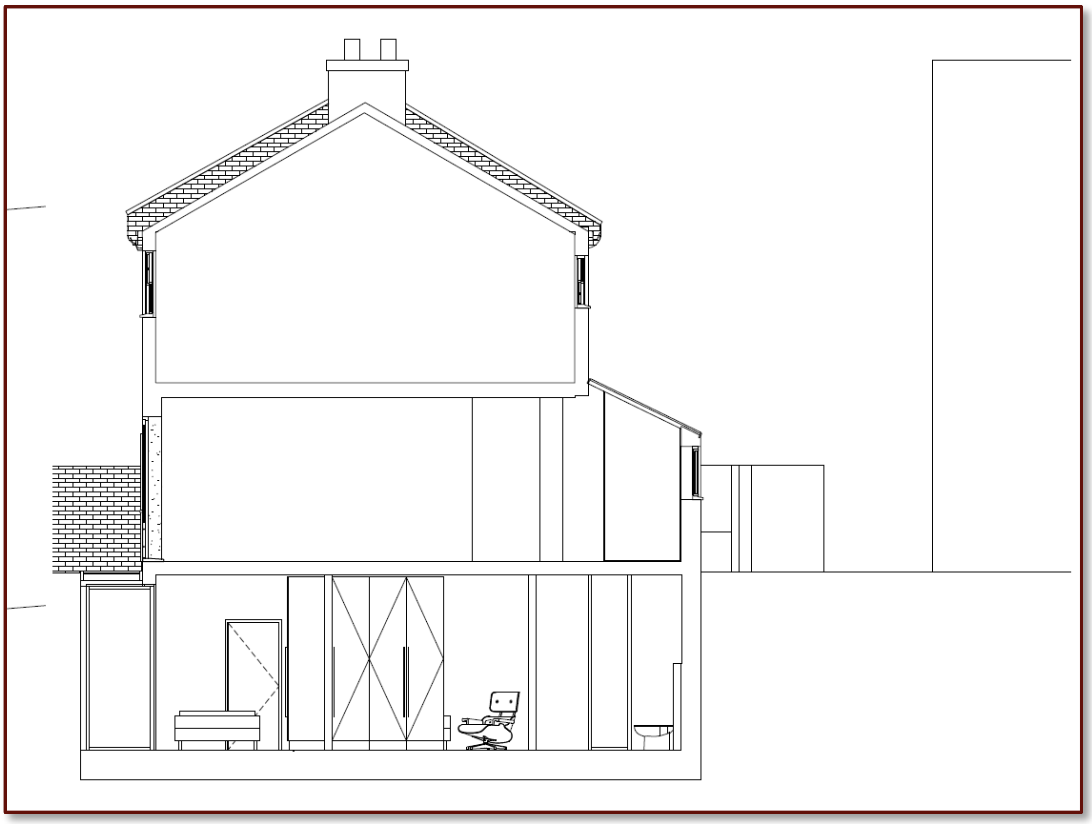
REPORT ON GROUND MOVEMENT ANALYSIS

PROPOSED BASEMENT CONSTRUCTION:

51 GLOUCESTER CRESCENT, LONDON NW1 7EG



Client:	**MRS CHERYL WALTERS** **51 Gloucester Crescent** **London NW1 7EG**
Consulting Engineers:	**SINCLAIR JOHNSTON & PARTNERS LIMITED** **93 Great Suffolk Street** **London SE1 0BX**
Report ref:	**10067A/JRCB/OT**
Date:	**30th November 2017 (Rev 2)**

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51 GLOUCESTER CRESCENT, LONDON NW1 7EG

DOCUMENT ISSUE STATUS:

Issue	Date	Description	Author	Checked / approved
Rev 0	09/05/16	First issue	John Bartley BSc, MSc, CGeol, FGS	Opher Tolkovsky BSc, MSc, DIC, CGeol, FGS
Rev 1	11/09/16	Additional analysis and preliminary damage assessment included	John Bartley BSc, MSc, CGeol, FGS	Opher Tolkovsky BSc, MSc, DIC, CGeol, FGS
Rev 2	30/11/17	Additional cases analysed	John Bartley BSc, MSc, CGeol, FGS	Opher Tolkovsky BSc, MSc, DIC, CGeol, FGS

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APPENDIX

EXECUTIVE SUMMARY

A single level basement is proposed beneath the existing 2-storey house. The basement excavation will extend to approximately 4.5m depth below existing ground level. A ground movement analysis has been carried out to determine the potential effects of the proposed basement construction on the adjacent properties, Nos 50 and 51A Gloucester Crescent, No 22 Regent's Park Crescent to the south-west and the public highway to the north. An assessment of performance of the new basement slab is also included.

Assessment of the settlement induced by new underpinning/foundations and 'global' ground movement due to the basement excavation has been carried out, with the stress changes within the ground being modelled using the Boussinesq closed-form solution for vertical loading of an elastic half-space. Elasticity theory has been used to determine associated ground movements, with appropriate stiffness values used to model short and long-term behaviour of the soil.

The ground sequence uses information gained from the following sources:

- an intrusive investigation carried out by Soil Consultants Ltd
- our in-house database of nearby investigations
- published geology

Traditional underpinning of the existing boundary and internal walls of No 51 Gloucester Crescent will be carried out, with subsequent excavation of the basement. When installing the underpinning, a high degree of workmanship will need to be exercised as these processes could potentially cause significant settlement beneath the existing foundations if poorly executed. The analysis has indicated that total net movements beneath the walls of the adjacent properties and the public highway due to the response of the ground to changes in stress should be <5mm.

Preliminary damage assessment has been carried out. On the basis that a well-designed and installed temporary lateral support system is used, it is concluded that a Category 0 damage classification ('Negligible') should be expected.

1.0 INTRODUCTION

Consideration is being given to the construction of a basement beneath 51 Gloucester Crescent, an existing detached property. In connection with the proposed scheme, Soil Consultants Ltd (SCL) were commissioned by the client, Mrs Cheryl Walters, to carry out analyses to assess the potential ground movements which could occur as a result of the basement construction. This report describes the analysis undertaken and then discusses the results in relation to No 51 and its adjacent properties. This revision (Rev 2) addresses comments made by Campbell Reith Hill LLP (see Section 2.0 below).

A ground investigation was carried out by SCL (Report ref 10067/BM/OT, dated 22/03/17) and we have incorporated data from the investigation into the analysis where appropriate. In addition, we have used information from nearby investigations and published data to supplement the investigation and to allow an assessment of characteristic geotechnical values for the ground sequence.

2.0 CAMPBELL REITH HILL AUDIT REPORT

The previous version of this report was audited by Campbell Reith Hill LLP (12466-87 Rev D2, dated October 2017), acting on behalf of the London Borough of Camden. This current revision specifically addresses those issues in the CRH audit which have a bearing on the ground movement analysis and includes an extended analysis to attend to these aspects. For ease of reference these issues are:

- The impact on adjacent properties 50 & 51A Gloucester Crescent and 22 Regents Park Terrace is now either included or further analysed, including internal walls perpendicular to the excavation as appropriate
- Potential ground movements relating to the Gloucester Crescent carriageway are now included
- Additional commentary regarding the strength profile of the London Clay used in the analysis has been included. The strength profile has been revised in response to CRH comments
- Whilst the potential grouting of the made ground has been mentioned, additional discussion has been included in the text explaining that this grouting does not affect the analysis, but is an issue purely relating to construction procedure
- The damage assessment has been extended to include those additional elements of 50 & 51A Gloucester Crescent and 22 Regents Park Terrace as appropriate

3.0 SITE DESCRIPTION AND EXISTING STRUCTURES

The site is located on the southern side of Gloucester Crescent. A full site description is included in our Site Investigation Report (referenced above) with summary points as follows:

- No 51 is a two-storey detached house
- No basement is currently present
- The footprint of the house is approximately 10m x 16m
- No topographical information was present but reference to OS spot levels nearby suggests a ground level at about +33mOD in the vicinity of the site
- Adjacent properties include 50 and 51A Gloucester Crescent to the west and east respectively and 22 Regent's Park Terrace to the south

4.0 PROPOSED BASEMENT

The proposed works are summarised as follows:

- A single level basement is to be constructed beneath the whole of the existing house footprint
- Light-wells are proposed to the front and rear, extending to new basement level
- A total excavation depth to approximately 4m below existing ground level is anticipated
- The existing walls are to be underpinned to about 4.5m depth. The investigation has indicated that a substantial thickness of made ground is present, extending to just below the proposed basement level, overlying competent London Clay

Plans and cross sections of the proposed basement are included in the Appendix.

5.0 GROUND SEQUENCE AND SOIL PARAMETERS

The 1:50,000 British Geological Survey map of the area indicates that the site is underlain by the London Clay Formation which extends to >40m depth in this area. The SCL investigation encountered a significant thickness of made ground overlying the London Clay.

A summary of the ground sequence and soil parameters adopted for the ground movement analysis is as follows. The investigation boreholes extended to 6m depth below ground level and we have therefore made an assessment of the London Clay's properties below this level based upon our experience. The sequence used for the analysis is summarised as follows:

Stratum	Depth of base of stratum	Description	Strength parameters for ground movement analysis
Made ground	4.5m	Predominantly cohesive but with subsidiary granular bands/pockets	The strength of the made ground is not relevant to the analysis technique used, as all global ground movements will be controlled by the behaviour of the soils below the basement excavation level of 4.5m depth. The underpinning and new column foundations will also be placed at this depth and hence no new vertical stresses will be imposed upon the made ground. For input purposes, an undrained shear strength of 40kPa has been taken for this deposit. Whilst there are some granular bands within the made ground, we consider this to be a conservative value for the overall made ground layer
London Clay	>40m	Firm becoming stiff brown CLAY	Undrained shear strength at the top of the stratum has been taken as 75kPa, based upon hand vane results and field assessment. The undrained shear strength increase with depth has been taken as 7.5kPa/m which in our experience is a reasonably conservative estimate
Ground-water	>4.7m depth below ground level		

6.0 DESCRIPTION OF GROUND MOVEMENT ANALYSIS AND INPUT PARAMETERS

Ground movement analysis has been carried out to model the global response of the ground due to excavation unloading from construction of the new basement. The response has been modelled using the closed-form solution for vertical loading of an elastic half-space originally formulated by Boussinesq. This solution is incorporated within our in-house software, which allows the superposition of loaded areas to be applied to deduce the overall applied stress field in the ground. Elasticity theory is then used to determine associated ground movements, with appropriate stiffness values used to model both short and long-term behaviour of the soil.

6.1 Soil parameters for Boussinesq analysis

The stiffness parameters for use in the Boussinesq analysis have been derived from the presumed strengths of the various strata as summarised in Section 5.0 above. Correlation factors ('f') have been applied to the strength parameters to provide undrained and drained moduli and these are summarised as follows:

Stratum	Depth	Strength	Unload modulus		Load modulus	
			Eu	Ed	Eu	Ed
Made ground	4.5 at base	Cu = 40kPa	20MPa (f=500)	10MPa (f=250)	16MPa (f=400)	6MPa (f=150)
London Clay	Below 4.5m depth	Cu=75kPa at 4.5m ΔCu=7.5kPa/m	37.5MPa at 4.5m ΔEu=3.75MPa/m (f=500)	18.75MPa at 5m ΔEu=1.88MPa/m (f=250)	30MPa at 4.5m ΔEu=3.0MPa/m (f=400)	11.25MPa at 4.5m ΔEu=1.12MPa/m (f=150)

Note: Poisson's Ratio = 0.5 undrained and 0.15 drained for all load cases

The unload/reload regime due to the proposed works will be relatively complex. In general terms, the heave response of the soil (and reversal up to existing stress) will be stiffer than the loading beyond existing stresses (ie the 'virgin' loading phase).

It is noted that the use of resin injection is being considered to assist in controlling potential groundwater inflows. This treatment will be confined to the made ground and would be expected to improve its geotechnical properties. The modified strength/density of the made ground will not affect the prediction of global movements due to ground heave as these are the result of the unloading of the London Clay below the 4.5m depth of proposed excavation. In addition, the underpinning and new column foundations will also be placed at this depth and hence no new vertical stresses will be imposed upon the made ground. A detailed discussion on the strength of the grouted soils is therefore not within the remit of this report but is an issue purely related to construction procedure.

6.2 Geometry and loadings for Boussinesq analysis

The analytical technique depends on the selection of appropriate rectangular areas to simulate unload and re-application of load from the new structure to the ground. Our approach for the analysis assumes that all elements equate to loads over a series of rectangular areas representing the underpinned foundations and the footprint of the basement, with uniform loading below each of the represented areas.

