Ground and Project
CONSULTANTS LTD

18 ORNAN ROAD, LONDON NW3 4PX

Basement Impact Assessment: Land Stability

January 2016

Client:

Ground and Water Ltd
2 The Long Barn
Norton Farm,
Selborne Road
Alton
Hampshire

GU34 3NB

This report has been prepared by Ground and Project Consultants Ltd, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client, and is provided by Ground and Project Consultants Ltd solely for the use of its client, Ground and Water Ltd.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to Ground and Project Consultants Ltd at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

This report is confidential to the client, Ground and Water Ltd. Unless otherwise agreed in writing by Ground and Project Consultants Ltd, no other party may use, make use of or rely on the contents of the report. No liability is accepted by Ground and Project Consultants Ltd for any use of this report, other than for the purposes for which it was originally prepared and provided.

1. Introduction

Ground and Project Consultants Ltd have been instructed by Ground and Water Ltd (G&W) to undertake the land stability element of a Basement Impact Assessment, for 18 Ornan Road, London NW3 4PX. The property is located in the London Borough of Camden, London in the Hampstead Town ward, its location is indicated on Figure 1.

Figure 1: Site Location

2. Scope and Objective

The scope of this report and approach is as follows:

- A review the existing data supplied by the client has been carried out, including the proposal drawings produced to date, Ground Investigation data, photos of the building and the background data available through London Borough of Camden's website and other freely available data such as BGS geological information and purchased environmental data.
- In line with the London Borough of Camden guidance, CPG4, latest revision:
- In line with the CPG4 guidance:
    - A detailed assessment of the published and encountered geology
    - Development of a ground model including an assessment of geotechnical properties
    - An engineering interpretation including an assessment of slope stability and commentary and assessment regarding ground movements.
- Recommendations for additional work/ monitoring and observation have been provided.
- Assessment of potential ground movements using CIRIA C580.

The report has not considered contaminated land aspects of the site.

This report and the work to support it has been carried out by Jon Smithson who is a Director of Ground and Project Consultants Ltd and is a Chartered Geologist (CGeol) with 30 years' experience.

3. BIA Screening for Slope/Land Stability

A screening exercise has been carried out as per the guidance in Camden's Guidance for Basements, CPG4 as follows:

Question	Answer	Action/ Comment
Question 1: Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approximately 1 in 8)	No. The property is located at around 75-76M AOD. The property is located towards the base of Highgate Hill. The land rises steadily to the North West at a gradient locally of around 1 in 10.	Further discussed in the Impact Assessment
Question 2: Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg? (approximately 1 in 8)	Yes, there will be a low height retaining wall at the front approx. 1.2m high. Otherwise understood no significant change to landscaping.	Further discussed in the Impact Assessment
Question 3: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg? (approximately 1 in 8)	No. There are no railway cuttings in the immediate vicinity.	None
Question 4: Is the site within a wider hillside setting in which the general slope is greater than 7degrees? (approximately 1 in 8)	No, although the site is at the base of Highgate Hill the general slope angles indicated on Arup Fig 16 are less than 7 degrees.	None
Question 5: Is the London Clay the shallowest strata at the site?	Yes, the geological map (sheet 256) indicates that the site is underlain London Clay with a potential for Head Deposits at site.	The presence of London Clay close to surface is further discussed in the Impact Assessment.
Question 6: Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	No but there are trees at and close to the property and a number of bushes and semi-mature trees in the gardens and adjacent gardens.	Further discussed in the Impact Assessment.
Question 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	None known. However London Clay is indicated as being present at the property. Head deposits can also have high plasticity.	Further discussed in the Impact Assessment.

