MR MARK STEINBERG

11 WADHAM GARDENS NW3 3DN

GROUND MOVEMENT REPORT

FINAL

December 2011

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1 Introduction

It is proposed to develop the site at 11 Wadham Gardens, London NW3. The proposed works include excavation under the existing dwelling and garden to form a new basement structure, including construction of a new below ground swimming pool facility, and construction of a car stacking machine within the front garden to the property. GCG have been instructed by the engineer for the scheme, Jampel Davison and Bell, on behalf of Mr Mark Steinberg, to undertake an assessment of the likely ground movements resulting from construction of the proposed scheme, to determine the potential magnitude of settlement or heave of the ground and the effects that such movements will have on the neighbouring properties.

This report summarises the available information about the site and the current scheme and presents the results of the ground movement assessment.

GCG have been supplied with information on the proposed development by Jampel Davison and Bell.

2 The property and the proposed re-development

The site is located on the north side of Wadham Gardens London NW3 (Fig. 1). It occupies a total area of approximately 18 metres by 48 metres, the longer axis being orientated approximately north-south, normal to the line of Wadham Gardens; ground level is around 50.0m OD. The site is occupied by an existing detached two storey brick built residential property with accommodation also in the roof space, which extends across almost the full width of the site, and is set back approximately 4m from the Wadham Gardens public highway. The main structure stretches for a length of about 14m, and there is a single storey extension to the rear of the property lengthening the structure by a further 8m. The rest of the site is formed by the rear garden to the property. The western section of the existing dwelling extends to the western boundary of the site, but is not structurally linked to the neighbouring property. A narrow alleyway runs between the eastern wall of the existing structure and the eastern boundary of the property, providing access to the rear garden from the front of the property and Wadham Gardens. The current structure is founded on shallow pads / strips, and has no basement.

Crossing from west to east under the back garden there is an existing Network Rail railway tunnel, the Primrose Hill (fast lines) Tunnel. This brick built tunnel of approximately 7.5m internal diameter was constructed between 1875 and 1876, and the crown of the tunnel lies at about 7m bgl. At its closest point, the tunnel is approximately 7.5m away from the rear of the house, measured in plan.

Fig 2 shows a plan of the proposed basement and a section through the site from north to south. The proposed underground development is predominantly under the existing structure, extending beyond the rearmost line of the existing structure by about 2.5m under the rear garden, such that it does not come within 5m of the plan position of the Primrose Hill rail tunnel. The sub-surface development includes a lower ground floor across the full plan area of the excavation, and an additional basement level under the rear for a swimming pool and plant room. This basement level will be locally deepened to form a drainage sump. Formation level for the Lower Ground Floor slab is approximately 4m below ground level (bgl), measured from the level in the back garden, or about 46.0m OD. Formation level for the basement slab is about 3m below the Lower Ground Floor, approximately 7m bgl or 43.0m OD. Formation level for the drainage sump will be about 41m OD.

In addition to the sub-surface development under the existing structure, a two-level ‘parklift’ vertical stacking car-parking system is to be installed at the front of the property, in the south-west corner of the site. This will require the construction of a pit with 5m internal depth, giving a formation level of about 5.5m bgl. The existing ground level at the front of the structure lies about 0.5m below the level of the rear garden, so the ‘parklift’ will require a formation level of about 44.0m OD. The excavation will be approximately 7m long by 4m.

It is anticipated that the sub-surface construction will be completed through a combination of underpinning of the existing structure and the installation of steel sheet piling, utilising the Giken silent piling ‘Press-in method’, with the use of Giken piling selected to minimise the plan area taken by the retaining wall to the excavation, and to limit noise and vibrations resulting from the pile installation process. The sheet pile wall will act to provide lateral support to the excavation during construction, and to provide a cut-off to possible water inflow into the excavation, with the permanent structural wall created by casting a reinforced concrete wall inside the piles providing the permanent waterproofing.

3 Ground Conditions

The geology of the area is shown on the British Geological Survey 1:10560 sheet TQ28NE (Fig. 3), and 1:50000 map sheet 256: North London. The site is underlain by the London Clay formation, which is believed here to be of the order of 60m thick. A BGS borehole shown on Figure 3, about 900m from the site to the south west, indicates that the geology consists of about 5m of Made Ground and drift deposits overlying nearly 80m of London Clay.

The soils of the Lambeth Group underlie the London Clay and this stratum is probably about 16 metres thick at the location of the site. About 8 metres of Thanet Sand underlie the Lambeth Group and Chalk is encountered thereafter.

