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Your Ref:

Our Ref: Ref: 15/23908-2
March 2017

15 LYNDHURST TERRACE,

LONDON NW3 5QA

BASEMENT IMPACT ASSESSMENT

Original Submission: November 2015

Revised Submission: March 2017

Prepared for

Emanuel and Carmel Mond

CONTENTS

1.0 NON TECHNICAL EXECUTIVE SUMMARY

1.1 Brief

At the request of Heyne Tillet Steel working on behalf of Emanuel and Carmel Mond, a Basement Impact Assessment has been carried out at 15 Lyndhurst Terrace, London, NW3 5PB in support of a planning application for a proposed development to the property which includes the demolition of the existing property at the site and construction of a new three to four-storey residential property including a single storey basement to 3.00m maximum depth (46.50mSD).

1.2 Desk Study Findings

From historical map evidence it would appear that the current property was constructed between 1974 and 1979 and has remained unchanged since its initial construction. Prior to the 20th century, the surrounding area was mostly agricultural followed by a large amount of urbanisation around the turn of the century. The surrounding area has been predominantly residential for the last 100 years or so.

1.3 Ground Conditions

The investigation has confirmed the expected ground conditions in that, below a small thickness of Made Ground, the Claygate Member was encountered overlying the London Clay, which was proved to the full depth investigated. The Made Ground extended to depths of between 0.40m to 1.20m depth below ground level (48.90 to 49.54mSD) and comprised pea gravel or brick paving over silty sandy clay with brick fragments. The underlying Claygate Member comprised soft becoming firm and then stiff silty sandy clay with lenses of clayey silty fine sand which extended to depths/levels of 9.40m (40.10mSD) in Borehole 1 and to the full depths of investigation of 8.30m in Boreholes 2 and 3 (41.30 to 42.20mSD) and 0.85m in Trial Pit 1 (49.24mSD). The London Clay Formation was encountered below the Claygate Member and consisted of stiff silty clay with occasional partings of silty fine sand and scattered gypsum crystals which extended down to the full depth of investigation of 15.00m below ground level in Borehole 1 (34.50mSD). All the boreholes were equipped with water monitoring standpipe piezometers with the response zones being from 3-6m depth. Groundwater was not subsequently encountered in these monitoring standpipes in July, August and September 2015 with return visits in December 2016 and February 2017.

1.4 Recommendations

Formation level of the 3.0m deep basement is likely to be within the Claygate Member. Groundwater was not encountered below the depth of the basement, although it would be recommended to continue to monitor the standpipes for as long as possible. Monitoring has been carried out over three seasons, with no groundwater encountered and give a good indication of seasonal variation on site. The chosen contractor should also have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

Trial excavations to the proposed basement depth could be carried by the main contractor to confirm the stability and composition of the soil and to further investigate the presence of any groundwater inflows.

1.5 Previous Planning Application

A previous planning application (Ref: 2015/6278/P) was registered in December 2015 and refused in February 2016. The contents and revision of this report address the comments made in relation to this previous application.

2.0 INTRODUCTION

2.1 Project Objectives

At the request of Heyne Tillet Steel working on behalf of Emanuel and Carmel Mond, a Basement Impact Assessment has been carried out at the above site in support of a planning application.

The purpose of this assessment is to consider the effects of a proposed basement construction on the local slope stability, surface water and groundwater regime at the existing residential property.

The recommendations and comments given in this report are based on the information contained from the sources cited and may include information provided by the Client and other parties, including anecdotal information. It must be noted that there may be special conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken into account in the report. No liability can be accepted for any such conditions.

This report does not constitute a full environmental audit of either the site or its immediate environs.

2.2 Planning Policy Context

The information contained within this BIA has been produced to meet the requirements set out by Camden Planning Guidance – Basements and Lightwells (CPG4) including Camden Development Policies DP27 – Basements and Lightwells (July 2015) in order to assist London Borough of Camden with their decision making process.

As recommended by the Guidance for Subterranean Development (Ref 1) the BIA comprises the following steps

1. Initial **screening** to identify where there are matters of concern
2. **Scoping** to further define the matters of concern
3. **Site Investigation and study** to establish baseline conditions
4. **Impact Assessment** to determine the impact of the basement on baseline conditions
5. **Review and Decision Making** (to be undertaken by LBC)

2.3 Qualifications

The qualifications required by Camden are fulfilled as documented in Table A below. All assessors meet the qualification requirements of the Council guidance.

Subject	Qualifications Required by CPG4	Relevant persons and qualifications/experience	
		Name/Qualifications	**Experience**
Surface flow and flooding	A hydrologist or a Civil Engineer specialising in flood risk management and surface water drainage, with either: • The 'CEng' (Chartered Engineer) qualification from the Engineering Council; or a Member of the Institution of Civil Engineers ('MICE') • The CWEM (Chartered Water and Environmental Manager) qualification from the Chartered Institution of Water and Environmental Management	Mr Neil Smith Eur Ing, BSc (Eng), MSc, CEng, FICE, FGS	40+ years' experience in geotechnics and hydrogeology, British Geotechnical Association Member, International Society for Soil Mechanics and Geotechnical Engineering
		Mr Tom Steel BSc MEng (Hons) CEng MIStructE	15+ years structural engineering experience
		Ms Roni Savage BEng (hons) MSc SiLC CGEOL MCIWM	25+ years of hydrogeological experience
		Mr Andrew Smith BSc(Hons) FGS MCIWEM	10 years of hydrogeological experience
Subterranean (ground water flow)	A hydrogeologist with the 'CGeol' (Chartered Geologist) qualification from the Geological Society of London	Ms Roni Savage BEng (hons) MSc SiLC CGEOL MCIWM	25+ years of hydrogeological experience
Land Stability	A Civil Engineer with the 'CEng (Chartered Engineer) qualification from the Engineering Council or specialising in ground engineering; or A Member of the Institution of Civil Engineers ('MICE') and a Geotechnical Specialist as defined by the Site Investigation Steering Group	Mike Brice BSc MSc DIC CGeol	30+ years of hydrological/geotechnical experience and Member British Geotechnical Association)
		Mr Tom Steel BSc MEng (Hons) CEng MIStructE	15+ years structural engineering experience

Table A – Qualification Summary (note all relevant signatures are at the end of the BIA)

3.0 SITE DETAILS

(National Grid Reference: 526672, 185227)

3.1 Site Location

The site is located on the western side of Lyndhurst Terrace in Hampstead, North London, NW3 5QA and comprises a two-storey residential property with front and rear garden areas. The site covers an area of approximately 0.03 hectares and the general area is under the authority of the London Borough of Camden.

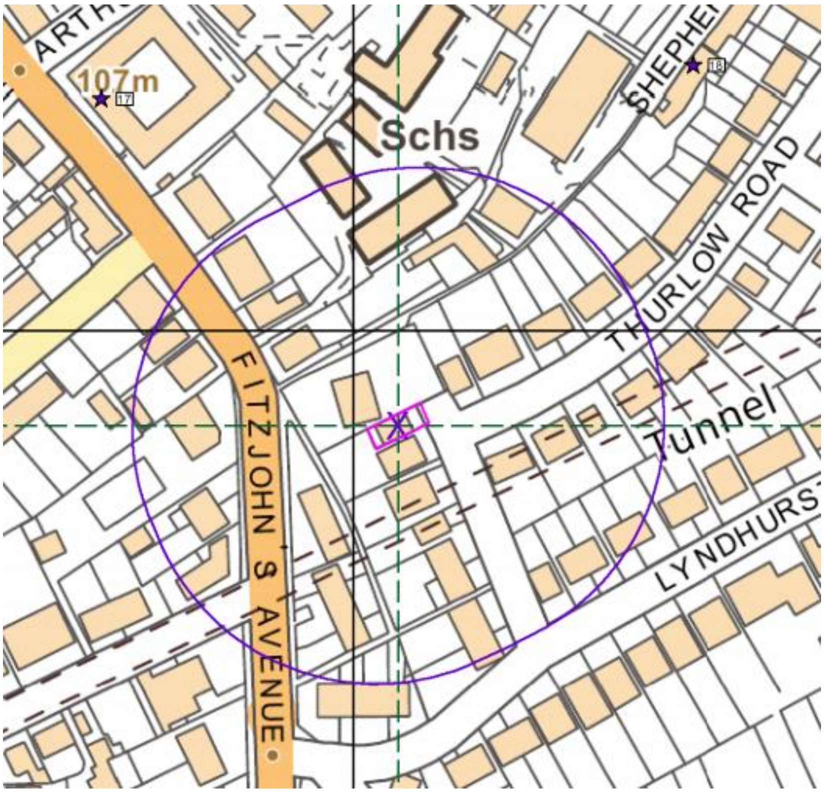


Figure 1. Site Location Plan

3.2 Site Layout and History

The site is accessed from Lyndhurst Terrace to the east and comprises of a two-storey residential property with front and rear garden areas. The front yard is covered by tarmacadam hardstanding and the rear is covered by shingle.

The site is bound by Lyndhurst Terrace to the immediate east, Spring Path to the west, Heath House (Language Studies International building) to the south and a residential property (Elm Bank) to the north. There is a single storey garage adjacent to the garden wall of No. 15 immediately to the north of the site.

The existing site is constructed on ground which slopes gently to the east with approximate Site Datum elevations of 50.20m at the rear (western) side of the site and 49.50mSD at the front (eastern) side of the site.

The existing ground level in the area of the proposed basement is believed to be approximately 95mOD. Available drawings relate levels to a site datum (SD), which will also be used for this assessment. The site slopes gently upward from front to rear; the ground level in the area of the proposed basement excavation is approximately 49.6mSD at the front to 50.5mSD at the rear.

It is understood that the proposed excavation level is to be taken as 46.1mSD (3.5m bgl at the front of the site, 4.4m bgl at the rear).

The neighbouring property at No.13 is understood to have a lower ground floor.

The above levels are related to an arbitrary site datum (SD); the general site level to Ordnance Datum is taken to be approximately 98mOD.

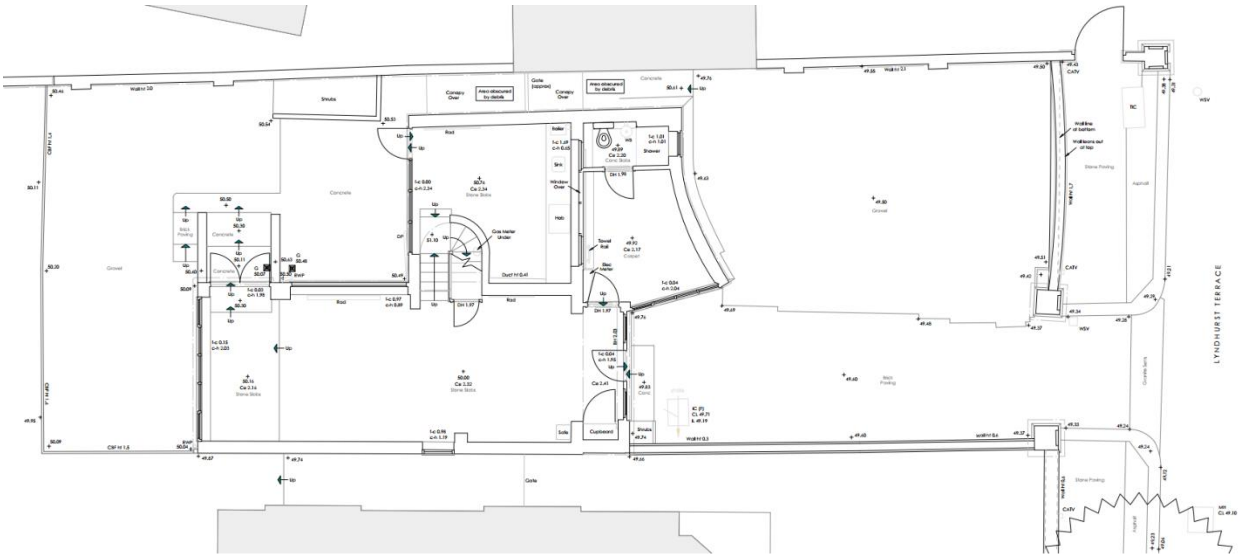


Figure 2. Site Survey showing differences in levels across site
(Arbitrary Datum of 50mSD used)

In the wider area, Lyndhurst Terrace slopes gently towards the south-east with an approximate slope of 1/16 to 1/30 recorded based on the available OS Maps and Figure 10 of the Camden Hydrogeological and Hydrological Study (Arup 2010) (replicated as Figure 3 below).

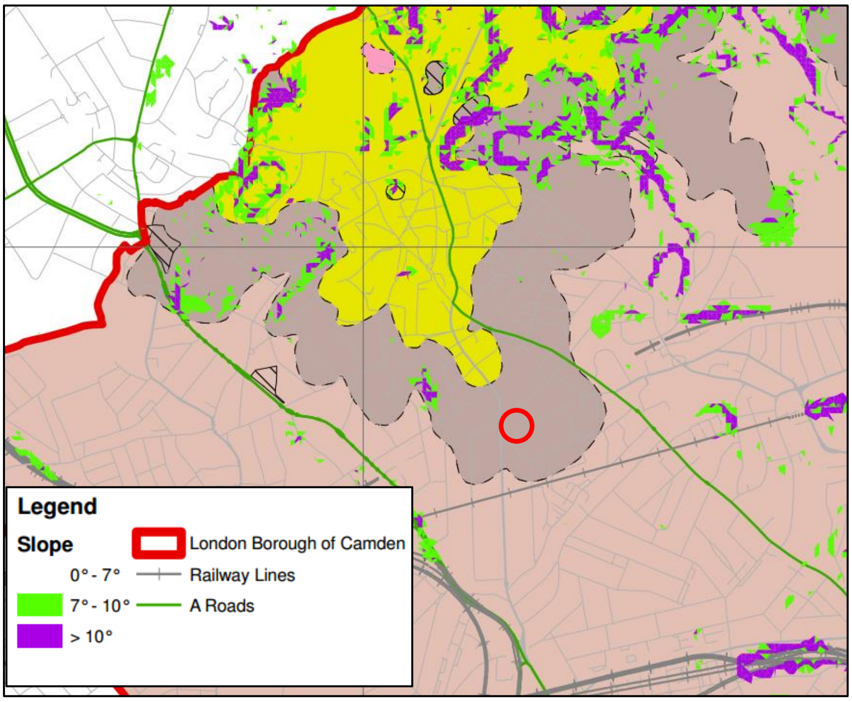


Figure 3. Exact from Figure 17 of the Camden CPG4 showing slope angles within the borough

There are no trees on-site, the closest being a Horse Chestnut located 1m to the north in the Garden of No. 17 and a Poplar located on the pavement outside Heath House 5m to the south. None of these nearby trees are being removed as part of the proposed works.

Network Rail, Transport for London and Cross Rail have all been contacted as part of this study. Whilst Transport for London and Cross Rail have confirmed that they do not have any assets within 50m of the site the site is located approximately 25m to the north of a Network Rail Tunnel which connects Hampstead Heath and Finchley Road & Frognal overground stations, which were constructed in 1879.

Elevation of the tunnel is not confirmed by factual data, but the Basement Impact Assessment presented in October 2011 by Michael Alexander Consulting Engineers at 22 Thurlow Road approximately 65m south-east of the site (document available on LBC Planning Portal) stated that the tunnel 'was found to be around 35m below existing ground level at the site'. A preliminary check on topography of the area seems to confirm such statement.

An exclusion zone of 10 m from the tunnel edge should be maintained at all times

The responses from Network Rail about the tunnel are included in this report as Appendix A, whilst plan of the site relative to the tunnel is detailed below as Figure 4.

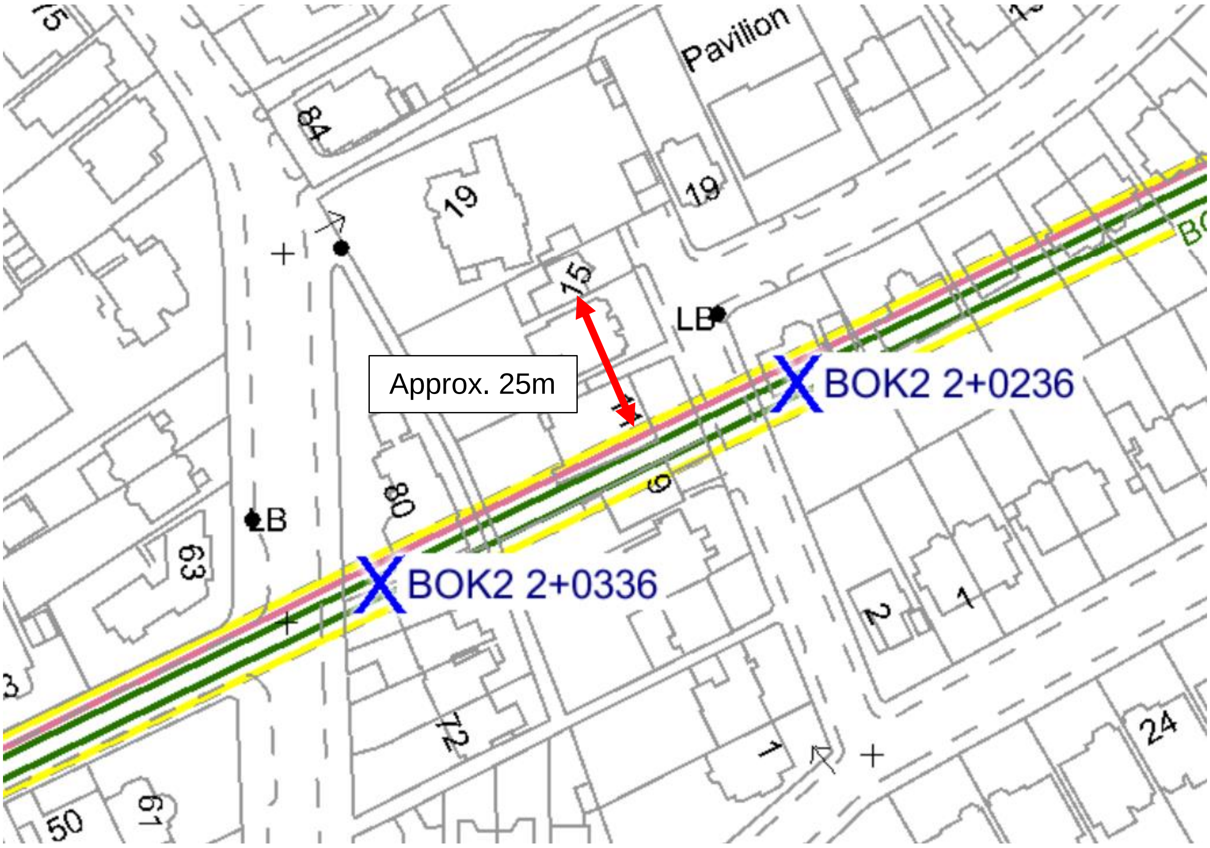


Figure 4. Detailing location of Network Rail owned tunnel approximately 25m to the south of the site.

From historical map evidence it would appear that the current property was constructed between 1974 and 1979 and has remained unchanged since its initial construction. Prior to the 20th century, the surrounding area was mostly agricultural followed by a large amount of urbanisation around the turn of the century. The surrounding area has been predominantly residential for the last 100 years or so.

3.3 Previous Reports

A Phase 1 Preliminary Risk Assessment (PRA) (SAS Report Ref: 15/23902-1) and Phase 2 Site Investigation (SAS Report Ref: 15/23902) has been undertaken across the site by Site Analytical Services Limited in between July and September 2015 and the results are discussed in this BIA.

3.4 Geology

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area is detailed in Figure 5 below and indicates the site to be underlain by the Claygate Member with the London Clay Formation at depth. Deposits of the overlying Bagshot Formation are indicated to be approximately 200m to the north-west of the site, whilst the boundary to the underlying London Clay Formation is approximately 250m to the south-west.

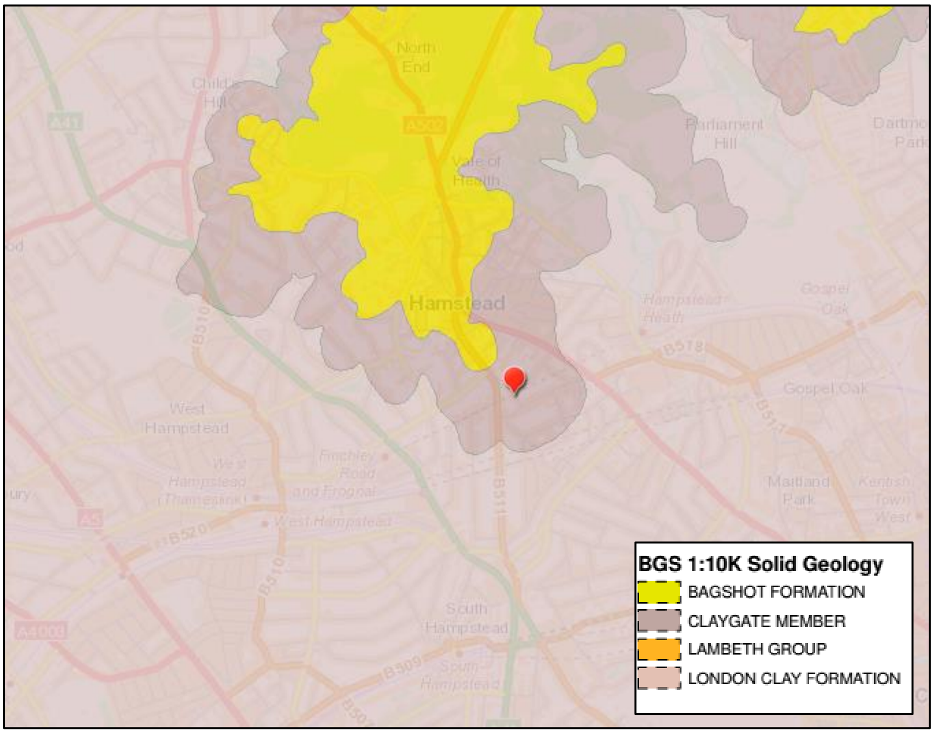


Figure 5. Geology of the Site (Ref. BGS Geoindex)

The British Geological Survey's online records indicate there are no boreholes located within 150m of the site, however a ground investigation undertaken in at 22 Thurlow Road (located 65m east of the site) was conducted by GEA in July 2011 and reported on by Arup in a Basement Impact Assessed dated July 2014 (reports available on LBC Planning Website).

