Appendix 3A
Site Investigation & Design Report

THE ALSTON EXTENSION TO LINHAY QUARRY, ASHBURTON, DEVON.

SITE INVESTIGATION & DESIGN REPORT

Sandybed Geological Services

January 2016

Drilling to prove limestone at Alston - Jan 2015

THE ALSTON EXTENSION TO LINHAY QUARRY, ASHBURTON, DEVON.

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THE ALSTON EXTENSION TO LINHAY QUARRY, ASHBURTON, DEVON.

1. Summary

A total of 40 DTH boreholes were sunk during the week commencing 12th January 2015, building on the information provided by the earlier electrical resistivity survey. Of these, 30 boreholes returned chippings later tested with dilute acid proving very strong fresh limestone. A further 6 holes encountered rockhead and the drilling progress indicated limestone had been encountered, but no sample was retrieved due to loss of drill flush. The boreholes confirmed the findings of the geophysical survey with an average thickness of 5.1m of overburden across the proposed Alston extension. However, the inherent variation predicted by the resistivity survey was confirmed. Targeted boreholes confirmed that in places the limestone was less than a metre below ground level. Elsewhere a number of clay filled sinkholes were discovered. Two trial pits were excavated where the limestone had been proven to be at shallow depth in order to take measurements on the bedding planes. From these exposures it is considered reasonable to conclude that the strike and dip of the strata in the proposed extension is similar to the existing Linhay quarry.

Attached to the report is a photographic record of the limestone samples retrieved, borehole logs, a plan showing the geophysical survey and a borehole location plan together with isopachyte contours of the overburden thickness.

This data has been used to calculate the volumes of overburden which requires removal and the associated earthworks to accommodate this material and screen the quarry workings. The quarry design is based on the parameters established at Linhay in order to calculate the reserves of limestone. A series of phased drawings and sections are attached to the report to illustrate the quarry development. It is estimated that the proposed quarry extension contains **redacted** of limestone reserve.

2. Introduction

Sandybed Geological Services has been commissioned by E & JW Glendinning Ltd to design an extension to the Linhay quarry at Ashburton, Devon. This report describes the site investigation and reports on the findings, records the calculations made on the volumes of overburden and limestone reserves and illustrates the design of the associated earthworks and quarry excavation.

3. Site Investigation

3.1 Published Data

The BGS one inch to the mile for the site is Sheet No. 338 Dartmoor Forest (Okehampton) and scale 1 : 50,000 Sheet No.339 Newton Abbot. This identifies the geolgical sequence as follows:-

Upper Devonian:	East Ogwell Limestone	grey to pink limestone	70m
	Foxley Tuff	volcanic pyroclastic	20–80m
	Chercombe Bridge Limestone	**grey limestone**	**130m**
Middle Devonian:	Denbury Crinoidal Limestone	limestone & slates	80m
	Nordon Slate	grey to green slates	80m

Linhay quarry is working the Chercombe Bridge Limestone. No other formations are seen in the quarry. The following reports have been reviewed in the preparation of this report.

Report title	Prepared by	Date
Report on the rock slope stability of existing and proposed workings at Linhay Hill Quarry, Ashburton, Devon.	Engineering Geology Ltd	March 1987
Linhay Quarry, Ashburton, Devon. Geotechnical Assessment of the stability of the excavated slopes and tips classified as Significant Hazard in accordance with the Quarries Regulations 99.	Jeremy Rickeard, Frederick Sherrell Ltd'	Aug 2008
Linhay Quarry, Ashburton, Devon. Geotechnical Assessment of the stability of the excavated slopes and tips classified as Significant Hazard in accordance with the Quarries Regulations 99.	Jeremy Rickeard, Frederick Sherrell Ltd	Sept 2010
Linhay Quarry. Letter report with plan and sections, Figs 1 & 2.	Jeremy Rickeard, Frederick Sherrell Ltd	July 2011
Linhay Quarry, Ashburton, Devon. Geotechnical Assessment of the stability of the excavated slopes and tips classified as Significant Hazard in accordance with the Quarries Regulations 99.	Jeremy Rickeard, Frederick Sherrell Ltd	May 2013
Quarry Development and Assessment of Reserves of Limestone in Linhay Quarry, Ashburton, Devon.	Sandybed Geological Services	May 2014
Aggregate Reserves Sterilised beneath the Lane separating Linhay Quarry from the Alston Land.	Sandybed Geological Services	May 2014
Resistivity Imaging Surveys to Characterise the Geological Boundary Between the Chercombe Bridge Limestone Formation and the Overlying Superficial Deposits.	Bentham Geoconsulting Ltd	Sept 2014

3.2 Electrical Resistivity Survey

Bentham Geoconsulting Ltd was commissioned to undertake a geophysical survey of Alston Farm lying to the east of Linhay Hill Quarry near Ashburton, Devon. The geophysical surveys took place between 15th and 19th September 2014.

The purpose of the survey was to provide reconnaissance level information upon the boundary between the Chercombe Bridge Limestone Formation and the overlying Superficial Deposits. In particular, it was hoped that the survey would provide an indication of the variations in the overburden thickness and identify any anomalous zones which may relate to solution activity within the limestone and their potential infilling.

The key to any geophysical survey design is to use a technique that can resolve differing subsurface materials. Resistivity imaging surveys produce vertical cross-sections of the sub-surface using the differences between the electrical properties of geological materials. Resistivity imaging surveys are a highly effective means to characterise stratigraphic relationships. For this to be possible a sufficient contrast in geophysical properties must be present. At the Alston Farm site the superficial deposits are expected to have a considerably lower resistivity than the Chercombe Limestone.

Eleven survey lines were collected from the Alston Farm site and these were approximately evenly spaced across the site. Drawing No: G/A/001 shows the location of the survey lines. The resistivity survey line locations were chosen prior to arrival at site. This was necessary since the resistivity lines had to pass through pre-cut gaps in the hedges. In the field the survey line centre point locations were located using WASS enabled GPS. Some small positional changes were necessary in order to achieve the best alignment through the hedges. At Alston Farm 64 electrodes were employed with a spacing of 5m along the majority of survey lines. On line 7, 96 electrodes were used to check whether the increased resolution was ultimately beneficial. Line 11 was an additional survey line and used electrode spacings of 3m to fit within the available space. The maximum depth of investigation for each survey line was set to around 25m to account for significant changes in the thickness of the overburden. The depth of investigation of line 11 was 15m because its electrode spacing was reduced.

The initial interpretation of the data suggests that there is a considerable variation in the thickness of superficial deposits over the site. In general the superficial deposits are between 8 and 4m in thickness. The superficial / limestone stratigraphic horizon appears to be sub-horizontal in many areas although there are localised areas where the thickness of superficial materials may reach 10-15m. The localised maximum thickness of superficial deposits may represent clay infilled solution features in the limestone. It is understand that localised clay infilled solution cavities were found with some regularity in the current Linhay Hill quarry. Limestone is at minimum depths (>5m) within a broad band running across the centre of the proposed extension area. In some areas the limestone appears to be within 1m of the ground surface as estimated from the resistivity values alone.

3.3 Drilling Program and Limitations

The drilling investigation was designed to:-

- Prove the limestone outcrop
- Confirm the accuracy of the geophysical electrical resistivity survey
- Determine the position of the fault position forming the limit of extraction along the northern boundary
- Define the excavation limits / boundary elsewhere
- Prove materials on proposed site perimeter to enable design of overburden slope heights and gradients
- Provide sufficient data to calculate overburden cut volumes and screen bank fill designs
- Provide sufficient data to illustrate a phased quarry design for submission of a planning application
- Calculate probable mineral reserves

The survey was not designed to:-

- Confirm the depth of deposit
- Prove the dip and strike of the limestone strata (later confirmed by trial pitting)
- Access samples to confirm physical properties of the aggregate quality
- Provide water table measurements
- Provide information on screen bank foundation requirements
- Pre-production fine tuning of information for design of phased earthworks contracts

3.4 Drilling Details

The drilling was undertaken over five days week commencing Monday 12th January 2015 by Associated Drilling Services using a tracked Comacchio MC 405 rig towing an Ingersoll Rand VHP 400 compressor capable of delivering 170 psi. The boreholes were DTH open hole made using a 3 inch button bit and hammer. The maximum depth probed was 19.2 metres, but generally the holes averaged circa 6 metres. Where possible, the boreholes were extended 2 metres into rockhead to prove limestone and to recover a chipping sample. The weather during the survey was variable and the ground conditions may be descibed as soft to firm. Access to the whole farm was available, but the fields of fine turf were not accessed due to crop damage. However, sufficient peripheral borehole data and the existing quarry face exposure, combined with the geophysical information, is considered adequate to make a reasonable interpretation of the overburden thickness and underlying geology. The location of boreholes and an interpreation of the overburden thickness illustrated by isopachyte contours is shown on Drawing No: G/A/002 accompanying this report.

