Ground and Project CONSULTANTS LTD

80 GREENCROFT GARDENS, NW6 3JQ

Basement Impact Assessment: Land Stability

August 2017

Report Ref: 30207-1

Client:

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Contents

Non-Technical Summary,

It is proposed to construct a 3.5m deep basement at 80 Greencroft Gardens, London, NW6 3JQ. The basement will be built under the full footprint of the existing house plus a small sunken garden and lightwells.

The screening exercise identified a number of issues for further consideration as follows:

- London Clay is the shallowest natural geological strata
- There are trees and bushes in the rear garden
- A 'lost river' runs relatively close to the site
- Groundwater may be encountered during construction works
- The basement will be deeper than neighbouring properties

The published geology suggests London Clay at site with the possibility of Head Deposits, which are softer and weaker.

A ground investigation was carried out by Ground & Water consisting of two boreholes, one 10.45m and the other 5m deep. These encountered Made Ground (i.e. ground placed by human activity) overlying thin Head Deposits to 1.20m depth. London Clay was found beneath the Head Deposits as a brown and grey silty clay and of high shrinkage potential. Groundwater was encountered during the investigation in a monitoring well at 4.7m.

The scoping and assessment of the BIA concluded that:

- Groundwater inflow, if encountered, should be properly managed and controlled such that there is no significant wash out of fine material.
- The retaining structure to the basement should be appropriately designed.
- The construction of the basement is carried out by competent and experienced contractors and precautions are taken to maintain the stability of the excavations.
- Care should be taken to minimise the disturbance and damage to bushes and their roots. Should bushes be removed then an assessment of the potential for swelling of the London Clay soils should be carried out.
- Concrete should be designed accounting for the sulphate conditions anticipated.
- Monitoring of the structures should be carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.
- Ground Movements affecting adjacent properties should be relatively small, provided that good construction practices are followed and the structural design is robust and appropriate to the ground conditions.

1. Introduction

Ground and Project Consultants Ltd have been instructed by Croft Structural Enginners to develop Ground Movement assessments and to amend the original report carried out for H Fraser Consulting which reports on the land stability element of a Basement Impact Assessment compliant with CPG4, at 80 Greencroft Gardens, NW6 3JQ. The property is located in the London Borough of Camden in the Swiss Cottage 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 of the existing data supplied by Croft has been carried out, including the proposal drawings produced to date, Ground Investigation data, desk study data from a Groundsure (Enviroinsight report), photos of the building and the background data available through LB Camden's website plus other freely available data such as BGS geological information.
- 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.

This report does not consider contaminated land aspects of the proposed basement construction.

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

3. BIA Screening for Slope/Land Stability

A screening exercise has been carried out as per the guidance in 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. There are no slopes at the property	None
Question 2: Will the proposed reprofiling of landscaping at site change slopes at the property boundary to more than 7deg? (approximately 1 in 8)	No. There are no changes in surface profile planned.	None
Question 3: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg? (approximately 1 in 8)	No.	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, the general slope in the area is around 1 in 40 (2^{o}) based on Ordnance Survey data. The site is some distance from Hampstead Heath and steeper ground	None
Question 5: Is the London Clay the shallowest strata at the site?	Yes, the mapped surface deposit is LONDON CLAY. MADE GROUND is likely to be encountered with the possibility of HEAD deposits overlying the London Clay.	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	It is understood that there will not be a need to fell trees. However the sites sits within South Hampstead conservation area. Trees are present at and close to site.	Further discussed in the Impact Assessment.

Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).		
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 relatively close to surface.	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 a 'Lost River' probably within 100m to the east and south of the property.	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 not within a source protection zone of a public water supply. However 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.	None
Question 12: Is the site within 5m of a highway or pedestrian right of way?	No. The basement will be around 10m from the highway and pavement	Health Safety and environmental measures will be required to be integrated into the building contractors methods of working

Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	It is understood that basements are not present at no. 82. No. 78 has gone through the planning process, it is not known whether construction has taken place.	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?	No.	None

4. Site Information

Existing Property and Basement Proposals

The property at 80 Greencroft Gardens, London, NW6 3JQ is located on the north side of the road, which is itself located approximately 2km north west of Regents Park and around 400m south of the Jubilee Line, 500m south west of Finchley Road and 600m south west of West Hampstead Stations. Swiss Cottage tube station is about 600m to the east.