The investigations by GEA were conducted over two visits (in July and October 2011) and included the drilling of 4 cable percussive boreholes to 15.0m maximum depth, the drilling of 5 window sample boreholes to 5.0m depth and the installation of groundwater monitoring standpipes in four of the boreholes. The ground investigation was referenced by GEA to an arbitrary datum considered to be more or less at the location of Borehole 1 and assigned 100mTBM. The elevations of the data given in mTBM were then corrected by 5.3m by Arup to give elevations in mOD (Note: the general site level at No.15 to Ordnance Datum is taken to be approximately 98mOD).

The ground parameters encountered in the investigation are summarised in the table below

Stratum	Top Level (mOD)	Thickness	Description
Made Ground	97.3	0.5	Clayey silt with gravel, root and rootlets, fine brick and charcoal fragments
Claygate Beds	96.8	9.0	Silty sandy clay, clayey silty sand and silty sandy clay
London Clay Formation	88.7	-	Stiff becoming very stiff clay

The boundary between the Claygate Member and London Clay Formation is interpreted to be at a level of 88.7mOD by Arup although, as the report states, the precise location of the boundary between the Claygate Member and London Clay can be difficult to determine as it is a gradational contact.

Arup measured the groundwater level in the four existing standpipes in June 2014. The maximum groundwater level was found at 7.9mbgl, i.e. at +89.4mOD.

In addition to these boreholes, the results from 26 Lyndhurst Road, NW3 located 150m south of the site (SAS 2015, available on LBC planning website) is summarised below. The results shows the interface between the Claygate Member and underlying London Clay Formation to decrease in level with the general topography of the area being at a level of between 88.70mOD within the vicinity of the site and then 78.08mOD to the south of the site.

Strata	22 Thurlow Road (BH1) (65m E of site)		26 Lyndhurst Road (SAS) (BH1) (150m S of site)	
	mBGL	mOD	mBGL	mOD
Made Ground	0.60	96.80	2.90	90.18
Claygate Member	8.10	88.70	10.60	82.48
London Clay Formation	15.00*	82.40	15.00*	78.08

Table 1. Summary of relevant historical boreholes (depths / levels to base of strata) (*maximum depth of drilling)

3.5 Hydrology and drainage

3.5.1 Surface Water

According to Mayes (1997), rainfall in the local area averages around 610mm and significantly less than the national average of around 900mm.

Evapotranspiration is typically 450 mm/yr resulting in about 160 mm/year as 'hydrologically effective' rainfall which is available to infiltrate into the ground or run-off as surface water flow.

With reference to Camden Geological, Hydrogeological and Hydrological Study (1999), Talling (2011) and Barton (1992) springs that sourced tributaries of the 'lost rivers' River Westbourne and River Tyburn were located approximately 200m south-west and 150m south of the site respectively (Figure 6). Both spring lines are shown on the annotated historical OS map dated 1871-79 (Figure 7).

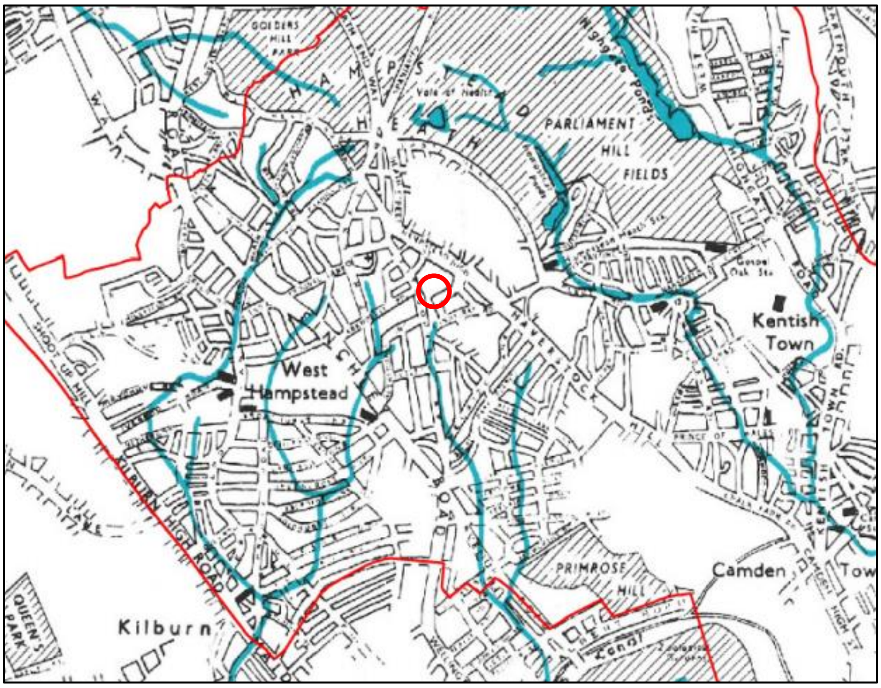


Figure 6. Location of site (circled) relative to the 'Lost Rivers' of London (Source: Barton, 1992)

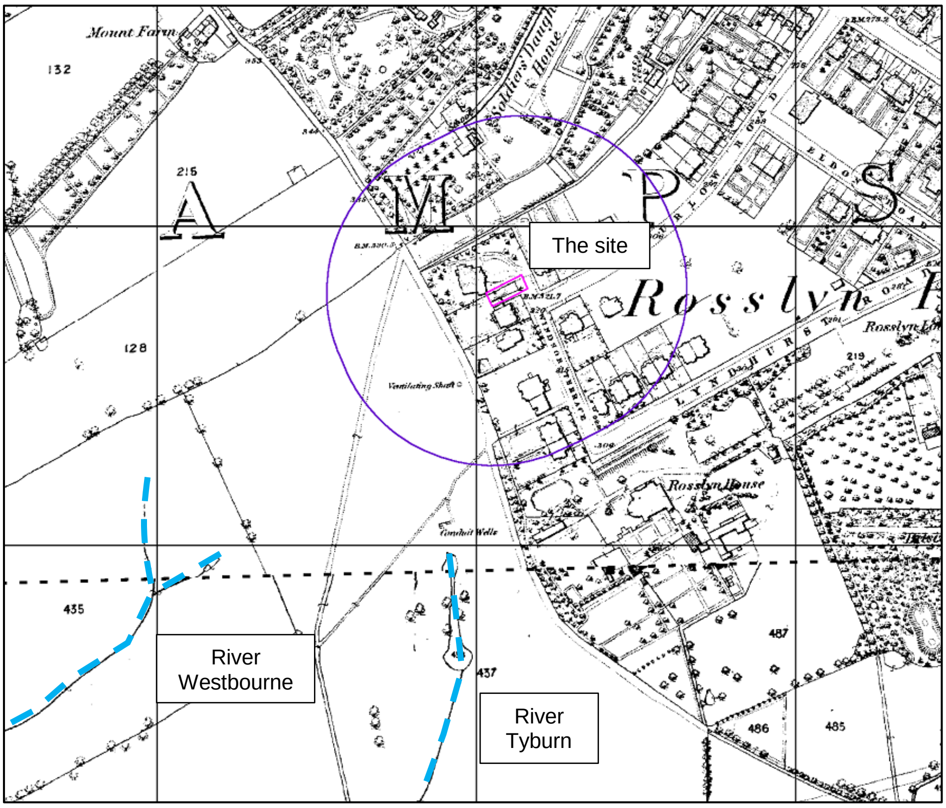


Figure 7. Location of River Tyburn and River Westbourne with respect to the site from OS map dated 1871 (Purple boundary indicates >100m distance)

The River Tyburn flowed in a southerly direction from Shepherds Well (or Conduit Well) located to the south of Spring Path as detailed is detailed on the 1879 OS map and also Stanford's 1896 map (Figure 8). A plaque on the corner of Fitzjohn's Avenue and Lyndhurst Road marks the approximate location of the well and from here it flowed southwards down Fitzjohn's Avenue, through Swiss Cottage and into Regent's Park, where it entered into a large lake (Barton, 1992). From the lake it flowed southwards through the West End and the City of Westminster, before issuing into the River Thames close to Vauxhall Bridge.

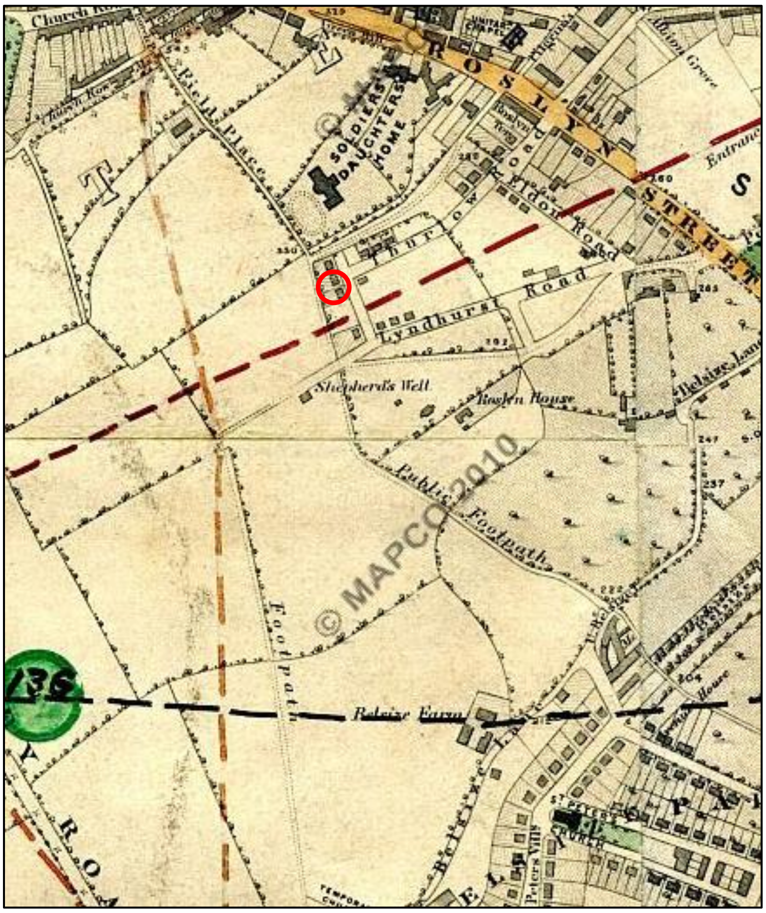


Figure 8. Former Location of Shepherd's Well relative to the site (circled)
(Source: Stanford, 1868, available online http://london1864.com/stanford)

The River Westbourne also flowed in a southerly direction, combining with the other tributaries in West Hampstead and then flowing through Kilburn and Paddington before issuing into the Serpentine in Hyde Park. From there the river flowed south through Chelsea before flowing into the River Thames opposite Battersea Park.

The watercourses have since been largely lost through a culverting system as the urban extent of the Borough has grown over time.

The nearest surface water feature from mapping evidence is the Hampstead No. 1 Pond within Hampstead Heath located 742m north-east of the site.

The area located immediately around the site is highly developed with more than 80% of the surface covered with hardstanding. Most of the rainfall in the area will run-off hard surface areas and be collected by the local sewer network.

Surface drainage from the site is assumed to be directed to drains flowing downhill to the south along Lyndhurst Terrace to Lyndhurst Road.

3.5.2 Flood Risk

3.5.2.1 River or Tidal flooding

According to Environment Agency Flood maps, the site lies within Flood Zone 1 which is defined as areas where flooding from rivers and the sea is very unlikely, with less than a 0.1 per cent (1 in 1000) chance of such flooding occurring each year. The EA's website also shows that this area does not fall within an area at risk of flooding from reservoirs. Based on this information a flood risk assessment will not be required.

3.5.2.2 Surface water flooding

Figure 9 shows that Lyndhurst Road did not flood during either the 1975 or the 2002 flood events. The closest road to the property which flooded in either of these events is Arkwright Road located 130m to the north-west which flooded in 1975 and 2002.

Figure 9. Extract from Figure 15 of the Camden CPG4 showing roads which flooded in 1975 (light blue), in 2002 (dark blue) and 'areas with potential to be at risk from surface water flooding' (wide light blue bands)

Further modelling of surface water flooding has been undertaken by the Environment Agency and was published on its website in January 2014; an extract from their model is presented in Figure 10. Whilst this map identifies four levels of risk (high, medium, low and very low) it is understood that it is based at least in part on depths of flooding. This modelling shows a 'Very Low' risk of flooding (the lowest category for the national background level of risk) for No.15 and the surrounding area.

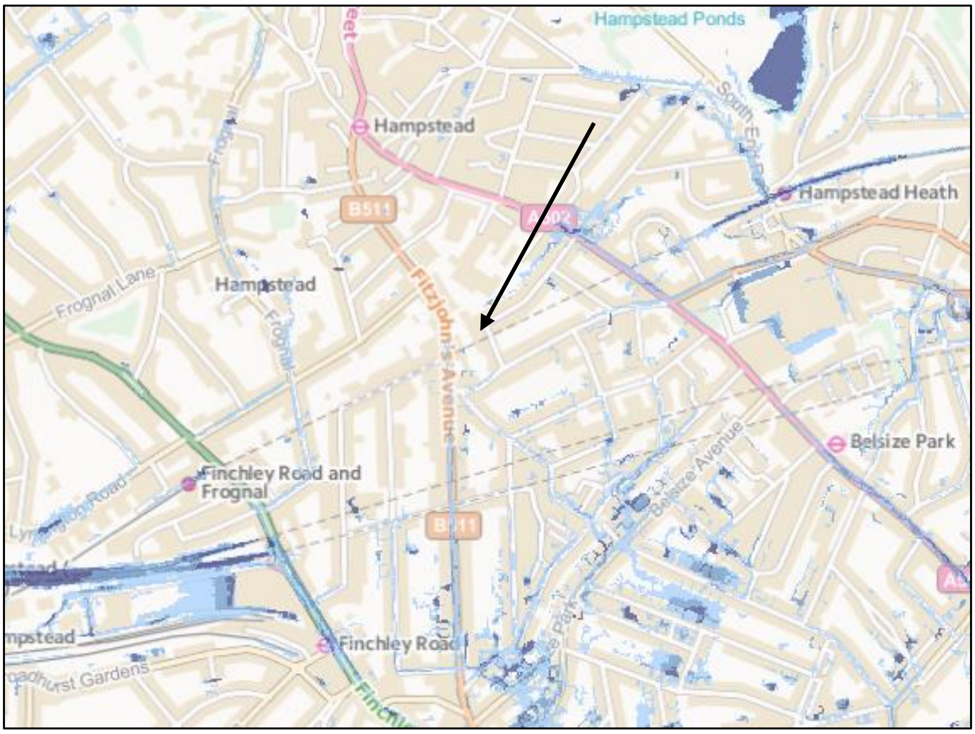


Figure 10. Extract from the Environment Agency's 'Risk of Flooding from Surface Water'. Ordnance Survey Crown copyright 2015. All rights reserved.

As detailed in Table 2 below, due to the presence of a green roof within the proposed, the scheme will result in a decrease in impermeable areas of approximately 60.2m^2.

Element	Existing (m^2)	Proposed (m^2)
Impermeable (hardstanding - building footprint, concrete areas)	100	39.8
If basement involved: permeable (at least 1m of soil above basement structure with permeable surface above this area (if applicable to new / extended basement application)	0	0
Permeable (soft landscaping - grassed areas, (including green roof), permeable and porous paving)	120	180.8
Total (should be the site area and remain the same)	220	220

Table 2. Existing and Proposed Permeable Areas.

3.5.2.3 Sewer flooding

The London Regional Flood Risk Appraisal (2009) advises that foul sewer flooding is most likely to occur where properties are connected to the sewer system at a level below the hydraulic level of the sewage flow, which in general are often basement flats or premises in low lying areas. There is no record of sewer flooding having occurred at 26 Lyndhurst Road and therefore the risk of sewer flooding is considered low.

3.6 Hydrogeological setting

The Environment Agency Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) and also their role in supporting surface water flows and wetland ecosystems. The Claygate Member is permeable, capable of storing and transmitting groundwater and is considered to be a Secondary A Aquifer; The underlying London Clay Formation is classed as unproductive strata or a non-aquifer. These are deposits with a low permeability that have negligible significance for water supply or river base flow.

Groundwater within the silty sandy clays of the Claygate Member is considered to be dominated by fissure flow. The absence of any significant sand bed horizons reduces the water bearing potential of the Claygate Member to that similar to the underlying London Clay. Due to the very low permeability of the London Clay, any groundwater flow will be at very low rates. Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1×10^{-10} m/s and 1×10^{-8} m/s, with an even lower vertical permeability. However, the Claygate Member is sandier in composition and permeability is expected to be higher.

Local perched groundwater may occur near surface in Made Ground and possibly also in any Head deposits which overlie the Claygate Member, in at least the winter and early spring seasons.

The presence of interbedded sands, silts and clays of the Claygate Member gives rise to various springs. The River Tyburn rises at the Shepherd’s Well near Fitzjohn's Street and is located approximately 150m south of the site. The direction of groundwater flow within the Claygate Member beneath the site is likely to be controlled by the local topography and is therefore likely to be in a southerly direction, in the direction that the former river flowed.

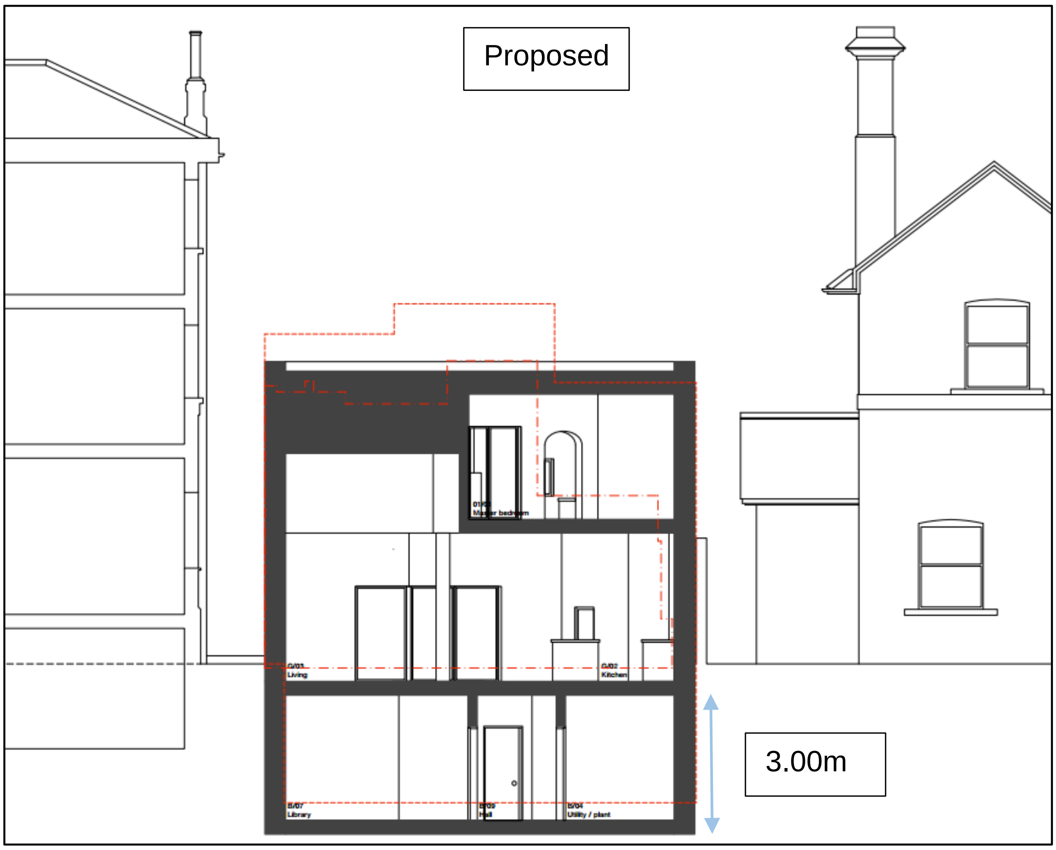
Based on the available data, the site is in considered to be at low risk from all sources of flooding. The replacement dwelling and basement can be constructed and operated safely in flood risk terms without increasing flood risk elsewhere and is therefore considered NPPF compliant.

Other hydrogeological data obtained from the Phase 1 Preliminary Risk Assessment (PRA) (SAS Report Ref: 15/23908-1) for the site include:

- The underlying soil classification of the site is of high leaching potential.
- There is a Zone II (Outer protection zone) source zone located 770m south of the site.
- There are no groundwater abstraction licences listed within one kilometre of the site.
- There are no surface water abstraction licences within 1km of the site.
- There are no public potable water supply abstraction licences within 1km of the site.

3.7 Proposed Development

It is proposed to demolish the existing property at the site and construct a new three to four-storey residential property including a single storey basement to 3.00m maximum depth (46.50mSD). Sections showing the existing and proposed layouts are detailed in Figure 10 below.



3.8 Results of Basement Impact Assessment Screening

A screening process has been undertaken for the site and the results are summarised in Table 3 below:

Table 3: Summary of screening results

Item	Description	Response	Comment
Sub-terranean (Ground water Flow)	1a. Is the site located directly above an aquifer.	Yes	The site lies above the Claygate Member. These deposits have been designated as Secondary A Class; permeable layers capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
	1b. Will the proposed basement extend beneath the water table surface.	Unknown – to be confirmed by Ground Investigation	Given the presence of an aquifer below the site it is possible that groundwater will be encountered during any excavations for the proposed basement, however this will be confirmed by the ground investigation.
	2. Is the site within 100m of a watercourse, well (used / disused) or potential spring line.	No	The nearest surface water feature from mapping evidence is the Hampstead No. 1 Pond within Hampstead Heath located 742m north-east of the site. According to publications regarding Lost Rivers of London (Barton, 1992) and (Talling, 2011) and Stanford (1868) the site is 150m north from the River Tyburn (Figures 5 and 6 of this report).
	3. Is the site within the catchment of the pond chains on Hampstead Heath?	No	With reference to the Camden Geological, Hydrogeological and Hydrological Study, the site is not within the catchment of the pond chains on Hampstead, nor the Golder's Hill Chain.
	4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas.	No	The scheme will result in a decrease in impermeable areas of approximately 60.2m2.
	5. As part of site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS).	No	Existing drainage paths are to be utilised where possible. Whether soakaways/SUDS are used on the proposed development is to be confirmed (beyond the scope of this report). An appropriately qualified engineer should be engaged to ensure mandatory requirements are met.
	6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring line.	No	The nearest surface water feature is recorded is located 742m north-east of the site.