3.5 Borehole Logs

Logs of the boreholes may be found in Appendix 1.

Date	Borehole	Overburden Depth by Drilling (m)	Overburden Depth by Resistivity	Limestone Rockhead Proved (m)	Sample Retrieved	Comments
12/1	1/15	2.8	4.0	2.2	Yes	
	2/15	12.0	15.0	2.3		sinkhole
13/1	3/15	10.5	7.0	2.0		
	4/15	0.5	0.5	3.0	Yes	
	5/15	0.7	0.5	2.8	Yes	
	6/15	8.3	8.0	2.0		
	7/15	2.0	5.0	1.5	Yes	
	8/15	2.1	3.0	1.4	Yes	
	9/15	0.8	1.5	2.7	Yes	
	10/15	3.0	3.5	2.0	Yes	
	11/15	0.5	1.5	1.5	Yes	
	12/15	0.5	1.5	3.0	Yes	
	13/15	0.5	7.0	3.0	Yes	
	14/15	1.5	5.0	2.6	Yes	Fractured
	15/15	4.2	5.0	2.3	Yes	
14/1	16/15	5.6	11.0	3.9	Yes	
	17/15	5.0	15.0	7.5	Yes	Voids?
	18/15	10.5	9.0	2.0	Yes	
	19/15	10.1	12.0	2.4		
	20/15	3.4	6.5	2.1	Yes	
	21/15	3.2	2.0	3.3	Yes	
	22/15	4.9	11.0	1.6	Yes	
	23/15	3.4	4.0	2.2	Yes	
15/1	24/15	6.7	5.5	2.8	Yes	
	25/15	2.8	4.0	2.4	Yes	
	26/15	5.7	7.0	4.2	Yes	Voids/water
	27/15	9.9		2.6	Yes	Voids/water
	28/15	7.4+				Water
	29/15	5.5+				Water
	30/15	3.5+				
	31/15	5.2+				Damp
	32/15	8.3	6.5	3.3	Yes	
16/1	33/15	5.5	8.0	2.0	Yes	
	34/15	7.8	9.0	1.7	Yes	
	35/15	10.0	10.0	2.0		Water
	36/15	10.5	9.0	?		Water
	37/15	6.8	6.0	2.0	Yes	Voids
	38/15	4.5	5.0	2.0	Yes	Voids
	39/15	5.7	5.0	0.8	Yes	
	40/15	12.8	12.0	1.0	Yes	Sinkhole
	Average	**5.13 (100%)**	**6.44 (125%)**			

Summary Table of Borehole Logs

3.6 Trial Pits

On 1st April 2105, a trial pitting exercise was undertaken to verify the strike and dip of the strata in the Alston extension area (See Appendix 4). Trial pit No.1 was excavated on the site of Borehole 9/15 and exposed 0.4 metres top soil overlying 1.9 metres limestone brash (mainly clay bound strong fresh limestone cobbles). At the north side of the pit the bedding was exposed and measured.

Trial pit No.2 was excavated on the site of Borehole 4/15 and exposed 0.3 metres topsoil overlying 0.8 fresh strong limestone. At the north side of the pit the bedding was exposed and measured.

A small limestone exposure was also measured on the northern side of the A38 roadside cutting c.50 metres east of the proposed extension. The assumed bedding was measure for dip and strike.

Roadside	Trial Pit No.1	Trial Pit No.2
35/145 (dip/dip direction)	42 / 142	31/153

This data compares with measurements made in Linhay quarry by Engineering Geology - 36 / 144 (dip / dip direction) and Frederick Sherrell - 37 degrees to the south east. It is therefore reasonable to conclude that the strike and dip of the strata in the proposed extension is similar to the existing Linhay quarry.

3.7 Nature of Materials

Samples of drilling cuttings were taken where the air flush returned dust and chippings to the surface. In all cases, drilling progress and the quality of the flush returns indicated very strong fresh blue limestone. Importantly no weathered or brown rock was observed. In a number of holes, voids, fissures and clay filled fissures / voids were encountered. This is considered normal in a karstic landscape. Indeed, the resistivity survey indicated several circular features with increased clay content which appear to be sinkholes. The drilling confirmed this in a number of cases. Photographs of the samples recovered are attached in Appendix 2. All samples were tested with dilute acid to prove limestone.

In boreholes 2/15, 3/15, 6/15, 19/15, 35/15 and 36/15 no samples were recovered due either to a loss of air flush through fissures / voids or water was encountered.

Whilst drilling boreholes 28/15, 29/15, 30/15 and 31/15 progress was slow and the holes abandoned.

The overburden materials, excluding any topsoil /subsoil, consisted of two differing clay materials. The first is generally a soft to firm red clay with occasional cobbles and boulders of limestone. This is typically of limestone weathering products. The second is a hard silty grey clay with a little fine angular mudstone gravel and usually overlies the softer clay. This is interpreted as “head” or “solifluction deposits” which have flowed off the adjacent higher ground during periglacial times.

4. Quarry Design

4.1 Introduction

As reported above, a considerable volume of overburden, principally of a clay nature, is present above the limestone reserve. It is propose to progressively strip this material and place in earth mounds around the perimeter of the site to screen the workings from external lines of sight. The volumes of cut and fill required to achieve this are shown on the phased drawings attached to this report and the volumes are tabulated below:

4.2 Assumptions and Limitations of Design

The quarry design has been prepared the using information gathered during the site investigation phase. However this has entailed making a number of assumptions which may prove inappropriate as the project proceeds through the various consultations. This includes:-

- unforeseen geological circumstances resulting in a change of dip or strike of the strata, or the deposit not continuing at depth.
- The depth of excavation not achievable due to practical constraints such as water ingress.
- Environmental constraints, including ecological, archaeological, hydrological, blast vibration or noise and dust limitations.
- Regulatory issues, planning constraints, standoffs to sensitive structures etc.

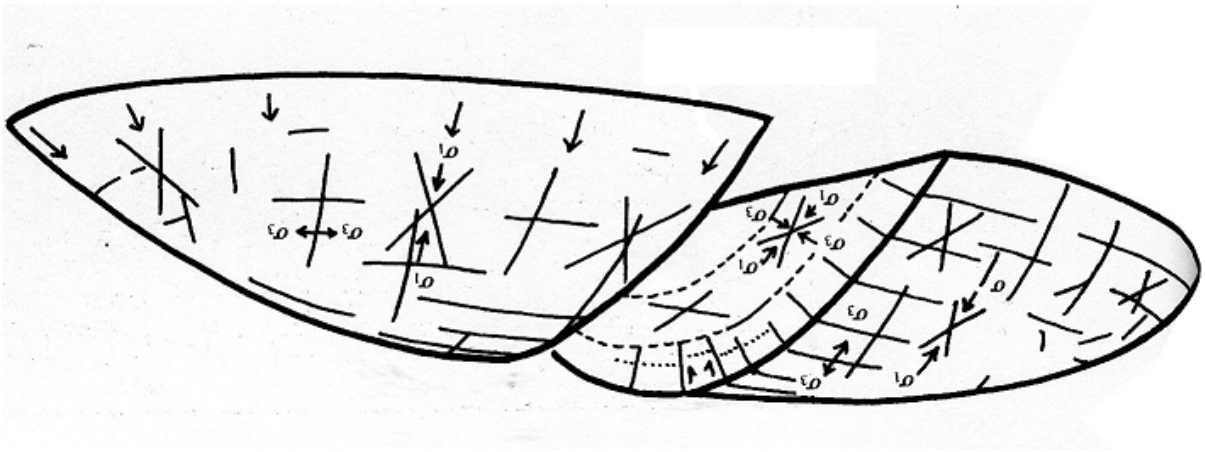
4.3 Overburden Excavation

It is proposed to remove the overburden in a number of phases illustrated in Drawing Nos: G/A/012A to G/A/012H. The material will be used to construct screen bunds around the perimeter of the site. Slope profiles have been chosen to reflect the nature of the materials and provide a natural landscape appropriate to the rural setting. The volumes of overburden in Alston, and Linhay / Alston reserve worked in each phase, are tabulated below