Underpinning of the existing foundations and the basement excavation would be expected to induce some movement in the foundations of the neighbouring properties, Nos 50 and 51A Gloucester Crescent, which are immediately adjacent to the site. Details of the foundations of these properties were not available at the time of reporting. The recent SCL investigation suggests that No 51 Gloucester Crescent is supported on spread foundations placed at about 1.1m depth; we have assumed similar foundations for the adjacent properties. No 22 Regent's Park Terrace (a Grade II listed building) lies just outside the south-western corner of the site, approximately 2.5m from the proposed basement line. Again, the foundation details of this property are unknown but we have, conservatively, assumed that the building is supported by shallow spread foundations; if this building incorporates a basement, the impact of the proposed scheme would be reduced significantly. The pavement of Gloucester Crescent is approximately 3m to the north of the basement line.

For the purposes of analysis, we have taken the following cases:

- **Nos 50 and 51A Gloucester Crescent:** we have assessed movements along the walls parallel to the basement retaining wall and also a theoretical wall which is perpendicular to the basement wall. No details of the actual structural arrangements of these properties have been provided and we have taken the most conservative approach, with the assumed wall and its movements being assessed to be mid-way along the basement excavation, where lateral and vertical movements will be greatest
- **No 22 Regent's Park Terrace**: again, no details of the existing structural arrangement of this property have been provided. We have therefore, conservatively, assessed ground movements along an assumed wall line which is perpendicular to the basement excavation
- **Gloucester Crescent carriageway**: we have assessed ground movements along the northern site boundary which is defined by Gloucester Crescent

There will basically be three mechanisms contributing to movement of the neighbouring foundations as follows:

New loading: transfer of the structural loads down to basement level by underpinning will induce some settlement in the bearing soils (London Clay). The foundations of the adjacent properties are assumed to be placed above this basement level and some resulting settlements would therefore be expected. We have estimated possible movements due to the loading of the ground by the underpinning, assuming that any settlement at depth will be directly translated as movement of the higher level neighbouring foundations; the method of analysis takes no account of the stiffness of the existing foundation systems and this approach is therefore considered to be conservative. Information supplied by the consulting engineers indicates that internal column loads of between 149kN and 184kN are anticipated, with wall loadings between 31kN/m and 78kN/m. Our ground investigation report identified that a bearing resistance of 140kPa would be appropriate for determining foundation dimensions and this has been used as the upper limit of pressures applied by the new underpinning/foundations.

Heave: this will occur following excavation of the No 51 basement due to stress reduction. This will extend beyond the basement footprint and affect the neighbouring foundations. Current proposals envisage excavation to a depth of about 4.5m and we have therefore assumed unload of 90kPa over the basement/light-well footprint.

Installation and excavation: the installation of the underpinning and excavation of the basement could arguably generate the largest ground movements. A reputable and experienced contractor should be employed to undertake the underpinning operation and a very high level of workmanship should be exercised. When the basement is excavated, lateral deflection of the underpinning could result in vertical movements beneath the neighbouring foundations. However, with appropriate lateral support in place, we anticipate that it should be possible to limit any such ground movements to acceptable levels; the requirement for a well-designed and robust support system is self-evident. The ground movements associated with these construction activities will thus vary depending on the sequencing, temporary lateral propping/support which is provided and level of expertise exercised, but we anticipate that with properly designed works it should be possible to keep these within acceptable limits. The estimated lateral movements due to excavation of the basement and damage assessment are discussed in Section 8.0 of this report.

7.0 RESULTS OF ANALYSES

The details of soil layers and parameters (as discussed previously), together with the relevant loadings and unloadings are summarised in the appended Figures 1 and 2. The results of the analyses are summarised as ground movement contour plots and these are included as Figures 3 to 6 in the Appendix. Using the ground movement data, as summarised on the contour plots, the predicted movements along the lines of load-bearing walls within 50 Gloucester Crescent, 51A Gloucester Crescent, 22 Regent's Park Terrace and the Gloucester Crescent pavement are discussed in the following sections.

7.1 Adjacent properties and Gloucester Crescent highway

The profiles of predicted movement are shown as Figures 7 to 12 in the Appendix. These show the ground movements due to a) the settlement of the new underpinning/foundations and b) the heave due to basement excavation and the results are shown in the following table. It is important to note that the calculated total settlement and heave movements will not in reality be experienced by the walls; the settlement will be simultaneously counteracted by the heave, and the **net** result provides a more realistic assessment of the actual movement:

Profile	Immediate short-term (mm)			Total long-term (mm)		
	Settlement	Heave	Net	Settlement	Heave	Net
50 Gloucester Crescent Parallel wall	+4.4	-6.6	-2.2	+10.2	-13.0	-2.8
50 Gloucester Crescent Perpendicular wall	+4.4	-6.6	-2.2	+7.9	-10.6	-2.7
51A Gloucester Crescent Parallel wall	+4.1	-5.7	-1.8	+9.6	-11.2	-2.3
51A Gloucester Crescent Perpendicular wall	+4.0	-5.7	-1.7	+9.3	-11.2	-1.9
22 Regent's Park Terrace Perpendicular wall	+1.4	-2.6	-1.2	+3.2	-5.1	-1.9
Gloucester Crescent pavement line	+1.4	-2.8	-1.4	+3.4	-5.5	-2.2

Notes:
(i) the maximum movements of the parallel and perpendicular walls are the same where they occur at the same point
(ii) the maximum settlement and heave does not necessarily occur at the same point

7.2 No 51 Gloucester Crescent basement slab (soil heave and hydrostatic pressure)

As discussed previously, the basement excavation will result in the removal of about 4.5m of soil, equivalent to an unloading of approximately 90kPa, resulting in short and long-term heave in the London Clay. Factors such as the length of the construction programme, the restraining effects of the retaining walls and the basement slab stiffness will generally determine the amount of heave which could occur. The contours of predicted ground movement (Figs 3 to 6) indicate the following:

- A maximum (long term) theoretical unrestrained heave of about heave of about 30mm could occur (Fig 6)
- About 15mm of this is expected to occur by the end of construction (Fig 4), leaving a maximum post-construction heave of about 15mm

- The post-construction settlements between the internal columns are estimated to be about 6mm (assume 10mm total with 4mm occurring by end of construction – Figs 3 and 5)
- The maximum theoretical unrestrained heave, with no constraint from a slab, would therefore be approximately 15 – 6 = 9mm

Assuming a linear relationship between heave pressure and movement, we would expect a potential maximum unconstrained residual heave pressure of about 45kPa. For an 'average' stiffness slab we would expect a heave pressure of about 20-25kPa with commensurate heave movement of <5mm.

It will also be necessary to consider uplift of the slab due to potential hydrostatic pressures and in this respect the guidelines incorporated in BS8102:2009 should be followed. The design will need to take account of potential seasonal fluctuations and/or accidental and flood conditions and we recommend at this stage that a design water level at 1m below external ground level is adopted. This would result in a theoretical hydrostatic uplift pressure of about 35kPa on the underside of a basement slab.

The model assumes hydrostatic conditions and uses the total stress throughout and thus includes the water pressure in the soil uplift pressures/stresses. In the long-term condition, if the soil is permitted to heave (the slab deflects or there is a void former beneath the slab) then the water pressure will still remain. It is therefore important to note that the water pressure is not additional to the heave pressure and should be taken as the minimum uplift pressure for design.

8.0 DAMAGE ASSESSMENT

The published method detailed by CIRIA C760:2017, based upon the Burland/Boscardin and Cording approach, provides a means of combining the prediction of potential vertical and horizontal ground movements within a structure, into a Damage Category Assessment. The values of movement are extracted from the published graphs, which are related to the geometry of wall installation and excavation depth and do not involve any geotechnical analysis.

We have carried out the assessment for the parallel and assumed perpendicular walls of 50 & 51A Gloucester Crescent and an assumed perpendicular wall for 22 Regent's Park Terrace. The ground movement profiles summarised in Figures 7 to 11 identify the calculated vertical settlements and provide the maximum differential vertical movement 'Δ'. With respect to horizontal strain, ie the strain due to the relative horizontal movements of two reference points at either end of the walls, the following approach has been taken:

Parallel walls: these walls are parallel to the basement excavation. For a single-level basement with a well-supported/propped wall, the horizontal movement within the length of the wall is likely to be very small/negligible and consequently the horizontal strain will be negligible. It would be reasonable to assume that the horizontal differential movement would be zero for these walls but to add an element of conservatism to the assessment, we have taken this differential movement to be 2mm for the parallel walls.

Perpendicular walls: these walls will be subject to demonstrable horizontal movement, especially if near to the centre of the basement wall where lateral deflections will be greatest. We have used the empirical charts in C760 (Fig 6.15a) to estimate the lateral movement at each end of the wall. The difference between these two values is then used to calculate the horizontal strain. We have assumed that a relatively stiff support system will be in place both during construction and in the permanent condition. If necessary, jacked propping may be required to keep horizontal movements to within tolerable limits.

Our assessment follows the procedure shown in C760 as follows:

(i) Establish L/H which is the ratio of the building length and height

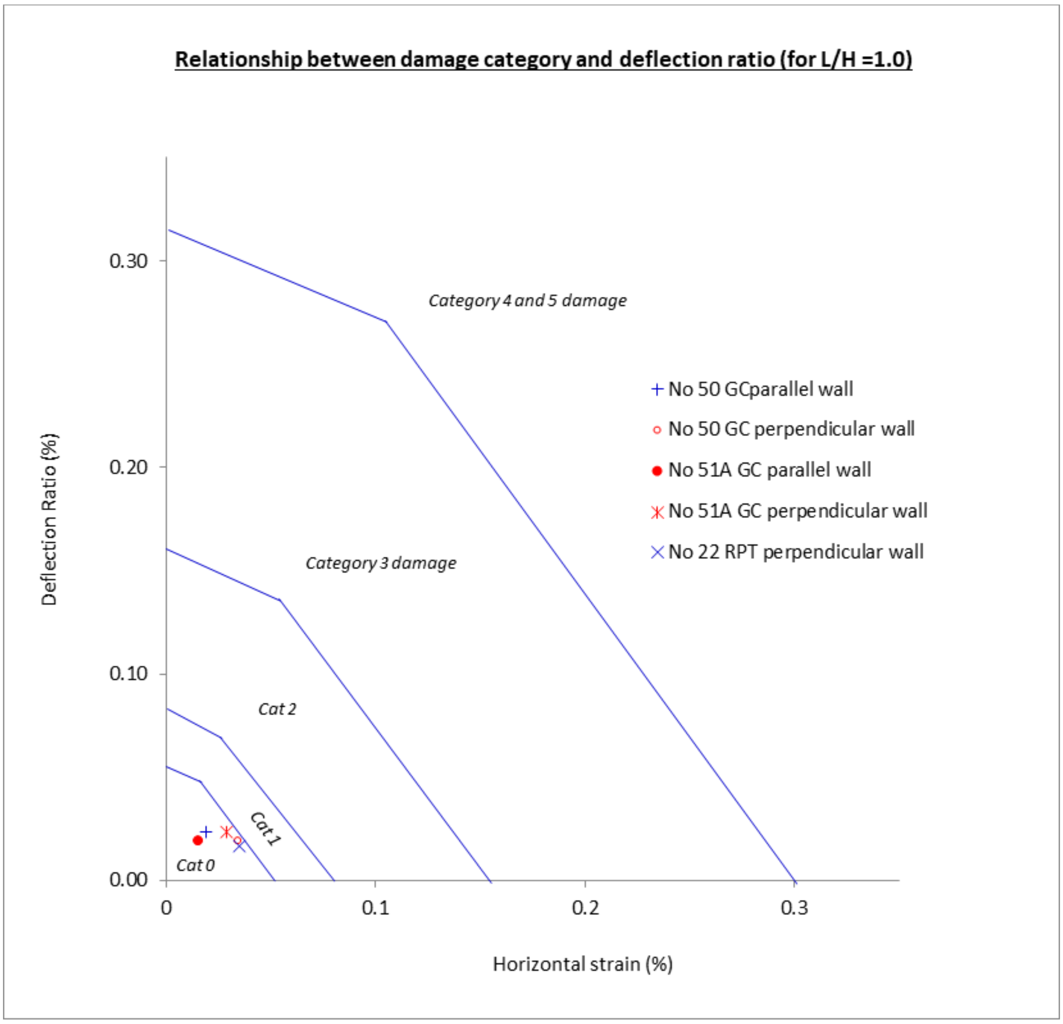
(ii) A value for L/H of 1.0 has been taken for these properties

(iii) The relationship between the Deflection Ratio (Δ/L for the vertical differential movement) and the horizontal strain (ε_h) for L/H = 1.0 are shown in the summary plot below together with the limiting strain values

(iv) As discussed above, the maximum vertical differential movements Δ are identified on the profile plots in Figures 7 to 12. For the parallel walls, horizontal differential movement along the length of the wall has (conservatively) been taken to be 2mm; as discussed above, the horizontal strain for the walls would theoretically be close to zero. The horizontal movements for the perpendicular walls have been estimated using C760. The results are summarised in the following table:

Element	L	Δ (vertical - see profiles)	Horizontal movement δ_h	Deflection Ratio Δ/L (vertical)	Horizontal strain ε_h
50 Gloucester Crescent Parallel wall	10.5m	2.5mm	2mm	0.024	0.019
50 Gloucester Crescent Perpendicular wall	10.5m	2mm	3.6mm	0.019	0.034
51A Gloucester Crescent Parallel wall	13.0m	2.5mm	2mm	0.019	0.015
51A Gloucester Crescent Perpendicular wall	10.5m	2.5mm	3mm	0.024	0.029
22 Regent's Park Terrace Perpendicular wall	6.0m	<1mm	2.1mm	0.017	0.035

The assessed damage categories for the walls are shown on the following summary plot:



Thus, our assessment indicates that Category 0 'Negligible' damage classification is likely to apply.