The property has a footprint of approximately 220m^2. There is an existing low height cellar at the property. The overall property (house) is a double fronted three storey detached building probably of late Victorian age. There is a narrow space between the properties either side.

Camden's planning portal indicates that there have been a number of successful basement applications on Greencroft Gardens in recent years. There has been a successful application for a basement next door at no. 78.

The basement proposals are for a new basement beneath the full footprint of the property, plus a small sunken garden/lightwell area to the rear. The basement will have a dividing wall down the middle with a bedroom, en-suite and living area and utility room on each side. The wider plans are to modernise the house into a series of apartments. The maximum excavated depth for the basement is understood to be 3.5m bgl. The front of the basement will be approximately 6.5m from the pavement.

Topography

The property is located on gently sloping ground well below the base of Hampstead Heath. Its elevation estimated from the OS map is approximately 41mAOD. The OS map shows that the ground surface falls gently to the SE over a gradient of around 1 in 40 (i.e. less than 2^o). The National Grid Ref for the property is TQ 26018 84306.

Geology

The available geological mapping (Ref 1.) indicates that the site lies on London Clay (plain brown colour in Figure 2) 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 a 'propensity' for Head Deposits to be present reasonably close by (~200m) to the east and also further to the west of the site. These are indicated by the stippled areas on Figure 2 below. Typically they 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 some depth below the property. See Figure 2 below.

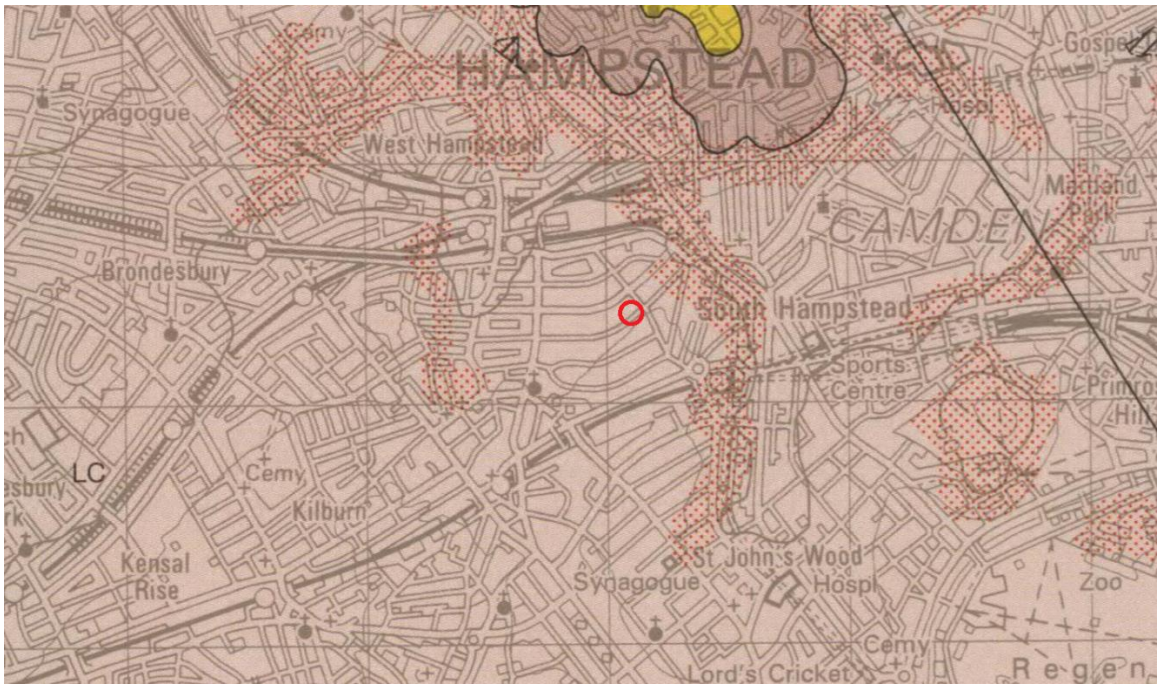

Figure 2: Geology Contains British Geological Survey materials © NERC 2006

Hydrology and Hydrogeology

The OS Map indicates that there are no surface water bodies in the vicinity of the site. The Grand Union Canal forms the northern boundary of Regents Parks some 1.5km to the SE. The Hampstead Ponds are approximately 3km to the NE. There are no springs shown on OS mapping.

