FIRST STEPS LTD
To Success

Summary

S1. This report has been commissioned by Mr Harlan Zimmerman of No.26 Redington Road and his neighbours at No.30, and reviews the Basement Impact Assessment (BIA) supporting Planning Application 2016/2997/P for the redevelopment of No.28 Redington Road and excavation of a basement.

S2. I am a Chartered Geologist and a Chartered member of the Institution of Water and Environmental Managers (CIWEM), with over 40years experience in ground engineering, and registered as an Adviser in the UK Register for Ground Engineering Professionals.

S3. The BIA contains factual errors and omissions that should disallow it from acceptance.

S4. Despite its considerable length (564 pages) and wealth of data, many specific problems have not even been identified. The BIA appears to be based on there being a Final design to deal with these matters, pending approval.

S5. That is a dangerous and unnecessary path to pursue because if key problems affecting stability and wetness are not identified at this stage and with this information, there is no guarantee they will be dealt with in the Final design. Once approval is granted there is no requirement for further external scrutiny such as this, and from then on it will be too late to remedy mistakes and omissions carried into the Final design.

S6. It is quite clear from the data already provided that:

- Ground stability requires considerably more analyses than given so far if monitoring of neighbouring properties is to be linked in a meaningful way with conditions evolving during excavation for the basement.

- Water within the London Clay has not been properly monitored and is a feature that needs further study especially when aspects of stability on the excavation floor have to be considered.

- The presence and behaviour of ground water in the superficial deposits on site remains largely unknown even though it is a problem for immediate neighbours and elsewhere in subterranean extensions along Redington Road. The secant pile wall proposed will dam and divert water from its present path of flow and no provision for managing this has even been considered, let alone proposed.

S.5. Given these concerns, based on the factual nature of the application presented, I have to conclude the BIA submitted fails to satisfy the requirements intended by CPG4 and DP27, which are there to protect both neighbours and the environment.

Unit 17, Hurlingham Studios, Ranelagh Gardens, London SW6 3PA. UK
Tel: 020 7736 6889 www.firststeps-geo.co.uk
Registered in Cardiff. Reg No. 03892675
VAT Number 893667267

1. Introduction

1.1 This report responds to elements of geology and geotechnics in the factual and interpretative reports submitted by Mott MacDonald as their Basement Impact Assessment (Revision E), dated July 2016, to the Linton group for development of No.28 Redington Road.

1.2 That report contains the Basement Impact Assessment (BIA) required by Camden's Planning Guidance (CPG4) including their Development Policies (DP27), and substantial supplementary supporting material in the form of a Desk study and Ground Investigation.

1.3 From this, the report concludes (Stage 4 Impact Assessment) that detailed design has not been completed but it is likely that the excavations will require propping, that ground water will require pumping. These are very general conclusions given the quantity of data on which they are based. No mention is made of the consequences to neighbours that will follow the diversion of groundwater around the basement of No.28.

1.4 The geology of the site causes these two aspects of the application for the development of this site to attract attention; viz. the stability of the ground surrounding No.28 in response to the deep excavations proposed there and its effect on Nos. 30 and 26, and the barrier to flow the basement will create to groundwater and its effect upon Nos. 30 and 26.

1.5 These issues will now be considered after which the BIA submitted will be reviewed in the light of what has been presented.

2. General setting

2.1 The geology of the site and surroundings is apparently simple; Redington Road lies in the western slopes of the Vale of Heath which is capped by sands and gravels of the Bagshot Formation that outcrop on the top of the hill around Hampstead Heath. Beneath them are the sands, silts and clays of the Claygate Member of the London Clay Formation, formerly called the Claygate Beds to distinguish them from the London Clay itself, upon which they sit. According to the map opf the Geological Survey (Sheet 265 North London) No.28 is located on the Claygate sediments not far below the junction with the Bagshot Beds.

2.2 From this it might be imagined that the geology has the character of a layered cake and at a general scale that is so, but there is a complication to this picture which comes from topography, because Redington Road is on a hill. That slope imparts to the ground shear stresses which, when the ground is too weak to resist them, will cause the ground to move downhill.

2.3 The recent geological history of the area has been dominated by the effects of the Ice Age when, during the Pleistocene, the country was subjected arctic conditions, the amelioration of which left the landscape in a very weak condition. In this area the upper levels of the ground would be saturated and much disturbed by the effects of freezing and thawing; in this condition the ground is susceptible to shear stresses arising from gravity (i.e. from the slope of the ground) and would fail by flowing and sliding . An observer standing on what is now the Finchley Road looking up towards the Heath would see a slope covers with mudflows and shallow landslides, and surface water; a landscape that would be difficult to traverse. The ground has now dried considerably from then but the legacy of these movements remains below ground level.

