, it is possible for the anomalies identified by the radar to be due to structures other than those expected. Secondly, it is not always possible to detect specific targets if adjacent anomalous material obscures the spatial patterning of the target sought. Lastly, the radar cannot provide absolute dates for anomalies although a relative date is sometimes evident from the relative position(s) of different anomaly groups. Dating is not at issue for this survey due to the historical material available.

One further potential problem in the use of GPR concerns the possibility of ground conditions, typically wet clay, to mask the existence of buried features through attenuation (loss) of the signal. Although the ground conditions were more attenuating (i.e. gave rise to higher losses) than initially anticipated, this has not been a problem of this survey. The data quality is very good.

Equipment

The equipment used for this survey was Utsi Electronics' Groundvue 3 with a pair of 400MHz antennas. Groundvue 3 uses bow-tie antennae for close ground coupling and arrayed antennae for narrowed signal beam. This improves the signal to noise (interference) ratio. The antennae are screened in order to prevent interference from adjacent objects above ground.

In case the concrete in either the workshop or the spray shop had been reinforced, a pair of 1GHz antennas was also brought to the site. However, as originally expected, this proved not to be the case and the 1GHz system was not used.

Site Conditions

Ground surface conditions for the survey were good. Although some minor detritus remained, the floors had been cleared of obstacles wherever possible.

It was not possible to survey the southern half of the inspection pit in the main garage (& chapel) due to the raised level of the wood above it. There was also 1 run which could not be completed due to the presence of raised nails in the floor. In both instances, the survey line was completed as far as possible on both sides of the obstacles.

There were several sections of sloping concrete in the yard to the south of the former garage and chapel. The slope resulted in sideways slippage of the radar which may distort the GPR data. However, the position of the markers in these areas is consistent with the distance measurements taken at the time of the survey so the error, if any, is not large.

Site Coverage

The full area of the site was covered starting at the North end of the site, 0.5m

from the inside of the north wall of the former workshop and continuing to 0.5m from the southern boundary wall of the yard.

Due to the relative positions of walls and doorways in the existing buildings, it was not possible to place survey reference lines across the whole site and survey in 1 single stage. The survey was therefore carried out in 3 stages:

- Area 1, the main workshop and the spray shop;
- Area 2, the main garage (former chapel); and
- Area 3, the current yard.

Figure 1, the combined time slice at current ground surface, shows the relative layout of the three areas.

Reference lines were established in each area and the position of every run recorded relative to its distance from the inside of the north wall in Area 1. For the survey in Area 1, lines 1 and 2 were laid out parallel to the west wall at distances of 16m and 2m respectively.

A third parallel line was established between lines 1 and 2, at 8m from the west wall of Area 1 in order to continue the survey into Area 2. Line 4 was laid out parallel to Line 3, at 10m to the East (i.e. towards Villiers St).

Line 5 was laid out parallel to lines 3 and 4, 8m to the east of line 3 and extended into the yard. Line 6, the second reference point for the survey in Area 3, runs parallel to line 5 and 6.6m to the west. This line also follows a sawcut in the concrete.

Survey Parameters

All of the survey lines were completed using a timesweep of 80ns which is approximately equivalent to 4m in dry soil (see also Calibration). The sampling interval along the line of travel of the radar was 5cm and the spacing between adjacent transects 0.5m.

Calibration

GPR depths are measured in nanoseconds time. To translate this into depths measured in metres, it is necessary either to know the speed of transmission through the ground or to calibrate using borehole data.

For internal work inside a building or on soils which are covered by concrete or tarmac, it is generally sufficient to assume a transmission speed of 0.1m/ns.

Where a void exists, the transmission speed is approximately three times as fast i.e. c. 0.3m/ns. Since the speed of transmission is approximately three times that in soil or building materials, the GPR data presents a distorted view both in vertical section and in horizontal time slice where voids exist alongside these deposits.

Fieldwork

The survey was carried out on 17th October 2006.

SURVEY RESULTS

Radar Output

The radar output was processed as follows:

Background removal applied;
Time based gain added; and
Bandpass Butterworth filter (200MHz to 600MHz) applied.

All 2-dimensional data is depicted running from West to East across the site. Numbers on the data indicate the position of the survey reference lines. Letters on the data indicate obstacles at ground level.

2-Dimensional Data

All 2-dimensional data is presented running from West to East from left to right across the page.

All of the data is relatively shallow i.e. lying within 35ns. In a dry soil this would be equivalent to 1.75m depth. Although this is shallower than might be expected, it is almost certainly due to the effect of extensive air gaps within the data. As explained above, radio waves travel at the speed of light through air. Calculated at a transmission speed of 0.3m/ns, 35ns is equivalent to 5.25m. Given the combination of concrete at the surface and a mixture of building materials and voids below ground, the site maximum depth lies somewhere in between. Without knowing the exact proportions of air and other materials at any given spot, it is not possible to estimate maximum depth.

The individual profiles vary considerably in their content. However, almost all of them contain evidence for significant underground features. Run 95, taken at 37m (i.e. towards the southern end of the yard) shows a typical level of complexity (Figure 2). There are underground features visible for the whole length of the run. From the western end until c. 9.5m distance, there appears to be a continuous gallery, supported at intervals by short pillars seen in the data as columns of strong black and white signal. There may be more than 1 level since the maximum depth of anomalies appears to dip below these columns: cf, for example, the signal return at 3m distance and 27ns depth. From c. 9.5m to 10.5m, there is a large feature for which both top and bottom are visible. Beyond c. 10.5m, the disturbance suggests another possible tunnel or gallery.

When viewing Figure 2, it is important to remember that strong signal returns indicate major changes in materials: the stronger the signal, the greater the difference in material composition. It is not, however, possible to say with absolute certainty which material any given signal represents. Nevertheless, on the basis of figure 2 (and the remainder of the data), the distribution of the vaults appears a) extensive & b) potentially complicated.

As can be seen from Figures 11 to 24, used for comparison purposes with the time slices, there are also indications of possible buried building remains and other objects.

In order to see which features can be traced from 1 run to the next, all runs were combined into a 3-dimensional data block from which time slices have been extracted.

The Time Slices extracted from the 3-Dimensional Data Block

Time slices were extracted at the following depths: 3ns, 5ns, 6.5ns, 8ns, 13ns, 18ns, 20ns and 27ns (Figures 3 to 10 inclusive). The basis of selection was maximum signal response for a coherent pattern in the data.

Although the time at which these slices have been extracted is accurate, the depths may not be at the same physical level, depending on the materials from which the signals have been returned. This is because the radio waves emitted by the radar travel at three times the transmission speed through air relative to the transmission speed through soil and building material. Unless all voids have been backfilled with rubble, the time slices will not be horizontal in absolute depth. The data does not suggest that such backfilling has taken place.

In all cases North is at the top of the time slice and Villiers Street lies to the East (right hand side of the page). The time slices begin 0.5m to the south of the North wall of the main workshop and end 0.5m before the southern boundary wall of the yard. The y axis (x = 0) lies along the position of survey reference line 3 (see Site Coverage and also Figure 1).

The metal door leading to the vaults lies to the East of Area 1, adjacent to the second indentation from the right. This area is blank on the time slices as it was not possible to survey and, in any case, no returns would have been obtained through the metal. The position of the relevant indentation runs from y = 8 to y = 10 (see also Figure 1).

Reference to specific positions within time slices is given in (x, y) format where x is the reading along the x-distance axis and y the reading along the y-distance axis.

3ns (16cm in soil; 47cm in air)

The first indication of possible man-made structures occurs around this level, relatively close to the current ground surface (Figure 3). In Area 1, the dark lines along the western wall and leading to the south of the northern wall, appear in the 2-dimensional data as simple hyperbolas and may indicate former construction material in situ although this is not certain. The dark areas in the interior of Area 1 appear different. These seem to be the highest points of underground arches. Taking (6.6, 4) as an example, the arch can be clearly seen close to the surface at 6.6m along run 8 (Figure 11).

Directly beneath this arch a series of repeat signals or echo effects, more commonly known as ringing, is visible. This is a common indicator of the presence of an air void. A similar effect can be seen from the known void (i.e. the inspection pit) in Area 2: see Figure 12.

The large anomaly towards the south of Area 1 also contains a substantial underground feature. The striped banding visible in Run 19 (Figure 13) suggests that

this is the topmost spur of a large section of level material. The lack of internal signals between the top and bottom signals suggests a homogeneous material. Although it is not possible to identify the material, it is possible that this represents former construction material in situ. Between –1m and 0, the complexity of the signals also suggests a wall viewed at right angles in which case this would mark the corner of a former building.

The main anomaly in Area 2 is the void of the inspection pit.

There are two major groups of anomalies in Area 3: a band across the northern part and two parallel lines in the SW corner. From Runs 65 & 66 (at 22 and 22.5m respectively) the former group of anomalies appears to be the upper surface of a possible former building, below which lies a complicated structure of tunnels or galleries. An extract from Runs 65 and 66 is shown at Figure 14. Run 66 appears to contain a separated area or vault immediately to the west of survey reference line 5.

The parallel lines in the SW corner are very similar. At this level, this appears to represent former building remains but there are subterranean features below.

5ns (25cm in soil; 75cm in air)

This time slice is shown in Figure 4. The anomalies lying along the western and northern edges of the area are not especially visible within the 2-dimensional data as they merge into the signal returns from the surface. It is likely that this indicates the position of the remains of construction materials. Given the regularity of the outline in time slice format, these may still be in situ.

The anomalies forming one long side and two partial short sides of a rectangle along the eastern edge are similar and may also indicate the boundary of a former building or part of a building.

A third group of anomalies in the SE corner of Area 1 represents an extension of the feature first observed at 3ns and illustrated vertically in Run 19 (Figure 13). This confirms the earlier suggestion of a partial outline of a former building, including one corner. It may also be related to the anomaly directly to the south and lying at right angles in Area 2.

The group of anomalies in the spray workshop also appears likely to be part of a former building. In this case there is evidence for possible tunnels directly below.

The main anomaly in area 2 remains the signals returned from the void of the inspection pit. Directly to the West of this is a linear anomaly which seems to be the partial remains of a former built structure. As mentioned above, this may be related to the linear anomaly visible in the SE corner of Area 1 since the two features lie at right angles to and in line with each other.

To the South and East of this linear feature lie two short linear features, centred on (3.8, 17.5) and (4.9, 18.5) respectively (Figure 4). Viewed vertically, these appear to form the top of a buried feature of unknown function: run 53 illustrates the first of these (Figure 15). The evidence from the two positions is similar suggesting that they

may be related. The change in outline from the first to the second, as well as their positioning on the time slice suggest that the feature they represent is lying at an angle to the travel path of the radar.

There is a faint series of dots forming a line at approximately 45° near to the SW corner of Area 2. The last and strongest of this series of anomalies is a single strong reflector which might be metallic. The reflections from the first few in the series are much fainter although they become more visible at 6.5ns, suggesting that this is a feature which deepens towards the SW. This may be a drain or similar channel.

The anomalies to the East of the possible drain and adjacent to the southern edge of the garage are similar to those on the north and western edges of Area 1 and may also represent building remains in situ. Immediately to the East, and a little lower down (and hence not visible on this time slice) is another archway and associated void.

There are a large number of strong signal returns from Area 3. The band of anomalies towards the northern boundary of this area is a continuation of that visible at 3ns. At this depth, this still appears to be former building remains but the greater part of the area covers tunnels &/or galleries.

Alon g the eastern edge, centred on (12.2, 30) the top of a substantial structure is visible. Run 81 illustrates this (Figure 16).

The feature previously noted in the SW corner is also visible at this depth. The more southerly of the two lines has been replaced by an anomaly much closer to the southern boundary of the survey area. Although it is not clear what this is, there are buried objects lying below: see 2.8m along Run 97 (Figure 17). Whatever this is appears quite different from the tunnels or vaults visible at the eastern end of this run.

6.5ns (33cm in soil; 98cm in air)

At this depth, remnants of the outline of former buildings can still be seen. The extent of the underlying vaults is also becoming visible (Figure 5).

In Area 1, there is a marked increase in the number of anomalies. Along the northern boundary, these do not appear to be tunnels, galleries or vaults. Along the eastern edge, the patterning in the data is similar to the northern edge although there are some indications of minor disturbances below the Victorian ground surface. There is therefore a possibility that this ground has been used for burial although there does not appear to be any good grounds for believing that the vaults extend into this area. Along the eastern edge, the partial rectangles appear to mark the footprint of former buildings.

The southern edge is completely different from the other 3 sides. In this area there appears to be the remains of a building footprint, lying directly over at least 1 tunnel and possibly connecting galleries (see Figure 13).

The strong signal returns from the inspection pit are still visible in Area 2. In addition, this area contains a series of interconnecting linear features to the west of the pit and also to the east. These do not appear to be associated with underground

tunnels or chambers and it is possible that they are the remains of former buildings. The possibility of a drainage channel has already been mentioned in connection with the line at c. 45° towards the SW corner of Area 2. There is, however, at least 1 arch along the southern edge, as noted above, presumably connected to survey Area 3.

Area 3 now appears to be packed with anomalous signals. The line previously observed across the north of the area is a composite of building remains and underlying tunnels or vaults. The latter lie primarily to the East of the area: runs 65 and 66 (Figure 14) are a good example.

A large L-shaped feature is visible with its base along the southern edge of the area, with the orthogonal line rising along c. x = 6m. This appears to be a partial building footprint. Although it is not obviously directly related to the burial vaults, the anomalies that lie to the east of it (i.e. towards Villiers St) are. Figure 18, Run 92 illustrates this.

To the west of the L-shaped feature, the anomaly groups are similar in nature to those of the L-shaped feature, suggesting that these are also building remains. However, there is also evidence of possible burial vaults towards the western edge. These do not appear to connect directly across the yard, except possibly at the southern end. Run 95 (at 37m) illustrates the evidence for burial vaults at the southern end (Figure 2). Run 86 (at 32.5m) illustrates the apparent lack of connection north of this point (Figure 21) and Run 96 (at 37.5m) illustrates discontinuity between the West and East complexes (Figure 22).

8ns (41cm in soil; 1.2m in air)

Although this time slice is very similar to the preceding one, the density of strong signal is less, improving the definition in Area 3 (Figure 6).

In Area 1, the anomalies along the western edge are very similar to the preceding time slice and do not appear to be associated with burial vaults although they may relate to shallower burials. Along the southern edge, the anomalies relate to a combination of vault and overlying construction material. This is unsurprising given the position relative to the one known access point (Figure 1).

Area 2 is surprisingly free of anomalies, including the inspection pit although the presence of at least 1 arch and associated void is evidenced by run 54 (Figure 19).

In area 3, the definition of the L-shape appears to extend to the East, towards Villiers St. The very large anomaly centred on (12.3, 25) is a vault roof. The anomaly centred on (11.8, 30) is the roof of another substantial buried feature. Most, if not all of the anomalies at this depth are reflections of from the burial chambers.

13ns (66cm in soil; 2m in air)

At this depth there appears to be a major change in the patterning in the time slices (Figure 7). In considering this change, it is important to remember the distortion effect of variable transmission speeds. In each of the three areas, the building footprints have disappeared. The obvious deduction is that the time slice represents

the buried structures lying below the level of the Victorian buildings and the Victorian ground surface.

In Area 1, the anomalies derive from vaults and tunnels, as previously commented on.

The nature of the anomalous material in theWest and in the South is not identical, as discussed above.

Area 2 is dominated by the signal from the floor of the inspection pit. This is interesting because it would not be unreasonable to expect a connection channel of some sort between the vaults in Area 1 and those in Area 3. Although it would be possible for such a channel to be masked by the ringing (echo effects) from the inspection pit, the absence of signal in the adjacent areas to the north of this void and to the south, in the area of the doorway, suggests that no such connection exists. There must therefore be at least 1 other entrance to the southern burial complex in Area 3.

In Area 3, the full extent of the burial vaults is now visible. The area is extremely complex and far from homogeneous. As an example, the square anomaly at (0.8, 20.5) on the northern boundary is the reflection from the top of a buried structure. Looked at in vertical profile, it becomes apparent that firstly this is something different in nature from the area of tunnels and galleries to the East and secondly that there are more remains in the immediate vicinity than appears to be the case from the time slice: see Runs 54 in Area 2 and 62 in Area 3 (Figures 19 & 20).

Although the north eastern sector of Area 3 appears to be packed with burial vaults, the remainder of the area appears to be accessed primarily (but not exclusively) through three lines along the eastern border, across the southern edge and along the western edge. All of these anomaly groups contain evidence of vaults, tunnels and voids as previously illustrated. However, there is a considerable variety of structures within the overall pattern. For example, at (5.3, 21.5) the anomaly is part of a vault. At (6, 24), the anomaly appears to be a large chamber to the west of the vaulted area and at (12, 30), the anomaly appears to be a large chamber to the east of a vault.