Phase	Volume by excavation (000's m3)	Screen Bank	Volume by Fill (000's m3)	Reserve (000's t)
1A	138	SB 1A/1B (A38)	145	Tonnages Redacted
1B	184	SB 2A (Caton 1)	184	
2A	187	SB 2B (Caton 2)	187	
2B	135	SB 2C (Caton 3)	135	
3	190	Linhay 0- 14m AOD	190	
4	295	Linhay 14 – 28m AOD	295	
5	-	-	-	
6	-	Restoration plan	-	
Total	**1,129**		**1,136**	

4.4 Structural Evaluation of the Limestone Quarry Excavation

Measurement of discontinuities in the quarry has been made by Engineering Geology Ltd and Frederick Sherrell Ltd referenced in Section 3.1 above. The main discontinuities which control the shape and stability of the excavation are the bedding planes. Lateral compression of the earth's crust has tilted these from horizontal to c. 38 degrees dipping to the south east. The strata is thus folded with a major anticline to the north west and a corresponding syncline to the south east. This basic structure has subsequently been altered by major faulting so that only the south easterly dipping limb remains as a linear limestone outcrop some 10kms long orientated along a north-east to south-west axis.



This understanding is important as it gives an indication of the type of joint pattern that may be expected in the quarry. In the figure above, two joint sets develop as the strata is compressed:-

- A tensile set normal and parallel to the maximum principal stress and
- A shear set at an acute angle to the maximum principal stress.

As the strata was folded the attitude of the joints was similarly re-orientated so that whilst the tensile set normal to the maximum principal stress remained vertical, the remaining sets were tilted to angles between 50 -70 degrees to the north east.

A further set of low angle thrust planes also formed in a plane parallel with the bedding. This again occurred early in the structural cycle when the beds were horizontal and the sediment relatively soft. These thrust planes have the same strike as the bedding, but cut through the bedding planes either more steeply or less steeply. It is the former which can give rise to unexpected sliding failures on the dip slope in the quarry.

4.5 Linhay Quarry Face Stability

From the aforementioned, the stability of the faces in Linhay quarry may be summarised as follows:-

- **North West:** Sliding failures along the persistent bedding planes. Design limits should reduce the risk to single bench scale failure. Sliding failures are also possible along thrust planes. Toppling failures may occur along the bedding planes with joints acting as release surfaces, again on a single bench scale.

- **South East:** Wedge failures along any combination of joint sets limited by design to single bench failure.

- **South West and North East:** Failures limited to isolated rockfall.

4.6 The Alston Extension Design

As the geology and geometry of the Alston reserve is an extension of Linhay quarry, it is reasonable to conclude that the design parameters specified for the Linhay quarry faces are acceptable in the new development:-

North West: after Sherrell 2011.
- Overall slope angle 35 degrees (from horizontal):
- Individual faces inclined at 80 degrees:
- Maximum face height 15 metres:
- Minimum bench widths 1.6 x face height of bench below later trimmed to 1.4 x face height:

South East: after Engineering Geology 1987.
- Overall slope angle 45 degrees:
- Individual faces inclined at 60 degrees:
- Maximum face height 15 metres:
- Minimum bench width 6 metres later modified by Sherrell to 7 metres:
- All soil slopes (greater than 5 metres in height) to be cut at 1 : 3 (vertical : horizontal) i.e. 18 degrees:

South West and North East: after Engineering Geology 1987.
- Overall slope angle 60 degrees
- Top rock face inclined at 60 degrees: Subsequent faces at 80 degrees:
- Maximum face height 15 metres:
- Minimum bench width 6 metres later modified by Sherrell to 7 metres:
- All soil slopes to be cut at 1 : 3 (vertical : horizontal) i.e. 18 degrees:

The quarry design is illustrated in a number of phases shown on Drawing Nos: G/A/012A to G/A/012H and cross sections Drawing No: G/A/009
(Note: these drawings were used in the preparation of the planning application drawings)

4.7 Water Table

The existing quarry development at Linhay quarry pre-dates the systematic recording of water table information. However, it is reasonable to assume that at the end of the working life of the quarry, should the water table be allowed to recover, then the quarry void will slowly fill to a level controlled by the adjacent hydrological features. The lowest point in the stream at the western side of the quarry complex is circa 96m AOD. If an overflow channel is cut from the quarry to the stream then the highest water level attainable will be c.97m AOD.

4.8 Limestone Reserves

The quarry soil and rock slope designs have been made in compliance with the guidelines set out in the documents listed above. The final depth of workings is has been set at 0m AOD. Access around the perimeter of the quarry workings has been incorporated at a level of 97m AOD or higher making due allowance for the estimated final water level in the restored flooded workings. Access to the workings above 97m AOD will be made via the southern buttress in Linhay quarry. Below this level access will be made from the remnant benches left along the north west faces. The reserves thus calculated and a critical path analysis are presented in the table overleaf.

Signature 

Date Jan 2016

Name JHF Sedman

Qualifications CEng FIMMM CGeol FGS

Table 1: Summary Table of Phased Working Plans

Phase	Overburden Volume (m3)	Location	Tonnage (t 000's)	Design Life (years)	Description / comment
1A	138	SB1A / 1B	Tonnages redacted	10.5	Strip area as previously. Overburden taken to A38 roadside bund. Quarrying focused on deepening Linhay to 41m AOD
1B	184	SB2A		3.2	Overburden strip area as previously. Bund construction started around Caton. Linhay deepened to 28m AOD.
2A	187	SB2B		2.8	Overburden strip area as previously. Caton bund extended anticlockwise to totally screen village. Linhay deepened to to 14m AOD.
2B	135	SB2C		15.1	Overburden strip extended. Final phase of Caton bund constructed. Linhay deepened to 0m AOD. Production mainly from Alston - benches 40 metres apart.
3	190	Linhay		8.3	Overburden strip extended to field boundaries. All production from Alston. Overburden backcast into Linhay void 0 - 14m AOD. New lagoon in base of Linhay
4	295	Linhay		19.5	Overburden strip extended to perimeter of Alston taking in final two fields. Overburden hauled to construct lagoon settlement ponds in Linhay 14 -18m AOD and cap off Balland lagoon.
5	N/A	N/A		9.0	Plant site worked out. New plant site on Balland pit. Production ceased after 70 years.
6	N/A	N/A		N/A	Drawing shows quarry flooded to 96 /97m AOD. Final water level achieved after 8 years.

Notes: 1. Karstic clay contaminated rock estimated to be additional 216,000m3

2. Additional void space for overburden waste - Linhay tip 45,000m3, Linhay bench restoration 12,000m3, topsoil sales 55,000m3, bund retaining Balland pit 25,000m3. Remaining Karstic waste deposited in base of Linhay during / after Phase 3.

3. Capping Balland pit requires c.125,000m3 during Phase 4. Balance from 295,000m3 deposited in floor of Linhay.

4. Total limestone reserve estimated to be Redacted

Table 2: Critical path for overburden stripping and limestone production

Phase	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Stage 0		138													
Stage 1 (A)															
Stage 1 (B)										184					
Stage 2 (A)													187		
Stage 2 (B)															
Stage 3															
Stage 4 / 5															

A38 Bund

Caton 1

Caton 2

138 Overburden volumes (in 000's m3)

All values redacted Limestone extraction (in 000's tonnes)

Year 16	Year 17	Year 18	Year 19	Year 20	to	Year 31	Year 32	to	Year 40	Year 41	to	Year 70
135					to							
						190		to				
									295		to	

Caton 3

Linhay Backfill 1

Linhay Backfill 2

Appendix 1. Borehole Logs

Borehole 1/15

Date 12/01/15 Elevation mAOD 131.8

Grid Ref Easting 277585 Northing 71780

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	2.8	2.8	Topsoil overlying CLAY
2.8	5.0+	2.2+	Very strong fresh blue LIMESTONE . Fractured with clay joint at 3.0m Hole dry. Sample taken

Borehole 2/15

Date 12/01/15 Elevation mAOD 134.4

Grid Ref Easting 277630 Northing 71828

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	12.7	12.7	Topsoil overlying CLAY with occasional cobbles
12.7	19.2	6.5	Alternating limestone BOULDERS and CLAY in equal measures.
19.2	21.5+	2.3+	Very strong fresh blue LIMESTONE . Hole wet. No sample

