Hydrogeological, Geotechnical & Ground Movement Assessment

of proposed development at

4 The Hexagon
Fitzroy Park
Camden
London
N6 6HR

for

Ms Lorraine Ashbourne

LBH4391a Ver 1.1

June 2016

LBH WEMBLEY

Geotechnical & Environmental

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Foreword-Guidance Notes

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The observations and conclusions described in this report are based solely upon the agreed scope of work. LBH WEMBLEY Geotechnical & Environmental has not performed any observations, investigations, studies or testing not specifically set out in the agreed scope of work and cannot accept any liability for the existence of any condition, the discovery of which would require performance of services beyond the agreed scope of work.

CONTAMINATION

Unless detailed in the report, no contamination investigation has been undertaken and no consideration has been given to any special measures that may be necessary in connection with possible contamination. Unless specifically commented upon, no approach has been made to the Local Authority or Environment Agency in order to establish any further information or requirements that may affect this site. These further investigations must be made, for example, to establish whether there is a risk of gaseous or liquid migration towards or away from the site. LBH WEMBLEY Geotechnical & Environmental can accept no responsibility for any claims resulting from the presence of Asbestos, Japanese Knot-Weed, Radioactivity or Unexploded Ordinance at this site.

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THIRD PARTY INFORMATION

The report may present an opinion on the disposition, configuration and composition of soils, strata and any contamination within or near the site based upon information received from third parties. However, no liability can be accepted for any inaccuracies or omissions in that information.

DRAWINGS

Any plans or drawings provided in this report are not meant to be an accurate base plan, but are used to present the general relative locations of features on, and surrounding, the site.

1. Introduction

1.1 Background

Following demolition of the existing building which has a partial lower ground floor, it is proposed to redevelop the site by construction of a three storey dwelling on approximately the same footprint with a lower ground floor area that will extend into the hillside beneath the full footprint.

1.2 Brief

LBH WEMBLEY Geotechnical & Environmental have been appointed to undertake a Basement Impact Assessment (BIA) for submission to London Borough of Camden in order to support a planning application for the proposed development. This report sets out the geotechnical and hydrogeological information that has been collected to inform the assessment.

1.3 Report Structure

This report initially describes the findings of the desk study searches, including the topographical, geological and hydrological setting of the site. Hydrogeological and geotechnical assessments are then provided and, finally, the report concludes with a ground movement assessment.

2. The Site

2.1 Site Location

The site is situated on the southern side of The Hexagon in the London Borough of Camden. The site may be located approximately by postcode N6 6HR or by National Grid Reference 527930,187185.

2.2 Topographical Setting

The site is situated on the southwestern slopes of Highgate Hill, on the southeastern side of a small valley that trends in a south-westerly direction towards the Highgate Ponds.

Street level to the northeast of the dwelling lies at a level of approximately +95.5m OD, while the rear garden stands at approximately +92.5m OD at its southwestern end, so that there is a 3m drop in ground level across the property.

2.3 Site Description

The site is currently occupied by a three storey detached house that is stepped into the hillside, including a lower ground floor situated at the rear of the property and a front parking area. The dwelling is located in the northeastern area of the site, set around 10m back from The Hexagon, with a ground floor level of approximately +94.5m OD.

Owing to the relative drop in ground level between the front of the property and the rear, the lower ground floor opens out into the rear garden, which is present to the west and south of the dwelling and contains various mature trees. The lower ground floor is set at approximately +92.3m OD.

Rear view of property showing the lower ground floor at approximately garden level

Northern view of garden containing a fir tree

The site is bordered to the southeast by a brick wall, beyond which is the garden of No. 6 The Hexagon. A Victorian brick wall is also present along the southwestern boundary, beyond which is the garden of No. 10 Fitzroy Park, while closed board fencing borders the site to the northwest, beyond which is the garden of No. 3 The Hexagon.

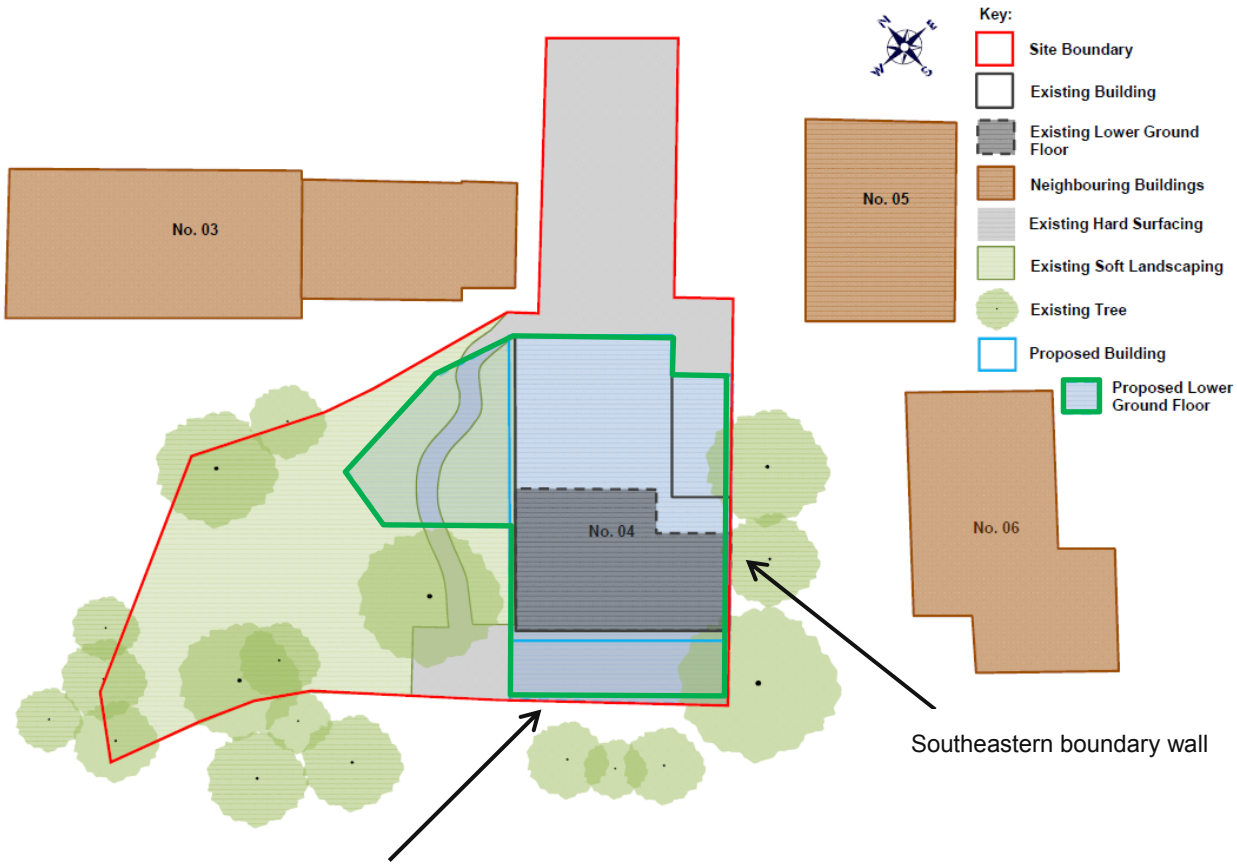
View of original Victorian brick garden wall running along the southern boundary of the site

View of eastern side of property

2.4 Proposed Development

The proposed development will include a three storey dwelling that will replace the existing house and will extend essentially over the same footprint.

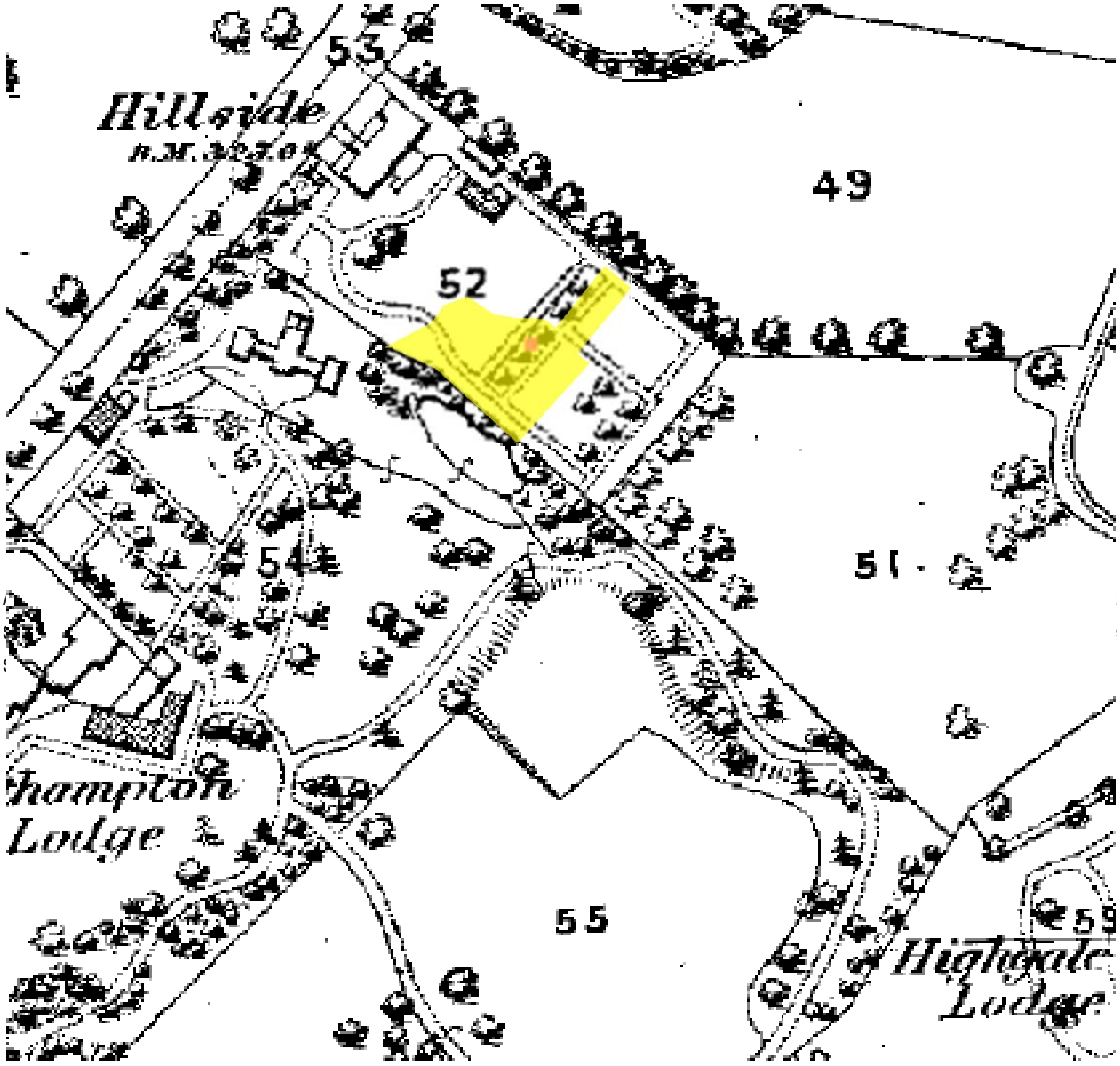
The development also includes a lower ground floor, which will be set around 0.5m below the existing lower ground floor and terrace in the south and will cut into the slope by up to some 2.5m depth on the northern side beside the car parking area.