2.4 There is evidence from the ground investigation undertaken for No.28 that the remains of such movement exist on this site and need to be considered in the design for the works. This is seen most clearly in Figs. 1 and 2.

2.5 Fig.1 is a vertical cross section based on the borehole data provided by the ground investigation submitted in support of the proposal. The blue defines the top of the London Clay and the green the Claygate sediments; these are not distinguished by name in the borehole logs but called by their more general name, the London Clay Formation. Here they have been distinguished.

2.6 The layer cake geology is seen on the left of the section, in the rear garden if No.28, but as the ground passes under No.28 the level of the London Clay is substantially lower beneath the front garden. One explanation for this difference in elevation is that a landslide has occurred that carried London Clay and Claygate beds downhill. Borehole 5, which is in the front garden, also intersected just over 2m of strange material, encountered as *“very soft”* (i.e. it can be squeezed between the fingers), a number of explanations for this are possible but it could well be the sole of such a slide. The possible location of such a slide, seen in plan, is illustrated in Fig. 2.

2.7 A further anomaly in this section is revealed in Borehole 4 where an unusual thickness of Bagshot – like material was encountered. This is most readily explained as hill wash, where unstable thicknesses of Bagshot sediment slide downhill eroding a valley for themselves in the process. The direction of such a feature, seen in plan, is indicated in Fig. 2. Here it should be noted that the general slope on which Redington Road sits, as mentioned earlier, is intersected by a secondary (or consequent) valley whose axis runs almost parallel to Redington Gardens. The overall slope from Oak Hill Park to Redington Gardens, as measured from the Ordnance Survey 1:25000 map is around 9°. That is more than enough to facilitate near surface gravitational movements of this kind.

2.8 Ground water flow will be considered later but at this stage it is appropriate to illustrate the strength of the ground across the site; this is shown in Fig.3. Fig 3 is not a cross section but shows all the boreholes at their respective elevations and to the same vertical scale so that comparisons with depth can be made.

2.9 Strength here is reflected by the resistance to penetration given by the value N. The top of the London Clay is as defined in Fig.1; material above the London Clay is not differentiated. The strength of this material is quite variable. That of the London Clay settles down with depth and maintains a reasonably uniform increase in strength with depth across the site. That suggests

- The identification of the top of the London Clay shown in Fig. 1 is correct, and

- The landslide at Borehole 5, if there, defines the present top of the London Clay and that the soft strata is probably the sole of former movement.

2.10 The plot of N with depth shown in Fig. 3 deviates from the straight line as the top of the London Clay is approached and this increase in strength can probably be attributed to desiccation from vegetation, the area in which the boreholes were drilled being open ground supporting mature trees. This is a strength which will probably be lost once the trees are felled and should the basement, once installed, cause groundwater levels to rise, that strength will fall even further.

2.11 An important aspect of strength in the ground is the relationship between the pressure of water in the ground at any point and the weight of the ground at that point. Some measure of the water pressure in the London Clay is provided by the way water encountered during drilling responded and how it responded in instruments inserted into boreholes for its measurement. These aspects are shown in Fig. 1.

2.12 The London Clay contains water that is flowing at different speeds; through the clay it is slow and through the silty horizons it is faster, sufficiently fast to fill a 200mm diameter hole 5m to 6m in 20minutes. Longer term measurements in Boreholes 4 and 5 show the water pressure sufficient to support pressure levels higher than those encountered during drilling. So there is no doubt that ground water in the London Clay is an active and fairly responsive independent force.

2.13 Water in the Claygate sediments can be expected to flow at a higher rate than that in the London Clay by virtue of their coarser grain size. Ground water is thus stratified, that in the Claygate sediments operating almost independently from that in the London Clay. Unfortunately, the instrumentation in Borehole 5 overlooks this possibility and connects the Claygate sediments to the London Clay so rendering the water level measured within it useless. Such a connection allows water in the Claygate sediments to recharge the London Clay, so the water level measured is neither that for the Claygate sediments nor that for the London Clay.

2.14 Observations on what this may mean for ground stability can now be made.

3. Ground Stability

3.1 The level of the basement proposed is shown on Fig.1 and illustrates the volume of ground to be excavated, ground level being shown by a dashed line. It is anticipated that a watertight box defining the perimeter of the excavation will first be made using secant piling to some specified depth below the formation level of the basement. Given that as a basic construction method, the following issues become evident from Fig. 1.

- Any cantilever reactions relied on will probably vary around the perimeter as the level of the London Clay varies.

- Near the front of site there exists 2m of “very soft” clay at around formation level; this will have to be addressed.

- The uplift on the base of the excavation will vary along its length by amounts which require a better and proper definition of porewater pressures at depth than exist at present.