Slope Stability	1. Does the existing site include slopes, natural or man-made greater than 7 degrees (approximately 1 in 8).	No	The existing site is constructed on ground which slopes gently to the east with approximate Site Datum elevations of 50.20m at the rear (western) side of the site and 49.50mSD at the front (eastern) side of the site. This slope is less than 7 degrees.
	2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7 degrees (approximately 1 in 8).	No	Re-profiling of landscaping at the site is not proposed.
	3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7 degrees (approximately 1 in 8).	No	The surrounding area drops to the south-east, but from survey information and with reference to Figure 17 from Camden CPG 4 this is at angles of less than 7 degrees.
	4. Is the site within a wider hillside setting in which the general slope is greater than 7 degrees (approximately 1 in 8).	No	There is a general slope in the area towards the south down to the south-east, but this is at an angle of less than 7 degrees.
	5. Is the London Clay the shallowest strata at the site.	No	The 1:50000 Geological Survey of Great Britain (England and Wales) indicates the site is underlain by the Claygate Member with the London Clay Formation at depth. Deposits of the overlying Bagshot Formation are indicated to be approximately 200m to the north-west of the site, whilst the boundary to the underlying London Clay Formation is approximately 250m to the south-west.
	6. Will any trees be felled as part of the development and/or are any works proposed within any tree protection zones where trees are to be retained.	No	There are no trees on-site, the closest being a Horse Chestnut located 1m to the north in the Garden of No. 17 and a Poplar Tree located on the pavement outside Heath House 5m to the south. None of these nearby trees are being removed as part of the proposed works. The basement does extend over a root protection zone of the horse chestnut tree, but an agricultural report was carried out by Dr Frank Hope which notes that horse chestnut tree is in poor condition and can be removed.
	7. Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site.	Unknown – to be confirmed by Ground Investigation	The Claygate Beds do have cohesive layers which can be prone to shrinking and swelling.

	8. Is the site within 100m of a watercourse or a potential spring line.	No	The nearest surface water feature from mapping evidence is the Hampstead No. 1 Pond within Hampstead Heath located 742m north-east of the site. According to publications regarding Lost Rivers of London (Barton, 1992) and (Talling, 2011) and Stanford (1868) the site is 150m north from the River Tyburn (Figures 5 and 6 of this report).
	9. Is the site within an area of previously worked ground.	No	The site is not in the vicinity of any recorded areas of worked ground, the nearest recorded on the geological map are close to Finchley Road and to the south of West Heath Road.
	10. Is the site within an aquifer. If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction.	Yes	According to the results of the most recent ground investigation the site lies above a Secondary A Aquifer (Claygate Member). However, the depth to the groundwater level is unknown and will be determined by the site investigation.
	11. Is the site within 50m of the Hampstead Heath Ponds	No	With reference to the Camden Geological, Hydrogeological and Hydrological Study, the site is not within the catchment of the pond chains on Hampstead, nor the Golder's Hill Chain.
	12. Is the site within 5m of a highway or pedestrian right of way.	No	The proposed development is set back approximately 6.60m from Lyndhurst Terrace.
	13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties.	Yes	The neighbouring property at No. 13 to the south is understood to have a lower ground floor. It is unknown whether No. 17 to the north has a basement level, but for the purposes of this report it is assumed to have one.
	14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines.	Yes	Network Rail, Transport for London and Cross Rail have all been contacted as part of this study. Whilst Transport for London and Cross Rail have confirmed that they do not have any assets within 50m of the site, the site is located approximately 25m to the north of a Network Rail Tunnel which connects Hampstead Heath and Finchley Road and Frognal overground stations and which was constructed in 1879.
Surface Water and Flooding	1. Is the site within the catchment of the ponds chains on Hampstead Heath	No	With reference to the Camden Geological, Hydrogeological and Hydrological Study, the site is not within the catchment of the pond chains on Hampstead, nor the Golder's Hill Chain.
	2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route.	No	On completion of the development the surface water flows will be routed similarly to the existing condition, with rainwater run-off collected in a surface water drainage system and discharged to a combined sewer. Any

			groundwater flows will not be impeded by the basement. The scheme offers betterment and reduces flood risk overall by in increasing permeable areas on the site. The basement will be beneath the footprint of the new dwelling therefore the 1m distance between the roof of the basement and ground surface as recommended by Chapter 5 of the Arup report, does not apply in these areas.
	3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas.	No	The scheme will result in a decrease in impermeable areas of approximately 60.2m2.
	4. Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses.	No	All surface water for the site will be contained within the site boundaries and collected as described above; hence there will be no change from the development on the quantity or quality of surface water being received by adjoining sites. The basement will be beneath the footprint of the dwelling therefore the 1m distance between the roof of the basement and ground surface as recommended by Chapter 5 of the Arup report does not apply across these areas.
	5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses.	No	The surface water quality will not be affected by the development as in the permanent condition collected surface water will generally be from roofs, domestic hard landscaping or collected from beneath the landscaping layer over the basement.
	6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature.	No	Lyndhurst Terrace did not flood during either the 1975 or the 2002 flood events. Also according to modelling by the Environment Agency, there is a 'Very Low' risk of surface water flooding (the lowest category for the national background level of risk) for No.15 and the surrounding area. There are no surface water features within 100m of the site which could create a flood risk for the proposed basement.

3.9 Non Technical Summary of Chapter 3.0

The site is located on the west side of Lyndhurst Terrace in Hampstead, North London, NW3 5QA and comprises a two-storey residential property with front and rear garden areas. The site covers an area of approximately 0.03 hectares and the general area is under the authority of the London Borough of Camden. It is proposed to demolish the existing property and construct a new three to four-storey residential property, including a single storey basement to 3.00m maximum depth beneath the current property (46.50mSD).

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area indicates the site to be underlain by the Claygate Member with the London Clay Formation at depth. The Claygate Member is permeable, capable of storing and transmitting groundwater and is considered to be a Secondary A Aquifer; The underlying London Clay Formation is classed as unproductive strata or a non-aquifer.

With reference to Camden Geological, Hydrogeological and Hydrological Study (1999), Talling (2011) and Barton (1992) springs that sourced tributaries of the ‘lost rivers’ River Westbourne and River Tyburn were located approximately 200m south-west and 150m south of the site respectively.

The nearest surface water feature from mapping evidence is the Hampstead No. 1 Pond within Hampstead Heath located 742m north-east of the site.

According to Environment Agency Flood maps the site lies within Flood Zone 1, which is defined as areas where flooding from rivers and the sea is very unlikely, with less than a 0.1 per cent (1 in 1000) chance of such flooding occurring each year. Lyndhurst Terrace did not flood during either the 1975 or the 2002 flood events. Modelling of surface water flooding by the Environment Agency shows a ‘Very Low’ risk of flooding (the lowest category for the national background level of risk) for No. 26 and the surrounding area.

The scheme will result in a decrease in impermeable areas of approximately 60.2m^2.

The Screening Exercise has identified the following potential issues which will be carried forward to the Scoping Phase

Subterranean Groundwater Flow

- Is the site located directly above an aquifer
- Will the proposed basement extend beneath the water table surface

Slope Stability

- Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site.
- Is the site within an aquifer. If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction.
- Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties.
- Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines.

Surface water and flooding

- Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas.

4.0 SCOPING PHASE

4.1 Introduction

This purpose of the scoping phase is to assess in more detail the factors to be investigated in the impact assessment. Potential impacts are assessed for each of the identified impact factors and recommendations are stated.

A conceptual ground model is usually complied at the scoping stage however, because the ground investigation has already been undertaken for this project, the conceptual ground model including the findings of the ground investigation is described under Chapter 4.

Subterranean (Groundwater Flow)

Potential Issue (Screening Question)		**Potential impacts and actions**
1a	Is the site located directly above an aquifer	**Potential impact:** Infiltration could be reduced. **Action:** Ground Investigation required, then review.
1b	Will the proposed basement extend beneath the water table surface?	**Potential impact:** Local restriction of groundwater flows (perched groundwater or below groundwater table). **Action:** Ground investigation required, then review.

Slope Stability

7	Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site?	**Potential Impact:** Ground movements will occur during and after the basement construction. **Action:** Ground investigation required, then review.
10	Is the site within an aquifer. If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction.	**Potential impact:** Infiltration could be reduced. **Action:** Ground Investigation required, then review.
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	**Potential impact:** Loss of support to the ground beneath the new foundations to neighbouring properties if basement excavations are inadequately supported. **Action:** Ensure adequate temporary and permanent support by use of best practice methods.

14	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines.	**Potential impact:** Excavation of basement damages the underlying tunnels **Action:** Ensure foundation solution is agreed with Network Rail prior to commencing on-site

Surface Water and Flooding

Potential Issue (Screening Question)		**Potential impacts and actions**
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas.	**Potential impact:** The proportional increase in hardstanding could potentially reduce rates of recharge reducing groundwater flow to a nearby watercourse. **Action:** Ground investigation required, then review.

These potential impacts have been further assessed through the ground investigation, as detailed in Section 4 below.

4.2 Non-Technical Summary of Chapter 4.0

The scoping exercise has reviewed the potential impacts for each of the items carried forward from Stage 1 screening, and has identified the following actions to be undertaken:

- A ground investigation is required (which has already been undertaken).
- Review of site's hydrogeology and groundwater control requirements.
- Review flood risk and include appropriate flood resistance and mitigation measures in the scheme's design.

All these actions are covered in Stage 4 or in Stage 3 for the ground investigation.

5.0 SITE INVESTIGATION DATA

5.1 Records of site investigation

A site-specific ground investigation was undertaken by Site Analytical Services Limited (SAS) in July 2015 and included one rotary percussive borehole (Borehole 1) drilled to 15m below ground level, two continuous flight auger boreholes (Boreholes 2 and 3) drilled to 8.30m below ground level and one hand dug trial pit (Trial Pit 1) excavated to 0.85m depth.

The factual findings from the investigation are presented in Appendix B, including a site plan, exploratory hole logs, groundwater monitoring and laboratory test results.

5.2 Ground conditions

The boreholes and trial pit revealed ground conditions that were consistent with the geological records and known history of the area and comprised Made Ground up to 1.20m in thickness resting on deposits of the Claygate Member with the London Clay Formation at depth.

5.2.1 Made Ground

The Made Ground extended down to depths of between 0.40m and 1.20m below ground level (48.90 to 49.54mSD) in the boreholes and trial pit and comprised pea gravel or brick paving over silty sandy clay with brick fragments.

5.2.2 Claygate Member

The Claygate Member comprised soft becoming firm and then stiff silty sandy clay with lenses of clayey silty fine sand which extended to depths/levels of 9.40m (40.10mSD) in Borehole 1 and to the full depths of investigation of 8.30m in Boreholes 2 and 3 (41.30 to 42.20mSD) and 0.85m in Trial Pit 1 (49.24mSD) in the rear garden area.

5.2.3 London Clay Formation

The London Clay Formation was encountered below the Claygate Member and consisted of stiff silty clay with occasional pockets and partings of silty fine sand and scattered gypsum crystals. These deposits extended down to the full depth of investigation of 15.00m below ground level in Borehole 1 (34.50mSD).

5.3 Groundwater

Groundwater was not encountered in the trial pit and Boreholes 2 and 3 and the soils remained essentially dry throughout. Groundwater was encountered in the Borehole 1 as detailed in Table 4 below.

Exploratory Hole	Depth (m)	Level (mSD)	Notes	Stratum
BH1	15.00	34.50	Very slight seepage	London Clay Formation

Table 4: Groundwater Strike Summary

It must be noted that the speed of excavation is such that there may well be insufficient time for further light seepages of groundwater to enter the boreholes and trial pit and hence be detected, particularly within more cohesive soils.

Isolated pockets of groundwater may also be present perched within any less permeable material found at shallower depth on other parts of the site especially within any Made Ground.

All the boreholes were equipped with water monitoring standpipe piezometers with the response zones being from 3-6m depth. Groundwater was not subsequently encountered in these monitoring standpipes.

BH	Ground Level	30/07/2015	21/08/2015	28/08/2015	12/12/2016	22/02/2017
	mSD	m	m	m	m	m
1	49.50	Dry	Dry	Dry	Dry	Dry
2	49.60	Dry	Dry	Dry	Dry	Dry
3	50.50	Dry	Dry	Dry	Dry	Dry

Table 5. Groundwater Monitoring Results.

It should be noted that the comments on groundwater conditions are based on observations made at the time of the investigation (July, August and September 2015 with return visits in December 2016 and February 2017) and that changes in the groundwater level could occur due to seasonal effects and also changes in drainage conditions. Monitoring has been carried out within three seasons, and no distinct changes have occurred, with no presence of groundwater beneath the site.

5.4 Foundations

Trial Pit 1 was excavated adjacent to the rear wall of the existing property on the site in order to expose the foundations and founding soils. The trial pit showed the rear wall is supported on mass concrete foundations resting on the Claygate Member at a depth of approximately 0.55m below ground level (49.54mSD).

5.5 In-Situ and Laboratory Testing

The results of the laboratory and in-situ tests are presented in the factual report contained in Appendix A.

5.5.1 Standard Penetration Tests

The results of the Standard Penetration Tests carried out in the natural soils are shown on the exploratory hole records in Appendix A. SPT ‘N’ values range between 11 and 31 which a general increase in depth apparent.

5.5.2 Undrained Triaxial Compression Test Results

Undrained Triaxial Compression tests was carried out on two undisturbed 100mm diameter samples taken from Borehole 1. The results indicate the samples to be of a high strength in accordance with BS 5930 2015.

5.5.3 Classification Tests

Atterberg Limit tests have been conducted on three selected samples taken from Boreholes 1 and 2, and showed the sample tested to fall into Classes CI according to the British Soil Classification System.

These are fine grained silty clay soils of intermediate plasticity and as such generally have a low permeability and a medium susceptibility to shrinkage and swelling movements with changes in moisture content, as defined by the NHBC Standards, Chapter 4.2. The results indicated Plasticity Index values of between 21% and 25%, with all of the samples being below the upper 40% boundary between soils assessed as being of medium swelling and shrinkage potential and those assessed as being of high swelling and shrinkage potential. These results are typical of the Claygate Beds.

5.5.4 Sulphate and pH Analyses

The results of the sulphate and pH analyses show the natural soil samples to have water soluble sulphate contents of up to 0.04g/litre associated with slightly acidic to acidic pH values.

5.6 Non-Technical Summary of Chapter 5.0

The boreholes and trial pit revealed ground conditions that were consistent with the geological records and known history of the area and comprised Made Ground up to 1.20m in thickness resting on deposits of the Claygate Member with the London Clay Formation at depth.

Boreholes 1, 2 and 3 were equipped with water monitoring standpipe piezometers with the response zones being from 3-6m depth. Groundwater was not subsequently encountered in these monitoring standpipes.

Trial Pit 1 was excavated adjacent to the rear wall of the existing property on the site in order to expose the foundations and founding soils. The trial pit showed the rear wall is supported on mass concrete foundations resting on the Claygate Member at a depth of approximately 0.55m below ground level (49.54mSD).

6.0 FOUNDATION DESIGN

6.1 Introduction

It is proposed to demolish the existing property at the site and construct a new three to four - storey residential property including a single storey basement to 3.00m maximum depth (46.50mSD).

6.2 Site Preparation Works

The Main Contractor should be informed of the site conditions and risk assessments should be undertaken to comply with the Construction Design Management (CDM) regulations. Site personnel are to be made aware of the site conditions. It is recommended that extensive searches of existing man-made services are undertaken over the site prior to final design works.

6.3 Ground Model

On the basis of the fieldwork, the ground conditions at the site can be characterised as follows:

- Made Ground extends to depths of between 0.40m to 1.20m depth below ground level (48.90 to 49.54mSD).

- The Claygate Member comprising soft becoming firm and then stiff silty sandy clay with lenses of clayey silty fine sand to a depth of 9.40m below ground level (40.10mSD).

- The London Clay Formation comprising stiff silty sandy clay with gypsum crystals to the full depth of investigation of 15.00m below ground level (34.50mSD).

- Groundwater was not encountered in the monitoring standpipes installed above 6.0m depth in Boreholes 1, 2 and 3. This suggests that the water table is deeper than 6.0m below ground level (i.e. below the base of the standpipe) across the site.

6.4 Construction Method Statement

A full Construction Method Statement (CMS) has been provided by the Structural Engineers for the project (Heyne Tillet Steel).

The structure will comprise a concrete frame up to first floor level, with the roof in lightweight construction supported off load bearing masonry or stud walls.

There is underpinning to the neighbouring walls and piled walls on the other parts of the site. This is based on the existing boundary wall with 13 Lyndhurst Terrace being demolished and the boundary/garage wall with 17 Lyndhurst Terrace being a party wall so underpinning is permitted.

Groundwater is not expected to be encountered in the basement excavation, but it would be prudent for the chosen contractor to have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

Trial excavations to the proposed basement depth could be carried by the Main Contractor to confirm the stability of the soil and to further investigate the presence of any groundwater inflows.

In accordance with general basement flood policy and basement design, the proposed development will utilise the flood resilient techniques recommended in the NPPF Technical Guidance where appropriate and also the recommendations that have previously been issued by various councils.

These include:

- Basement to be fully waterproofed (tanked) and waterproofing to be tied in to the ground floor slab as appropriate: to reduce the turnaround time for returning the property to full operation after a flood event.

- Plasterboards will be installed in horizontal sheets rather than conventional vertical installation methods to minimise the amount of plasterboard that could be damaged in a flood event.

- Wall sockets will be raised to as high as is feasible and practicable in order to minimise damage if flood waters inundate the property.

- Any wood fixings on basement / ground floor will be robust and/or protected by suitable coatings in order to minimise damage during a flood event.

- The basement waterproofing where feasible will be extended to an appropriate level above existing ground levels.

- The concrete sub floor as standard will likely be laid to fall to drains or gullies which will remove any build-up of groundwater to a sump pump where it will be pumped into the mains sewer. This pump will be fitted with a non-return valve to prevent water backing up into the property should the mains sewer become full.

- Insulation to the external walls will be specified as rigid board which has impermeable foil facings that are resistant to the passage of water vapour and double the thermal resistance of the cavity.

6.5 Spread Foundations

Based on the ground and groundwater conditions encountered in the boreholes and trial pits, it should be possible to support the proposed new development on conventional strip or basement raft foundations taken down below the Made Ground and any weak superficial soils and placed in the natural firm sandy silty clay deposits which occur at a depth of approximately 3.00m below ground level over the site. Foundations should be placed in the natural deposits at a minimum depth of 1.00m below final ground level in order to avoid the zone affected by seasonal moisture content changes.

Using theory from Terzaghi (1943), strip foundations placed within natural soils may be designed to allowable net bearing pressures of approximately 140kN/m^2 at 3.00m depth in order to allow for a factor of safety of 2.5 against general shear failure. The actual allowable bearing pressure applicable will depend on the form of foundation, its geometry and depth in accordance with classical analytical methods, details of which can be obtained from “Foundation Design and Construction”, Seventh Edition, 2001 by M J Tomlinson (see references) or similar texts.

Any soft or loose pockets encountered within otherwise competent formations should be removed and replaced with well compacted granular fill.

In addition, foundations may need to be taken deeper should they be within the zones of influence of both existing or recently felled trees and any proposed tree planting. The depth of foundation required to avoid the zone likely to be affected by the root systems of trees is shown in the recommendations given in NHBC Standards, Chapter 4.2, April 2010, “Building near Trees" and it is considered that this document is relevant in this situation.

6.6 Piled Foundations

In the event that the use of conventional spread foundations proves either impracticable or uneconomical due to the size and depth of foundation required, then a piled foundation will be required. In these ground conditions, it is considered that some form of bored and in-situ cast concrete piled foundation with reinforced concrete ground beams should prove satisfactory.

The construction of a piled foundation is a specialist activity and the advice of a reputable contractor, familiar with the type of soil and groundwater conditions encountered at this site should be sought prior to finalising the foundation design. The actual pile working load will depend on the particular type of pile chosen and method of installation adopted.

To achieve the full bearing value a pile should penetrate the bearing stratum by at least five times the pile diameter.

Where piles are to be constructed in groups the bearing value of each individual pile should be reduced by a factor of about 0.8 and a calculation made to check the factor of safety against block failure.

Driven piles could also be used and would develop much higher working loads approximately 2.5 to 3 times higher than bored piles of a similar diameter at the same depth. However, the close proximity of adjacent buildings will in all probability preclude their use due to noise and vibration.

6.7 Retaining Walls

Several methods of retaining wall construction could be considered. These may include retaining structures cast in an underpinning sequence, or the use of temporary or sacrificial works to facilitate the retaining structure's construction. The excavation of the basement must not compromise the integrity of adjacent structures.

The full design of temporary and permanent retaining structures is beyond the scope of this report. However, the following design parameters for each element of soil recorded in the relevant exploratory holes are provided in Table 5 below to assist the design of these structures.

Stratum	Depth to top (mSD)	Bulk Density (Mg/m3) (ɣ)	Effective Angle of Internal Friction (Φ)
Made Ground	49.50 to 50.50	1.70	20
Claygate Member	48.90 to 49.54	1.85	25
London Clay Formation	40.10	2.00	25

Table 5. Retaining Wall Design Parameters

The designer should use these parameters to derive the active and passive earth pressure coefficients ka and kp. The determination of appropriate earth pressure coefficients, together with factors such as the pattern of the earth pressure distribution, will depend upon the type/geometry of the wall and overall design factors.

6.8 Chemical Attack on Buried Concrete

The results of the chemical analyses show the natural soil samples tested to have water soluble sulphate contents of up to 0.04g/litre associated with slightly acidic to acidic pH values.

In these conditions, it is considered that deterioration of buried concrete due to sulphate or acid attack is unlikely to occur. The final design of buried concrete according to Tables C1 and C2 of BRE Special Digest 1:2005 should be in accordance with Class DS-1 conditions.

However, segregations of gypsum were noted within the London Clay and also are well known to occur within London Clay deposits. Consequently, it is considered that any buried concrete at depth may be attacked by such sulphates in solution and that it would be prudent to design any such concrete in accordance with full Class DS-2 conditions.

6.9 Non-Technical Summary of Chapter 6.0

It is proposed to demolish the existing property at the site and construct a new three to four - storey residential property including a single storey basement to 3.00m maximum depth (46.50mSD).