A site specific desk study report and a ground investigation report have been completed by Ground Engineering Limited. One cable percussion borehole (BH1) was completed on the site to a maximum depth of 22.0m below ground level (bgl), while a window sample hole (WS2) was completed in the back garden to a depth of 10.0m bgl. Due to the limited access into the back garden restricting the size of plant that could be brought to site, it was not possible to complete intrusive works there to a greater depth. Borehole BH1 was located in the front garden, with an assumed ground level of 49.4m OD, while WS2 was completed from an assumed ground level of 49.9m bgl.

The intrusive investigations undertaken indicated that there was a layer of Made Ground present across the site. This stratum appeared to be 0.7m thick in the back garden, and 1.0m thick in front of the house, and was comprised of sandy silty clay, with gravel, ash, coal fragments and demolition waste. In BH1 in the front garden, this layer appeared distinct from the underlying soil, whereas in WS2 in the back garden, there is some indication of a gradational boundary.

Beneath the Made Ground was a firm (BH1) or soft to firm (WS2) slightly gravelly, silty clay. This was identified on the borehole logs as a Head deposit, being composed of material transported from elsewhere. Most likely, this is material eroded from the London Clay deposits up-slope to the north, in the region of Hampstead Heath. Due to the variation in ground level between the front and the back of the house, the boundary between the Made Ground and the Head varies between 49.20m OD in the back garden to 48.40m OD in the front garden. Thickness of the Head varies between 1.1m and 1.8m, giving a base level of the stratum of 48.1m OD (back garden) and 46.6m OD (front garden).

Below the Head, weathered London Clay is encountered, becoming unweathered with depth. Initially encountered as a firm or stiff, fissured clay with occasional fine gravel, as the extent of weathering decreases, it becomes very stiff, fissured clay, with occasional shell fragments. The unweathered London Clay extends to at least the base of each hole: 22.0m bgl (27.40m OD) in BH1 and 10.45m bgl (39.45m OD) in WS2. At 7.0m to 7.1m bgl (42.3m to 42.4m OD) in BS1, a weak calcareous siltstone was encountered.

The log for WS2 shows the upper layer of unweather London Clay to be unfissured, which is inconsistent with the condition of the material otherwise determined during the investigation. The base of this unfissured material layer was found to be at 3.0m bgl (46.9m OD), which places it very close to the elevation determined for the base of the Head deposit in BH1, and it is therefore suspected that this stratum was mis-logged, and that it is actually Head material (derived from London Clay).

Small live roots were identified in BH1 to 1.0m bgl, decayed tree roots were present in BH1 to 5.0m bgl and in WS2 to 3.5m bgl.

Based on this site specific ground investigation data, combined with the published BGS geological maps, an assumed stratigraphy has been developed for the site, as follows:

Made Ground	0.0	to	1.0m depth
Head (firm clay)	1.0m	to	3.0m depth
Weathered London Clay	3.0m	to	9.5m depth
London Clay	9.5m	to	approximately 60m depth.

The proposed excavation will therefore penetrate through the Head deposits and into the weathered London Clay, but will not extend into the unweathered material.

Groundwater was encountered during the intrusive works at 7.1m bgl in BH1, at the location of a siltstone, and seepage at 1.2m was noted in WS2. Inflow rates observed during drilling were very small. Long term monitoring indicates that water within the Made Ground and Head may be at about 0.5m bgl, while pore pressures in the London Clay appear to be sub-hydrostatic relative to this level. The deep aquifer (in the Chalk) at this location lies at considerable depth (Environment Agency, 2011), and will therefore not be encountered during the proposed development works.

4 Ground Movements

The proposed development works have the potential to cause ground movements through a number of processes. Pile installation can cause a degree of movement of the surrounding soil, as can the installation of underpins to the existing structure. The bulk excavation required to create the basement space may generate vertical and horizontal movements of the ground outside of the excavation, and it may also lead to a change in the total vertical stress acting at the elevation of the base of the excavation, leading to settlement or heave.

In some circumstances, the creation of an excavation can cause potential slope instability issues. The site at 11 Wadham Gardens is generally flat and level, with no significant slope. Therefore, while support to the excavation will be required to prevent localised failure of the excavation walls, there is no credible risk of broader slope instability being caused by the proposed works.

4.1 Movements due to underpinning, pile installation and excavation.

The magnitude and extent of ground movements resulting from installation of a piled retaining wall and excavation in front of such a wall are typically estimated based on the guidance given in CIRIA publication C580 *Embedded retaining walls – guidance for economic design*. The guidance in the CIRIA publication is based on the behaviour of embedded walls at numerous sites in London. These are predominantly walls embedded in London Clay, though typically with some near surface deposits composed of other materials, and it is therefore evident that the ground conditions at 11 Wadham Gardens are consistent with the data set on which the CIRIA guidance is based.