Borehole 3/15

Date 13/01/15 Elevation mAOD 132.2

Grid Ref Easting 277703 Northing 71774

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	10.5	10.5	Topsoil overlying CLAY with limestone cobbles becoming boulders at depth. Clay content = 80%
10.5	12.5+	2.0+	Very strong fresh blue LIMESTONE . No sample

Borehole 4/15

Date 13/01/15 Elevation mAOD 125.6

Grid Ref Easting 277732 Northing 71675

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	0.5	0.5	Topsoil overlying CLAY with limestone cobbles becoming boulders at depth. Clay content = 80%

0.5	3.5+	3.0+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 5/15

Date 13/01/15 Elevation mAOD 121.8

Grid Ref Easting 277767 Northing 71620

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	0.7	0.7	Topsoil overlying CLAY with limestone cobbles becoming boulders at depth. Clay content = 80%
0.7	3.5+	2.8+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 6/15

Date 13/01/15 Elevation mAOD 116.8

Grid Ref Easting 277819 Northing 71542

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	8.3	8.3	Topsoil overlying CLAY with cobbles /boulders Clay content 50%

8.3	10.5	2.2	Very strong fresh blue LIMESTONE .
10.5	12.0	1.5	Fractured rock / clay filled?
12.0	14.0+	2.0+	Fractured LIMESTONE
			Water flush / no recovery

Borehole 7/15

Date 13/01/15 Elevation mAOD 118.0

Grid Ref Easting 2777872 Northing 71570

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	2.0	2.0	Topsoil overlying CLAY with BOULDERS
2.0	3.5+	1.5+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 8/15

Date 13/01/15 Elevation mAOD 120.0

Grid Ref Easting 277935 Northing 71590

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	2.1	2.1	Topsoil overlying CLAY
2.1	3.5+	1.4+	Very strong fresh blue LIMESTONE .

Sample taken

Borehole 9/15

Date 13/01/15 Elevation mAOD 122.7

Grid Ref Easting 278005 Northing 71638

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	0.8	0.8	Topsoil overlying CLAY
0.8	3.5+	2.7+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 10/15

Date 13/01/15 Elevation mAOD 125.2

Grid Ref Easting 277957 Northing 71680

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description

0.0	1.5	1.5	Topsoil overlying CLAY with cobbles /boulders
1.5	2.0	0.5	Limestone Boulder
2.0	3.0	1.0	Fractured rock / clay filled?
3.0	5.0+	2.0+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 11/15

Date 13/01/15 Elevation mAOD 122.9

Grid Ref Easting 277890 Northing 71637

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	0.5	0.5	Topsoil overlying CLAY with BOULDERS
0.5	2.0	1.5	Fractured / weathered LIMESTONE
2	3.5+	1.5+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 12/15

Date 13/01/15 Elevation mAOD 125.4

Grid Ref Easting 277824 Northing 71682

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description

0.0	0.5	0.5	Topsoil overlying CLAY
0.5	3.5+	3.0+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 13/15

Date 13/01/15 Elevation mAOD 128.4

Grid Ref Easting 277913 Northing 71733

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	0.5	0.5	Topsoil overlying CLAY
0.5	3.5+	3.0+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 14/15

Date 13/01/15 Elevation mAOD 130.8

Grid Ref Easting 277869 Northing 71780

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	1.5	1.5	Topsoil overlying CLAY

1.5	6.7	5.2	Fractured LIMESTONE
6.7	7.3	0.6	Soft CLAY
7.3	9.9	2.6	Fractured LIMESTONE
9.9	12.5+	2.6+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 15/15

Date 13/01/15 Elevation mAOD 133.0

Grid Ref Easting 277824 Northing 71835

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	4.2	4.2	Topsoil overlying CLAY with occasional cobbles (c.10 percent)
4.2	6.5+	2.3+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 16/15

Date 14/01/15 Elevation mAOD 128.5

Grid Ref Easting 277792 Northing 71738

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	5.6	5.6	Topsoil overlying CLAY
5.6	6.1	0.5	very strong fresh blue LIMESTONE
6.1	6.4	0.6	Fractured LIMESTONE
6.4	9.5+	3.1+	Very strong fresh blue LIMESTONE . Sample taken

Borehole 17/15

Date 14/01/15 Elevation mAOD 136.3

Grid Ref Easting 277677 Northing 71874

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	5.0	5.0	Topsoil overlying very dense dry silty CLAY
5.0	6.5	1.5	very strong fresh blue LIMESTONE
6.5	7.2	0.7	Clay / void / Fractured LIMESTONE (?)
7.2	12.5	5.3+	Very strong fresh light grey/mauve LIMESTONE Damp @ 12.5m. Sample taken

Borehole 18/15

Date 14/01/15 Elevation mAOD 137.0

Grid Ref Easting 277760 Northing 71907

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	4.5	4.5	Topsoil overlying light brown very dense SILT
4.5	10.5	6.0	soft CLAY
10.5	12.5	2.0+	Very strong fresh blue LIMESTONE . Minimal flush return. Small sample taken

Borehole 19/15

Date 14/01/15 Elevation mAOD 132.8

Grid Ref Easting 277736 Northing 71800

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	5.5	5.5	Topsoil overlying light brown very dense SILT
5.5	10.1	4.6	soft CLAY
10.1	12.5	2.0+	Very strong fresh blue LIMESTONE . No flush return. No sample taken.

Borehole 20/15

Date 14/01/15 Elevation mAOD 128.0

Grid Ref Easting 277659 Northing 71690

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	3.4	3.4	Topsoil overlying CLAY
3.4	5.5+	2.1+	Very strong fresh med grey LIMESTONE . Sample taken

Borehole 21/15

Date 14/01/15 Elevation mAOD 131.3

Grid Ref Easting 277646 Northing 71760

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	3.2	3.2	Topsoil overlying hard brown silty CLAY
3.2	6.5+	3.3+	Very strong fresh med grey LIMESTONE . Very fractured. Sample taken

Borehole 22/15

Date 14/01/15 Elevation mAOD 129.0

Grid Ref Easting 277596 Northing 71719

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	4.5	4.5	Topsoil overlying light brown very dense SILT
4.5	4.9	0.4	soft CLAY / VOID
4.9	6.5+	1.6+	Very strong fresh blue LIMESTONE . Sample taken.

Borehole 23/15

Date 14/01/15 Elevation mAOD 122.6

Grid Ref Easting 277642 Northing 71603

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	3.4	3.4	Topsoil overlying CLAY
3.4	5.6	2.2+	Very strong fresh med grey LIMESTONE . Sample taken

Borehole 24/15

Date 15/01/15 Elevation mAOD 125.0

Grid Ref Easting 277582 Northing 71652

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	3.5	3.5	Topsoil overlying brown very dense SILT
3.5	6.7	3.2	soft CLAY with occasional cobbles
6.7	9.5+	2.8+	Very strong fractured fresh blue LIMESTONE .
			Sample taken.

Borehole 25/15

Date 15/01/15 Elevation mAOD 127.7

Grid Ref Easting 277523 Northing 71699

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	2.8	2.8	Topsoil overlying firm silty CLAY
2.8	5.2+	2.4+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 26/15

Date 15/01/15 Elevation mAOD 136.5

Grid Ref Easting 277570 Northing 71886

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	5.7	5.7	Topsoil overlying CLAY with occasional cobbles
5.7	7.0	1.3	Very strong fresh blue LIMESTONE .
7.0	7.4	0.4	Void
7.4	8.6	1.2	Very strong fresh blue LIMESTONE .
8.6	9.6	1.0	Void
9.6	9.9+	0.3+	Very strong fresh blue LIMESTONE .
			Sample taken

Borehole 27/15

Date 15/01/15 Elevation mAOD 137.8

Grid Ref Easting 277530 Northing 71927

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	9.9	9.9	Topsoil overlying CLAY
9.9	10.9	1.0	LIMESTONE (?)
10.9	11.6	0.7	VOID
11.6	12.5+	0.9+	LIMESTONE
			Water in Hole - minimal sample
			No discernable reaction with acid

Borehole 28/15

Date 15/01/15 Elevation mAOD 141.4

Grid Ref Easting 277480 Northing 71950

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	5.9	5.9	Topsoil overlying CLAY with some cobbles
5.9	7.4+	1.5+	Water in hole to ground level. No flush / No sample. Hammer blocking off / no penetration
			Hole abandonned. MUDSTONE (?)