In the centre of the area marked out by these main lines of anomaly groups, there is a faint rectangle, marked out by 3 lines. The strongest signal reflection comes from the eastern (right hand) line at (7.9, 32.5). Run 86, at 32.5m (Figure 21), shows that this appears to be a large central chamber. This profile also illustrates the presence of burial tunnels to the East and, to a lesser extent, to the West.

The broad sweep of anomalies along a line close to the southern edge of area 3 covers more than 1 profile: see runs 95 (Figure 2), and 96 (Figure 22). Both profiles suggest that burial activity is continuous across the site at this point. Both also suggest that the major burial location is at the SW end and that the floor of the tunnel or gallery slopes down towards this corner. In addition, Figure 22 suggests a continuous gallery at 37.5m as evidenced by the continuous black & white banded signal from the floor of this feature. Although it is possible that there is access from the East to the West, neither run seems to indicate this and run 96 suggests discontinuity. This implies that there may be a third entry point into the western vaults.

It was not possible to survey the SW corner of the site due to the amount of debris stored in the buildings in this area. The 13ns time slice suggests that the burial vaults may extend into this area in 2 places: along the line at y = 37m & 37.5m and at y = c. 31m.

18ns (92cm in soil; 2.77m in air)

The pattern of burial vaults simplifies at this depth enabling some further interpretation of the data (Figure 8).

The extent of such activity in Area 1 is very well defined. The absence of the anomalous material from the western edge is consistent with the 2-dimensional data being shallower and less extensive than the vaults.

Area 2 is again free from anomalies with the exception of part of the inspection pit although the southern edge is known to contain at least 1 arch (Figure 16).

Area 3 shows a concentration of anomalies in the NE corner but these are grouped around a series of linear features. It is likely that this indicates the position of the major galleries. The fainter lines leading away from these should not be ignored as all of these anomaly groups are of a similar nature. There is a "dogleg" leading westwards and to the south in the centre of Area 3. There are also a number of curvilinear lines in the northwestern sector, which appear to connect to the dogleg and possibly also the western edge.

Run 71 (at 25m) shows a vertical cross section through Area 3 (Figure 23). This profile illustrates the sloping gallery floor in this area and the apparently separate vault at the western end.

The time slice illustrates the same phenomenon in the southern sector. As discussed above, the extent of archaeological remains in the SW corner appears deeper than in the NW and the apparent lack of continuity between the western and eastern vaults along this line is also illustrated. This may be more apparent than real if the image has been significantly distorted by relative transmission speeds.

20ns (1m in soil; 3m in air)

This time slice, while being similar to the previous one, illustrates some different connections in the galleries in Area 3 supporting the previous contention of more material in this area (Figure 9). The anomalies visible in Area 2 are echo effects from the void of the inspection pit.

There is some evidence in Area 1 of other objects to the north of the main burial area. The small anomaly at (6.9, 7.5) is one of a group of other objects visible in run 15 (Figure 24). It is not possible to say what these are although curve fitting tests on the data confirm that they lie below ground and not above.

27ns (1.36m in soil; 4m in air)

The majority of the signals from the burial vaults have disappeared by this depth

(Figure 10). In Area 1 a totally new series of linear features forming the outline of a possible building are visible.

The linear feature in Area 2 is ringing from the void of the inspection pit and does not represent archaeological material.

Conclusions & Recommendations

The 2 and 3-dimensional data from the GPR survey of the Villiers St site illustrates the presence of a complex series of interconnecting tunnels and vaults. The total area covered by these is extensive. On the basis of the radar evidence, there appears to be 3 discrete areas which may have been used for burials. The largest of these is primarily concentrated on the NE sector of survey Area 3 but which extends across much of this area and into the southern edge of Area 2. The access point for this network has not been identified. The second area lies along the southern edge of survey Area 1, apparently under the remains of a former building and connects with the known access, currently secured by a metal door. Lastly, there are areas along the western edge of survey Area 3 which may connect to the primary burial area but are more likely to have a separate entrance. On the basis of the concentration of archaeological remains, the SW corner would seem to be a likely point of entry but an access point has not been identified and the full extent of the SW corner has not been surveyed by GPR.

The data illustrates the complexity of these vaults. They are not homogeneous: not only is there variation in size and type of roof (arched or not), there appear to be adjacent chambers in some areas. There is also evidence that these galleries slope downwards which also makes their full extent difficult to image in time slice. The 13ns time slice gives a good outline of all the relevant areas with the exception of the southern edge of Area 2 (Figure 7). The 18ns and 20ns time slices give an indication of the possible ground plan of the tunnels (Figures 8 & 9). Care should be taken with further investigations of the southern edge of Area 2 and all of Area 3 as the galleries may be more extensive than these figures suggest (cf. Figures 19 & 21).

In the western sector of survey Area 1, there is a considerable volume of evidence of disturbance and of buried material. The nature of the evidence is quite different from the burial vaults referred to above. It is not possible to say what these archaeological remains represent beyond noting that they lie above the outline of a former building. An external burial site cannot be ruled out and care should be exercised in investigating this area.

In addition to the evidence for vaults, tunnels or galleries used for burial there are a number of rectangular outlines which appear to indicate the position of former buildings on the site. One of these lies below the level of the vaults in the area referred to in the previous paragraph (Figure 10). We recommend that the building outlines be compared with any known plans or other historical information in case the buildings can be identified from these sources.

There is some evidence for other structures of unknown function, notably in the NW corner of survey Area 3, the south of Area 2 and immediately north of the area used for burial vaults in survey Area 1.

It is important not to think of the time slices as being completely horizontal site plans due to the variable effect of the changes in transmission speed as the electromagnetic pulses pass through different materials. Nevertheless they have given useful indications of the archaeological material buried beneath the present concrete surface of the Villiers St site.

Further Information

Any queries arising from the content of this report or the GPR survey to which it refers should be addressed in the first instance to Mrs Erica Utsi, Director, Utsi Electronics Ltd.

Utsi Electronics Ltd
Sarek, Newton Road
Harston, Cambridge
CB2 5NZ

Tel: 01223 874318
Fax: 01223 874332

e-mail: enquiries@utsielectronics.co.uk

Appendix A: Figures

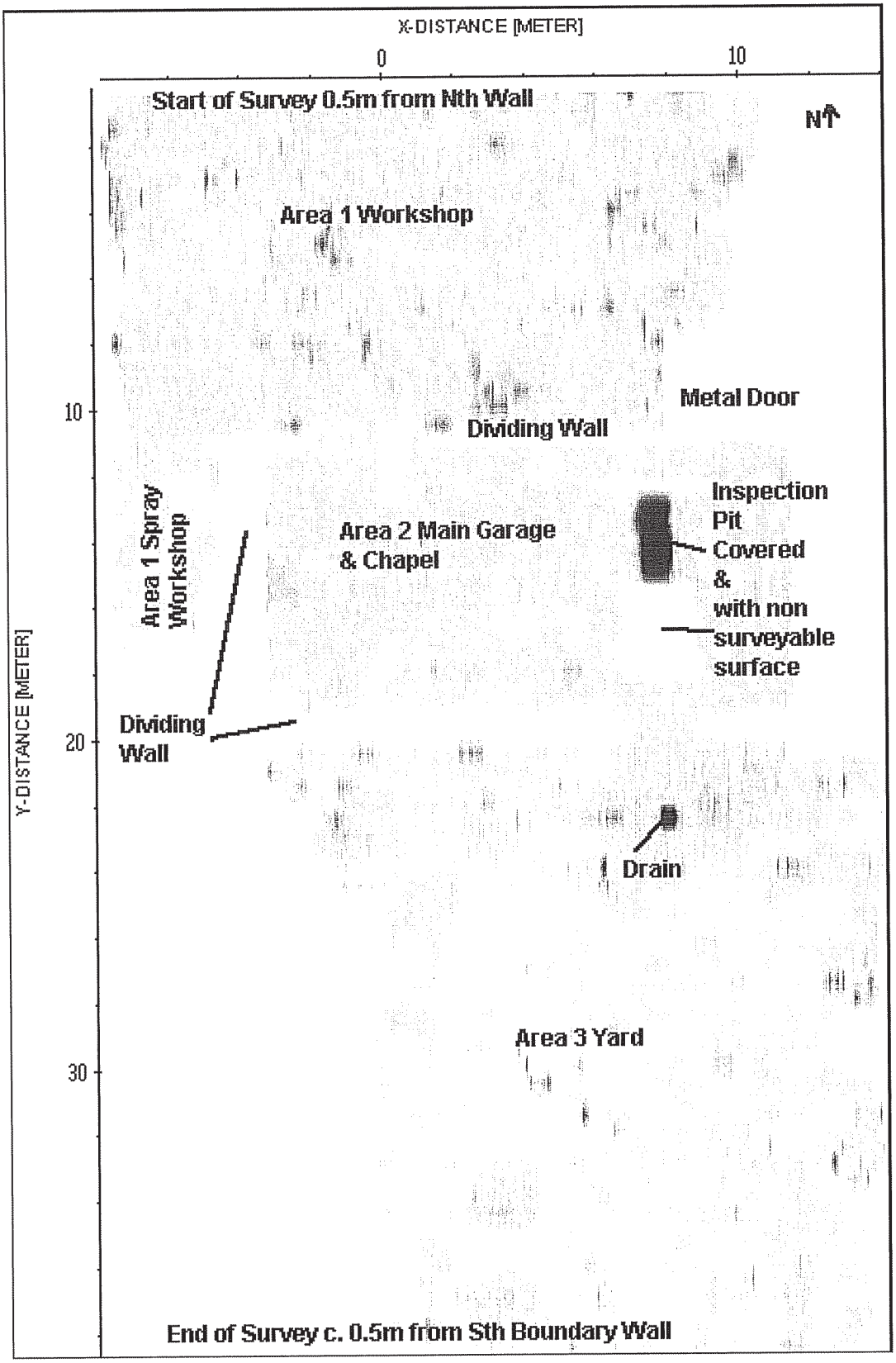


Figure 1: Survey Area (taken from Surface Time Slice)