The Arup study for Camden (Fig 11, extracted above) indicates a 'Lost River' running southwards to the east and south of the property, probably within 100m. This appears to be a tributary of the River Westbourne and will have been culverted probably in the late nineteenth century.

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 not within a source protection zone of a public water supply. There are no groundwater abstraction licenses within 2 km of the site and no source protection zones within 500 m of the site. (Ref 5. Groundsure Report).

Other Environmental Data

A Groundsure report centred locally gives useful background data on local environmental issues and hazards. The key issues are summarised in the table below:

Drift Deposits	None are indicated on BGS mapping
Made Ground	None are indicated on BGS mapping
Shrink/ Swell	There is a moderate Hazard of shrink and swell from the London Clay soils
Landslide	Very Low Risk
Soluble Rocks	Negligible Risk
Compressible Ground	Negligible Risk
Collapsible Ground	Very Low Risk
Running Sand	Very Low Risk
Mining	None recorded

5. Ground Investigation

A ground investigation (GI) has been carried out at the site by Ground & Water Ltd and results of these have been made available by H Fraser Consulting. The GI was carried out in July 2016. The work comprised of two boreholes BH1 to 10.45m, drilled using a Terrier rig and WS2 to 5.00m drilled using hand held window sample equipment. Two trial pits were excavated in the front and rear of the property to expose the existing foundation of the property and adjacent property.

Borehole BH1 was drilled in the front garden of the property and WS2 in the rear garden. They encountered a thin cover of made ground (0.65 to 0.80m) which is probably reworked natural ground associated with the construction.

This was found to overlie a thin layer of Head Deposits in both boreholes. These represent reworked London Clay by natural processes and are summarised as mid brown/orange brown gravelly CLAY. Gravel is rare, fine to medium, sub-rounded to sub-angular flint. Note that given the proximity to a 'lost river' the head Deposits may be interpreted as Alluvium.

The surface of the London Clay was encountered in both boreholes at 1.20m bgl. The boreholes were both terminated within the London Clay. It was encountered as a mid-brown occasionally mottled grey silty CLAY becoming dark brown and grey with depth. Note that the Head Deposits may be interpreted as Alluvium associated with the River Westbourne Tributary. A standpipe piezometer was installed in BH1 with a response zone between 1.0 and 5.0m bgl. The works included Standard Penetration Tests (SPTs) in BH1 and disturbed samples were taken throughout both BHs.

The SPT'N' Values show a steady increase in depth from a value of 6 (taken across the Head Deposit/London Clay interface) to 11 and 13 within the basement depth. These latter values can be correlated with undrained shear strength. Using Stroud's correlation for high plasticity clays a factor of 4 or 5 suggests an undrained shear strength range within the basement depth of around 50 to 75kN/$m^{2,}$ i.e. firm becoming firm to stiff. Below 3m the SPT 'N' values show a fairly linear increase from 17 at 4m to 34 at 9m, probably suggesting firm to stiff soils becoming stiff or very stiff with depth. Note that the ground investigation at no.78 (next door) found a firm becoming stiff clay at around2.0/2.5m with shear vanes at 3m of 120kPa and >140kPa (i.e. beyond the limit of the vane) at 4.0m. This reflects a firm to stiff /stiff clay.

Two trial holes were dug by hand to expose the foundations at the front and rear of the property. TP1 was dug at the front of the property. It was excavated to 1.10m bgl and found that the house foundation of concrete at 0.84m bgl is located upon a Head Deposits. TP2 was excavated in the rear and similarly found a concrete foundation to the house but in this case was founded on Made Ground at 0.67m.

Groundwater was not encountered in the boreholes during drilling. A monitoring standpipe was installed in BH1. Monitoring indicated a level of 4.70m bgl on 3 August 2016.

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

5 No. Atterberg Limit test, including moisture content determination
2 No. Sulphate on Soil

The Atterberg tests were all performed on London Clay. The results are summarised as follows:

Moisture content:	28 to 35%
Plastic Limit:	29 to 34%
Liquid Limit:	77 to 83%
Plasticity Index:	48 to 51%
Liquidity Index	-0.06 to 0.06

The tests indicate that the moisture content is slightly higher than but close to the plastic limit, except at depth where the moisture content is below plastic limit. This is likely to indicate a firm to stiff to stiff consistency and corresponding shear strength at shallow depth and a stiff or very stiff consistency with depth. The atterberg results and SPT's therefore show some correlation, although the SPTs are lower than expected. The range of liquidity indices from 0.06 to -0.06 suggests shear strengths in excess of 100kN/m^2.

