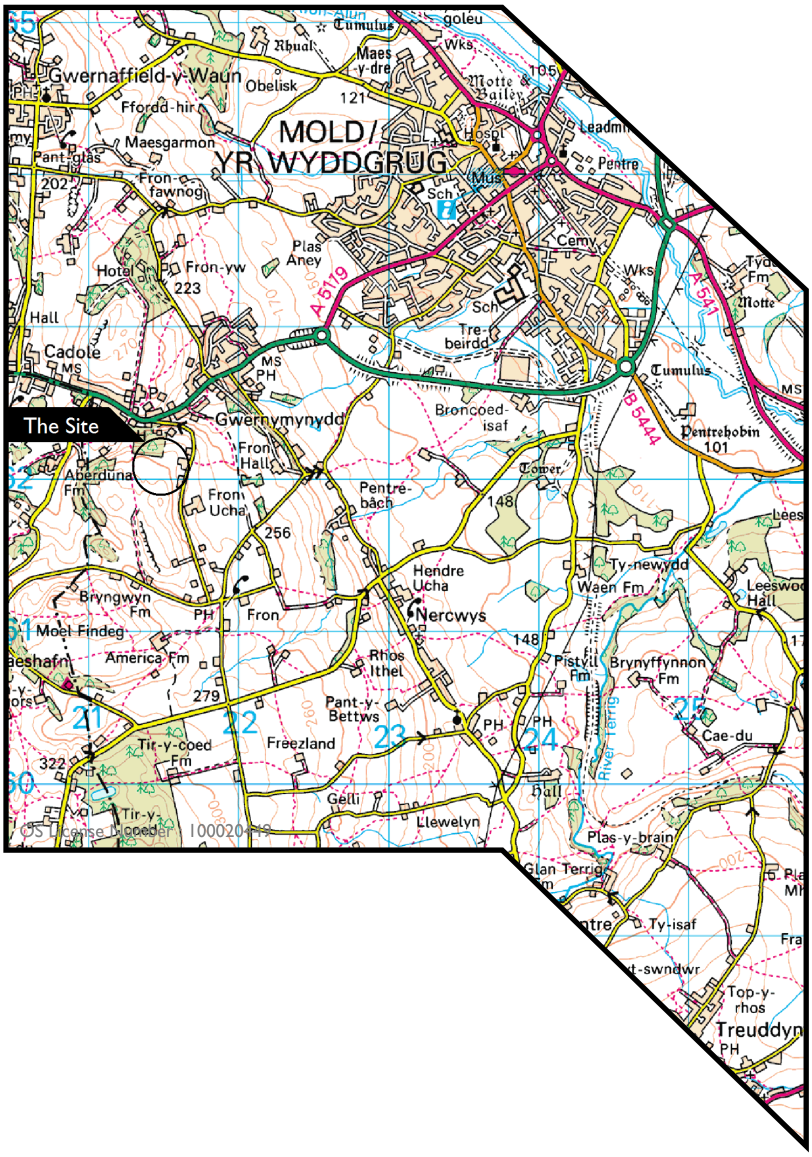


Stability Assessment at

Cambrian Quarry, Gwernymynydd, Mold

Interpretative Report

for
ASH Resources (Cambrian Quarry)

Engineer : Sloane Mead

Project Number : PN122722

February 2013

Issuing office :

North West Office
Geotechnics Limited
The Geotechnical Centre
Unit 1, Borders Industrial Park
River Lane, Saltney
Chester
CH4 8RJ
T: 01244 671 117
F: 01244 671 122
mail@chester.geotechnics.co.uk

Head Office Coventry
Geotechnics Limited
The Geotechnical Centre
203 Torrington Avenue
Tile Hill
Coventry
CV4 9AP
T: 024 7669 4664
F: 024 7669 4642
mail@geotechnics.co.uk

South West Office
Geotechnics Limited
The Geotechnical Centre
7 Pinbrook Units
Venny Bridge
Exeter
EX4 8JQ
T: 01392 463 110
F:01392 463 111
mail@exeter.geotechnics.co.uk

Geotechnics Limited, Registered in England No. 1757790 at The Geotechnical Centre, 203 Torrington Avenue, Tile Hill, Coventry CV4 9AP

Stability Assessment
at

Interpretative Report

Cambrian Quarry, Gwernymynydd, Mold

for
ASH Resources (Cambrian Quarry)

Engineer :
Sloane Mead

Project No:
PN122722
February 2013

LIST OF CONTENTS

APPENDICES

1.0 INTRODUCTION

A stability assessment was undertaken by Geotechnics Ltd within an existing quarry known as Cambrian Quarry (CQ) at Gwernymynydd, near Mold in Flintshire. The investigation was carried out to the instructions of Sloane Mead (SLM) who were acting as Project Manager on behalf of the Client, ASH Resources (Cambrian Quarry) Ltd (ASH).

The stability assessment has been carried out as part of an Environmental Impact Assessment (EIA) that is being undertaken to support a Planning Application for the reclamation of Cambrian Quarry by infilling with inert materials. This Report comprises Section 11 of the Environmental Statement.

This report describes the work undertaken and presents the data obtained together with an evaluation of their significance in relation to the proposed works. Additional comments and recommendations have also been made with respect to the stability of the main site access road, in the vicinity of old recorded mine workings, and with respect to the stability of the proposed slopes within the quarry.

Geotechnics Ltd have been commissioned separately to undertake an assessment of the site as a Regionally Important Geological or Geomorphological Site (RIGS). The RIGS assessment is addressed elsewhere.

2.0 OBJECT AND SCOPE OF THE INVESTIGATION

The object of the investigation was to obtain information to enable an assessment of the medium-to long-term stability of the quarry high walls, within the limitations posed by the exposed quarry faces, access constraints and the scope of approved survey time on site.

The investigation comprised a formal rock slope discontinuity survey and reporting. A geotechnical interpretation and evaluation of the data obtained with respect to rock slope stability was also commissioned.

In addition, assessments have been made on the possible impact of past mine workings on the stability of the main site access road, and on the stability of the proposed slopes within the quarry.

3.0 PRESENTATION

A description of the site and a summary of the procedures followed during the investigation process are presented in Sections 4 and 5. The factual data so obtained are presented in Appendix 3 of this report.

A formal desk study to seek information which may already exist about the site, its history, geology and ground conditions was not commissioned. However, Geotechnics Ltd hold a number of relevant reports relating to the geology of the general area and these have been reviewed. The findings are described in Section 6.

An interpretation of the data obtained is presented in Section 7 together with and an evaluation of its significance in relation to proposals available at the time of preparation of this report.

Appendices 4 and 5 comprise larger (more legible) prints of supporting technical data referred to in the report text.

Appendix 6 comprises an Exploratory Hole Location Plan showing the positions of three boreholes drilled as part of the investigation works. The corresponding borehole records are included in Appendix 7

Attention is drawn to the General Notes and Investigation Procedures presented in Appendix 8 to aid an understanding of the procedures followed and the context in which the report should be read.

4.0 THE SITE

4.1 Location

The site is located to the southwest of Gwernymynydd, approximately 2km southwest of Mold, in Flintshire. The approximate Ordnance Survey National Grid Reference for the site is SJ 214 620 and an extract from the relevant 1:50,000 Scale O.S. Map is included as Appendix 2. The nearest recorded post code to the site is CH7 5LW.

4.2 Description

The site comprises a former quarry excavated for the extraction of limestone and silica sand. The quarry occupies a plan area of approximately 24,400m^2 and is roughly rectangular in shape, with its long axis orientated north to south.

A site layout plan is included as Appendix 2 of this report.

It should be noted that the site lies within an area recently scheduled as a Site of Special Scientific Interest (SSSI). Photographs of the key southern and eastern high walls of the site taken during the fieldwork follow:

Plate 1: Southern quarry high wall

Plate 2: Eastern quarry high wall

4.3 Proposals

The proposals within the Planning Application are for the reclamation of Cambrian Quarry by infilling with inert materials. This report has been prepared as part of an Environmental Impact Assessment undertaken to support the Planning Application.

5.0 PROCEDURE

5.1 General

The work was awarded following submission of a proposal for ground investigation of the site in accordance with the Client's requirements. The procedures followed in this site investigation are based on *BS 5930:1999 + A2:2010 - Code of Practice for Site Investigation.*

The rocks encountered have been described in general accordance with BS5930:1999 + A2:2010 and BS EN ISO 14688-1:2002 and BS EN ISO 14689-1:2003. Rock discontinuity data (i.e. discontinuity dip, dip direction, etc) has been collected to allow for a rock slope stability analysis to be undertaken in accordance with the methods proposed by Matheson (1983) in TRL Report 1039, *Rock stability assessments in preliminary site investigations – Graphical Methods*.

The Survey Data Records are included in Appendix 3. The approximate locations of the scan-line survey locations are annotated on the layout plan in Appendix 2.

5.2 Survey Procedure

The fieldwork was undertaken by a two man survey team on 3rd and 4th May 2012.

Scan-line surveys were undertaken at accessible locations along both the southern and eastern quarry high walls. A total of five scan-line surveys were undertaken. Two of these scan-lines (CQ1 and CQ2) were located along the southern high wall. The remaining three scan-lines (CQ3, CQ4 and CQ5) were undertaken along the eastern quarry high wall.

Access constraints at the site (and associated health and safety issues) restricted the scan-line survey locations to the base of the quarry floor (CQ1, CQ2, CQ3 and CQ4) and a relatively easily accessible bench near the base of the eastern high wall (CQ5).

Surveys were undertaken along subhorizontal scan-lines on both the southern and eastern quarry high walls, with an additional short subvertical scan-line carried out on the southern high wall. This combination of scan-line orientations should minimise the bias known as the "Terzhagi Effect". This effect is most obvious where a vertical hole is drilled in rock with many near-vertical discontinuities and relatively few subhorizontal discontinuities. The subhorizontal features will be preferentially encountered in the borehole. Similarly, horizontal scan-lines will be biased against subhorizontal discontinuities. By collecting data along three near-orthogonal axes the potential effects of this inherent bias are minimised.

At each scan-line location the geology of the location was described, together with key rock mass characteristics. Along the survey lines the following data was collected for each discontinuity present.

- Joint Type
- Dip (^{0}) and Dip Direction (^{0} from North)
- Persistence
- Aperture
- Infilling
- Waviness (Amplitude and wavelength)
- Presence of water

5.3 Rotary Open-hole Boreholes

Three (3 No.) 120mm diameter boreholes were sunk utilising open hole, rock-roller drilling techniques to depths of 40.00m (BH1), 12.00m (BH2) and 6.50m (BH3) below ground level. The work was carried out between 2nd and 6th July 2012.

An inspection pit was excavated at each borehole location using hand tools to a depth of 1.20m below ground level to check for the presence of underground services.

The drilling equipment on this particular contract utilised compressed air as the flushing medium. The strata descriptions are the Drilling Foreman's estimate based on sediment and chipping returns in the flushing medium. The rate of penetration is also used as an indicator of the type of material being drilled, particularly where there is loss of flush returns. Definitive classification in terms of geology or degree of disturbance is not usually possible from these sources.

On completion the boreholes were backfilled with bentonite grout.

6.0 PUBLISHED GEOLOGY

6.1 Available Information

Information published by the British Geological Survey (BGS) on published geological maps of the area, geological memoirs and other relevant literature was consulted. For this site reference has been made to the following:-

- 1:63,360 Scale Geological Survey Map (Sheet No. 108 – Flint), Drift Edition, dated 1965
- 1:50,000 Geological Survey Map (Sheet No. 108 – Flint) Solid and Drift Edition, dated1999
- "Geology of the Country around Flint." British Geological Survey, (2004), HMSO
- http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html
- "Deeside (North Wales) thematic geological mapping" Campbell & Hains BGS Technical Report WA/88/2 (1988)

6.2 Geology

The 1:63360 Drift Edition Map indicates that the site lies within the lower part of the outcrop of the Cefn-y-Fedw Sandstone which is recorded to be associated with Chert Beds. The "Passage Beds" of the Carboniferous Limestone Series lie beneath.

There is more detail shown on the subsequent 1999 Solid and Drift Edition Geological Map which shows a similar generalised geology. However, in this case, it is apparent that the site is associated with a sub-division of the Cefn–y-Fedw Sandstone known as the "Lower Tongue". The rocks formerly referred to as the Carboniferous Limestone Series are now referred to as the Minera Formation.

The lithologies of the Cefn-y-Fedw Sandstone (and associated Pentre Chert Formation), the Minera Formation and the Holywell Shales are fully described in the BGS Memoir. The amount of detail is beyond the scope of this report. The following figure however is taken from that document. Geotechnics Ltd have added the approximate horizon of the Cambrian Quarry outcrop by the position of the vertical red line. This figure is also reproduced in a more legible format in Appendix 4.