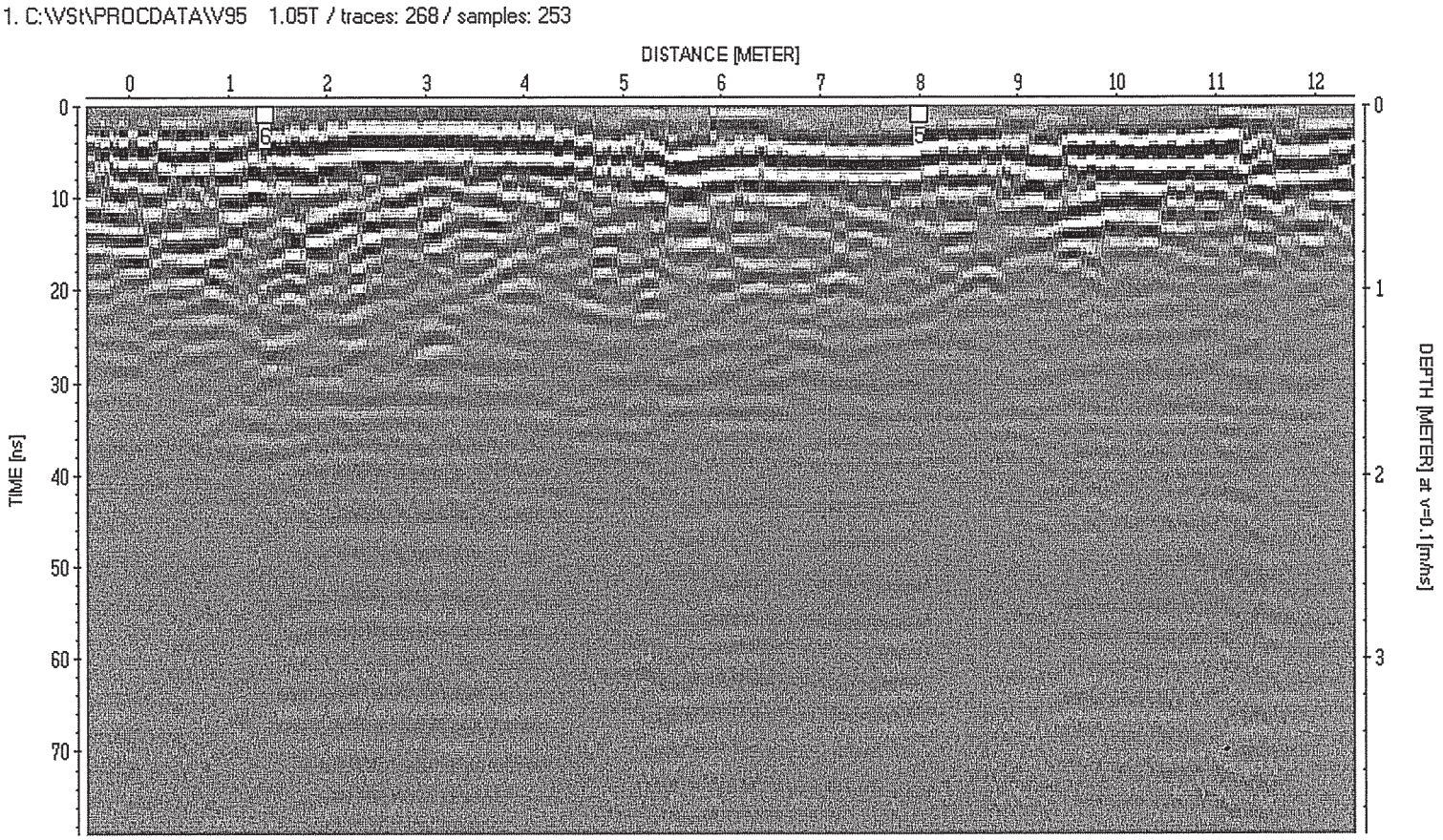


Figure 2: Run 95 (at 37m) showing evidence for extensive underlying features

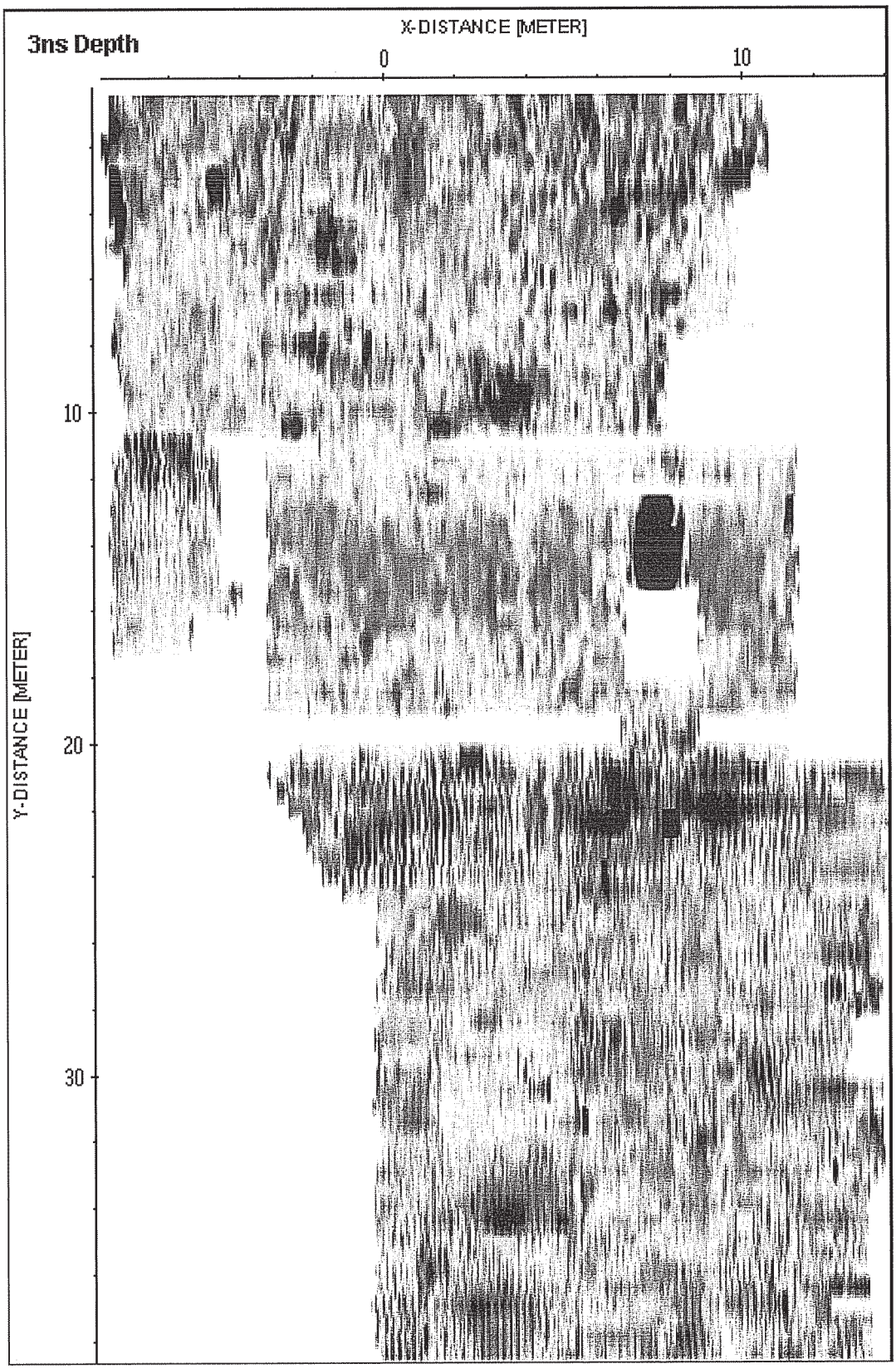


Figure 3: Time Slice at 3ns

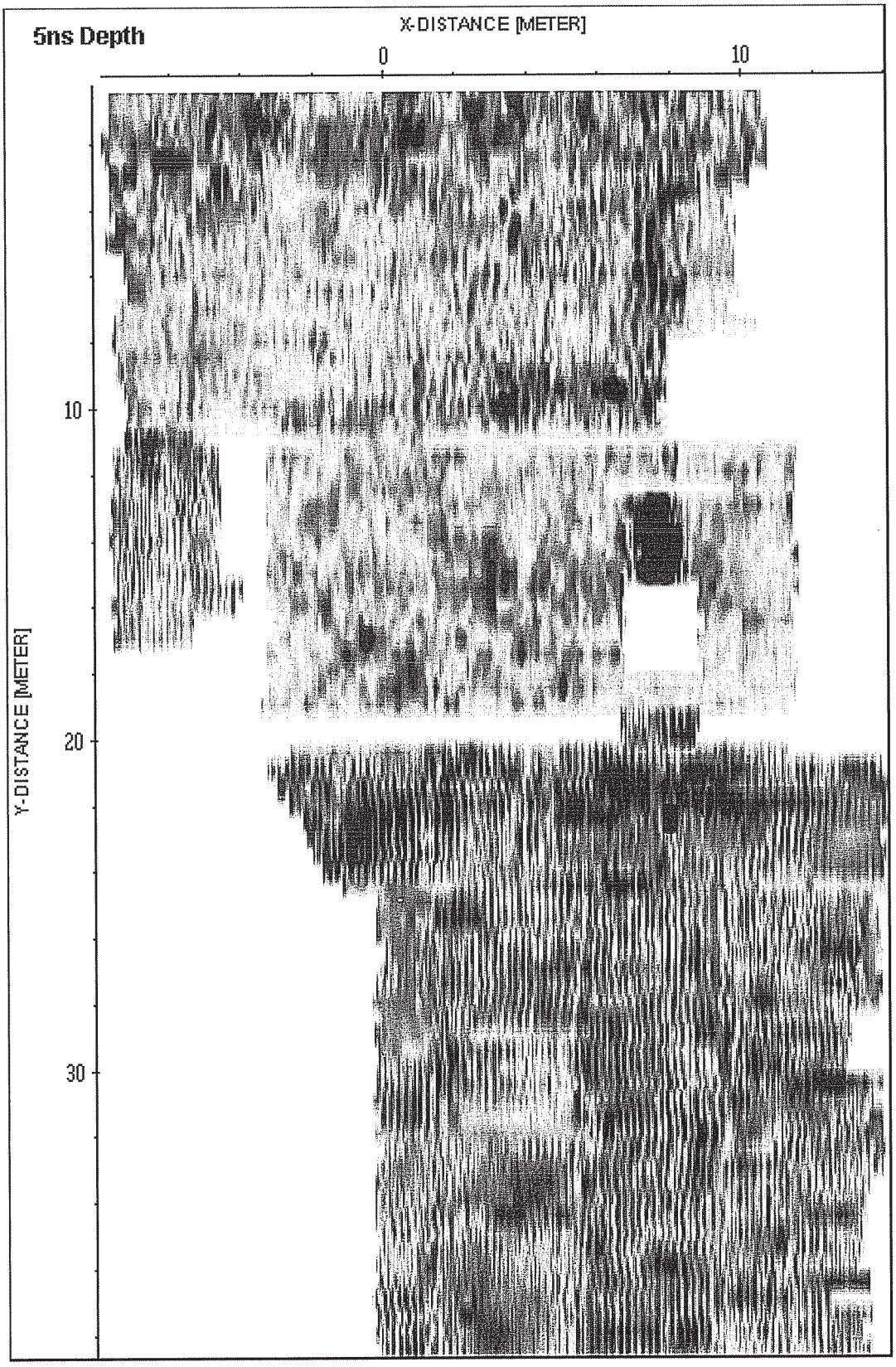


Figure 4: Time Slice at 5ns

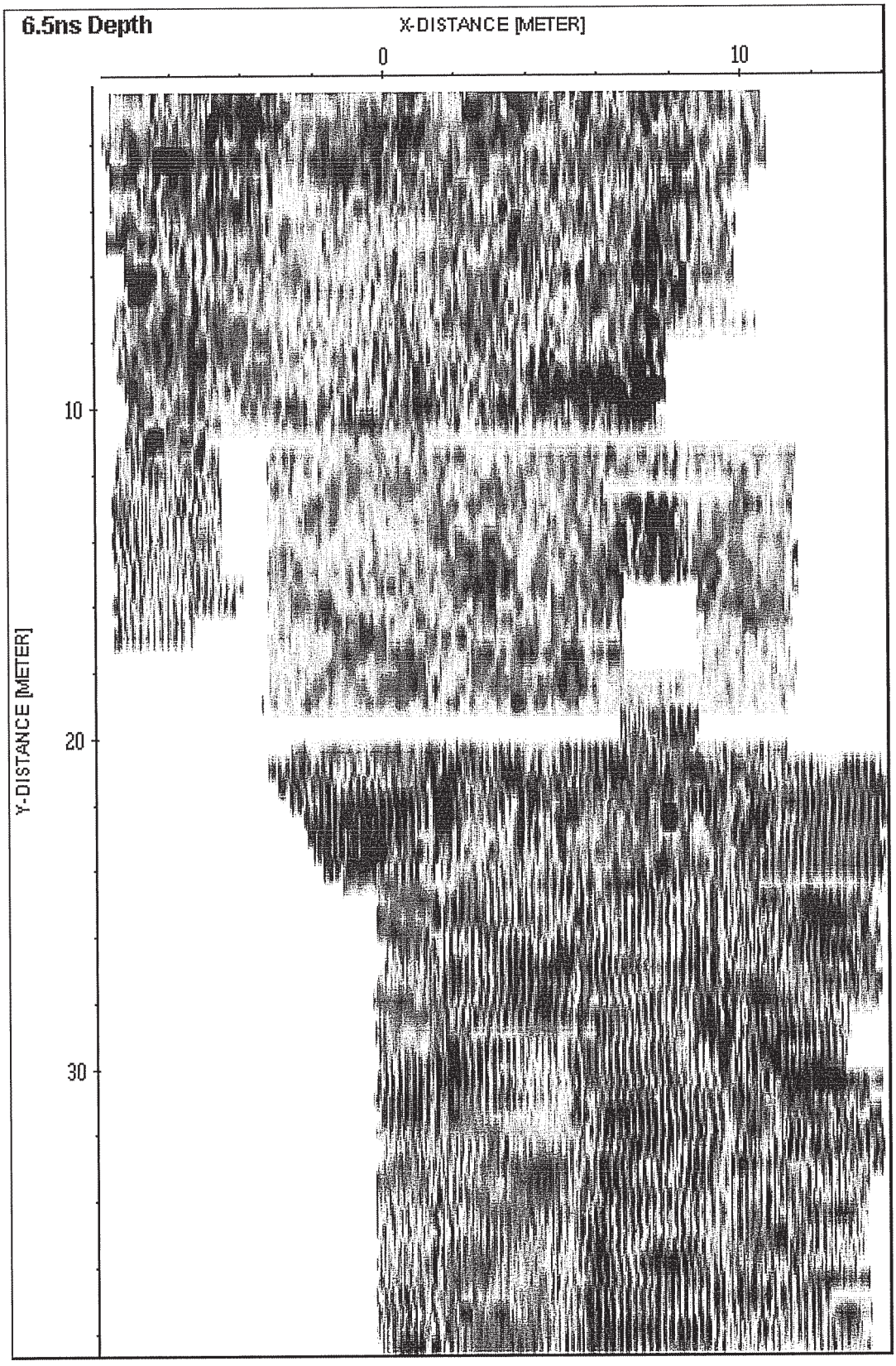


Figure 5: Time Slice at 6.5ns

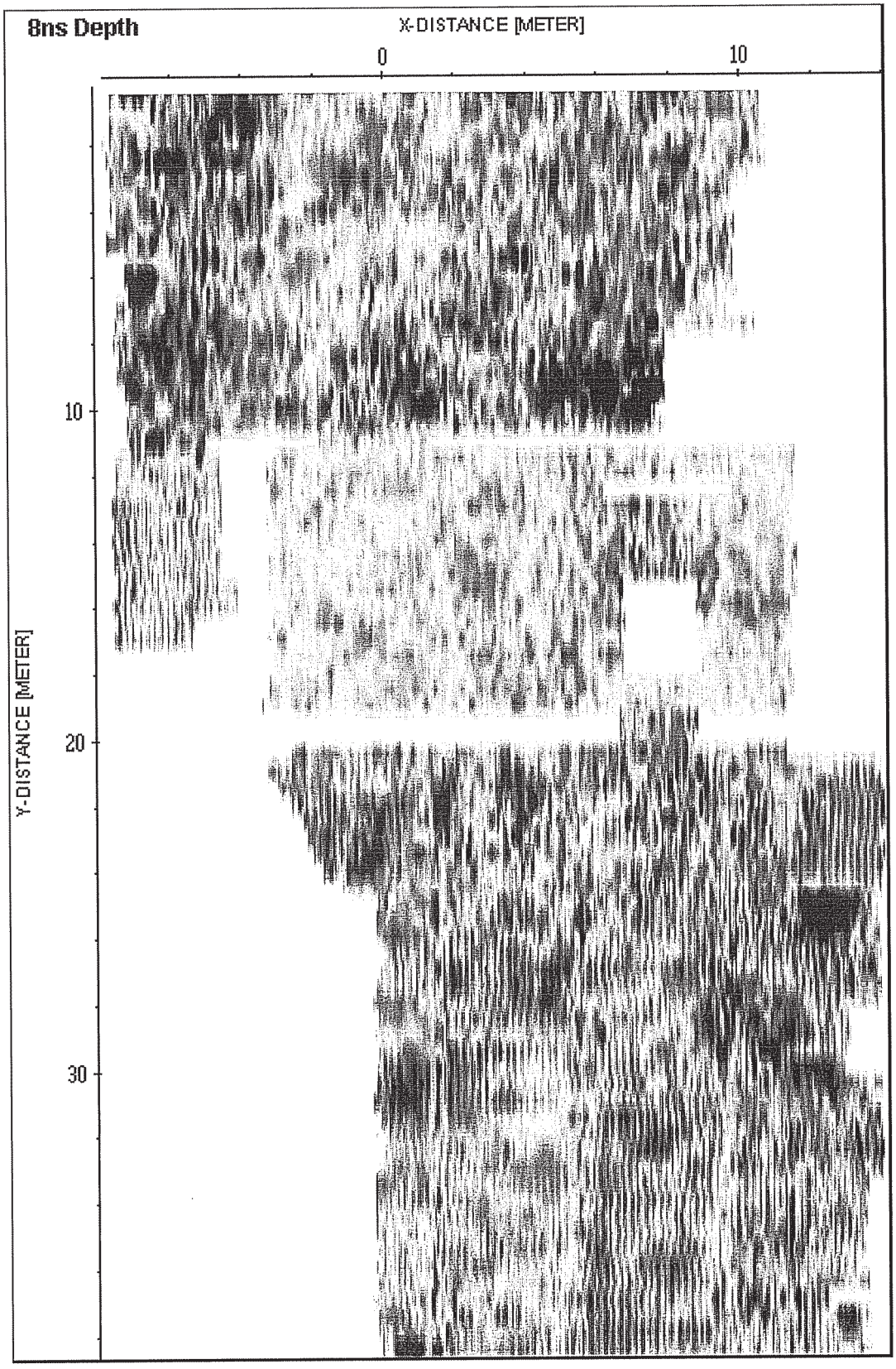


Figure 6: Time Slice at 8ns

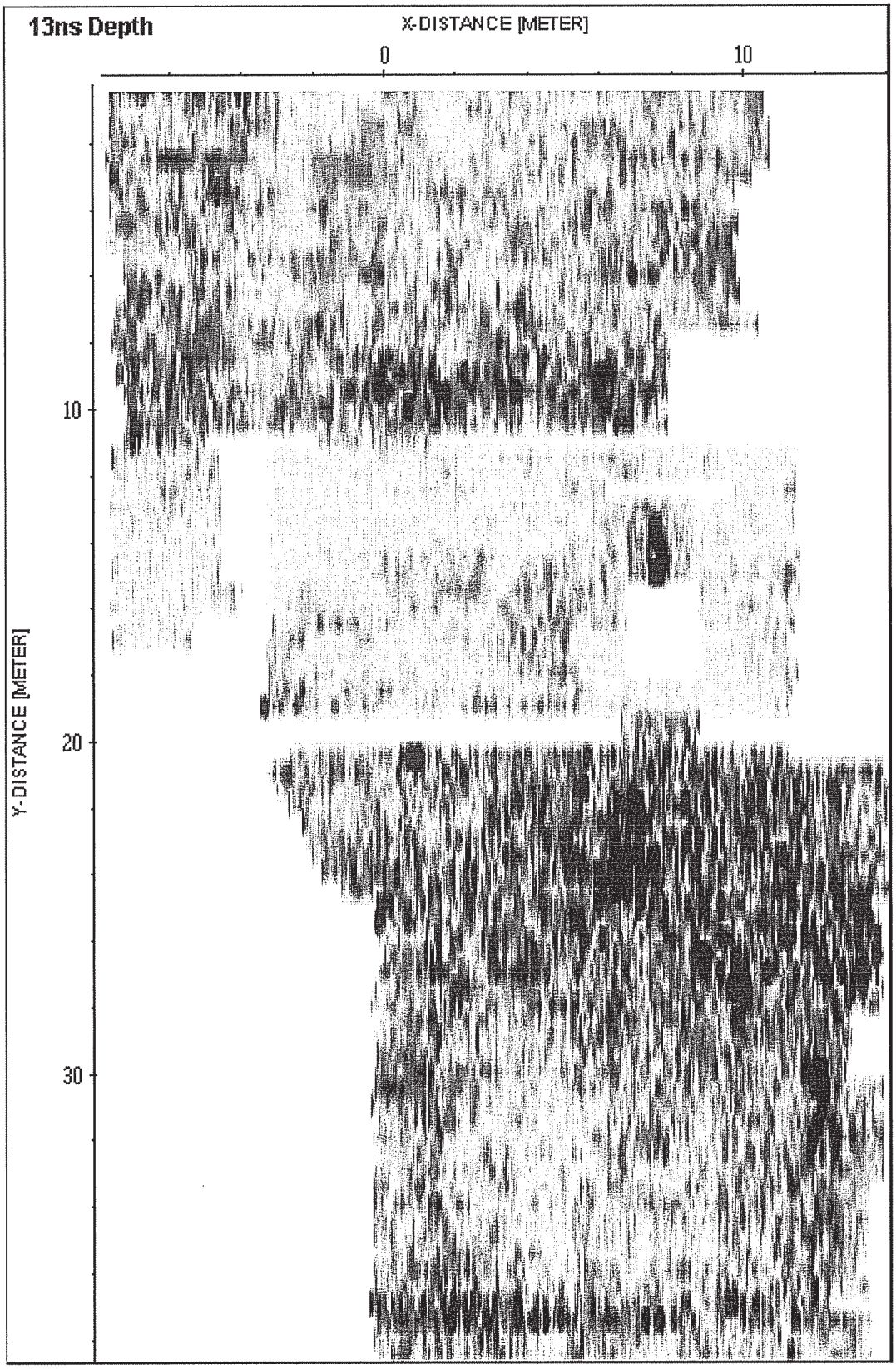


Figure 7: Time Slice at 13ns