- The undrained strength of the London Clay appears to be that seen in the samples form bore holes 2 and 5, at around 150kPa at 10% axial strain. However, it is evident that axial strains to failure, from samples taken in boreholes 2 and 3, can change substantially, varying for peak strengths of 120kPa from 8% to 20%. The results of laboratory have to be accepted with some latitude but it looks as if moisture content is a major variable, the brittle sample from borehole 3 being from the desiccated zone of London Clay.

- The lateral loads on the retaining wall will probably vary around the perimeter, possibly by significant amounts. The soft clay near the front to the house will offer little in the way of support and with the possibility of relict shear surfaces beneath former mass movements on the hillside, now at residual strength, being intersected along the sides of the wall it is probable that the shear strengths generated from the consolidated undrained triaxial tests (ø'24°, c'47kPa) could seriously mislead an analyst using modelling software.

3.2 The conclusions to all this is that there are major analytical problems yet to be addressed let alone solved and it is alarming that none of this even figures in the report submitted. The design of the ground investigation itself does not reflect the conceptual model of the ground, as based on its topography, geological history and the engineering requirements of the client (a large basement), from which it should be derived.

3.3 This is not to criticise the ground investigation *per se* as the nature of its commissioning is unknown, but for whatever reason, there are major shortcomings in this work.

4. Groundwater

4.1 The Ordnance Survey map of Hampstead, surveyed in 1866 and published in 1870 is illustrated in the Envirocheck list of maps searched, but stated as published in 1879; it shows clearly a minor headwater tributary of the River Westbourne. Arup, in their 2016 report, show this headwater rose just uphill from the site at Heysham Lane and was known as the Cannon Stream; it flowed down what is now Redington Gardens. A pump is also shown on the Arup map close to the boundary between Nos 26 and 30. None of this water originated from the London Clay; it all came from the Bagshot and Claygate sediments. The surface water stream is now below ground level but the groundwater that fed it remains.

4.2 That flow of groundwater will be travelling northwest across the site of No.28 and so the proposed basement will form an underground dam to its progress as it will entirely cutoff beneath its footprint the sediments overlying the London Clay and carrying the water which formally fed those streams. Impounding of groundwater can be expected on the boundary between Nos. 26 and 30 with some rise in water level resulting. The diversion of groundwater around the basement of No.28 would discharge in a concentrated flow near the entrance of No.30

4.3 Nothing is known about this superficial groundwater on the site. The boreholes drilled record dry conditions but this contradicts the evidence of the old maps, the evidence from geology and the experience of residents whose observations over many years put such short term records as presented in the BIA into a better perspective.

4.4 The residents of No.30 have experienced problems of groundwater ingress to their property on the uphill side of their subterranean communal entrance; exactly where such problems would be expected first to be seen given the evidence from the old maps and geology. Considerable sums were expended to tank the area and exclude the water. The cause of this dampness was not determined although its date was known (2010) and it would be instructive to know who was building what in the immediate area at that time.

4.5 There are many problems associated with shallow ground water in these strata as follows;

- The finer grained horizons are prone to erosion if an opportunity exists for them to be washed into a void such as a broken drain or a forgotten utility; such erosion can result in local settlement and an instance of this is has occurred in Redington Road and is recorded.

- Many soak-aways, sumps and broken/abandoned utilities discharge rainwater into these superficial deposits at rates far greater than can occur through infiltration, sending pulses of recharge through the system. These are not seen with water level measurements taken once every 7 or 10 days. Nothing is known about such events for this site yet the underground dam the basement will create can only exacerbate such effects for No.30.

- On this site there is the added problem of what appears to be an eroded valley infilled with sediments derived from the Bagshot Formation (shown at Borehole 4 in Fig.1), whose grainsize could allow the feature to carry water more readily than the Claygate sediments through which it cuts, and thus act as a natural source of recharge to them.

4.6 In addition to these problems, ground movement around the excavation will cause differential settlements which, if they extend to No.30 could damage the seal of the tanking that was recently installed. Reference to Figs 1 and 3 shows the calculation of such movements will not be an easy matter for software assuming layer cake, isotropic homogeneous conditions below a horizontal ground level.

4.7 None of these aspects has been addressed in the proposal and the major concern is not that they may be addressed wrongly (which of course is a concern) but that they will not be addressed at all, as they have not been considered. What has been considered is summarised in the BIA which will now be reviewed in the light of the observations made so far.

5 The Basement Impact Assessment

5.1 This is reviewed with the benefit of the ground investigation that it instigated. Given that the report had the ground investigation data when it was submitted it is difficult to reconcile the Responses given in the BIA to the knowledge that existed at the time of its writing. This suggests that the information obtained has not been properly appreciated and this is supported by the fact that none of the information appears to have been used to come to any conclusions other than the most general.