The basic data in the CIRIA guide refers to the effects of excavations and retaining walls acting in plane strain; that is, it takes no account of the plan geometry of the excavation, and the stiffening effects of corners to the excavation, though an appendix to the guide does note that movements around corners are significantly reduced in practice.

The proposed excavation at 11 Wadham Gardens is relatively small when viewed in plan, and so the stiffening effect of the corners to the excavation should help reduce movements all around the perimeter of the excavation, as compared to the maximums indicated by the CIRIA report.

It is proposed to install the piled retaining wall to the excavation using the Giken ‘silent piling’ system with ‘Zero’ sheet piles. This may be installed using a standard push-in mode, or using water jet mode; given the depth of the proposed excavation and the maximum length of piles installed using this technique, it is likely that the water jet mode will be utilised.

Pushing piles into the ground generally causes displacement of the soil, leading to movements of the ground either side of the pile up and away from the pile. However, the Giken ‘Zero’ piler is designed to install piles within 50mm of an adjacent structure. No significant ground movements affecting neighbouring properties (including the network rail railway tunnel) are therefore likely to result from the pile installation process.

Movements resulting from excavation in front of the wall are dependent on the depth of the excavation and the stiffness of any support system installed. The excavation generally will be about 7m bgl; under the existing structure, the depth will be less, and there will be a localised sump extending to 9m bgl, however, the size of this sump is such that it will not have a significant effect on the ground response to the excavation. Given the close proximity of the excavation to neighbouring structures and that it extends under the existing structure at 11 Wadham gardens, it is anticipated that the excavation will be propped using a high-stiffness support system. Current proposals show three levels of support to the excavation (see Figure 4), which for an excavation of this size and depth, should provide a very stiff response.

From the CIRIA guide C580, the maximum vertical movement resulting from the excavation of a 7m basement supported by a retaining wall with high-stiffness support is 0.1% of the excavated depth, with a corresponding horizontal movement of 0.15% of the depth. Thus, ground settlement of around 7mm may be expected around the piles following excavation of the basement, with horizontal movement inward of the pile head of around 10mm. Ground movements may extent up to 4 times the depth of the excavation, so negligible ground movements would generally result from the works beyond 28m. However, given the size of the excavation in plan, and the effects of the existing house and underpins, these theoretical movements are likely to be much reduced, both in the magnitude of movements and in the extent to which they occur. Moreover, the database on which the CIRIA figures are derived from is for excavations 8m or more deep; the proposed excavation is thus on at the lower limit of the data range for which these relationships apply. It is thus unlikely that significant ground movements will occur as a result of excavations much beyond twice the excavated depth, or 14m. Thus movements will affect the neighbouring 9 Wadham Gardens and 13 Wadham Gardens, but should not extend beyond these properties. Since the crown of the network rail tunnel is below the general formation level of the basement and lies 5m from the proposed works at its closest approach, and sub-surface movements extend less far from the excavation than surface movements, it is not anticipated that ground movements following excavation will impact on the tunnel.

Given their close proximity to the property boundaries, the neighbouring properties will likely experience close to the maximum predicted ground movements, with settlements and horizontal displacements approaching 5mm, allowing for the stiffer nature of the excavation due to its shape and size. Movements on the far side of these structures will be negligible, so strains acting across the structures will be around 0.05% strain. CIRIA C580 includes details of the Burland damage classification system, and a horizontal strain of this magnitude which suggests that damage to 9 and 13 Wadham gardens will fall into category 1: very slight, resulting in the formation of fine cracks, remediated during normal redecoration. The actual nature and extent of any damage will however, depend on the precise nature of the construction of these properties. For example, both 9 and 13 Wadham Gardens are known to have a rear conservatory, and the predicted ground movements may lead to cracking between this and the main structure, leading to a loss of weather tightness where the structures connect.

The effects of the proposed underpinning under the existing residential property on 11 Wadham Gardens are not anticipated to be significant. It is proposed to complete the underpinning sequentially, using five sets of pins, to be installed externally from the structure. Additionally, piles are to be installed within the existing structure, to provide temporary support during the construction works. The excavation will then be undertaken top down within the existing house, in three lifts, with three levels of temporary support installed during the process. The combined effects of the temporary bracing and the existing structure will provide for a very stiff excavation, and ground movements should not exceed those anticipated for the piled excavation for the rear part of the basement.

In addition to the main basement excavation, the redevelopment of the property is also proposed to include a 'parklift' car stacking system, which will involve a piled excavation to approximately 5.5m depth, to the front of the existing residential structure, close to the boundary with 9 Wadham Gardens. This will be a relatively small excavation, so the stiffening corner effects will help to limit ground movements to a greater extent than for the main excavation. Since the 'parklift' pit will be less deep than the main excavation, and is further from the structure of 9 Wadham Gardens, it is not anticipated to exacerbate the ground movements experienced by this neighbouring property.