9.0 GENERAL COMMENTS AND CONCLUSIONS

The analyses have indicated the following:

- Net movements in all cases are calculated to be <5mm
- Net movement along the pavement line of Gloucester Crescent is calculated to be <5mm with equivalent angular rotation of 1:10,000. This is expected to be well within the tolerances of any services within the pavement
- Damage assessment suggests that Category 0 'Negligible damage' applies to all walls. We understand that Camden requires that damage impact is maintained at Category 1 or below and thus the proposed scheme would be acceptable under this criterion
- Long-term heave pressure on the basement slab is estimated to be approximately 20-25kPa, with associated movement of <5mm. Hydrostatic pressures for design are expected to be more critical than soil heave pressures. If a design water level at 1m depth are below ground level is taken, hydrostatic pressures of about 35kPa can be expected (this should not be added to the above soil heave pressure)

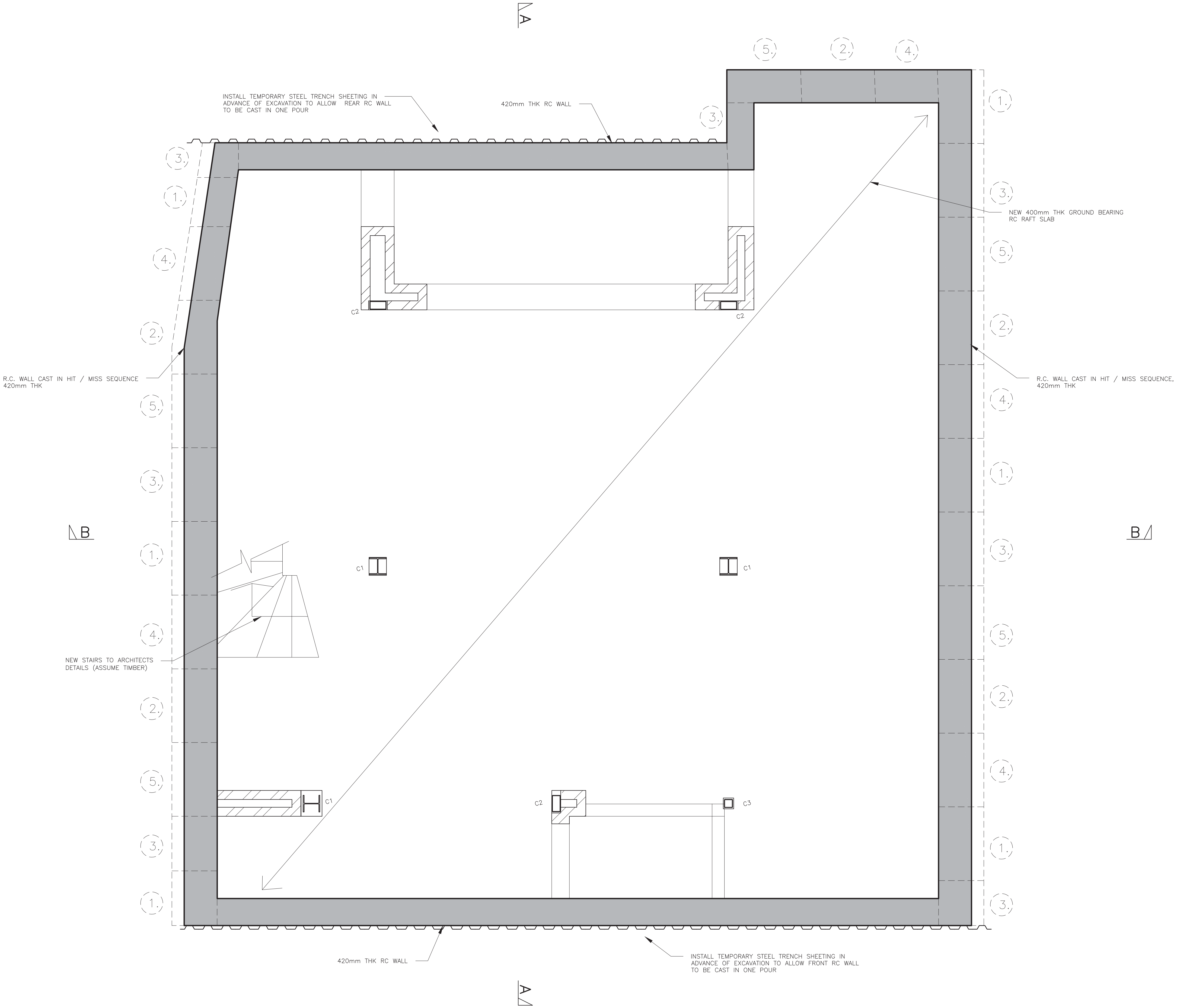
The basement construction will involve underpinning through variable, non-engineered made ground and the London Clay. Groundwater is likely to be present at the top of the London Clay and we understand that consideration is being given to resin grouting as a control measure. Foundation movements associated with the construction works and grouting are purely related to construction procedure and are not part of our analysis. These movements are related to temporary works have the potential to exceed those due to load-induced soil movements if they are not well-designed and carried out in a diligent manner by a competent contractor. A very high level of workmanship will be required, and we recommend that a well-established specialist who has extensive experience with this type of project is employed. Jacked propping may be required to ensure that horizontal movements during construction are not excessive.

It should be noted that the Boussinesq-based analysis assumes a linear relationship between modulus and strain. In reality this relationship is non-linear, with a significantly stiffer response occurring as the strain decreases. Further, the overall stiffness of the soils will increase as they are loaded and consolidation occurs. For these reasons, whilst being a perfectly good tool for estimating ground movements for the current scenario, the Boussinesq-based analysis will tend to provide an upper bound (conservative) estimate of ground movements. In addition, the analysis does not model either the restraining effects of the existing structures, the new retaining walls or the new basement structure and all of these factors will clearly have a beneficial effect in reducing both total and differential ground movements.

We understand that a programme of structural monitoring will be instigated prior to any grouting works on site. It would clearly be beneficial to extend the monitoring to include the underpinning and basement construction to ensure that any excessive ground movements are avoided.

APPENDIX

- Scheme drawings
- Figures 1 to 2 - Input data for Boussinesq analysis
- Figures 3 to 6 - Contour plots for Boussinesq analysis
- Figures 7 to 12 - Ground movement profiles



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3. All dimensions are in millimetres and levels in metres.

KEY:

DENOTES NON-LOADBEARING SOLID BLOCK WALL

COLUMN SCHEDULE	
C1	203x203UC46
C2	200x100 RHS
C3	100x100x10 SHS

THIS DRAWING IS NOT FOR CONSTRUCTION

Rev	Date	Issued	Amendment
B	09.05.17	SH	For planning
A	05.05.17	SH	For planning
–	24.03.17	SH	For comment

Status PLANNING

SINCLAIRJOHNSTON
Consulting Civil & Structural Engineers

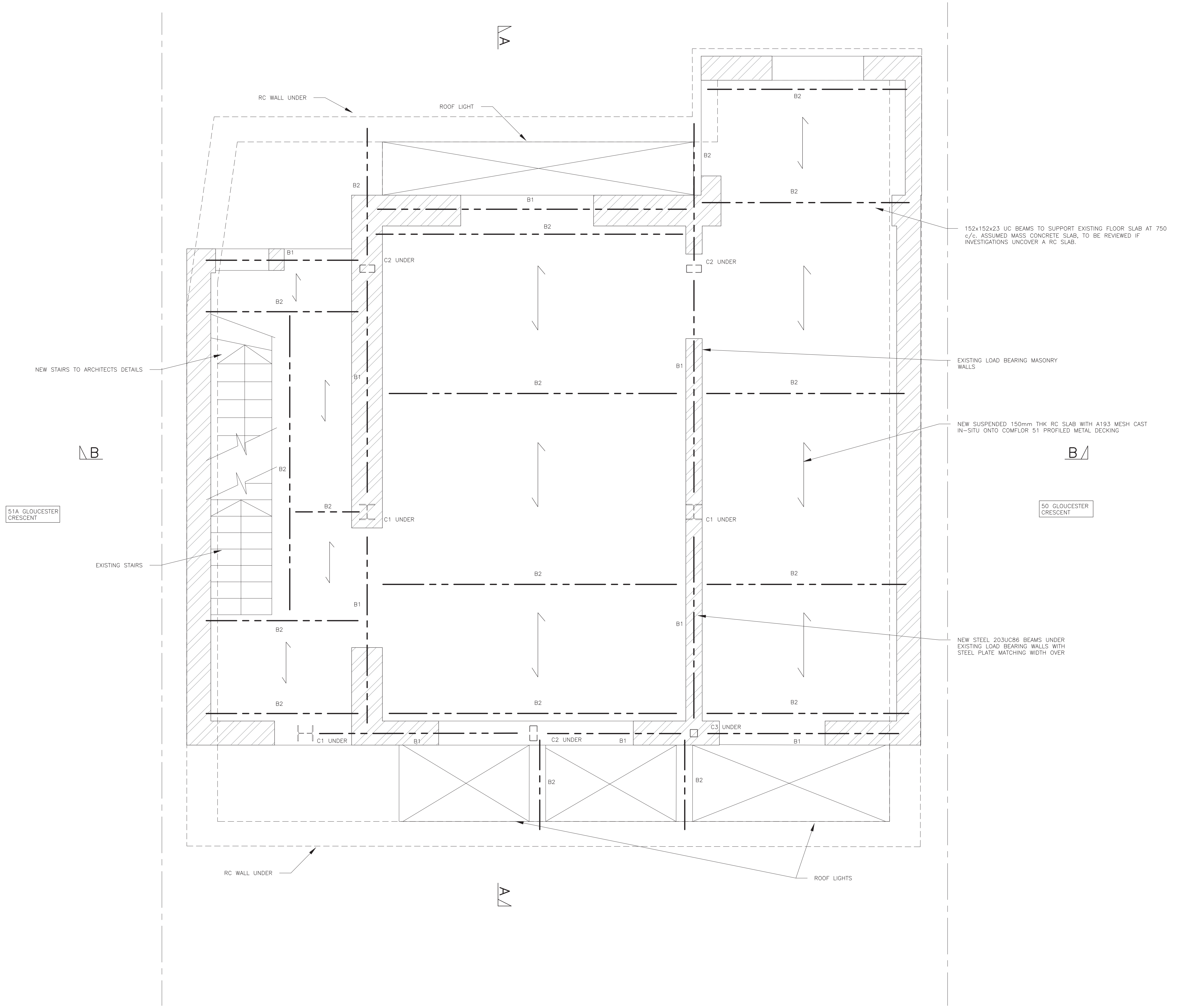
93 Great Suffolk Street
London SE1 0BX
T: 020 7593 1900
F: 020 7593 1910
www.sinclairjohnston.co.uk

51 Gloucester Crescent NW1

Proposed Basement

Drawn S Hill Scale 1:25 at A1

Project No./Drawing No. 8761/009 Rev B



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KEY:

DENOTES EXISTING SOLID BRICKWORK

DENOTES SPAN OF EXISTING RC SLAB

DENOTES STRUCTURE UNDER

BEAM SCHEDULE	
B1	203x203UC86
B2	203x203UC46

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SINCLAIRJOHNSTON
Consulting Civil & Structural Engineers