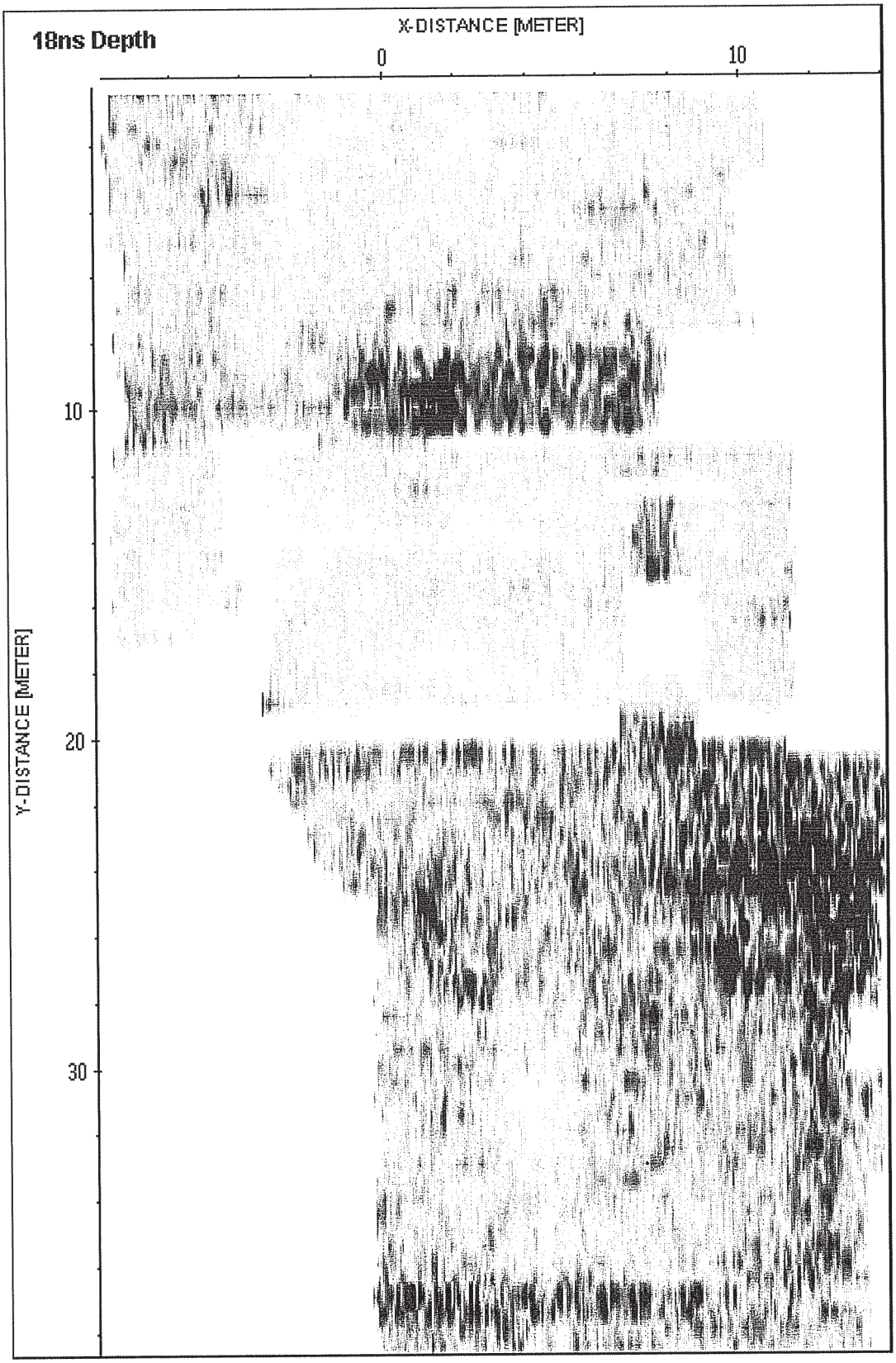


Figure 8: Time Slice at 18ns

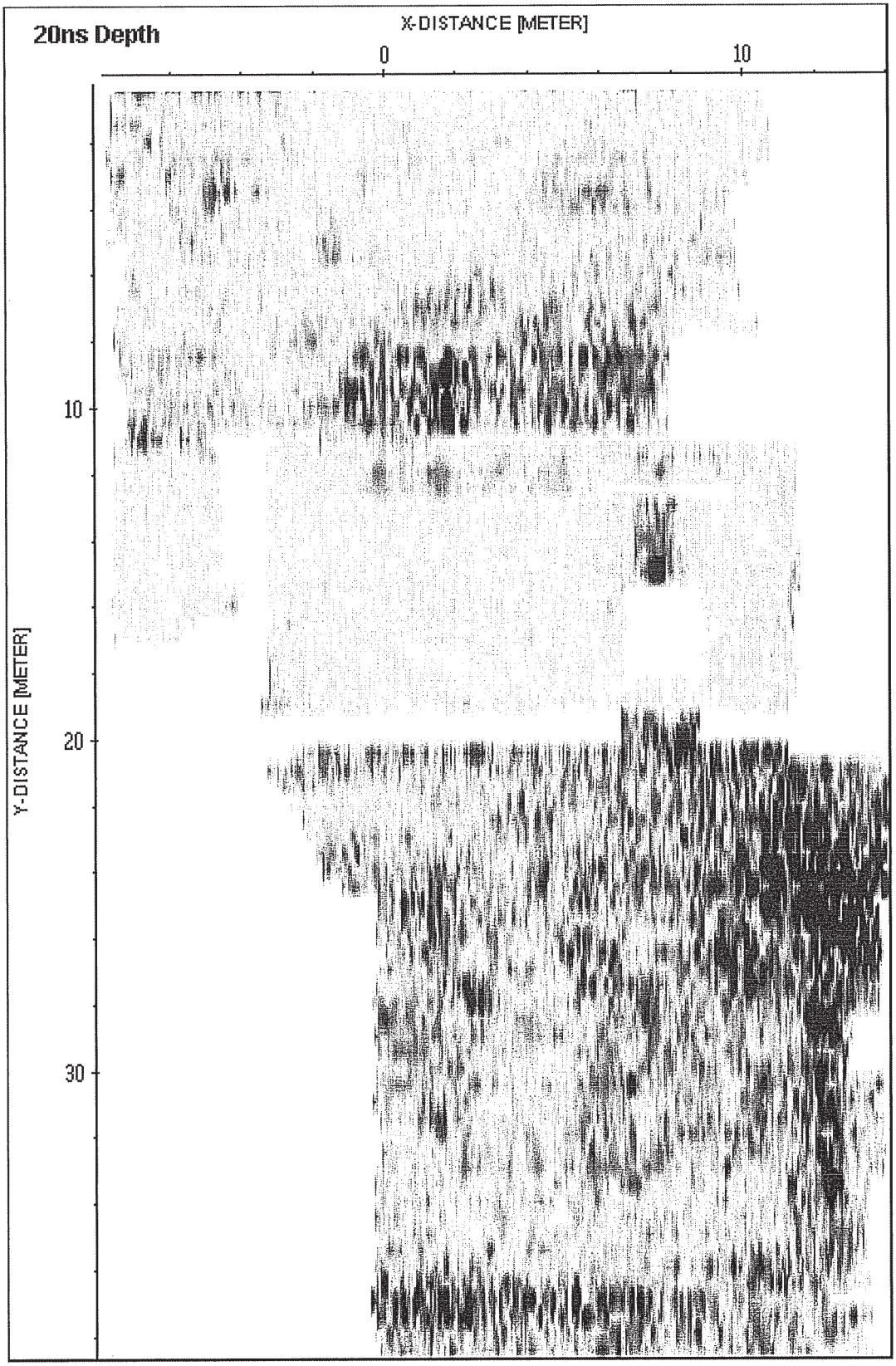


Figure 9: Time Slice at 20ns

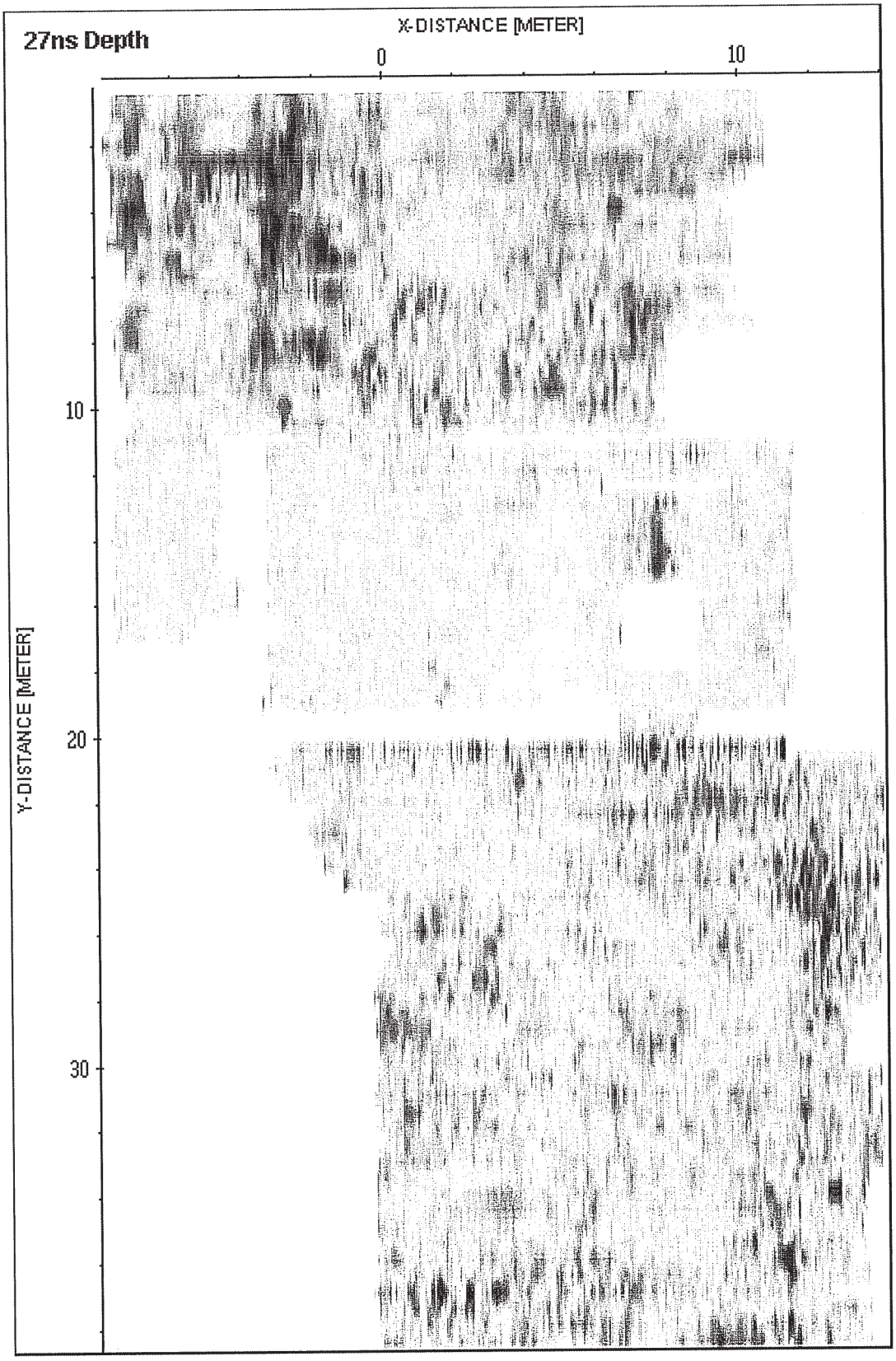


Figure 10: Time Slice at 27ns

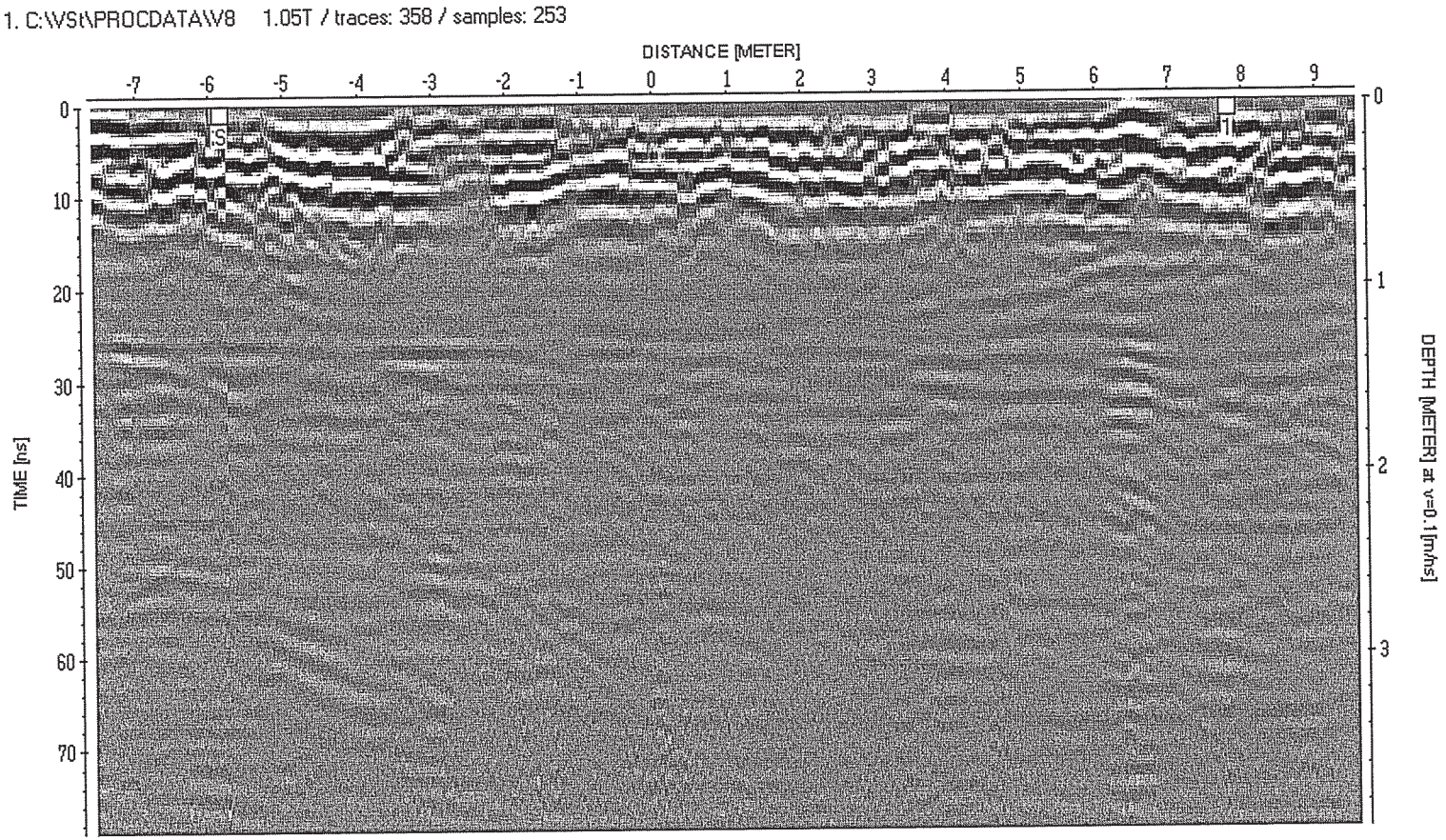


Figure 11: Run 8 (at 4m) showing an Arch at 6.6m distance

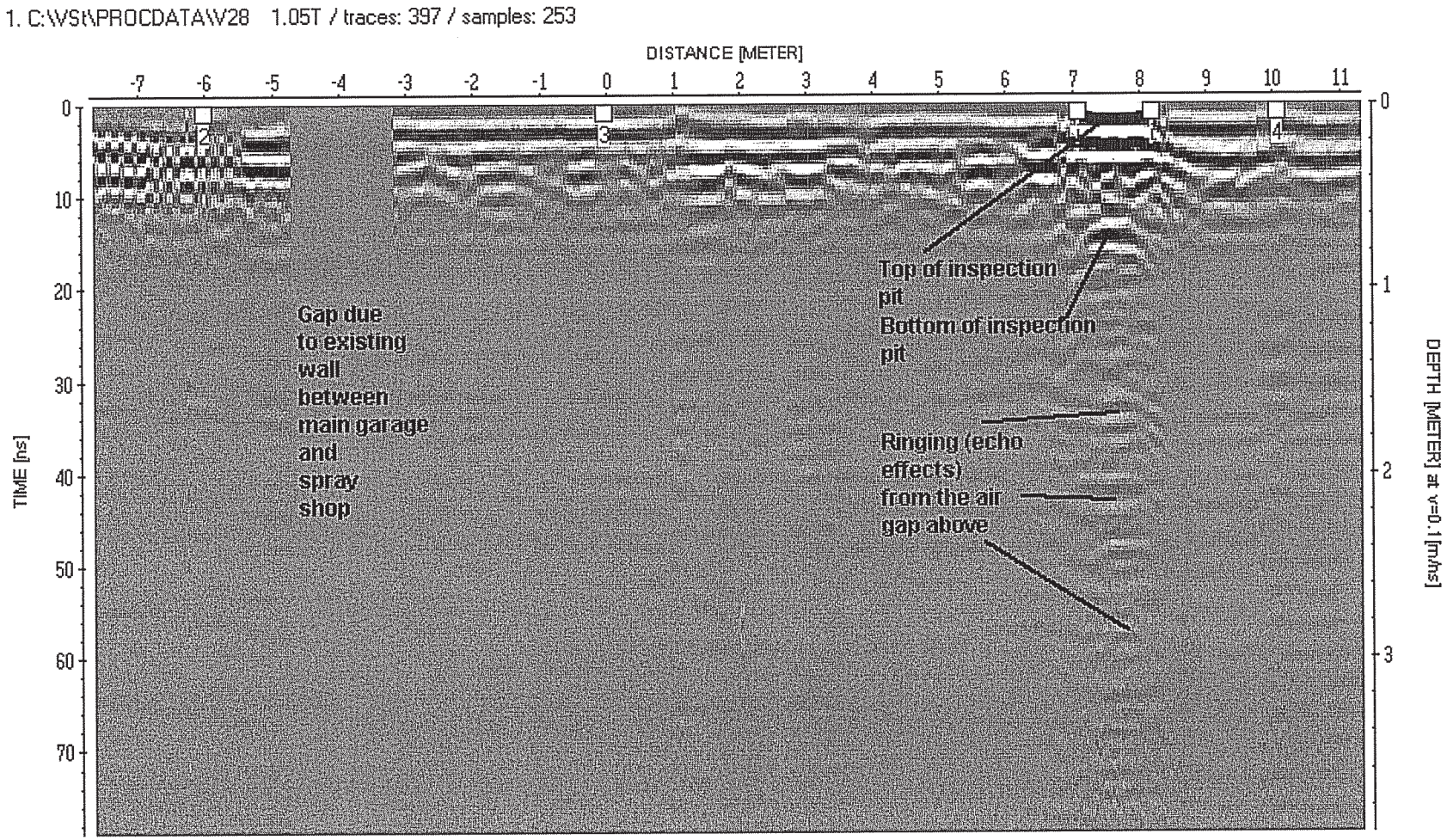


Figure 12: Run 28 showing the echo effects from the void of the Inspection pit ("i" to "i")