4.2 Movements due to change in vertical loading

In addition to the horizontal and vertical movements caused by pile installation and the excavation, the removal of soil to create the basement space will likely cause a change in the vertical stress acting at the formation level.

Based on the assumed excavation depth of 7m over the rear part of the basement excavation, the ground will be unloaded by approximately 140 kN/m^2. Under the existing residential property, the proposals are for only a single level of excavation, to the lower-ground floor level, with the excavation being approximately 4m bgl, giving a change in total vertical stress of about 80kN/m^2. The 'parklift' to the front of the property requires an excavation of approximately 5.5m, giving in reduction in vertical load of 110 kN/m^2.

As assessment of the likely ground movements resulting from these values of unloading was undertaken, using undrained (short-term) soil parameters, reflecting likely behaviour of the soil in the immediate aftermath of excavation, before any new construction has occurred.

For the long term case, the analysis was re-run, using appropriate drained soil parameters, but with the magnitude of the unloading reduced, to allow for the effect of the permanent structural works. Since the final internal layout is still at the time of the analysis under review, the permanent dead load from the new structure was very conservatively taken as equivalent to 1m thick of concrete over the two-level basement and 0.5m under the existing house (approximately equivalent to the total sum thickness of concrete slab to be included in the basement development), giving net unloading of 116 kN/m^2 over the extent of the deep basement and 70 kN/m^2 under the house. The weight of water within the swimming pool was not included with the total weight of the structure, since this is not a fixed load but can be removed (the pool can be drained).

The effects of the sump beneath the 7m deep slab were not explicitly modelled, since this feature is small in size, and the approach to modelling possible heave was otherwise conservative.

The effects of vertical load change were modelled using the OASYS program PDISP (v19.2). This program assumes a linear elastic behaviour of the soil and a flexible structure. In reality, the proposed development will have a finite stiffness which will restrict movements of the soil, tending to reduce the magnitude and smooth out the distribution of ground movement. Additionally, the piled retaining wall and loads imposed through the underpinning under the main house will act to restrict any heave movements that are predicted to occur outside of the excavation. The predicted ground movements therefore represent free field movements, unaffected by the stiffness of the structure, and are therefore likely to be conservative. Details of the parameters used within the analysis are included in Appendix A.

The short term assessment indicated ground heave will occur, with around 15mm of movement within the 7m deep portion of the excavation (peak value 17mm), and 10-15mm under the existing house (see Figure 5). Heave immediately adjacent to the boundary of the excavation is predicted as 5-10mm, while at the distance from the excavation of the neighbouring properties, heave of about 2mm is indicated. As noted, the output from PDISP takes no account of the stiffening effects of structures and of the piled retaining walls, and allowing for these effects suggests that no significant short term heave of the neighbouring structures will occur.

The long term analysis showed a higher magnitude of maximum heave, with ground movements acting over a larger area. Heave under the 7m excavation is shown to be in excess of 25mm, with a peak value of about 30mm; under the existing house, heave values of 20 to 25mm are predicted (see Figure 6). Outside the excavation, the near faces of the adjacent properties are predicted by the PDISP analysis to undergo heave of 4-8mm, with less than 2mm on the far side of the property. These values are all overall gross movements, not net movements after the short term case. Moreover, as previously stated, the load imposed by the proposed new structure was modelled very conservatively, and in practice it is anticipated that the long term unloading of the soil will be significantly lower than was assumed herein, leading to a smaller magnitude of heave. Additionally, the effects of the structure and the piled wall will act to reduce long term ground movements outside of the excavation just as they will affect the short term movements. It is therefore anticipated that the long term heave of the ground resulting from the proposed basement construction will cause the near face of the neighbouring buildings to move up by less than 5mm, with negligible movements on the far side of these buildings.

It may be noted that the reduction in vertical stress caused by the excavation tends to generate heave (upward) movement, and therefore any heave that does occur outside of the excavation box will tend to counteract the settlements likely to occur during pile installation and excavation. Hence although heave movements are likely to be low, such movements as do occur may be expected to have a positive influence overall, mitigating the effects of settlement from the excavation to some degree.

5 Comments

The proposed development at 11 Wadham Gardens involves excavating to a depth of 7m bgl (locally, 9m bgl) and will inevitably cause some degree of ground movement surrounding the excavation, with the associated potential to cause movement and possibly damage to the existing structure on the site and the neighbouring structures.