The boreholes and trial pit revealed ground conditions that were consistent with the geological records and known history of the area and comprised Made Ground up to 1.20m in thickness resting on deposits of the Claygate Member with the London Clay Formation at depth.

The Claygate/London Clay boundary follows the general topography of the area decreasing in level towards the south-east of the site.

Groundwater is not expected to be encountered in the basement excavation, but it would be prudent for the chosen contractor to have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

In accordance with general basement flood policy and basement design, the proposed development will utilise the flood resilient techniques recommended in the NPPF Technical Guidance where appropriate and also the recommendations that have previously been issued by various councils

Based on the ground and groundwater conditions encountered in the boreholes and trial pit, it should be possible to support the proposed new development on conventional strip or basement raft foundations taken down below the Made Ground and any weak superficial soils and placed in the natural firm sandy silty clay deposits which occur at depths of between approximately 3.00m below ground level over the site.

In the event that the use of conventional spread foundations proves either impracticable or uneconomical due to the size and depth of foundation required, then a piled foundation will be required.

Several methods of retaining wall construction could be considered. These may include retaining structures cast in an underpinning sequence, or the use of temporary or sacrificial works to facilitate the retaining structure's construction. The excavation of the basement must not compromise the integrity of adjacent structures.

7.0 BASEMENT IMPACT ASSESSMENT

7.1 Summary

The screening identified a number of potential impacts. The table below summarises the previously identified potential impacts and the additional information that is now available from the site investigation in consideration of each impact.

Potential Impact	Site Investigation conclusions	Impact sufficiently addressed without further justification?
The site is directly above an aquifer.	The most recent soils investigation has proven that the site lies above the Claygate Member. These are generally aquifers formerly classified as minor aquifers.	No – see below for further details.
The proposed basement extends beneath the water table surface.	Groundwater was not encountered in the monitoring standpipes installed above 6.0m depth. This suggests that the water table is deeper than 6.0m below ground level (i.e. below the base of the standpipe) across the site. This is below the depth of the proposed basement at 46.50mSD and therefore the influence of the development on groundwater is expected to be minimal.	Yes
There a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site.	The Claygate Member was proven below the site and was recorded as having a medium susceptibility to shrinkage and swelling. However, the base of proposed basement will extend well below the potential depth of root action.	Yes
The proposed basement will significantly increase the differential depth of foundations relative to neighbouring properties.	The development will result in the extension of the foundation depth of the basement relative to neighbouring properties.	No – see below for further details.
The site is within 50m of a Network Rail tunnel	The retention system will ensure the stability of the nearby tunnels at all times. Correspondence with Network Rail must be undertaken prior to and during the final design of the basement to insure the safety of the underlying tunnel.	Yes

7.2 Outstanding risks and issues

The Site is located directly above a Secondary A Aquifer

Formation level of the 3.0m deep basement is likely to be within the Claygate Member. Groundwater was recorded as being below the depth of the proposed basement at 46.50mSD although it would be recommended to continue to monitor the standpipes for as long as possible in order to determine equilibrium level and the extent of any seasonal variations. The groundwater regime has been assessed over three seasons, with no groundwater being present throughout, and any seasonal changes being negligible if any at all. The chosen contractor should also have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

The Claygate Member underlying the site is able to transmit small to medium quantities of groundwater and recharge would be by leakage and vertical infiltration across the aquifer outcrop area. Groundwater will also be able to flow through the largely granular Made Ground. Groundwater gradients will follow the local topography and flows and will generally be from north-west to south-east. The groundwater will eventually discharge from the aquifer at a series of small springs and wells located to the edge of its outcrop area around 250m south-west of the site.

The presence of sandy lenses within the Claygate Member means the natural flow of groundwater below the site will be able to continue to flow around the new basement. This behaviour is acknowledged in the Camden GHHS which noted that even extensive excavations for basements in the City of London have not caused any serious problems in 'damming' groundwater flow, with groundwater simply finding an alternative route (Arup, 2010, paragraph 205). On this basis, it is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal.

The proposed basement will need to be fully waterproofed in order to provide adequate long-term control of moisture ingress from the groundwater. Detailed recommendations for the waterproofing system are beyond the scope of this report, although it is noted that as a minimum, it would be prudent for the system to be designed in compliance with the requirements of BS8102:2009.

Due care and attention should be paid to ensure that no contamination incidents occur as a result of the development. No change to the existing drainage arrangements is proposed and therefore existing rates of rainfall infiltration and groundwater recharge will remain unchanged.

The proposed basement will significantly increase the differential depth of foundations relative to neighbouring properties.

The excavation and construction of the basement at the site has the potential to cause some movements in the surrounding ground if not properly managed. However, it is understood that ground movements and/or instability will be managed through the proper design and construction of mitigation measures during the works. This will require close collaboration with the appointed contractor's temporary works coordinator.

The Party Wall Act (1996) will apply to this development because neighbouring houses lie within a defined space around the proposed building works. The party wall process should be followed and adhered to during this development.

A ground movement assessment was carried out at the site by Applied Geotechnical Engineering under the instruction of Site Analytical Services Limited (Report Reference P4118). The report is provided as Appendix C to this report and concludes the predicted level of damage to the houses at Nos 13 and 17 Lyndhurst Terrace, arising from the excavation of a basement at No 15, is ‘very slight’ or less, as defined in Ref 2.

The above assumes a high standard of workmanship.

Damage to the separate garage structure at No 17 is predicted to lie at the low end of ‘slight’, but this structure is understood to be of basic bare-brick construction and in a condition indicating limited maintenance. The predicted level of damage, which is aesthetic only, would appear therefore to be inconsequential, and may go unnoticed.

7.3 Advice on Further Work and Monitoring

A monitoring plan should be set out at design stage and should include a monitoring strategy, instrumentation and monitoring plans and action plans. Trigger levels on movements will need to be defined. Precise levelling or reflective survey targets should be installed at the garden walls and neighbouring buildings. Monitoring should take place in advance of the proposed works as a base-line survey, during the works and for a period following the completion of the works, to understand the long term effects.

It would be prudent to continue to monitor the standpipes for as long as possible in order to determine equilibrium level and the extent of any seasonal variations. The chosen contractor should also have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

Trial excavations to the proposed basement depth could be carried by the main contractor to confirm the depth of made ground and stability of the soil specifically at the locations of the excavations and to further investigate the presence of any groundwater inflows.

7.4 Non-Technical Summary of Chapter 7.0

The excavation and construction of the basement at the site has the potential to cause some movements in the surrounding ground if not properly managed. However, it is understood that ground movements and/or instability will be managed through the proper design and construction of mitigation measures during the works.

It is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal. Also, given limited scope of the scheme and no increase in impermeable areas, the scheme is also considered compliant with the surface water management and flood risk elements of NPPF and Camden policy.

The predicted level of damage to the houses at Nos 13 and 17 Lyndhurst Terrace, arising from the excavation of a basement at No 15, is ‘very slight’ or less, as defined in Ref 2.

The above assumes a high standard of workmanship.

Damage to the separate garage structure at No 17 is predicted to lie at the low end of 'slight', but this structure is understood to be of basic bare-brick construction and in a condition indicating limited maintenance. The predicted level of damage, which is aesthetic only, would appear therefore to be inconsequential, and may go unnoticed.

It would be prudent to continue to monitor the standpipes for as long as possible in order to determine equilibrium level and the extent of any seasonal variations. The chosen contractor should also have a contingency plan in place to deal with any perched groundwater inflows as a precautionary measure.

Trial excavations to the proposed basement depth could be carried by the main contractor to confirm the composition and stability of the soil and to further investigate the presence of any groundwater inflows.

8.0 REFERENCES

1. CIRIA Special Publication 69, 1989. The engineering implications of rising groundwater levels in the deep aquifer beneath London

2. Environment Agency, 2006. Groundwater levels in the Chalk-Basal Sands Aquifer in the London Basin

3. Tomlinson, M J, 2001. “Foundation Design and Construction”, Seventh Edition, Prentice Hall (ISBN 0-13-031180-4).

4. British Standards Institution, 2015. Code of Practice for Site Investigations, BS5930, BSI, London

5. British Standards Institution, 1986. Code of practice for foundations, BS 8004, BSI, London.

6. British Standards Institution, 2009. Code of Practice for Protection of Below Ground Structures Against Water from the Ground. BS 8102, BSI, London

7. CIRIA, 2000. Sustainable Urban Drainage Systems: Design Manual for England and Wales. CIRIA C522, Construction Industry Research and Information Association, London

8. Environment Agency Status Report 2010. Management of the London Basin Chalk Aquifer. Environment Agency

9. NHBC Standards, Chapter 4.1, "Land Quality - managing ground conditions", September 1999.

10. NHBC Standards, Chapter 4.2, "Building near Trees", April 2010.

Appendix A. Responses from Network Rail, TFL and Crossrail

Debbie Miller

From: Rachael Katz <RachaelKatz@crossrail.co.uk> on behalf of Safeguarding <Safeguarding@crossrail.co.uk>
Sent: 23 July 2015 16:01
To: Debbie Miller
Subject: CRL-00-141210 Ref: 16405DM - Site : 15 Lyndhurst Terrace, London, NW3 5QA

Dear Debbie Miller

Crossrail Ref: CRL-00-141210

Ref: 16405DM - Site : 15 Lyndhurst Terrace, London, NW3 5QA

Thank you for your letter dated 23 July 2015, requesting the views of the Crossrail Project Team on the above.

The area in question is outside the limits of consultation shown in the Safeguarding Direction issued by the Secretary of State for Transport on 24 January 2008.

The implications arising from Crossrail have been considered, and we do not wish to make any comments.

The Crossrail Bill which was introduced into Parliament by the Secretary of State for Transport in February 2005 was enacted as the Crossrail Act on the 22nd July 2008. The first stage of Crossrail preparatory construction works began in early 2009. Main construction works have started with works to the central tunnel section to finish in 2018, to be followed by a phased opening of services.

In addition, the latest project developments can be found on the Crossrail website www.crossrail.co.uk/safeguarding, which is updated on a regular basis.

I hope this information is helpful, but if you require any further assistance then please feel free to contact a member of the Safeguarding Team on 0345 602 3813, or by email to safeguarding@crossrail.co.uk

Yours sincerely

Rachael Katz | Community Relations Assistant
Crossrail | 25 Canada Square, Canary Wharf, London E14 5LQ
Helpdesk (24hr) 0345 602 3813
helpdesk@crossrail.co.uk | www.crossrail.co.uk

MOVING LONDON FORWARD

Transport for London
London Underground

UNDERGROUND

Your ref: 16405DM
Our ref: 20878-SI-3-050815

London Underground
Infrastructure Protection

3rd Floor
Albany House
55 Broadway
London SW1H 0BD

www.tfl.gov.uk/tube

Debbie Miller
Groundwise Searches
DMiller@groundwise.com

05 August 2015

Dear Debbie,

15 Lyndhurst Terrace London NW3 5QA

Thank you for your communication of 23rd July 2015.

I can confirm that London Underground assets will not be affected by works at the above location.

However, there are Network Rail assets close to this site.

Please contact the following to query what affect if any your proposals will have on the railway:

Asset Protection Anglia Route
Network Rail
Floor 11
One Stratford Place
Stratford
London
E20 1EJ

Telephone number 0203 356 2510

Email: AssetProtectionLNEEM@networkrail.co.uk

If I can be of further assistance, please do not hesitate to contact me.

Yours sincerely

Shahina Inayathusein
Information Manager
Email: locationenquiries@tube.tfl.gov.uk
Direct line: 020 7918 0016

Network Rail

Underground Services Team
National Records Centre
Audax Road
YORK

YO30 4GS
Tel:

NRSWA Asset Enquiries

Date: 03 August 2015

Your Reference **2015_8011**
Our Reference: **SET137867 JD5**

Dear NRSWA,

Re: Underground Services Search: **OP 15 Lyndhurst Terrace, London**

Please find information available as per the checklist.

The information contained herein is based on Network Rail's records and, where appropriate, third parties such as utility companies. The search enclosed does not cover a search of local council records. Also, schematic Signal and Telecom (S&T) cables plans are not provided as part of the search results, therefore you must assume S&T cables are present until proven otherwise.

Although at the date of this letter the information is as up to date as possible, it is NOT a statement of validity, accuracy or completeness as to any of the enclosed search information and must not be relied on as such.

Your risk assessment MUST take into account:

- That the information supplied, including the services shown on the map from the Geographical Information Portal (GIP), does not provide any guarantee as to the accuracy of the actual location of services on site and MUST be considered as for guidance purposes only.
- That new/unrecorded services are likely to be present
- That the enclosed Underground Services search information has been collated only for the ELR and Mileage boundaries as stated on the original request form

Included in your underground services search is a list of local engineers and managers you MUST contact before any ground disturbance is carried out, to check whether further information is held locally.

Further guidance can be obtained from the Health and Safety Executive publication HSG47 "Avoiding Danger from Underground Services" and the Network Rail Publication NR/L2/BUS/1030

Should you become aware of any additional underground services or assets within the locality during your investigations and/or works, including redundant assets, please identify them as a matter of urgency to the site manager. Records of the location of these assets should be kept for onward transmission to the Hazard Editor for entry into the Hazard Directory.

Yours sincerely

John Devanney

Distribution Administrator

GUIDELINES TO BE READ IN CONJUNCTION WITH THE ENCLOSED INFORMATION

The information contained herein is based on Network Rail's records and, where appropriate, third parties such as utility companies. The search enclosed does not cover a search of local council records. Also, schematic Signal and Telecom (S&T) cables plans are not provided as part of the search results, therefore you must assume S&T cables are present until proven otherwise.

Although at the date of this letter the information is as up to date as possible, it is **NOT** a statement of validity, accuracy or completeness as to any of the enclosed search information and must not be relied on as such.

Your risk assessment **MUST** take into account:

- That the information supplied, including the services shown on the map from the Geographical Information Portal (GIP), does not provide any guarantee as to the accuracy of the actual location of services on site and **MUST** be considered as for guidance purposes only.
- That new/unrecorded services are likely to be present
- That the enclosed Underground Services search information has been collated only for the ELR and Mileage boundaries as stated on the original request form

Included in your underground services search is a list of local engineers and managers you **MUST** contact before any ground disturbance is carried out, to check whether further information is held locally.

Further guidance can be obtained from the Health and Safety Executive publication HSG47 "Avoiding Danger from Underground Services" and the Network Rail Publication NR/L2/AMG/1030.

Should you become aware of any additional underground services or assets within the locality during your investigations and/or works, including redundant assets, please identify them as a matter of urgency to the site manager. Records of the location of these assets should be kept for onward transmission to the Hazard Editor for entry into the Hazard Directory.

UNDERGROUND SERVICES INFORMATION CHECKLIST

Network Rail

YOUR REF	2015_8011	**OUR REF**	SET137867
LOCATION	**OP** 15 Lyndhurst Terrace, London	**ELR**	BOK2
MILEAGE FROM	2.0236	**MILEAGE TO**	2.0336

Utility Company/Internal Source	Category	Enc	Notes
GI Portal	Marlin	Yes	
Hazard Directory	Hazard	Yes	
Civils SE	NRG	Yes	
eBrowser	NRG	No	NIL RETURN - see below

NIL RETURN: After interrogating the information made available to us, no records containing underground services information have been returned for this worksite.

However, reference must be made to the guidelines supplied with this underground services search, which contain important information on safe working practices.

Upon receipt can you please check that the information provided agrees with this listing and if there are any discrepancies please contact the Underground Services Team at:

National Records Centre, Audax Road, York. YO30 4GS

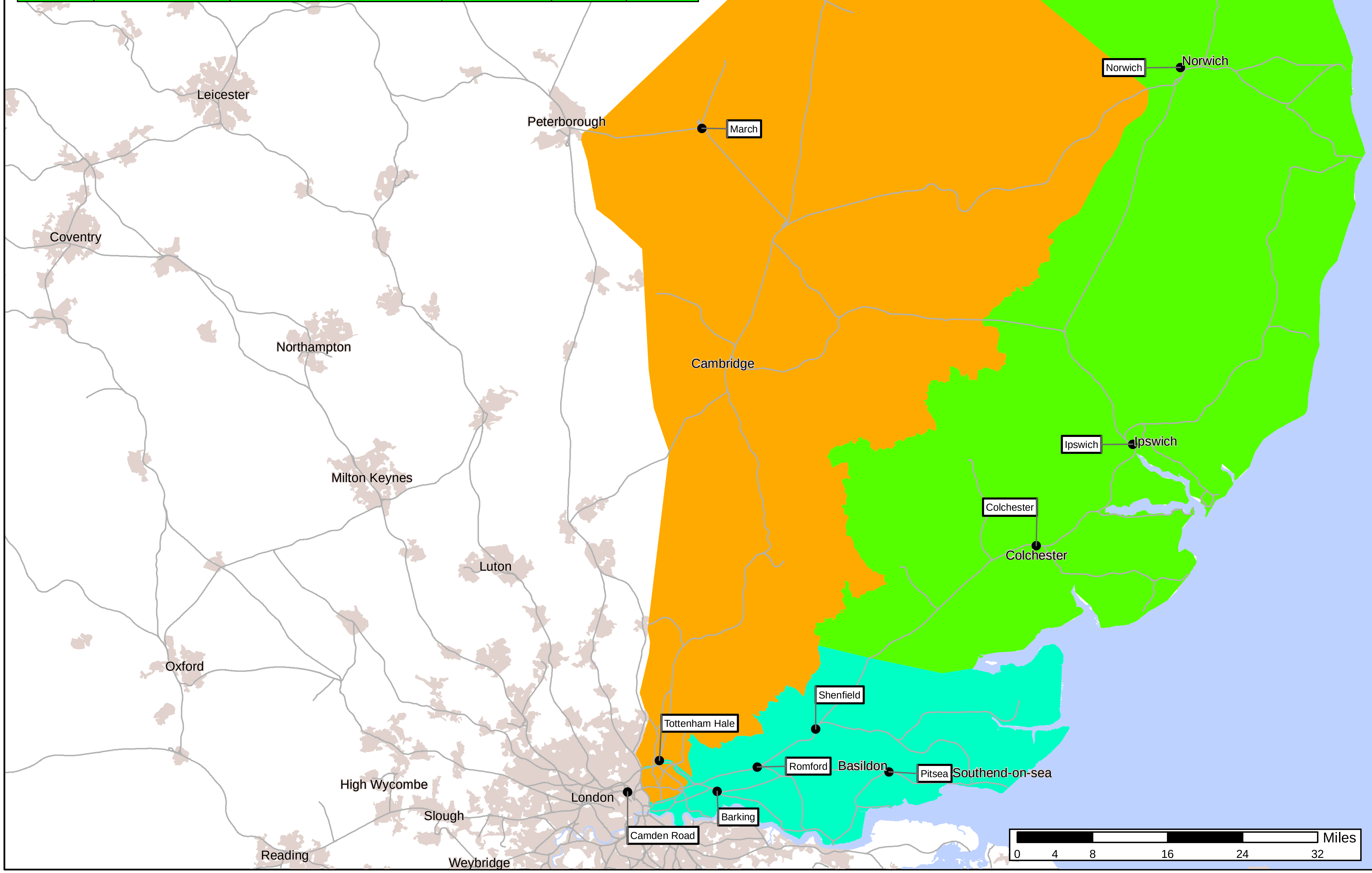
buriedservicesnst@networkrail.co.uk

Checklist printed on: 03/08/15

Route	Delivery Unit	Role	Name	Tel:	Mobile:
Anglia	**Tottenham**	Section Manager (Signalling)	Tim O'Connell	020 89290938	07801 840830
		E&P Maintenance Engineer	Daniel Collison	N/A	07801 840991
		S&T Maintenance Engineer	Chris O'Connell	0207 9836656	07860 500907
		Route Communications Engineer	Dave Flatman	N/A	07799 864214
	Cambridge	Section Manager (Signalling)	Alan White	01223 453797	07801 840855
	Ely	Section Manager (Signalling)	Paul Brown	N/A	07801 841345
	Camden	Section Manager (Signalling)	Antony Osborne	0207 9836634	07824 410768

Route	Delivery Unit	Role	Name	Tel:	Mobile:
Anglia	**Romford**	S&T Maintenance Engineer	Mark Dunnage	N/A	07860 500481
		Acting Section Manager (D&P)	Clifford Loeber	01708 662157	07966 337228
		Route Communications Engineer	Dave Flatman	N/A	07799 864214
	Barking	Section Manager (Signalling)	Mick Sams	0207 0236661	07801 841044
	Shenfield	Section Manager (Signalling)	Russell Drain	0207 4659723	07825 259423
	Stratford	Section Manager (Signalling)	Douglas Kerr	N/A	07808 245326
	Liverpool St	Section Manager (Signalling)	Anthony Chin	0207 9229178	07967 667791

Route	Delivery Unit	Role	Name	Tel:	Mobile:
Anglia	**Colchester**	Section Manager (Signalling)	Richard Candy	01473 693727	07967 667880
		Section Manager (D&P)	Bob Ings	01473 693603	07801 840983
		Infrastructure Maintenance Engineer	Bill Fordham	N/A	07801 840849
	Ipswich	Section Manager (Signalling)	Mike Harvey	01473 693239	07967 667895
	Norwich	Section Manager (Signalling)	Paul Weeks	01603 675314	07515 621482



NetworkRail

Asset Information - Data Services

GeospatialReportingAnalysis@NetworkRail.co.uk

LEGEND

- Stations
- Rail Network

IMDM Boundaries

- IMDM Colchester
- IMDM Romford
- IMDM Tottenham

Local Contacts List - Anglia IMDMs

Client: Buried Services

Job No: 10104 101 [Internal Use Only]

Scale : 1 : 1 700 000

Date : 16/07/2015

GI Portal

Company Ownership

Bridge (Rail over River)
Bridge (Rail over Road)
Bridge (Road over Rail)
Bridge (Rail over Rail)
Level Crossing
Tunnel
Contracted for Sale
Leasehold Ownership
Freehold Ownership
Prohibitive Interest

Annotation

Points

Bench Mark
Boundary Post or Stone
Historic Site
Disused Feature
General Feature
Positioned Boulder
Positioned Coniferous Tree
Positioned Nonconiferous Tree
Railway Structure
Roadside
Spot Height
Tidal Water
Inland Water
Inland Water

Symbols

Bench Mark
Boundary Half Mereing
Direction of Flow
Switch
Road Related Flow

Line Features

Building
Building
Building Overhead
General Feature Edge
General Feature
General Feature Underground
Top of Slope
Top of Slope
Bottom of Slope
Bottom of Slope
Narrow Gauge Railway
Standard Gauge Railway
Overhead Construction
validate General Feature
Mean High Water
Mean High Water
Mean Low Water
Mean Low Water

Historic Cable Route

Miscellaneous

Business Space
Miscellaneous Asset Portfolio
Easements Wayleaves Telecoms

Utilities

Business Space
Miscellaneous Asset Portfolio
Easements Wayleaves Telecoms

Centre of Map Window (E,N): 526581 , 185298

Company Ownership
- Bridge (Rail over River)
- Bridge (Rail over Road)
- Bridge (Road over Rail)
- Bridge (Rail over Rail)
- Level Crossing
- Tunnel
- Contracted for Sale
- Leasehold Ownership
- Freehold Ownership
- Prohibitive Interest

Annotation

Points
- Bench Mark
- Boundary Post or Stone
- Historic Site
- Disused Feature
- General Feature
- Positioned Boulder
- Positioned Coniferous Tree
- Positioned Nonconiferous Tree
- Railway Structure
- Roadside
- Spot Height
- Tidal Water
- Inland Water
- Inland Water

Symbols
- Bench Mark
- Boundary Half Mereing
- Direction of Flow
- Switch
- Road Related Flow

Line Features
- Building
- Building
- Building Overhead
- General Feature Edge
- General Feature
- General Feature Underground

- Top of Slope
- Top of Slope
- Bottom of Slope
- Bottom of Slope
- Narrow Gauge Railway
- Standard Gauge Railway
- Overhead Construction
- validate General Feature
- Mean High Water
- Mean High Water
- Mean Low Water
- Mean Low Water
- Historic Cable Route

Miscellaneous
- Business Space
- Miscellaneous Asset Portfolio
- Easements Wayleaves Telecoms

Utilities
- Business Space
- Miscellaneous Asset Portfolio
- Easements Wayleaves Telecoms
- Track Link

SET137867
15 Lyndhurst Terrace, London

Plot Scale	1:2500
Plot Date	3/8/2015

Network Rail

Output Created from the GI Portal – A3 Landscape

Network Rail

National Hazard Directory

Terms and Conditions

The National Hazard Directory (NHD) is issued by Network Rail to provide information on those hazards recorded as present on Network Rail's infrastructure. Its' purpose is to alert user(s) to the typical hazards that may be encountered on or around the Infrastructure during works . The NHD is made available to Network Rail employees and Network Rail contractors in order to assist in the identification and design of appropriate safety measures.