The soils have a high Plasticity Index and high Liquid Limit which classifies the London Clay here as clay soil of very high plasticity, which means they are highly prone to swell and shrinkage with variations in Moisture content. Moisture contents at the time of testing are likely to be lower than their winter seasonal peak. Whilst foundations are likely to be below the seasonable variations, the presence of local trees means that design should account for the potential for volume change in the soils.

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 (based on GI boreholes)**	**Geotechnical Properties – Tentative Characteristic Values***	**Other**
Made Ground	Orange brown silty clay and sand MADE GROUND containing brick and gravel	Ground level to between 0.65m and 0.80m	N/A	Made Ground is unlikely to be encountered to a significant depth except around existing foundations. It should not be relied upon as a bearing strata.
Head Deposits	Mid brown/orange brown gravelly CLAY	From between 0.65 and 0.80m to 1.20m bgl		May be variable and contain 'perched' water.
London Clay	Firm to stiff brown silty CLAY, occasional sandy or silty zones, Dark grey at depth.	1.2m to base, full thickness unproven	C' =0 ϕ' = 20° Cu = 75kN/m^2 down to formation**, increasing to 150kN/m^2 at 9m Allowable Bearing Pressure = 150kN/m^2	Very high plasticity, high volume change potential
Groundwater		4.70m bgl (monitored level 3/8/16)		May exhibit significant variability seasonally or after prolonged wet or dry periods. Higher levels, e.g. ground level are advisable in structural design. Perched water may be present at or near the base of made ground and within Head Deposits.

Table 3: Summary of Strata Characteristics

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

**The undrained shear strength of the clay should be validated during construction works

7. Impact Assessment

There are no major issues which should seriously affect the viability of the construction of the new basement. However the assessment of the geological environment of 80 Greencroft Gardens and the screening exercise indicate some areas for further discussion in this report with suggested mitigation where appropriate.

London Clay: The basement will be excavated through and founded in London Clay. The London Clay soils at this site are of very high plasticity and high volume change potential. The basement will be founded with a maximum excavated of around 3.5m bgl, therefore below any seasonal shrink and swell. The basement structure should be designed to account for swelling pressures. It will be important to account for the nature of the existing foundations at the property and its neighbours. Any change in drainage or significant interruption/change to groundwater levels and flow patterns will need to be assessed for its implication on soil water content and consequential effect on soil volume change. 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.

Trees: Trees are located in the vicinity and the property is within the South Hampstead conservation area. There are trees and bushes in rear garden of the property and adjoining properties. There are some trees in the pavement and front gardens but these appear to be some distance from the property. Roots have been noted in the ground investigation to 0.8m bgl. Care should be taken to minimise root and tree damage during construction works. Tree or bush removal will cause changes in moisture conditions and may result in soil volume changes which could affect (in particular) shallow foundations.

Basement Depth: It is proposed to be construct the basement to a level of approximately 3.5m maximum excavated depth below the existing ground floor. The property is detached but very close to its neighbours on both sides. No. 78 may have a basement. The proposal to construct the basement is understood to be via underpinning at the party and rear and front walls. Underpinning proposals are likely to involve a 'hit and miss' approach in stages so each 'panel' is separated by 4-5 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 and ground loss into the new excavation. Temporary face support should be maintained where practicable. Most ground movement should occur during wall installation, excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements. Heave movements will occur due to removal of soils.

It is strongly recommended that an assessment of ground movements and a related assessment of building damage is carried out, to understand the effect on adjoining properties.

A number of factors will assist in limiting ground movements:

- The speed of propping and support
- Good workmanship
- 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.
- Avoidance of ground loss through the gaps between the piles.
- Avoid leaving ground unsupported.
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control groundwater inflows and manage dewatering to minimise fines removal and drawdown.

Groundwater: Monitoring of the standpipe piezometer has indicated groundwater levels at 4.70m bgl. Groundwater levels can vary significantly on a seasonal basis or after prolonged wet weather and it should be noted that the reading was taken in the summer. It is possible that groundwater will be encountered during construction. It will be important to limit the size and time of face exposures left open during construction, to limit groundwater inflow and softening of exposed soils. Should significant flows be encountered during construction, for example from exposures of the sandy layers in the London Clay, measures must be taken to prevent wash out of fines. Settlement from any dewatering itself (i.e. if loss of fines is prevented) is likely to be of low magnitude. High groundwater levels should be used in design of the basement structure to account for seasonal variations, flooding and mains leakages. The excavation should be kept dry during construction. Design of drainage systems should consider the requirements of sustainable urban drainage. It is recommended that ongoing monitoring of groundwater levels is carried out during construction.