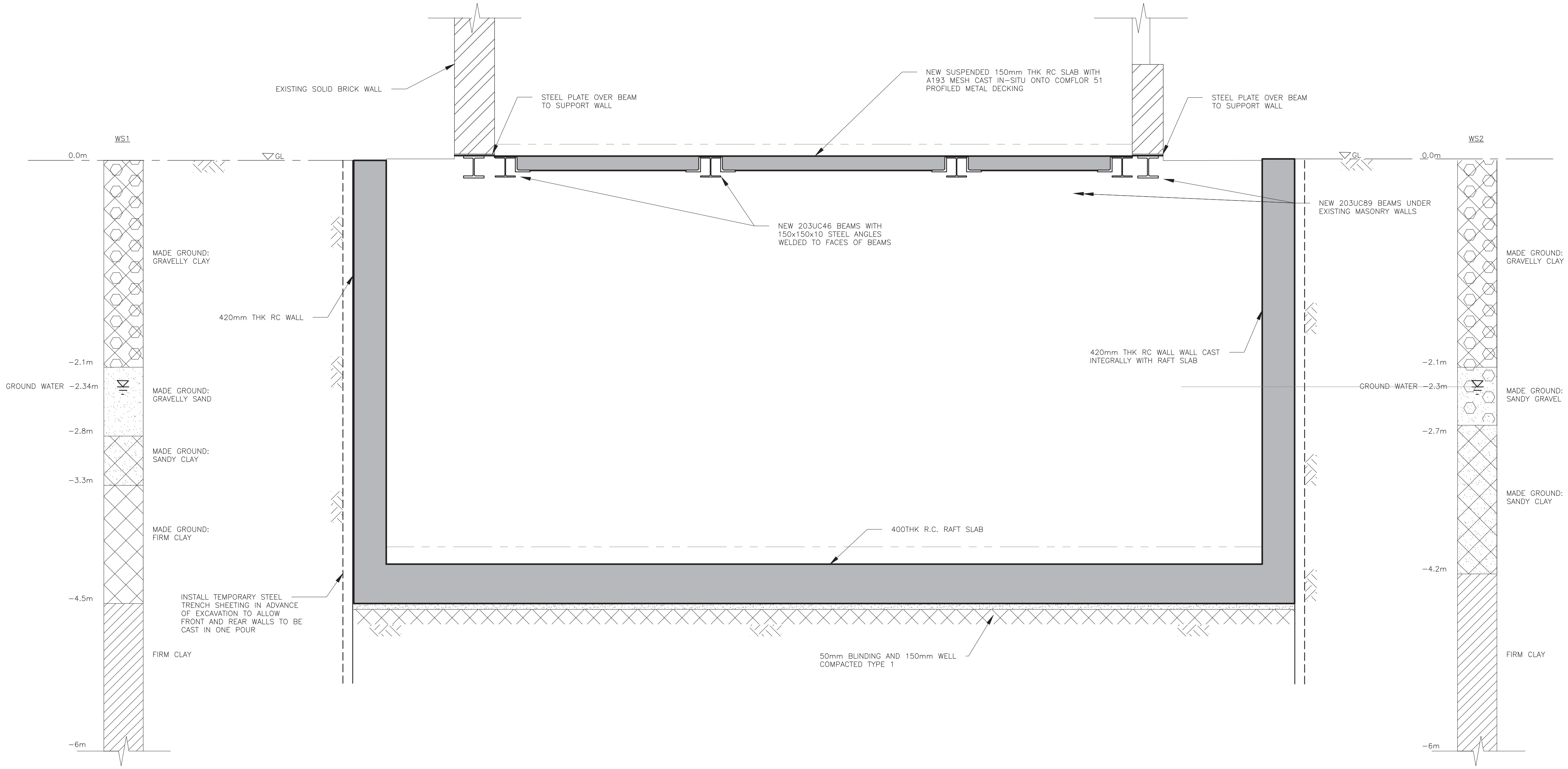
93 Great Suffolk Street
London SE1 0BX
T: 020 7593 1900
F: 020 7593 1910
www.sinclairjohnston.co.uk

51 Gloucester Crescent NW1

Proposed Ground Floor

Drawn S Hill | Scale 1:25 at A1

Project No./Drawing No. 8761/010 | Rev B



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SINCLAIR JOHNSTON
Consulting Civil & Structural Engineers

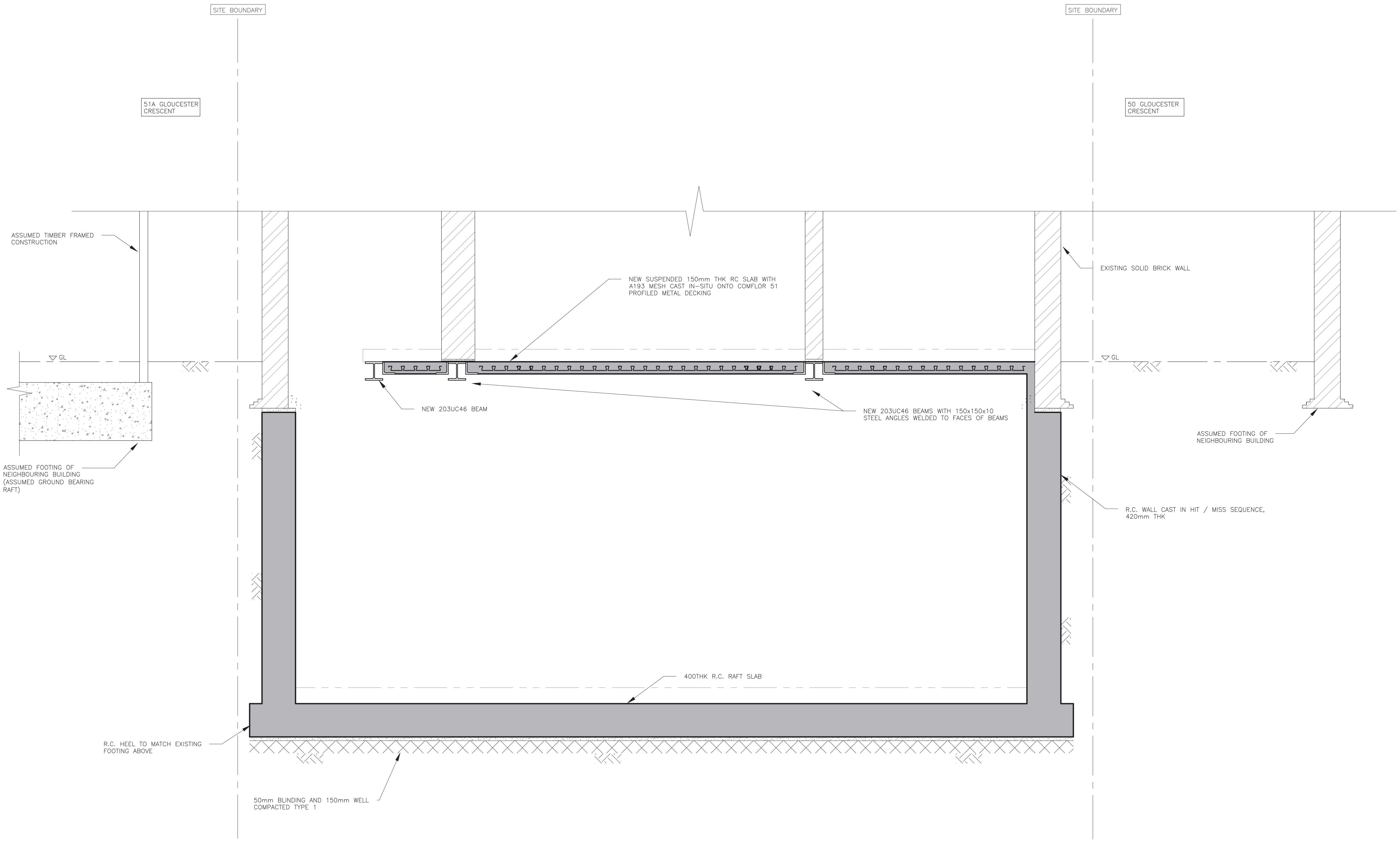
93 Great Suffolk Street
London SE1 0BX
T: 020 7593 1900
F: 020 7593 1910
www.sinclairjohnston.co.uk

51 Gloucester Crescent NW1

Proposed Section A–A

Drawn S Hill | Scale 1:25 at A1

Project No./Drawing No. 8761/030 | Rev B



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SINCLAIRJOHNSTON
Consulting Civil & Structural Engineers

93 Great Suffolk Street
London SE1 0BX
T: 020 7593 1900
F: 020 7593 1910
www.sinclairjohnston.co.uk

51 Gloucester Crescent NW1

Proposed Section B–B

Drawn	S Hill	Scale	1:25 at A1
Project No./Drawing No.	8761/031	Rev	B

Boussinesq analysis – input parameters (foundations – load)

Loaded areas: **12**

Ref	X1	Y1	X2	Y2	p	za
1	9.9	5.3	10.5	16.1	130.0	45.500
2	10.5	15.5	19.3	16.1	52.0	45.500
3	19.3	9.5	19.9	16.1	130.0	45.500
7	12.4	7.3	13.5	8.4	140.0	45.500
8	16.5	7.3	17.7	8.4	140.0	45.500
9	12.3	11.2	13.9	12.2	140.0	45.500
10	16.7	11.0	17.8	12.1	140.0	45.500
11	12.3	14.0	13.4	15.1	140.0	45.500
12	18.0	14.0	19.3	15.0	140.0	45.500

Strata: **2**

No	Ref level [mOD]	Cu or N	d(Cu or N)/dz	Eu [kN/m^2]	Ed [kN/m^2]	nu	nd	Name
1	50.000	40	0.00	16,000	6,000	0.5	0.15	MG
2	45.500	75	7.50	30,000	11,250	0.5	0.15	London Clay

Layers: **12**

No	Top	Bottom	Stratum	H	MidLevel	Stratum Name
1	50.00	45.50	1	4.50	47.75	MG
2	45.50	45.00	2	0.50	45.25	London Clay
3	45.00	44.50	2	0.50	44.75	London Clay
4	44.50	44.00	2	0.50	44.25	London Clay
5	44.00	43.00	2	1.00	43.50	London Clay
6	43.00	42.00	2	1.00	42.50	London Clay
7	42.00	41.00	2	1.00	41.50	London Clay
8	41.00	40.00	2	1.00	40.50	London Clay
9	40.00	35.00	2	5.00	37.50	London Clay
10	35.00	30.00	2	5.00	32.50	London Clay
11	30.00	25.00	2	5.00	27.50	London Clay
12	25.00	20.00	2	5.00	22.50	London Clay

Geometry

Geometry	X1	0.0	Width	60	units
extents	Y1	-10.0	Breadth	70	units
	X2	30.0	Points	4331	
	Y2	25.0			

Grid	dx	0.50	Stresses and settlements are calculated at each point of the grid
	dy	0.50	

FIGURE 1

Boussinesq analysis – input parameters (excavation – unload)

Loaded areas: 3

Ref	X1	Y1	X2	Y2	p	za
1	10.0	5.3	12.9	7.9	-90.0	46.000
2	10.0	7.9	19.7	15.9	-90.0	46.000
3	12.9	6.4	19.4	7.9	-90.0	46.000

Strata: 2

No	Ref level [mOD]	Cu or N	d(Cu or N)/dz	Eu [kN/m^2]	Ed [kN/m^2]	nu	nd	Name
1	50.000	40	0.00	20,000	10,000	0.5	0.15	MG
2	45.500	75	7.50	37,500	18,750	0.5	0.15	London Clay

Layers: 12

No	Top	Bottom	Stratum	H	MidLevel	Stratum Name
1	50.00	46.00	1	4.00	48.00	MG
2	46.00	45.50	1	0.50	45.75	MG
3	45.50	44.50	2	1.00	45.00	London Clay
4	44.50	44.00	2	0.50	44.25	London Clay
5	44.00	43.00	2	1.00	43.50	London Clay
6	43.00	42.00	2	1.00	42.50	London Clay
7	42.00	41.00	2	1.00	41.50	London Clay
8	41.00	40.00	2	1.00	40.50	London Clay
9	40.00	35.00	2	5.00	37.50	London Clay
10	35.00	30.00	2	5.00	32.50	London Clay
11	30.00	25.00	2	5.00	27.50	London Clay
12	25.00	20.00	2	5.00	22.50	London Clay

Geometry

Geometry	X1	0.0	Width	60	units
extents	Y1	-10.0	Breadth	70	units
	X2	30.0	Points	4331	
	Y2	25.0			

Grid

dx	0.50	Stresses and settlements are calculated at each point of the grid
dy	0.50	