Question 8: Is the site within 100m of a watercourse or a potential spring line?	Possibly: Figure 11 of the Arup report indicates the 'headwaters' of a 'Lost River' to the southwest of the property. The site is close to the boundary of the London Clay and overlying Claygate Member, and therefor there is a potential for springs in the vicinity.	This is further discussed in the Impact Assessment.
Question 9: Is the site within an area of previously worked ground?	None known or suspected.	None
Question 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No. The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The site is close to the Claygate Member boundary, this deposit being a Secondary A Aquifer. The basement may extend into the water table.	This is further discussed in the Impact Assessment.
Question 11: Is the site within 50m of the Hampstead Heath ponds?	No. The ponds are around 0.5km to the north northeast.	None
Question 12: Is the site within 5m of a highway or pedestrian right of way?	Yes. The basement will be approximately 5m from the highway and pavement.	Health Safety and environmental measures will be required to be integrated into the building contractor's methods of working. This is further discussed in the Impact Assessment.
Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes, there is no basement in the adjoining (attached) property (no.20). There is a basement in no.16 Ornan Rd. The base of the basement slab will be around 3.3m below the existing ground floor.	This is further discussed in the Impact Assessment.
Question 14: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Potentially. The site is close to the Belsize Tunnel which pass at depth around 5m **in plan** form the front of the property.	This is further discussed in the Impact Assessment.

4. Site Information

4.1 Existing Property and Basement Proposals

The property at 18 Ornan Road is located on the north side of the road, close its junction with Perceval Avenue. Hampstead Heath Park lies around 700m to the North. The elevation of the site is around 75-76mAOD. The land rises to the North and North West. The London Overground Line runs beneath the site just to the south. See Figure 2 below. The northern line also runs some distance to the east.

The property is large semi-detached house, probably late-Victorian age, with footprint of approximately 160m^2. The plot is approximately 310m^2.

The property is semi-detached with the adjoining property (No. 20) being of similar age and design. It is understood that the property is in good structural condition, although some past subsidence of the bay has taken place due to the presence of a tree.

The National Grid reference for the property is TQ 27101 85209. The location of the property is provided in Figure 1 above.

There are a number of small trees and bushes in both the front and back garden.

The basement proposals comprise a single storey beneath the full footprint of the building plus lightwells to the front (1no.) and rear (2no.). The basement depth will be around 3.3m. There will be a low height (approx. 1.2m) retaining wall at the front boundary of the property.