Lost River: There appears to be a 'lost river' within 100m to the east and south of the property. This will have been put into culvert probably in the late nineteenth century. Close examination of the map indicates that the course of the river is shown some distance and crosses Greencroft Gardens to the east of its junction with Fairhazel Gardens before turning west towards Aberdare Gardens. It is therefore considered the there is a low risk of the course of the river impacting on the construction of the basement.

8. Assessment of Ground Movement

Movement due to wall installation and excavation

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

- Movements have been assessed for the adjoining properties at 78 and 82 Greencroft Gardens which are predicted to arise due to the excavation of the basement. Movements at No 80 will reflect those predicted for the near side of the adjoining properties
- The magnitude of ground movements has been assessed for the excavation in front of the retaining structure, i.e. the basement wall.
- Movement due to Wall installation has been discounted at this stage as it is understood that the property will be underpinned, and as such a wall will not be installed into the ground. Rather the 'wall' will be installed in sections into the excavation.
- It is important to note that CIRIA report C760 is written for embedded retaining walls. Therefore movement calculations for the excavation of soil and installation of underpins does not strictly apply to C760. There is no recognised method for calculating ground movements due to underpinned basements so C760 is used as a convenient and recognised approach.
- It is recognised that settlements are generally small where care and appropriate measures are taken in this type of basement construction.

Design drawings developed by the architect have been reviewed and used to inform this assessment.

The following key assumptions have been made:

- The detailed design of the basement (and associated temporary works) has been carried out by an appropriately qualified and experienced structural engineer, to current professional standards and best practice
- The maximum excavation depth is approximately 3.5m below lower ground floor level.
- The method of basement construction will be via underpinning.
- A high wall stiffness has been assumed.
- The wall will be propped using stiff closely spaced props in the temporary case both at basement floor and ceiling levels.
- In the permanent case the wall will always be propped at high level.
- The adjoining properties are very close to the subject property.
- For the purposes of the calculations, the width and height of the subject properties have been estimated to be as follows:
- Height: 13m
- Width: 9.5m (no.78) and 13.5m (no.82)

The undrained shear strength of the clay has been shown to have an impact on the ground movement anticipated. There was some discrepancy between the SPT N Values and the Liquidity Index of the clays soils in the excavated zone. The natural moisture contents of the soils are slightly above or slightly below their plastic limit indicating a stiff to very stiff clay. The SPTs are lower than we might expect, with values of 11 to 17 in the London Clay within the excavation depth correlating to shear strengths in the range firm to firm to stiff. The Borehole at no. 78 had shear vane testing and showed a firm becoming stiff clay at around 2.0/2.5m with shear vanes at 3m of 120kPa and >140kPa at 4.0m. These correlate well with the atterbergs at no. 80. This reflects a firm to stiff /stiff clay can be expected and the use of much more onerous and pessimistic movement curves for soft clay cannot be justified. It is proposed that in-situ testing is undertaken as the underpins are formed to prove the minimum required undrained shear strength at formation level e.g. hand shear vane testing.

It is assumed that the soils are competent soils i.e. stiff clays, thus the following ground movements have been calculated, using figure 6.15 in C760.

No's 78 and 82 Greencroft Gardens

	78 Greencroft Gardens		82 Greencroft Gardens	
Distance from wall (m)	**2.5 (Near side)**	**12.0 (Far side)**	**0.5 (Near side)**	**14.0 (Far side)**
Horizontal Movement (mm)	5	0	5	1
Vertical Movement (mm)	3	0	2	<1

This assumes that the wall is propped high and at formation level 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. Where new basements exist founded at similar depths to that proposed for 80 Greencroft Gardens, the calculated ground movements and associated estimates of damage will be of lower magnitude.

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

- Most ground movement will occur during excavation of the basement 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 calculation assumes the wall is in competent soil.