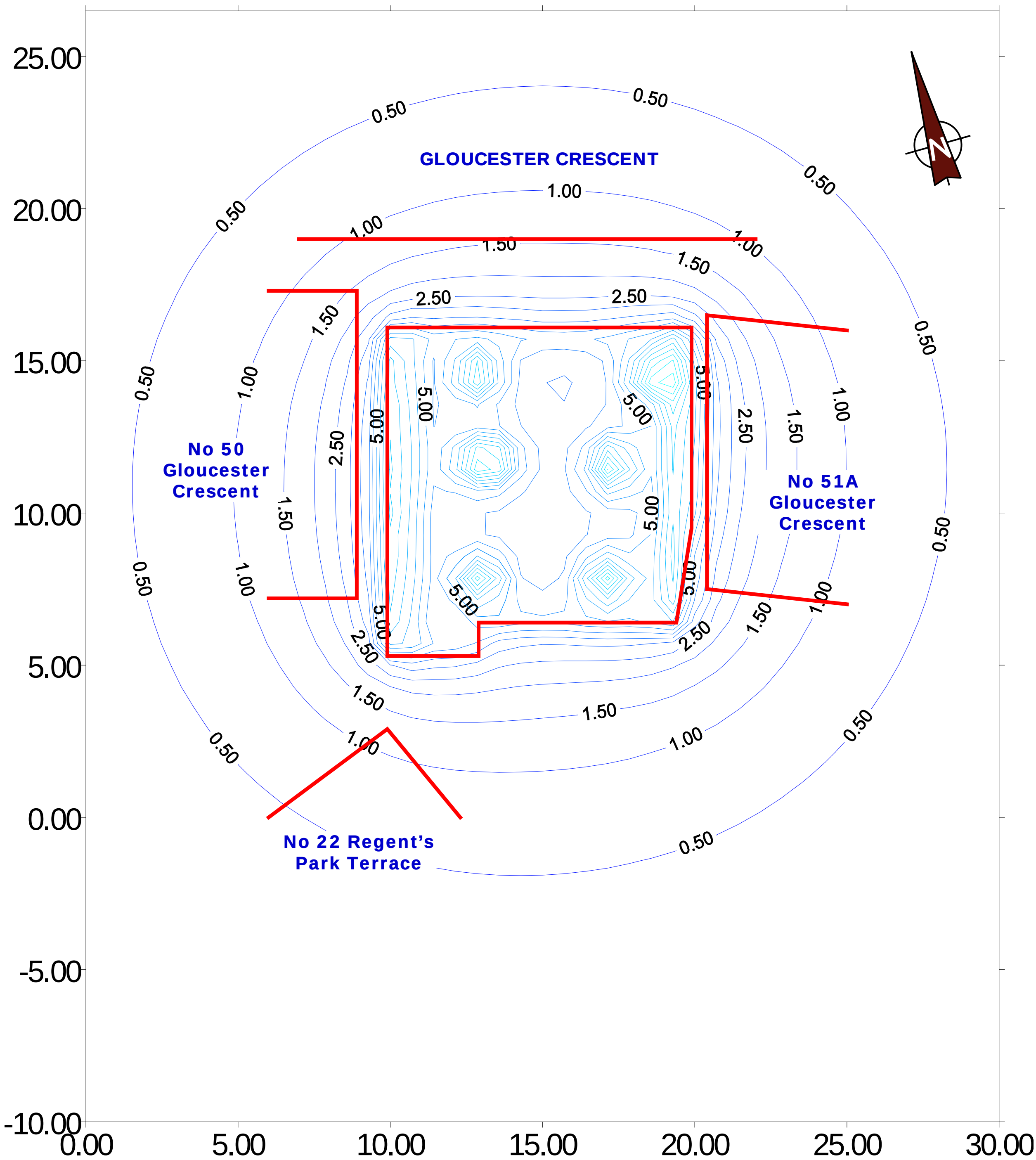
FIGURE 2

Site & Location

51 Gloucester Crescent
London NW1 7EG

Report No: **10067A/JRCB**

Contours showing settlement due to underpinning (immediate/short term)



Notes:

a) contours show 100% immediate and 20% long term settlement

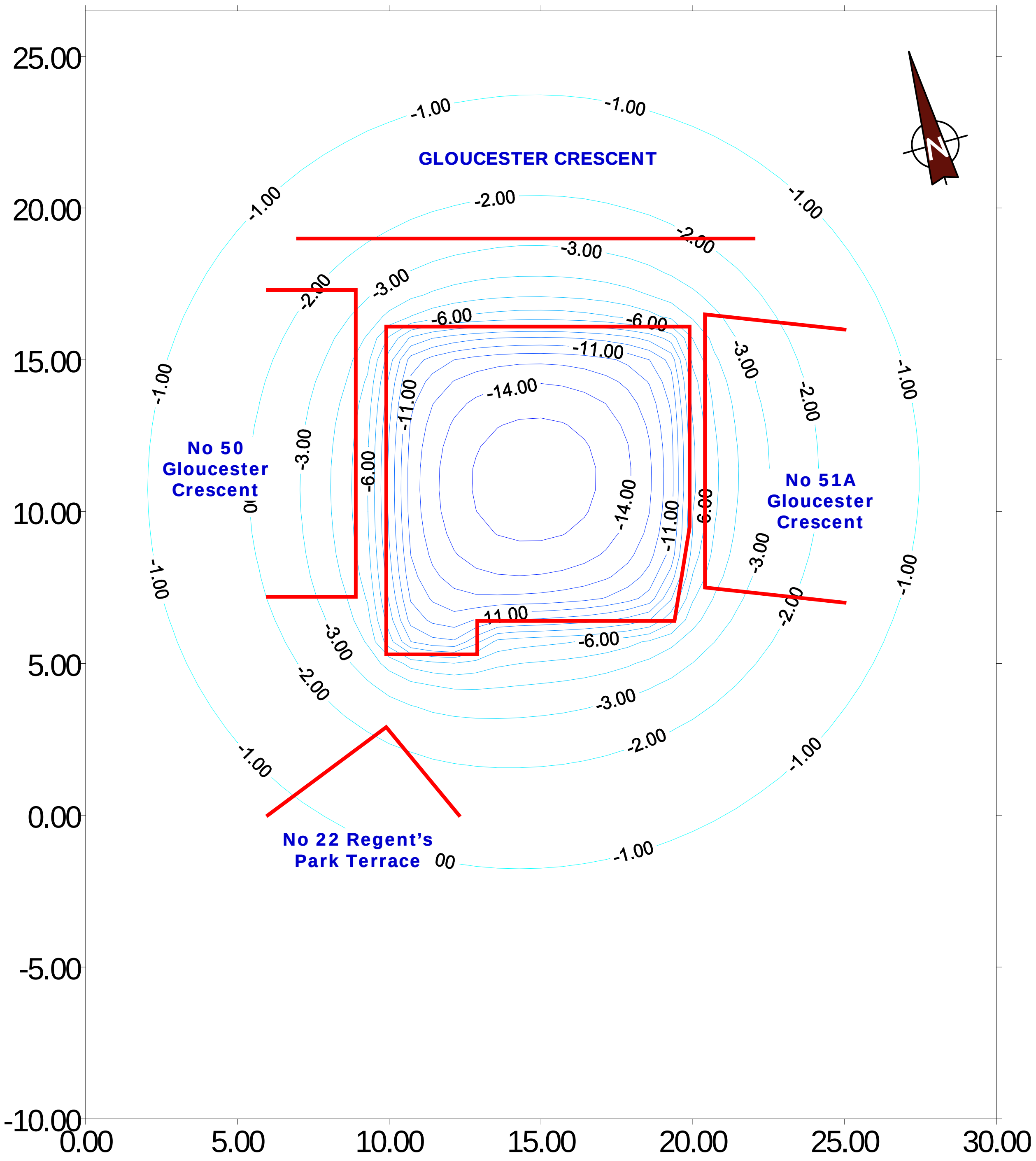
b) contours show ground movement at underpinning level, approximately 4.5m depth

c) negative movement is upward (heave), positive movement is downward (settlement)

FIGURE 3

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: **10067A/JRCB**

Contours showing heave due to basement excavation (immediate)



Notes:

a) contours show 100% immediate and 20% long term heave

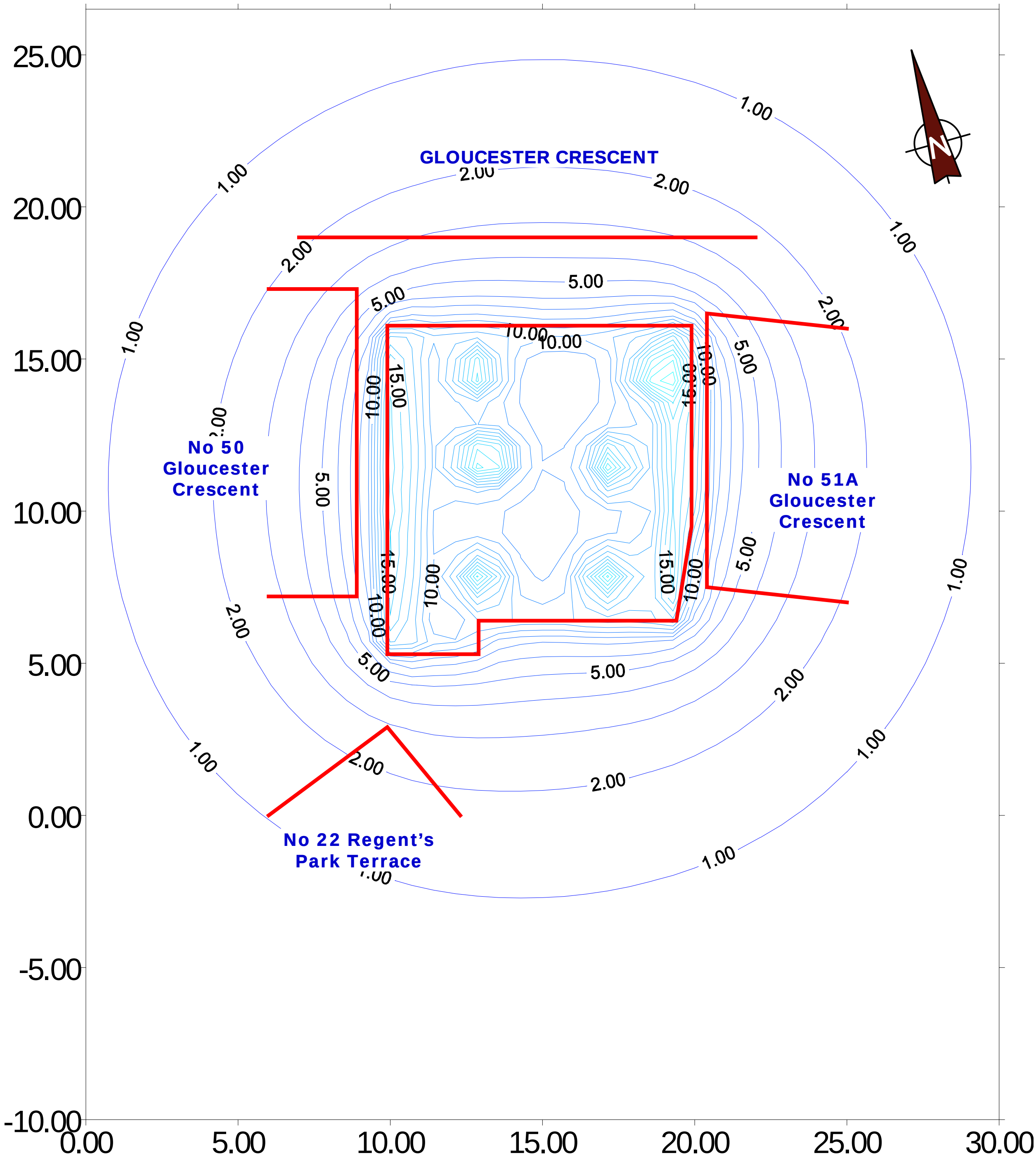
b) contours show ground movement due to basement excavation at approximately 4.5m depth

c) negative movement is upward (heave), positive movement is downward (settlement)

FIGURE 4

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: **10067A/JRCB**

Contours showing settlement due to underpinning (total)