Although Network Rail believes its content is reasonably correct as at the date of issue, it includes information from records of varying age and levels of accuracy, and accordingly Network Rail gives no warranty as to accuracy, completeness or suitability for use in any particular circumstances. Users must particularly note that all searches (including searches of utility companies) should be conducted together with a site visit and site specific risk assessment, all as appropriate to the activity concerned. Network Rail accepts no liability in respect of the content or subsequent use of this system or the data held within it.

Users of the Directory must note that when working on or near the line that the appropriate requirements of the Rule Book, especially the provisions of the track safety rules, must be applied as appropriate to the activity concerned.

National Hazard Directory

Customised Report

Search Criteria: ELR(s) = BOK2; Mileage From = 2.0236; Mileage To = 2.0336
Date: 03/08/2015

5 Hazards found.

ELR	ELR Name	Mileage From	Mileage To	Hazard Code	Hazard Description	Local Name	Track ID	Free Text
BOK2	CAMDEN RD JN - KENSAL GREEN JN	0.1441	5.0214	HEO	25Kv Overhead Electrification		All/Multiple Tracks	
BOK2	CAMDEN RD JN - KENSAL GREEN JN	1.1386	2.0814	HCC	Restricted Clearance	Hampstead Heath Tunnel	Down Main/Fast	Status =In Use. Safety Validated =Not Available.
BOK2	CAMDEN RD JN - KENSAL GREEN JN	1.1386	2.0814	ESC	Conservation Area	Finchley Road and Frognal	Down Main/Fast	Conservation Area Area above short section of Hamsted Tunnel which runs beneath Frognal NW3. INDEX: CA/418. Status =In Use. Safety Validated =Not Available.
BOK2	CAMDEN RD JN - KENSAL GREEN JN	1.1400	2.1033	HT	Hazard-Tripping	Hampstead Heath Tunnel	All/Multiple Tracks	Tripping Hazard in Hampstead Heath Tunnel due to cross track cables cleated to slab track at various locations trhough the tunnel.
BOK2	CAMDEN RD JN - KENSAL GREEN JN	1.1400	2.1033	HWR	Red Zone Working Prohibited	Hampstead Heath Tunnel	All/Multiple Tracks	Red Zone Working only permitted when Fixed or Semi-Permanent ATWS, or TOWS, or LOWS, or PeeWee in use. Note: No equipment is currently installed by Network Rail.

Devanney John (York)

From: Morris Lee
Sent: 30 July 2015 07:57
To: BS_Transmittals
Subject: Underground Services search: NRS **OP** 15 Lyndhurst Terrace, London (SET137867)

Action taken by NRG:

No records found

NST Ref: SET137867

National Records Group

Appendix B. Ground Investigation Factual Report

Site Analytical Services Ltd.

Site Investigations, Analytical & Environmental Chemists, Laboratory Testing Services.

Units 14 + 15, River Road Business Park,
33 River Road, Barking, Essex IG11 0EA

Directors: J. S. Warren, M.R.S.C., P. C. Warren, J. I. Pattinson, BSc (Hons). MSc
Consultants: G. Evans, BSc., M.Sc., P.G. Dip., FGS., MIEnvSc. A. J. Kingston, BSc C.Eng. MIMM
F. J. Gibbs, F.I.B.M.S. F.I.F.S.T., F.R.S.H. K. J. Blanchette

Tel: 0208 594 8134
Fax: 0208 594 8072
E-Mail: services@siteanalytical.co.uk

Your Ref: Our Ref:

Ref: 15/23908
November 2015

15 LYNDHURST TERRACE, LONDON NW3 5QA

FACTUAL REPORT ON A GROUND INVESTIGATION

Prepared for

Emanuel and Carmel Mond

CONTENTS

1.0 INTRODUCTION

1.1 Outline and Limitations of Report

At the request of Richard Mitzman Architects LLP, acting on behalf of Emanuel and Carmen Mond, a ground investigation was carried out in connection with a proposed residential basement development at the above site. A Phase 1 Preliminary Risk Assessment (Desk Study) is presented under separate cover in Site Analytical Services Limited Report Reference 15/23908-1.

The information was required for the design and construction of foundations and infrastructure for the proposed development at the existing site.

The recommendations and comments given in this report are based on the ground conditions encountered in the exploratory holes made during the investigation and the results of the tests made in the field and the laboratory. It must be noted that there may be special conditions prevailing at the site remote from the exploratory hole locations which have not been disclosed by the investigation and which have not been taken into account in the report. No liability can be accepted for any such conditions.

2.0 SITE DETAILS

(National Grid Reference: TQ 266 853)

2.1 Site Location

The site is located on the west side of Lyndhurst Terrace in Hampstead, North London, NW3 5QA and comprises a two-storey residential property with front and rear garden areas. The site is bound by residential properties to the north, south and west.

The site covers an area of approximately 0.03 hectares and the general area is under the authority of the London Borough of Camden.

2.2 Geology

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area indicates the site to be underlain by the Claygate Member with the London Clay Formation at depth.

2.3 Previous Investigations

A Phase 1 Preliminary Risk Assessment (PRA) (SAS Report Ref: 15/23908 dated August 2015) has been undertaken across the site by Site Analytical Services Limited.

3.0 SCOPE OF WORK

3.1 Site Works

The proposed scope of works was agreed by the Client prior to the commencement of the investigation. To achieve this, the following works were undertaken:-

- The drilling of one rotary percussive borehole to a depth of 15.00m below ground level (Borehole 1).
- The drilling of two continuous flight auger boreholes to 8.00m below ground level (Boreholes 2 and 3)
- The excavation of one trial pit to 1.50m maximum depth to expose existing foundations at the site (Trial Pit 1).
- Sampling and in-situ testing as appropriate to the ground conditions encountered in the boreholes and trial pit.
- Laboratory testing to determine the engineering properties of the soils encountered in the exploratory holes.
- Factual reporting on the results of the investigation.

3.2 Ground Conditions

The locations of the exploratory holes are shown on the site sketch plan, Figure 1.

The boreholes revealed ground conditions that were consistent with the geological records and known history of the area and comprised Made Ground up to 1.20m in thickness resting on deposits of the Claygate Member with the London Clay Formation at depth.

These ground conditions are summarised in the following table. For detailed information on the ground conditions encountered in the boreholes, reference should be made to the exploratory hole records presented in Appendix A.

The levels described in the table are related to an arbitrary site datum (SD); the general site level to Ordnance Datum is taken to be approximately 98mOD.

Strata	Depth to top of strata (mbgl)	Level to top of strata (mOD)	Depth to base of strata (mbgl)	Level to base of strata (mbgl)	Description
Made Ground	0.00	-	0.40 to 1.20	48.90 to 49.54	Pea gravel/brick paving over silty sandy clay with brick fragments.
Claygate Member	0.40 to 1.20	48.90 to 49.54	0.25 (Base of TP1) to 9.40	49.24 (Base of TP1) to 40.10	Soft becoming firm and then stiff silty sandy clay with lenses of clayey silty fine sand
London Clay Formation	9.40	40.10	15.00 (Base of BH 1)	34.50	Firm becoming stiff silty sandy clay with gypsum crystals

Table A: Summary of Ground Conditions in Exploratory Holes

3.3 Groundwater

Groundwater was not encountered within Boreholes 2 and 3 or the trial pit and the soils remained essentially dry throughout. Groundwater was encountered in the Borehole 1 as detailed in Table B below.

Exploratory Hole	Depth (m)	Level (mOD)	Notes	Stratum
BH1	15.00	34.50	Very Slight Seepage	London Clay Formation

Table B: Groundwater Strike Summary

It must be noted that the speed of excavation is such that there may well be insufficient time for further light seepages of groundwater to enter the boreholes and trial pit and hence be detected, particularly within more cohesive soils.

Isolated pockets of groundwater may also be present perched within any less permeable material found at shallower depth on other parts of the site especially within any Made Ground.

Following drilling operations groundwater monitoring standpipes were installed in Boreholes 1, 2 and 3 to approximately 6.00m below ground level (43.4 to 44.49mSD). Groundwater was not subsequently encountered in these monitoring standpipes after a period of approximately two months.

It should be noted that the comments on groundwater conditions are based on observations made at the time of the investigation (July, August and September 2015) and that changes in the groundwater level could occur due to seasonal effects and also changes in drainage conditions.

4.0 IN-SITU TESTING AND LABORATORY TESTS

4.1 Standard Penetration Tests

The results of the Standard Penetration Tests carried out in the natural soils are shown on the exploratory hole records in Appendix A. SPT 'N' values range between 11 and 31 with a general increase in depth apparent.

4.2 Mackintosh Probe / Hand Vane Tests

Mackintosh Probe tests were made at regular depth increments in order to assess the relative density of the soils encountered in Boreholes 2 and 3. The results can be interpreted using the generally accepted correlation for Mackintosh Probe Tests which is as follows:

Mackintosh N75 X 0.38 = SPT 'N' Value

or

Mackintosh N300 X 0.1 = SPT 'N' Value

The results of the in-situ tests are shown on the appropriate exploratory hole records contained in Appendix A.

4.3 Undrained Triaxial Compression Test Results

Undrained Triaxial Compression tests was carried out on two undisturbed 100mm diameter samples taken from Borehole 1.

The results of the tests are presented on Table 1, contained in Appendix B.

4.4 Classification Tests

Atterberg Limit tests were conducted on three samples taken at depth in Boreholes 1, 2 and 3 and showed the samples tested to fall into Class CI according to the British Soil Classification System.

Particle size distribution tests were conducted on two selected samples taken from the natural essentially granular soils present in the borehole using wet sieving methods.

The test results are given in Table 2, contained in Appendix B.

4.5 Sulphate and pH Analyses

The results of the sulphate and pH analyses made on three soil samples are presented on Table 3 contained in Appendix B.

p.p. SITE ANALYTICAL SERVICES LIMITED

A P Smith BSc (Hons) FGS MCIWEM
Senior Geologist

5.0 REFERENCES

1. British Standards Institution, 1986. Code of practice for foundations, BS 8004, BSI, London.

2. British Standards Institution, 1990. Methods for test for soils for civil engineering purposes, BS1377, BSI, London

3. British Standards Institution, 1994. Code of practice for earth retaining structures, BS8002, BSI, London

4. British Standards Institution, 20. Code of Practice for Site Investigations, BS5930: 2015, BSI, London

5. British Standards Institution, 2004. Geotechnical Design, BS EN 1997-1 BSI, London

6. Building Research Establishment Special Digest 1, 2005, "Concrete in Aggressive Ground – Third Edition."

7. Driscoll, R (1983) "The influence of vegetation on the shrinking and swelling of clay soils in Great Britain", Geo-technique 33, 93-107

8. Eurocode 1: Actions on structures – BS EN 1991-1-1:2002: General actions – Densities, self weight and imposed loads, BSI, London

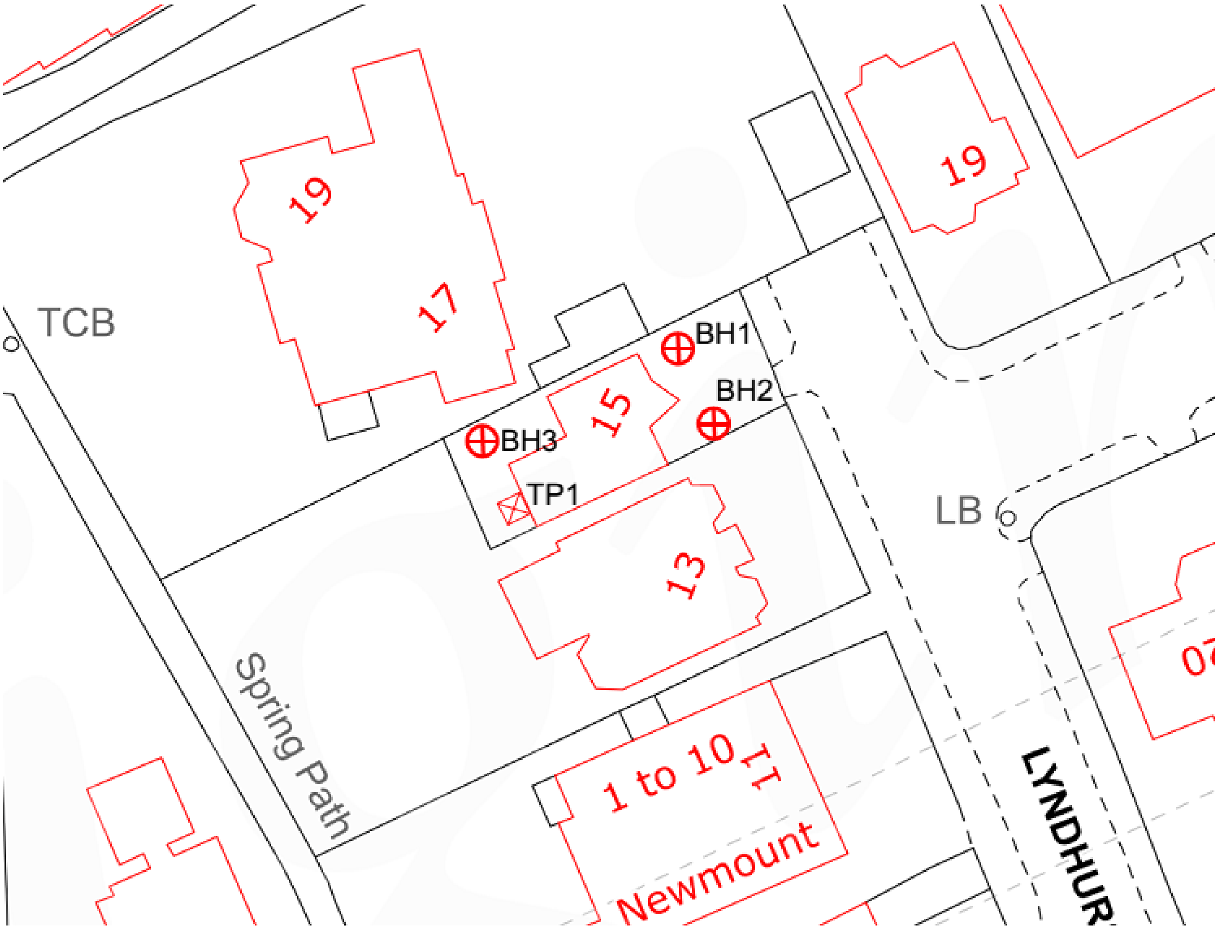
9. NHBC Standards, Chapter 4.1, "Land Quality - managing ground conditions", September 1999.

10. NHBC Standards, Chapter 4.2, "Building near Trees", April 2010.

11. Stroud M.A. and Butler F.G. (1975) Symposium on the Engineering Behaviour of Glacial Materials; the Midland Soil Mechanics and Foundation Engineering Society; pgs 124 et seq.

12. Tomlinson, M J, 2001. “Foundation Design and Construction”, Seventh Edition, Prentice Hall (ISBN 0-13-031180-4).

Site Analytical Services Ltd.				REF: 15/23908
LOCATION:	15 Lyndhurst Terrace, London, NW3 5QA			FIG: 1
TITLE:	Site Sketch Plan	DATE:	Nov' 2015	SCALE: NTS



A P P E N D I X `A’

Borehole / Trial Pit Logs

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	**BH1**

Boring Method	Casing Diameter	Ground Level (mSD)	Client	Job Number
ROTARY PERCUSSIVE	128mm cased to 0.00m	49.50	EMMANUEL AND CARMEN MOND	1523908
	Location	**Dates**	**Architect**	**Sheet**
	TQ266853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mSD)	Depth (m) (Thickness)	Description	Legend	Water
					49.35	(0.15) 0.15	MADE GROUND: Pea gravel over a brick and hardcore rubble.		
						(0.25)			
0.25	D1								
					49.10	0.40	MADE GROUND: Silty sandy clay with occasional brick fragments.		
0.50	D2								
							Firm very silty very sandy CLAY with frequent laminations of yellow silty fine sand.		
0.75	D3								
1.00-1.45	SPT(C) N=11		DRY	1,2/3,2,3,3					
1.00	D4								
1.75	D5								
2.00-2.45	SPT N=27		DRY	3,6/7,6,7,7		(3.35)			
2.00	D6								
2.75	D7								
3.00-3.45	SPT N=25		DRY	3,4/5,6,7,7					
3.00	D8								
					45.75	3.75	Medium dense slightly clayey silty fine SAND		
3.75	D9								
4.00-4.45	SPT N=17		DRY	3,3/4,5,4,4					
4.00	D10								
4.75	D11					(2.15)			
5.00-5.45	SPT N=16		DRY	3,3/4,4,4,4					
5.00	D12								
					43.60	5.90	Firm becoming stiff very silty very sandy CLAY with occasional laminations of yellow silty fine sand.		
6.00	D13								
6.50-6.95	SPT N=16		DRY	2,3/3,4,4,5					
6.50	D14								
7.50	D15								
						(3.50)			
8.00-8.45	SPT N=16		DRY	2,3/4,4,4,4					
8.00	D16								
9.00	D17								
					40.10	9.40	Stiff dark grey brown blue silty sandy CLAY with occasional partings of silty fine sand and occasional gypsum crystals.		
9.50-9.95	U1			100 blows					
						(0.60)			

Remarks
SPT = Standard Penetration Test
SPT(C) = Standard Penetration Test (Cone)
D = Disturbed sample
U = Undisturbed 100mm diameter sample
Excavating from 0.00m to 1.00m for 1 hour.

Scale (approx)	Logged By
1:50	TM

Figure No. 1523908.BH1

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	BH1

Boring Method	Casing Diameter	Ground Level (mSD)	Client	Job Number
ROTARY PERCUSSIVE	128mm cased to 0.00m	49.50	EMMANUEL AND CARMEN MOND	1523908
	Location	**Dates**	**Architect**	**Sheet**
	TQ266853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mSD)	Depth (m) (Thickness)	Description	Legend	Water
					39.50	10.00	Stiff dark grey brown blue silty sandy CLAY with occasional partings of silty fine sand and occasional gypsum crystals.		
10.50	D18								
11.00-11.45 11.00	SPT N=27 D19		DRY	3,4/5,7,7,8					
12.00	D20								
12.50-12.95	U2			110 blows		(5.00)			
13.75	D21								
14.55-15.00 14.55	SPT N=31 D22		15.00	5,6/7,7,8,9					
				Very slight seepage(1) at 15.00m. 24/07/2015:15.00m	34.50	15.00	Complete at 15.00m		∇1

Remarks
SPT = Standard Penetration Test
SPT(C) = Standard Penetration Test (Cone)
D = Disturbed sample
U = Undisturbed 100mm diameter sample

Scale (approx)	Logged By
1:50	TM

Figure No. 1523908.BH1

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	BH2

Boring Method	Casing Diameter	Ground Level (mSD)	Client	Job Number
CONTINUOUS FLIGHT AUGER	100mm cased to 0.00m	49.60	EMMANUEL AND CARMEN MOND	1523908
	Location	**Dates**	**Architect**	**Sheet**
	TQ266853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mSD)	Depth (m) (Thickness)	Description	Legend	Water
					49.55	0.05	MADE GROUND: Brick paving		
0.25	D1					(0.65)	MADE GROUND: Brown silty sandy gravelly brown clay containing brick fragments. Gravel is fine to medium of subrounded to sub angular flint		
0.50	D2								
0.75	D3				48.90	0.70	Soft becoming firm orange brown very silty very sandy CLAY with frequent laminations of yellow silty fine sand.		
1.00	D4								
1.00-1.30	M1 85/300								
1.50	D5								
1.50-1.80	M2 82/300								
2.00	D6								
2.00-2.30	M3 97/300					(3.30)			
2.50	D7								
2.50-2.80	M4 91/300								
3.00	D8								
3.00-3.30	M5 107/300								
3.50	D9								
3.50-3.80	M6 120/300								
					45.60	4.00	Medium dense yellow brown slightly clayey silty fine SAND		
4.00	D10								
4.00-4.30	M7 131/300								
4.50	D11								
4.50-4.80	M8 149/300								
5.00	D12								
5.00-5.30	M9 158/300					(2.50)			
6.00	D13								
6.00-6.30	M10 164/300								
					43.10	6.50	Firm becoming stiff orange brown and grey very silty very sandy CLAY with occasional laminations of yellow silty fine sand.		
7.00	D14								
7.00-7.30	M11 173/300					(1.80)			
8.00	D15								
8.00-8.30	M12 186/300								
				24/07/2015:DRY	41.30	8.30	Complete at 8.30m		

Remarks
D = Disturbed sample
M = Mackintosh Probe - Blows/Penetration (mm)
Groundwater was not encountered during the excavation
Excavating from 0.00m to 1.00m for 1 hour.