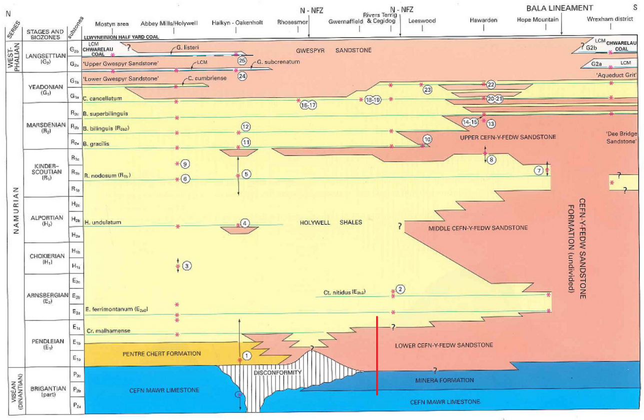


Figure 1: Extract from BGS Memoir

The Campbell and Hains (1988) report has an accompanying series of maps on various subjects relating to planning and development. Each of these maps has been reviewed and the following table also summarises the available information:

Table 1: Summary of Campbell & Hains Thematic Mapping

Map Content	Comment
Bedrock Geology	Confirms the presence of cherty rocks associated with sandstone. and indicates a dip to the east locally of approximately 20^0
Superficial Geology	Superficial strata appears to be limited to the recorded presence of Made Ground associated with the quarry access roads
Boreholes and Drift Thickness	No relevant information
Mining - Coal / Metalliferous	Records the presence of Made Ground associated with mining and at least two mine entrances within the immediate vicinity of the site
Bedrock Resources	Records the presence of a disused sandstone quarry and a potential resource locally associated with the outcrop of "quartzitic sandstone"
Sand and Gravel	No relevant information
Hydro-geology	Records the presence of an aquifer associated with Namurian sandstones locally

Observations made during the survey works, combined with the results of the desk study allow the following basic geology to be established for the site:

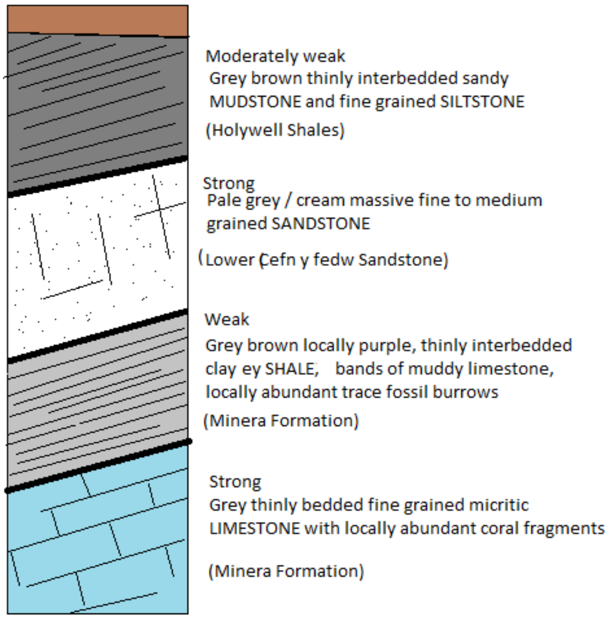


Figure 2: Summary of Local Geology

The general dip of the strata is to the east (i.e. the rocks young in an easterly direction).

The following photographs illustrate the typical nature of these four strata:

Plate 3: Minera Formation (limestone) exposed in south-western corner of quarry – dip to the east (towards the camera)

Plate 4: Uppermost Minera Formation ("Passage Beds") exposed in south-eastern corner of quarry

Plate 5: Lower leaf of the Cefn-y-Fedw Sandstone exposed in the southern quarry high wall

Plate 6: Transition from Lower Cefn-y-Fedw Sandstone to overlying thinly bedded Holywell Shales

7.0 INTERPRETATION

7.1 Graphical Analysis

For those unfamiliar with stereographical projection of three dimensional (3D) data the following basic introduction is provided. Further details on these techniques are described in Matheson (1983) TRL Report 1039, *Rock stability assessment in preliminary site investigations – graphical methods.*

Any plane in 3D space can be represented on a two dimensional surface by a stereographic projection on a projected hemispherical grid. Conventionally in geological and geotechnical design a lower hemispherical projection is utilised. This can be thought of as being the lower half of a ball, with the intersection that a plane in 3D space makes with the perimeter of the ball marking out a great circle, as indicated in the following sketch.

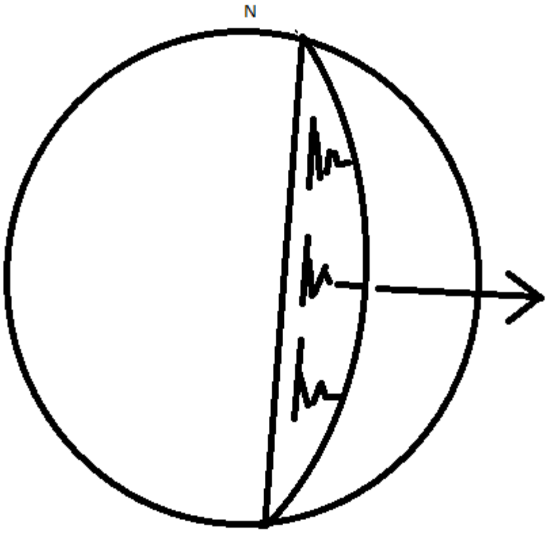


Fig 3: Lower Hemisphere Great Circle

Thus a relatively steeply dipping slope (dipping in a direction just south of due east in this case), subtends a unique great circle on the projected lower hemisphere. Furthermore, it is possible to define a single plane in three dimensional space by a point (termed the pole) which uniquely represents the great circle so defined.

The following plot indicates how the great circle can be represented by a single pole.

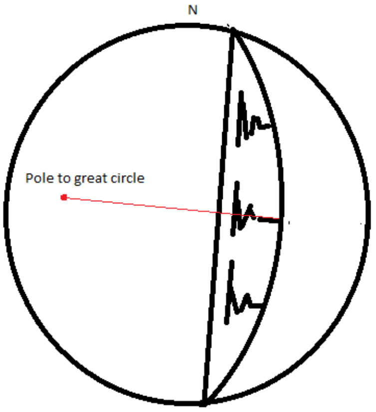


Fig 4: Pole representing a Great Circle as a single point

The ability to plot the orientation of planes in space as single points allows complex statistical techniques and analysis to be undertaken to determine the presence of groups of data, concentrations and to assess the orientation of the joints in space with respect to the orientation of the open slope faces.

Geotechnics Ltd utilise the computer package “DIPS” to undertake stereographic analysis. For the purposes of this report the data has been gathered in a systematic manner with the specific intention of minimising the effects of directional bias, and the data in the analyses are presented therefore unweighted with respect to this bias.

Whilst it is apparent from our inspection that the joint patterns are significantly different in the thinly bedded Holywell Shales and Minera Formation when compared to the much more massive Cefn-y-Fedw Sandstone, it is reasonable to treat all the data gathered as a single data set.

The following lower hemispherical projection shows the combined data for all the joint measurements undertaken at the site, represented as poles to great circles. This indicates a cluster located just to the west of the centre of the plot. This cluster represents the great circles associated with the bedding in the quarry which dips at a gentle angle toward the east.

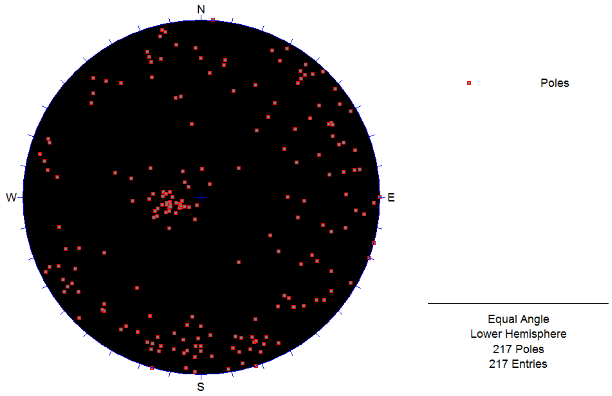


Fig 5: Lower hemisphere projection, poles to great circles, all recorded data.

The somewhat more scattered poles located around the perimeter of the projection record the presence of much more steeply dipping joints (vertical joints plot on the outside of the circle, with a great circle running through the centre of the projection).

This figure, along with subsequent contoured plots are reproduced for clarity, at larger scales in Appendix 5.

The data can be made more meaningful to work with by contouring the degree of clustering to identify the major joint sets present. This has been done in the following plot:

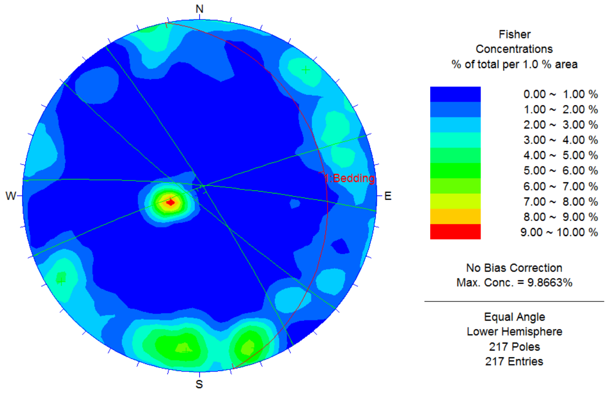


Figure 6: Contoured plot with mean great circles of cluster concentrations added

This allows the locus of the major joint concentrations to be established. In this case it is apparent that there are five major joint sets present comprising the shallow dipping bedding which dips towards the east (shown in red) and four steeply dipping (near vertical) joint sets.

The following table summarises the orientation of the major joint sets identified:

Table 2: Summary of Major Joint Sets

Joint Set	Dip	Direction (Bearing)	Comment
Bedding	19°	079°	Dominates Holywell Shale and Minera Formation
Sub-vertical (i)	83°	005°	Most readily identified in the Cefn-y-fedw Sandstone
Sub-vertical (ii)	85°	058°	Most readily identified in the Cefn-y-fedw Sandstone
Sub-vertical (iii)	85°	340°	Most readily identified in the Cefn-y-fedw Sandstone
Sub-vertical (iv)	86°	220°	Most readily identified in the Cefn-y-fedw Sandstone

Rock slope failures can be conveniently sub-divided into four main types comprising:

- Planar Failures, originating by simple sliding along a basal failure surface
- Wedge Failures, originating as a slide along the line of intersection between two co-occurring planes with the line of intersection dipping out of the slope
- Toppling Failures, originating as a consequence of steeply dipping discontinuities
- Ravelling / Weathering / Undercutting Failures associated with the presence of soft bands beneath more competent strata

The potential for the first three modes can be assessed using stereographic techniques.

This requires the establishment of the daylight envelope, friction circle, and toppling envelope based on the orientation of the surfaces defined by the slopes. In this case, a friction circle of 45° has been assumed based on a typical basic friction angle of 35°, with an additional 10° allowed to account for the significant joint roughness and waviness apparent on the majority of the joints described.

The following plot shows the daylight envelopes for the two main slopes plotted with the joint set data as defined in Figure 6 and a friction circle, representing a friction angle on joint surfaces of 45°. Instability would be anticipated for planar failures at locations where pole concentrations fall inside the daylight envelope but outside the friction circle. There are no recorded occurrences of this type of failure.

Similarly for wedge type failures it would be anticipated that failures could be anticipated where the intersection of two planes (i.e. the location where the two great circles cross) lies inside the daylight envelope and outside the friction circle. Again. there are no such occurrences.

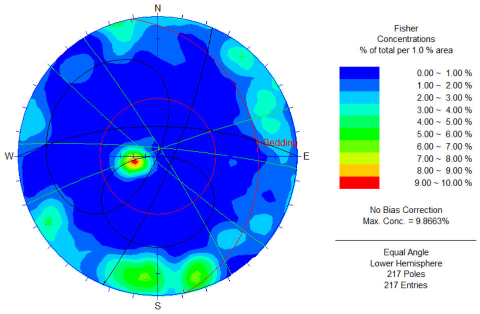


Figure 7 Wedge Analysis

However, it can be seen that the intersection of two planes in the south-eastern quadrant does lie within the daylight envelope of the north facing southern slope. This suggests that given enough variation within the data set it could reasonably be anticipated that a small number of problematic wedges may be encountered associated with two steep joints dipping to the north east (Joint Set ii) and southwest (Joint Set iv), respectively. A number of such wedges can be seen in the photograph below.

Plate 7: Potential wedge and planar failures in southern (northerly facing) slope.

Detailed analytical techniques are available to assess potential toppling failure. However, there is no evidence that toppling is a significant mode of failure in either the southern or eastern quarry faces. This is entirely consistent with the observation that the relatively shallow eastward dipping bedding is the dominant discontinuity type within the rock mass. Toppling would therefore be associated with steep faces on easterly facing slopes, with blocks released by steep orthogonally orientated joints. This is likely to have been problematic for the western (easterly facing) quarry slope and will explain why this slope was originally laid back at a much shallower angle than the other quarry slopes.

7.2 Other Observations

As with any statistical treatment there needs to be some caution in interpretation to ensure that the statistical values calculated are representative of the key data. With respect to slope stability it is important that single discrete discontinuities that are "counted out" by the contouring process are checked for by visual inspection. In this case it is apparent that in addition to the potential wedge failures identified above, there are a number of discrete potential failures apparent in the eastern high wall which are of concern. Some of these features, which are apparent primarily in the Cefn-y-Fedw Sandstone, are shown in the following photograph:

Plate 8: Adversely orientated steeply dipping joint causing potential significant instability issues

Plate 9: Close-up of Plate 8 showing incipient failure on joint sub-parallel to major problematic feature. These joints are orientated at about 82° from the horizontal towards 280° from North, and were not identified as a major joint set in the statistical analysis.

It should be noted that two minor failures were witnessed from the eastern quarry high wall during the period of site survey work. Whilst these were of relatively small extent (and followed the wettest April on record for the UK), they present clear evidence of ongoing instability of the eastern high wall.

There are many areas on benches and the floor of the quarry where there is evidence of significant rockfall and instability. A selection of photographs illustrating these failures follow. Plates 12 and 13 illustrate a failure mode that is common along the eastern quarry high wall.