Borehole 29/15

Date 15/01/15 Elevation mAOD 139.2

Grid Ref Easting 277458 Northing 71907

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	3.5	3.5	Topsoil overlying CLAY
3.5	5.5+	2.0+	Water in hole to ground level. No flush / No sample. Hammer blocking off / no penetration
			Hole abandonned. MUDSTONE (?)

Borehole 30/15

Date 15/01/15 Elevation mAOD 135.6

Grid Ref Easting 277484 Northing 71875

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	2.0	2.0	Topsoil overlying CLAY
2.0	3.5+	1.5+	MUDSTONE (?) Hammer blocking off / no penetration. Hole dry - abandonned.

Borehole 31/15

Date 15/01/15 Elevation mAOD 134.2

Grid Ref Easting 277503 Northing 71860

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	3.0	3.0	Topsoil overlying CLAY
3.0	5.2+	2.2+	MUDSTONE (?)Hammer blocking off / No penetration. Little water at 3.0m-abandonned

Borehole 32/15

Date 15/01/15 Elevation mAOD 133.6

Grid Ref Easting 277523 Northing 71844

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	6.5	6.5	Topsoil overlying hard CLAY with much cobbles
6.5	8.3	1.8	soft CLAY with occasional cobbles
8.3	11.6+	3.3+	Very strong fresh blue LIMESTONE . Hole dry. Sample taken.

Borehole 33/15

Date 16/01/15 Elevation mAOD 130.1

Grid Ref Easting 277455 Northing 71740

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	5.5	5.5	Topsoil overlying CLAY with occasional cobbles
5.5	7.5+	2.0+	Very strong fresh blue LIMESTONE . Hole dry. Sample taken.

Borehole 34/15

Date 16/01/15 Elevation mAOD 134.6

Grid Ref Easting 277373 Northing 71812

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	6.0	6.0	Topsoil overlying hard silty CLAY
6.0	7.8	1.8	soft CLAY
7.8	9.5+	1.7+	Very strong fresh blue LIMESTONE . Hole dry. Sample taken.

Borehole 35/15

Date 16/01/15 Elevation mAOD 139.9

Grid Ref Easting 277328 Northing 71853

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	8.5	8.5	Topsoil overlying hard silty CLAY
8.5	10.0	1.5	Moderately strong MUDSTONE (?)
10.0	12.0	1.7+	Very strong LIMESTONE (?) Water strike @ 8.5m. No flush return. No sample

Borehole 36/15

Date 16/01/15 Elevation mAOD 135.7

Grid Ref Easting 277279 Northing 71800

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	10.5	10.5	Topsoil overlying hard silty CLAY
10.5	11.8+	1.3+	Rockhead - probably limestone
			Water strike @10.5. No flush

Borehole 37/15

Date 16/01/15 Elevation mAOD 132.4

Grid Ref Easting 277328 Northing 71760

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth Start	Finish	Thickness	Description
0.0	6.8	6.8	Topsoil overlying hard silty CLAY with cobbles
6.8	7.5	0.7	Very strong fresh blue LIMESTONE .
7.5	8.3	0.8	VOID

8.3	9.5+	1.2+	Very strong fresh blue LIMESTONE . Hole dry. Sample taken

Borehole 38/15

Date 16/01/15 Elevation mAOD 130.3

Grid Ref Easting 277385 Northing 71705

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth			
Start	Finish	Thickness	Description
0.0	4.5	4.5	Topsoil overlying firm silty CLAY with occasional cobbles, becoming softer with depth.
4.5	5.5	1.0	Very strong fresh blue LIMESTONE .
5.5	6.5+	1.0+	Broken ground with VOIDS Hole dry. Sample taken.

Borehole 39/15

Date 16/01/15 Elevation mAOD 128.2

Grid Ref Easting 277407 Northing 71663

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth			
Start	Finish	Thickness	Description
0.0	5.7	5.7	Topsoil overlying hard silty CLAY with occasional cobbles

5.7	6.5+	0.8+	Very strong fresh blue LIMESTONE .
			Hole dry. Sample taken.

Borehole 40/15

Date 16/01/15 Elevation mAOD 132.0

Grid Ref Easting 277443 Northing 71780

Drill Comacchio MC 405 with 3" DTH button bit and air flush

Depth

Start	Finish	Thickness	Description
0.0	9.5	9.5	Topsoil overlying soft CLAY
9.5	12.8	3.3	Soft CLAY and limestone BOULDERS.
12.8	13.8+	1.0+	Very strong fresh blue LIMESTONE .
			Hole dry. Sample taken.

Appendix 2. Photographs of Samples


BH 1/15
BH 5/15
BH 7/15
8/15


9/15
BH 10/15
11/15
12/15
13/15
14/15
15/15
16/15


17/15
18/15
20/15
21/15
22/15
23/15
24/15


25/15
26/15
27/15
37/15

Below: Reaction with dilute acid

Appendix 3: Elevation of Rockhead

Date	Borehole	Collar Elevation (Approx mAOD)	Overburden Depth by Drilling (m)	Rockhead elevation (Approx mAOD)	Comments
12/1	1/15	131.8	2.8	129.8	
	2/15	134.4	12.0	122.4	Sinkhole
13/1	3/15	132.2	10.5	121.7	Sinkhole
	4/15	125.6	0.5	125.1	
	5/15	121.8	0.7	121.1	
	6/15	116.8	8.3	108.5	Sinkhole
	7/15	118.0	2.0	116.0	
	8/15	120.0	2.1	117.9	
	9/15	122.7	0.8	121.9	
	10/15	125.2	3.0	122.2	
	11/15	122.9	0.5	122.4	
	12/15	125.4	0.5	124.9	
	13/15	128.4	0.5	127.9	
	14/15	130.8	1.5	129.3	Fractured
	15/15	133.0	4.2	128.8	
14/1	16/15	128.5	5.6	122.9	Sinkhole
	17/15	136.3	5.0	131.3	Voids?
	18/15	137.0	10.5	126.5	
	19/15	132.8	10.1	122.7	Sinkhole
	20/15	128.0	3.4	124.6	
	21/15	131.3	3.2	128.1	
	22/15	129.0	4.9	124.1	
	23/15	122.6	3.4	119.2	
15/1	24/15	125.0	6.7	118.3	Sinkhole
	25/15	127.7	2.8	124.9	
	26/15	136.5	5.7	130.8	Voids/water
	27/15	137.8	9.9	128.9	Voids/water
	28/15	141.4	7.4+		B/h terminated early
	29/15	139.2	5.5+		B/h terminated early
	30/15	135.6	3.5+		B/h terminated early
	31/15	134.2	5.2+		B/h terminated early
	32/15	133.6	8.3	125.3	
16/1	33/15	130.1	5.5	124.6	
	34/15	134.6	7.8	126.8	
	35/15	139.9	10.0	129.9	Water
	36/15	135.7	10.5	125.2	Water
	37/15	132.4	6.8	125.6	Voids
	38/15	130.3	4.5	125.8	Voids
	39/15	128.2	5.7	122.5	
	40/15	132.0	12.8	119.2	Sinkhole

Appendix 4: Trial Pits

Above: JCB excavating Trial Pit N0.1. Below: Bedding exposed in Trial Pit No.1.

Above: Trial Pit 2 – Bedding exposed in pit. **Below:** Bedding exposed on A38 roadside, east of planned extension