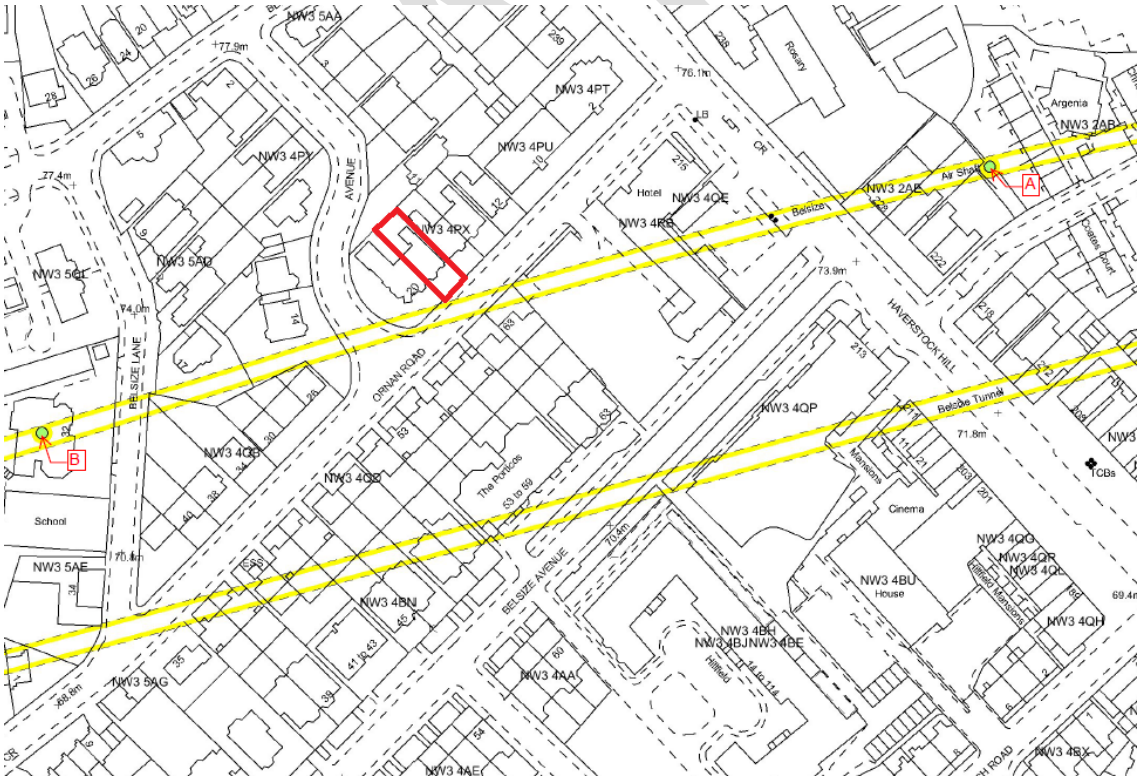

Figure 2: Tunnel Location

4.2 Topography

The OS map indicates the property is at around 75-76m AOD. The ground surface rises towards the north and north west at around 1 in 10 (~6°) towards Highgate Hill. The topography to the south is more subdued.

4.3 Geology

The available geological mapping (Ref 1.) indicates that the site lies on London Clay which typically comprises a stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. The geological map (North London 256) indicates that the property is within or very close to areas of 'propensity' for Head Deposits, associated with the higher ground of Highgate Hill. Typically these deposits are thin (<2m) and consist of soft, ocherous brown silty clay with blue-grey mottling in places and angular, frost-shattered fragments of flint occur sporadically throughout. The base of the London Clay is likely to occur significant depth below the property. The overlying Claygate Member outcrops around 100m to the west. See figure 3 below.