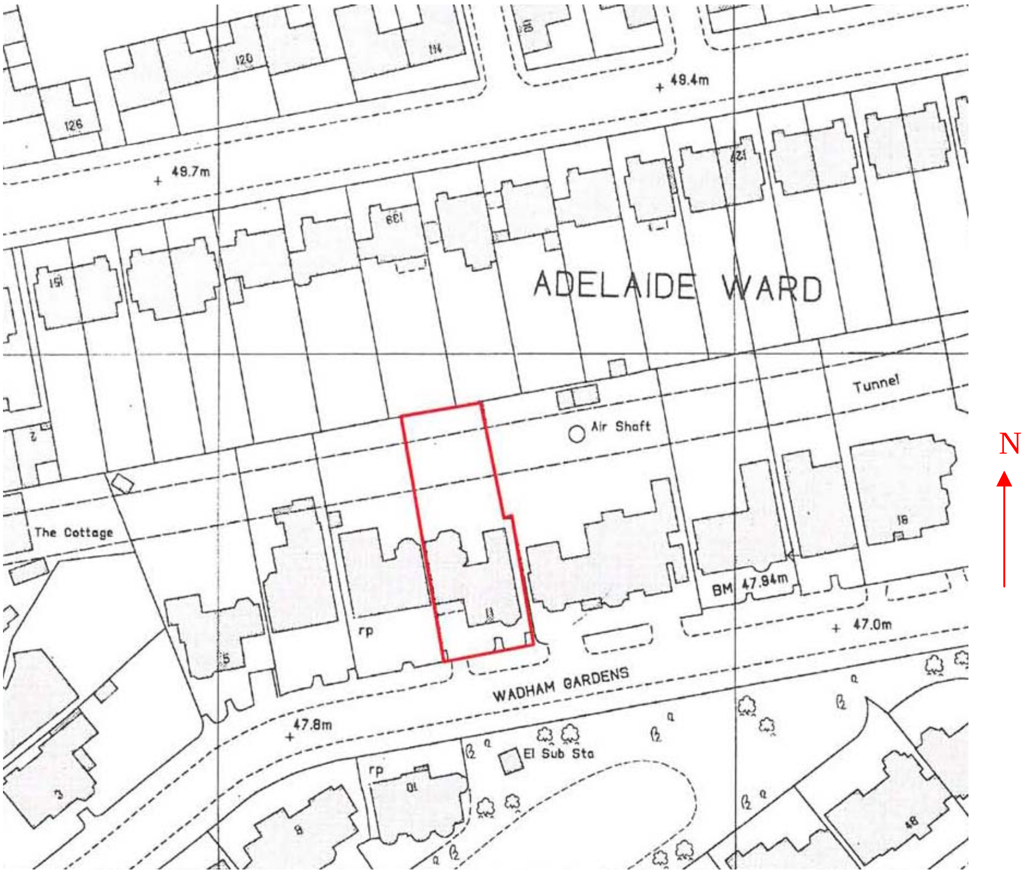
The proposed works include measures to minimise disturbance to both existing and neighbouring properties, through the use of push-in ‘silent piling’, which will also contribute towards controlling ground movements during pile installation. Proposed extensive bracing should provide tight controls on ground movements during the excavation process. The excavation is expected to result in an overall reduction in the total vertical stress acting at formation level, and therefore a measure of ground heave is to be expected, though any such movements will in part counteract any settlements caused directly by the excavation process.

Overall, it is not anticipated that the proposed excavation will cause ground movements such that significant damage is caused to any neighbouring properties, nor is it expected that the proposed works will cause non-trivial damage to the existing structure at 11 Wadham Gardens, though throughout the excavation and construction process, it would be appropriate to maintain a strict system of control on the works, to ensure that they are undertaken to a high quality of workmanship.