Key:
Site Boundary
Existing Building
Existing Lower Ground Floor
Neighbouring Buildings
Existing Hard Surfacing
Existing Soft Landscaping
Existing Tree
Proposed Building
Proposed Lower Ground Floor
No. 03
No. 04
No. 05
No. 06
Southeastern boundary wall
Southwestern Victorian Wall

3. Desk Study

3.1 Site History

By the late 19th Century, the site appeared to have already been landscaped and planted with trees as part of the grounds to a large detached house called Hillside, which fronted onto the existing Fitzroy Park road. The existing garden wall that runs along the southern boundary of the site was also present by this time. Greenhouses and small outbuildings associated with Hillside were located some 20m to the southeast of the site.



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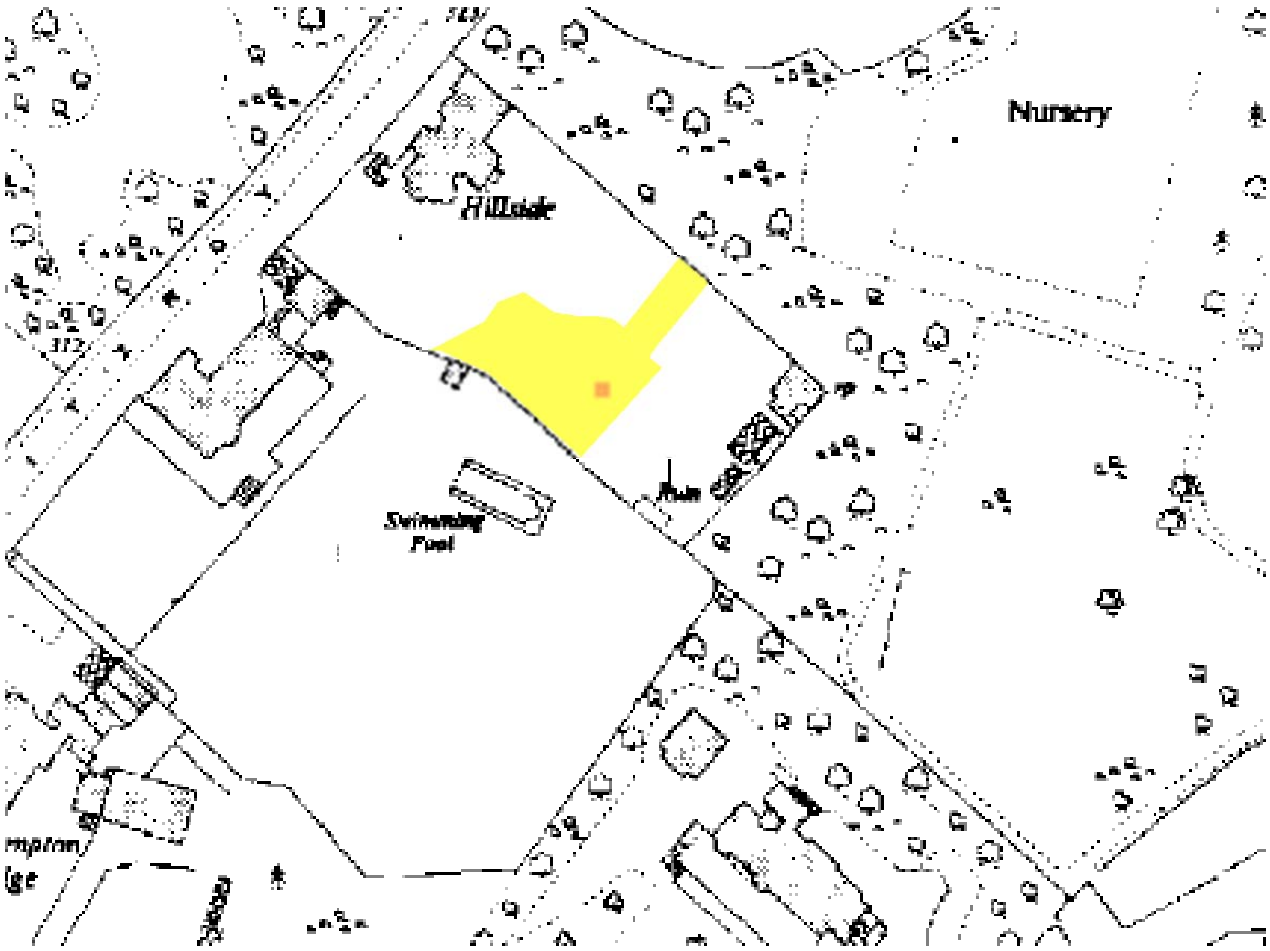
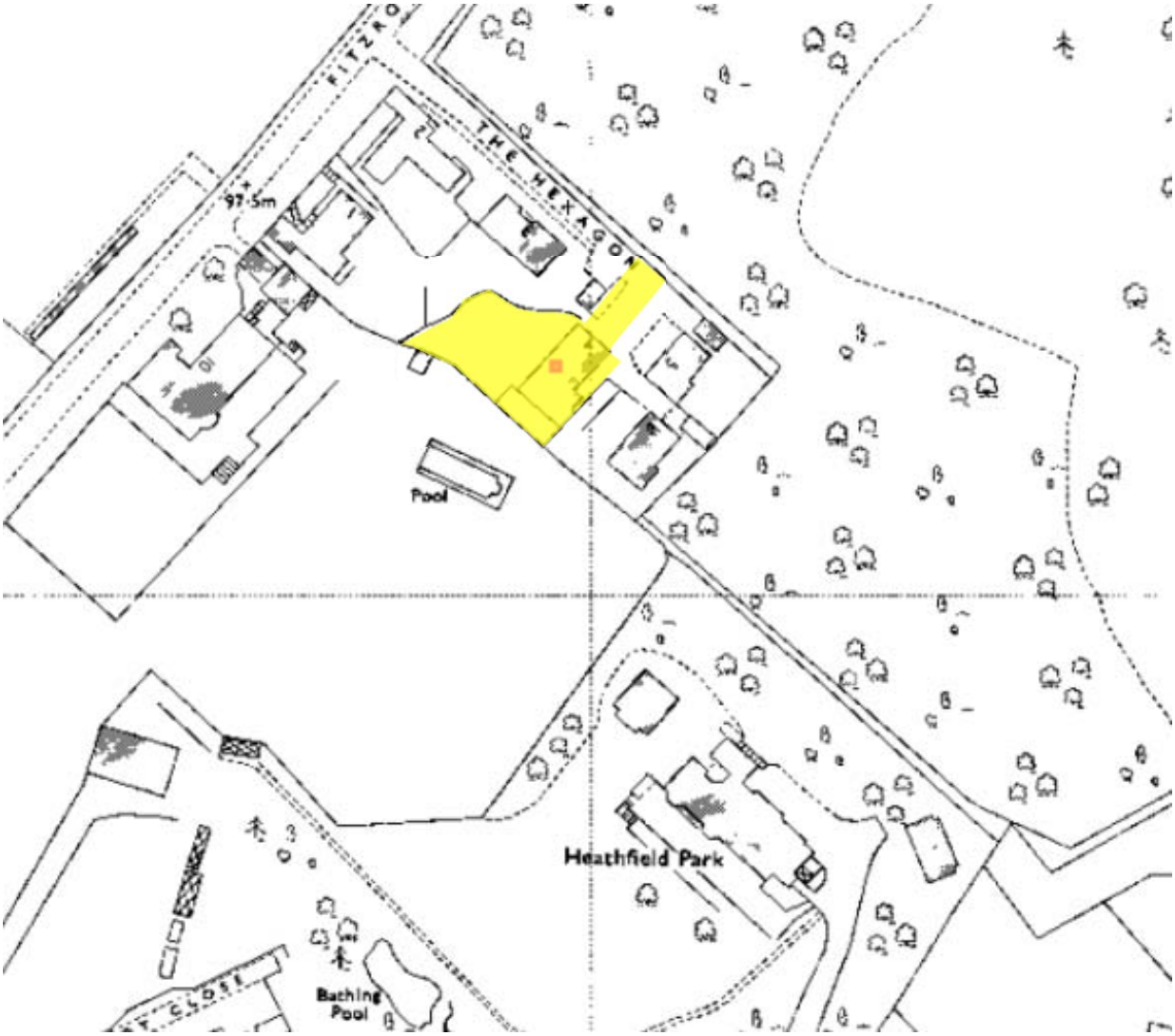


1952

During the 1960s, it appears that the site was developed with existing building and garden. During this time, the neighbouring dwellings that were also constructed along The Hexagon access road.



1970

3.2 Geological Information

The British Geological Survey (BGS) records of the area show the site to be underlain by soils of the Claygate Member, which is subsequently underlain by the London Clay Formation.

Stratigraphically younger soils of the Bagshot Sand Formation are indicated to be capping the very top of Highgate Hill, a relatively short distance to the northeast of the site.

The Claygate Member comprises a variable sequence of fine-grained sands, silts and firm to stiff clays, although the soils are generally expected to be sandier in the uppermost parts.

The Claygate Member is expected to rest upon the underlying London Clay Formation at around +85.00 m OD. The London Clay generally consists of very stiff fissured grey clay.