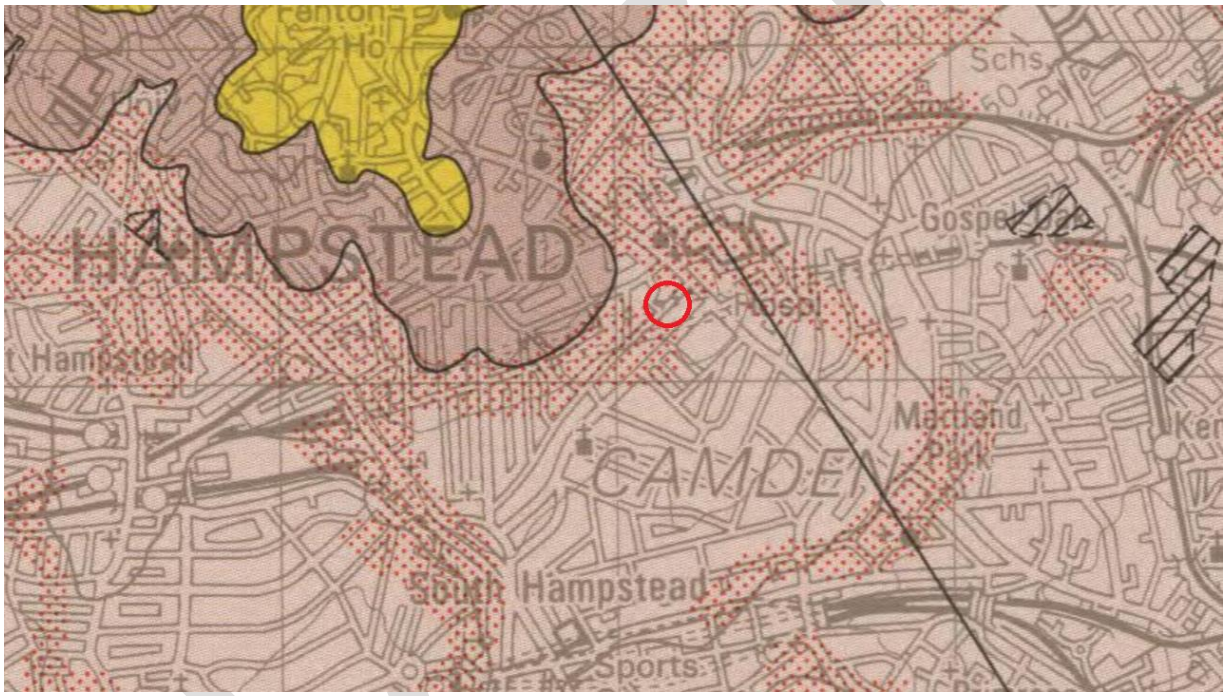

Figure 3: Geology

4.4 Hydrology and Hydrogeology

The OS Map indicates that Hampstead Ponds are located around 750m to the North. Figure 11 of the Arup report indicates the 'headwaters' of a 'Lost River' to the southwest of the property. . There are no springs shown on OS mapping although the boundary between the London Clay and Claygate Member is associated with springs and emergent groundwater.

The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The Claygate Member is classified as a Secondary A Aquifer.

4.5 **Other Environmental Data**

The Groundsure report gives a wealth of background data on local environmental issues and hazards. (See Appendix A). The key issues relevant to land stability are summarised in the table below:

Drift Deposits	None are indicated on BGS mapping (note comments re Head Deposits above)
Made Ground	None are indicated on BGS mapping
Groundwater & Abstraction	Site on unproductive strata. Secondary A Aquifer indicated ~120m to W (Claygate Member). There is a groundwater abstraction point 963m to S, and others within 1 and 2km.
Current Uses	Petrol Station on Haverstock Rd, 80m to east Electricity substations 100+ m various directions
Historical Uses	Hospital to East, Garage at junction of Ornan Road and Haverstock Hill (now site of Premier Inn). Mapped 19m to the east.
River Network	Culvert ~101m to E, running N-S
Flooding	Very Low Risk
Ground Subsidence Risk	Moderate
Shrink/ Swell	There is a moderate Hazard of shrink and swell from the London Clay soils. Report advises: "Ground conditions predominantly high plasticity. Do not plant or remove trees or shrubs near to buildings without expert advice about their effect and management. For new build, consideration should be given to advice published by the National House Building Council (NHBC) and the Building Research Establishment (BRE)."
Landslide	Very Low Risk
Soluble Rocks	Negligible Risk
Compressible Ground	Negligible Risk
Collapsible Ground	Very Low Risk
Running Sand	Negligible Risk
Mining	None recorded
Radon	Not in a Radon Affected Area

5. Ground Investigation

A ground investigation (GI) has been carried out at the site by Ground and Water Ltd (G&W) and results of these have been made available by G&W. The GI was carried out in June and August 2015.

The work comprised two window sample boreholes (WS1 and 2) to 5.00m bgl in the front and rear gardens respectively and two hand excavated trial pits to expose foundations (TP FE1 and 2) to the front and rear of the property respectively. A dynamic probe (DP1) was carried out at the location of WS1 to 10m depth. A standpipe piezometer was installed into the base of WS1 with the response zone from 1 to 5m bgl.

Below is a summary derived from the Ground Investigation report. The boreholes encountered a cover of Made Ground between 1.25 and 1.75m thick. This can be summarised as a dark brown silty sandy clay with gravel or a light brown clayey silty sand with gravel. Below this the boreholes encountered a light brown silty CLAY sometimes grey mottled with rare lignite inclusions. The boreholes terminated within this deposit at 5.00m. Given the location of the property in relation to the boundary between the London Clay and the overlying Claygate Member and the propensity for Head Deposits in the vicinity, it is possible that these deposits represent Head Deposits as opposed to London Clay. The lignite inclusions may also be indicative of a Head Deposit.