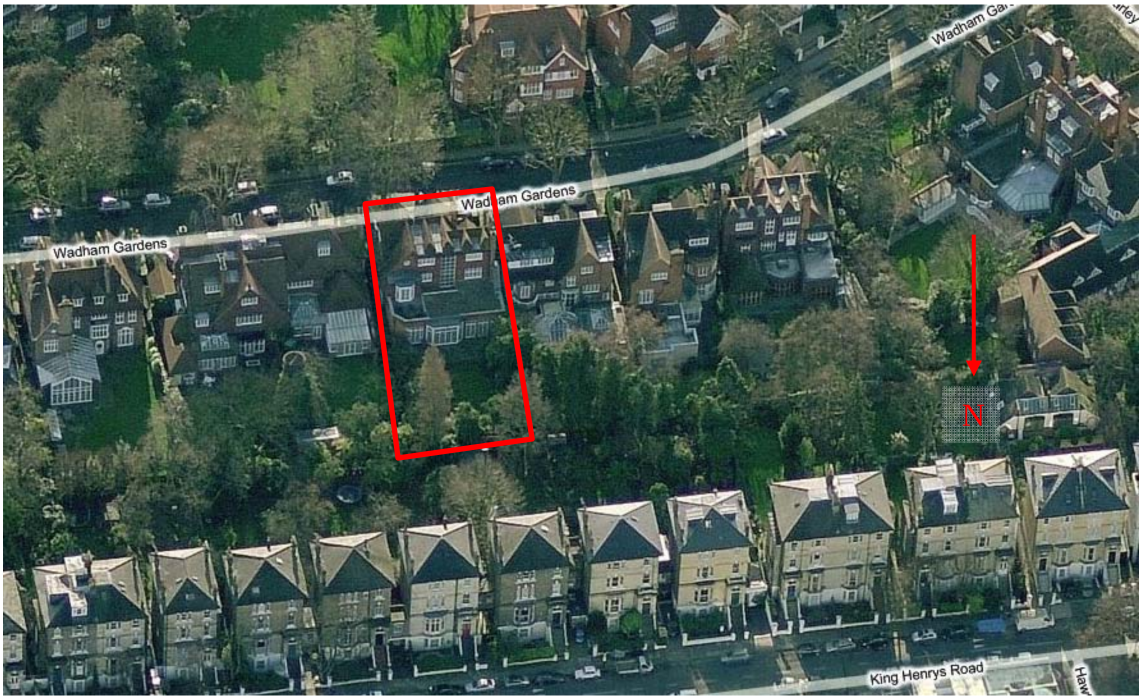
References :

BGS map sheet TQ28NE (1:10,560).
BGS map England and Wales Sheet 256 North London (Solid and Drift). 1:50,000.
CIRIA (2003): Embedded retaining walls – guidance for economic design. C580.
Environment Agency (2011): Management of the London Basin Chalk Aquifer.
Ground Engineering Limited 2011: Desk study report. 11 Wadham Gardens, Camden London NW3. Report Reference No. C12520. November 2011.
Ground Engineering Limited 2011: Ground Investigation Report, 11 Wadham Gardens, Camden London NW3. Report Reference No. C12520a. November 2011.
Ordnance Survey Explorer sheet 173: London North (1:25,000).

FIGURES



(a)



(b)