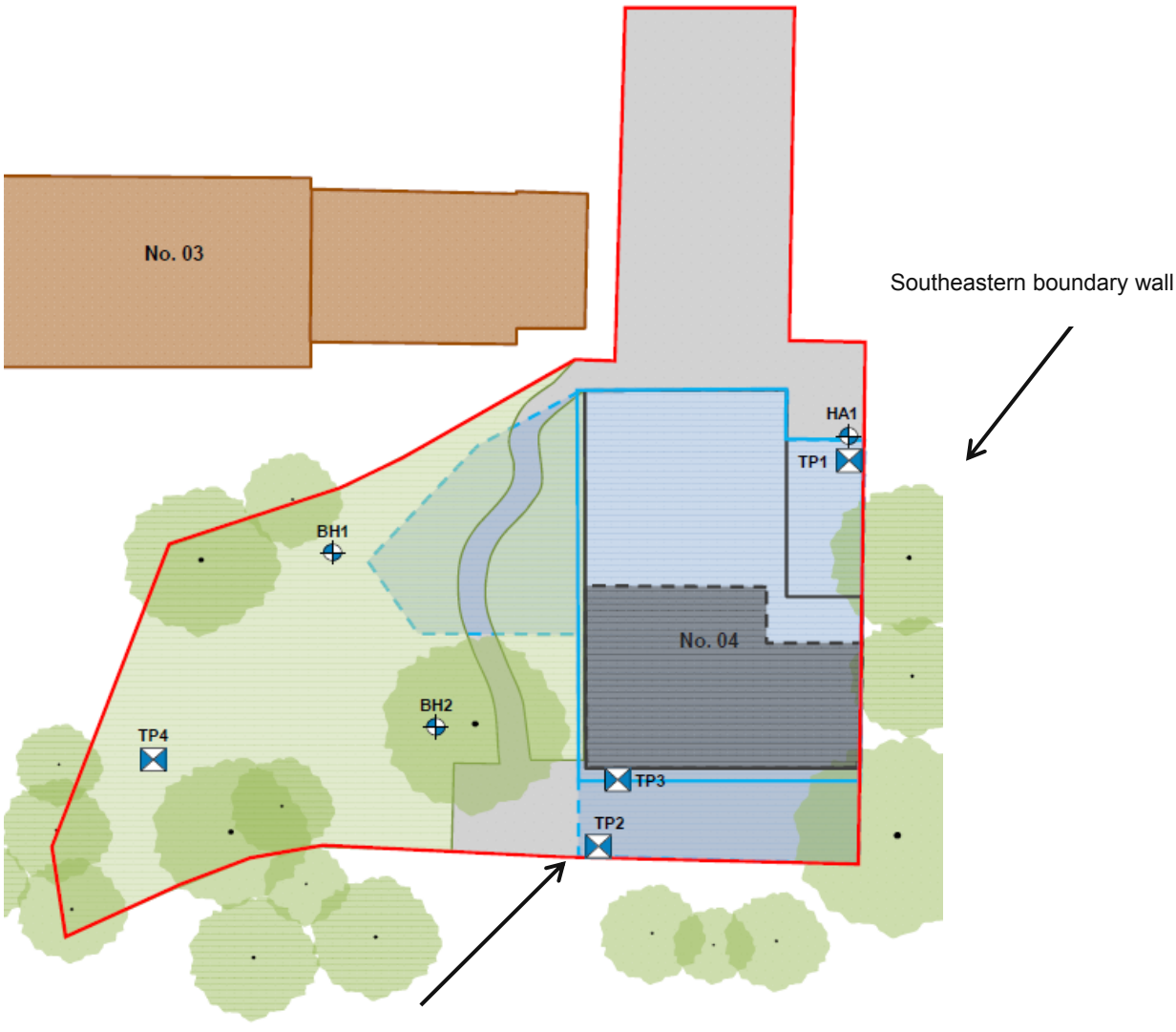
4. Ground Investigation

On 17th February 2016, two windowless sampler boreholes were constructed in the rear garden, supplemented by continuous dynamic probing in order to investigate the ground conditions and allow the recovery of disturbed samples for geotechnical testing. A standpipe was installed in one borehole to allow subsequent groundwater monitoring.

In addition, three hand-dug trial pits were excavated in order to expose foundations to the existing building as well as foundations to the boundary walls.

On 10th March 2016, a further borehole was constructed to the side of the property to confirm the ground conditions in the northeastern area of the site and to permit the installation of a second standpipe.

The exploratory borehole records and dynamic probe results, together with the results of geotechnical laboratory testing carried out on selected soil samples are appended. The Ordnance Datum (OD) levels shown on these records have been interpolated from a topographical survey provided.



4.1 Existing Foundations

The trial pit investigation indicates that the existing building appear to be supported by strip foundations at a depth of around 0.7m (approx. +91.4m OD), bearing upon soft to firm sandy clay with occasional gravel and rootlets.

In addition, the investigation also suggests that the southeastern boundary wall and old Victorian wall also appear to be supported by strip foundations at a depth of around 0.6 and 0.65m respectively, bearing upon similar soils beneath the existing building.

4.2 Ground Conditions

The ground investigations confirmed the expected general strata comprising a limited thickness of made ground directly overlying clay of the Claygate Member, which was subsequently found to be overlying the London Clay Formation.

4.3 Made Ground

Across the site there appears to be generally less than 1m of made ground present. Slightly deeper areas of made ground was recorded in the southwestern area of the garden.

The made ground generally comprised dirty brown sandy clayey fill with occasional rootlets and scattered brick, tile and ash. The slightly deeper of made ground included abundant brick.

4.4 Downwash and Claygate Member

Beneath the made ground, the Claygate Member comprised firm pale brown mottled light grey sandy clay, which was found to be locally very sandy. The presence of occasional flint gravel within the soft to firm upper levels of the stratum indicates that the upper 2 to 3m comprises material that has been subject to downhill creep or downwash.

Below this, undisturbed firm to stiff Claygate clay was found to extend to approximately +87.5m OD, (around 4.5m depth below the proposed basement), below which possible London Clay was encountered.

4.5 London Clay Formation

Stiff greyish brown, locally slightly sandy, clay was met at around 5m depth and was proved to approximately +84.2m OD. This material is interpreted as probable London Clay Formation.

4.6 Groundwater

During the investigation, no groundwater was encountered within the Claygate Member or underlying London Clay. However, it is apparent that there is some high level water seepage running through the more permeable zones of made ground over the top surface of the natural clay soils. Thus, an intermittent perched groundwater table may be assumed to be present at the base of the made ground.

5. Hydrological / Hydrogeological Assessment

5.1 Hydrological Conditions

The site is situated in a small valley, which does not contain any permanent water courses. However, the site may be liable to some intermittent flooding during storm events. Reference to the Environment Agency (EA) flood risk maps indicates that the western part of the site is at a low risk of flooding from surface waters.

The nearest surface water feature is a bathing pool and pond, situated some 100m down the valley to the south of the site, and Fitzroy Pond around 150m down the valley to the southwest of the site. The Highgate Ponds are situated approximately 350m to the southwest of the site, which eventually drain into the River Fleet to the south.

5.2 Hydrogeological Conditions

An intermittent perched groundwater table is present at the base of the made ground.

The permeability of the Claygate Member depends entirely upon the connectivity and continuity of any sandier seams and lens. At this site, it is evident that the Claygate lithology does not include significant seams or lenses of sand and hence that no significant groundwater is present at depth.

5.3 Potential Hydrogeological Impacts of the Proposed Development

5.3.1 Impact of Groundwater Flow

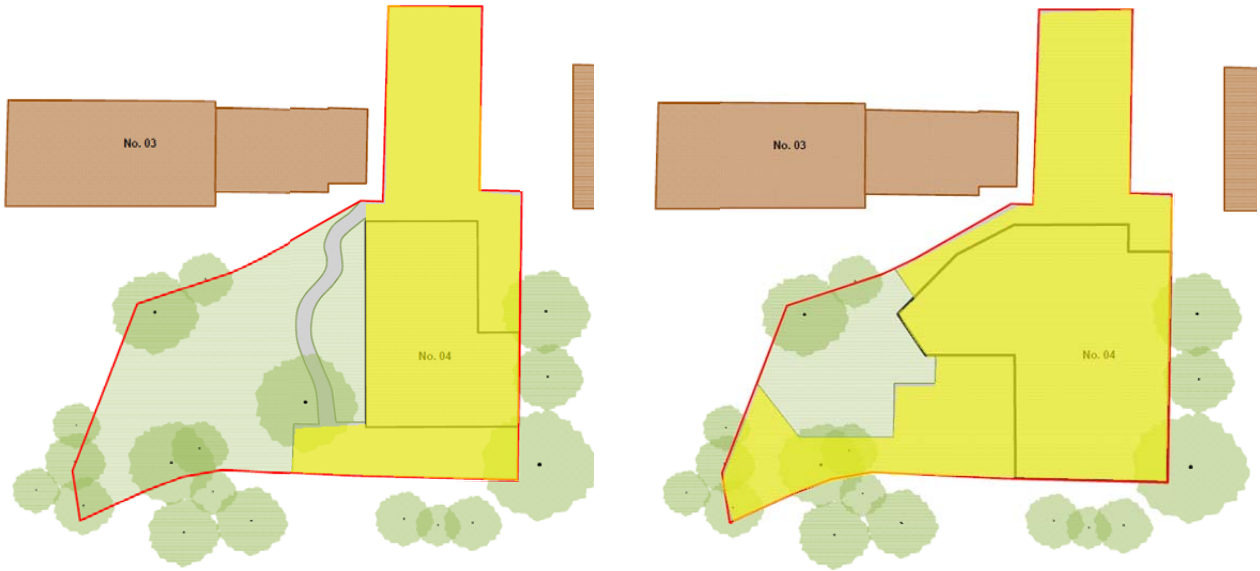
It is proposed to cut into the existing slope to construct the new dwelling. It is estimated that the lower ground floor of the house will generally lie at around +91.8m OD, correlating with approximate depths 0.5m and 2.5m below existing lower ground floor and the upslope car parking area to the northeast respectively.

Given the absence of groundwater at depth, the proposed development is not expected to have any impact upon groundwater flow.

There is some intermittent high level water seepage running through the more permeable zones of made ground over the top surface of the natural clay soils, and in order to ensure that development does not impact any near-surface ground water flow regime through the made ground a by-pass drainage system should be installed around the new structure. The installation of such a system early in the construction works will also serve to protect the basement excavation from any surface or high level water seepages.

5.3.2 Impact on Infiltration

Given the increase in the amount of hard surface or paved areas associated with the development there will be some increase in the amount of rainfall to be collected and discharged. However, given the importance of the neighbourhood as part of the catchment to the Hampstead Ponds it will important to maintain the existing amount of infiltration and to include SUDS infiltration measures rather than to increase the amount of discharge to the sewer.



Comparison of existing and new areas of hard surfacing

5.3.3 Impact on Surface Water Flooding and Surface Water Flow

On the assumption that any increase in the hard surfaced areas will be drained via SUDS infiltration rather than to the sewer, the new development is expected to have a negligible effect upon surface water flooding or surface water flow.

6. Geotechnical Assessment

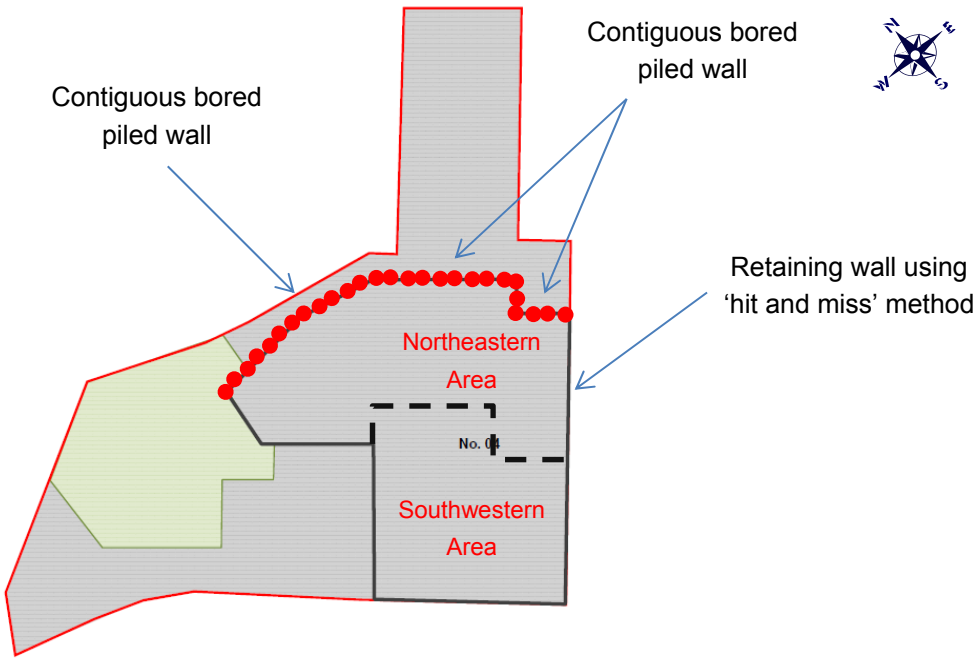
6.1 Discussion of Basement Construction Issues

Following demolition of the existing building, the new building will be constructed within an excavation that will include sections cut into the hillside to the northeast. The maximum depth of excavation will occur in the northeastern area and will extend to around 2.5m depth.