Site Investigation & Design Report
Drawings

Drawing ref G/A/001: Geophysical survey

Drawing ref G/A/002: Alston Farm – Site Investigation

Drawing ref G/A/012A: Quarry Development Phase 1A

Drawing ref G/A/012B: Quarry Development Phase 1B

Drawing ref G/A/012C: Quarry Development Phase 2A

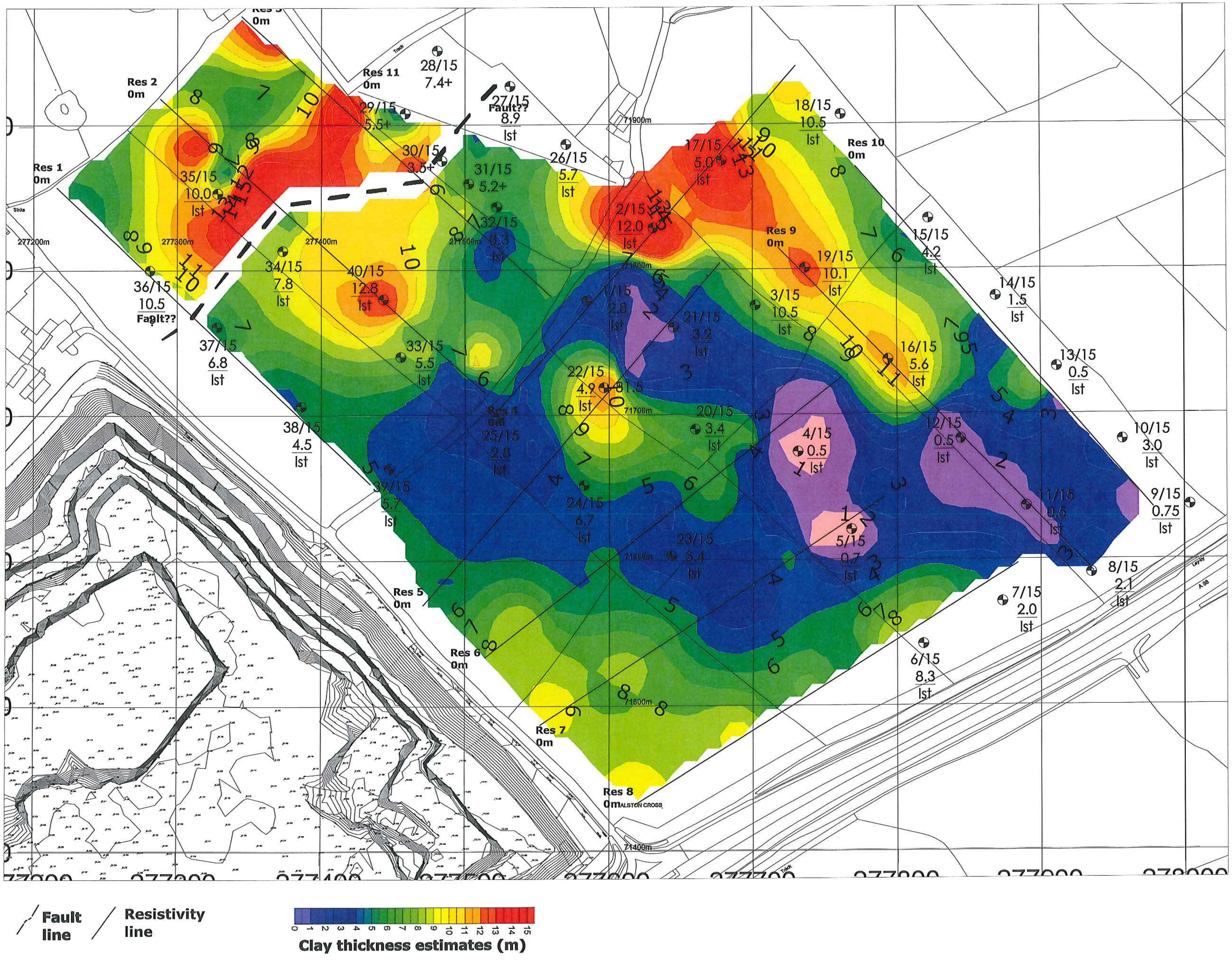
Drawing ref G/A/012D: Quarry Development Phase 2B

Drawing ref G/A/012E: Quarry Development Phase 3

Drawing ref G/A/012F: Quarry Development Phase 4

Drawing ref G/A/012G: Quarry Development Phase 5

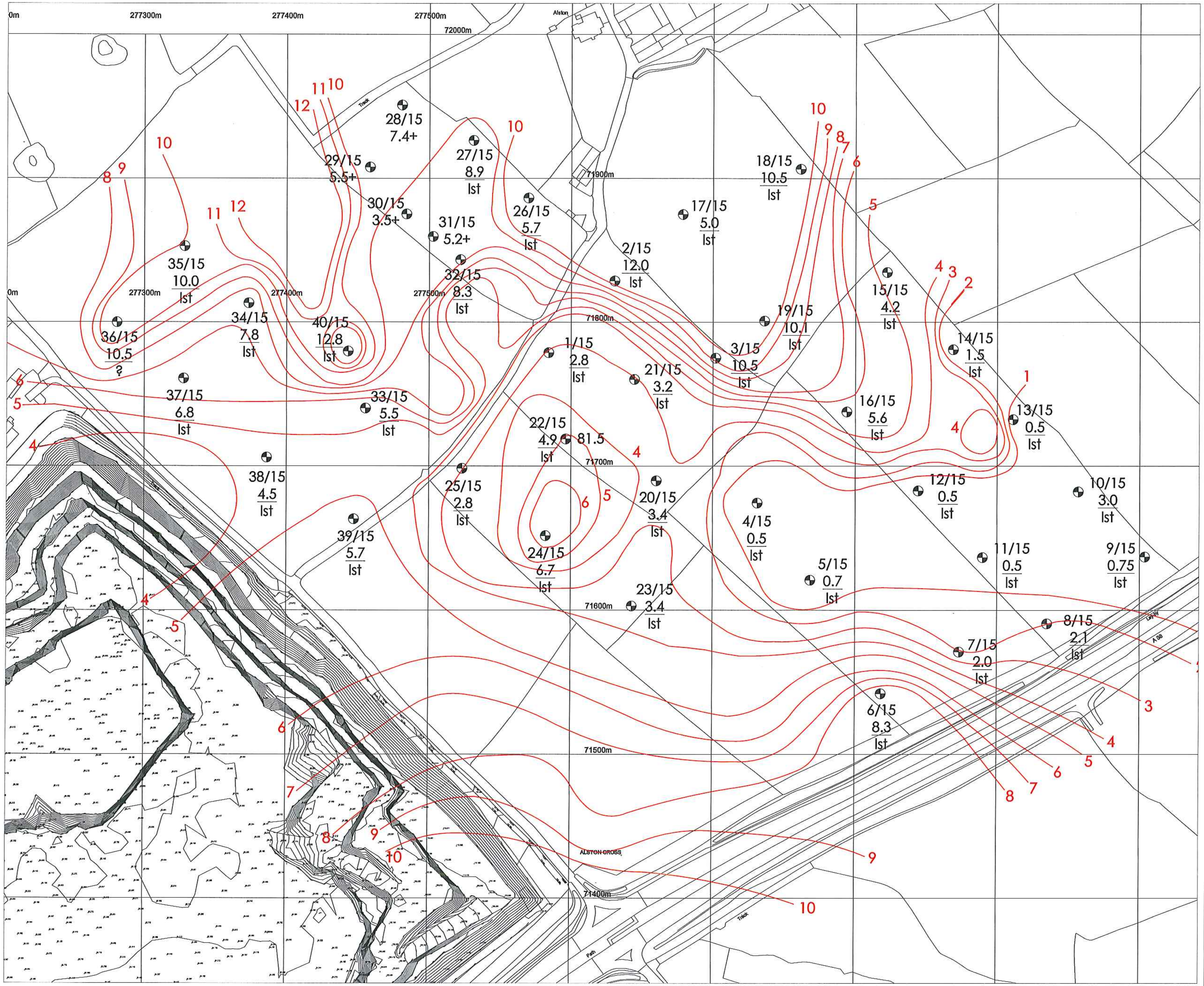
Drawing ref G/A/012H: Quarry Development Phase 6



Superfical Deposits. Estimated Thickness Map.
Contour intervals at 1m.