Scale (approx)	Logged By
1:50	TM

Figure No. 1523908.BH1

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	BH3

Boring Method	Casing Diameter	Ground Level (mSD)	Client	Job Number
CONTINUOUS FLIGHT AUGER	100mm cased to 0.00m	50.50	EMMANUEL AND CARMEN MOND	1523908
	Location	**Dates**	**Architect**	**Sheet**
	TQ266853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mSD)	Depth (m) (Thickness)	Description	Legend	Water
					50.45	0.05	MADE GROUND: Pea gravel over concrete underlay		
0.25	D1						MADE GROUND: Brick rubble		
0.50	D2					(1.15)			
0.75	D3								
1.00 1.00-1.30	D4 M1 111/300				49.30	1.20	Soft orange brown very silty very sandy CLAY with frequent laminations of yellow silty fine sand.		
1.50 1.50-1.80	D5 M2 80/300								
2.00 2.00-2.30	D6 M3 85/300								
2.50 2.50-2.80	D7 M4 97/300					(2.80)			
3.00 3.00-3.30	D8 M5 106/300								
3.50 3.50-3.80	D9 M6 102/300								
4.00 4.00-4.30	D10 M7 125/300				46.50	4.00	Firm becoming stiff orange brown very silty very sandy orange brown CLAY with laminations of yellow silty fine sand.		
4.50 4.50-4.80	D11 M8 130/300								
5.00 5.00-5.30	D12 M9 140/300								
6.00 6.00-6.30	D13 M10 158/300					(4.30)			
7.00 7.00-7.30	D14 M11 162/300								
8.00 8.00-8.30	D15 M12 184/300			24/07/2015:DRY	42.20	8.30	Complete at 8.30m		

Remarks
D = Disturbed sample
M = Mackintosh Probe - Blows/Penetration (mm)
Groundwater was not encountered during the excavation
Excavating from 0.00m to 1.00m for 1 hour.

Scale (approx)	Logged By
1:50	TM

Figure No. 1523908.BH3

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	BH1

Installation Type	Dimensions	Client	Job Number
Single Installation	Internal Diameter of Tube [A] = 19 mm Diameter of Filter Zone = 128 mm	EMMANUEL AND CARMEN MOND	1523908

Location	Ground Level (mSD)	Architect	Sheet
TQ266853	49.50	RICHARD MITZMAN ARCHITECTS LLP	1/1

Legend	Water	Instr (A)	Level (mSD)	Depth (m)	Description
					Bentonite Seal
			48.50	1.00	Cement/Bentonite Grout
			46.50	3.00	Sand Filter
			43.70	5.80	
			43.50	6.00	Piezometer Tip
					General Backfill
			34.50	15.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)
24/07/15		15.00	0.00	Very slight seepage					

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
24/07/15				DRY			15.00		15.00	34.50

Instrument Groundwater Observations

Inst. [A] Type : Standpipe Piezometer

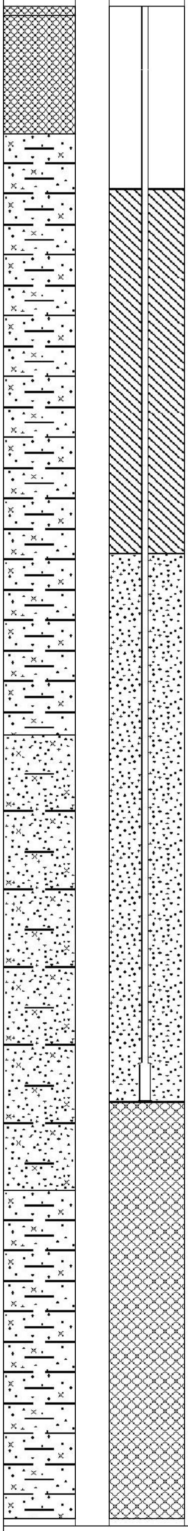
Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks

Remarks
Lockable cover set in concrete.

Site Analytical Services Ltd.	Site: 15 LYNDHURST TERRACE, LONDON, NW3 5QA	Borehole Number: BH2

Installation Type	Dimensions	Client	Job Number
Single Installation	Internal Diameter of Tube [A] = 19 mm Diameter of Filter Zone = 128 mm	EMMANUEL AND CARMEN MOND	1523908

Location	Ground Level (mSD)	Architect	Sheet
TQ266853	49.60	RICHARD MITZMAN ARCHITECTS LLP	1/1



Legend	Water	Instr (A)	Level (mSD)	Depth (m)	Description
					Bentonite Seal
			48.60	1.00	
					Cement/Bentonite Grout
			46.60	3.00	
					Sand Filter
			43.80	5.80	
			43.60	6.00	Piezometer Tip

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
24/07/15				DRY			8.30		DRY	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe Piezometer

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks

Remarks
Lockable cover set in concrete.

Site Analytical Services Ltd.

Site	Borehole Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	BH3

Installation Type	Dimensions	Client	Job Number
Single Installation	Internal Diameter of Tube [A] = 19 mm Diameter of Filter Zone = 128 mm	EMMANUEL AND CARMEN MOND	1523908

Location	Ground Level (mSD)	Architect	Sheet
TQ266853	50.50	RICHARD MITZMAN ARCHITECTS LLP	1/1

Legend	Water	Instr (A)	Level (mSD)	Depth (m)	Description
					Bentonite Seal
			49.50	1.00	
					Cement/Bentonite Grout
			47.50	3.00	
					Sand Filter
			44.70	5.80	
			44.50	6.00	Piezometer Tip

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
24/07/15				DRY			8.30		DRY	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe Piezometer

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

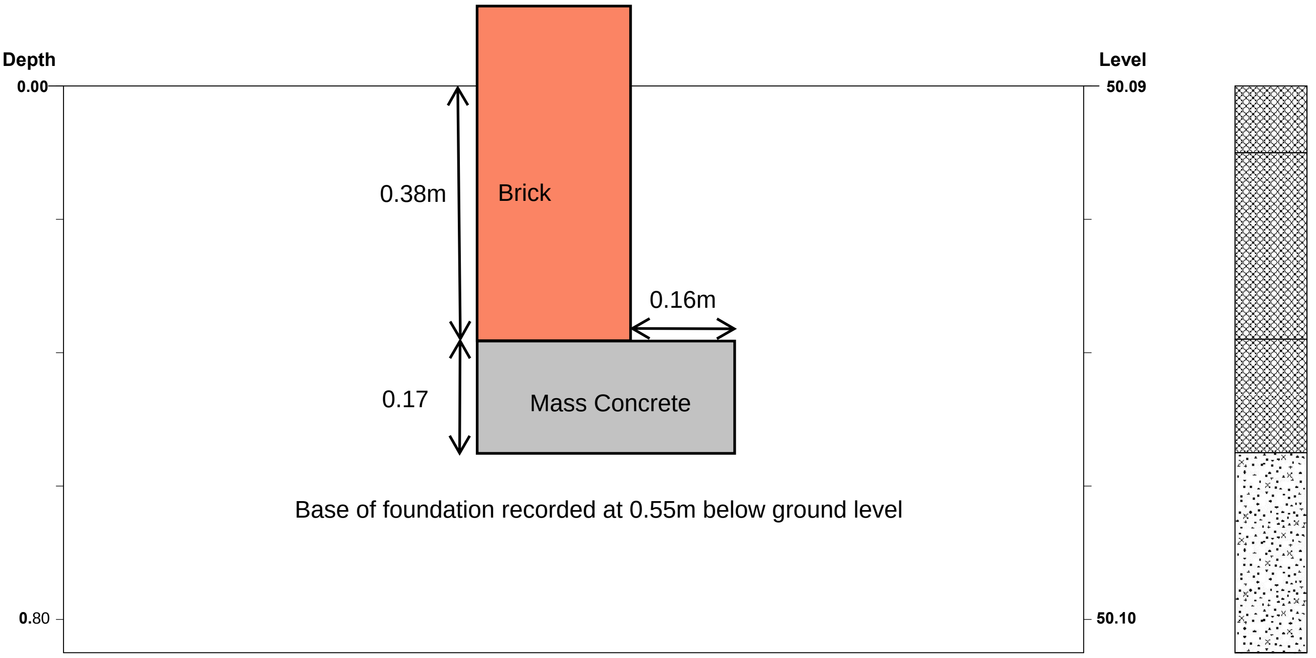
Remarks
Lockable cover set in concrete.

Site Analytical Services Ltd.

Site	Trial Pit Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	TP1

Method	Dimensions	Ground Level (mSD)	Client	Job Number
Trial Pit	300 x 300	50.09	EMMANUEL AND CARMEN MOND	1523908

Orientation	Location	Dates	Architect	Sheet
A, B, C, D	TQ 266 853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	1/1



Strata

Depth (m)	No.	Description
0.00-0.10	1	MADE GROUND : Pea gravel over brick paving underlay
0.10-0.38	2	MADE GROUND : Soft silty very sandy clay
0.38-0.55	3	MADE GROUND : Loose silty fine sand with occasional brick fragments
0.55-0.85	4	Loose yellow brown silty fine sand

Samples and Tests

Depth (m)	Type	Field Records
0.25	D1	
0.55	D2	
0.55-0.85	M1 45/300	

Excavation Method:
HAND EXCAVATION

Shoring / Support:
N/A

Stability:
Good

Backfill:
Arisings

Remarks
Groundwater was not encountered during the excavation
M = Mackintosh Prove - Blows/Penetration (mm)
For details of foundation exposed - see sketch

Logged By	: APS
Checked By	: JW
Figure No.	: 1523908.TP1

Site Analytical Services Ltd.

Site	Trial Pit Number
15 LYNDHURST TERRACE, LONDON, NW3 5QA	TP1

Excavation Method	Dimensions	Ground Level (mSD)	Client	Job Number
HAND EXCAVATION	300 x 300	50.09	EMMANUEL AND CARMEN MOND	1523908
	Location	**Dates**	**Architect**	**Sheet**
	TQ 266 853	24/07/2015	RICHARD MITZMAN ARCHITECTS LLP	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mSD)	Depth (m) (Thickness)	Description	Legend	Water
				49.99	0.10	MADE GROUND : Pea gravel over brick paving underlay		
0.25	D1			49.71	(0.28) 0.38	MADE GROUND : Soft silty very sandy clay		
0.55 0.55-0.85	D2 M1 45/300			49.54	(0.17) 0.55	MADE GROUND : Loose silty fine sand with occasional brick fragments		
			24/07/2015:DRY	49.24	(0.30) 0.85	Loose yellow brown silty fine sand		
						Complete at 0.85m		

Plan

Remarks

Groundwater was not encountered during the excavation
M = Mackintosh Prove - Blows/Penetration (mm)
For details of foundation exposed - see sketch

Scale (approx)	Logged By	Figure No.
1:50	APS	1523908.TP1

A P P E N D I X `B'

Laboratory Test Data

Ref: 15/23908

UNDRAINED TRIAXIAL COMPRESSION TEST

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

BH/TP No.	MOISTURE CONTENT %	BULK DENSITY Mg/m^3	LATERAL PRESSURE kN/m^2	COMPRESSIVE STRENGTH kN/m^2	COHESION kN/m^2	ANGLE OF SHEARING RESISTANCE degrees	DEPTH m
BH1	23	2.04	250	196	98		9.75
	24	2.01	190	298	149		12.75

Table 1

Ref: 15/23908

PLASTICITY INDEX &
MOISTURE CONTENT
DETERMINATIONS

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

BH/TP No.	Depth m	Natural Moisture %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Passing 425 µm %	Class
BH1	1.75	21	39	18	21	100	CI
BH2	3.00	19	41	16	25	100	CI
	4.00	19	39	15	24	97	CI

Ref: 15/23908

SULPHATE & pH DETERMINATIONS

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

BH/TP No.	DEPTH BELOW GL m	SOIL SULPHATES AS SO_4 TOTAL %	SOIL SULPHATES AS SO_4 WATER SOL g/l	WATER SULPHATES AS SO_4 g/l	pH	CLASS	SOIL - 2mm %
BH1	6.00		0.04		5.4	DS-1	100
BH2	2.00		0.02		4.1	DS-1	100
BH3	8.00		0.03		4.9	DS-1	100

Classification – Tables C1 and C2 : BRE Special Digest 1 : 2005

Ref: 15/23908

GROUNDWATER MONITORING

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

MONITORING DATE 30th July 2015

BOREHOLE REF:		**BH1**	**BH2**	**BH3**
Water Level	(m.bgl)	DRY	DRY	DRY
Depth to base of well	(m.bgl)	6.10	6.19	6.01
Depth to base of well	(mSD)	43.4	43.41	44.49

Table 4

Ref: 15/23908

GROUNDWATER MONITORING

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

MONITORING DATE 21st August 2015

BOREHOLE REF:		**BH1**	**BH2**	**BH3**
Water Level	(m.bgl)	DRY	DRY	DRY
Depth to base of well	(m.bgl)	6.10	6.19	6.01
Depth to base of well	(mSD)	43.4	43.41	44.49

Table 4a

Ref: 15/23908

GROUNDWATER MONITORING

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

MONITORING DATE 28th September 2015

BOREHOLE REF:		**BH1**	**BH2**	**BH3**
Water Level	(m.bgl)	DRY	DRY	DRY
Depth to base of well	(m.bgl)	6.10	6.19	6.01
Depth to base of well	(mSD)	43.4	43.41	44.49

Table 4b

GROUNDWATER MONITORING

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

MONITORING DATE 12th December 2016

BOREHOLE REF:		**BH1**	**BH2**	**BH3**
Water Level	(m.bgl)	DRY	DRY	DRY
Depth to base of well	(m.bgl)	6.10	6.19	6.01
Depth to base of well	(mSD)	43.40	43.41	44.49

Table 4c

GROUNDWATER MONITORING

LOCATION 15 Lyndhurst Terrace, Hampstead, London, NW3 5QA

MONITORING DATE 22nd February 2017

BOREHOLE REF:		**BH1**	**BH2**	**BH3**
Water Level	(m.bgl)	DRY	DRY	DRY
Depth to base of well	(m.bgl)	6.10	6.19	6.01
Depth to base of well	(mSD)	43.40	43.41	44.49

Table 4d

Appendix C. Ground Movement Assessment

REPORT CONTROL SHEET

15 Lyndhurst Terrace, London NW3

Damage Category Assessment

Project number P4118

Report number P4118/02
Revision number 02
Issue number 01

Archive number

This document has been produced for and on behalf of
Applied Geotechnical Engineering

Made by:	M G Brice	Associate
Checked by:	N A Smith	Director

Revisions:

Revision No	Details	Date
01	Drawing '1424 Basement Plan for GMA.pdf' and comment on soil stiffness added to Addendum.	27/2/17
02	Minor text revision Section 5.12	9/3/17

Distribution:

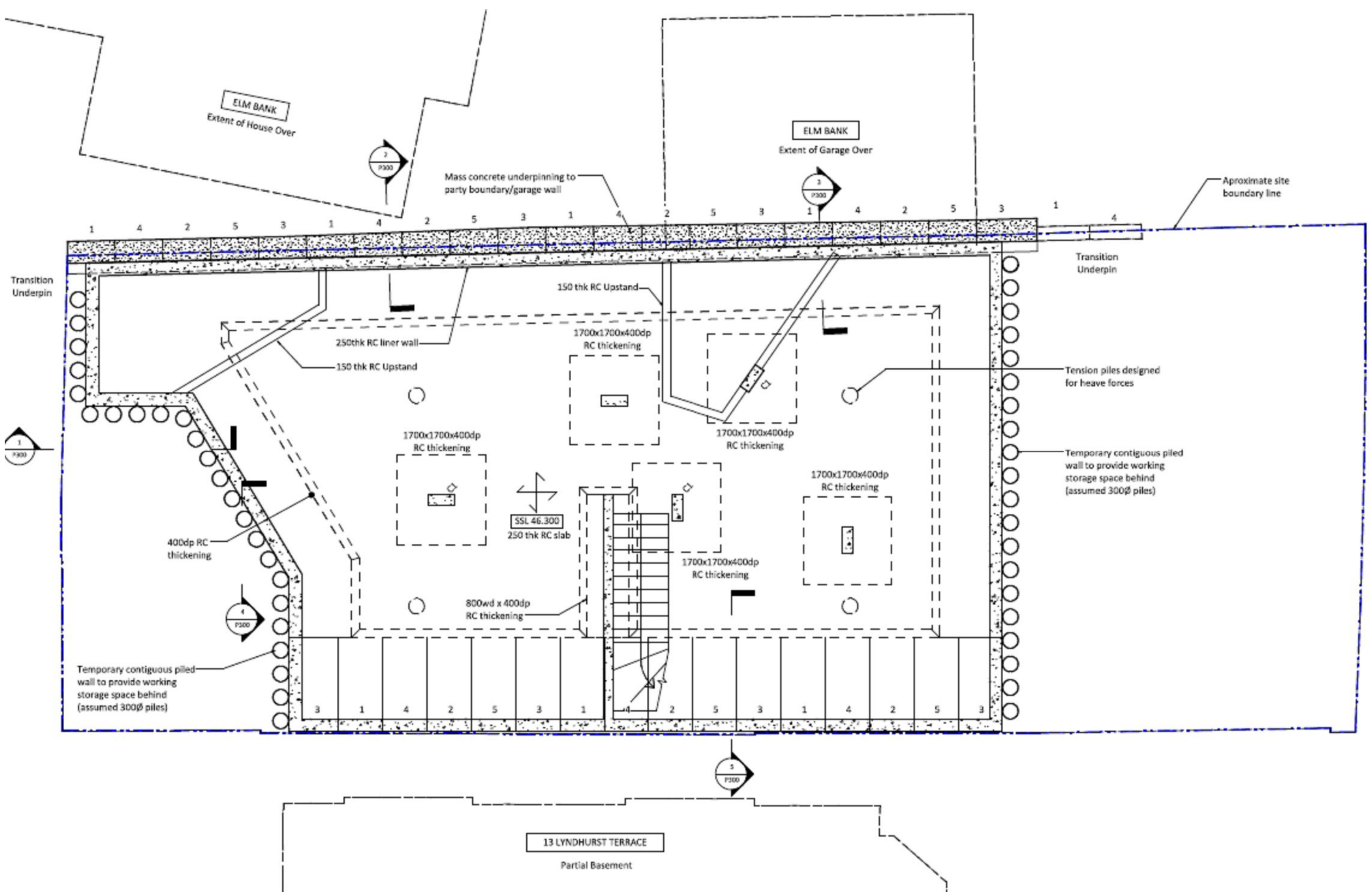
Issue No	Date	Distribution	No of copies
1	March 2017	Site Analytical Services Ltd	1 x pdf
1	March 2017	AGE	1 x pdf

Addendum to report No P4118/01 dated 26/10/15, issued 2/11/15 to Site Analytical Services.

Following the issue of the report as above the proposed basement scheme has been amended, as reflected in the following documents received in February 2017, and associated email correspondence:-

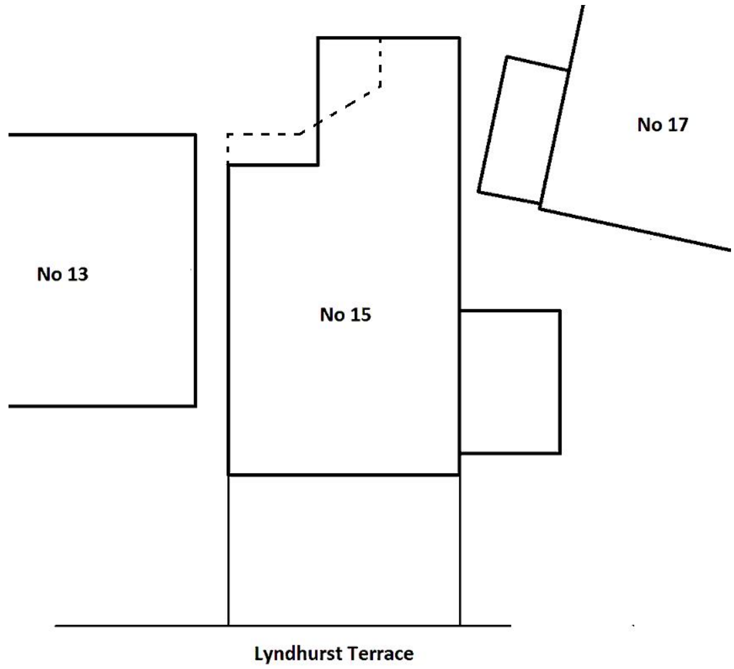
Heyne Tillet Steel sketch No 1424/SK06
HTS drawing file '1424 Basement plan for GMA.pdf' (reproduced below).

It is understood that the proposed depth of the basement is as was proposed for the original scheme, the construction methods are also similar, and the loads are of a similar order of magnitude to those in the original scheme.



HTS drawing file '1424 Basement plan for GMA.pdf'

On the basis of the above, in the context of the original damage category assessment, the only significant change is to the plan geometry of the excavation, at the rear. In particular, the proposed left flank wall of the basement now extends further rearwards, to the same rearward extent as the right flank wall of No 13 Lyndhurst Terrace (shown dashed in the figure below, overlain onto original proposal, shown solid).



In our opinion the amendment to the basement layout will tend to reduce the degree of vertical distortion suffered by the right flank wall of No 13, as the differential ground movements around the corner of the excavation will be displaced rearwards. In other respects there are no apparent significant changes from the original scheme that would impact on our original Damage Category Assessment of the original scheme.

The soil stiffness used in the original analysis has been queried by the checker. We believe this is due to a misunderstanding: the combination of small-strain undrained stiffness (Euo) and non-linear degradation curve adopted in the analysis, yields a stiffness (Eu) of 800Su at 0.1% strain. We believe this is acceptable to the checker.