5.2 The fear here is that a 564page report will be seen as far exceeding that normally required for such applications and well above “industry standard” and thus perfectly satisfactory for approving the proposal, leaving the conditionality of an S106 to supply the missing data. All that is irrelevant if insufficient thought has been given to the data obtained in the first place, and crucial evidence missed leaving vital conclusions not drawn. An S106 provides no guarantee that the Final design will be any better but simply allows the Council to shift responsibility from its desk to that of the developer.

5.3 In this respect, therefore, it is important to bring to the attention of the Council that despite such a weight of evidence provided by the BIA, the application fails to satisfy the Council's own requirements intended by CPG4 and DP27.

Stage 1 Screening

5.4 Table 2.1 Subterranean (Groundwater) Flow Screening
Q1b Will the proposed basement extend beneath the water table surface?
Response; Likely

First Steps' Comment. It is stated that long-term ground water levels are almost 5m below ground level at the front of the house and nearer 6m at the rear. It is very unlikely this is correct and the measures taken to confirm this have put instruments in the wrong place within the ground (see Fig.1) and measured them over intervals that are too long (see ESG Groundwater Monitoring Record Table C2). Further, no attempt has been made to related the water levels measured to rainfall and infiltration in the area.

5.5 Table 2.2 Slope Stability Screening
Q1 Does the existing site include slopes, natural or manmade, great than 7°?
Response; No

First Steps' Comment. Slopes of around 4° to 5° are reported and this is credible if measurements are taken locally either within or around the site, however reference to the Ordnance Survey1:25000 topographic map for that part of the hill shows the slope towards Redington Gardens is in the order of 9°. That makes an important difference to the way these slopes and this ground should be considered, for the reasons explained in Section 2. The same applies to the answer to Q4 of this Table.

Q4 Is the site within a wider hillside setting in which the general slope is greater than 7°
Response; No

First Steps' Comment. Reference to topographic maps would have indicated this is not true.

Q6 Is the site within 100m of a water course or a potential spring line?
Response. No

First Steps' Comment. This suggests the character of ground water on this hill has not been appreciated. The geological map of the British Geological

Survey, the topographic map of the Ordnance Survey and the historic maps produced by Arup in 2016 all show where spring lines and near surface water can be expected. If not within 100m of the site then these are certainly very close to 100m and thus should alert the reviewer to the problems this question is asking them to consider.

Q13 Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?
Response. Unknown

First Steps' Comment. Reference to Fig. 1 will show it is most likely and that to state "unknown" is to avoid the problems this question is asking the reviewer to address.

Stages 2 & 3 Scoping &Site Investigation

5.6 These report the reasons for the ground investigation and its factual findings. No interpretation is presented. Final conclusions are presented in the next stage, Stage 4.

Stage 4 Impact Assessment

5.7 This is where the possible impacts of the work on neighbouring ground should be presented and justified. No such impacts are quantified and the assurances given are of a most general nature.

6. Conclusions

6.1 It seems the application is based on there being a Final design post approval, however the problem here is that, 564pages later, many specific problems have not even been identified. If they are not identified at this stage and with this information, there is no guarantee they will be dealt with in the Final design.

6.2 It is quite clear from the data already provided that

- Ground stability will be an issue that is not straightforward and will require considerably more thought if monitoring of neighbouring properties is to be linked in a meaningful way with conditions evolving within the excavation for the basement.

- Water within the London Clay is a feature that needs further study especially when aspects of heave have to be considered.

- The presence and behaviour of ground water in the superficial deposits is largely unknown even though it is already a problem for neighbours.

The secant pile wall will dam and divert water from its present path and no provision for managing this is even considered.

6.3 Given these concerns, based on the factual nature of the application presented, I have to conclude the application fails to satisfy the requirements intended by CPG4 and DP27, which are there to protect both neighbours and the environment.

MH de Freitas PhD, DIC, C.Geol, C.WEM
Director First Steps Ltd, and
Emeritus Reader in Engineering Geology
Imperial College London.
Ground Engineering Adviser,
UK Register of Ground Engineering Professionals (RoGEP) (68302453)

Attached
Fig 1: General cross section
Fig 2: Features seen in Plan
Fig 3: Strength with depth

References

28 Redington Road Basement Impact assessment for the Linton Group July 2016. Mott MacDonald

Redington Frognal Neighbourhood Forum Sub-Surface Water Features Mapping. ARUP. April 2016