Geophysical Survey Date: September 15-19th 2014

SANDYBED GEOLOGICAL SERVICES	
Project:	Linhay Quarry
Client:	E.&J.W. Glendinning Ltd
Title:	Alston Farm - Geophysical Survey with Borehole Info.
scale: 1:1250	drawn: mep
date: Jan '15	Rev: P1
Dwg. No:	G/A/001



N

Thickness of overburden (metres)

SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry
Client:	E.&JW. Glendinning Ltd
Title:	Alston Farm - Site Investigation
scale: 1:1250	drawn: msp | date: Jan '15 | Rev: P1
Dwg. No:	G/A/002

N

Phase 1A
Overburden 185,000m³

SB1A
122,000m³

SB1B
23,000m³

Linhay Hill Quarry

Catsin

SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 1a				
scale: 1:2500	drawn: mep	chk'd:	date: Jan '16	Rev:	
Dwg. No:	G/A/12A				

N

Phase 1A
Overburden 138,000m³

Phase 1B
Overburden 184,000m³

SB2A
(94,000m²)

SB1B
23,000m²

SB1A
122,000m²

Linhay Hill Quarry
(Limestone)

SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 1b				
scale: 1:2500	drawn: map	chk'd:	date: Jan '16	Rev:	
Dwg. No:	G/A/012B				

N

Phase 2A
Overburden MP.200m²

Phase 1B

S1A
122,000m²

S1B
23,000m²

S2A
(34,000m²)

S2B
(47,200m²)

Linhay Hill Quarry

SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 2a				
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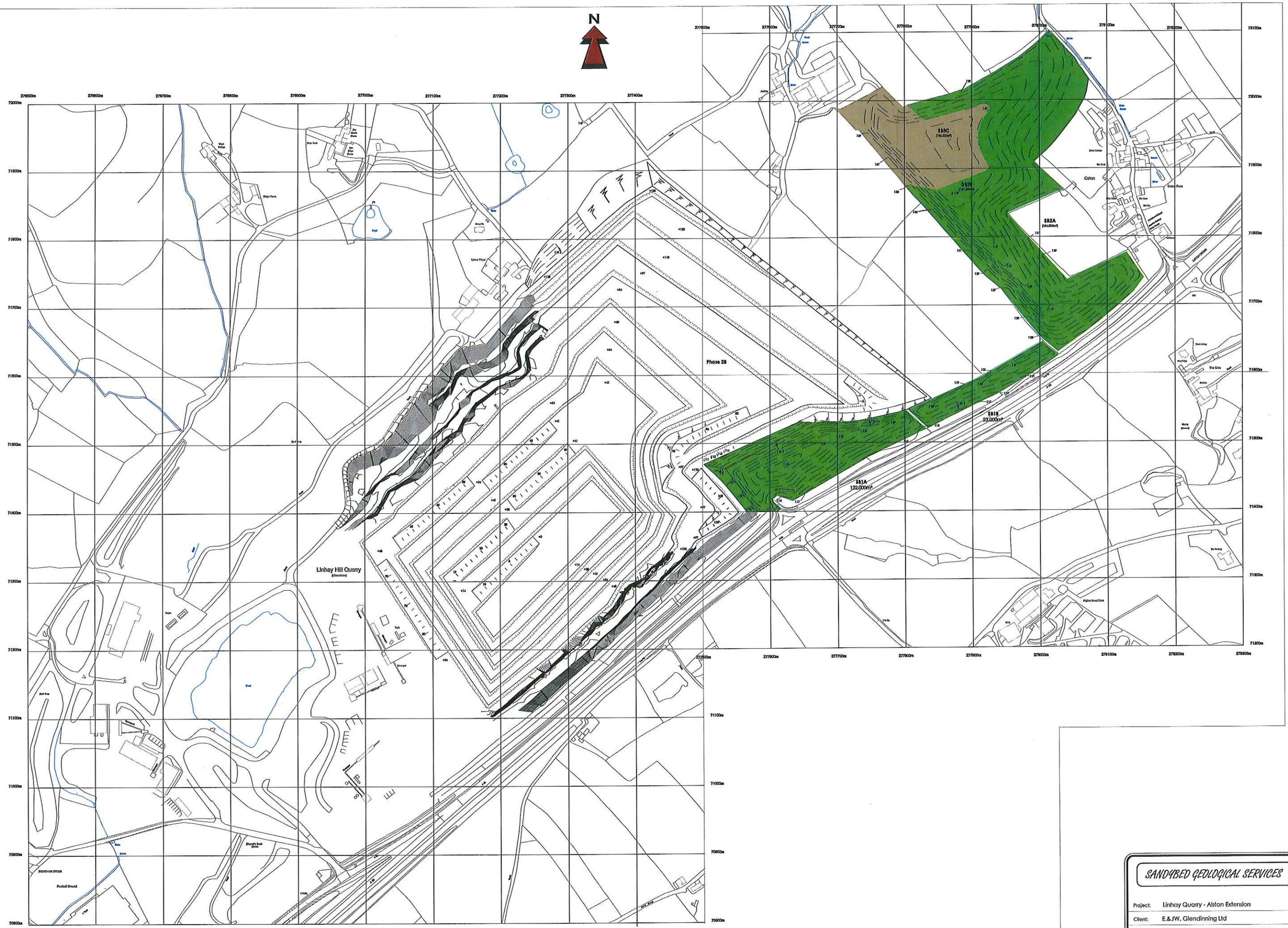
Dwg. No:	G/A/012C				



SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry - Alston Extension				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 2b				
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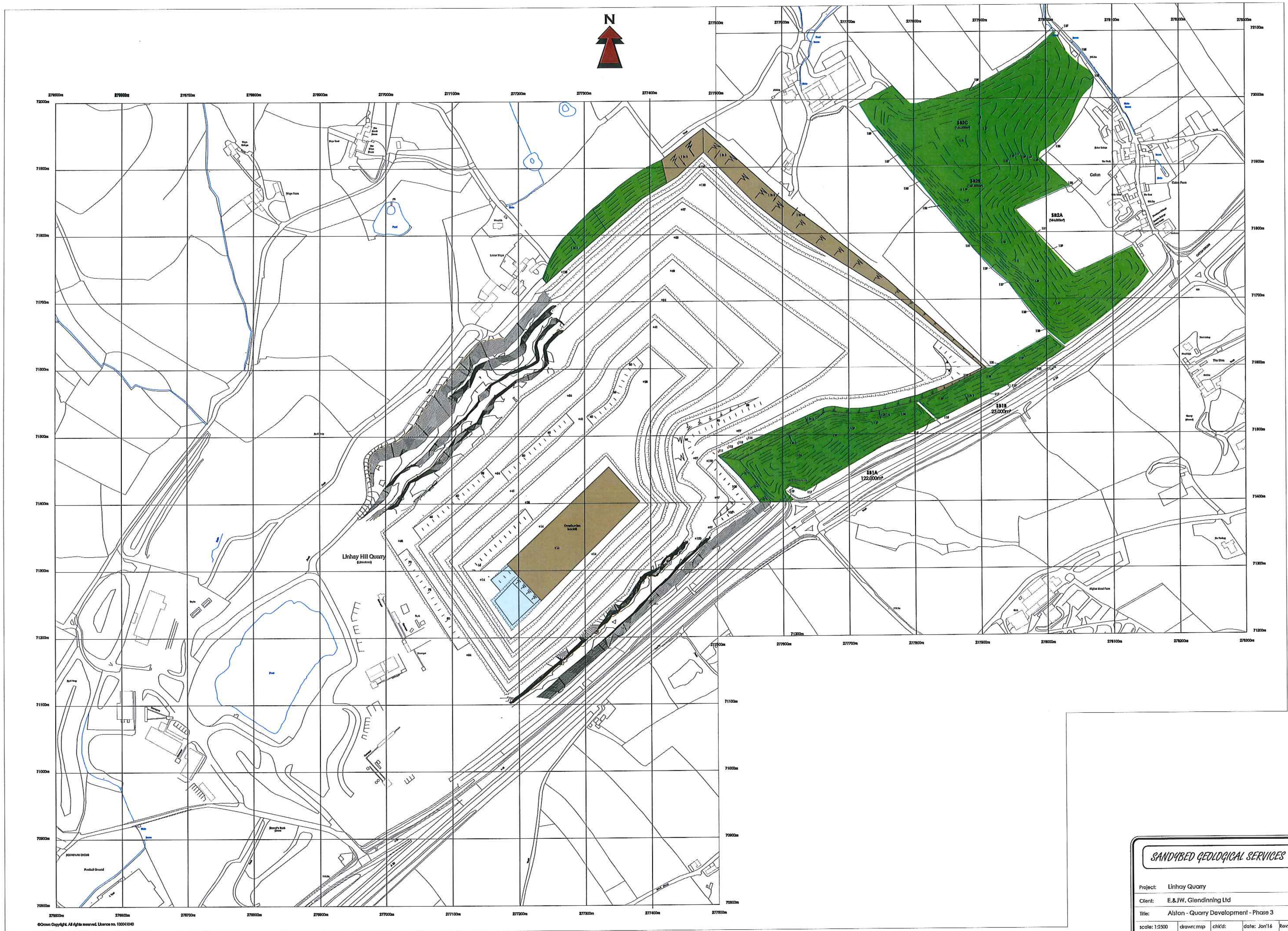
Dwg. No:	G/A/012D				



SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry
Client:	E.&JW. Glendinning Ltd
Title:	Alston - Quarry Development - Phase 3