Notes:

a) contours show 100% immediate and 100% long term settlement (Note: this movement is theoretical and will not actually occur)

b) contours show ground movement at underpinning level, approximately 4.5m depth

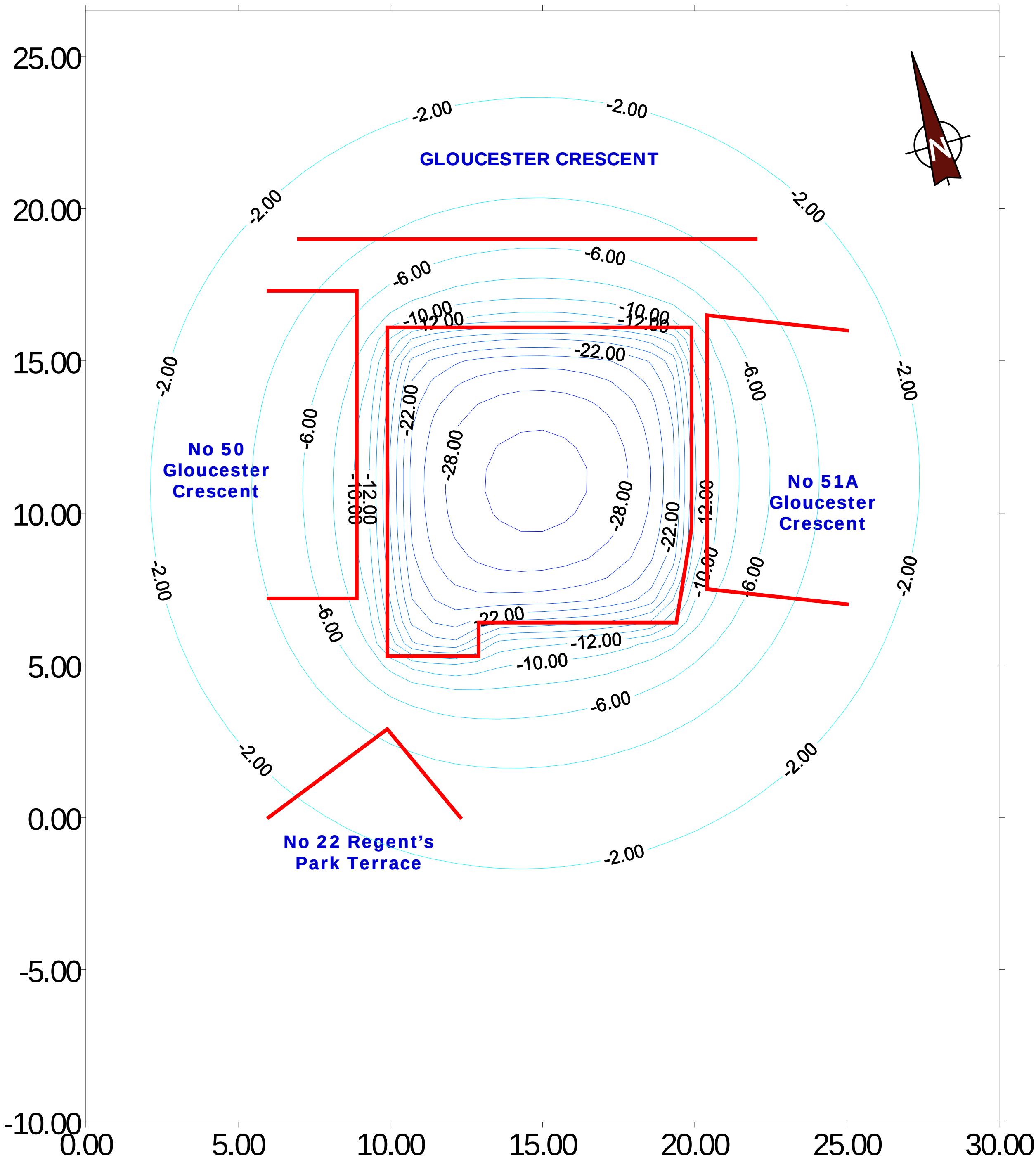
c) negative movement is upward (heave), positive movement is downward (settlement)

FIGURE 5

SoilConsultants

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: 10067A/JRCB

Contours showing heave due to basement excavation (total)



Notes:

a) contours show 100% immediate and 100% long term heave (Note: this movement is theoretical and will not actually occur)

b) contours show ground movement due to basement excavation at approximately 4.5m depth

c) negative movement is upward (heave), positive movement is downward (settlement)