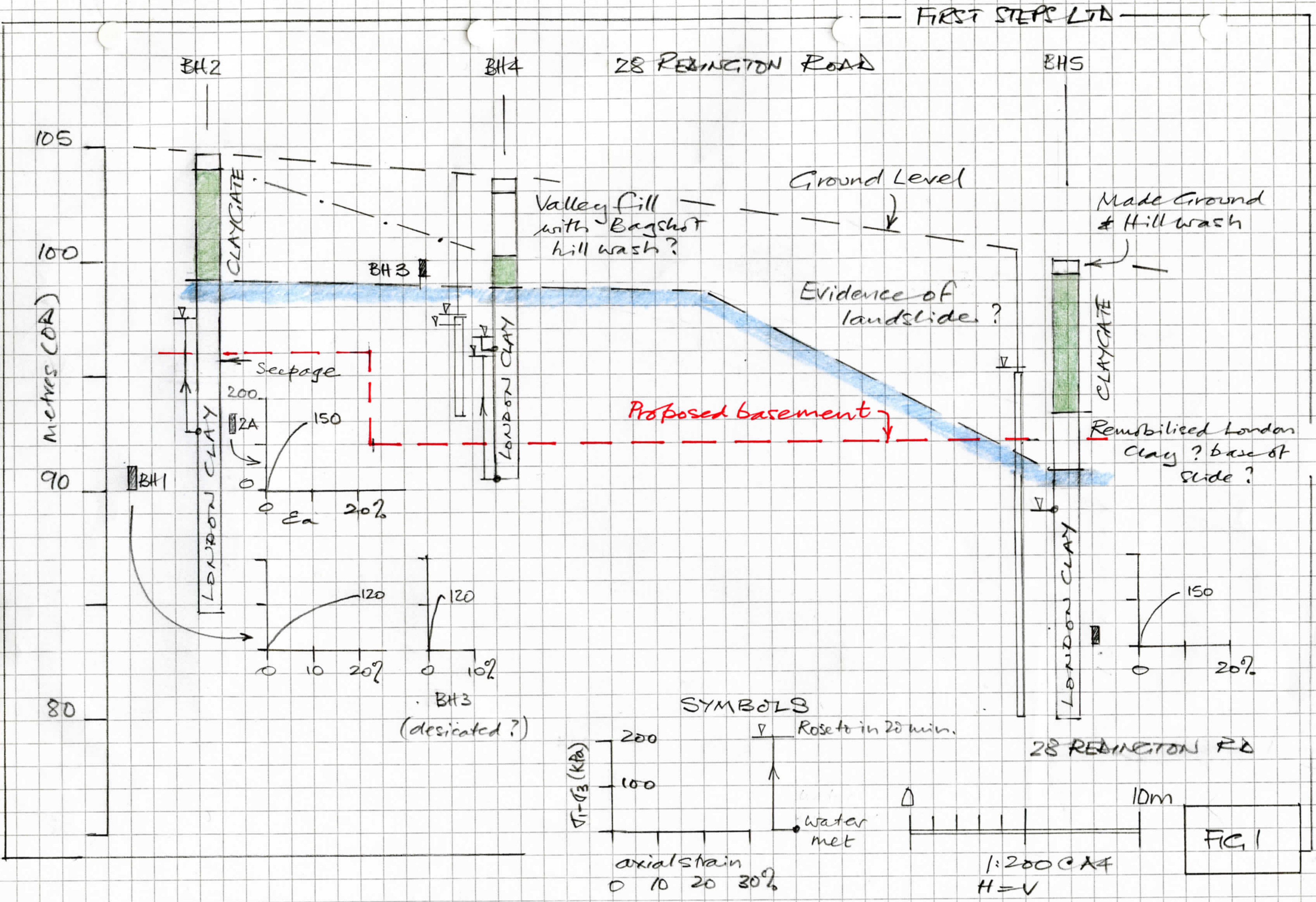

FIRST STEPS LTD
28 REDINGTON ROAD
BH2
BH4
BH5
Metres (OD)
105
100
90
80
CLAYGATE
LONDON CLAY
Valley fill with Bagshot hill wash?
Ground Level
Made Ground & Hill wash
BH3
Evidence of landslide?
Seepage
Proposed basement
Remobilised London Clay? base of slide?
BH1
2A
200
150
0
ϵ_a
20%
120
10
10%
BH3 (desiccated?)
SYMBOLS
Rose to in 20 min.
water met
$\sigma_1 - \sigma_3$ (kPa)
100
axial strain
0 10 20 30%
28 REDINGTON RD
10m
1:200 @ A4
H=V