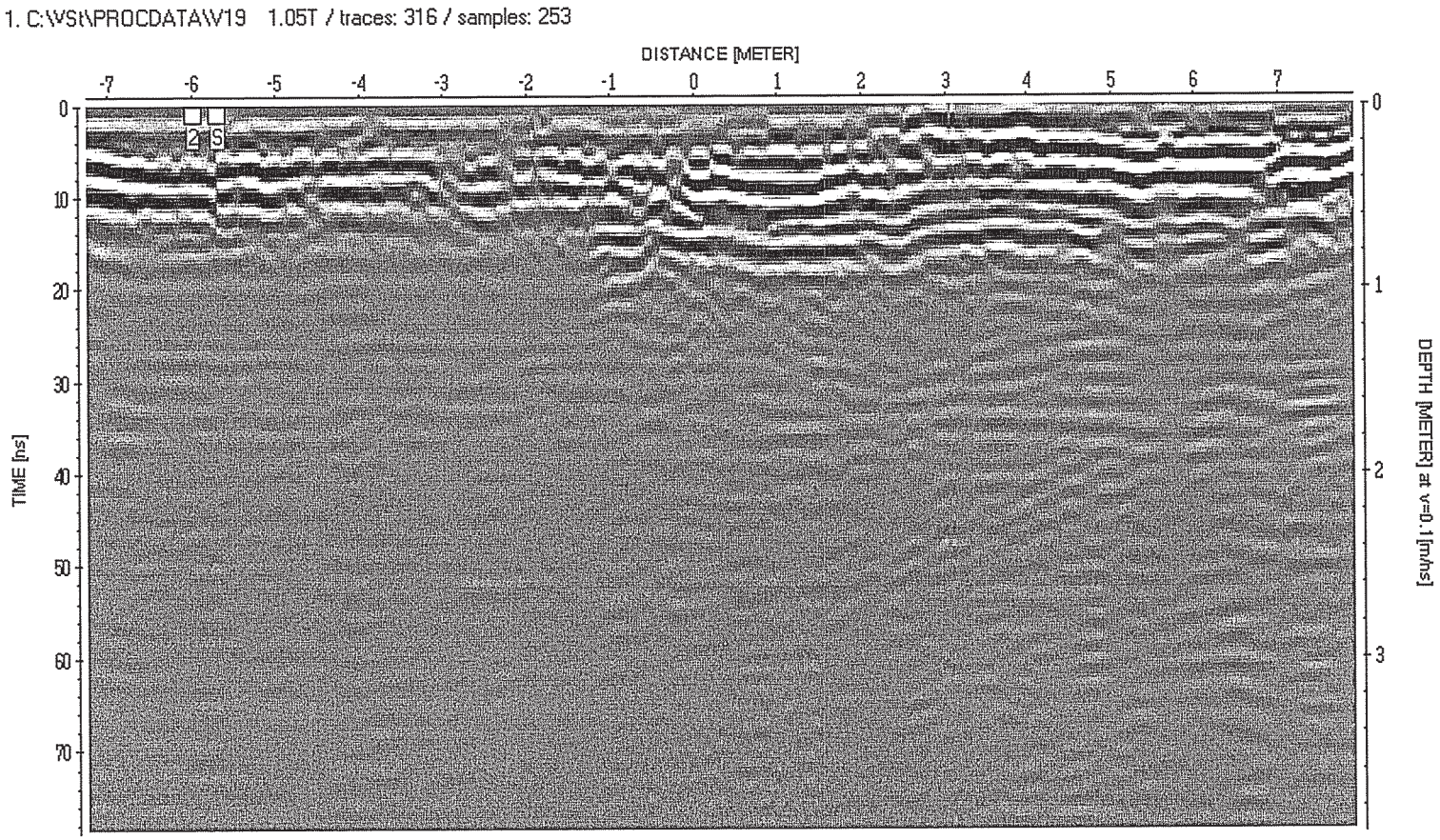


Figure 13: Run 19 (at 9.5m) showing a length of level homogeneous material and a possible corner

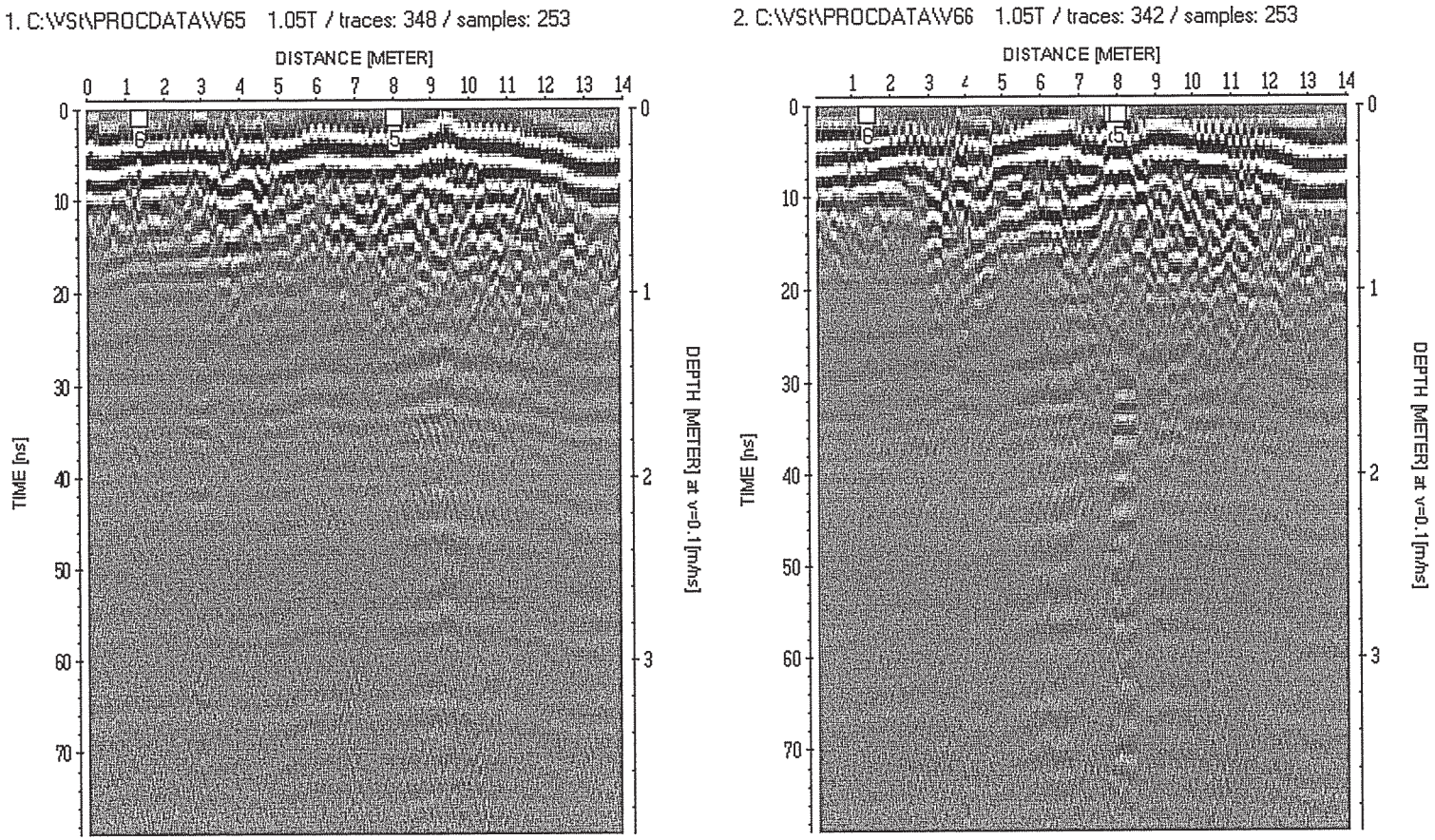


Figure 14: Extracts from Runs 65 & 66 showing possible former building remains with galleries below