Plate 10: Failure associated with locally developed steeply dipping joint set (set only developed at 2-3% significance amongst the data set apparent in Figure 6).

Plate 11: Ravelling failure at face corner

At or about the transition from the Cefn-y-Fedw Sandstone to what are thought to be the local occurrence of the Holywell Shales are two grey shaly mudstones (possibly the *Cr. malhamense* and *E. ferrimontanum* marine bands indicated on Figure 1). These bands are prone to weathering and are significantly softer than the immediately overlying strata. As can be seen from Plates 8 and 9, preferential weathering of the soft material produces a sequence of overhanging blocks of jointed materials. These overhangs are in rock that is jointed and fractured, and unable to sustain any significant overhang beyond a few tens of centimetres. As the soft horizon is weathered this produces ongoing localised failures above, now evident from the scree collecting on the bench below the slope.

Plate 12: Close-up of preferential weathering along soft shaley bands

Plate 13: Failed rock forming scree on bench (note close proximity of boundary fence at this location).

It is understood that the crest of the slope along the eastern site boundary lies close to the ownership boundary and consequently close to third party land interests. The stability of the eastern high wall is therefore of concern not only for the current land owners, but also for adjacent land owners.

Anecdotal evidence suggests that there was a *"major collapse of the north-western face in the late 1990's"*. It is understood that the landowner has no information on this incident. Geotechnics Ltd have inspected the land to the northwest of the quarry void (a public footpath runs across an area of grazing) and have seen no evidence of any significant features likely to be associated with such a collapse. The features that are present on the land to the west of the site appear to relate to past historic mining activity.

7.3 Conclusions with Respect to Existing Slope Stability

In summary, it is evident that both the southern and eastern quarry high walls are showing signs of recent and potential slope instability. For the most part, failures are likely to be of relatively small volume and associated with weathering. However, there are some locations where there is significant potential for planar and wedge failures to occur. The risks associated with such failures would generally be acceptable in a working quarry or mine environment but are unacceptable with respect to public access and for the long-term maintenance of secure ownership boundaries.

It should be noted that our instructions to date do not include any *formal* analysis of the implications on slope stability of the potential presence of abandoned shallow mine workings (known to be present in the north-eastern corner of the site). Any ongoing instability associated with the pillars of the former Cambrian Mine is likely to exacerbate instability problems of the quarry faces where they interact.

The act of filling the quarry void above the level of the workings will contribute significant lateral restraint to the pillars in close proximity to the quarry void and will therefore aid stability.

Any works proposed within the underground workings are likely to require formal opening of the mine (the mine will be deemed to be "worked" as and when any works are carried out below ground) and working will need to be undertaken in accordance with the requirements of the Mines Inspectorate.

7.4 Infilling Operations - Stability

Maximum safe slope angles with respect to proposed infilling materials to be placed in the quarry need to be defined on the basis of their actual material characteristics and the perceived risk of instability associated with the proposed future land use. The relevant material characteristics in respect of slope stability are the shear strength parameters, known as cohesion (c) and friction angle (phi). For the long-term condition associated with permanent slopes and embankments it is the "effective" parameters (c' and phi') that are of concern. In this regard, it is assumed that all slopes will be free draining. It is understood that the imported material used for filling will

- not include unsuitable, saturated, contaminated or highly organic materials, and
- be laid in lifts not exceeding 1m, and
- be dozed flat with nominal compaction from the plant.

Based on this and following discussions with the Client, it is Geotechnics Ltd's opinion that:

- bench heights should not exceed 5m,
- berm widths should not be less than 3m, and
- the local slope angle (between toe of slope and crest of bench) should be no greater than 23°.

This is based on a Factor of Safety of 1.15 on phi' = 26°, with c' assumed to be negligible. The assumed phi' value of 26° equates to a typical effective friction angle for soft to firm clay fill materials.

The relatively low Factor of Safety reflects the fact that there will be no public access during construction, and the fact that as the entire quarry lies within a basin like structure there is no significant risk of tipped material escaping from the site.

It will be possible to engineer steeper slopes if required, however this will require design of retaining structural bunds of coarse granular fill within the tipped material, and will require formal slope stability design, based on actual known material characteristics.

Including the bench, this configuration will allow for an overall slope angle of about 20° over a two bench height. This should only be used for preliminary design purposes and all the fill design should be done in such away that there is no potential route for slipped material to escape the confines of the quarry.

It should also be noted that self weight settlement of the infill materials will occur for some considerable time after placement. Such settlement can be minimised by the use of adequate compaction and grading screening control to minimise the volume of voids in the placed fill.

7.5 Access Road Interface with Recorded Mine Workings

Two of the three Rotary Open-hole Boreholes drilled (BH2 and BH3) encountered a thick sequence of apparent infill material. In Borehole BH1, the absence of past shallow workings was proven to a depth of 40m.

In Boreholes BH2 and BH3, it appears that the drilling works encountered either:

- an infilled collapse, or
- an infilled surface stope.

In either event, it would appear that there are no near-surface open voids associated with the recorded mine voids. Consequently road design will only be required to consider a loose fill sub-grade, and does not need to be designed as a raft or bridge structure to span the potential void at this location.

Signed for and on behalf of Geotechnics Limited.

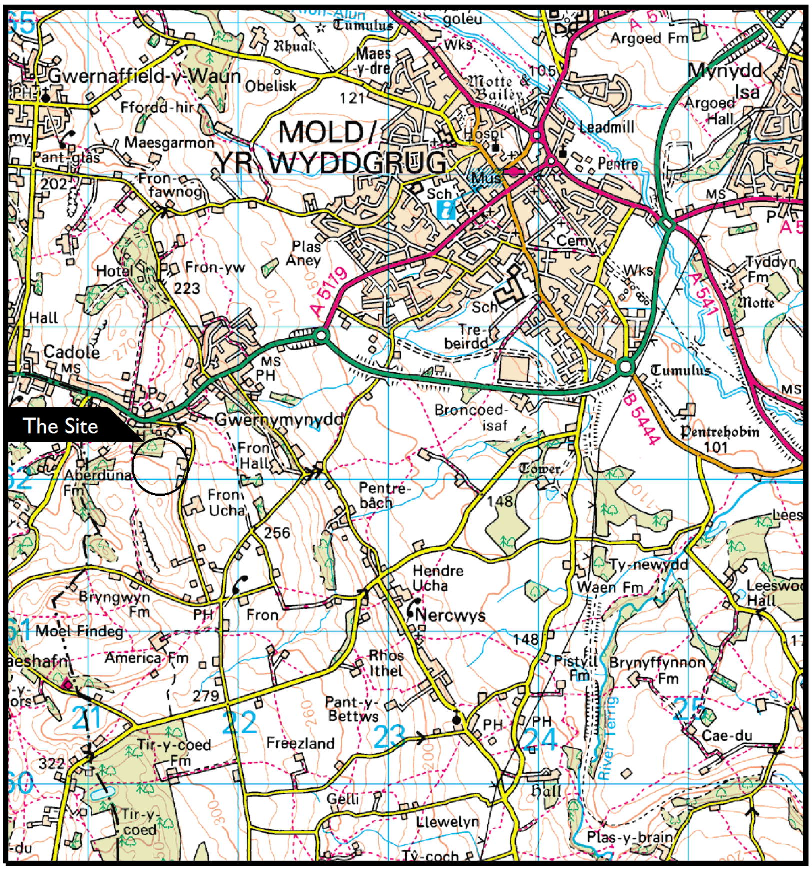
Written By: …………………………
Keith Nicholls BSc MSc FIMMM MICE MIQ CEng
Principal Engineer

Checked By: ………………………..
John Knowles, BSc (Hons), PGCE, MSc, C.Geol, FGS
Principal Engineer
for GEOTECHNICS LIMITED - North West Office

APPENDIX 1

SITE LOCATION PLAN

SITE LOCATION PLAN



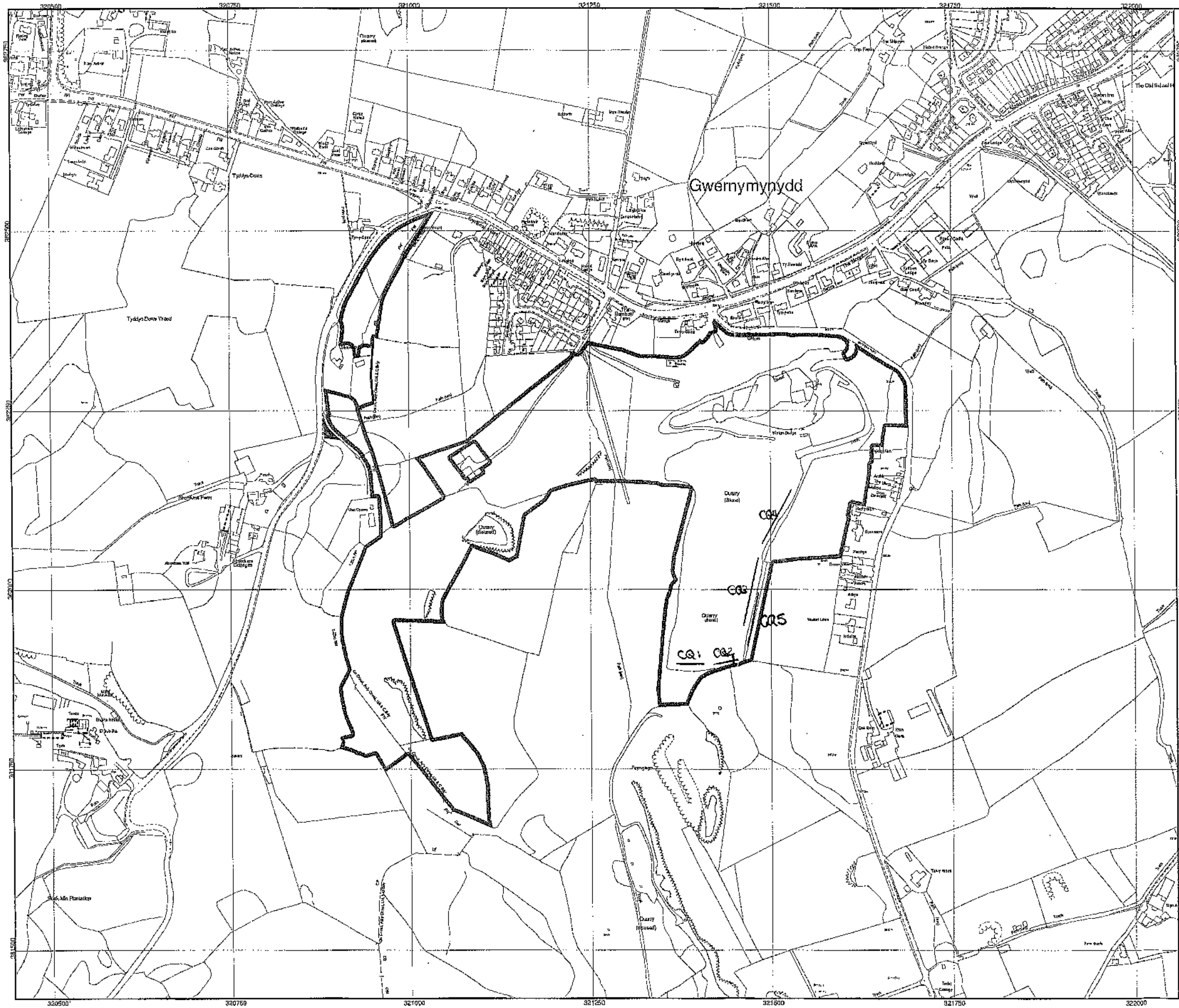
© Crown Copyright Reserved, OS License Number: 100020449

Stability Assessment
at
Cambrian Quarry, Gwernymynydd,
Mold
for
ASH Resources (Cambrian Quarry)

geotechnics

APPENDIX 2

SITE SURVEY DRAWING



Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

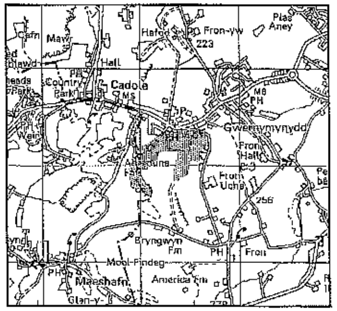
CHWAREL CAMBRIAN / CAMBRIAN QUARRY, GWERNYMYNYDD

Sir Ddinbych / Denbighshire
Sir y Fflint / Flintshire

▬	Safle o Ddiddordeb Gwyddonol Arbennig **Site of Special Scientific Interest**
1:5000	Graddfa **Scale**
23.1 ha	Arwynebedd **Area**
21/06/2011	Hysbyswyd **Notified**
	Cadarnhad **Confirmation**
1281	Rhif y safle **Site id**

— LINESCAN SUB HORIZONTAL

+ LINESCAN SLOPE PARALLEL



Graddfa 1:50,000 Scale 1:50,000

APPENDIX 3

SURVEY DATA SHEETS

geotechnics

ROCK MASS SURVEY DATA SHEET

SITE LOCATION CQ 1

DATE OF SURVEY DD 3 MM 5 YEAR 12

Operator KN/KF

JOB NO: PN 122722

CLIENT ASM

Engineer ~~KN/KF~~ SLOANE MEAD.