A retaining wall will be constructed in order to maintain support to the adjacent buildings at Nos. 3 and 5 the Hexagon (refer to Marked-up plan showing proposed foundations and load takedown. Drg No. S – 900). Although the theoretical 45^{o} zones of support to the foundations to both these properties lie outside the proposed excavation, given the presence of sloping ground it is recommended that full support be maintained at all times to the neighbouring properties by means of a contiguous bored pile retaining wall around the deeper sections of cut.

The new basement retaining wall on the southeastern side will be alternatively formed by means of the 'hit and miss' excavation methods that are normally adopted for underpinning.

The new building will extend right up to the southeastern boundary wall. In order to maximise space, it would be desirable to remove and reconstruct this if a piled retaining wall solution is adopted.



Plan showing suggested minimum extent bored pile retaining wall

6.2 Spread Foundations

The structural loads applied by the new building should be accommodated with a pad foundation solution.

Outside the zone of influence of trees, isolated spread foundations placed in suitably firm natural soils at a minimum depth of 1m below ground level may be designed to apply a net allowable bearing pressure of 120kN/m^2.

6.3 Effect of Trees

An arboricultural assessment will be required as the nearest tree to the proposed basement is approximately 3.5m away, which may either affect or be affected by the development proposal.

Laboratory index property determinations confirm that the clay soils are of high shrinkage potential.

Within the potential zone of influence of trees, it is recommended that the minimum founding depths and further precautions provided by the National House Building Council guidance are followed for the new building design.

6.4 Basement Waterproofing

Groundwater was not encountered within the envisaged depth of the basement excavation. Nevertheless, there is potential for water to collect around the basement structure in the long term unless perimeter and under floor drainage is assured. Hence, it is recommended that the basement should be fully waterproofed and designed to withstand hydrostatic pressures in accordance with the guidance provided in BS8102:2009, Code of Practice for the Protection of Below-Ground Structures against Water from the Ground. An assumed groundwater level at +94m OD would be prudent for the purposes of assessing hydrostatic pressures.

6.5 Retaining Walls

The retaining wall should be designed to minimise lateral movement by propping in the short term, whilst the basement is under construction, and also in the long term situation. In order to keep movements to a minimum it will be important to adopt a Ko approach rather than a conventional Ka approach. The following parameters may be considered in the design of the retaining walls:-

Stratum	Bulk Density	Effective Cohesion	Effective Friction Angle
	(kg/m^3)	(c' - kN/m^2)	(ϕ' - degrees)
Made Ground	1800	Zero	20
Claygate Beds	2000	Zero	23

6.6 Foundation Concrete

The results of chemical analyses carried out on selected samples of the soils encountered indicate soluble sulphate concentrations falling within Class DS-2 as defined by BRE Special Digest 1 (2005). The recommendations of that guidance for Class DS-2 sulphate conditions should therefore be followed, assuming an Aggressive Chemical Environment for Concrete (ACEC) site classification of AC-2 for mobile groundwater.

7. Ground Movement Assessment

A key factor in the design of the new basement construction will be the need to preserve the stability of the adjacent structures at all times, both during excavation and construction and in the permanent situation.

7.1 Neighbouring Structures

There are a number of structures surrounding the site, which have been assessed for the purpose of ground movement.

7.1.1 No. 3 The Hexagon

No. 3 The Hexagon is present roughly 2m to the north of the proposed basement, which is a 1960s two storey detached brick-built building.

7.1.2 No. 5 The Hexagon,

No. 3 The Hexagon is present some 5.5m to the northeast of the proposed basement and is a similar 1960s two storey detached brick-built building.

7.1.3 Other Structures

No. 6 The Hexagon has not been assessed for the purpose of ground movement as it is located approximately 8.5m away from the proposed basement excavation and is not upslope of the property.

There is a low boundary wall running along the southeastern side of the development that will be affected, but it is recommended that this should if possible be removed and re-constructed following the development.

To the southwest, the new development will abut the old Victorian garden wall. However, it would appear that this is founded at a level below that of the intended excavation.

7.2 Ground Model

Excavation of the basement will result in partial unloading of the ground leading to theoretical heave movement of the underlying soil in both the short and long term, depending upon any reapplication of loading. An analysis has been carried out for a modelled situation, based on the following soil model. The soil layers of this model are detailed in the table below:

Analysis Layer:	Upper Boundary (m OD)	Thickness (m)	Average C_u (kN/m^2)	Soil Stiffness (kN/m^2)	
				E_u	E'
Claygate Member (cohesive)	+92.0	1	50	22500	12500
Claygate Member (cohesive)	+91.0	1.5	55	24750	13750
Claygate Member (cohesive)	+89.5	2	70	31500	17500
London Clay Formation (cohesive)	+87.5	3	75	33750	18750
London Clay Formation (cohesive)	+84.5	3	110	49500	27500
London Clay Formation (cohesive)	+81.5	3	130	58500	32500
London Clay Formation (cohesive)	+78.5	3	145	65250	36250
London Clay Formation (cohesive)	+75.5	3.5	160	72000	40000
Assumed Rigid	+72.0				

The Undrained Modulus of Elasticity (Eu) for the clay has been based upon an empirical relationship of Eu = 450 x Cu, and the Drained Modulus of Elasticity (E') has been based upon an empirical relationship of 250 x Cu.

Poisson's Ratios of 0.5 and 0.2 have been used for short term (undrained) and long term (drained) conditions respectively.

7.3 Method of Analysis

The analysis, undertaken using the SAPPER programme, uses classic modified Boussinesq elasticity theory, assuming uniform (fully flexible) loading/unloading of rectangular arears applied to a semi-infinite elastic half-space, using the above parameters for stratified homogeneity and with the introduction of an assumed rigid boundary at 20m depth (+72.0m OD).

The analysis calculates the theoretical Boussinesq elastic stress decrease due to the applied net unloading beneath the given unloaded areas at the mid-level of each of the 8 No. soil layers defined above.

The unfactored dead and live loading information was provided by the structural engineers for the existing strip foundations (refer to plan showing loading arrangement for existing foundations. Drg No. SK – L – 0900 Rev. 01)).

Similarly, loading information was provided for the proposed foundations on the basis of the loading being accommodated via pad foundations (refer to plan showing proposed foundations and load takedown. Drg No. S – 900)). By convention, when considering the actual average loading condition, the figures have been reduced to be 100% dead load plus 25% live load.

Short-term and long-term movements are then calculated at each calculation point for each stratum, using the given values of Stiffness Moduli and Poisson's Ratio over the whole area of the site on a 0.5m by 0.5m grid.

7.3.1 Short Term Movements

There are three theoretical components of short term movement that will interact to potentially affect the neighbouring structures. These are settlements and horizontal movements associated with the pile installation, settlements and horizontal movements behind the wall due to yielding of the completed wall as excavation in front of the wall proceeds and lastly vertical heave movements due to demolition and soil unloading as the excavation proceeds.

The ground surface movements arising from the proposed installation of the retaining wall and from consequent yielding of the wall due to excavation may be estimated using the principles outlined with CIRIA report C580.

7.3.2 Settlement & horizontal movement due to pile installation

The ground surface movements arising from the installation of the bored pile retaining wall may be estimated using default values contained within CIRIA report C580. The curves presented in Figure 2.8a and 2.8b of the same guidance allow the profile of ground movements behind the wall to be estimated.

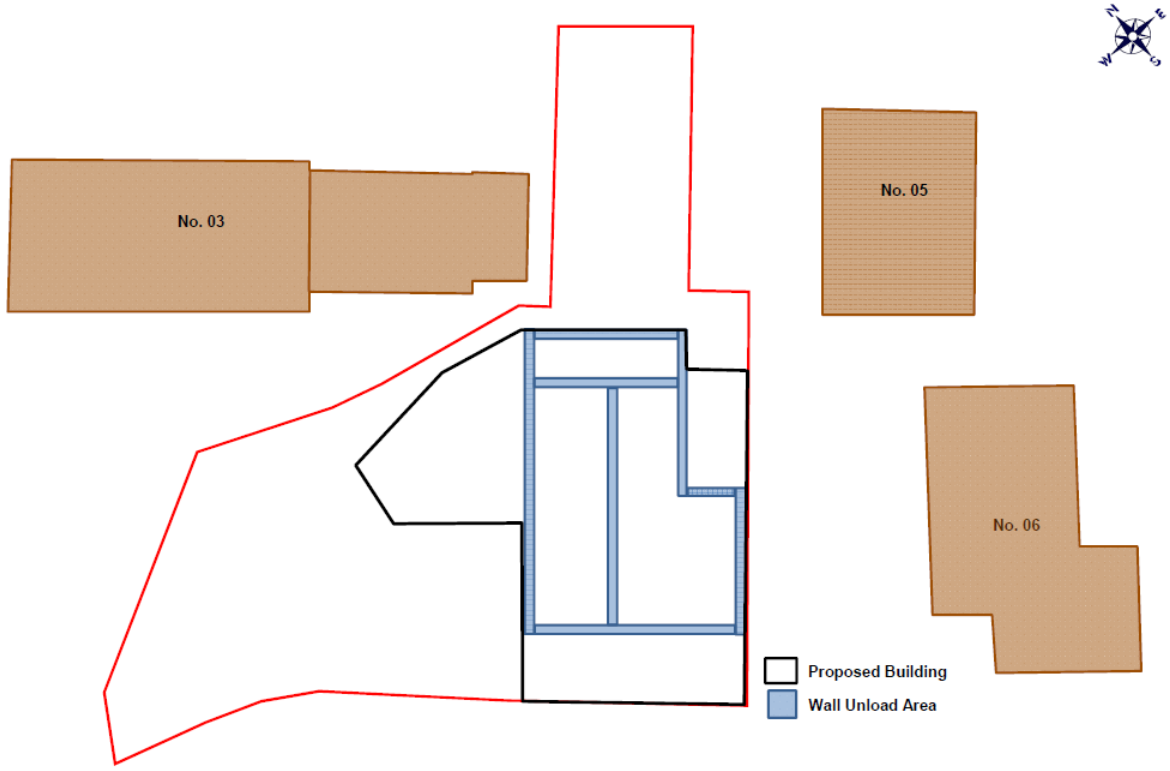
It should be noted that the amount of predicted movement is related to the wall depth and that for the purposes of this assessment the predictions can be made on the basis of a pile depth equivalent to 1.5 times the maximum retained height.

The analysis suggests that as a result of the piling operating during pile installation, No. 3 The Hexagon could experience a maximum of 2mm settlement.

The horizontal movements arising from pile installation may also be estimated. The analysis suggests that that No. 3 The Hexagon may also experience up to 2mm horizontal movement.