The dynamic probe hole can be summarised as having N100 values less than 5 to 4 m bgl, between 5 to 10 from 4 to 8m bgl and over 10 below 8m bgl. G&W have equated these results to SPT equivalents and correlated these to undrained shear strength. They summarise that the undrained shear strength range for the London Clay (possible head deposit) is between 20 and 60 kPa from 1.75 to 5m bgl and 60 to 130kPa from 5.0 to 10.0 m bgl.

TP FE1 was excavated next to the west side of the front bay window. It encountered made ground with a brick wall to 0.5m onto a probable concrete foundation the base of which was unproven at 1.3m bgl. TP FE2 was located on the rear wall. It encountered made ground with a brick wall to 0.4m bgl onto a probable concrete foundation, the base of which was found at 0.7m bgl.

Laboratory tests were carried out on the samples collected from the boreholes. Testing consisted of the following:

5 No. Atterberg Limit test including moisture content determination
2 No. Soluble Sulphate, pH and related tests for Concrete Classification on soil samples
1 No. one dimensional Consolidation Test

All of the Atterberg tests were conducted in the London Clay/Head Deposit. These show no discernible pattern with depth with measured values as follows:

- Moisture content: 23 to 35%
- Plastic Limit : 16 to 30%
- Liquid Limit: 35 to 88%
- Plasticity Index: 19 to 58%
- Liquidity Index 0.09 to 0.37

The wide variation in liquid, plastic limits and plasticity index is possibly indicative more variable Head Deposits rather than London Clay, which tends to be more consistent. There is little evident correlation to the dynamic probe tests. The lower liquidity index values probably equate a firm or firm to stiff consistency.

The lowest measured moisture content at 1.5m may be indicative of desiccation due to vegetation demand for water.

The consolidation test was performed on a presumably remoulded sample is of limited value but indicates a soil of low compressibility for the higher applied pressures.

6. Conceptual Ground Model

From the above a conceptual Ground model has been developed and is presented in tabular form below:

Strata	Typical Description	Depth at Property encountered in GI	Geotechnical Properties – Tentative Characteristic Values*	Other
Made Ground	Brown silty clayey sand with gravel/ silty sand clay with gravel is brick, concrete, flint	Ground level to 1.25m to 1.75m	N/A	Made Ground is unlikely to be encountered to a variable and possibly significant depth. It should not be relied upon as a bearing strata.
London Clay/ Head Deposit	Brown silty clay. Probably firm becoming firm to stiff.	1.25- 5.00m (base not proven)	C' =0 $\phi' = 20^o$ Cu = 30 increasing to 80kN/m^2 at formation. **	London Clay/Head Deposit. May vary considerably if proven to be a Head deposit
Groundwater		3.44m bgl		Reflects summer levels. May significantly vary seasonally or after prolonged wet or dry periods.

Table 3: Summary of Strata Characteristics

*The determination of parameters is tentative due to the lack of test data.

**Strength should be verified by hand held shear vane/ inspection during ground excavation.

7. Impact Assessment

There are no apparent major issues which should seriously affect the viability of the construction of the new basement. However the assessment of the geological environment of 18 Ornan Road and the screening exercise indicate some areas for further discussion in this report with suggested mitigation where appropriate.

7.1 **Slopes:** The property is at the base of Highgate Hill. Slope angles locally are generally at around 6^{o} (around 1 in 10). The nature of the foundation soils and their potential as Head Deposits should be further assessed during or before construction.

7.2 **Landscaping/ Reprofiling:** There will be a low height retaining wall at the front of the property. This should be designed to account for overall stability as well as overturning, sliding and bearing capacity/settlement.

7.3 **London Clay/Shrink and Swell:** The basement will be founded in London Clay/Head Deposits. The soils are of variable sometimes high plasticity and high volume change potential. The basement will be founded at around 3.3m bgl, therefore below any seasonal shrink and swell. The London Clay soils are known for their high levels of soluble sulphate. The concrete mix design should take appropriate account of sulphate levels in accordance with BRE Special Digest 1. The basement structure should be designed to account for swelling pressures

7.4 **Trees:** Semi-mature and bushes are located in the garden and in the vicinity of the property. There is some possible indication of dessication in the upper soils although this may be reflective its variable clay content. Care should be taken to minimise root damage during construction works. Should trees be removed there is potential for the soils to swell as a result which may affect this and neighbouring properties and this should be accounted for in design.