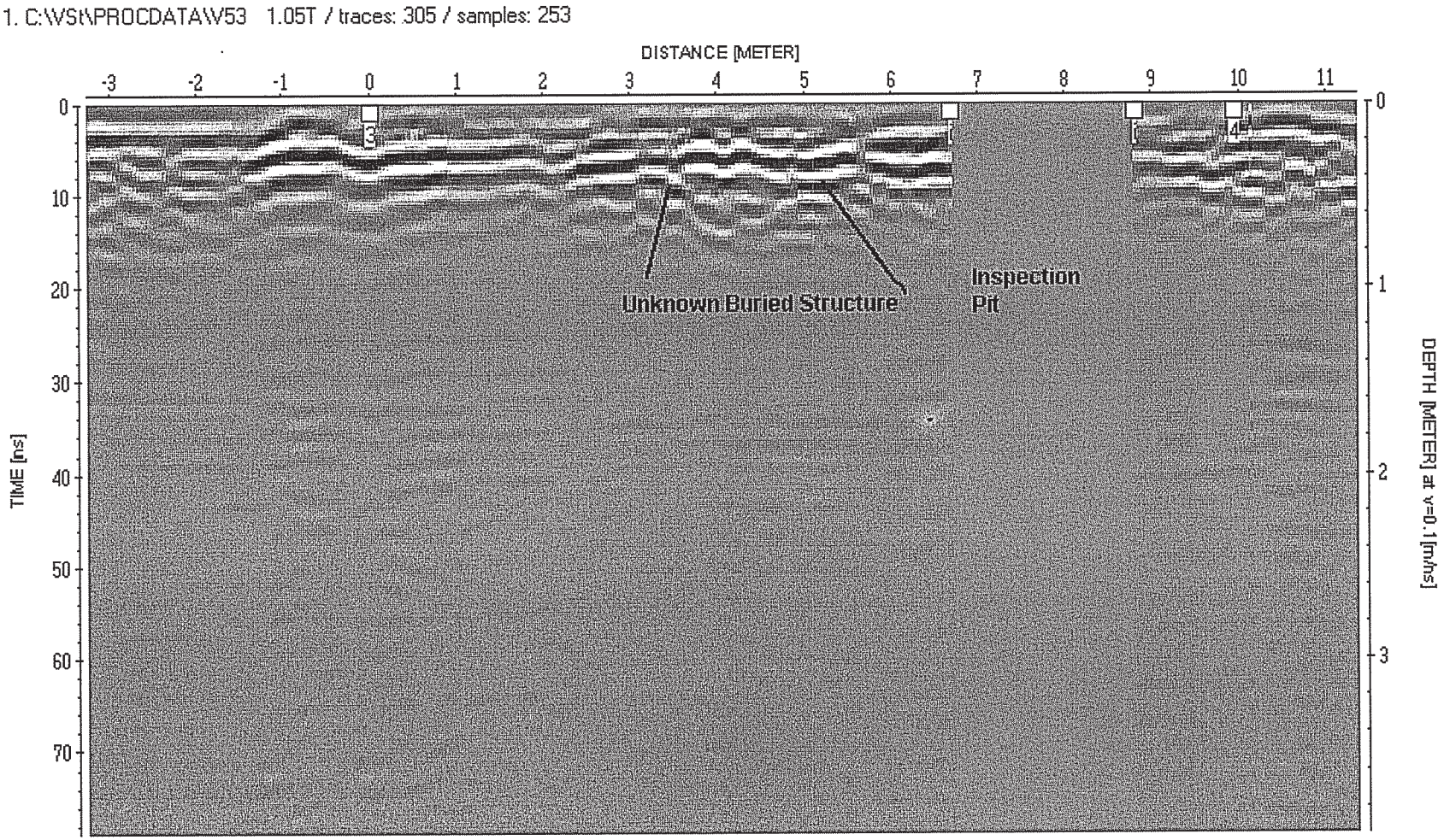


Figure 15: Run 53 (at 17.5m) showing Buried Feature of unknown Function

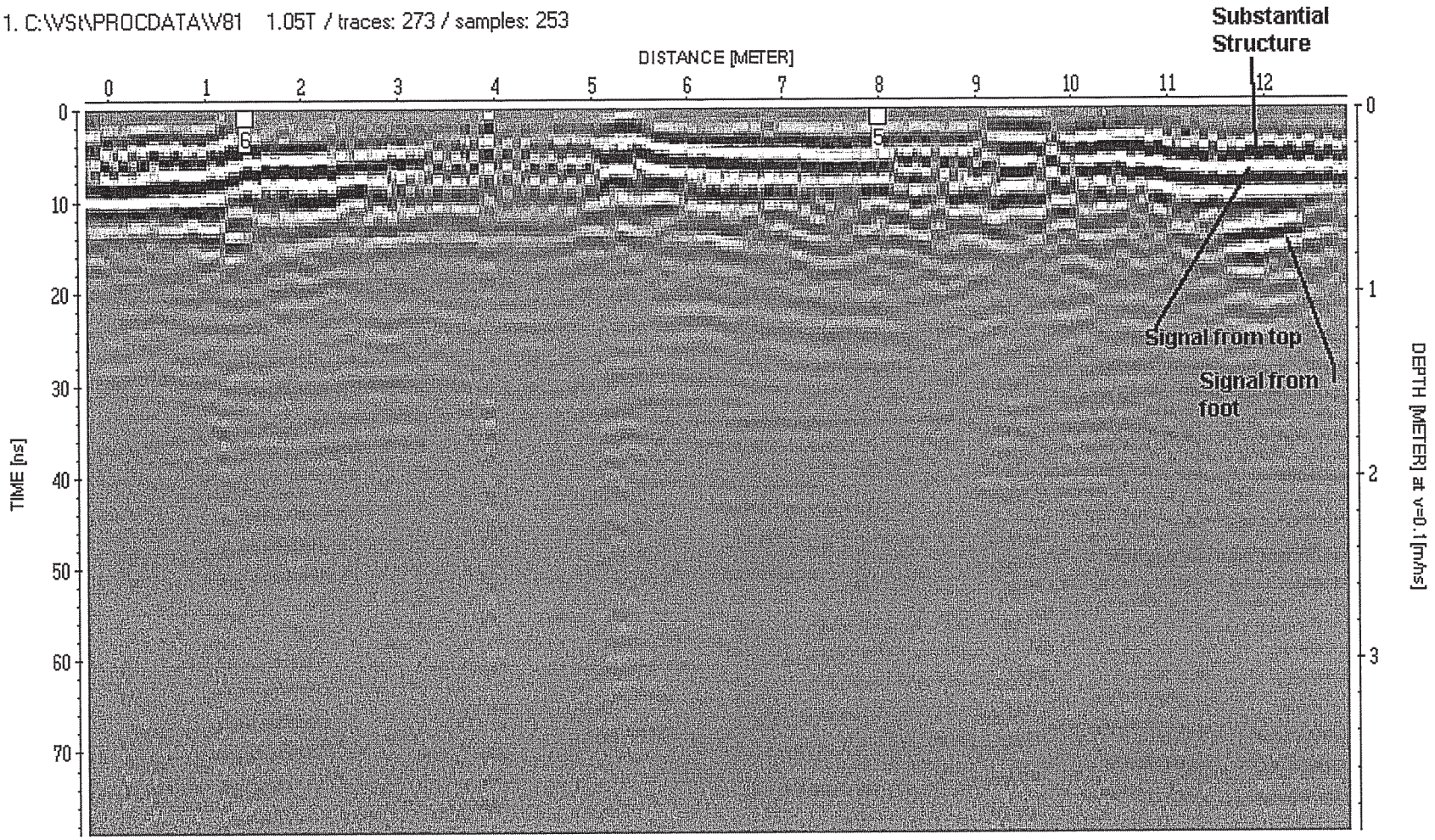


Figure 16: Run 81 (at 30m) showing a substantial buried feature

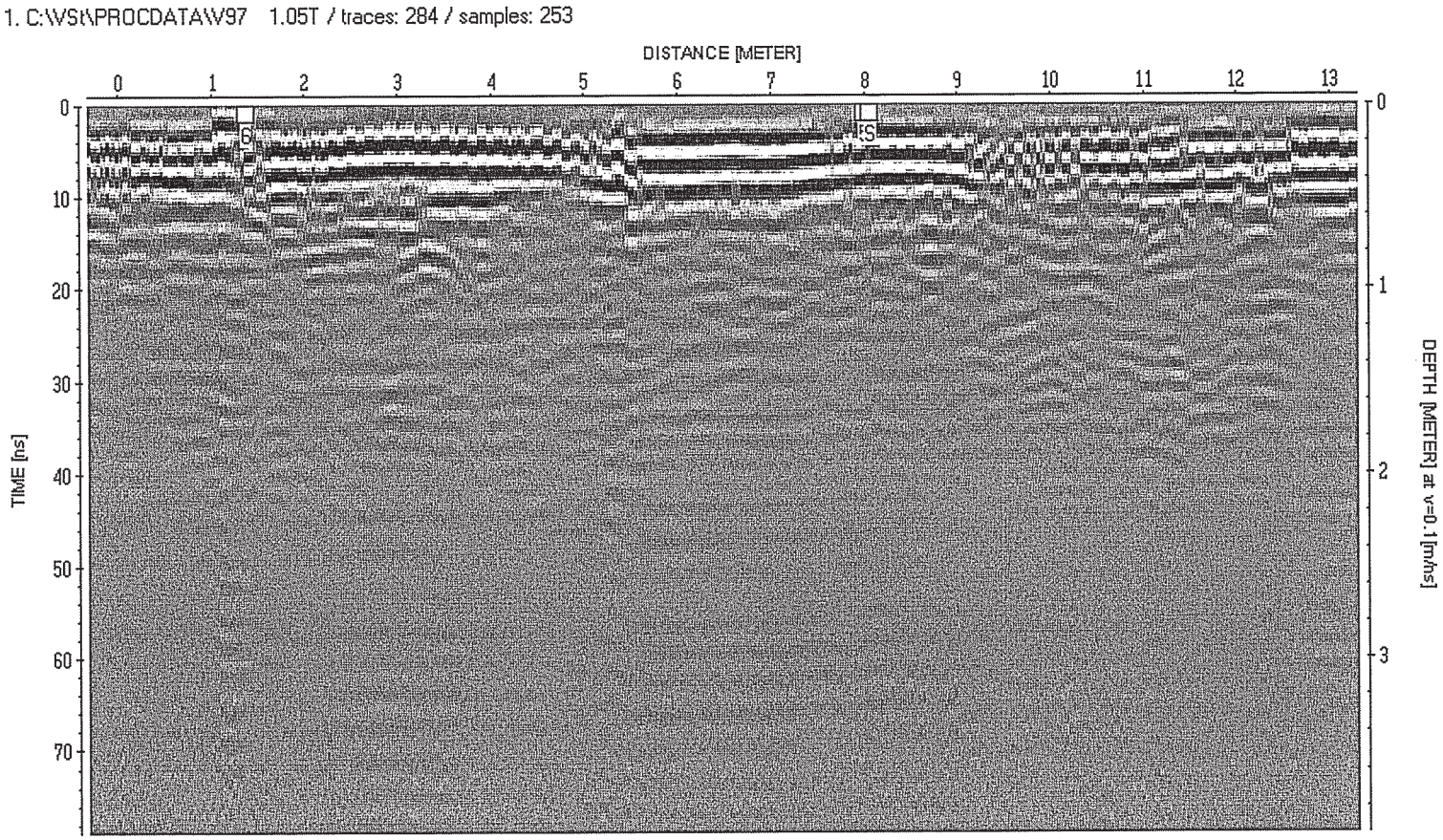


Figure 17: Run 97 (at 38m) showing buried objects to the East and possible vaults to the West

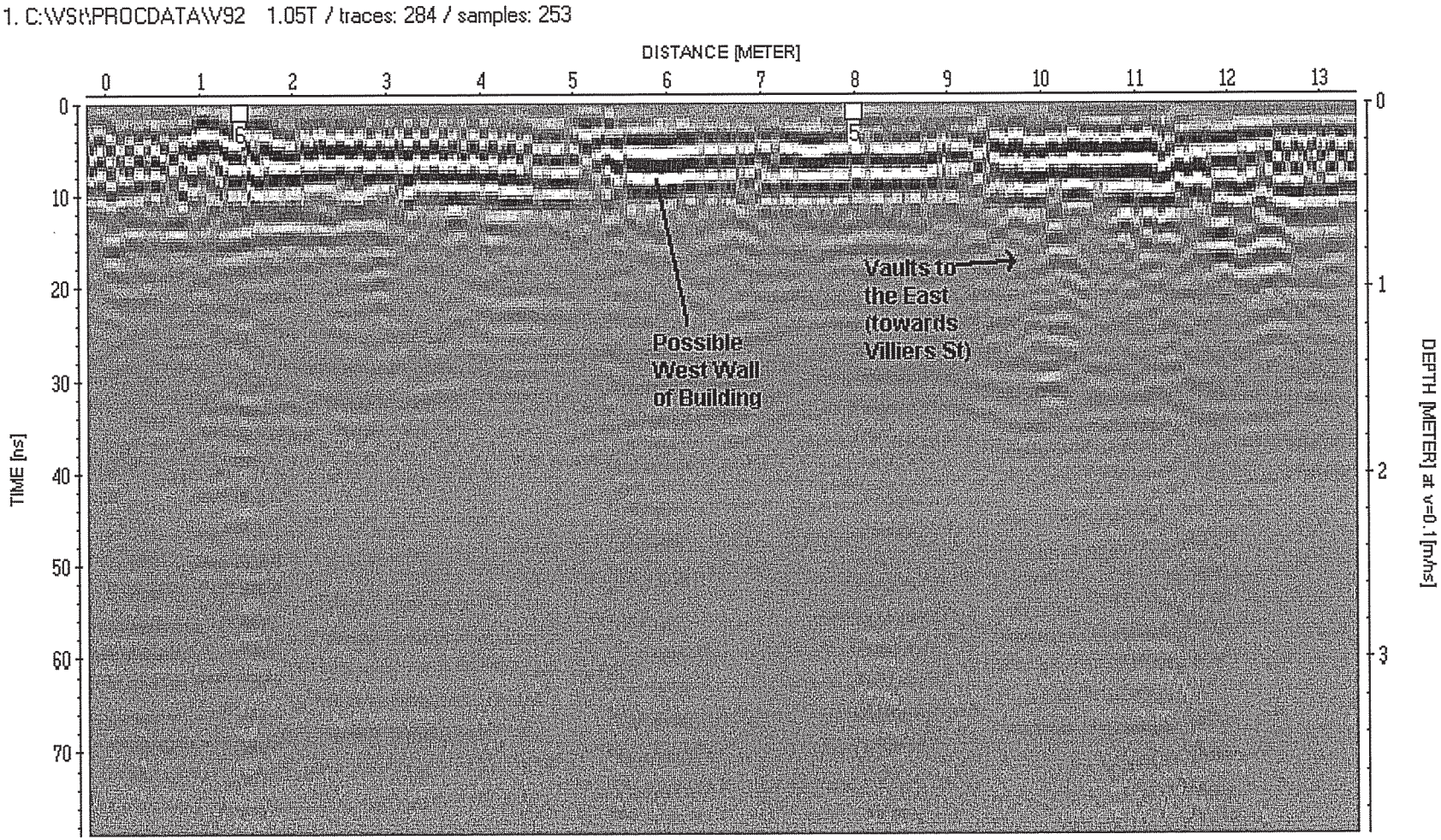


Figure 18: Run 92 (at 35.5m) showing relative positions of possible wall & burial vaults

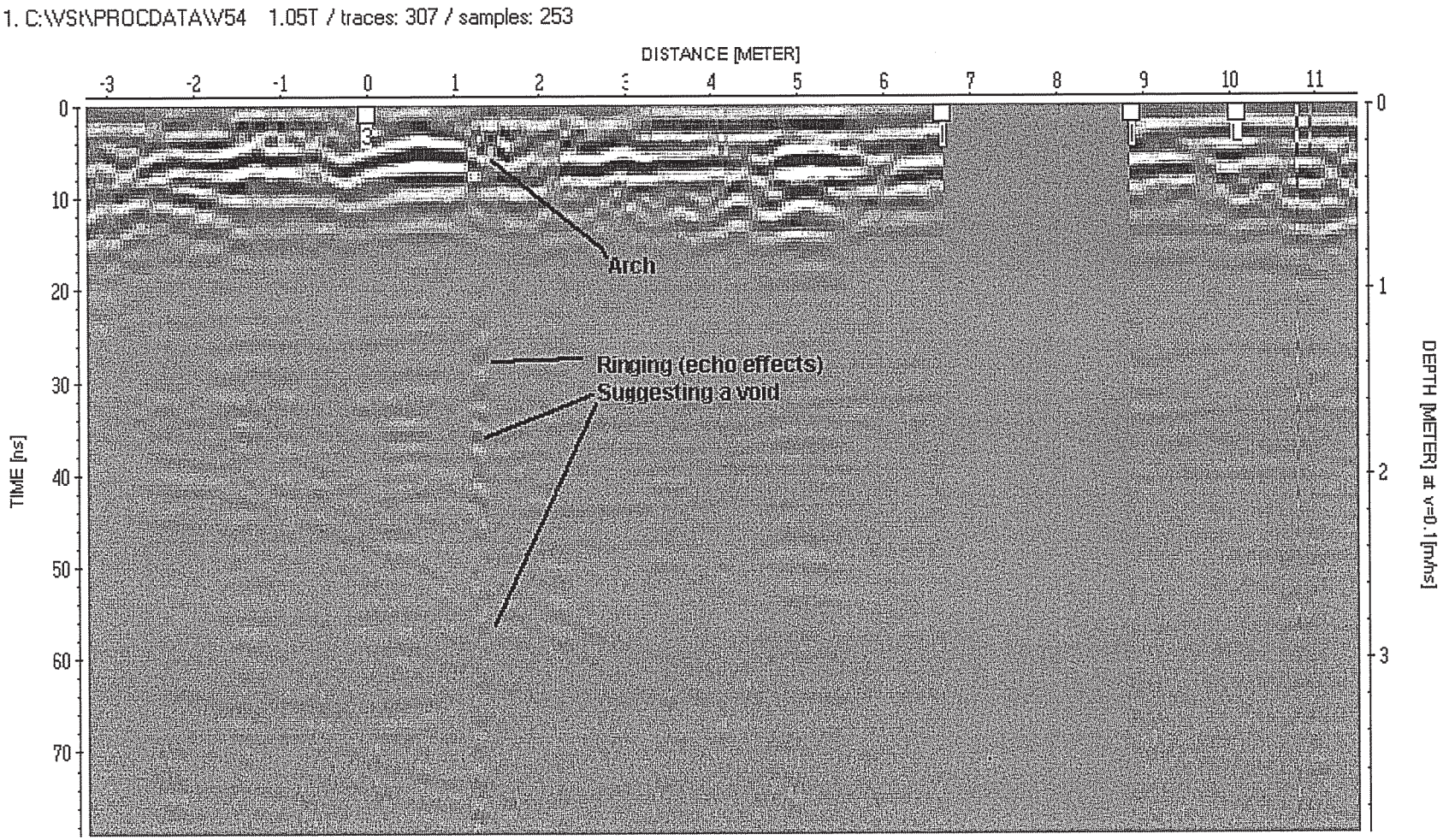


Figure 19: Run 54 (at 18m) showing evidence of a vault at the Southern end of Area 2

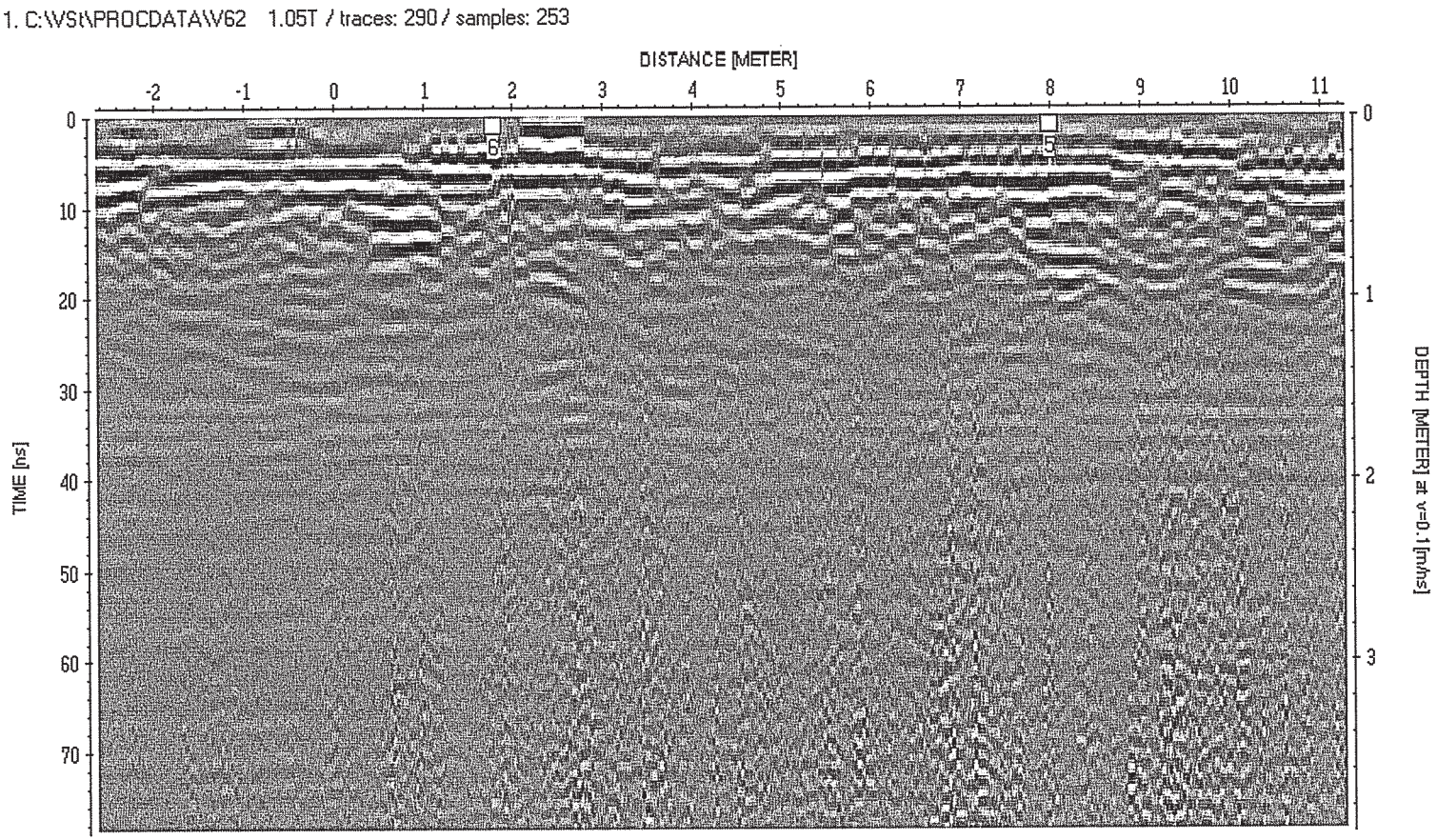


Figure 20: Run 62 (at 20.5m) showing a variety of buried structures along the northern edge of Area 3