- Larger movements will be expected where soft or loose 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.
- Avoidance of ground loss through the gaps between the piles (if used).
- Avoid leaving ground unsupported.
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control and appropriate design and selection of dewatering to minimise fines removal and drawdown.
- A survey in relation to the party walls should be carried out. This should be carried out at detailed design stage.

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 from those anticipated by the investigation. Computer analysis suggests that ground movements are highly sensitive to prop and wall stiffness, so the use of stiff props both in the temporary and permanent cases is essential.

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 as follows:

78 Greencroft Gardens assessed to be category 1, 'Very Slight'

82 Greencroft Gardens assessed to be category 0, 'Negligible'.

Movement will also be experienced by no. 80 itself. This has been calculated to be of the order of 5mm horizontal and around 1mm vertical. Again the actual magnitude of these movements will depend upon a number of factors described above and the nature of the ground expected may give rise to larger movements.

Thames Water Assets

There are Thames Water Assets in the road (Greencroft Gardens). The water main is approx 15m from the basement and according to the TW sheets is 900mm below GL. At 3.5m basement depth this represents a distance of over 4 times the basement depth and therefore there will not be a significant impact. Likewise, the sewer is around 13m and again just under 4x basement depth away and it will be about 2-3m deep. The CIRIA curves show that at 2 times the excavation depth there will be no surface vertical movement at these distances and about 0.01% horizontal movement to wall depth so less than 0.5mm at the sewer. In reality this will likely be less as the sewer is deeper and will be less

effected as its almost the same depth as the basement. No horizontal movement is predicted at the water main distance.

Basal Heave

Basal Heave is likely to occur due to the presence of London Clay at and below formation.

Using elastic and consolidation theories, both immediate and longer term heave movements have been calculated for the basement. These are calculated figures and apply to the centre of the basement. The figures will be significantly lower at the edges and lower still at the corners and estimates are provided. The figures presented represent estimates and are based on a number of assumptions.

Immediate upward (elastic) movements have been calculated at around 10mm. These will be completed upon completion of soil excavation usually within about 7 days.

Longer term soil swelling of the London Clay is also likely to occur. The rate of this longer term swelling will be determined largely by the availability of water and the low permeability of the London Clay. As a result this may take many years to reach full equilibrium. The basement slab will need to be sufficiently stiff or otherwise designed to enable it to accommodate the swelling displacements/pressures developed underneath it. The amount of long term swelling has been calculated to be of the order of 15mm for the centre of the excavation with the centre of basement edges and corners having calculated values of the order of 8mm and 4mm respectively.

9. Conclusions

The methodology and approach of CPG4 has been followed in developing this BIA with respect to Land stability. It is concluded that the construction of the new basement at 80 Greencroft Gardens should not have significant impacts on land stability provided that:

- Groundwater inflow, if encountered, is reduced to a minimum and properly designed, managed and controlled such that there is no significant wash out of fine material. Groundwater levels outside the excavation should be monitored before and during construction.
- Design of basement permanent and temporary works should be carried out by a competent and experienced Structural Engineer, who should assess and approve method statements as appropriate.
- The construction of the basement is carried out by competent and experienced contractors and precautions are taken to maintain the stability of the excavations. Anticipated conditions are such that the support of excavated ground will need to be carefully managed in order to provide adequate and good support to the ground to prevent excessive movements against the temporary and permanent support.
- The retaining wall should be appropriately designed.
- Propping of the wall both in the temporary and permanent cases is critical and stiff props should be utilised.
- Care should be taken to minimise the disturbance and damage to trees and their roots.
- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate pH and groundwater 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.

10. Summary

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 80 Greencroft Gardens 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. Pumping from a sump is likely to be the most effective way of dealing with groundwater inflow.
- 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. The adequacy of wall support in the temporary case should be strictly enforced as discussed in section 8.
- Care should be taken to minimise the disturbance and damage to trees and their roots.
- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate conditions measured and anticipated.
- Monitoring of the structures and groundwater is carried out before and during construction. The exact nature of the structural monitoring should be determined by the structural engineer.

11. References

1. BGS open source mapping: http://mapapps2.bgs.ac.uk/geoindex/home.html
2. Arup: Camden Geological, Hydrogeological and Hydrological Study
3. Archian: Design drawings available at the time of reporting.
4. Ground&Water Ground investigation report, 80 Greencroft Gardens.
5. Groundsure Enviroinsight report GS-2103155.
6. CIRIA Report C580: Embedded Retaining Walls, Guidance for Economic Design.