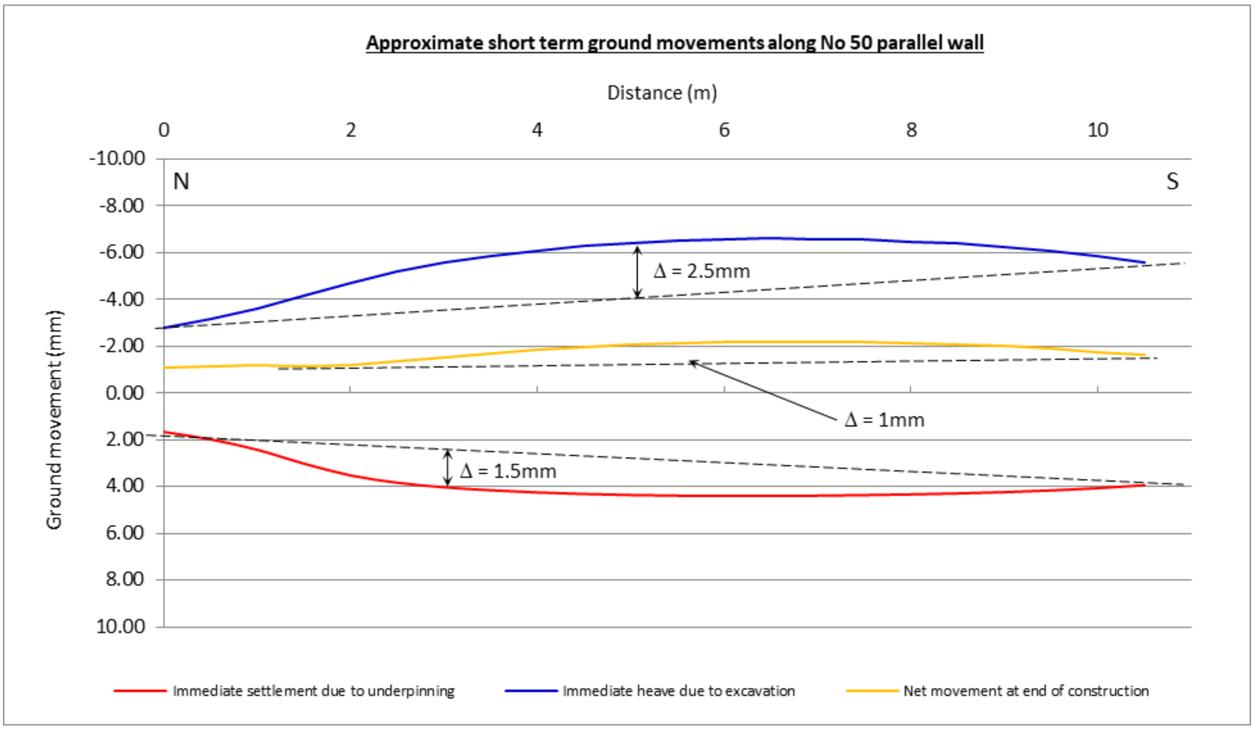
FIGURE 6

Soil Consultants

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: **10067A/JRCB**

Movement profiles along No 50 Gloucester Crescent parallel wall

Short term



Long term

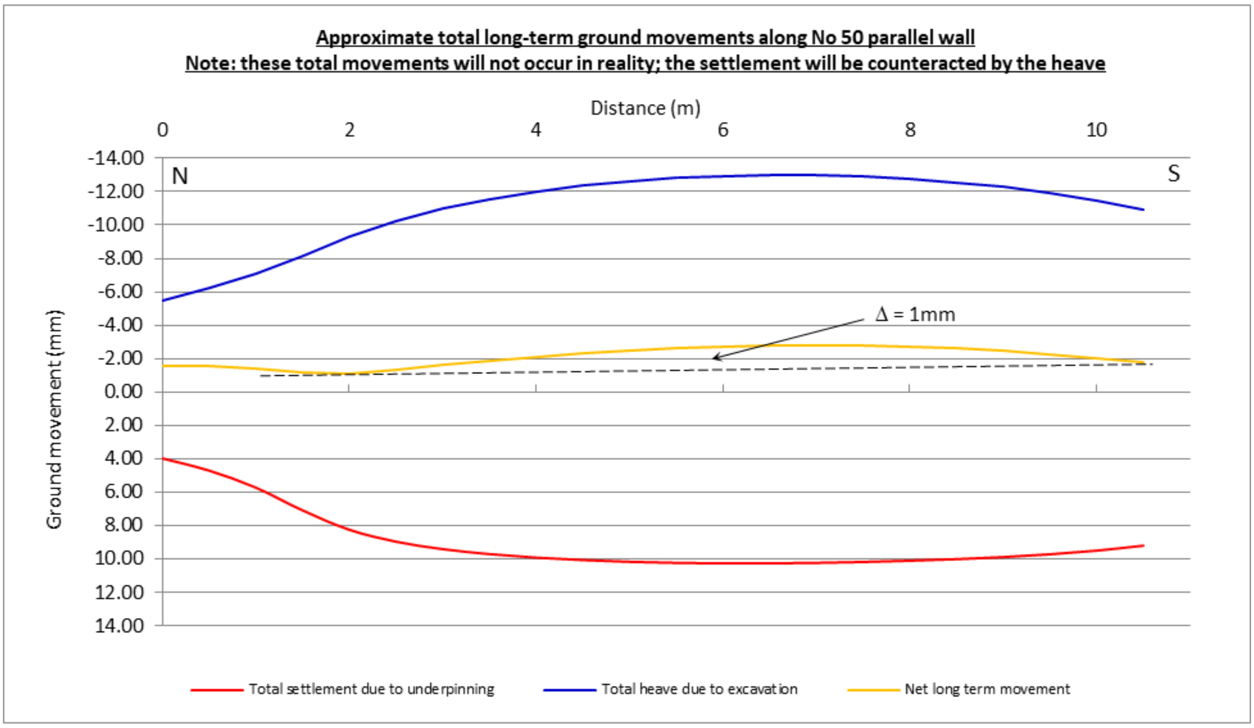


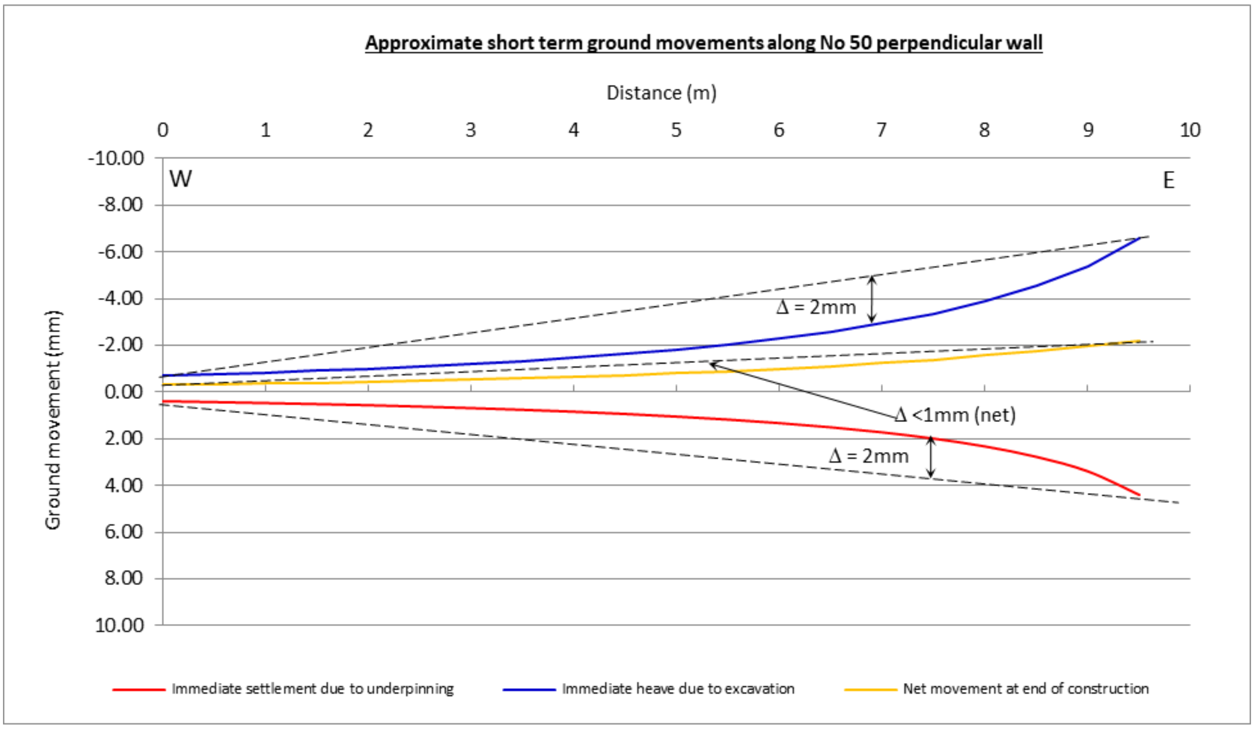
FIGURE 7

SoilConsultants

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: **10067A/JRCB**

Movement profiles along No 50 Gloucester Crescent perpendicular wall

Short term



Long term

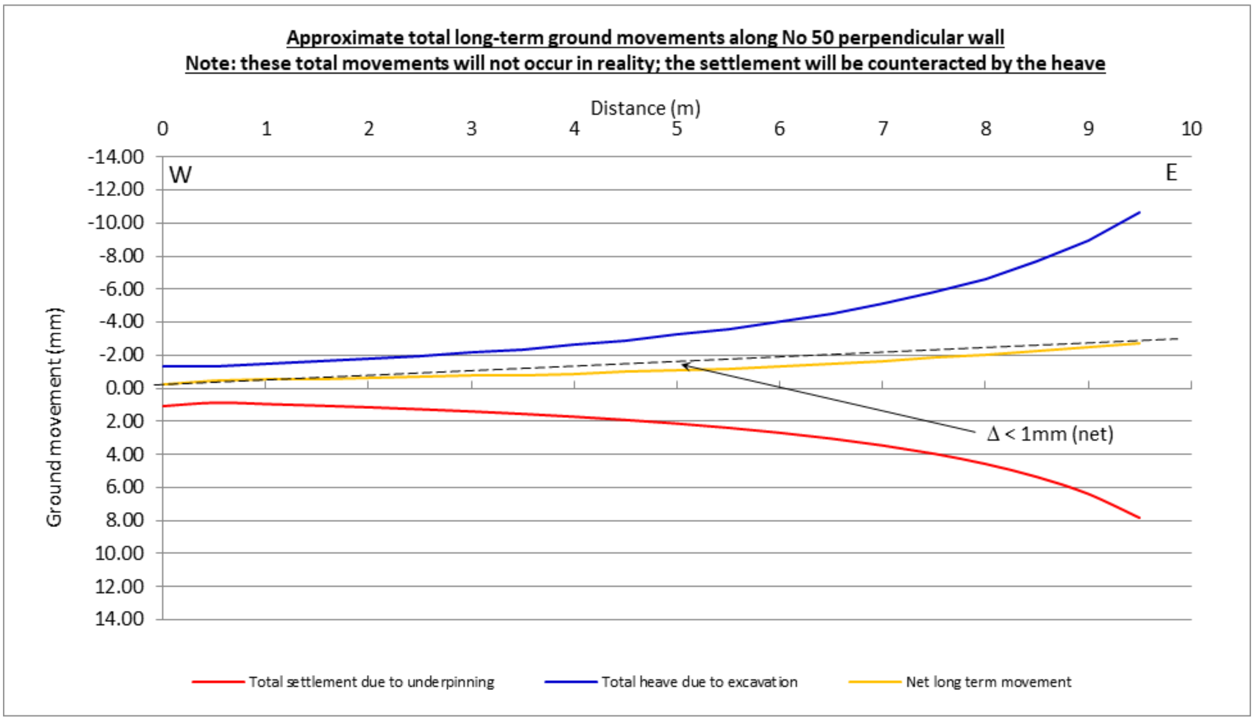
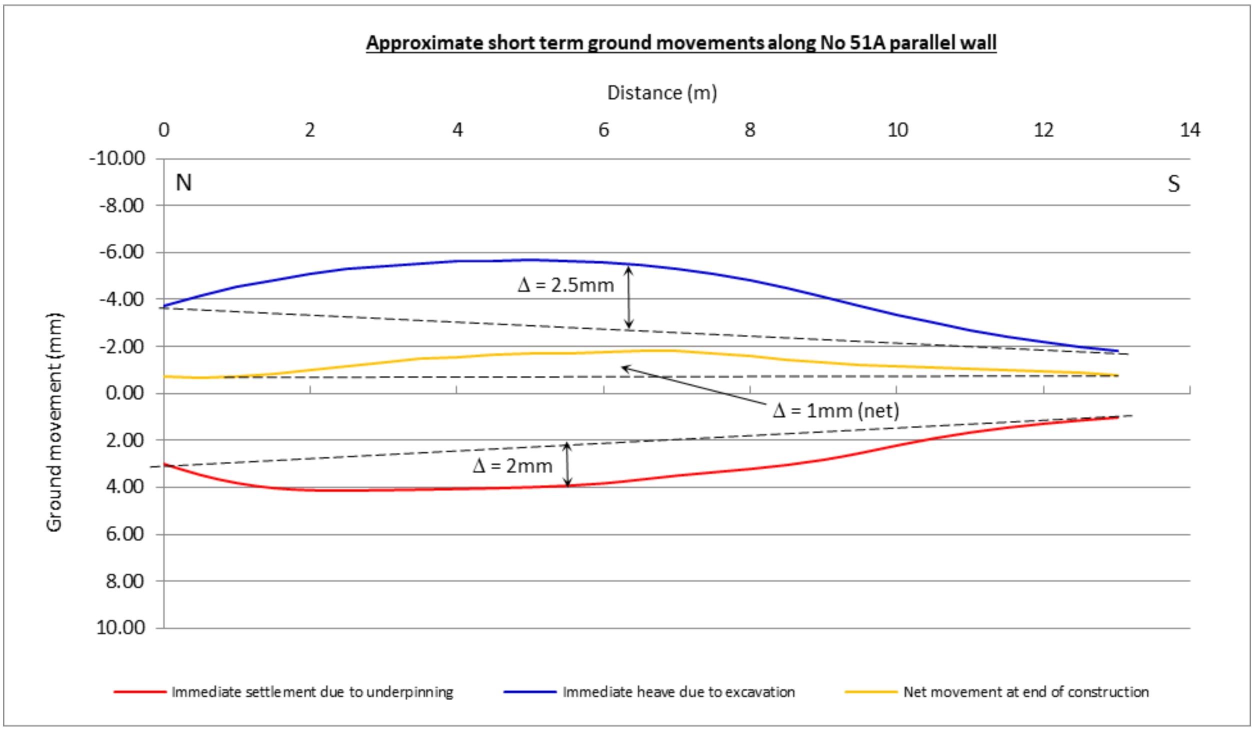


FIGURE 8

Soil Consultants

Movement profiles along No 51A Gloucester Crescent parallel wall

Short term



Long term

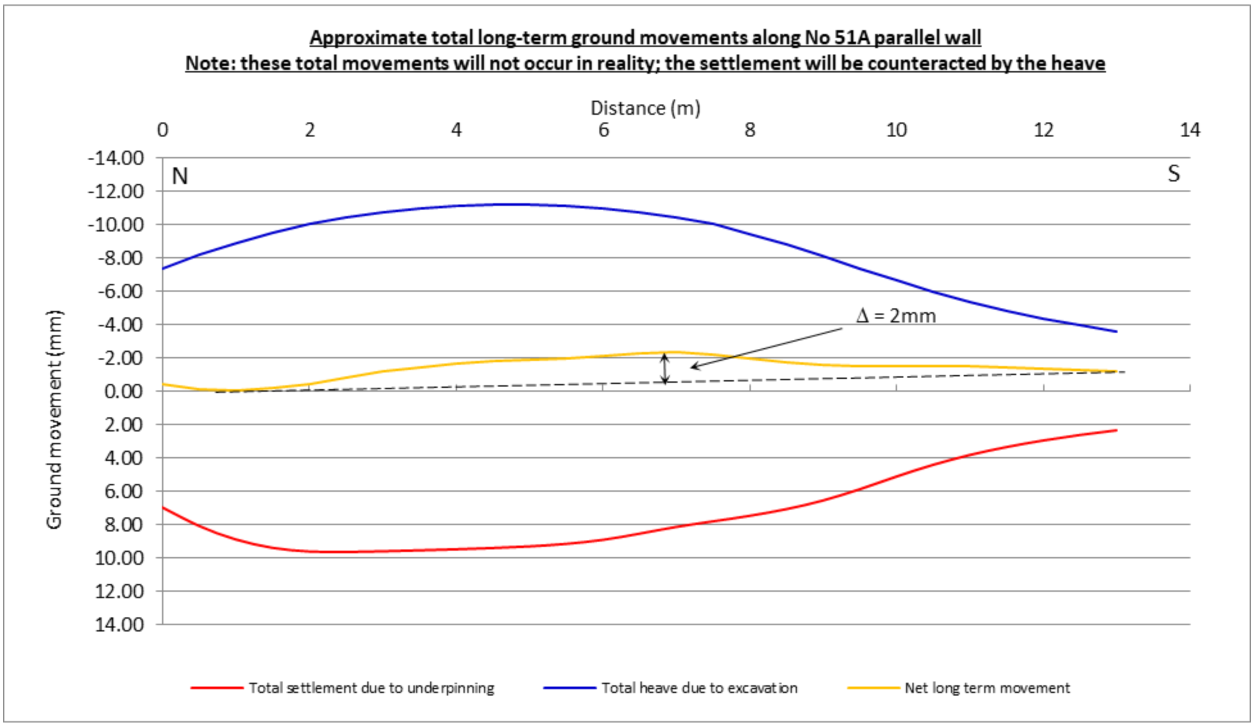
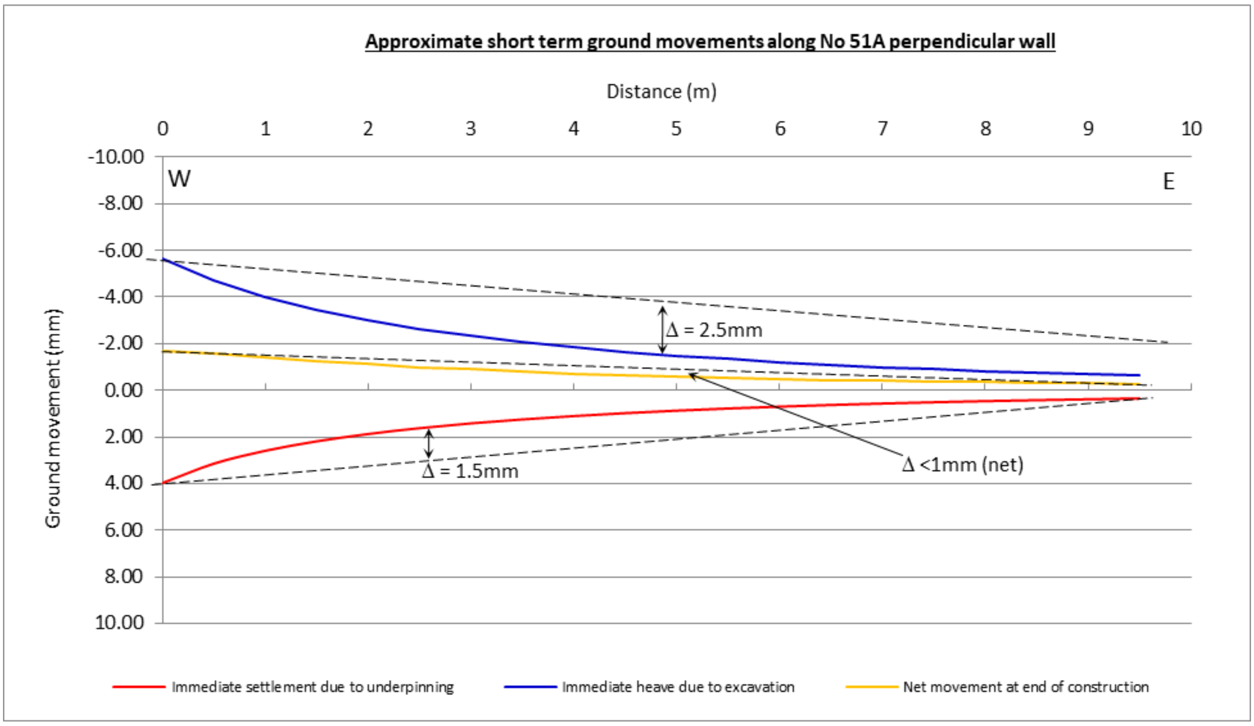