7.3.3 Short term heave movements due to demolition and excavation

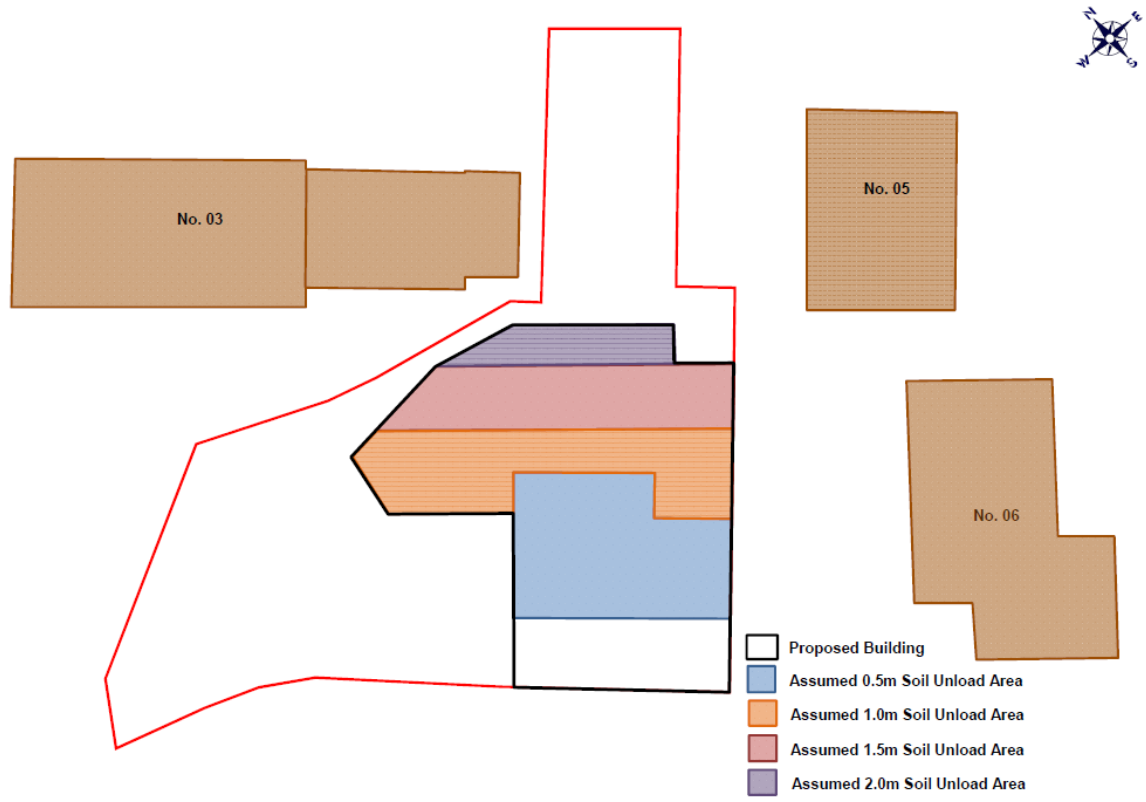
Existing loading information has been provided, whereby the loading is bearing upon strip foundations, which are assumed to be 0.55m wide.



Plan showing modelled unload areas due to demolition based on plan showing loading arrangement for existing foundations. Drg No. SK – L – 0900 Rev. 01.

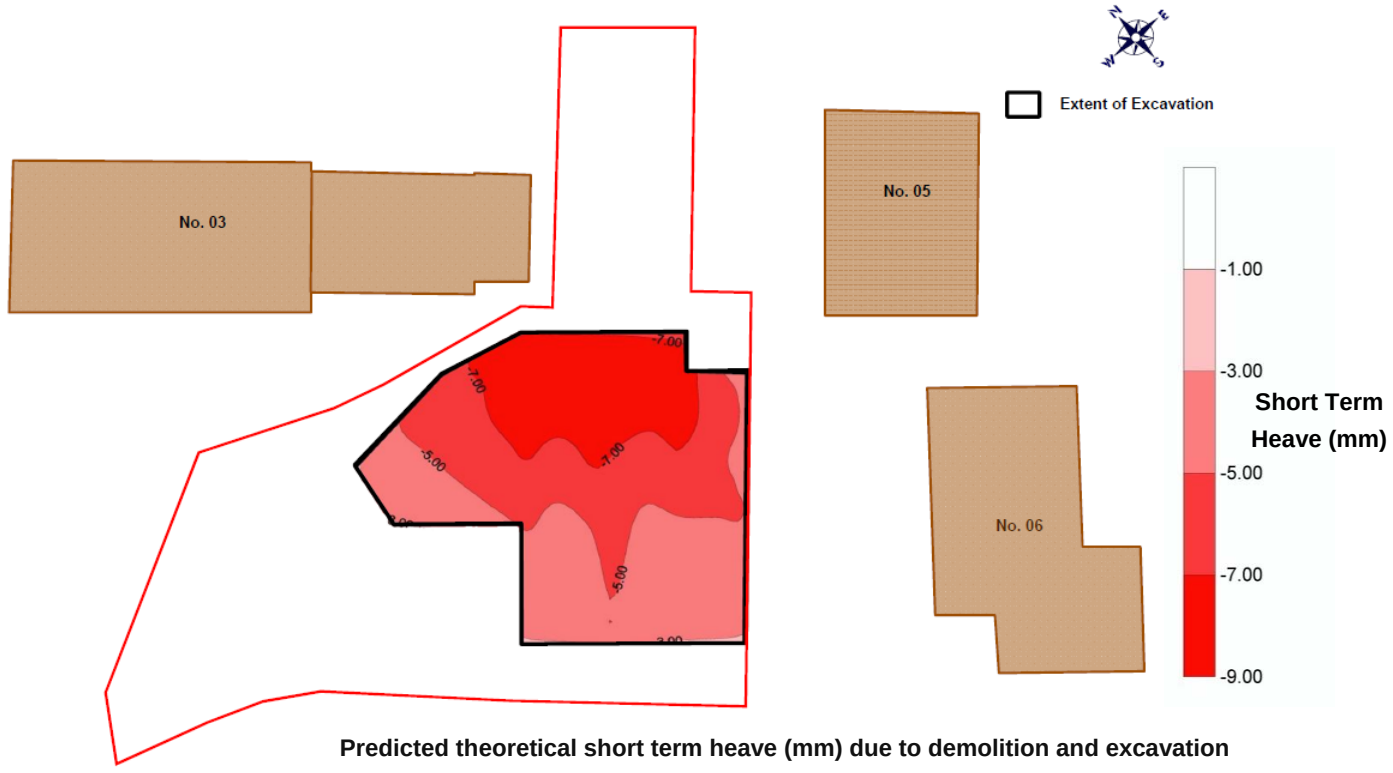
The potential effect of the demolition of the existing buildings has been considered by applying a net unloading on the strip foundations of up to around -50kn/m^2.

As the ground is sloping to the south, the excavation depth will vary. It is envisaged that the maximum excavation depth will be around 2.5m in the northern area, hence a maximum net soil unloading due to excavation of -50kN/m^2 is predicted. The excavation will decrease to around 0.5m in the southern area, reducing the net soil unloading to -10kN/m^2.



Plan showing modelled unload areas due to soil excavation

The analysis suggests that by the time demolition and basement excavation is complete, a maximum of 9mm of heave may have taken place in the northeastern area of the basement excavation.



Predicted theoretical short term heave (mm) due to demolition and excavation

7.3.4 Settlements & horizontal movements due to pile wall yielding

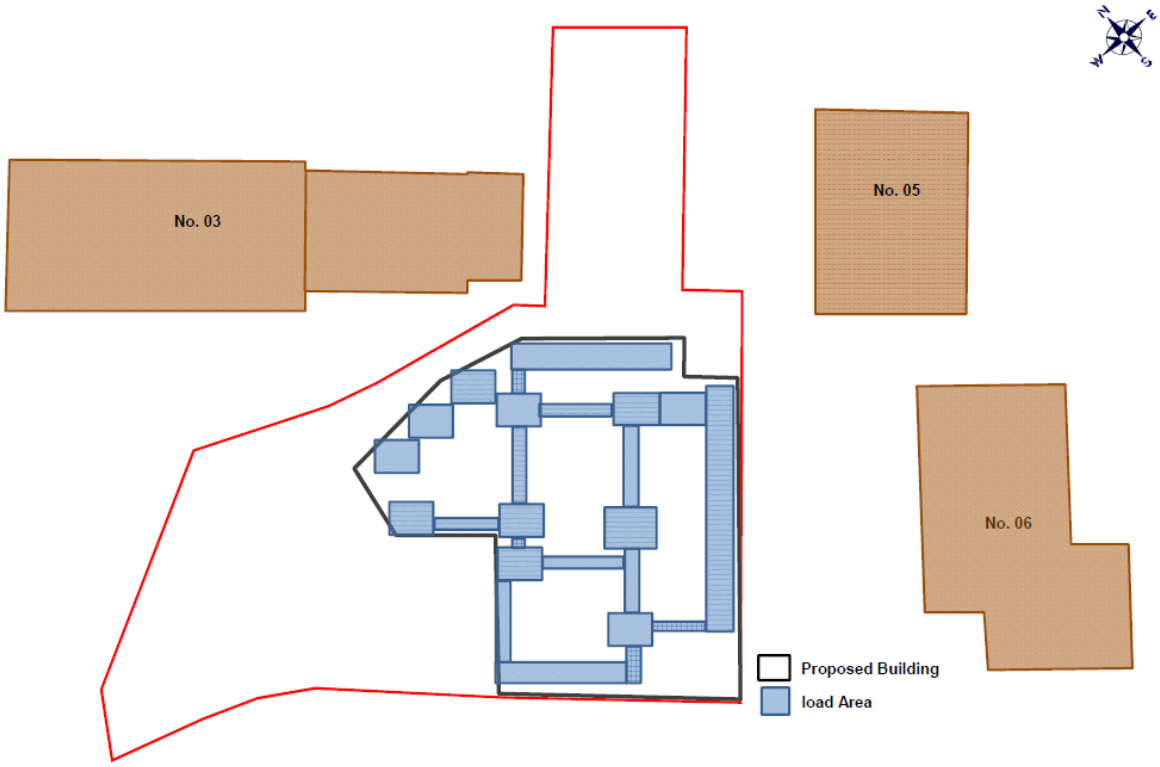
The ground surface movements arising from excavation in front of the bored pile retaining wall and consequent yielding of the piled wall may be estimated using Figures 2.11a and 2.11b of CIRIA report C580.

The analysis suggests that, on the basis of a high stiffness wall, No. 3 The Hexagon could experience a maximum of 3mm settlement in conjunction with up to 5mm horizontal movement.

7.3.5 Long Term Movements

Following excavation of the new basement, loading will be reapplied to the soil as a result of the weight of the new structure. Loading information has been provided, which indicate that the new structural loading will be applied to the Claygate Member largely by means of pad foundations and trench fill foundations. The maximum load condition on the pad foundations is around 100kN/m^2, while the maximum load condition on the trench fill foundations is around 85 kN/m^2.

Due to the irregular area of the site, a number of rectangular loaded areas have been modelled.