Method of Location
1 By Coordinates
2 Chainage
[✓ 3 Located on drawing (attached)]
4 Other

Locality Type 3
1 Natural exposure
2 Construction excavation
[✓ 3 Quarry Slope]
4 Tunnel
5 Other

Size of exposure m2 100

SLOPE DIP 76 degrees

either / or not both

SLOPE DIP DIRECTION 0 degrees from North

SLOPE STRIKE degrees from north

ROCK MATERIAL DATA

ROCK STRENGTH Strong

COLOUR grey

GRAINSIZE medium grained

ROCK TYPE LIMESTONE

REMARKS indicate state of material weathering grade for Mercia Mudstone, chalk etc, changes in rock type, major faulting / folding apparent?

BASE OF LOCAL SEQUENCE, DIPPING GENTLE ANGLE TO THE EAST. THICKLY BEDDED, LYING BENEATH SHALY [illegible] SUBJECT OF CQ2.

ROCK MASS DATA

1 No of major joint / discontinuity sets

[✓ Y] / N plus random

Line Survey Y / N

Plunge of line 6 degrees from horizontal

Line Direction 100 degrees from north

Joint Set	Dip	Dip Direction / ~~Strike~~ (delete)
1	14	~~[illegible]~~/100
2		
3		
4		
5		

geotechnics

DATA COLLECTION SHEET

SHEET 1 OF 2

CQ1

CHAINAGE (m)	Type	Dip	Direction ~~/Strike~~	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness Amplitude	Waviness Wavel'th	Water
0	Joint	88°	346	1m	—	—	—	100mm	1m	dry
1	Joint	88	300	5m +	10	clay	—	150mm	1m	Damp
2	Joint	88	300	1m	10	clay	—	75	100mm	Damp
3	Joint	78°	060	2m +	100	clay	—	100	1m	Wet
4	Joint	46°	330	0.7	75	cly gravel	—	10mm	300mm	Dry
5	Joint	82°	220	—	—	—		—	—	—
6	Joint	36°	120	0.75	10mm	cly gravel	—	10mm	100mm	Dry
7	bed	30°	016	3m +	10mm	sandy clay	—	75mm	1m	Damp
8	Joint	80°	220	1.5m	20mm	open	—	25mm	75mm	Damp
9	Joint	80°	160	1.5m +	—	—	—	100mm	1m	—
10	Fault	52°	220	5m +	25mm	clay + gravel	—	75mm	1m	Dry
11	Joint	72°	320	1.5m +	—	—	—	50mm	0.3m	—
12	Bed	28°	075	2m +	1mm	tight		50mm	1m	Dry
13	Bed	20°	075	0.2m	1mm	tight		50mm	1m	Dry
14	Joint	76°	190	1.25m	—	—		75mm	1m	—
15	Joint	82	260	0.25	—	—		1cm	10cm	—
16	Joint	78°	160	1.25 +	—	tight		1cm	1cm	Dry
17	Joint	82°	015	1.25	—	—		1cm	5cm	—
18	Joint	80	360	0.6	tight	Clay + moss		1cm	10cm	Damp
19	Joint	72°	360	0.4	1mm	Clay + moss		1cm	5cm	Dry
20	Joint	84	260	0.1	—	—		5mm	10cm	Dry
21	Joint	84	260	0.1	—	—		5mm	10cm	Dry
22	Joint	88°	005	4m +	—	—		10cm	1m	—
23	Joint	80°	340	1m +	3mm	clay		15mm	260mm	Damp

geotechnics

DATA COLLECTION SHEET

SHEET 2 OF 2

C Q 1

CHAINAGE (m)	Type	Dip	Direction	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
24	Bed	18°	090	15m	—	—	—	50mm	1m.	
25	Joint	vertical	290	2m+	—	—	—	250mm	30mm	—
26	Fault.	82°	260	5m+	100mm	Open		100mm	1m	Damp
27	Joint	10	130	2m	3mm	Clay	—	25mm	150m	Damp
28	Fault	60	272	4m+	50mm	Clay	—	75mm	250mm	Damp.
29	Joint	78°	346	3m+	—	—	—	200mm	0.5m	—
30	Joint	52°	270	4m+	25mm	Clay	—	75mm	200mm	Damp.
31	Bed.	20°	145?	1·25+	1mm	tight		75mm	250mm	Dry.
32	Joint	70	250	5m+	5mm	Clay		25mm	150mm	Damp
33	Joint	70	250m	5m+	5mm	Clay —		25mm	150mm	Damp.
34	Bed	22	066	5m+	2mm	— tight		25mm	150mm	Damp
35	Joint	80	178	1·5m	—	—		100mm	0.5m	—
36	Joint	58	282	2m+	—	—		0.1m	0.5m	—
37	Joint	Vert	265	5m+	—	—		300mm	1.5m	—
38	Bed.	20°	1[illegible] ?	35m	1cm	Clay		15mm	0-5m	Damp.
39	Joint	86°	305	~~[illegible]~~ 1·50	2mm	Clay		75mm	1m	Damp
40	Joint	Vert	270	1·50	3mm	clay	Stepped →	75mm	150	Damp.
41										
42										
43										
44										
45										
46										
47										

geotechnics

ROCK MASS SURVEY DATA SHEET

SITE LOCATION Combran Quay

DATE OF SURVEY DD 3 MM 05 YEAR 2012

Operator KN/KF

JOB NO: PN PN122722

CLIENT Ash.

Engineer Sloane Mead

Method of Location ☐
- 1 By Coordinates
- 2 Chainage
- 3 Located on drawing (attached)
- ✓4 Other ______

Locality Type ☐
- 1 Natural exposure
- 2 Construction excavation
- ✓3 Quarry Slope
- 4 Tunnel
- 5 Other ______

Size of exposure m2 8×20

SLOPE DIP 80° degrees

either / or not both

SLOPE DIP DIRECTION 355 degrees from North

SLOPE STRIKE ☐ degrees from north

ROCK MATERIAL DATA

ROCK STRENGTH ☐

COLOUR ☐

GRAINSIZE ☐

ROCK TYPE ☐

REMARKS indicate state of material weathering grade for Mercia Mudstone, chalk etc, changes in rock type, major faulting / folding apparent?

Interbedded Strong limestone - grey and weak yellowish grey shales

fine grained micritic limestone.

ROCK MASS DATA

1 No of major joint / discontinuity sets

Y / N plus random

Line Survey Y / N 1m length

Plunge of line 72° degrees from horizontal

Line Direction 340 degrees from north

Joint Set	Dip	Dip Direction / Strike (delete)
1		
2		
3		
4		
5		

geotechnics

DATA COLLECTION SHEET

SHEET 1 OF 1

CG2

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
	B	16	076	∞	TIGHT			3mm	10cms	Damp
	B	14	062	∞	"			"	"	"
	B	14	066	∞	"			"	"	"
	B	14	072	∞	"			"	"	"
	B	15	063							
	B	14	066							
	B	10	048							
	B	12	060							
	B	19	058							
	B	12	078							

Sung 2m height. Sub vertical scan line

exposure dominated by bedding in interbedded shales and limestones

geotechnics

ROCK MASS SURVEY DATA SHEET

SITE LOCATION: Cumbrian Quarry

DATE OF SURVEY: DD 03 MM 05 YEAR 2012

Operator: Kf.

JOB NO: PN DN02722

CLIENT: Ash

Engineer:

CQ3.

Method of Location:
1 By Coordinates
2 Chainage
3 Located on drawing (attached)
[✓ 4 Other] ______

Locality Type:
1 Natural exposure
2 Construction excavation
[✓ 3 Quarry Slope]
4 Tunnel
5 Other ______

Size of exposure m2: 2 by 30 m

SLOPE DIP 72 degrees

either / or not both

SLOPE DIP DIRECTION 268 degrees from North

SLOPE STRIKE degrees from north

ROCK MATERIAL DATA

ROCK STRENGTH:

COLOUR:

GRAINSIZE:

ROCK TYPE:

REMARKS indicate state of material weathering grade for Mercia Mudstone, chalk etc, changes in rock type, major faulting / folding apparent?

Inter-bedded purplish red ~~[illegible]~~weak shale and ~~[illegible]~~ creamish light grey fine grained SST weak-mod weak. + Strong med grained micritic lst. (light greyish cream).
beds various thickness 5-30cm.

ROCK MASS DATA

1 No of major joint / discontinuity sets

Y / N plus random

Line Survey Y / N

Plunge of line degrees from horizontal

Line Direction 347. degrees from north

Joint Set	Dip	Dip Direction / Strike (delete)
1		
2		
3		
4		
5		

geotechnics

DATA COLLECTION SHEET

SHEET 1 OF 2

CQ3

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness Amplitude	Waviness Wavel'th	Water
0	Bed	21	072	—	tight			10mm	0.1m	
1	Joint	78	042	0.5	3mm	clay	—	10mm	0.2m	Damp.
2	Joint	82	056	0.3	—	—	—	3mm	0.1	
3	Joint	84	103	0.2	—	—	—	2mm	0.2	
4	bed	22	077	—	tight			10mm	0.1mm	
5	Joint	52	339	0.05	—	—	—	1mm	0.05	
6	Joint	98	190	0.07	2mm	gravel		2mm	3cm	Dry
7	Joint	98	190	0.07	2mm	gravel	—	2mm	3cm	Dry
8	Joint	64	002	0.04	—	—	—	2mm	0.01m	
9	bed	21	072	—	[illegible]	—		10mm	0.1m	
10	Joint	76	011	0.04	5mm	gravel		1mm	0.2cm	Dry.
11	Joint	76	011	0.3	6mm	gravel		2mm	2cm	Dry.
12	Joint	84	110	0.1	—	—		2mm	5cm	—
13	Joint	78	098	0.2	—	—		10mm	3cm	—
14	Bed	74	086	—	—	—		3mm	0.05	—
15	Joint	74	234	1m	1mm	tight		10mm	0.1m	Dry.
16	Joint	84	306	1m	—	—		13mm	0.1m	—
17	Joint	vert	162	0.5	—	—		3mm	0.1m	
18	Bed	20	072	—	—	tight		3mm	0.03	—
19	Joint	66	234	0.4	—	—		5mm	0.1	—
20	Joint	74	249	0.6	—	—		10mm	0.1	—
21	Joint	79	249	0.5	—	—		10mm	0.1	—
22	Joint	84	138	0.15	1mm	no	Stepped	3mm	10mm	Dry.
23	Joint	78	206	0.4	—	—		10mm	0.1m	—

geotechnics

DATA COLLECTION SHEET

SHEET 2 OF 2

CCB

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness Amplitude	Waviness Wavel'th	Water
24	Joint	80	134	1.0	—	—	—	10mm	0.1	—
25	Joint	80	141	0.1	—	—	—	3mm	0.1	
26	Joint	79	017	1.0m	—	—	—	10mm	0.1	
27	Joint	73	067	0.3	—	—	—	3mm	0.1	
28	Bed	20	080	—	—	—	—	10mm	0.1	
29	Joint	60	169	0.5	2mm	Clay	—	10mm	0.1	Damp
30	Joint	72	158	1.2	3mm	Clay	—	6mm	0.1	Damp
31	Joint	88	240	0.3	—	—	—	10mm	0.1	—
32	Joint	Vert	342	0.05	2	Clay	—	2mm	0.05	Damp
33	Joint	78	164	0.1	2mm	Clay	—	2mm	0.05	Dry
34	Joint	89	351	1.5	—	—	—	20mm	0.1	—
35	Joint	82	171	0.4	—	—	—	10mm	0.1	—
36	Joint	72	325	0.6	—	—	—	15mm	0.1	—
37	Joint	80	309	1.0	40mm	Clay	Stepped	60mm	0.1	damp
38	Joint	87	168	0.4	—	—	Stepped	30mm	0.1	—
39	Joint	77	001	0.4	40m	gravelly	—	70mm	0.1	Damp
40	Bed	15	090	—	[illegible]		—	10mm	0.1	—

geotechnics

ROCK MASS SURVEY DATA SHEET

SITE LOCATION: Cambrian Quarry

DATE OF SURVEY: DD 03 MM 05 YEAR 2012

Operator: kf.

JOB NO: PN PN122722

CLIENT: Ash

Engineer:

CQ4

Method of Location

1 By Coordinates
2 Chainage
3 Located on drawing (attached)
[✓ 4 Other] ______

Locality Type

1 Natural exposure
2 Construction excavation
[✓ 3 Quarry Slope]
4 Tunnel
5 Other ______

Size of exposure m2 15 by 25

SLOPE DIP 78 degrees

either / or not both

SLOPE DIP DIRECTION 293 degrees from North

SLOPE STRIKE degrees from north

ROCK MATERIAL DATA

ROCK STRENGTH:

COLOUR:

GRAINSIZE:

ROCK TYPE:

REMARKS indicate state of material weathering grade for Mercia Mudstone, chalk etc, changes in rock type, major faulting / folding apparent?

Strong yellowish grey f-m grained Quartzite

ROCK MASS DATA

3 No of major joint / discontinuity sets

[✓ Y] / N plus random

Line Survey Y / N

Plunge of line degrees from horizontal

Line Direction 072 degrees from north

Joint Set	Dip	Dip Direction / Strike (delete)
1		
2		
3		
4		
5		

geotechnics

DATA COLLECTION SHEET

SHEET 1 OF 2

CQ4.