Figure 1: Site location, (a) street and (b) aerial view

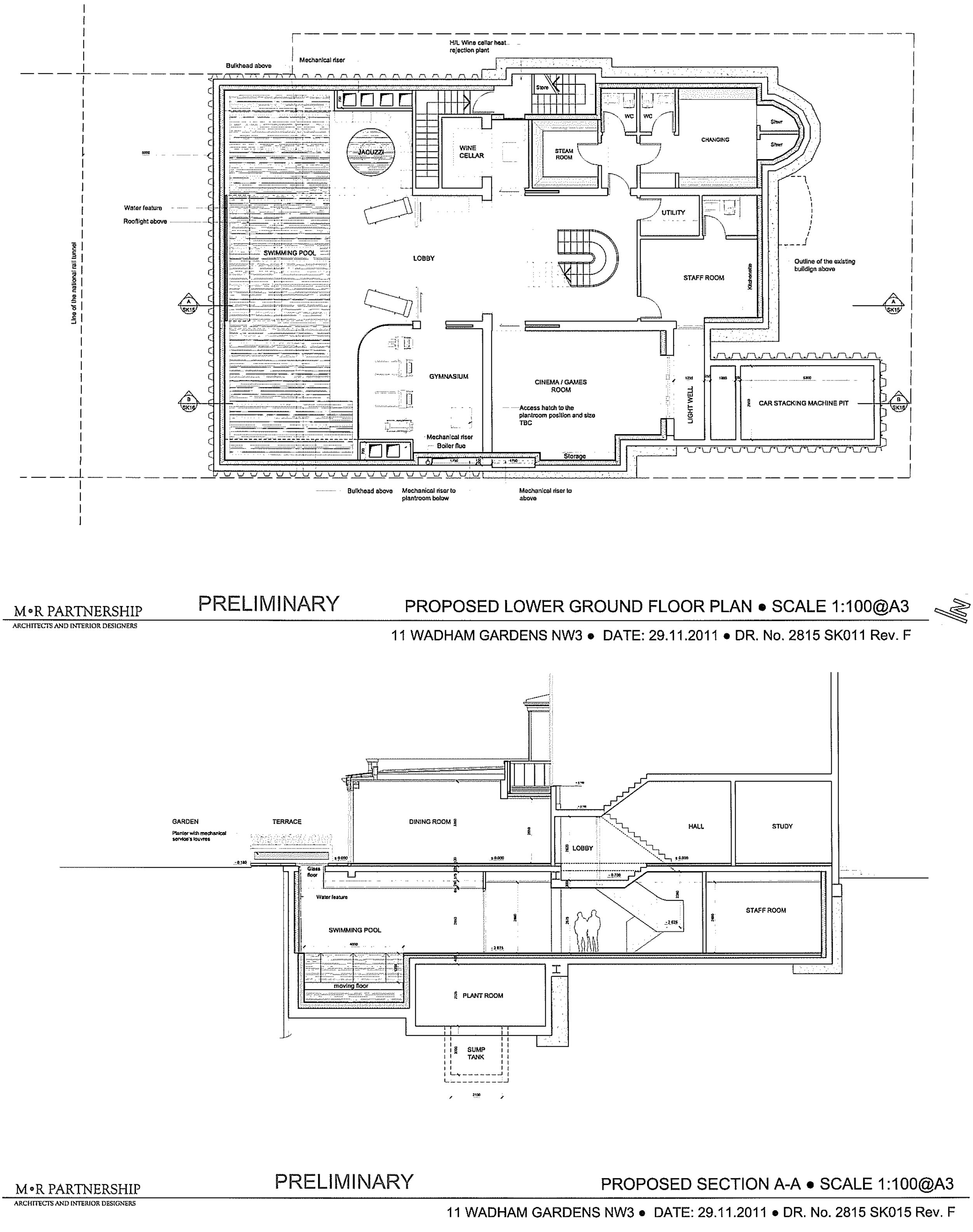


Figure 2: Proposed basement plan and North - South section

Note that details are provisional.

Figure 3: Geology of the area - extract from the British Geological Survey 1:10560 sheet TQ28NW.