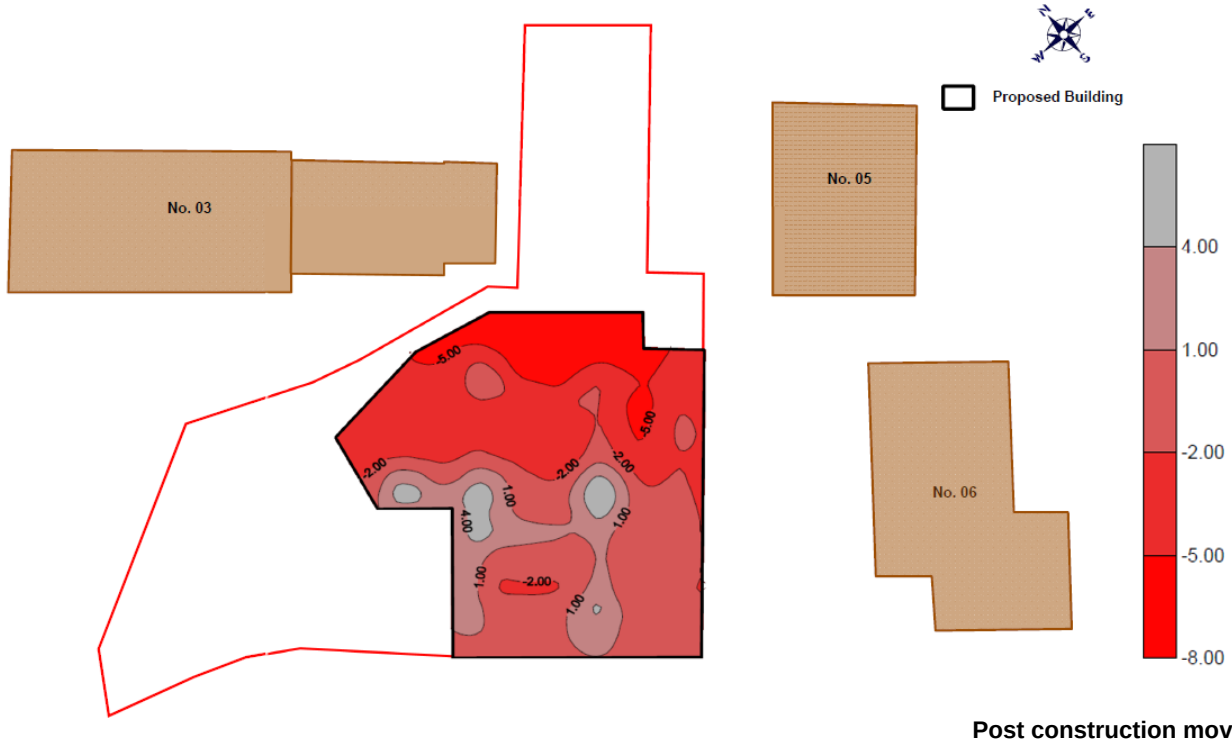


Plan showing modelled load areas due to construction based on plan showing proposed foundations and load takedown. Drg No. S – 900

In the northeastern area where the excavation depth is at its maximum, there will be a mismatch between the weight of the soil and building that is to be removed and the weight of the new structure that is to replace this. In this situation there will potentially be a component of long term heave that could proceed after completion of the new development. The analysis suggests that long term heave of up to approximately 8mm could be experienced as a result of this mismatch.

However, in the southwestern area, where the excavation depth is at its minimum, there will potentially be a component of long term settlement that could proceed after completion of the new development. The analysis suggests that long term settlement of up to approximately 4mm could be experienced as a result of this mismatch.

The worst case long term differential movements appear to be less than 3mm beneath adjacent pad foundations.



Predicted theoretical post – construction movements (mm)

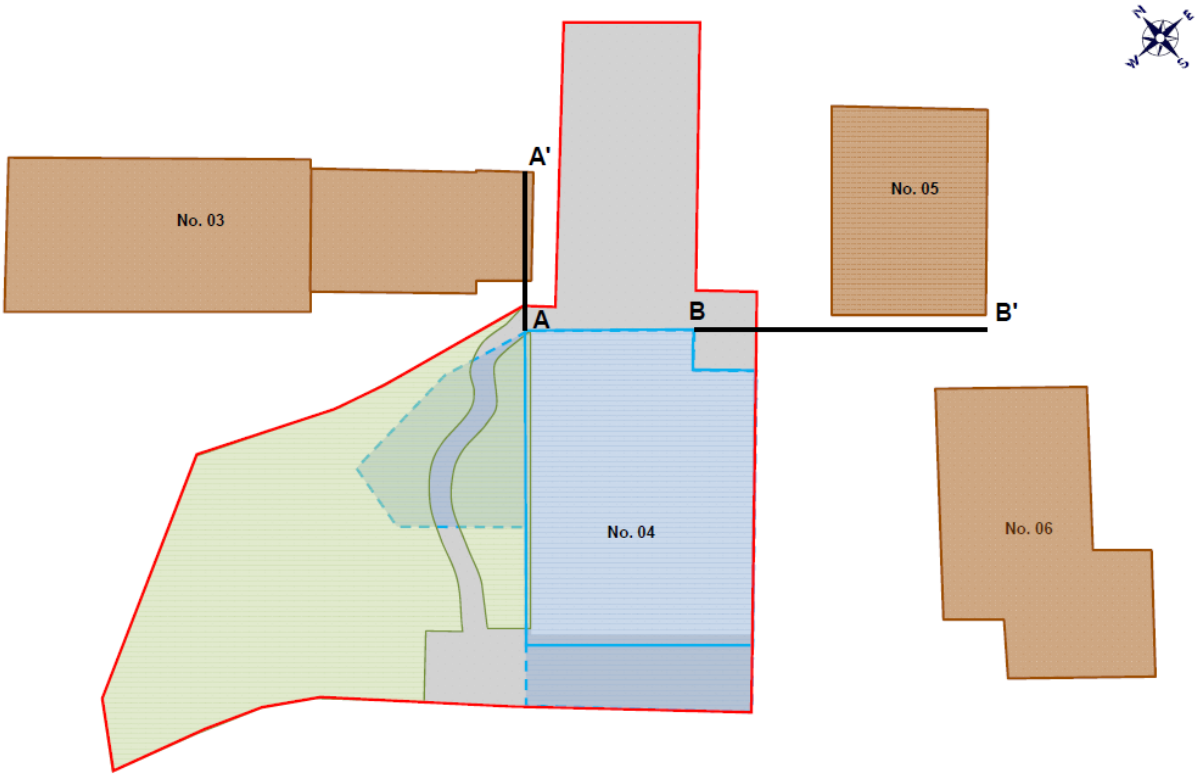
8. Damage Assessments

The ground movements discussed above have been used to determine a damage category for the properties at Nos. 3 and 5 The Hexagon, using the methodology proposed by Burland as described in CIRIA C580.

The deflection ratio (Δ / L) has been calculated from the predicted net movements at either end of the section under assessment.

The length (L) of No. 3 The Hexagon has been assumed to be 6m with an approximate wall height (H) of 6.5m. Similarly, L and H for No. 5 Hexagon have been assumed to be 7m and 6m respectively.

The strain has been assessed over the full length of each property.



Plan showing line of sections for damage assessment

Although No. 5 The Hexagon does not lie at a distance perpendicular to the proposed basement, in order to determine a damage category, it was assumed that No. 5 The Hexagon lies on Section B-B'.

8.1 No. 3 The Hexagon (A-A')

The maximum horizontal strain, ε_h (δ_h / L) = 0.065%, and the maximum deflection ratio Δ / L = -0.0017 have been calculated over the full length of the property.

Based upon Figure 2.18b for L / H = 0.9, the limiting strain to No. 3 The Hexagon is assessed as 0.062%, less than the upper bound of 'very slight' (Burland Category 1).

8.2 No. 5 The Hexagon (B-B')

The maximum horizontal strain, ε_h (δh / L) = 0.044%, and the maximum deflection ratio Δ / L = -0.00143 have been calculated over the full length of the property.

Based upon Figure 2.18b for L / H = 1.2, the limiting strain to No. 3 The Hexagon is assessed as 0.045%, less than the upper bound of 'negligible' (Burland Category 0).

9. Mitigation of Movements

CPG4[1] states that mitigation measures are expected where any risk of damage is identified of Burland Category 1 'very slight' or higher.

9.1 Construction

The analysis suggests that, given the construction of a high stiffness basement retaining wall, the potential for damage is limited to Burland Category 1 'very slight'.

The piled basement retaining wall should be designed and maintained in as rigid state as is possible, through the installation of appropriate propping prior to any excavation and the installation of additional propping as necessary as the excavation proceeds, with the intention of allowing negligible deflection and yielding at any level.

The selection of larger diameter piles would allow increased reinforcement to be included and similarly increased rigidity to be achieved.

9.2 Monitoring

Monitoring of the neighbouring properties will be an essential tool in the prevention of unacceptable movements. The monitoring plan must include a clear set of achievable contingency actions to be completed as an immediate response to any movement that exceed agreed trigger levels.

[1] Camden Planning Guidance 4 (2015) Basement and Lightwells – London Borough of Camden

APPENDIX

BOREHOLE LOGS

DYNAMIC PROBE RESULTS

GEOTECHNICAL TEST RESULTS

BURLAND DAMAGE CATEGORY ASSESSMENTS

ENVIROCHECK REPORT (SEPARATE FILE)

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**BOREHOLE BH1**
CLIENT:	Ms. Lorraine Asbourne		

BORING METHOD:	Premier 100 Modular Window Sampler Rig	Date: 17/02/16
GROUND WATER:	Seepage encountered at 0.5m during drilling Groundwater monitored at 0.5m depth on 01/03/16	
REMARKS:	Inspection pit hand-dug to 1.2m 19mm diameter standpipe installed to 5m, with a response zone between 0.5m and 5m	

G.L. approx. +92.7m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					0.50	MADE GROUND (topsoil over dirty brown sandy clayey fill with rootlets, stones, occasional brick and ash)
1	D	1.00				Firm pale brown mottled light grey sandy CLAY, locally very sandy with occasional rootlets, small claystone nodules and occasional scattered gravel (DOWNWASH)
2	D	2.00			2.00	*approx.*
3	D	3.00				Firm to stiff pale brown mottled light grey sandy CLAY (CLAYGATE)
4	D	4.00				
5	D	5.00			5.00	

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**BOREHOLE**
CLIENT:	Ms. Lorraine Asbourne		**BH1**

BORING METHOD:	Premier 100 Modular Window Sampler Rig	Date: 17/02/16
GROUND WATER:	Seepage encountered at 0.5m during drilling Groundwater monitored at 0.5m depth on 01/03/16	
REMARKS:	Inspection pit hand-dug to 1.2m 19mm diameter standpipe installed to 5m, with a response zone between 0.5m and 5m	

G.L. approx. +92.7m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					5.00	Stiff greyish brown CLAY locally slight sandy (LONDON CLAY)
6	D	6.00				
7	D	8.00				
					8.20	

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

Sheet No: 2 of 2

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**BOREHOLE BH2**
CLIENT:	Ms. Lorraine Asbourne		

BORING METHOD:	Premier 100 Modular Window Sampler Rig	Date: 17/02/16
GROUND WATER:	Not encountered	
REMARKS:	Inspection pit hand-dug to 1.2m	

G.L. approx. +92.4m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					1.10	MADE GROUND (topsoil over dirty brown sandy clayey fill with rootlets, bricks, stones, and occasional ash)
1	D	1.50				Firm pale brown mottled light grey sandy CLAY, locally very sandy with occasional rootlets, small claystone nodules and occasional scattered gravel (DOWNWASH)
2	D	2.50			2.50	…small claystone at 2.3m *approx.*
3	D	3.50			4.00	Firm to stiff pale brown mottled light grey sandy CLAY (CLAYGATE)
					5.00	Firm to stiff pale brown mottled light grey slightly sandy clay with scattered selenite crystals (CLAYGATE)

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**BOREHOLE BH2**
CLIENT:	Ms. Lorraine Asbourne		

BORING METHOD:	Premier 100 Modular Window Sampler Rig	Date: 17/02/16
GROUND WATER:	Not encountered	
REMARKS:	Inspection pit hand-dug to 1.2m	

G.L. approx. +92.4m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					5.00	Stiff greyish brown CLAY locally slight sandy (LONDON CLAY)
					8.20	

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

Sheet No: 2 of 2

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**BOREHOLE HA1**
CLIENT:	Ms. Lorraine Asbourne		