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
0	Joint	84	253	0.8	—	—	—	5mm	0.1	—
1	Bed	24	091	—	—	—	—	50mm	0.6	—
2	Joint	32	66	0.4	3mm	Gravel		20mm	0.6	Damp
3	Joint	32	66	0.4	10mm	Gravel		20mm	0.6	Damp
4	Joint	30	233	0.3	10mm	clay	Stepped	40mm	0.2	Damp
5	Joint	86	166	0.4	—	—		40mm	0.2	—
6	Joint	68	210	3m	1mm	—		70m	1m	
7	Joint	86	222	4m +	1mm	—		60mm	1m	—
8	Joint	84	059	1.2	—	—	—	20mm	1m	
9	Joint	82	335	4m	2mm	clay		30mm	1m	
10	bed	20	076	—	—	—		50mm	0.6	—
11	Joint	86	064	2m	2mm	gravel		10mm	1m	Dry
12	Joint	86	332	1.1m	2mm	—		10mm	1m	Dry
13	Joint	72	023	1.2m	—	—	—	30mm	1m	—
14	Joint	84	018	1.5	—	—	—	10m	1m	—
15	Joint	80	241	0.5	5mm	Sandy		10m	0.5	Damp
16	Joint	59	250	0.5	—	—	—	15mm	0.5	—
17	Joint	83	064	0.4	—	—	—	10mm	0.4	—
18	Joint	68	304	0.3	—	—	—	3mm	0.3	—
19	Bed	30	073	—	—	—	—	30mm	0.2	—
20	Joint	84	346	0.4	—	—	—	70mm	0.4	—
21	Joint	68	218	0.3	—	—	—	10mm	0.3	—
22	Joint	70	164	0.3	—	—	—	30mm	0.3	—
23	Joint	84	218	0.2	—	—	—	10mm	0.2	—

geotechnics

DATA COLLECTION SHEET

SHEET 2 OF 2

CG4

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
24	Joint	73	299	7 m	—	—	—	20mm	0·3	—
25	Joint	82	160	0·25 —	1mm	tight		10mm	0.28	Dry.
26	Joint	60	166	0·05	1mm	tight		3mm	0·05	Dry.
27	Joint	18	182	0·04	1mm.	tight		2mm	0·04	Dry.
28	Joint	79	344	0.3	—	—	—	4mm	0·3	—
29	Joint	85	111	0·3	—	—	—	10mm	0·3	—
30	Joint	64	060	0·5	—	—	—	40mm	0·2	—
31	Joint	78	131	1m	—	—	—	3mm	0·3	—
32	Joint	74	319	8m	—	—	—	30mm	1m	—
33	Joint	10	214	0·3	2mm	Sand		2mm	0·1	Dry
34	Joint	15	014	0·2	3mm	Sand		5mm	0·1	Damp
35	Joint	6	026	0·4	5mm	Sand		10mm	0·2	Damp.
36	Joint	82	052	0·6	—	—	Stepped	50mm	0·2	—
37	Joint	48	294	0·8	—	—	—	10mm	0·3	—
38	Joint	74	336	2m	2mm	Sand		16mm	0·2	Dry
39	Joint	69	224	7m	15mm	Sandy clay	—	20mm	0·5	Damp
40	Joint	70	298	3m	—	—	—	40mm	0·7	—

C05

geotechnics

ROCK MASS SURVEY DATA SHEET

SITE LOCATION Cambrian Quarry **DATE OF SURVEY** DD 6 MM 5 YEAR 2012 **Operator** km/kj

JOB NO: PN PN122722 **CLIENT** ASH **Engineer**

Method of Location
1 By Coordinates
2 Chainage
3 Located on drawing (attached)
[✓ 4] Other

Locality Type
1 Natural exposure
2 Construction excavation
[✓ 3] Quarry Slope
4 Tunnel
5 Other

Size of exposure m2 100 by 20

SLOPE DIP 64° degrees

either / or not both

SLOPE DIP DIRECTION 6 280 degrees from North

SLOPE STRIKE degrees from north

ROCK MATERIAL DATA On the east hanging wall of quarry

ROCK STRENGTH Strong

COLOUR Pale grey–creamish

GRAINSIZE fine

ROCK TYPE Quartzite

REMARKS indicate state of material weathering grade for Mercia Mudstone, chalk etc, changes in rock type, major faulting / folding apparent?

General dip: towards east.
On a bench 6–10m above floor of quarry.

ROCK MASS DATA

3 No of major joint / discontinuity sets

[✓ Y] / N plus random

Line Survey Y / N
Plunge of line degrees from horizontal
Line Direction 280 degrees from north

Joint Set	Dip	Dip Direction / Strike (delete)
1		
2		
3		
4		
5		

geotechnics

DATA COLLECTION SHEET

SHEET 1 OF

CQ5

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
0	Joint	84	220	1.5+	—	—	—	35mm	0.5	—
1	Joint	82	340	0.5	—	—	—	25mm	0.5	—
2	Joint	78	260	1.5	—	—	—	30mm	1.0	—
3	Joint	80	360	5m	3mm	clay	—	25mm	0.3	Dry
4	Joint	72	260	3m+	—	—	—	75mm	1.0	—
5	Joint	76	180	0.5	3mm	—	—	10mm	0.5	Dry
6	Bed	20	100	3m+	1mm	tight		10mm	1.0	—
7	Bed	24	098	3m+	1mm	tight	—	10mm	1.0	—
8	Joint	82	005	1.2	5mm	gravel + clay		50mm	1.0	Dry
9	Joint	44	105	1.2	1mm	clay		10mm	0.1	Dry
10	Joint	82	340	5m	2mm	Sand		25mm	0.1	Dry
11	Joint	82	100	0.5+	2mm	clay		25mm	0.1	Dry
12	Joint	82	340	2m+	3mm	clay		75mm	1.0	Dry
13	Joint	80	240	2m+	—	—	—	75mm	1.0	—
14	J	68	004	0.7	—	—	—	30mm	0.7	Dry
15	J	84	356	0.7				40mm	0.7	—
16	J	85	271	1.2	4mm	Clay + gravel		50mm	1.0	Damp
17	J	64	197	0.3	10mm	gravel		20mm	0.20m	Dry
18	J	78	078	0.8m	—	—		30mm	0.80m	Dry
19	J	88	167	0.4m	10mm	gravel		10mm	0.30m	Dry
20	J	57	240	0.5m	—	—		30mm	0.50	Dry
21	J	80	385	0.2m	1mm	tight		10mm	0.30m	Dry
22	J	83	210	0.5m	[illegible]			5mm	0.50m	Dry
23	J	79	282	0.6m				20mm	0.2m	

geotechnics

DATA COLLECTION SHEET

SHEET 2 OF

CG 5

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
24	J	86	105	0.5m				10mm	0.50m	
25	J	89	007	0.6m				10mm	0.60	
26	J	78	269	1.5m				30mm	1.00	
27	J	82	020	0.30m	2mm	Sand & clay		10mm	0.30	Damp
28	"	"	"	"	"	"		"	"	"
29	J	45	173	30cm	4mm	Clay & sand		20mm	30cm	Dry
30	J	76	356	0.80m	4mm	Sand & clay		40	0.80	Dry
31	J	86	226	1.5	3mm	clay	Iron Staining	100mm	1.0	Dry
32	J	28	045	3m	2mm	clay		25mm	0.1	Dry
33	J	78	060	2m+	2mm	Sand		50mm	0.5	Dry
34	J	64	035	5m+	5mm	sand + clay + gravel		25mm	0.2	Dry
35	J	72	320	1.5m+	—	—	—	25mm	1.0	—
36	J	88	045	3m	2mm	clay		25mm	0.5	Damp
37	J	84	310	1.0	tight	—		10mm	1.0	Dry
38	J	80	232	0.5	—	—	—	25mm	1.0	—
39	J	84	342	6m+	—	—	—	75mm	0.5	—
40	J	76	145	1m+	2mm	clay	—	50mm	0.5	Dry
41	J	74	190	1m+	3mm	—	—	50mm	1.0	Dry
42	J	79	240	3m	3mm	sand + clay	—	25mm	0.3	Dry
43	J	80	300	1.2	—	—	—	50mm	1.0	—
44	J	80	040	1.5	3mm	clay		100mm	1.0	Dry
45	J	82	312	1.2	—	—	—	75mm	1.0	—
46	J	82	360	1.5	2mm	clay	—	75mm	0.5	Damp
47	J	74	285	1.0m+	—	—	Stepped	50mm	0.75m	—

PARALLEL & IDENTICAL

geotechnics

DATA COLLECTION SHEET

SHEET 3 OF

CQS

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness Amplitude	Waviness Wavel'th	Water
48	J	86	065	0·4	—	—	—	5mm	0·4	—
49	J	86	055	0·5	—	—	—	5mm	0·5	—
50	J	80	630	4m	25mm	clay + gravel	—	25mm	1·0	Dry
51	J	84	231	1·2m				50mm	1·0	
52	B	14	133	0·15m				20mm	0·07	
53	J	70	283	1·50m				30mm	0·50	
54	J	V	016	2·50m				40mm	1·50	
55	J	V	016	~~[illegible]~~ 1·00m				"	"	
56	J	78	069	0·40m				10mm	0·40m	
57	J	80	317	0·30m				10mm	0·30m	
58	J	80	041	1·20m	3mm	—		40mm	1·10	Dry
59	J	53	106	0·60m				75mm	0·60	
60	J	72	006	1·20m				40mm	1·20m	
61	B?	30	094	0·40						
62	B?	42	087	0·76						
63	J	80	002	0·40				10mm	0·40m	
64	J	88	272	0·30				20mm	0·30m	
65	J	84	015	0·30	3mm	No		20mm	0·30m	Damp
66	J	61	220	0·20				10mm	0·20m	
67	J	82	348	0·10				5mm	0·10m	
68	J	87	218	0·20				5mm	0·20m	
69	J	83	006	0·30	20mm	~~[illegible]~~ clay		5 ~~[illegible]~~mm	0·30	Damp
70	J	85	206	0·20				10mm	0·20m	
71	J	82	018	0·20				10mm	0·10m	

[illegible]

geotechnics

DATA COLLECTION SHEET

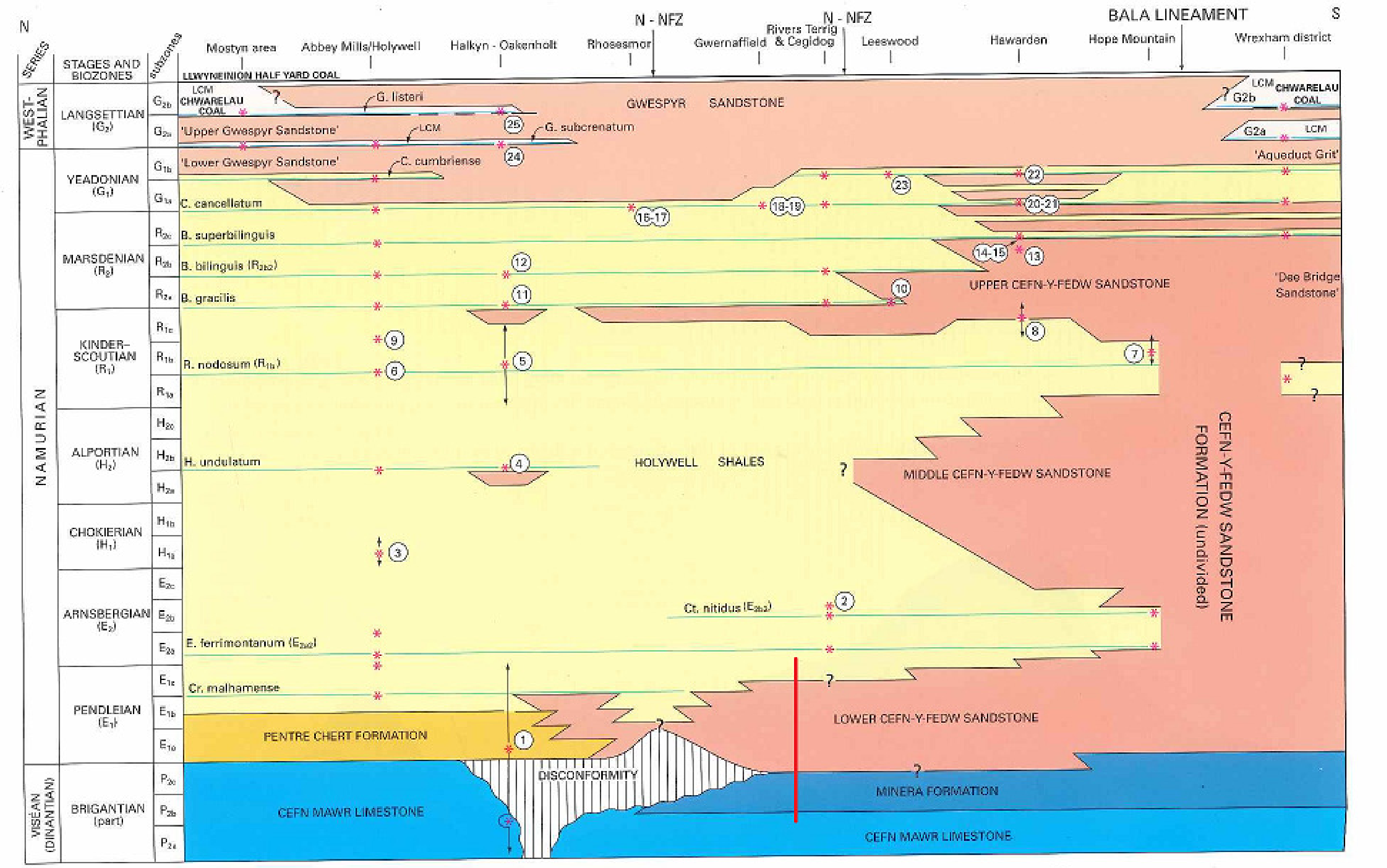
SHEET 4 OF

CHAINAGE (m)	Type	Dip	Direction / Strike	Persistence (m)	Aperture (mm)	Infilling	Weathering	Waviness		Water
								Amplitude	Wavel'th	
72	J	84	056	30cms	4mm	Clay		10mm	30cms	Damp
73	J	82	275	15cms	5mm			5mm	15cms	
74	J	78	007	30cms	1mm	Clay		10mm	15cms	Damp
75	J	82	031	40cms	1mm	Clay		5mm	0.40m	Damp
76	J	84	337	40cms				5mm	0.40m	
77	B	25	079	∞		Tight		1cm	1cm	
78	J	81	249	0.40m				5m	0.40m	
79	J	78	245	0.2	—	—	—	5mm	0.2	
80	J	78	320	0.2	—	—	—	5mm	0.2	
81	B	22	095	10m	—	—	—	100mm	1m	
82	J	86	005	0.2	1mm	clay	stepped	5mm	0.2	
83	B	22	080	10m	tight.			100mm	5m	
84										
85										
86										
87										
88										
89										
90										
91										
92										
93										
94										
95										