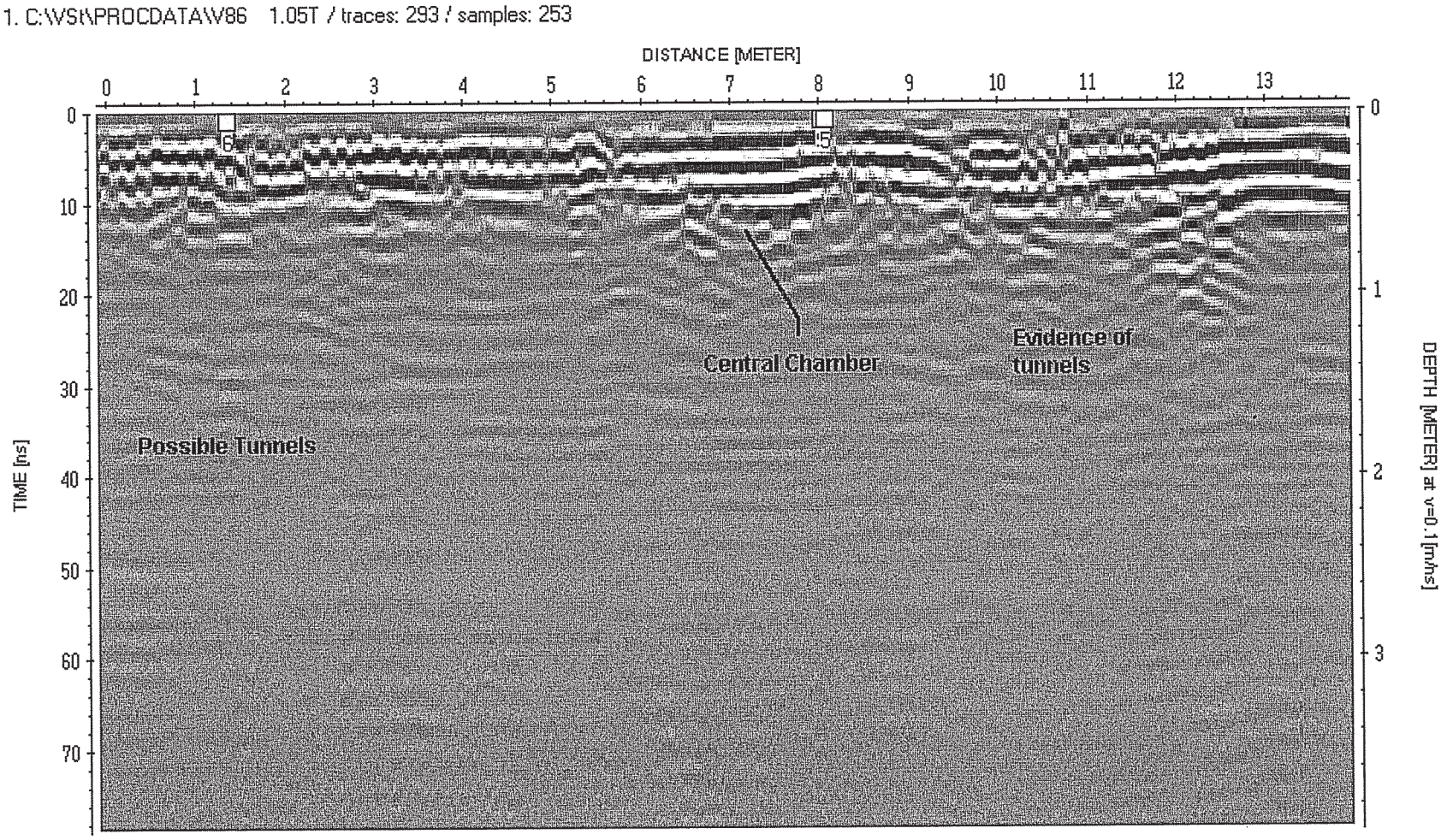


Figure 21: Run 86 (at 32.5m) showing the variation in possible burial structures

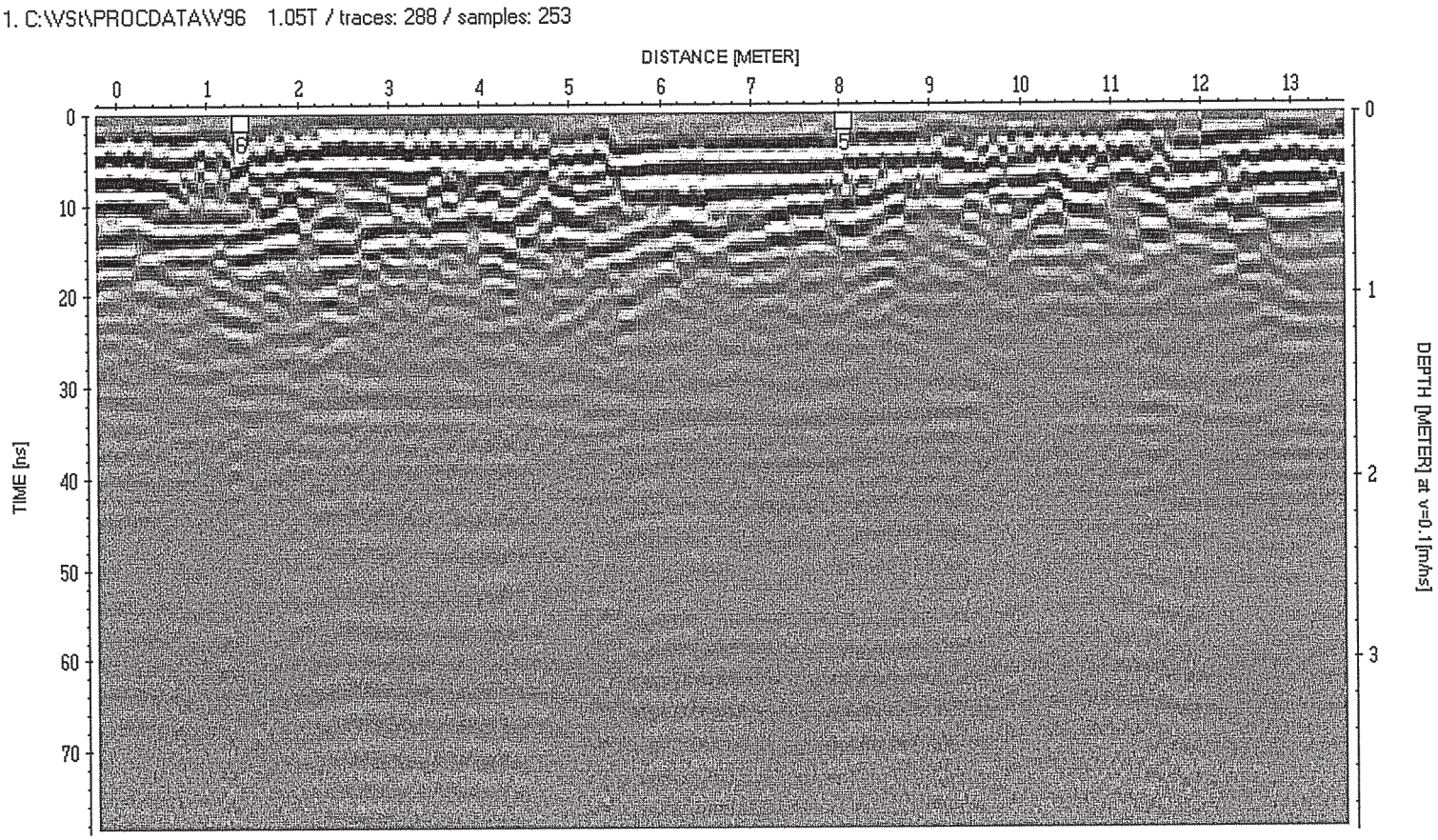


Figure 22: Run 96 (at 37.5m) showing separation between the West & East tunnel complexes

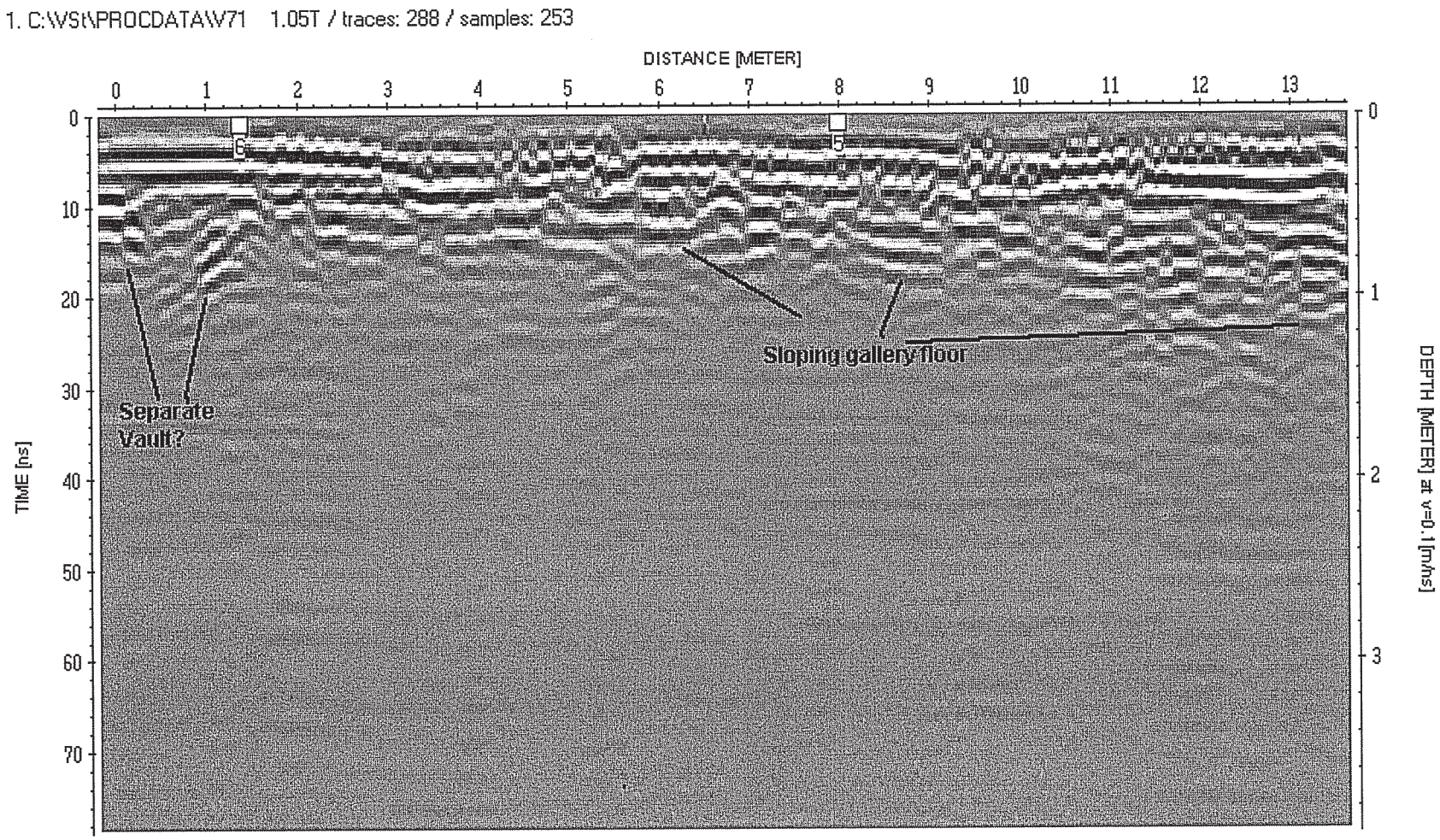


Figure 23: Run 71 (at 25m) showing a cross section of Area 3

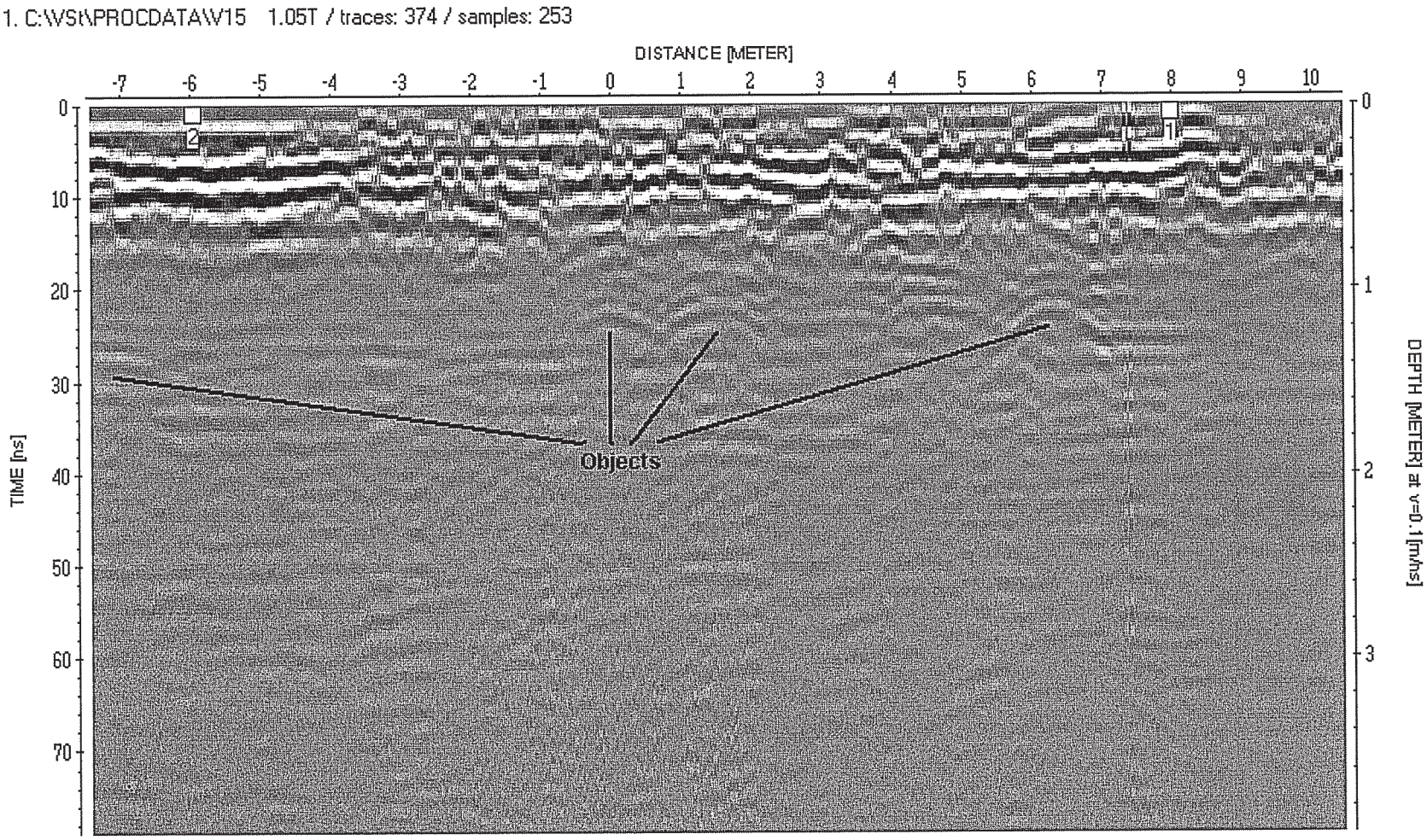
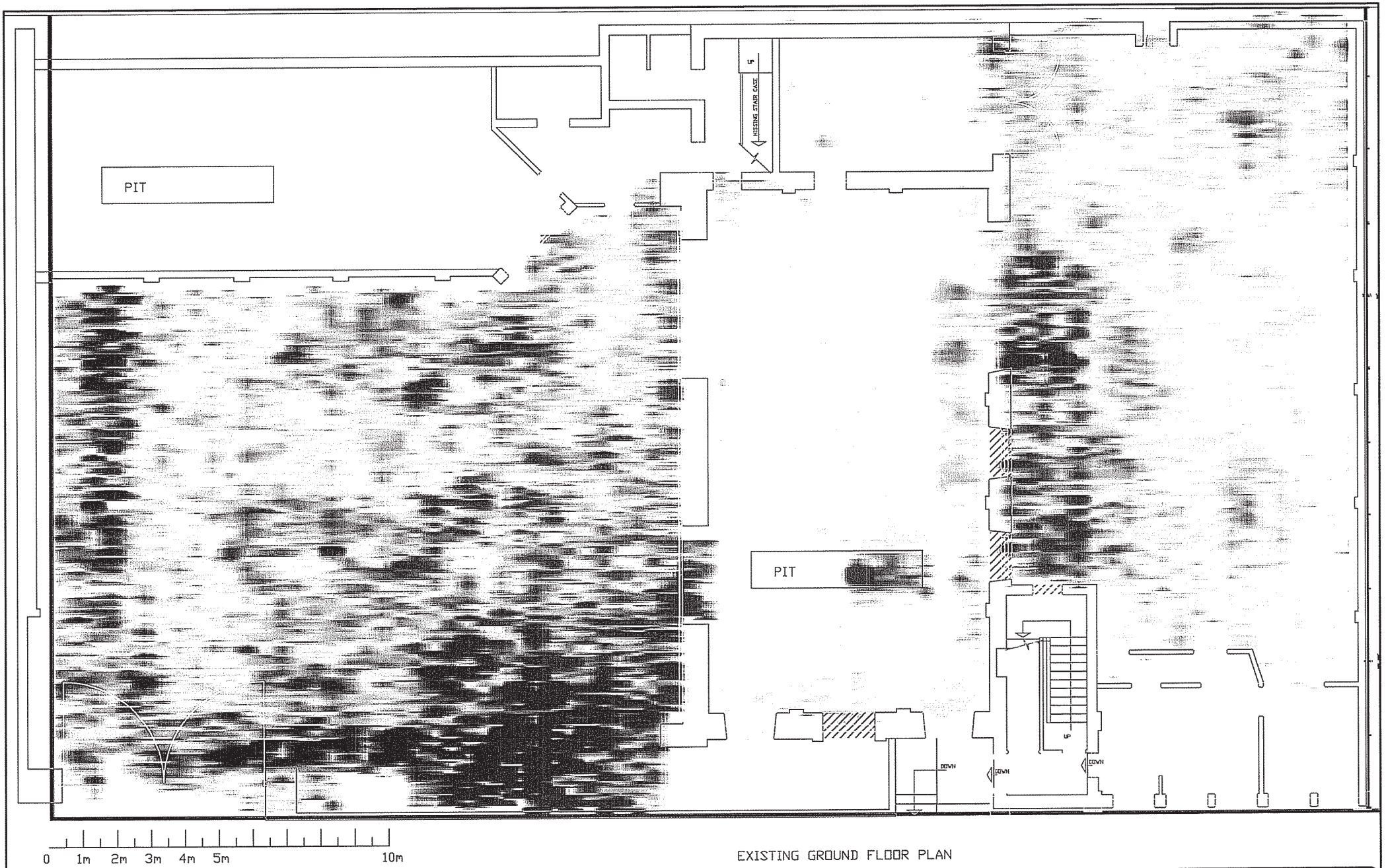


Figure 24: Run 15 (at 7.5m) showing unidentified objects

APPENDIX 4

GPR OVERLAY &

CHAPEL LAYOUT



0 1m 2m 3m 4m 5m 10m

EXISTING GROUND FLOOR PLAN

Notes:

BLOCKED UP OPENINGS

N

FIGURED DIMENSIONS TO BE USED IN PREFERENCE TO SCALE.