7.5 **Groundwater/Aquifer**: Groundwater was encountered below the proposed basement formation level. However this was a summer measurement and winter and prolonged wet weather groundwater levels may be much higher. It is recommended that a design level of ground surface is used, this accounts for seasonal variations and leaks from water supply, etc. Groundwater may be encountered during the works, particularly as seepages through sandy silty layers within London Clay/Head Deposits or at the base of the Made Ground. These should be managed carefully to prevent ground loss particularly through loss of fines. Softening of formation due to water ingress is a risk and softened soils should be excavated and replaced where practicable. Consideration should be given to limiting the size and time of face exposures during construction should significant flows be encountered during construction. Baseline and ongoing regular monitoring of the building and its immediate neighbours for settlement and movement/distress is highly recommended during building works and for a short period after completion. It is recommended that ongoing monitoring of groundwater levels is carried out during and up to the end of construction of the basement structure.

7.6 **Lost River:** There is a lost river indicated some distance form site which is probably represented by the culvert which runs north-south some 101m minimum distance from the property. It is considered that this can have no impact on the proposal.

7.7 **Tunnel:** Belsize Railway tunnel runs very close to the site (<5m) in plan. At Ornan Road the crown of the tunnel is approximately 25m deep and the tunnel is around 8m in diameter. Two ventilation shafts are located to the east and west of the property at approximate tunnel chainages 535m and 895m. The tunnel passes beneath Ornan Road at approximate chainage 705m. An inspection sketch has been received for December 2003 which show no tunnel lining defects in the vicinity of the property. Network Rail make various stipulations in terms of activities and approvals and impose liabilities on the 'proposer'. These must be understood and adhered to. It is understood that piling is not required or planned for the basement construction. Network Rail will need to be informed if this changes.

7.8 **Basement Depth**: The basement is proposed to be constructed involving an excavation to approximately 3.3m below the existing ground floor. The property adjoins its neighbouring house at no.20 and is approximately 1.5m from no.16. The proposals to construct the basement is likely to be via underpinning at the party wall. Underpinning proposals are understood to involve a 'hit and miss' approach in stages so each 'panel' is separated by 3-5 others from the next open one. It will be important that the building contractor is closely supervised and is experienced in this type of construction. It will be critical to prevent exposed faces from collapse or significant ground loss into the new excavation and temporary face support should be maintained where practicable. (See discussion on Ground Movements in Section 8. below).

8. Assessment of Ground Movement

An assessment of ground movements has been carried out as follows:

- Movements have been assessed for the adjoining property (No.20) due to the excavation of the basement which will directly adjoin and form part of the party non-adjoining property at No.16.
- The magnitude of ground movements has been assessed for the excavation in front of the retaining structure.
- Movement due to Wall installation has been discounted at this stage as it is understood that at this stage the property will be underpinned, and as such a wall will not be installed into the ground. Rather the 'wall' will be installed into the excavation.
- It is important to note that CIRIA report C580 is written for embedded retaining walls. Therefore movement calculations for the excavation of soil and installation of underpins does not strictly apply to C580.

Outline planning drawings developed by STS Structural Engineering and supplied by G&W have been reviewed and used to inform this assessment.

The following key assumptions have been made:

- The maximum excavation depth is approximately 3.3m bgl.
- The method of basement construction will be via unperpinning using a 'hit and miss' approach.
- A high wall stiffness has been assumed.
- In the permanent case the wall will always be propped at high level.
- The adjoining property (No.16) is 2m from the subject property.
- No.20 is attached to the property.
- The width of both no. 16 and no. 20 has been assumed to be 8m.
- A London Clay soil of at least firm to stiff consistency has been assumed.