Worm burrows

APPENDIX 4

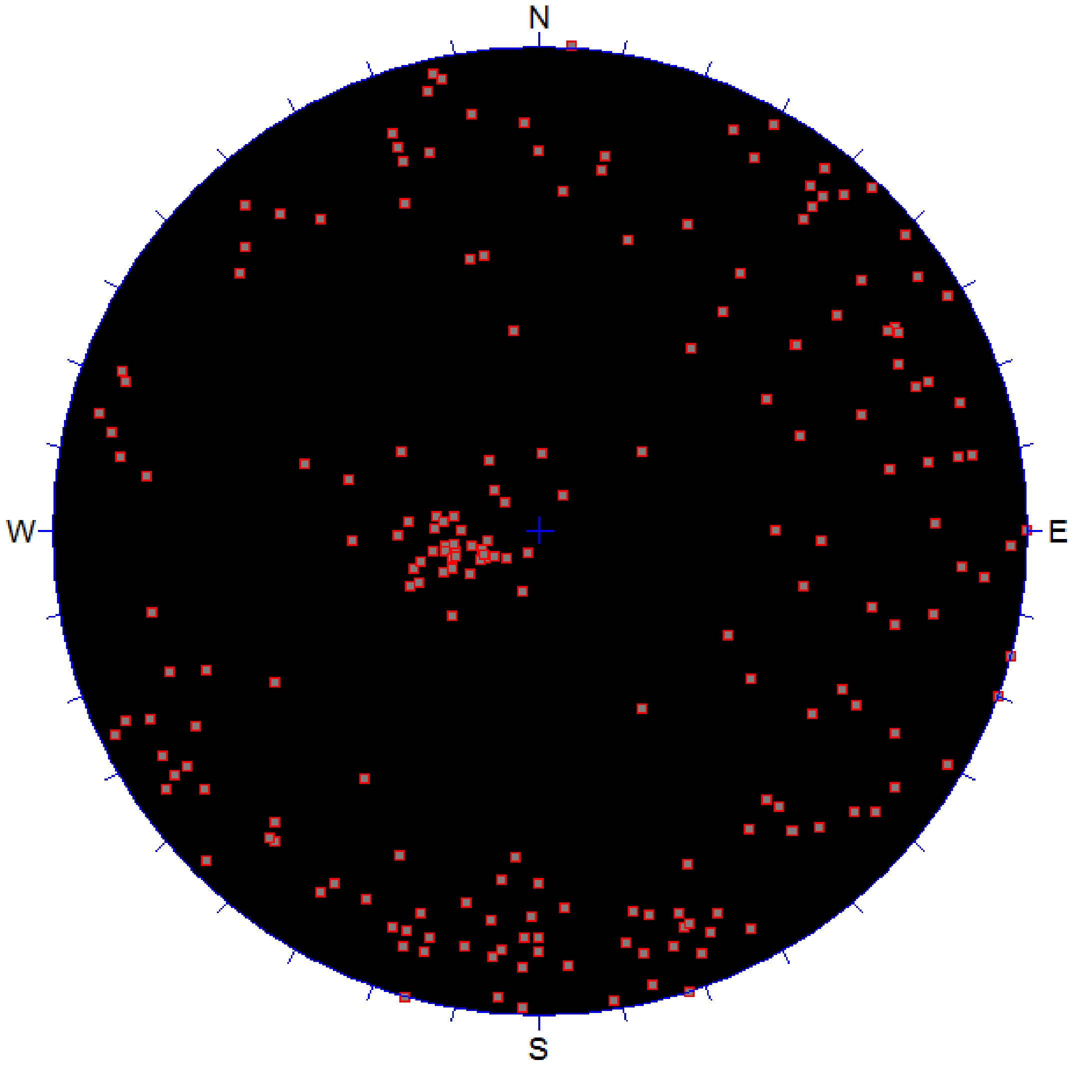
EXTRACT FROM BGS MEMOIR



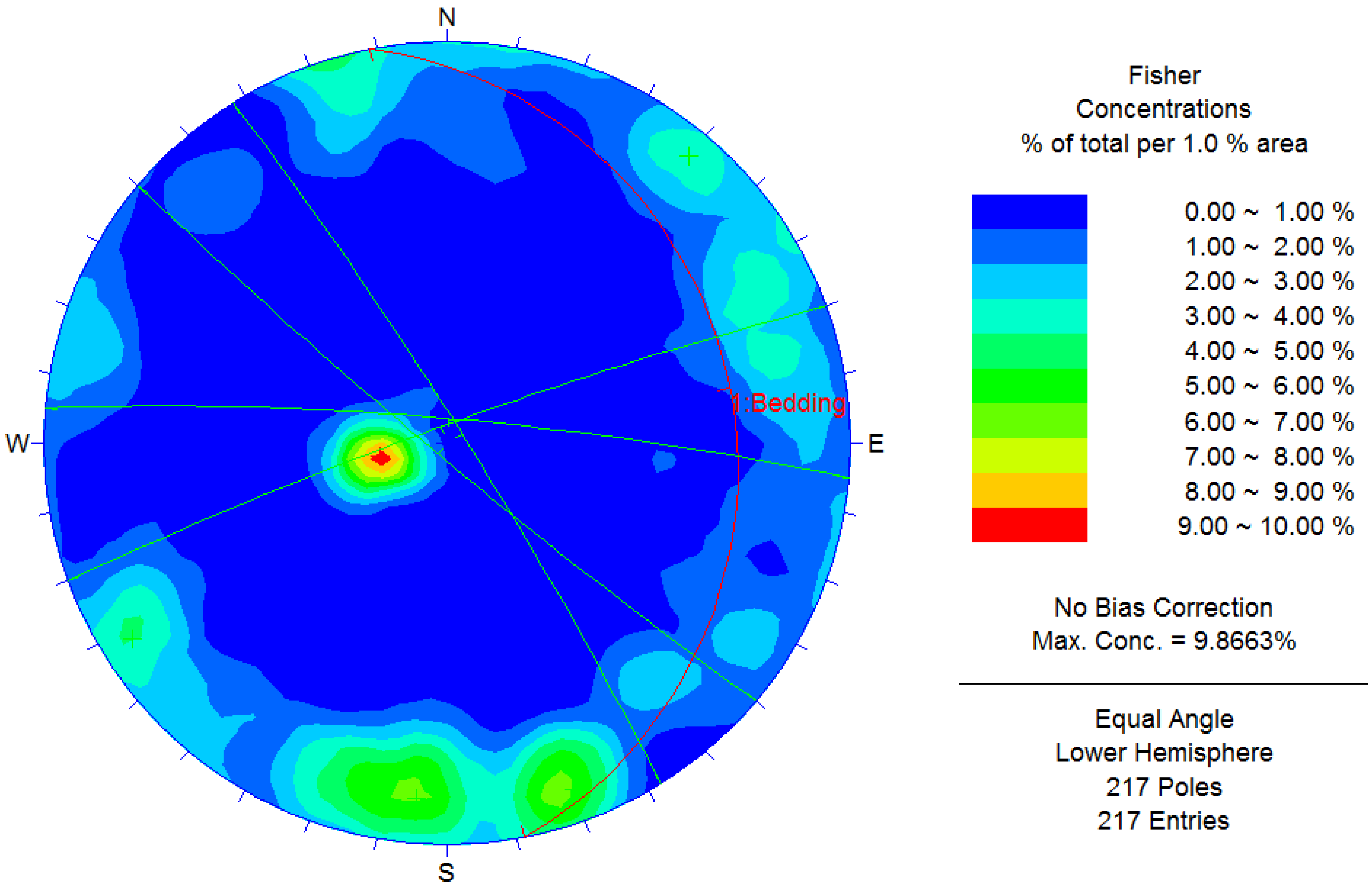
APPENDIX 4: Copy of Figure 1: Extract from BGS Memoir (Approximate position of stratigraphy within the local stratigraphic sequence is shown by the vertical red line