BORING METHOD:	Hand Auger	Date: 10/03/16
GROUND WATER:	Not encountered	
REMARKS:	Inspection pit hand-dug to 0.8m 19mm diameter standpipe installed to 4m, with a response zone between 3.5m and 4m	

G.L. approx. +94.3m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					0.60	MADE GROUND (topsoil over dirty brown sandy clayey fill with rootlets, bricks and stones)
					3.00	Soft, becoming firm pale brown mottled light grey sandy CLAY, locally very sandy with occasional scattered gravel (DOWNWASH) *approx.*
					4.00	Firm to stiff pale brown mottled light grey sandy CLAY (CLAYGATE)

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

Sheet No: 1 of 1

PROJECT: No. 4 The Hexagon, Camden, London

CLIENT: Ms. Lorraine Asbourne

LBH4391

TRIAL PIT No 1

Pit inspected 18.02.16
Pit dimensions 400 x 300
All dimensions in millimetres
Do not scale
No ground water encountered

PROJECT: No. 4 The Hexagon, Camden, London	LBH4391	**TRIAL PIT No 2**
CLIENT: Ms. Lorraine Asbourne		

Pit inspected 18.02.16
Pit dimensions 550 x 500
All dimensions in millimetres
Do not scale
No ground water encountered

PROJECT: No. 4 The Hexagon, Camden, London

CLIENT: Ms. Lorraine Asbourne

LBH4391

TRIAL PIT No 3

Pit inspected 18.02.16
Pit dimensions 550 x 500
All dimensions in millimetres
Do not scale
No ground water encountered

PROJECT:	No. 4 The Hexagon, Camden, London	LBH4391	**TRIAL PIT No. 4**
CLIENT:	Ms. Lorraine Asbourne		
METHOD:	Hand-Dug		Date: 18/02/16
GROUND WATER:	Not Encountered		

REMARKS:

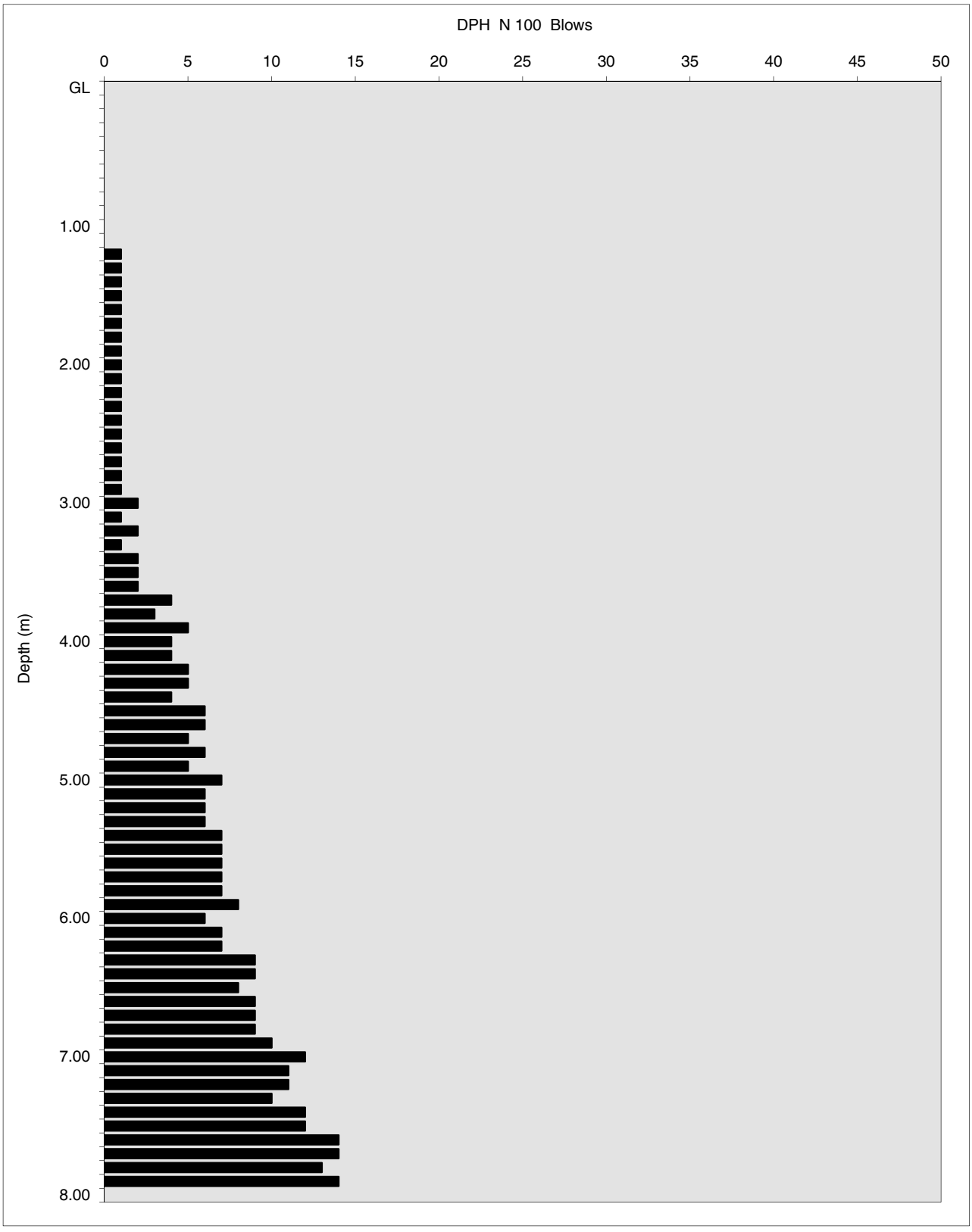
G.L. approx. +92.4m OD

Samples No	Type	Depth m	Tests	Legend	Depth m	Description
					0.40	MADE GROUND (topsoil over dirty brown sandy clayey fill with rootlets, stones, bricks and occasional tile fragments)
					0.45	MADE GROUND (pale brown gravelly sand)
					1.10	MADE GROUND (pale brown mottled light grey sandy clayey fill with stones, brick and ash, occasional tile fragments and rootlets)
					1.20	POSSIBLE DOWNWASH (soft to firm grey sandy clay with abundant rootlets and occasional gravel)

U=Undisturbed
B= Bulk
D=Disturbed
W=Water

PROJECT:	No. 4 The Hexagon, Camden, London	**DYNAMIC PROBE RESULTS**
CLIENT:	Ms. Lorraine Asbourne	

Probe No: BH1 Date: 17/02/2016



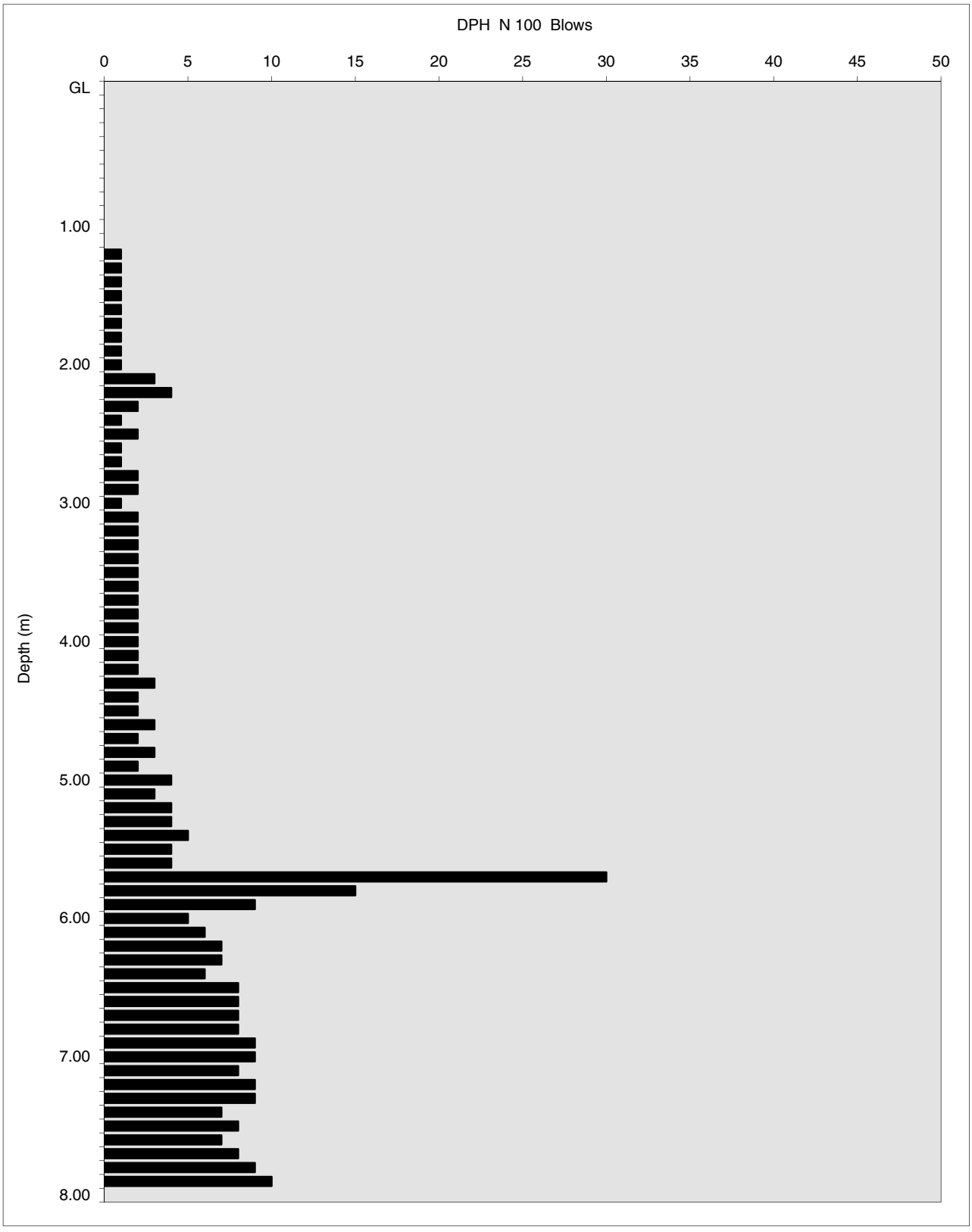
Remarks : Apparatus BS1377:Part 9:1990 - DPH.

Project No	**LBH WEMBLEY Geotechnical & Environmental**
LBH4391	

PROJECT:	No. 4 The Hexagon, Camden, London	**DYNAMIC PROBE RESULTS**
CLIENT:	Ms. Lorraine Asbourne	

Probe No: BH2

Date: 17/02/2016



Remarks : Apparatus BS1377:Part 9:1990 - DPH.