FIGURE 9

Movement profiles along No 51A Gloucester Crescent perpendicular wall

Short term



Long term

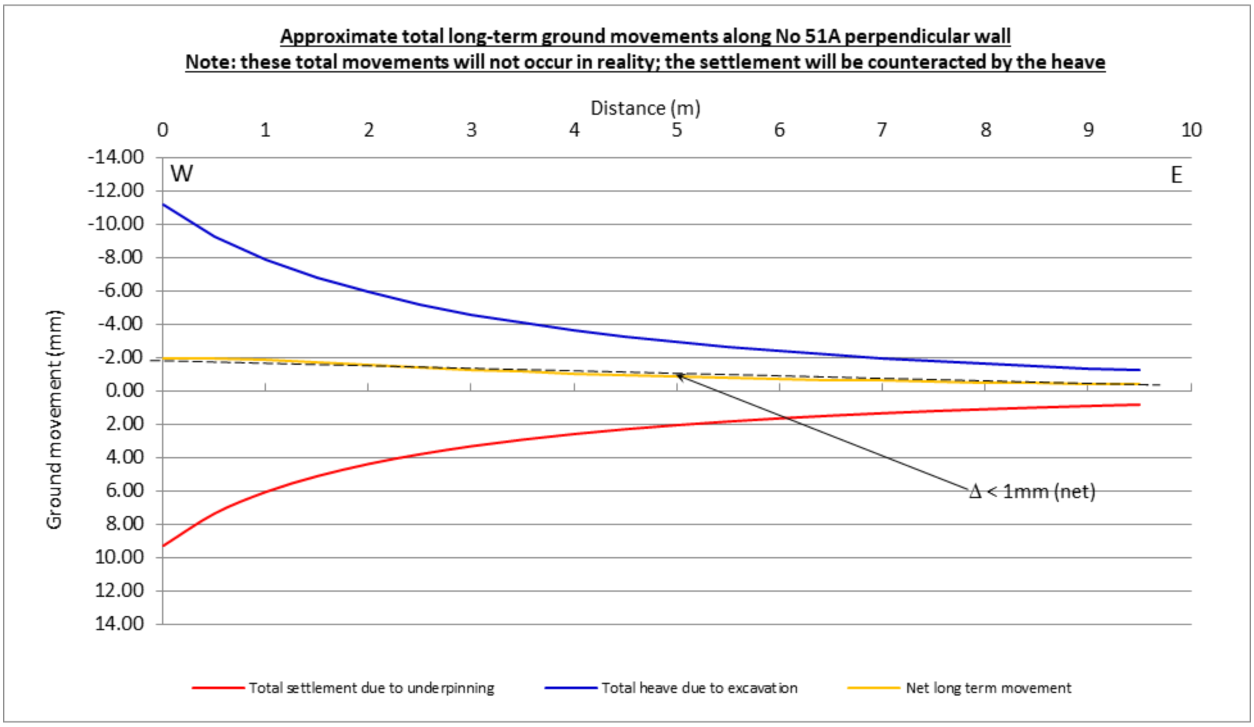
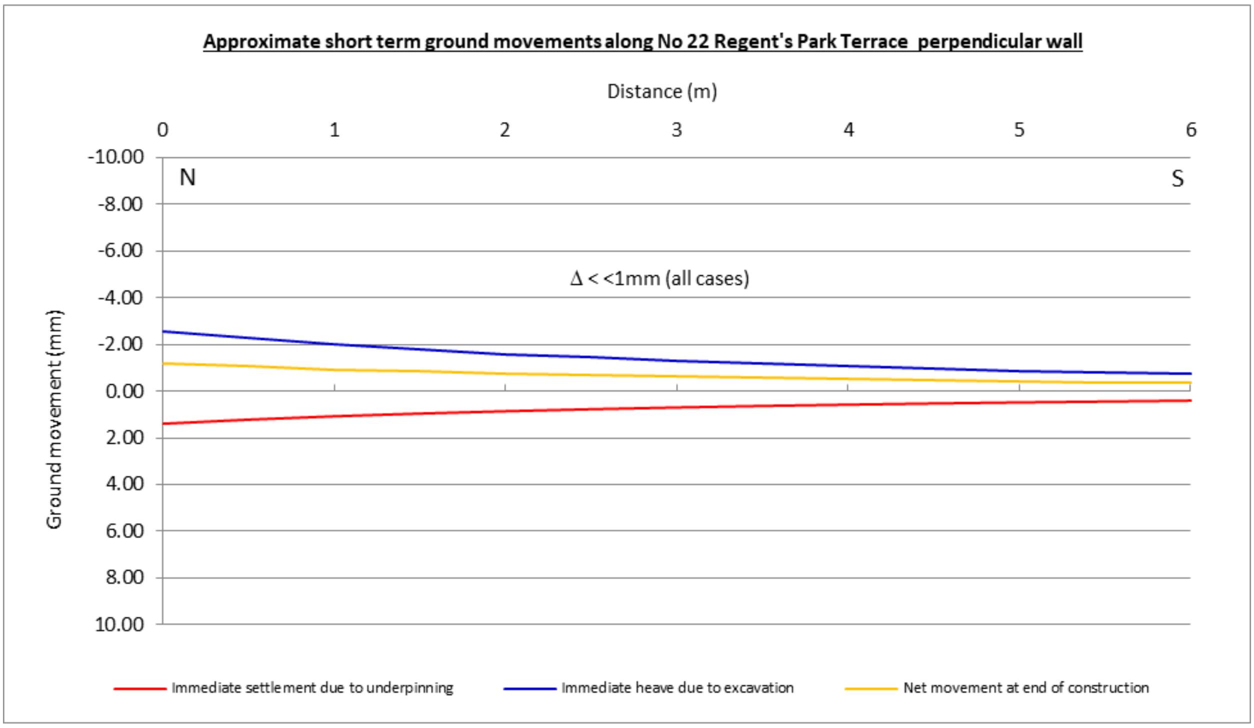


FIGURE 10

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: 10067A/JRCB

Movement profiles along No 22 Regent's Park Terrace perpendicular wall

Short term



Long term

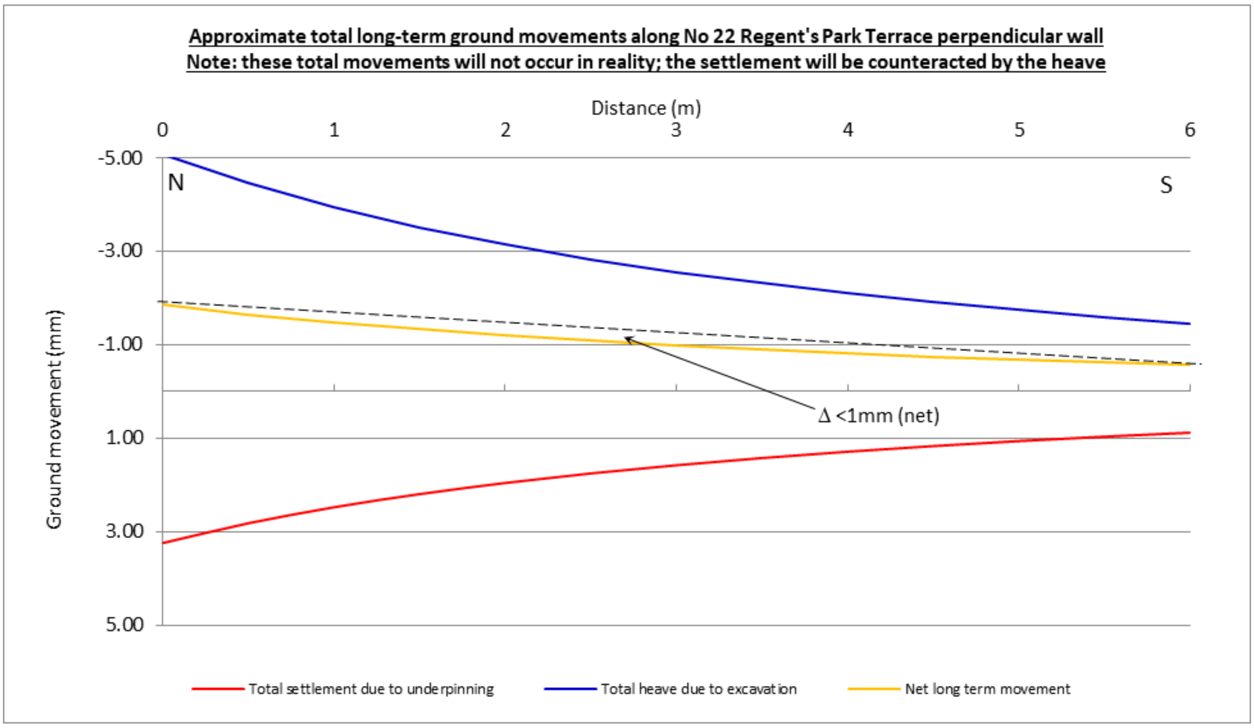


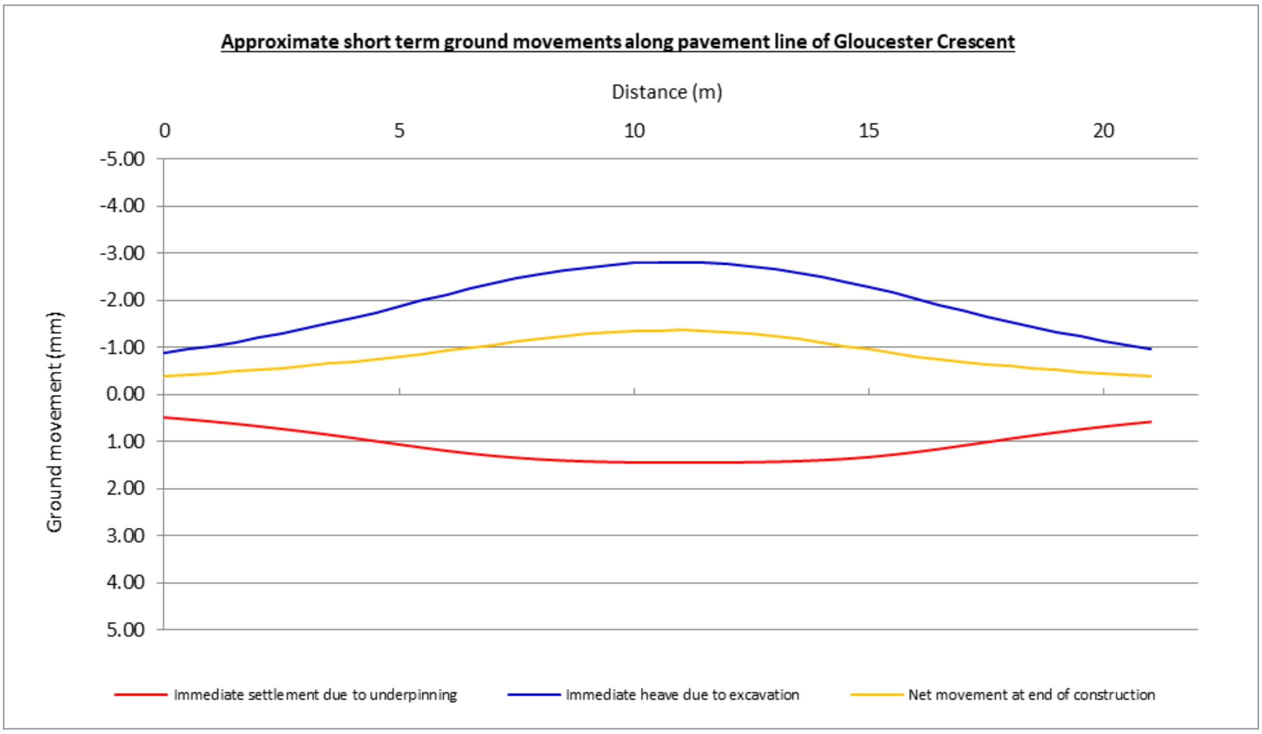
FIGURE 11

SoilConsultants

Site & Location	51 Gloucester Crescent London NW1 7EG	Report No: 10067A / JRCB

Movement profiles along Gloucester Crescent pavement

Short term



Long term

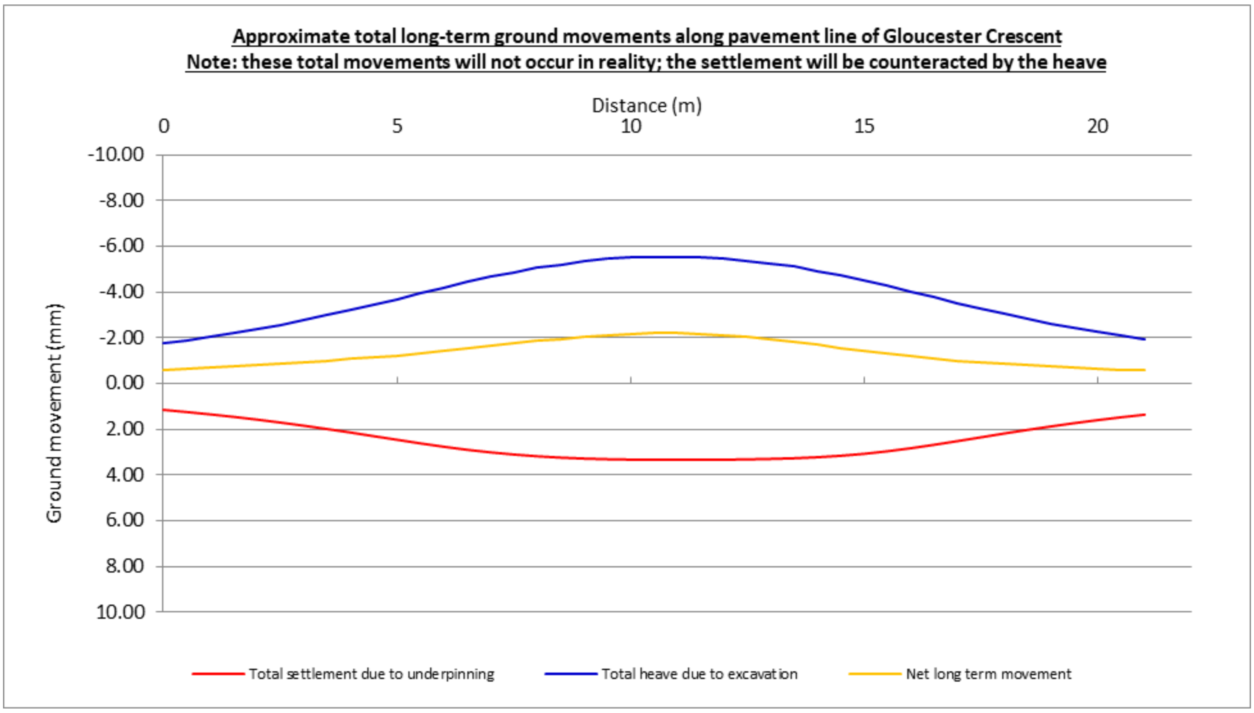


FIGURE 12