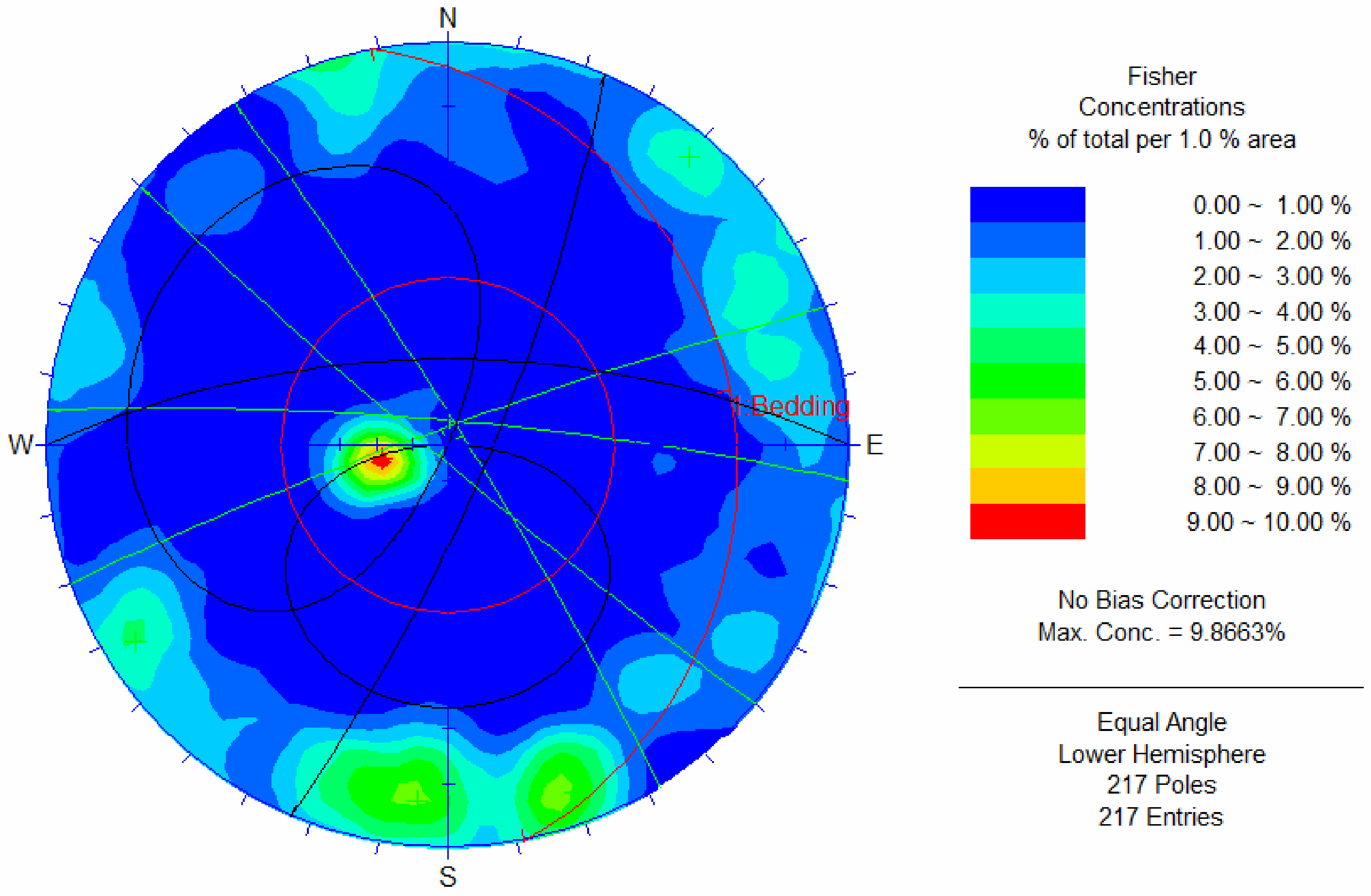
APPENDIX 5

LOWER HEMISPHERICAL PLOTS



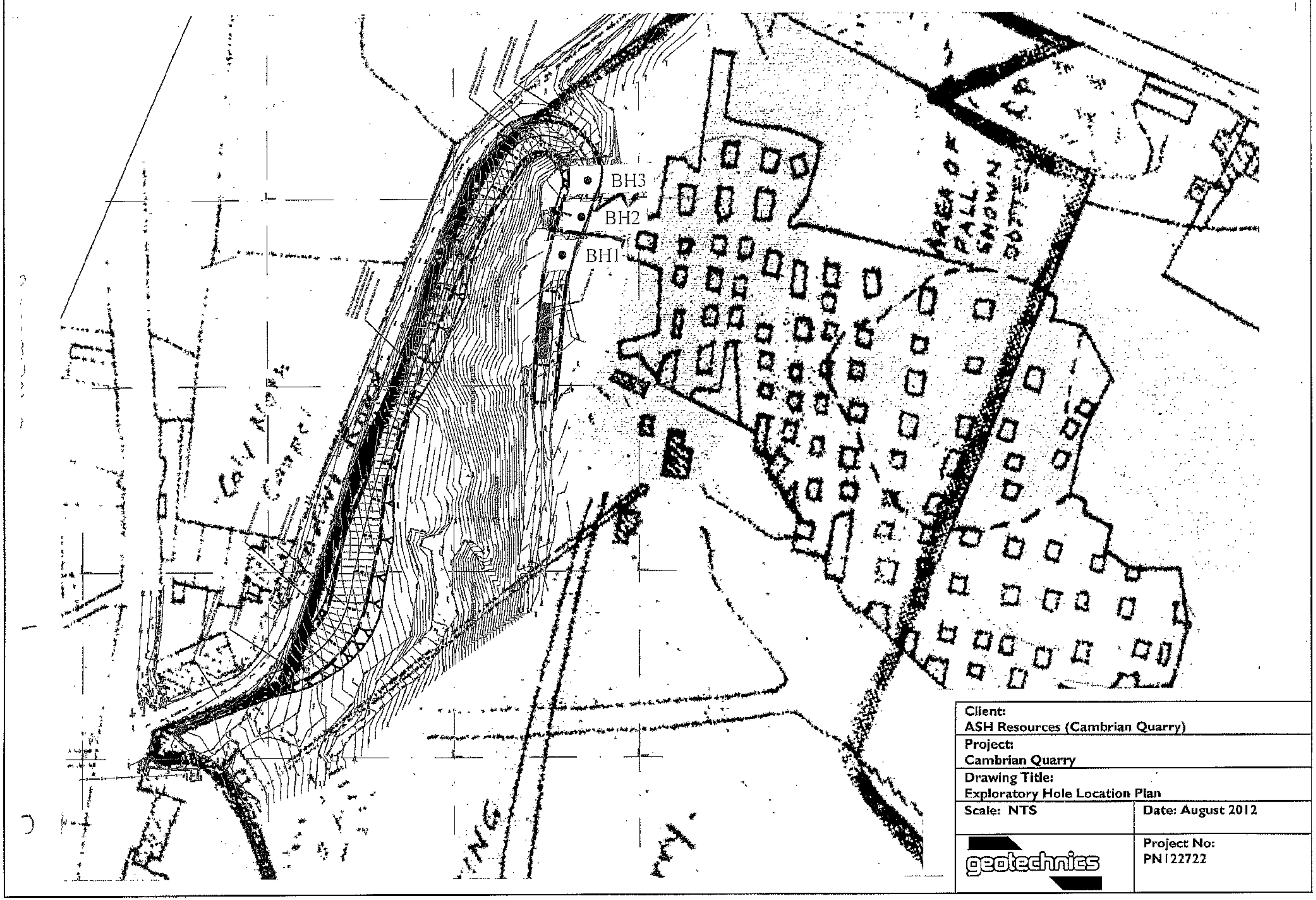
Equal Angle
Lower Hemisphere
217 Poles
217 Entries


N
W
E
S
1:Bedding
Fisher
Concentrations
% of total per 1.0 % area
0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %
7.00 ~ 8.00 %
8.00 ~ 9.00 %
9.00 ~ 10.00 %
No Bias Correction
Max. Conc. = 9.8663%
Equal Angle
Lower Hemisphere
217 Poles
217 Entries


N
W
E
S
1 Bedding
Fisher
Concentrations
% of total per 1.0 % area
0.00 ~ 1.00 %
1.00 ~ 2.00 %
2.00 ~ 3.00 %
3.00 ~ 4.00 %
4.00 ~ 5.00 %
5.00 ~ 6.00 %
6.00 ~ 7.00 %
7.00 ~ 8.00 %
8.00 ~ 9.00 %
9.00 ~ 10.00 %
No Bias Correction
Max. Conc. = 9.8663%
Equal Angle
Lower Hemisphere
217 Poles
217 Entries

APPENDIX 6

EXPLORATORY HOLE LOCATION PLAN



Client:
ASH Resources (Cambrian Quarry)

Project:
Cambrian Quarry

Drawing Title:
Exploratory Hole Location Plan

Scale: NTS

Date: August 2012

geotechnics

Project No:
PN122722

APPENDIX 7

BOREHOLE RECORDS

DATA SHEET - Symbols and Abbreviations used on Records

Sample Types

B	Bulk disturbed sample
BLK	Block sample
C	Core sample
D	Small disturbed sample (tub/jar)
E	Environmental test sample
ES	Environmental soil sample
EW	Environmental water sample
G	Gas sample
L	Liner sample
LB	Large bulk disturbed sample
P	Piston sample (PF - failed P sample)
TW	Thin walled push in sample
U	Open Tube - 102mm diameter with blows to take sample. (UF - failed U sample)
UT	Thin wall open drive tube sampler - 102mm diameter with blows to take sample. (UTF - failed UT sample)
V	Vial sample
W	Water sample
#	Sample Not Recovered

Insitu Testing / Properties

CBRP	CBR using TRL probe
CHP	Constant Head Permeability Test
COND	Electrical conductivity
HV	Strength from Hand Vane
ICBR	CBR Test
IDEN	Density Test
IRES	Resistivity Test
MEX	CBR using Mexecone Probe Test
PKR	Packer Permeability Test
PLT	Plate Load Test
PP	Strength from Pocket Penetrometer
Temp	Temperature
VHP	Variable Head Permeability Test
VN	Strength from Insitu Vane
w%	Water content

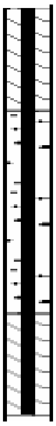
(All other strengths from undrained triaxial testing)

S	Standard Penetration Test (SPT)
C	SPT with cone
N	SPT Result
-/-	Blows/penetration (mm) after seating drive
-*/- (mm)	Total blows/penetration
( )	Extrapolated value

Groundwater

Water Strike	∇
Depth Water Rose To	▼

Instrumentation



Seal

Filter

Seal

Strata

Made Ground Type 1

Type 2

Topsoil

Cobbles and Boulders

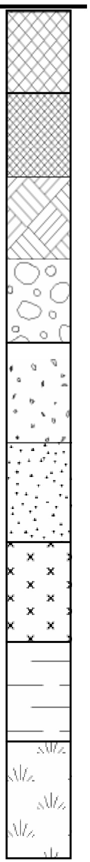
Gravel

Sand

Silt

Clay

Peat



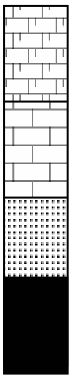
Note: Composite soil types shown by combined symbols

Chalk

Limestone

Sandstone

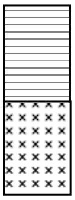
Coal



Strata, Continued

Mudstone

Siltstone

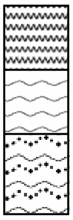


Metamorphic Rock

Fine Grained

Medium Grained

Coarse Grained

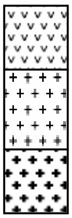


Igneous Rock

Fine Grained

Medium Grained

Coarse Grained



Backfill Materials

Arisings

Bentonite Seal

Concrete

Fine Gravel Filter

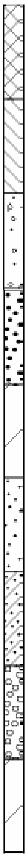
General Fill

Gravel Filter

Grout

Sand Filter

Tarmacadam



Rotary Core

RQD	Rock Quality Designation (% of intact core >100mm)
FRACTURE INDEX	Fractures/metre
FRACTURE SPACING (mm)	Maximum Minimum
NI	Non-intact core
NR	No core recovery
AZCL	Assumed zone of core loss

(where core recovery is unknown it is assumed to be at the base of the run)

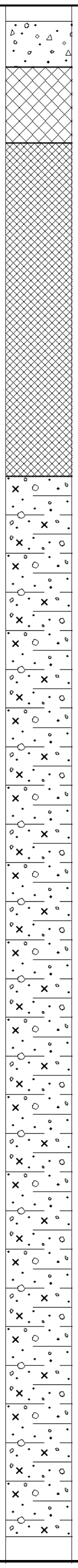
BOREHOLE RECORD - *Rotary Open Hole*

Project CAMBRIAN QUARRY
Engineer ASH RESOURCES (CAMBRIAN QUARRY)
Borehole **BH1**
Project No PN122722

Client SLOANE MEAD

Drilling | Properties/Sampling | Strata | Scale 1:50

Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
								G.L.	
						MADE GROUND: "Road chippings"*			
						MADE GROUND: "Brick & Limestone"*		0.30	
						MADE GROUND: "Limestone Fill"*		0.80	
						Stiff reddish brown slightly sandy gravelly CLAY with low cobble content		3.00	



Drilling | Progress | Groundwater

Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
0.80	0.80	Inspection Pit	IB	G.L.			02/07/12	08:00						
40.00	0.12	Rotary Open Hole	IB	0.80			02/07/12	18:00						
				0.80			04/07/12	08:00						
				26.00			04/07/12	18:00						
				26.00			05/07/12	08:00						
				40.00			05/07/12	18:00						

Remarks AGS

Inspection pit (800mm square) hand excavated to 0.80m depth.
The Borehole was terminated at a depth of 40.0m on proving absence of any significant mine related voids
The borehole was backfilled on completion using bentonite grout
* Drillers description.
Air / mist flush - 100% returns maintained

No significant groundwater inflows recorded

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **1 of 4**
13/07/2012

geotechnics

BOREHOLE RECORD - *Rotary Open Hole*

Project **CAMBRIAN QUARRY**

Engineer **ASH RESOURCES (CAMBRIAN QUARRY)**

Borehole **BH1**

Project No **PN122722**

Client **SLOANE MEAD**

Drilling		Properties/Sampling				Strata			Scale 1:50
Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
						Strong light grey massive to thickly bedded fine to medium grained SANDSTONE (Cefn y Fedw Sandstone)	**At 17.00m, becomes thinly bedded, with bands of weak red sandy MUDSTONE**	**10.20**	
						Weak grey, in places red,		**19.80**	

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks AGS

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **2 of 4**

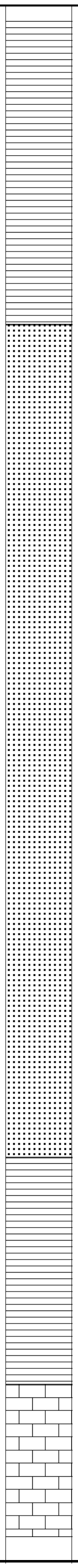
13/07/2012

BOREHOLE RECORD - *Rotary Open Hole*

Project	CAMBRIAN QUARRY	Engineer	ASH RESOURCES (CAMBRIAN QUARRY)	**Borehole** Project No	**BH1** PN122722
Client	SLOANE MEAD				

Drilling | **Properties/Sampling** | **Strata** Scale 1:50

Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
						thinly bedded MUDSTONE		22.00	
						Medium strong grey, in places red thinly bedded SANDSTONE		27.50	
						Weak grey thinly bedded MUDSTONE, with thin bands of limestone (Passage Beds)		29.00	
						Strong grey, locally red, LIMESTONE (Minera Formation)			



Drilling | **Progress** | **Groundwater**

Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **3 of 4**
13/07/2012

geotechnics

BOREHOLE RECORD - *Rotary Open Hole*

Project CAMBRIAN QUARRY

Engineer ASH RESOURCES (CAMBRIAN QUARRY)

Borehole **BH1**

Project No **PN122722**

Client SLOANE MEAD

Drilling		Properties/Sampling				Strata			Scale 1:50
Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
								40.00	
						End of Drillhole			

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **4 of 4**

13/07/2012

geotechnics

BOREHOLE RECORD - *Rotary Open Hole*

Project CAMBRIAN QUARRY

Engineer ASH RESOURCES (CAMBRIAN QUARRY)

Borehole **BH2**

Project No PN122722

Client SLOANE MEAD

Scale 1:50

Drilling / Properties/Sampling / Strata

Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth
								G.L.
						MADE GROUND: "Road chippings"*		0.20
						MADE GROUND: "Brick and Limestone"*		0.80
						MADE GROUND: "B/Fill"*		9.50
						MADE GROUND: "Backfilled limestone rubble"*		

Drilling

Depth	Hole Dia	Technique	Crew
1.20	0.80	Inspection Pit	IB
12.00	0.12	Rotary Open Hole	IB

Progress

Depth of Hole	Depth Cased	Depth to Water	Date	Time
G.L.			02/07/12	08:00
1.20			02/07/12	18:00
1.20			03/07/12	08:00
12.00			03/07/12	18:00

Groundwater

Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks

Inspection pit (800mm square) hand excavated to 1.20m depth.
The Borehole was terminated at a depth of 12.0m on losing flush returns, whilst still in backfill materials
The borehole was backfilled on completion using bentonite grout
* Drillers description.
Air / mist flush
No significant groundwater inflows recorded

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **1 of 2**
13/07/2012

geotechnics

BOREHOLE RECORD - *Rotary Open Hole*

Project **CAMBRIAN QUARRY**
Engineer **ASH RESOURCES (CAMBRIAN QUARRY)**
Borehole **BH2**
Project No **PN122722**

Client **SLOANE MEAD**

Drilling		Properties/Sampling				Strata			Scale 1:50
Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
								12.00	▨
						End of Drillhole			