FIG 1

FIRST STEPS LTD

28 REDINGTON ROAD

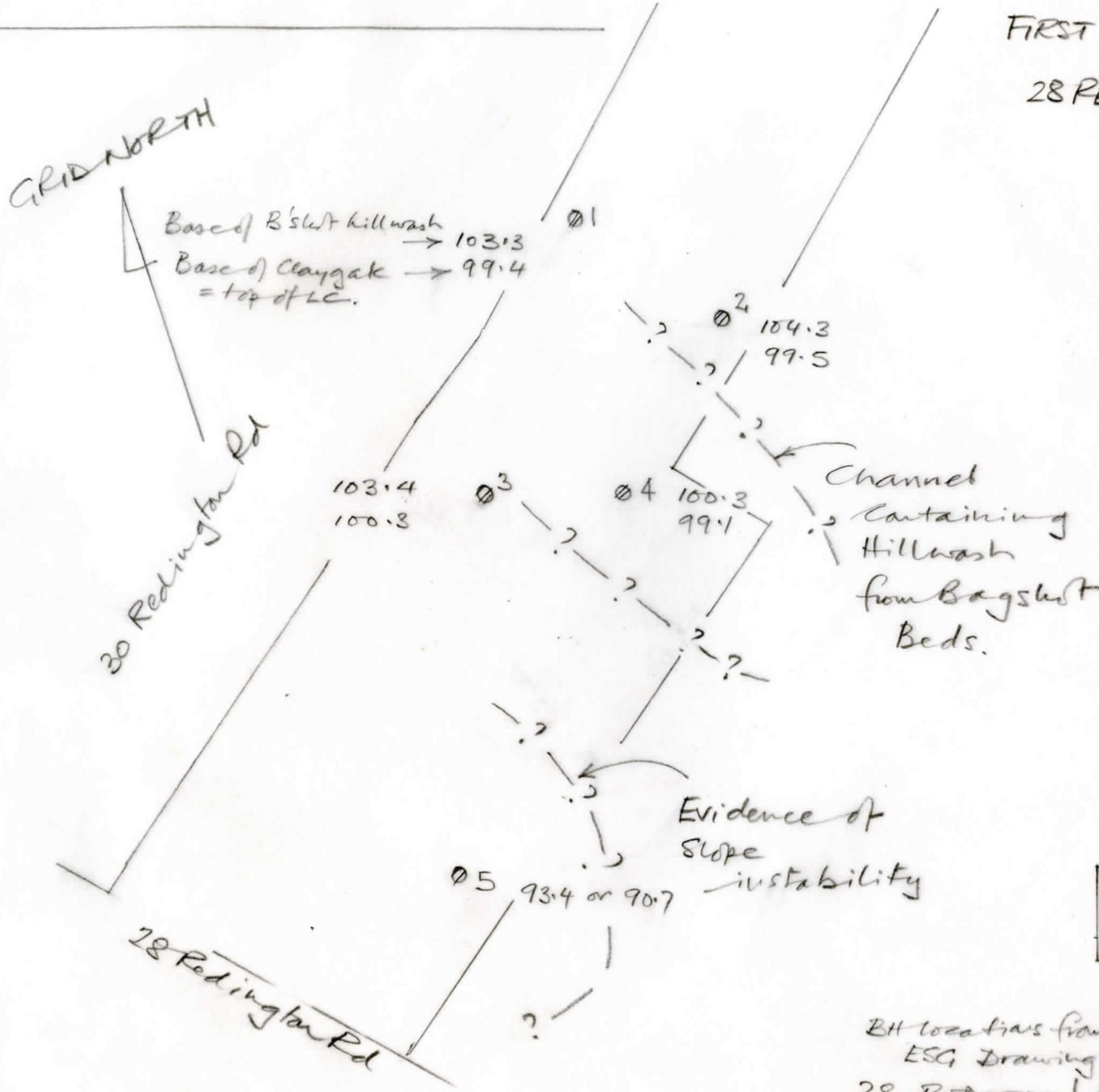


FIG. 2.