In our opinion, therefore, the conclusions of the original Damage Category Assessment, reproduced below, remain applicable to the revised scheme.

1.0 Introduction

In connection with the proposal to redevelop No 15 Lyndhurst Terrace, London NW3 5QA, including the demolition of the existing structure and construction of a new dwelling with a basement level, Applied Geotechnical Engineering Ltd (AGE) has been instructed by Site Analytical Services Ltd (SAS), on behalf of their client, to provide information on the effect of these excavations on the neighbouring properties. These are Nos 13 and 17 Lyndhurst Terrace (also known as 'Elm Bank'). No 13 lies to the left of No 15, and No 17 lies to the right.

The terms 'right', 'left' and 'rear' are as viewed from the front of the property on Lyndhurst Terrace. The relative locations of the buildings are given below in Figure 1.

The structural engineer for the project is Heyne Tillet Steel (HTS). A plan showing the proposed basement is given below in Figure 2.

The existing ground level in the area of the proposed basement is believed to be approximately 95mOD. Available drawings relate levels to a site datum (SD), which will also be used for this assessment. The site slopes gently upward from front to rear; the ground level in the area of the proposed basement excavation is approximately 49.6mSD at the front to 50.5mSD at the rear.

It is understood that the proposed excavation level is to be taken as 46.1mSD (3.5m bgl at the front of the site, 4.4m bgl at the rear).

The neighbouring property at No13 is understood to have a lower ground floor.

A combined underpin and bored-pile wall construction method is proposed for the excavation works.

It is required that predicted damage category assessments be made on the neighbouring buildings; Nos 13 and 17 Lyndhurst Terrace.

2.0 Information Provided

The following relevant information has been used for these calculations:-
i) SAS Borehole and Trial Pit logs dated 24/7/2015, with associated lab test results.
ii) HTS sketches 1424_SK01-SK04 (incorporating loading information)
iii) HTS drawings 1424/P002P1, P003, P004, P090P1, P100P1, P110, P120.
iv) Email correspondence SAS-AGE dated 20/10/2015 to 21/10/2015.

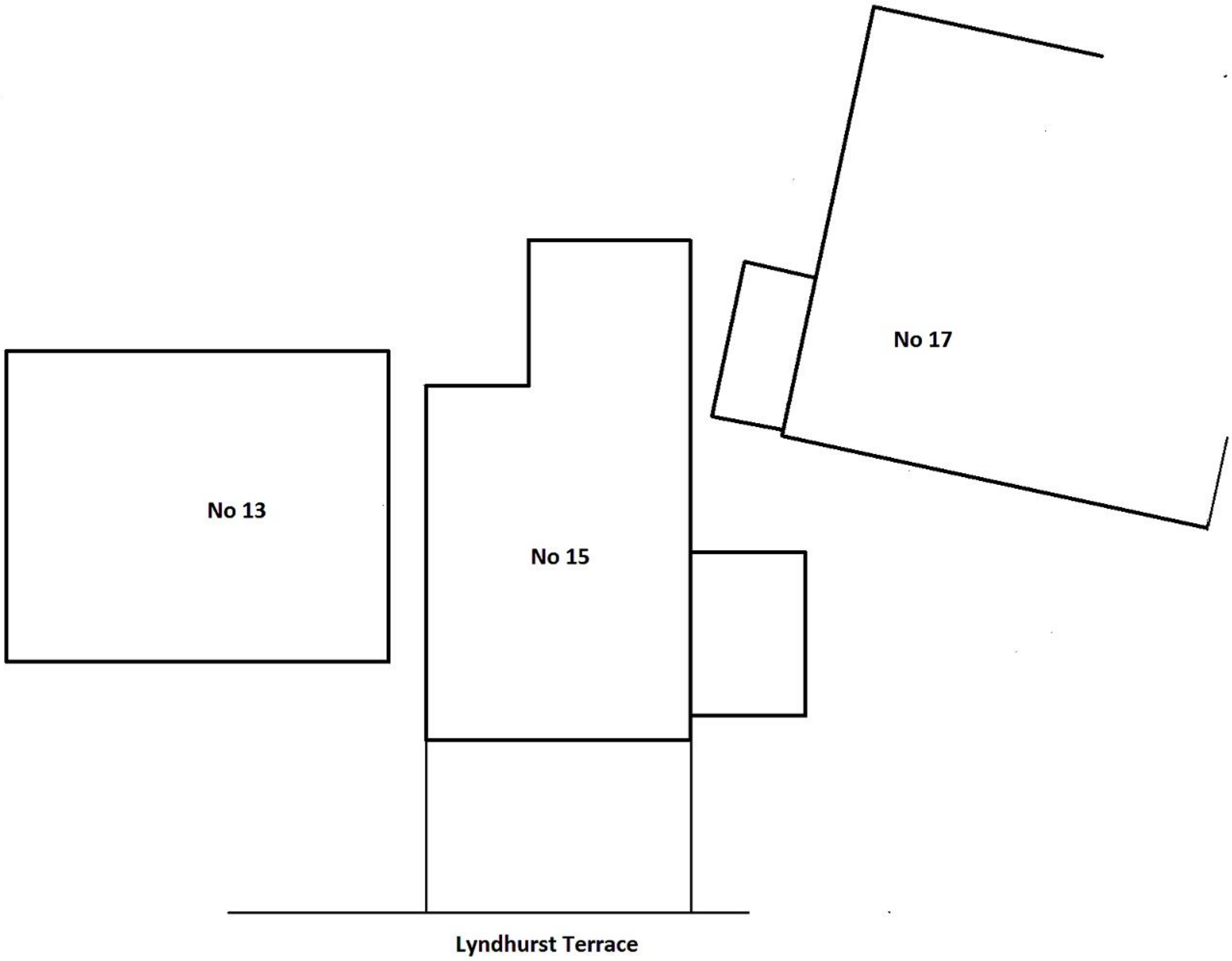
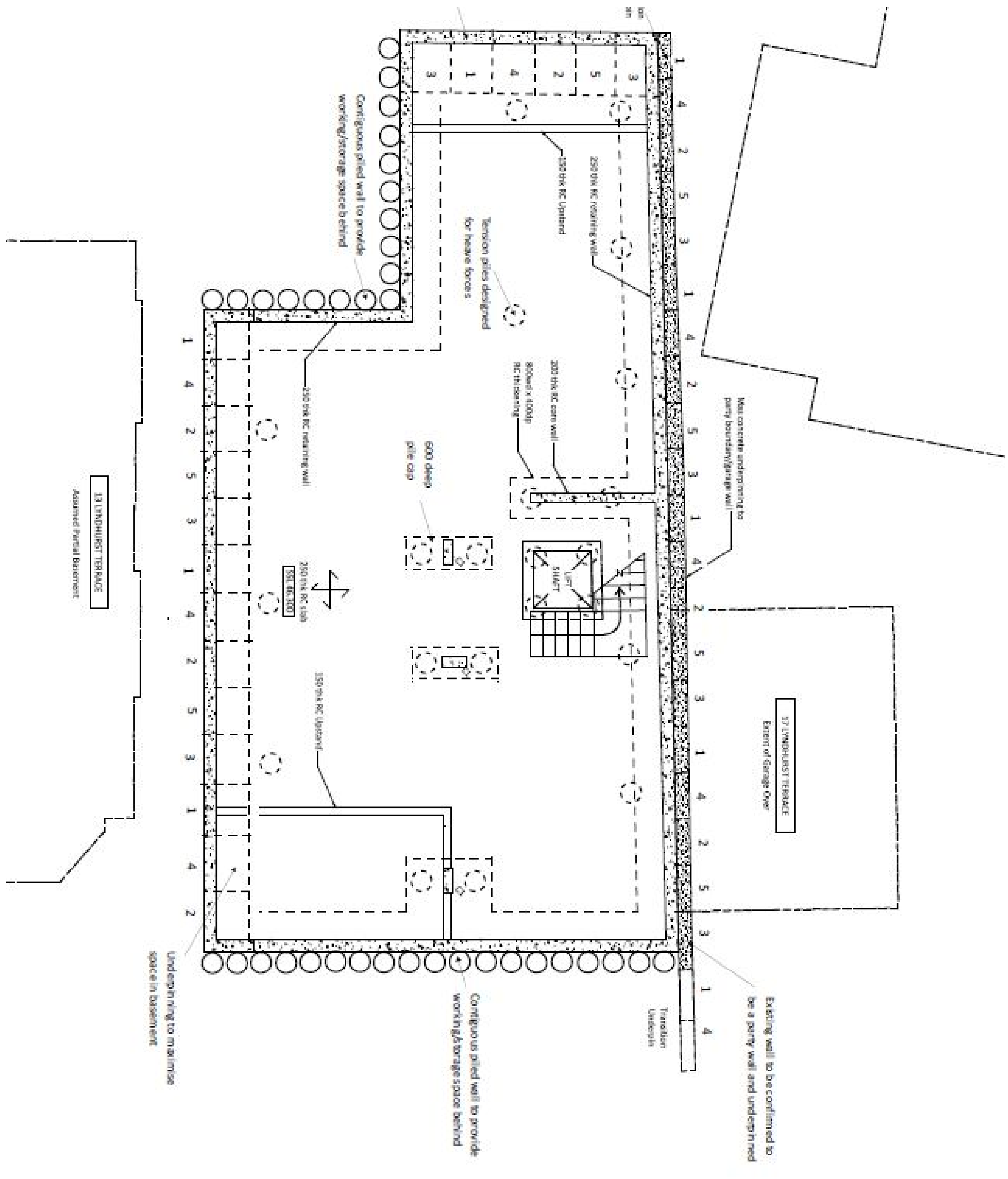


Figure 1 – Site location

REAR



FRONT

Figure 2 –Proposed LGF
(Extract of HTS Drawing 1424/P090 P1)

3.0 Anticipated Ground Conditions

For the practical purposes of this report the existing external ground level in the area of the site is taken to be, on average, approximately 95mOD or 50mSD. The variations in ground level from front to rear of the property, as detailed above, will be accounted for in the assessment.

The published geological map (BGS 1:50 000 sheet 256: North London) indicates the site to lie on Claygate Beds (silt and fine sand) overlying the London Clay (silty clay). On a developed site such as this Made Ground is also anticipated.

On the basis of the published mapping the base of the London Clay is anticipated to lie at approximately –18mOD. This corresponds to a depth of approximately 113m below ground level.

A ground investigation was undertaken at the site at the end of July 2015 (Item 'i' in Section 2 above). This comprised three boreholes and a hand-dug trial pit.

Two boreholes (BHs 1 +2) were sunk at the front of the existing house; a rotary percussion borehole (BH1) sunk to 15m depth (34.5mSD), and a continuous flight auger borehole (BH2) sunk to 8.3m depth (41.3mSD). At the rear of the house a second CFA borehole (BH3) was also sunk to 8.3m depth (42.2mSD). A hand-dug trial pit was excavated adjacent to the rear wall of the existing property to identify foundation depth.

The boreholes at the front of the site confirmed between 400mm and 700mm of Made Ground overlying very sandy clay, interpreted as Claygate Beds, to a depth of approximately 9.4m (40.1mSD). In both boreholes the Claygate Beds included a 1.5-2.1m bed of slightly clayey fine sand below 45.6mSD. The Claygate Beds were underlain by the London Clay.

BH3 at the rear of the house encountered Made Ground to a reported depth of 1.3m (49.3mSD), underlain by the very sandy clay of the Claygate Beds (but with no layer of clayey sand). This persisted to the base of the borehole at 42.2mSD.

Plasticity index determinations were undertaken on three samples of the Claygate Beds from the boreholes. These yielded results in the range PI=21-25% with an average of 23%.

Groundwater was encountered as a 'very slight' seepage at 15m depth in BH1, but otherwise the boreholes were dry during excavation. All the boreholes were equipped with water-monitoring standpipe piezometers. The response zones were from 3-6m depth in all three boreholes (coincident with the clayey sand layer in BHs 1+2).

Subsequent monitoring of the standpipes, from July to September 2015, indicated them to be dry.

On the basis of the above, the soil sequence at the site is taken to be:-

General surrounding ground level:- 95mOD (50mSD; 49.6mSD at front, 50.5mSD at rear)
Base of Made Ground:- 49.2mSD
Base of Claygate Beds 40.1mSD
Base of London Clay -18mOD (113mbgl, -63mSD).

The Made Ground lies above the proposed excavation level and therefore does not influence the ground movement beneath the adjoining properties, it will therefore not be considered further.

During the ground investigation, standard penetration tests (SPT) were undertaken in BH1 and Mackintosh Probes were undertaken in BH2+3. The Mackintosh probe is not a standardised test, but previous experience indicates it can be very approximately indicative of the equivalent SPT blow-count (N). By comparison of the SPT results from BH1 with the Mackintosh Probe results from the nearby BH2 it is found that a reasonable correlation between the two tests can be had by taking $N_{300}/10$ = SPT'N' (where N300 is the number of blows of the Mackintosh probe hammer required to advance the probe 300mm). The results of these tests (with the Mackintosh Probe results converted to approximate equivalent SPT 'N' values as above) have been plotted in Figure 3 below.

It is seen that the correlation is not supported between depths of 2m and 4m, where unusually high SPT blow counts were recorded in BH1. The reason for this is not clear but desiccation or root-strike related to a nearby tree at No 17 may be responsible. Nevertheless below the proposed excavation level (3.5m-4.5mbgl) the correlation is reasonable, and appears to persist when extrapolated down into the London Clay.

It is noted that the SPT results (including Mackintosh Probe equivalent results) for the Claygate Beds align reasonably well with those for the underlying London Clay, which are also plotted in Figure 3. On this basis a single trend line is proposed for both soils, this line is described by:-

SPT'N' = $7 + 1.6z_1$

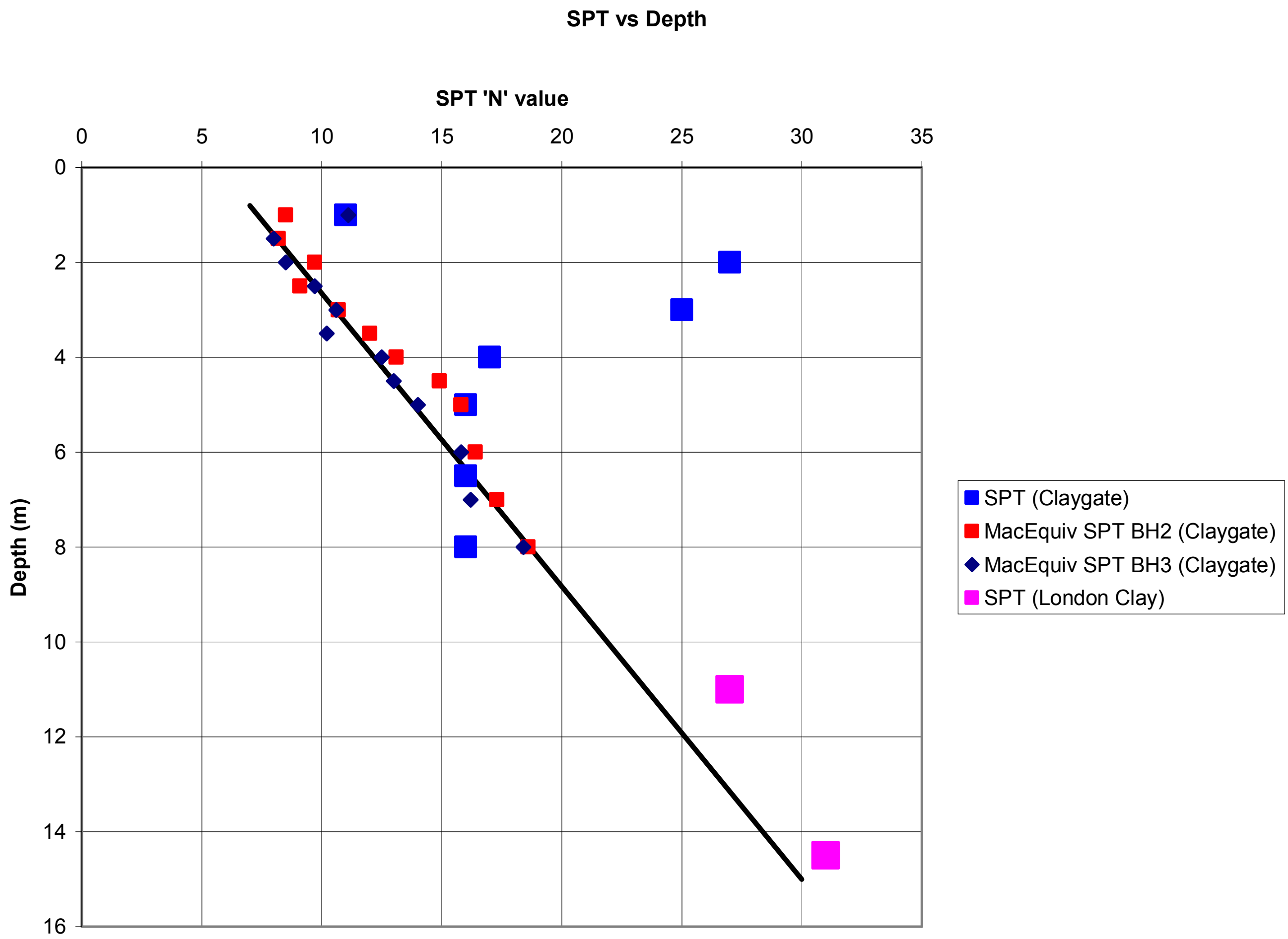


Figure 3 –SPT profile

Where z_1 is the depth below the top of the Claygate beds at 0.8m depth (49.2mSD).

The standard penetration test results can be correlated with undrained strength by reference to the work of Stroud (Ref 1). In the Claygate Beds a correlation coefficient of 4.8 has been adopted based on the measured plasticity index of 23%, in the London Clay the correlation coefficient is typically of the order of 4.4, based on previous experience and published data. By these means the SPT values (including Mackintosh Probe equivalent) in Figure 3 have been converted to undrained strength values and plotted in Figure 4. Two unconsolidated undrained triaxial tests has also been carried out on samples of the London Clay, and the results of these also appear in Figure 4.

On the basis of Figure 4, and for the purposes of this report only, the undrained strength (Su) combined profile for the Claygate Beds and London Clay has been taken as:-

$Su = 35 + 7.4z_2$ (kPa) to 30mbgl (20mSD), changing to:-

$Su = 251 + 3.7z_2$ (kPa) to the base of the London Clay (-18mOD).

Where z_2 is the depth in metres below the top of the Claygate Beds (at 49.2mD, or approximately 0.8m depth). The use of a bilinear profile, with reduced rate of strength increase at depth, reduces the tendency to predict excessive strengths (and stiffness values) at depth.

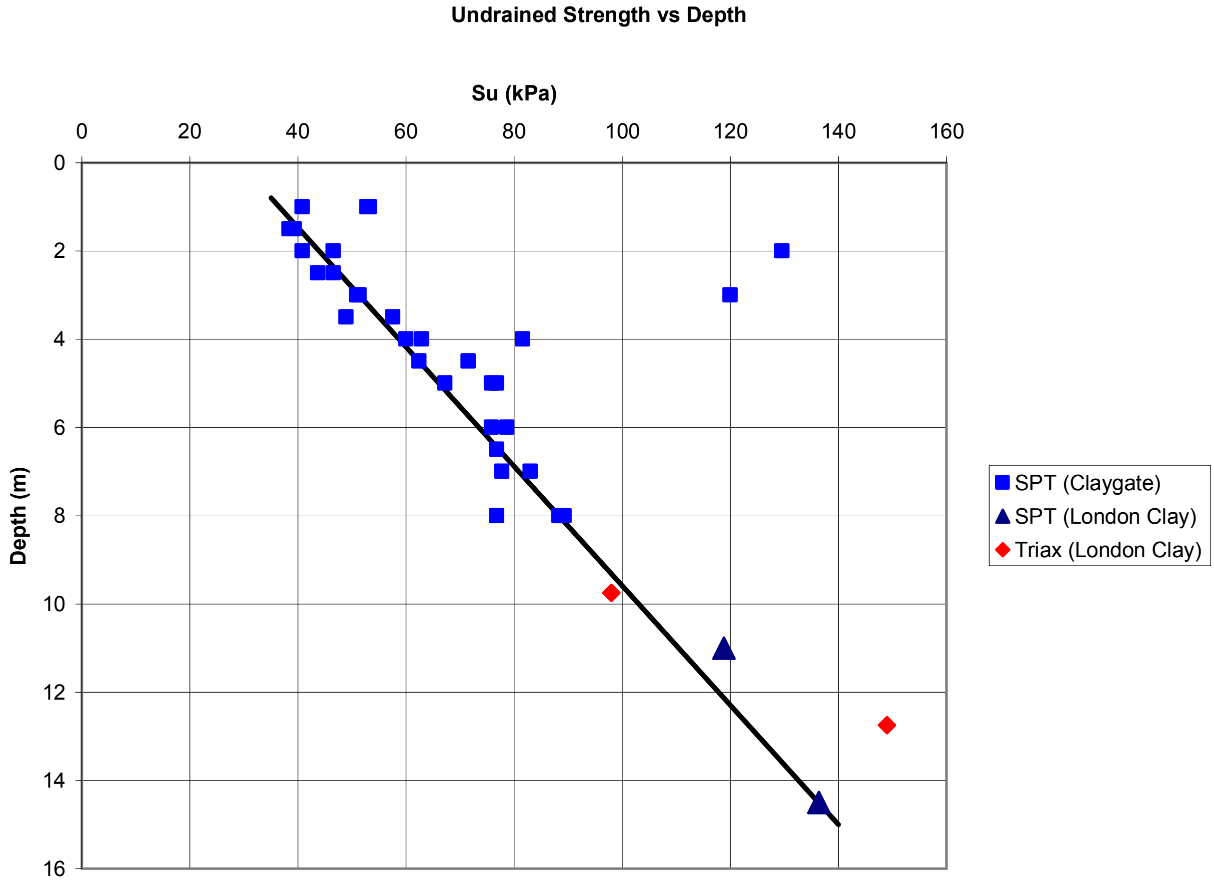


Figure 4 – Su Profile

(Reference to SPT in key includes equivalent-SPT from Mackintosh Probes)

A trial pit (TP1) was excavated against the existing rear wall of No 15. This revealed the corbelled foundations to lie at approximately 0.5m depth (49.5mSD), bearing on apparent in situ ground of loose silty fine sand, which was penetrated to approximately 0.8m depth. This material is interpreted to be a sand layer within the Claygate Beds. For the purposes of this report, and in the absence of other information, it is assumed that all the existing foundations, of this property and of No 17, are founded at the top of the Claygate Beds at an adopted average level of 49.2mOD.