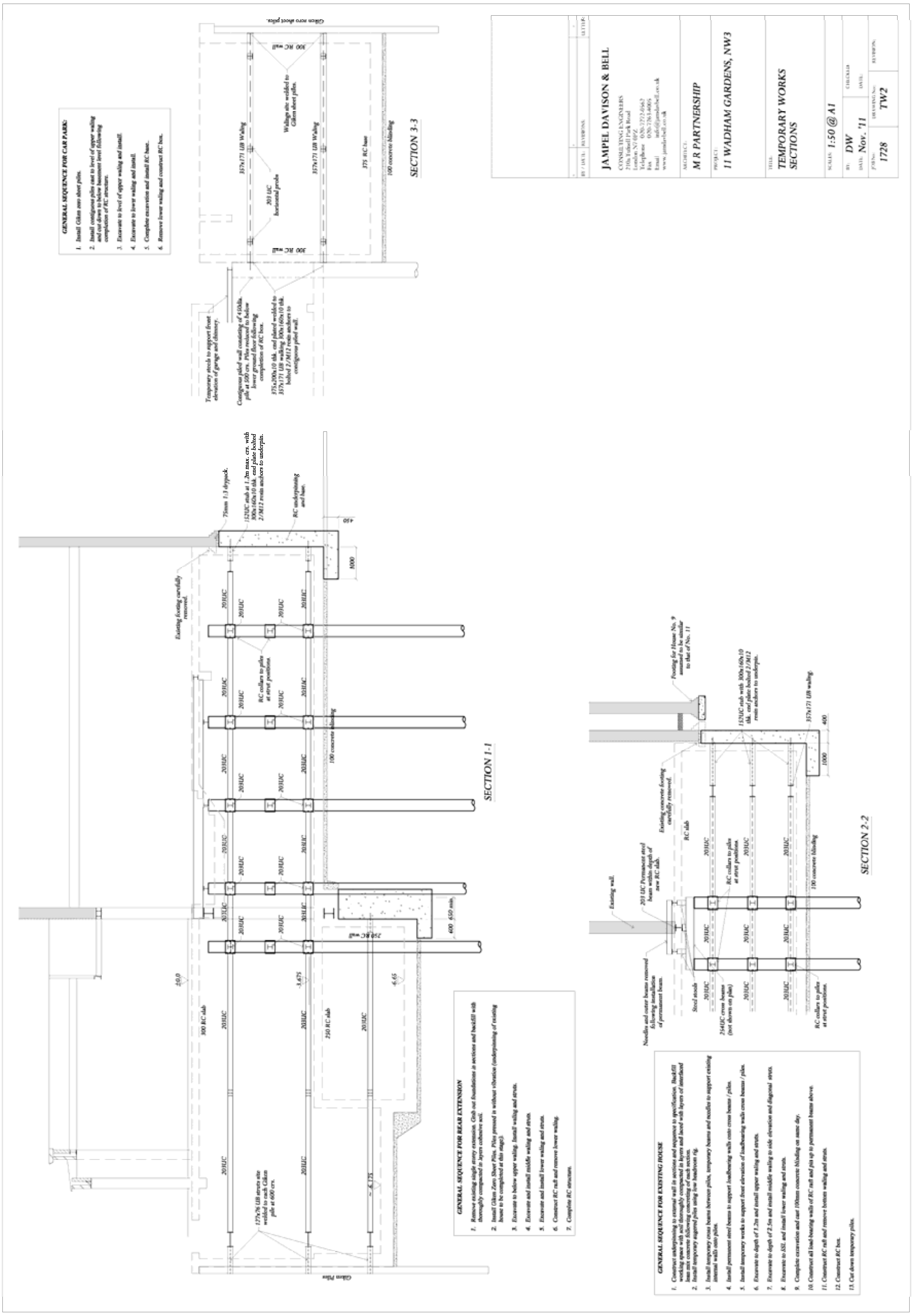


Figure 4: Proposed temporary works

Oasys

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11 Wadham gardens
Undrained assessment
Heave assessment

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Drg. Ref.		
Made by PGS	Date 30-Nov-2011	Checked

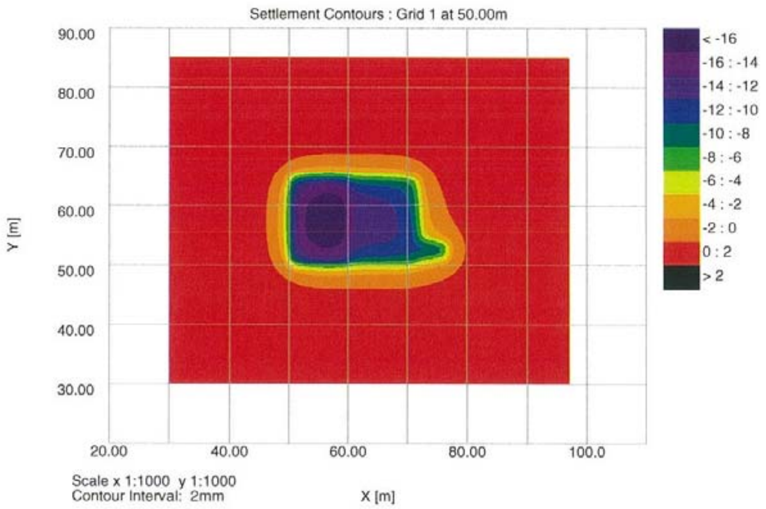

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Figure 5: PDISP output contour plot, undrained (short term).

Oasys

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11 Wadham gardens
Drained assessment
Heave assessment

Job No.	Sheet No.	Rev.
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Drg. Ref.		
Made by PGS	Date 30-Nov-2011	Checked

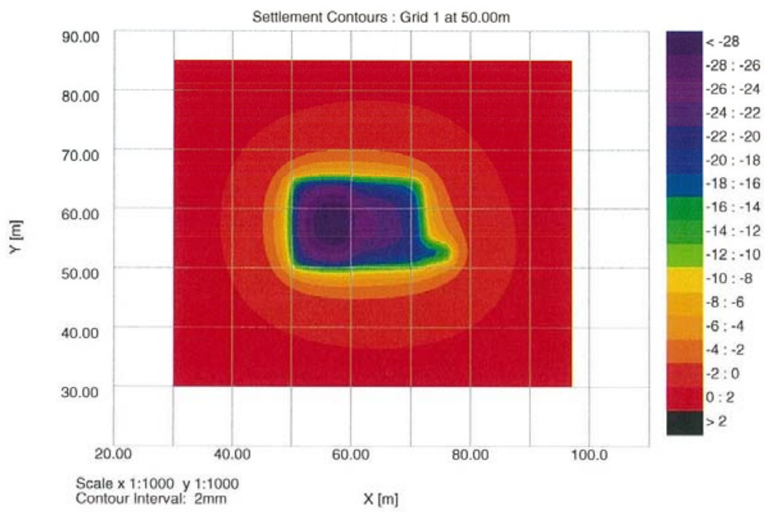

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Figure 6: PDISP output contour plot, drained (long term).

APPENDIX A

11 Wadham Gardens – Soil Stratigraphy and Properties

Undrained assessment (short term case).

Strata	Level at top (mOD)	Young's Modulus (kPa)		Poisson's ratio
		Top	Bottom	
Made Ground	50.0	5000	5000	0.50
Head	49.0	8500	25500	0.50
Weathered London Clay	47.0	25500	34000	0.50
London Clay	40.5	34000	64000	0.50

Rigid boundary taken as -30.0m OD

Drained assessment (long term case).

Strata	Level at top (mOD)	Young's Modulus (kPa)		Poisson's ratio
		Top	Bottom	
Made Ground	50.0	3750	3750	0.20
Head	49.0	6375	19125	0.20
Weathered London Clay	47.0	19125	25500	0.20
London Clay	40.5	25500	48000	0.20

Rigid boundary taken as -30.0m OD