From figure 2.11 in C580 the following calculated assessments of ground movements have been developed due the excavation of soils in front of the wall. An excavation depth of 3.3m has been assumed.

No 16

Distance from wall* (m)	**2 (Near side of 16)**	**10 (Far side of 16)**	
Horizontal Movement (mm)	4	3	
Vertical Movement (mm)	3	1	The near wall of no.16 is also the location of maximum vertical movement

No 20

Distance from wall*(m)	0m (Near side of 20)	8m (Far side of 20)	Max Vertical Movement
Horizontal Movement (mm)	4	3	
Vertical Movement (mm)	1	1	3mm at 2m from no.18

- This is the wall adjacent at no.18

This assumes that the wall is propped high and therefore a high stiffness can be assumed when reading from the graphs. It is understood that there will be adequate propping in the temporary case to justify this assumption and in the permanent case the structure will provide adequate support to the retaining walls and act as a high level prop.

There are a number of key points to note in using this assessment:

- It is important to note that CIRIA report C580 is written for embedded retaining walls. Therefore movement calculations for the excavation of soil and installation of underpins does not strictly apply to C580. The values calculated are likely to represent lower bound numbers.
- Most ground movement will occur during excavation and construction so the adequacy of temporary support will be critical in limiting ground movements.
- The speed of propping and support is key to limiting ground movements
- Good workmanship will contribute to minimising ground movements.
- The assessment assumes the wall is in stiff/competent clay.
- Larger movements will be expected where soft soils are encountered at, above and below formation.

Ground movement can be minimised by adopting a number of measures, including:

- Ensuring that adequate propping is in place at all times during construction
- Installation of the first (stiff) support quickly and early in the construction sequence for each underpin panel.
- Avoiding unsupported faces and developing good contact between the ground and the wall
- Avoid leaving ground unsupported
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control dewatering to minimise fines removal and drawdown.

It must be noted that the movements are calculated values based on the findings and methods of CIRIA C580. Larger movements may be generated if any one or any combination of the above recommendations and/or assumptions are not heeded or if ground conditions are different to a firm to stiff or stiff London Clay.

In terms of building damage assessment and with reference to Table 2.5 of C580 (after Burland et al, 1977), the 'Description of typical damage' given the *calculated* ground movements is likely to be:

- For no. 16 :'Very Slight'
- For no. 20 :'Very Slight' to 'Slight'

9. Conclusions

The methodology and approach of CPG4 has been followed in developing this BIA with respect to Land stability. It is concluded that with the construction of the new basement at 10 Ornan Road should not have significant impacts on land stability provided that:

- Groundwater inflow, if encountered, is reduced to a minimum and properly controlled such that there is no significant wash out of fine material. Groundwater levels should be monitored before and during construction.
- The retaining wall should be appropriately designed.
- The construction of the basement is carried out by a competent and experienced building contractor and precautions are taken to maintain the stability of the excavations.
- Care should be taken to minimise the disturbance and damage to trees and their roots. Should tress be removed then an assessment of the potential for swelling of the London Clay soils should be carried out.
- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate conditions anticipated.
- Monitoring of the structures is carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.
- The movements calculated have been based on C580 which is written for embedded walls. Calculated movements are therefore indicative and may be exceeded.

10. References

1. BGS Geological Map Sheet 256.
2. Ordnance Survey Map, Explorer 173, London North
3. Arup: Camden Geological, Hydrogeological and Hydrological Study.
4. STS Planning Drawings
5. Network Rail: Conditions And Requirements For Engineering Works In The Vicinity Of Network Rail Tunnels Issued In Connection with: EN11510 London: 18 Ornan Street – Proposed Basement Construction
6. Ground&Water GWPR1313: Ground Investigation Report: 18 Ornan Road.
7. Groundsure Enviroinsight report for 18 Ornan Rd, GS-2701129
8. CIRIA C580

APPENDIX

Groundsure Enviroinsight Report GS-2701129