Summary of Natural Moisture Content, Liquid Limit and Plastic Limit Results

Job No.	Project Name	Programme	
20522	No. 4 The Hexagon	Samples received	03/03/2016
		Schedule received	07/03/2016
Project No.	Client	Project started	08/03/2016
LBH4391	LBH Wembley	Testing Started	17/03/2016

Hole No.	Sample				Soil Description	NMC	Passing 425µm	LL	PL	PI	Remarks
	Ref	Top	Base	Type		%	%	%	%	%	
BH1		3.00		D	Brown CLAY with blue grey veins	33	100	73	28	45	
BH2		1.50		D	Brown CLAY with blue grey veins and orange brown sandy patches	28	100	60	23	37	

Test Methods: BS1377: Part 2: 1990:
Natural Moisture Content : clause 3.2
Atterberg Limits: clause 4.3 and 5.0

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU

Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials **J.P**

Date: 18/03/2016

Sulphate Content (Gravimetric Method) for 2:1 Soil: Water Extract and pH Value - Summary of Results

Tested in accordance with BS1377 : Part 3 : 1990, clause 5.3 and clause 9

Job No.	Project Name	Programme	
20522	No. 4 The Hexagon	Samples received	03/03/2016
		Schedule received	07/03/2016
Project No.	Client	Project started	08/03/2016
LBH4391	LBH Wembley	Testing Started	11/03/2016

Hole No.	Sample				Soil description	Dry Mass passing 2mm	SO3 Content	SO4 Content	pH	Remarks
	Ref	Top	Base	Type		%	g/l	g/l		
BH1		3.00		D	Brown CLAY with blue grey veins	100	0.06	0.07	7.79	
BH2		1.50		D	Brown CLAY with blue grey veins and orange brown sandy patches	100	0.05	0.06	7.70	

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU
Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials J.P

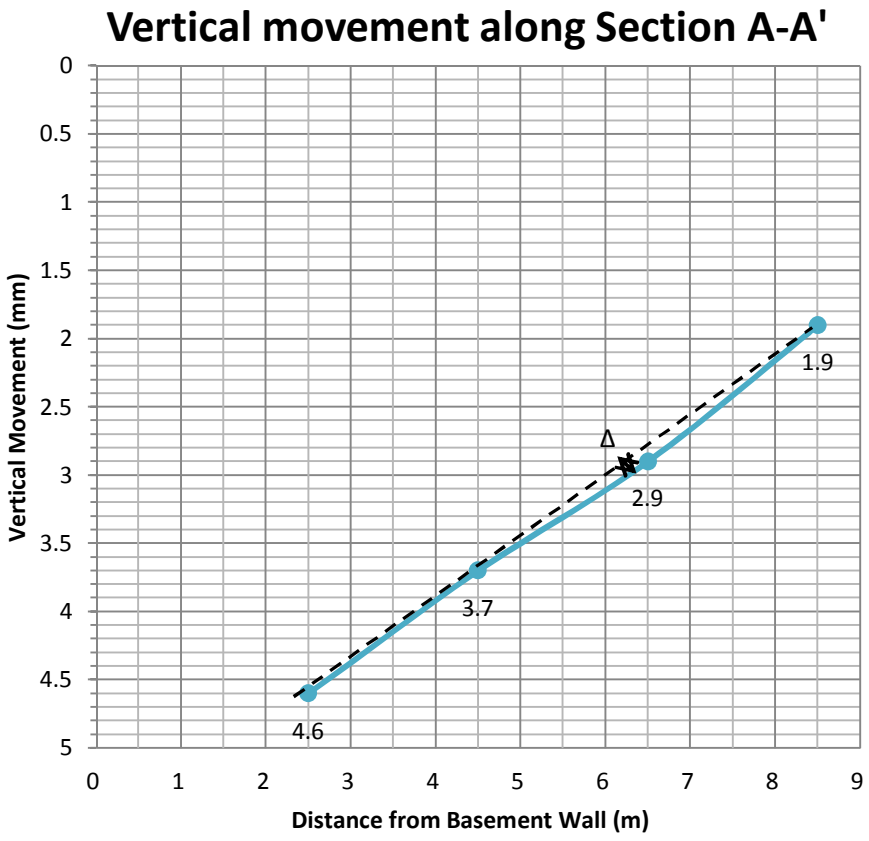
Date: 18/03/2016

Reference: **LBH4391**
Site: **No. 4 The Hexagon**
Section: **No. 3 The Hexagon**
Date of analysis: **9th June 2016**
Project Engineer: **RL**

The damage category can be assessed from the calculated horizontal strain and deflection ratio of a "beam" under hogging or sagging.

Length of wall	**L =**	**6**	**m**
Height of wall	**H =**	**6.5**	**m**
Horiz. deflection	**Δ_{horiz} =**	**3.6**	**mm**
Vert. deflection	**Δ =**	**0.1**	**mm**

x	y	distance from wall	Vert. mov'nt	Horiz. mov'nt
m	m	m	mm	mm
29	28.5	2.5	4.6	6
29	30.5	4.5	3.7	4.6
29	32.5	6.5	2.9	3.5
29	34.5	8.5	1.9	2.4



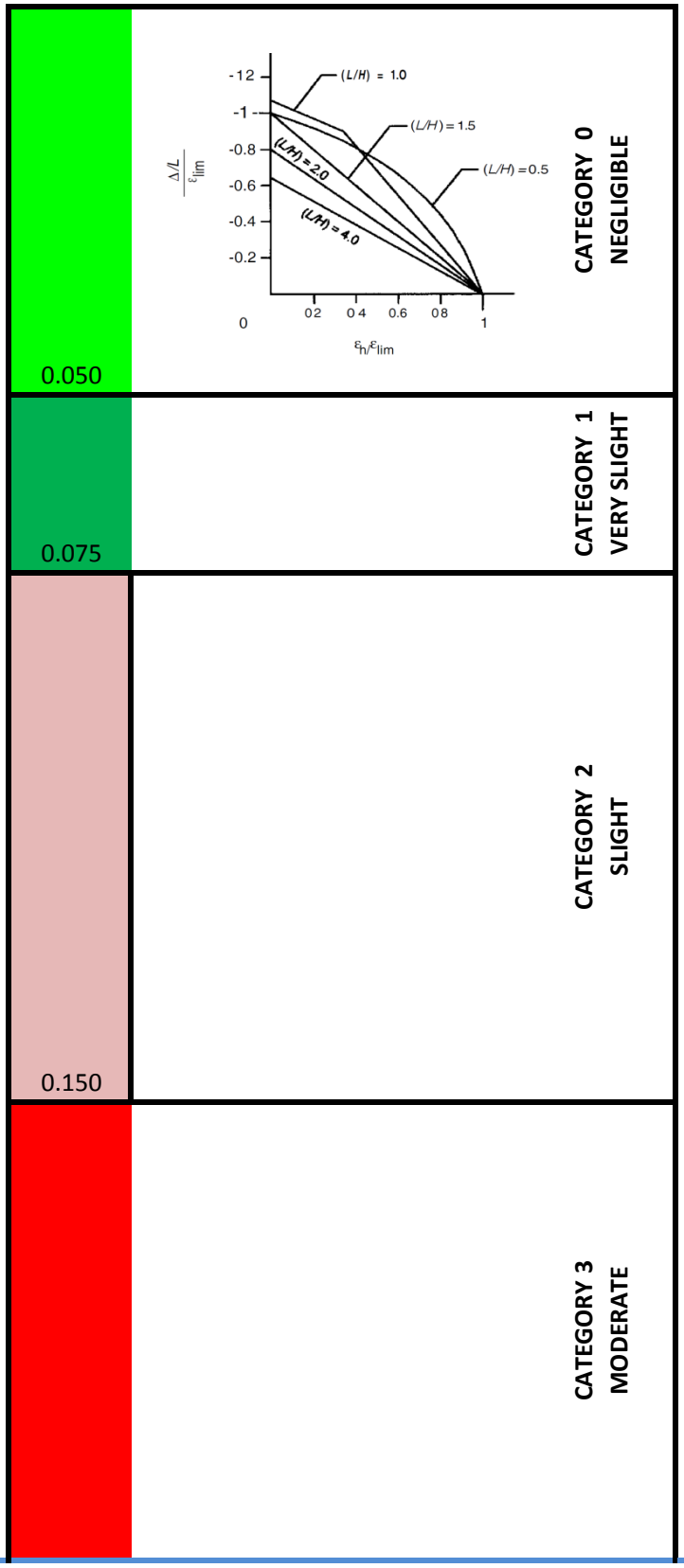
Reference: **LBH4391** Section: **No. 3 The Hexagon**

L/H = 0.9

Horiz. Strain ε_h = 0.06 % ε_{lim} = 0.060 %

Deflection ratio Δ/L = -0.00167

DAMAGE LEVEL -->

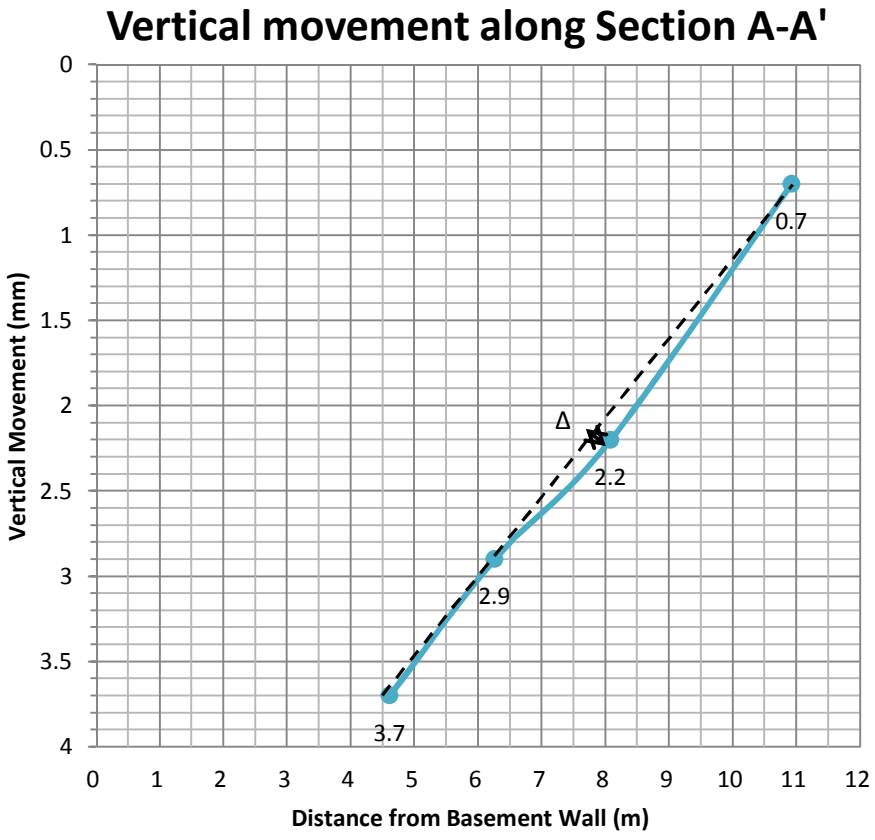


Reference: **LBH4391**
Site: **No. 4 The Hexagon**
Section: **No. 5 The Hexagon**
Date of analysis: **9th June 2016**
Project Engineer: **RL**

The damage category can be assessed from the calculated horizontal strain and deflection ratio of a "beam" under hogging or sagging.

Length of wall	**L =**	**7**	**m**
Height of wall	**H =**	**6**	**m**
Horiz. deflection	**Δ_{horiz} =**	**3.1**	**mm**
Vert. deflection	**Δ =**	**0.1**	**mm**

x	y	distance from wall	Vert. mov'nt	Horiz. mov'nt
m	m	m	mm	mm
42.5	26	4.61	3.7	4.6
44.5	26	6.26	2.9	3.7
46.5	26	8.08	2.2	2.7
49.5	26	10.92	0.7	1.5



Reference: **LBH4391** Section: **No. 5 The Hexagon**

L/H = 1.2

Horiz. Strain ε_h = 0.044286 % ε_{lim} = 0.045 %

Deflection ratio Δ/L = -0.00143

DAMAGE LEVEL -->