BH locations from ESG Drawing A2. 28 REDINGTON RD

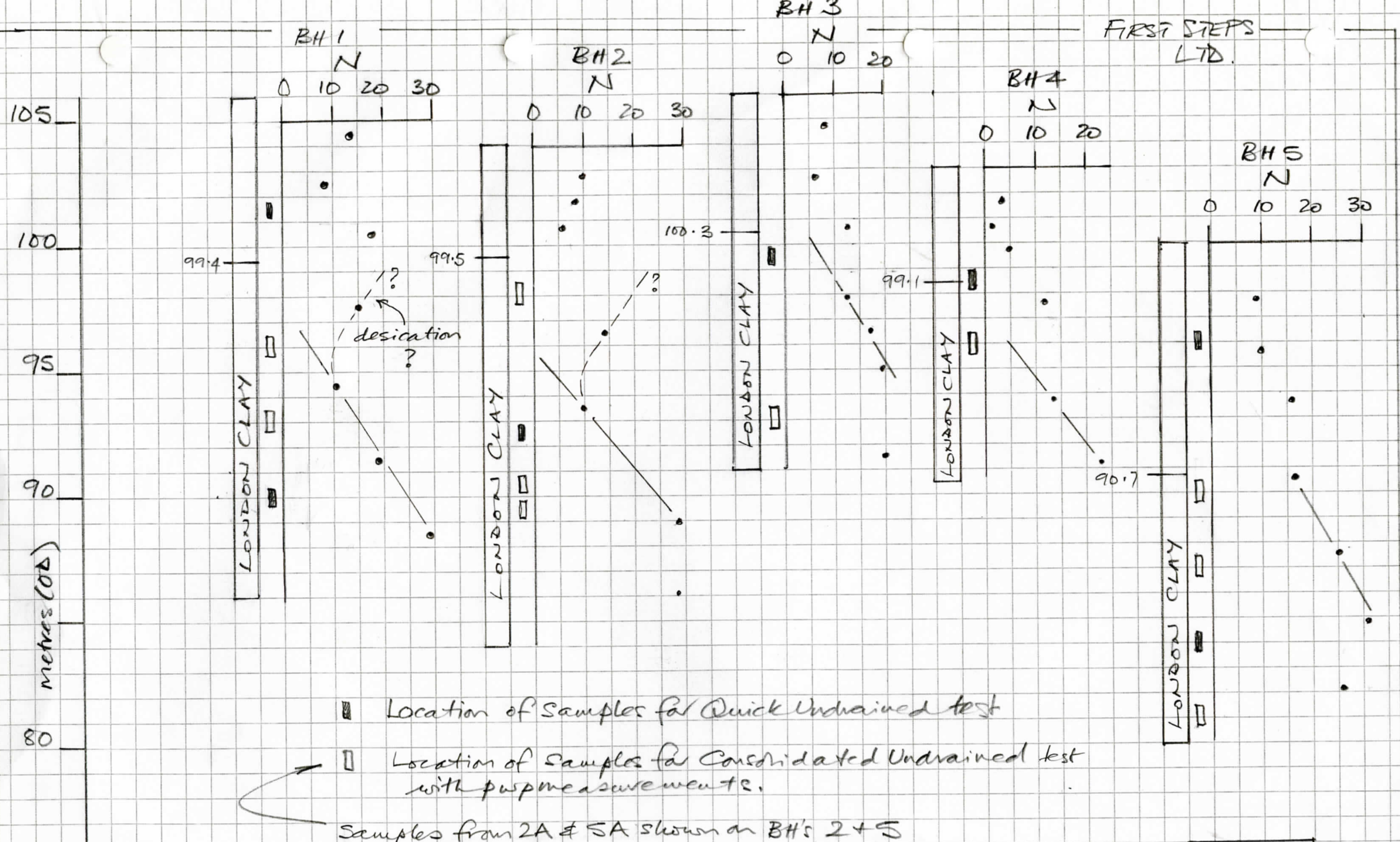
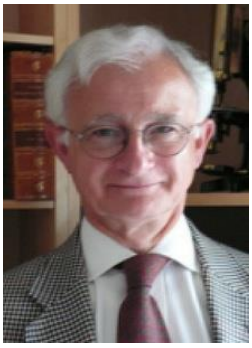


FIG 3

NOT A CROSS SECTION
BUT DRAWN TO VERTICAL SCALE (1:200 @ A4)
SO BH's CAN BE COMPARED.

28 REDINGTON ROAD



SHORT BIOGRAPHY (2016)
Dr Michael Henry de FREITAS C.Geol., C.WEM
UK Registered Ground Engineering Adviser (RoGEP)

Present position:	Emeritus Reader in Engineering Geology, Imperial College London and Director of First Steps Ltd., Director & Co-owner of First Steps Ltd
Higher Education:	BSc (Hons) 1st Class. Geology. London 1964 PhD. Engineering Geology. London 1982 Diploma of Imperial College. 1982
Chartership:	Chartered Geologist. 9710. 1990 Chartered Water & Environmental Manager 2009
Registration:	UK Registered Ground Engineering Adviser (RoGEP); 68302453. 2014
Awards:	Sir Henry Miers Prize of the Mineralogical Society; 1964. Safety in Construction medal of the Institution of Civil Engineers; 1997. Chevalier L'Ordre des Palmes Academiques; 2001 Rudolph Glossop Medal of the Geological Society; 2008 William Smith Medal of the Geological Society, 2016
Publications:	The authorship of two text books, contributor to four books, editor of seven books, author of over 50 refereed papers in geotechnical journals, and of 24 un-refereed publications in conferences.