ALL DIMENSIONS MUST BE OBTAINED FROM OR CHECKED ON SITE.

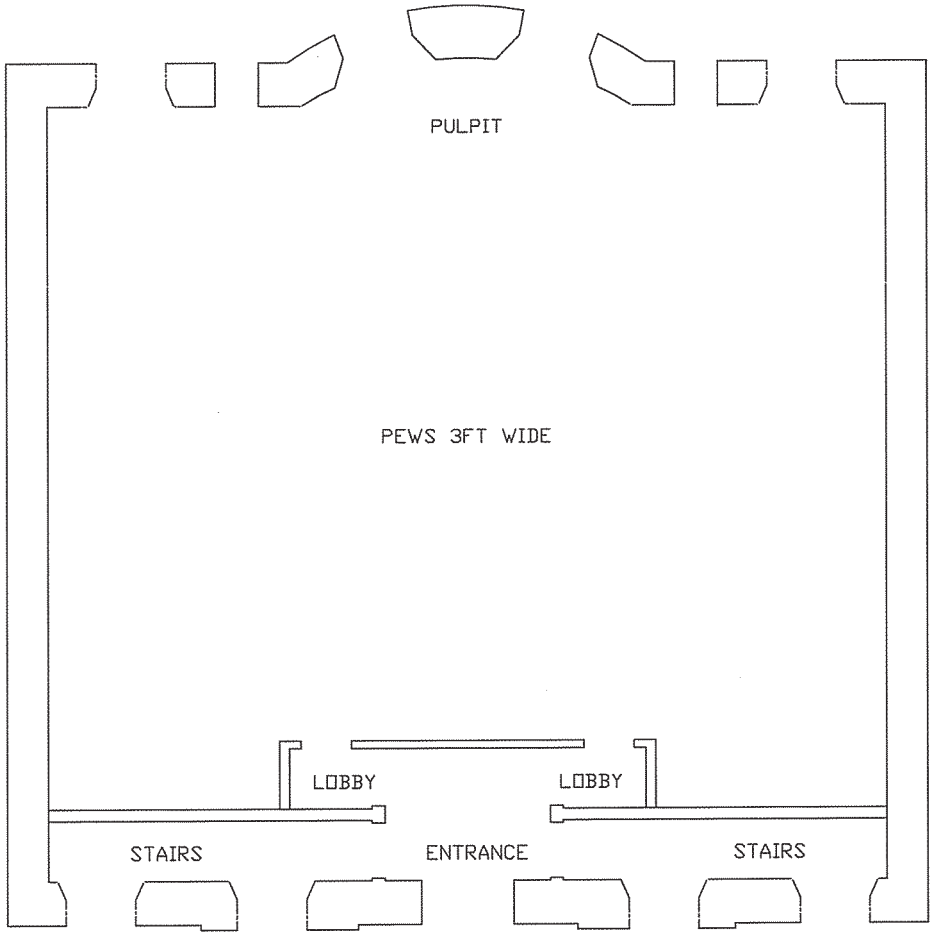
ANY DISCREPANCIES MUST BE REPORTED.

ILLUSTRATIONS ARE FOR THE BENEFIT OF THE ADDRESSEE ONLY.

Ian Farmer Associates
Geotechnical and Environmental Specialists
Unit 1, Bamburgh Court, Team Valley Trading Estate
Gateshead, NE11 0TX
Tel: 0191 482 8500
E.Mail: newcastle@ianfarmerassociates.co.uk

Date: 12.09.06
Scale: 1:100
Sheet Size: A3
Drg No: 9 of 11

Title: GPS AT 20ns OVERLAY OVER GROUND FLOOR
Project:
EXISTING DRAWINGS OF
12-14 VILLIERS ST
SUNDERLAND
TYNE/WEAR
SR1 1HA



Notes:

BLOCKED UP OPENINGS

N

FIGURED DIMENSIONS TO BE USED IN PREFERENCE TO SCALE.

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Ian Farmer Associates
Geotechnical and Environmental Specialists
Unit 1, Bamburgh Court, Team Valley Trading Estate
Gateshead, NE11 0TX
Tel: 0191 482 8500
E.Mail: newcastle@ianfarmerassociates.co.uk

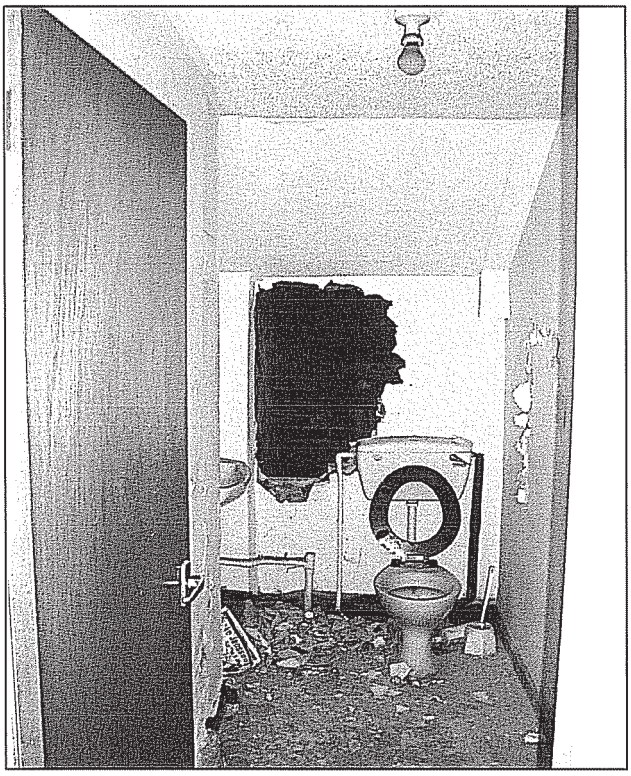
Date: 12.09.06
Scale: 1:100
Sheet Size: A3
Drg No: 10 of 11

Title: REPRODUCTION OF VICTORIAN SKETCH
Project:
EXISTING DRAWINGS OF
12-14 VILLIERS ST
SUNDERLAND
TYNE/WEAR
SR1 1HA

APPENDIX 5

PHOTOGRAPHIC RECORD

Fig. A5.1 Access to the vaults through the former staff toilet



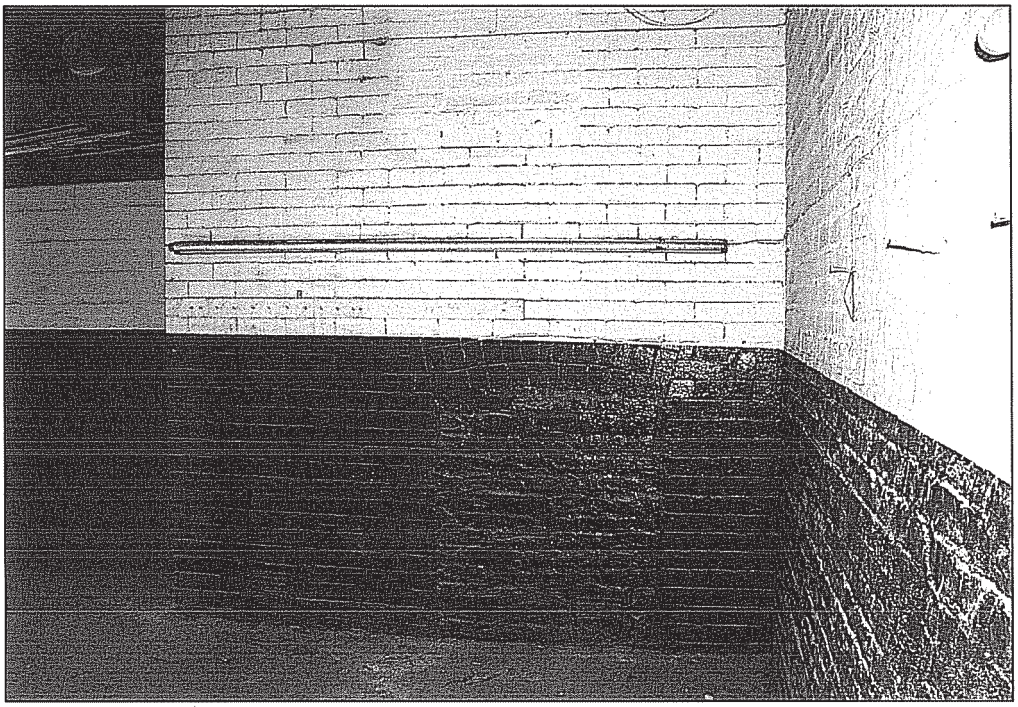


Fig. A5.2 Bricked-up archway in western protrusion wall

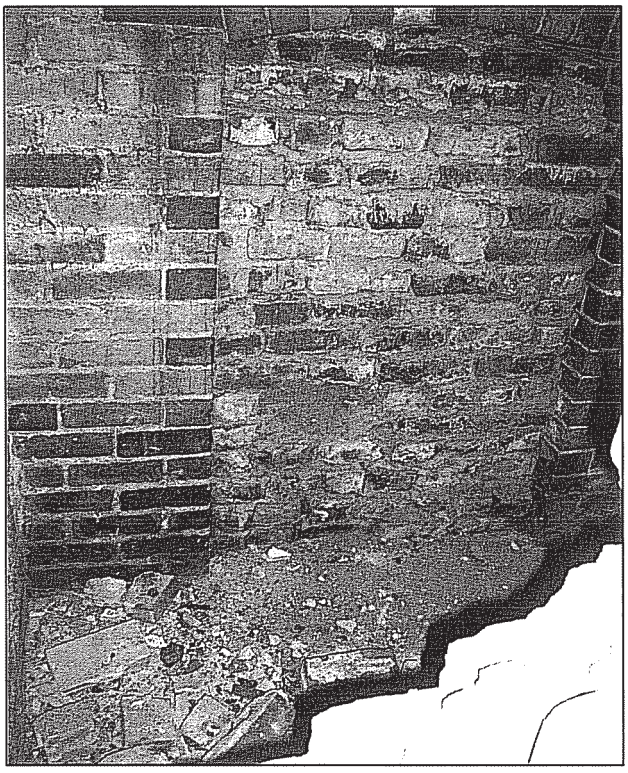


Fig. A5.3 Cast-iron gate within the protrusion's ground floor

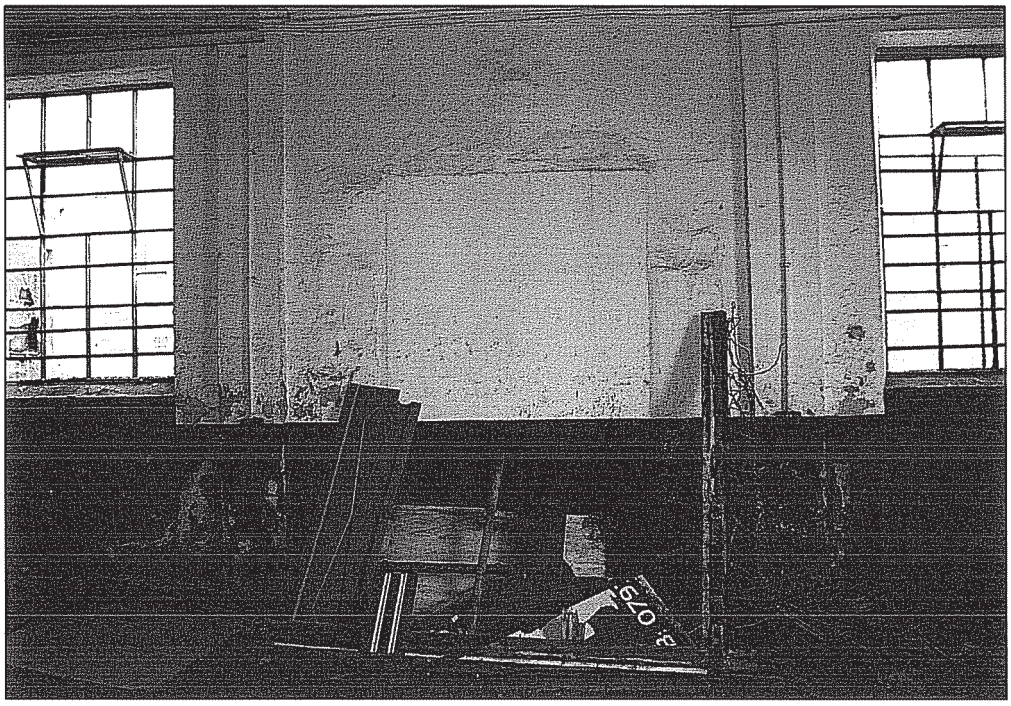
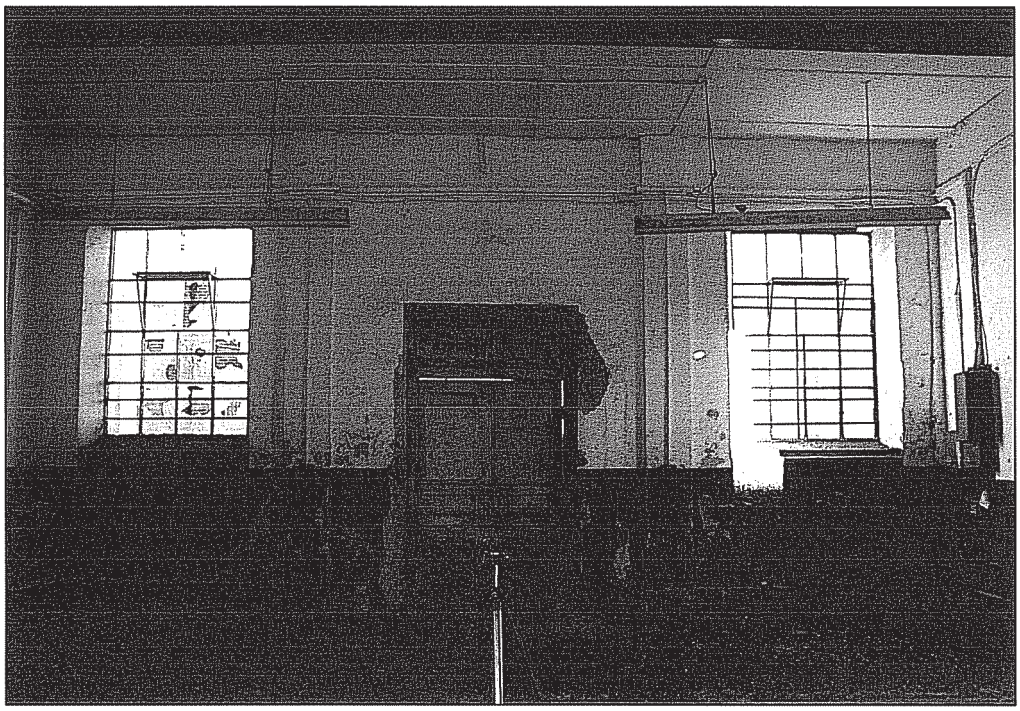


Fig. A5.4 Door in eastern ground floor wall of former Sunday School



APPENDIX 6

OASIS