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks AGS

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **2 of 2**
13/07/2012

geotechnics

BOREHOLE RECORD - *Rotary Open Hole*

Project **CAMBRIAN QUARRY**

Engineer **ASH RESOURCES (CAMBRIAN QUARRY)**

Borehole **BH3**

Project No **PN122722**

Client **SLOANE MEAD**

Drilling | Properties/Sampling | Strata | Scale 1:50

Core Run/Depth (Core Dia)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %		Description General	Description Detail	Depth	Legend
								G.L.	
						MADE GROUND: "Road chippings"*		0.30	⁘
						MADE GROUND: "Brick / limestone Fill"*		1.20	▨
						MADE GROUND: "Limestone Fill"*		1.90	▩
						MADE GROUND: "Limestone Boulders"* (Possible collapsed void)		6.00	▨
						MADE GROUND: "Soft Material"	At 6.50m, Obstruction encountered associated with loss of flush - Probable top of intact Sandstone stratum	6.50	▧
						End of Drillhole			

Drilling

Depth	Hole Dia	Technique	Crew
1.20		Inspection Pit	IB
6.50	0.13	Rotary Open Hole	IB

Progress

Depth of Hole	Depth Cased	Depth to Water	Date	Time
G.L.			02/07/12	08:00
1.20			02/07/12	18:00
1.20			06/07/12	08:00
6.50			06/07/12	18:00

Groundwater

Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks

Inspection pit (800mm square) hand excavated to 1.20m depth.
The Borehole was terminated at a depth of 6.5m on losing flush returns, whilst drilling on an obstruction. An attempt was made to resite the rig at BH3A but the steep slope and wet conditions did not allow a stable rig footing to be maintained.
The borehole was backfilled on completion using bentonite grout
* Drillers description
Air / mist flush
No significant groundwater inflows recorded

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:1999 + A2:2010

Figure **1 of 1**

13/07/2012

geotechnics

APPENDIX 8

INVESTIGATION TECHNIQUES AND GENERAL NOTES

INVESTIGATION TECHNIQUES

INTRODUCTION

The following brief review of Ground Investigation techniques, generally used as part of most Site Investigations in the UK, summarises their methodology, advantages and limitations. Detailed descriptions of the techniques are available and can be provided on request. This review should be read in conjunction with the accompanying General Notes.

TRIAL PITS

The trial pit is amongst the most simple yet effective means of identifying shallow ground conditions on a site. Its advantages include simplicity, speed, potential accuracy and cost-effectiveness. The trial pit is most commonly formed using a backacting excavator which can typically determine ground conditions to some 4 metres below ground level. Hand excavation is often used to locate, expose and detail existing foundations, features or services. In general, it is difficult to extend pits significantly below the water table in predominantly granular soils, where flows can cause instability. Unless otherwise stated, the trial pits will not have been provided with temporary side support during their construction. Under such circumstances ground conditions to some 1.20 metres can be closely inspected, subject to stability assessment, but below this depth, entrance into the pit is not permitted in the absence of shoring and hence observations will have been made from ground surface and samples taken from the excavator bucket.

Trends in strata type, level and thickness can be determined, shear surfaces identified and the behaviour of plant, excavation sides and excavated materials can be related to the construction process. They are particularly valuable in land slip investigations. Some types of insitu test can be undertaken in such pits and large disturbed or block samples obtained.

CABLE PERCUSSION BORING

The light Cable Percussion technique of soft ground boring, typically at a diameter of 150mm, is a well established simple and flexible method of boring vertical holes and generally allows data to be obtained in respect of strata conditions other than rock. A tubular cutter (for cohesive soils) or shell with a flap valve (for granular soils) is repeatedly lifted and dropped using a winch and rope operating from an "A" frame. Soil which enters these tools is regularly removed and either sampled for subsequent examination or test, or laid to one side for backfilling. Steel casing will have been used to prevent collapse of the borehole sides where necessary. A degree of disturbance of soil and mixing of layers is inevitable and the presence of very thin layers of different soils within a particular stratum may not be identified. Changes in strata type can only be detected on recognition of a change in soil samples at surface, after the interface has been passed. For the foregoing reasons, depth measurements should not be considered to be more accurate than 0.10 metre.

In cohesive soils cylindrical samples are retrieved by driving or pushing in 100mm nominal diameter tubes. In soft soils, piston sampling or vane testing may be undertaken. In granular soils and often in cohesive materials, insitu Standard Penetration Tests (SPT's) are performed. The SPT records the number of standard blows required to drive a 50mm diameter open or cone ended probe for 300mm after an initial 150mm penetration. A modified method of recording is used in more dense strata. Small disturbed samples are obtained throughout.

The technique can determine ground conditions to depths in excess of 30 metres under suitable circumstances and usually causes less surface disturbance than trial pitting.

ROTARY DRILLING

Rotary Drilling to produce cores by rotating an annular diamond-impregnated tube or barrel into the ground is the technique most appropriate to the forming of site investigation boreholes through rock or other hard strata. It has the advantage of being able to be used vertically or at an angle. Core diameters of less than 100mm are most common for site investigation purposes. Core is normally retrieved in plastic lining tubes. A flushing fluid such as air, water or foam is used to cool the bit and carry cuttings to the surface.

Examination of cores allows detailed rock description and generally enables angled discontinuity surfaces to be observed. However, vertical holes do not necessarily reveal the presence of vertical or near-vertical fissures or joint discontinuities. The core type and/or techniques used. Where open hole rotary drilling is employed, descriptions of strata result from examination at surface of small particles ejected from the borehole in the flushing medium. In consequence, no indication of fissuring, bedding, consistency or degree of weathering can be obtained. Small scale plant can be used for auger drilling to limited depths where access is constrained.

Depths in excess of 60 metres can be achieved under suitable circumstances using rotary techniques, with minimal surface disturbance.

WINDOW SAMPLING

This technique involves the driving of an open-ended tube into the ground and retrieval of the soil which enters the tube. The term "window sample" arose from the original device which had a "window" or slot cut into the side of the tube through which samples were taken. This has now been superseded by the use of a thin-walled plastic liner within a sampler which has a solid wall. Diameters range from 36 to 86mm. Such samples can be used for qualitative logging, selection of samples for classification and chemical analysis and for obtaining a rudimentary assessment of strength.

Driving devices can be hand-held or machine mounted and the drive tubes are typically in 1m lengths. The hole formed is not cased, however, and hence the success of this technique is limited when soils and groundwater conditions are such that the sides of the hole collapse on withdrawal of the sampler. Obstructions within the ground, the density of the material or its strength can also limit the depth and rate of penetration of this light-weight investigation technique. Nevertheless, it is a valuable tool where access is constrained such as within buildings or on embankments. Depths of up to 8m can be achieved in suitable circumstances but depths of 4m to 6m are more common.

EXPLORATORY HOLE RECORDS

The data obtained by these techniques are generally presented on Trial Pit, Borehole, Drillhole or Window Sample Records. The descriptions of strata result from information gathered from a number of sources which may include published geological data, preliminary field observations and descriptions, insitu test results, laboratory test results and specimen descriptions. A key to the symbols and abbreviations used accompanies the records. The descriptions on the exploratory hole records accommodate but may not necessarily be identical to those on any preliminary records or the laboratory summaries.

The records show ground conditions at the exploratory hole locations. The degree to which they can be used to represent conditions between or beyond such holes, however, is a matter for geological interpretation rather than factual reporting and the associated uncertainties must be recognised.

DYNAMIC PROBING

This technique typically measures the number of blows of a standard weight falling over a standard height to advance a cone-ended rod over sequential standard distances (typically 100mm). Some devices measure the penetration of the probe per standard blow. It is essentially a profiling tool and is best used in conjunction with other investigation techniques where site-specific correlation can be used to delineate the distribution of soft or loose soils or the upper horizon of a dense or strong layer such as rock.

Both machine-driven and hand-driven equipment is available, the selection depending upon access restrictions and the depth of penetration required. It is particularly useful where access for larger equipment is not available, disturbance is to be minimised or where there are cost constraints. No samples are recovered and some techniques leave a sacrificial cone head in the ground. As with other lightweight techniques, progress is limited in strong or dense soils. The results are presented both numerically and graphically. Depths of up to 10m are commonly achieved in suitable circumstances.

The hand-driven DCP probing device has been calibrated by the TRL to provide a profile of CBR values over a range of depths of up to 1.50m.

INSTRUMENTATION

The most common form of instrument used in site investigation is either the standpipe or else the standpipe piezometer which can be installed in investigation holes. They are used to facilitate monitoring of groundwater levels and water sampling over a period of time following site work. Normally a standpipe would be formed using rigid plastic tubing which has been perforated or slotted over much of its length whilst a standpipe piezometer would have a filter tip which would be placed at a selected level and the hole sealed above and sometimes below to isolate the zone of interest. Groundwater levels are determined using an electronic "dipmeter" to measure the depth to the water surface from ground level. Piezometers can also be used to measure permeability. They are simple and inexpensive instruments for long term monitoring but response times can limit their use in tidal areas and access to the ground surface at each instrument is necessary. Remote reading requires more sophisticated hydraulic, electronic or pneumatic equipment.

Settlement can be monitored using surface or buried target plates whilst lateral movement over a range of depths is monitored using slip indicator or inclinometer equipment.

GENERAL NOTES

1. The report is prepared for the exclusive use of the Client named in the document and copyright subsists with Geotechnics Limited. Prior written permission must be obtained to reproduce all or part of the report. It is prepared on the understanding that its contents are only disclosed to parties directly involved in the current investigation, preparation and development of the site.

2. Further copies may be obtained with the Client's written permission, from Geotechnics Limited with whom the master copy of the document will be retained.

3. The report and/or opinion is prepared for the specific purpose stated in the document and in relation to the nature and extent of proposals made available to Geotechnics Limited at that time. Re-consideration will be necessary should those details change. The recommendations should not be used for other schemes on or adjacent to the site without further reference to Geotechnics Limited.

4. The assessment of the significance of the factual data, where called for, is provided to assist the Client and his Engineer and/or Advisers in the preparation of their designs.

5. The report is based on the ground conditions encountered in the exploratory holes together with the results of field and laboratory testing in the context of the proposed development. The data from any commissioned desk study and site reconnaissance are also drawn upon. There may be special conditions appertaining to the site, however, which are not revealed by the investigation and which may not be taken into account in the report.

6. Methods of construction and/or design other than those proposed by the designers or referred to in the report may require consideration during the evolution of the proposals and further assessment of the geotechnical and any geoenvironmental data would be required to provide discussion and evaluations appropriate to these methods.

7. The accuracy of results reported depends upon the technique of measurement, investigation and test used and these values should not be regarded necessarily as characteristics of the strata as a whole (see accompanying notes on Investigation Techniques). Where such measurements are critical, the technique of investigation will need to be reviewed and supplementary investigation undertaken in accordance with the advice of the Company where necessary.

8. The samples selected for laboratory test are prepared and tested in accordance with the relevant Clauses of BS 1377 Parts 1 to 8, where appropriate, in Geotechnics Limited's UKAS accredited Laboratory, where possible. A list of tests is given.

9. Tests requiring the use of another laboratory having UKAS accreditation where possible are identified.

10. Any unavoidable variations from specified procedures are identified in the report.

11. Specimens are cut vertically, where this is relevant and can be identified, unless otherwise stated.

12. All the data required by the test procedures are recorded on individual test sheets but the results in the report are presented in summary form to aid understanding and assimilation for design purposes. Where all details are required, these can be made available.

13. Whilst the report may express an opinion on possible configurations of strata between or beyond exploratory holes, or on the possible presence of features based on either visual, verbal, written, cartographical, photographic or published evidence, this is for guidance only and no liability can be accepted for its accuracy.

14. Classification of materials as Made Ground is based on the inspection of retrieved samples or exposed excavations. Where it is obvious that foreign matter such as paper, plastic or metal is present, classification is clear. Frequently, however, for fill materials that arise from the adjacent ground or from the backfilling of excavations, their visual characteristics can closely resemble those of undisturbed ground. Other evidence such as site history, exploratory hole location or other tests may need to be drawn upon to provide clarification. For these reasons, classification of soils on the exploratory hole records as either Made Ground or naturally occurring strata, the boundary between them and any interpretation that this gives rise to should be regarded as provisional and subject to re-evaluation in the light of further data.

15. The classification of materials as Topsoil is generally based on visual description and should not be interpreted to mean that the material so described complies with the criteria for Topsoil used in BS 3882 (2007). Specific testing would be necessary where such definition is a requirement.

16. Ground conditions should be monitored during the construction of the works and the report should be re-evaluated in the light of these data by the supervising geotechnical engineers.

17. Any comments on groundwater conditions are based on observations made at the time of the investigation, unless specifically stated otherwise. It should be noted, however, that the observations are subject to the method and speed of boring, drilling or excavation and that groundwater levels will vary due to seasonal or other effects.

18. Any bearing capacities for conventional spread foundations which are given in the report and interpreted from the investigation are for bases at a minimum depth of 1m below finished ground level in naturally occurring strata and at broadly similar levels throughout individual structures, unless otherwise stated. The foundations should be designed in accordance with the good practice embodied in BS 8004:1986 - Foundations, supplemented for housing by NHBC Standards. Foundation design is an iterative process and bearing pressures may need adjustment or other measures may need to be taken in the context of final layouts and levels prior to finalisation of proposals.

19. Unless specifically stated, the investigation does not take account of the possible effects of mineral extraction or of gases from fill or natural sources within, below or outside the site.

20. The costs or economic viability of the proposals referred to in the report, or of the solutions put forward to any problems encountered, will depend on very many factors in addition to geotechnical or geoenvironmental considerations and hence their evaluation is outside the scope of the report.