Membership of Professional Bodies, Learned Societies, etc.:

Geological Society of London (F) 1960 – onwards
International Soc. Rock Mechanics 1967 – onwards
Institution of Water & Environmental Management (M) 1969 – onwards
Royal Geographical Society (F) 1974 – onwards
International Assoc. Engineering Geologists (M) 1979 – onwards
International Assoc. Hydrogeologists 1983 – onwards
British Geotechnical Society (M) 1985 – onwards
Geologists' Association (M) 1989 - onwards

Learned Society (Geological Society) & Professional service

2012 – onwards	Lead Author; Geol Soc Working Party Report (Glacial & Periglacial EG)
2012	Panel Member for the 2012 audit for C.Geol
2011 – onwards	Panel Member for the Register of Ground Engineering Professionals
2010	Panel Member for the 2010 audit for C.Geol
2009 – onwards	Chairman London Basin Forum Working Gp. of the Geol. Soc. London
2008	Glossop Lecturer
2005 – 2007	Chairman of the Fellowship and Validation Committee
2004 – 2005	Member of the Fellowship and Validation Committee.
1998 – onwards	Provider of Continuing Professional Development courses
1993 – onwards	Scrutineer for status of Chartered Geologist
1990 – 1994	Member of the Geological Society Awards Committee.
1990 – 19922	Chairman Engineering Group, Geological Society

1988 – 1990	Vice Chairman. Engineering Group of the Geological Society,
1981 – 1984	Editor Quart. Jour. Engineering Geology for the Geological Society.
1978 – 1979	Vice-President of the Geological Society.
1971 – 1984	Editor Geological Society Handbooks.
1976 – 1979	Member of Council of Geological Society and Chairman for the Promotion Co-ordinating Committee

International Society (Int. Assoc. Engineering Geologists) service

1996 – 2003	Chairman for International Assoc. Engineering Geologists Commission on Teaching and Training.
1994 – 1996	Secretary for International Assoc. Engineering Geologists

Research Council and national bodies

1996 – 1997	Chairman of the CIRIA working party report for British Stratigraphical Nomenclature
1991 – 1994	Member of ICE (Ground Board Committee) on Inadequate Site Investigation
1991 – 1993	Member BSI Committee: Ground Investigation, for the revision of BS 5930
1986 – 1988	Panel Member Natural Environment Research Council Research Grants Committee for Geology.

International invitations

1984 – onwards	External Examiner for the Technical University of Delft & Hong Kong, and many universities in the UK.
1974 - onwards	Visiting lecturer to Technical University of Athens; University of Complutense. Madrid; University of Stockholm (KTB); Guest touring lecturer, Beijing and Wuhan. University of Wuhan & University of Seoul.
1997	Commission 4 Rapporteur for Int. Assoc. Eng. Geol. (Athens)
1994	Rapporteur. 7th Int. Congr. Int. Assoc. Eng. Geol. (Lisbon)

Personal consulting

1974 – onwards	Widely on practical matters of engineering geology to contractors, designers and regulators both in the private and the public sector, in the UK and overseas. Work involving the practical solutions of problems arising from groundwater, stability and materials at surface and below ground. Previous contracts include:-Brighton Outfall tunnel; Dublin City Corporation (Dublin Port Tunnel); Railway Procurement Agency (Ireland) (Metro North Tunnel & surface works); ARUP Geotechnics (Havant Thicket reservoir); South African Council of Geoscience (Nuclear power sites), United Utilities Penrith UID scheme (for consortium Kier Murphy Interserve), London Borough of Camden, Donaldson Associates (various tunnels and pipelines), Parish of St Helier, Jersey (dispute resolution).

Of particular relevance to Basements;

Advice to and involvement with ARUP, the Heath and Hampstead Soc and London Borough of Camden with the drafting and implementation of CPG4

Advisor on hydrology to Heath and Hampstead Soc

Consultant for 23 basements to date within the London Borough of Camden, and others within the Royal Boroughs of Kensington & Chelsea, and Richmond upon Thames, with particular reference to the practical assessment of ground water management and ground response both on site and below surrounding properties.

Expert witness for the basement at 9 Downshire Hill, 2 Green Close & 9 Pilgrim’s Lane

Research experience

Over 40 years' experience in the geological controls on geotechnical properties gained from studying the stability and behaviour of rock and soil slopes, the shear strength of clean and infilled rock surfaces, comminution in shear zones, rock and mineral reaction to water, weak rocks and the nature of boundary layers. Also the influence of basement tectonics and their reactivation on the sedimentation and geotechnical characters of cover rock sequences and their implication for ground investigation and ground models.

Present employment

My time has been divided between teaching on the MSc in Engineering Geology in the Dept. Civil Engineering at Imperial College London, working at First Steps, the company I founded with a colleague in 2000, consulting as outlined above and continuing research with colleagues at Imperial and elsewhere. All major consultants and many contractors have sent staff to our courses at First Steps; in-house courses are also provided, the largest being to the Royal Engineers at Chatham. Web-based learning systems have also been developed to train those involved with creating Ground Models, the latest being Lapworth's Logs. All courses are endorsed by the Geological Society of London.