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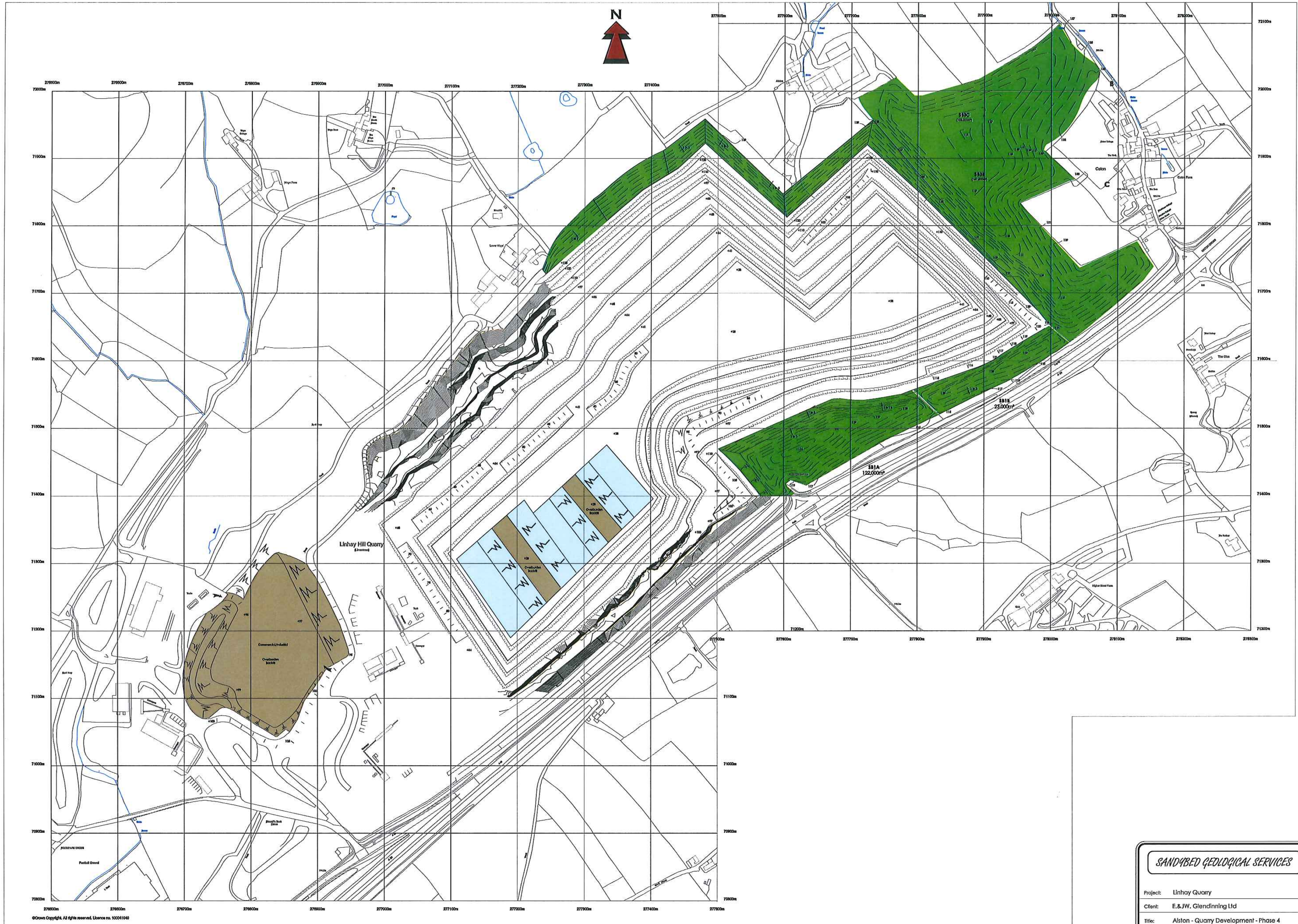
Dwg. No: G/A/012E



SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry
Client:	E.&JW. Glendinning Ltd
Title:	Alston - Quarry Development - Phase 4

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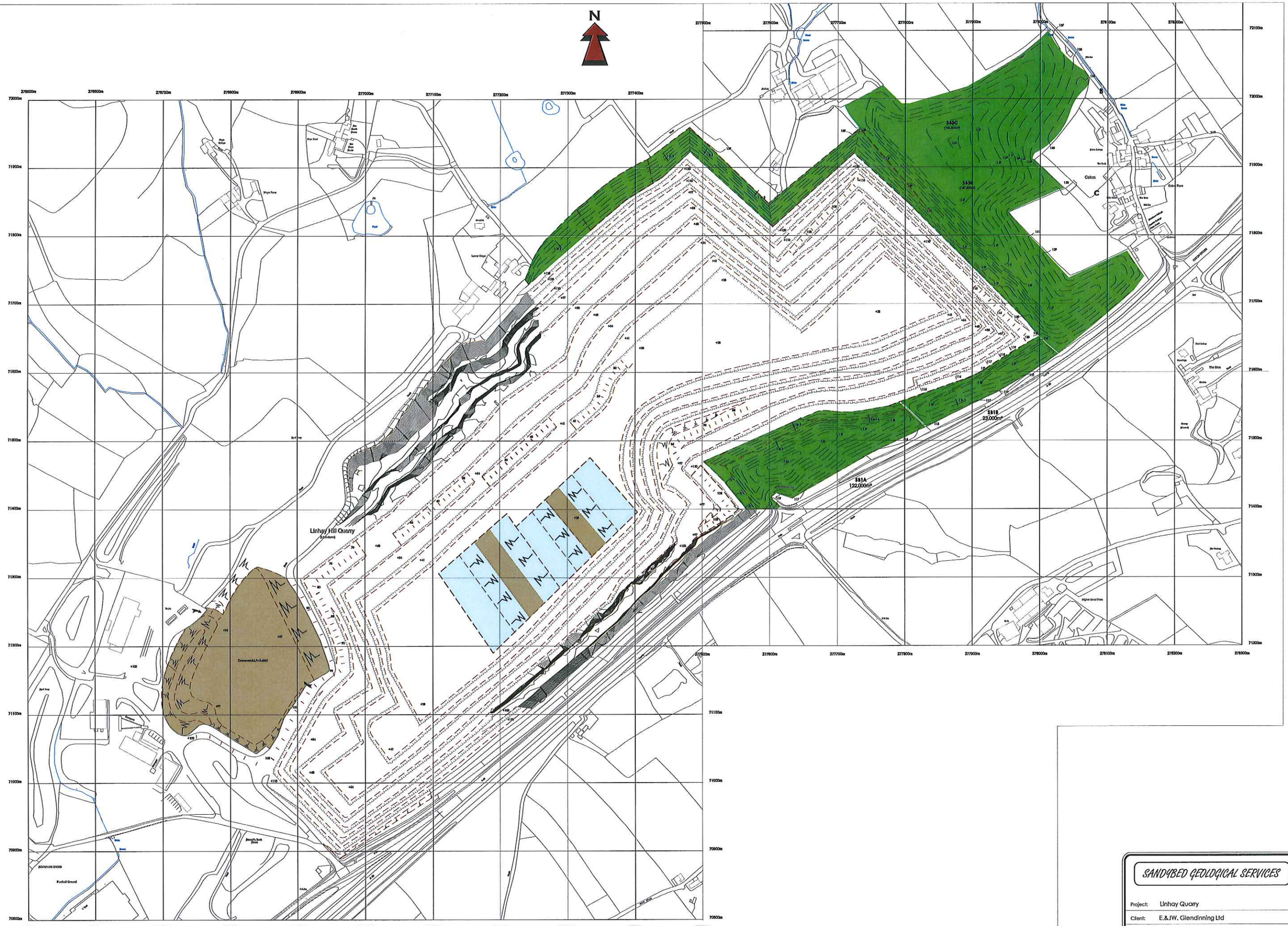
Dwg. No:	G/A/012F			



SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 5				
scale: 1:2500	drawn: mjp	chk'd:	date: Jan '16	Rev:	
Dwg. No:	G/A/012G				

N

96m AOD

Linhay Hill Quarry

Cotton

SB1A
122,000m²

SB1B
23,000m²

SB2C

SB3D

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SANDYBED GEOLOGICAL SERVICES

Project:	Linhay Quarry				
Client:	E.&J.W. Glendinning Ltd				
Title:	Alston - Quarry Development - Phase 6 (Final)				
scale: 1:2500	drawn: msp	chk'd:	date: Jan '16	Rev:	
Dwg. No:	G/A/012H				