On the basis of Google Streetview images, and the information provided, we estimate No 13 to be founded at approximately 47.5mSD.

4.0 Loads

Vertical building loads, which are taken here as DL+LL/2 for the purposes of settlement calculation, have been provided as follows (Item 'ii' in Section 2 above):-

a) Existing line loads along walls range from 17kN/m run to 54kN/m run.

b) Proposed line loads along walls range from 20kN/m run to 100kN/m run.

c) Proposed internal column loads range from 375kN to 500kN.

It is understood that proposed column loads, and selected wall loads, will bear onto piles, while the remaining wall loads will bear onto L-shaped underpin bases. The relative locations of these elements are shown in Figure 2 above.

Excavation, from existing ground level to the new basement level, will yield a significant load reduction; a bulk unit weight of 20kN/m^3 has been adopted for the calculation of this unload.

It is understood that a number of heave-resisting piles are proposed within the excavation, these will have a limited effect on ground movement outside the excavation, and they have not been modelled in the analysis. This is conservative.

5.0 Estimated movement

5.1 Temporary support to the basement walls.

It is assumed within the following calculations that the excavation perimeter retaining walls will be stiffly and safely propped at all stages of construction in line with BS5975:2008 and current good practice. Inadequate propping is likely to result in increased ground movements, and therefore increased damage to adjacent properties, as well as increased risk of injury to personnel.

It is generally recommended that consideration be given to the preloading of temporary excavation wall props, and to the monitoring of prop loads during critical stages of excavation.

5.2 Soil stiffness values

An equivalent-elastic analysis has been carried out using the program PDisp. The program takes no account of structural (building) stiffness.

The soil stiffness parameters are as given below.

In general, there is little published information regarding the stiffness characteristics of the Claygate Beds clay. However, Hellings et al (Ref 5) carried out a series of high-quality tests on Claygate Beds and London Clay samples from the Bell Common site in Essex. They concluded that the Claygate Beds were more than 2x stiffer than the London Clay over a range of strains between 0.01% and 1% strain, when normalised against in situ stress. The greater Ko values measured in the London Clay in that study was insufficient to compensate for this greater normalised stiffness, therefore the stiffness of the Claygate Beds can be taken to be greater than that of the London Clay at that site, with due account taken for depth of burial.

It is therefore assumed here that the Claygate Beds and the London Clay can be taken to act as a single unit, and that the stiffness of that unit can be taken to be represented by the stiffness of the London Clay. On the basis of the limited data available this assumption is considered to be conservative.

The London Clay has been treated as a non-linear material. The small-strain stiffness is taken as 80% of the small-strain stiffness calculated from recent high quality data (Bond Street Station). Those data yielded E_{uo} = 1940Su, therefore for the purposes of the current analysis take:-

E_{uo} = 1550 × Su; (Poisson's ratio = 0.5)
E'_o = 1240 × Su; (Poisson's ratio = 0.2)

Which, from the Su profile defined above in Section 3, yields:-

From top of Claygate Beds (49.2mSD) to 20mSD:-

$E_{uo} = 54 + 11.5z_2$ (MPa)
$E'_o = 43 + 9.2z_2$ (MPa)   (Where z_2 = depth below top of Claygate Beds in metres).

and from 20mSD to base of London Clay (-63mSD):-

$E_{uo} = 390 + 5.7z_2$ (MPa)
$E'_o = 312 + 4.6z_2$ (MPa)   (Where z_2 = depth below top of Claygate Beds in metres).

A non-linear degradation curve relating stiffness to strain, based on published data for the London Clay, has been used.

5.3 Causes of ground movement outside the excavations

The analysis considers three causes of ground movement outside the excavations, these are:-
i) Vertical ground movement due to vertical changes in load resulting from building works and excavation
ii) Vertical and horizontal movement due to installation of underpin and piled walls
iii) Vertical and horizontal movement due to deflection of underpin and piled walls, following removal of support from in front of the walls by excavation.

The first of these causes is investigated using equivalent-elastic analysis in the program PDISP as described above. The second and third are based upon case-history data presented in Figures 2.8, 2.9 and 2.11 in CIRIA C580 (Ref 3). These data relate to pile wall installation in stiff clays, though reference to the individual case histories indicates there were substantial thicknesses of Made Ground and Terrace Gravel present at many of the sites, therefore the results are taken to be applicable to this site. It is currently understood that the plots presented by CIRIA in the above figures include short-term movement arising from cause 'i' above. Therefore in this report short-term movements are calculated using the CIRIA data, and subsequent long-term movement is calculated using PDISP.

The CIRIA plots relate vertical and horizontal ground movement to the depth of the wall installed (for Cause 'ii' above), or to the depth of excavation within that wall (for Cause 'iii' above) as appropriate. Data relating to the secant bored pile wall case history in Ref 3 Figure 2.8 are considered to be unreliable and have been ignored. In addition, data relating to counterfort diaphragm walls have not been taken into account in this analysis. No data are presented by CIRIA for underpinned walls, and no other data are available from other sources for underpin walls. Underpin walls are therefore, of necessity, assumed to be similar in behaviour to plane diaphragm walls and bored pile walls.

The CIRIA data indicate that:-

a) Adjacent to the underpin or pile wall, vertical ground settlement resulting from wall installation can be taken to equal 0.04% of wall depth, reducing linearly to zero at a distance of 2 x wall depth from the wall (Ref 3, Figures 2.8b and 2.9b).

b) Adjacent to the underpin or pile wall, vertical ground settlement resulting from wall deflection can be taken to equal 0.04% of excavation depth, increasing to 0.08% of excavation depth at a distance of 0.6 x excavation depth from the wall, then reducing approximately linearly to zero at a distance of 3 x excavation depth from the wall. (Ref 3, Figure 2.11b).

c) Adjacent to the underpin or pile wall, horizontal ground movement resulting from wall installation can be taken to equal 0.04% of wall depth, reducing linearly to zero at a distance of 1.5 x wall depth from the wall (Ref 3, Figures 2.8a and 2.9a).

d) Adjacent to the underpin or pile wall, horizontal ground movement resulting from wall deflection can be taken to equal 0.15% of excavation depth, reducing linearly to zero at a distance of 4 x dig depth from the wall. (Ref 3, Figure 2.11a).

The above trends rely on good workmanship and stiffly-propped, stiff walls. Temporary support of excavations should be designed to BS5975 and BS8002.

It is understood that the piles have yet to be designed, therefore, for the purposes of this assessment only, pile lengths will be assumed to be the greater of 1.4 x adjacent excavation depth, or the estimated length required to carry the imposed vertical loads.

It will be noted that the horizontal ground movements described in 'c' and 'd' above will tend to yield consistent average ground strains; these are (0.04%/1.5 =) 0.0267% average horizontal ground strain resulting from wall installation, and (0.15%/4 =) 0.0375% average horizontal ground strain resulting from yielding of the wall due to bulk excavation within. There is therefore a consistent prediction, following wall installation and subsequent bulk excavation, of a total of 0.064% average total horizontal ground strain within a distance of 1.5 x wall depth from the excavation, reducing, at greater distance, to 0.0375% horizontal ground strain, out to a distance of 4 x excavation depth from the excavation. These results are used in the following sections.

CIRIA C580 is used to predict the ground movement under plane-strain conditions. Where the wall lengths are comparatively short, plane-strain conditions are only likely to develop near the mid-points of the walls, if at all. Therefore the buttressing influence of the excavation corners has been taken into account in calculating the predicted vertical ground movements, using the method of Fuentes and Devriendt (Ref 4). This method has not been sufficiently verified for the case of horizontal ground movements, and therefore is not taken into account rigorously in the analysis, however the tendency for horizontal ground movement to be reduced at excavation corners is noted below, where appropriate.

Note that, in all the plots of vertical movement, settlement is taken as positive and heave as negative. The CIRIA data are understood to relate to movement at, or close to, ground level.

The analysis assumes that excavation is carried out reasonably uniformly across the footprint of the basement. If this is not the case, and there are temporary substantial variations in the excavation depth, then more severe short-term wall distortions may arise than are predicted here.

5.4 Predicted movement – No 13 Lyndhurst Terrace, front wall.

5.4.1 Vertical Movement

Profiles of predicted short- and long-term vertical ground movement along the front wall of No 13 Lyndhurst Terrace have been calculated and plotted in Figure 6.

The length of this wall is not known with certainty but, from Google Earth imagery, it is estimated to be approximately 12.6m long. Its position is shown on the plan in Figure 6.

The analysis indicates a maximum overall tilt of 3.4mm along the 12.6m length of this wall. This equates to a whole-wall gradient of less than 1 in 3700. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 0.8mm within an 11.6m length of the wall. This equates to a deflection ratio of 0.007%. Taking the limiting tensile strain between the 'very slight' and 'slight' damage categories as being 0.075% (Ref 2) then the worst-case ratio of deflection ratio to limiting tensile strain =0.093. By reference to Figure 5 (Ref 2 Figure 6) and taking the length of the wall as being approximately equal to its height, a horizontal strain/limiting tensile strain ratio of 0.93 is obtained, therefore a horizontal strain of 0.07% is acceptable for a 'very slight' category of damage. This analysis does not take account of the stiffness of the wall; the result is therefore conservative in this respect.

5.4.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the excavation at No 15 Lyndhurst Terrace is predicted to be 0.064%. This is less than the 0.07% limit for very slight damage calculated above. The predicted damage category for the wall is therefore 'very slight' or less (as defined in Ref 2).

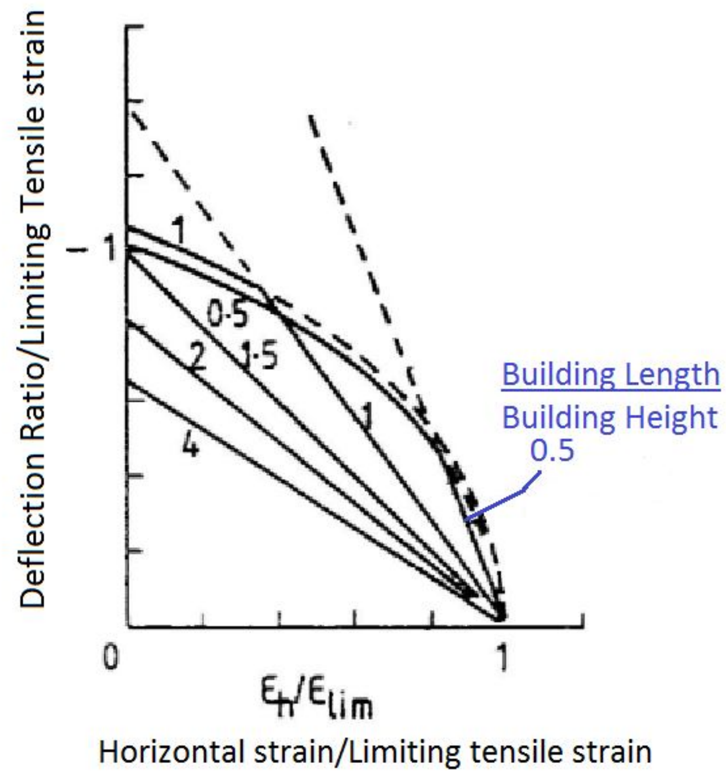


Figure 4 (from Ref 2)

5.5 Predicted movement – No 13 Lyndhurst Terrace, rear wall.

Profiles of short- and long-term vertical ground movement along the rear wall of No 13 have been calculated and plotted in Figure 7.

The length of this wall is not known with certainty but, from Google Earth imagery, it is estimated to be approximately 12.6m long. Its position is shown on the plan in Figure 7.

The analysis indicates a maximum overall tilt of approximately 2.7mm along the 12.6m length of this wall. This equates to a whole-wall gradient of less than 1 in 4600. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 0.4mm within an 11.6m length of the wall. By comparison with the front wall analysis (Section 5.4 above) the predicted damage category for the wall can be taken as ‘very slight’ or less (as defined in Ref 2).

5.6 Predicted movement – No 13 Lyndhurst Terrace, right flank wall.

5.6.1 Vertical Movement

Profiles of short- and long-term vertical ground movement along the right flank wall of No 13 Lyndhurst Terrace have been calculated and plotted in Figure 8.

The wall is understood to be approximately 11.4m long, and lies in the position shown on the plan in Figure 8.

The analysis indicates a maximum overall tilt of 1mm along the 11.4m length of this wall. This is negligible.

The maximum predicted wall distortion (Delta – as defined by Burland, Ref 2) is 0.7mm within a 9.6m length of the wall. This equates to a deflection ratio of 0.007%. Taking the limiting tensile strain between the ‘very slight’ and ‘slight’ damage categories as being 0.075% (Ref 2) then the worst-case ratio of deflection ratio to limiting tensile strain =0.093. By reference to Figure 5 (Ref 2 Figure 6) and taking the length of the wall as being approximately equal to its height, a horizontal strain/limiting tensile strain ratio of 0.93 is obtained, therefore a horizontal strain of 0.07% is acceptable for a ‘very slight’ category of damage. This analysis does not take account of the stiffness of the wall; the result is therefore conservative in this respect.

5.6.2 Lateral movement.

Due to the nature of the proposed works the horizontal strain along the plane of this wall can be taken to be negligible. The predicted damage category for the wall is therefore ‘very slight’ or less (as defined in Ref 2).

5.7 Predicted movement – No 17 Lyndhurst Terrace, front wall.

Profiles of short- and long-term vertical ground movement along the front wall of No 17 have been calculated and plotted in Figure 9.

The length of this wall is not known with certainty, but from Google Earth imagery, it has been estimated at approximately 16.1m. It lies in the position shown on the plan in Figure 8. This wall lies oblique to the coordinate axes, nevertheless locations along its length are adequately represented by the X-coordinate.

The analysis indicates a maximum overall tilt of 4.5mm along the 16.1m length of the wall. This equates to a whole-wall gradient of less than 1 in 3500. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 1.6mm within the 16.1m length of the wall. This equates to a deflection ratio of 0.01%. Taking the limiting tensile strain between the ‘very slight’ and ‘slight’ damage categories as being 0.075% (Ref 2) then the worst-case ratio of deflection ratio to limiting tensile strain =0.133. By reference to Figure 5 (Ref 2 Figure 6) and taking the length of the wall as being approximately equal to 2x its height, a horizontal strain/limiting tensile strain ratio of 0.835 is obtained, therefore a horizontal strain of 0.063% is acceptable for a 'very slight' category of damage. This analysis does not take account of the stiffness of the wall; the result is therefore conservative in this respect.

5.7.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the excavation at No 15 Lyndhurst Terrace is predicted to be 0.064%. This is greater than the 0.063% limit calculated above for 'very slight' damage. However this degree of horizontal strain only affects ground within 1.5x wall depth, or 6.6m, of the proposed basement wall at No 15. This suggests that the proximal 3.3m length of the front wall of No 17, where vertical distortion is minimal, will be subject to a ground strain of 0.064%, the remainder will be subject to a lesser ground strain (0.037% - see Section 5.3 above).

The analysis does not take into account the stiffness of the wall, in the horizontal or vertical directions. On the basis of the above it is considered that the predicted damage category for the wall can be taken as 'very slight' or less (as defined in Ref 2).

5.8 Predicted movement – No 17 Lyndhurst Terrace, main left flank wall.

Profiles of short- and long-term vertical ground movement along the left flank wall of No 17 have been calculated and plotted in Figure 10.

The length of this wall is not known with certainty, but from Google Earth imagery, it has been estimated at approximately 16.1m. It lies in the position shown on the plan in Figure 10. This wall lies oblique to the coordinate axes, nevertheless locations along its length are adequately represented by the Y-coordinate.

The analysis indicates a maximum overall tilt of 4.1mm along the 16.1m length of this wall. This equates to a whole-wall gradient of less than 1 in 3900. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 0.5mm within a 13.2m length of the wall. By comparison with the front wall of the property (Section 5.7 above) and taking into account that the horizontal ground strain along the plane of this wall, arising from the excavation at No 15,will be negligible, the predicted damage category for this wall is 'very slight' or less, as defined in Ref 2.

5.9 Predicted movement – No 17 Lyndhurst Terrace, minor left flank wall.

Profiles of short- and long-term vertical ground movement along the minor left flank wall of No 17 have been calculated and plotted in Figure 11.

This wall is taken to be approximately 5.6m. It lies in the position shown on the plan in Figure 11. This wall lies oblique to the coordinate axes, nevertheless locations along its length are adequately represented by the Y-coordinate.

The analysis indicates a maximum overall tilt of 0.7mm along the 5.6m length of the wall. This equates to a whole-wall gradient of 1 in 8000. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 0.4mm within a 4.4m length of the wall. This equates to a deflection ratio of 0.009%. Taking the limiting tensile strain between the 'very slight' and 'slight' damage categories as being 0.075% (Ref 2) then the worst-case ratio of deflection ratio to limiting tensile strain =0.120. By reference to Figure 5 (Ref 2 Figure 6) and taking the length of the wall as being approximately equal to its height, a horizontal strain/limiting tensile strain ratio of 0.912 is obtained, therefore a horizontal strain of 0.068% is acceptable for a 'very slight' category of damage. This analysis does not take account of the stiffness of the wall; the result is therefore conservative in this respect.

5.9.2 Lateral movement.

Due to the orientation of the wall with respect to the excavation at No 15 the horizontal ground strain in the plane of the wall can be taken as negligible, therefore the predicted damage category for the wall can be taken as 'very slight' or less (as defined in Ref 2).

5.10 Predicted movement – No 17 Lyndhurst Terrace, Garage, front and rear walls.

It is not clear that the damage category assessment for the property needs to include the separate garage structure. However, for completeness, it has been considered here.

5.10.1 Vertical Movement

Profiles of predicted short- and long-term vertical ground movement along the front and rear walls of the garage of No 17 Lyndhurst Terrace, have been calculated and plotted in Figures 12 and 13.

Each of these walls is understood to be approximately 4.2m long, and to lie in the locations shown in Figures 12+13.

The predicted overall movement, and the distortion, of the front wall is less than that of the rear wall due to the buttressing effects that reduce ground strains near the front corner of the excavation at No 15. Therefore the comments below relate to the rear wall.

The analysis indicates a maximum overall tilt of 0.4mm along the 4.2m length of this wall. This equates to a whole-wall gradient of less than 1 in 10 000. This is considerably less than the 1:400 gradient recognised as requiring remedial action.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is 1.05mm within the 4.2m length of the wall. This equates to a deflection ratio of 0.025%. Taking the limiting tensile strain between the 'very slight' and 'slight' damage categories as being 0.075% (Ref 2) then the worst-case ratio of deflection ratio to limiting tensile strain =0.333. By reference to Figure 4 (Ref 2 Figure 6) and assuming the length of the wall as being approximately equal to 1.5x its height, a horizontal strain/limiting tensile strain ratio of 0.66 is obtained, therefore a horizontal strain of 0.049% is acceptable for a 'very slight' category of damage. This analysis does not take account of the stiffness of the walls; the result is therefore conservative in this respect.

5.10.2 Lateral movement.

From Section 5.3 above, the greatest average horizontal ground strain adjacent to the excavation at No 15 Lyndhurst Terrace is predicted to be 0.064%. This is greater than the 0.049% limit for very slight damage calculated above. The analysis therefore indicates a predicted damage category of 'slight' which in the current context extends from a horizontal ground strain of 0.049% to 0.124%.

The analysis does not take account of the stiffness of the wall, horizontally or vertically, nor of the fact that the mode of distortion is sagging, rather than the more damaging hogging mode considered by Burland in his original analysis; the result is conservative in these respects.

Nevertheless, the predicted damage category for the garage walls is at the low end of 'slight', as defined in Ref 2.

5.11 Predicted movement – No 17 Lyndhurst Terrace, Garage, Left flank wall.

It is not clear that the damage category assessment for the property needs to include the separate garage structure. However, for completeness, it has been considered here. The left flank wall of the garage of No 17 lies on the property boundary, and is to be underpinned in order to form the basement at No 15.

The vertical movement of underpinned walls is not defined by the CIRIA C580 data, which apply outside the excavation. Instead the short-term settlement of this section of party wall, above ground, will be controlled by movements occurring during the underpin construction process. However, such movements depend on the condition of the existing wall, the precise underpinning technique and the quality of workmanship and so cannot reliably be predicted. Experience shows that, in most cases, such movements are minimal and may go unnoticed. However, in adverse circumstances, some millimetres of movement could be realised from this cause.

For the purposes of this report the short-term wall settlement due to underpinning has arbitrarily been assumed to be 5mm. It is considered unlikely that this value will be exceeded, assuming good workmanship.

Profiles of predicted short- and long-term vertical ground movement along the wall, have been calculated and plotted in Figure 14.

The wall is understood to be approximately 6m long, and to lie in the location shown in Figure 14.

The analysis indicates a maximum overall tilt of 0.1mm along the 6m length of this wall. This is negligible.

The maximum wall distortion (Delta – as defined by Burland, Ref 2) is also predicted to be negligible, in the context of the above comments. The predicted damage category for this wall is therefore 'very slight' or less, as defined in Ref 2.

5.12 Predicted damage summary

On the basis of the available information the predicted level of damage to the houses at Nos 13 and 17 Lyndhurst Terrace, arising from the excavation of a basement at No 15, is 'very slight' or less, as defined in Ref 2.

The above assumes a high standard of workmanship.

Damage to the separate garage structure at No 17 is predicted to lie at the low end of 'slight', but this structure is understood to be of basic bare-brick construction and in a condition indicating limited maintenance. The predicted level of damage, which is aesthetic only, would appear therefore to be inconsequential, and may go unnoticed.

A contour plot of the calculated maximum predicted settlement around the proposed excavations is presented in Figure 15 below.

6.0 Groundwater

It is understood that excavations to a level of 46.1mSD are proposed at the site. These will penetrate Made Ground and Claygate Beds, which overlie a thick deposit of London Clay.

Observations during the ground investigation, and subsequent standpipe readings, indicate that, during the observation period, the groundwater level beneath the site lay below the proposed excavation depth.

It is therefore anticipated that any existing local groundwater flow paths, and groundwater storage, will not be significantly affected by the proposals.

Therefore it is concluded that the development will not significantly affect the local groundwater regime.

References:

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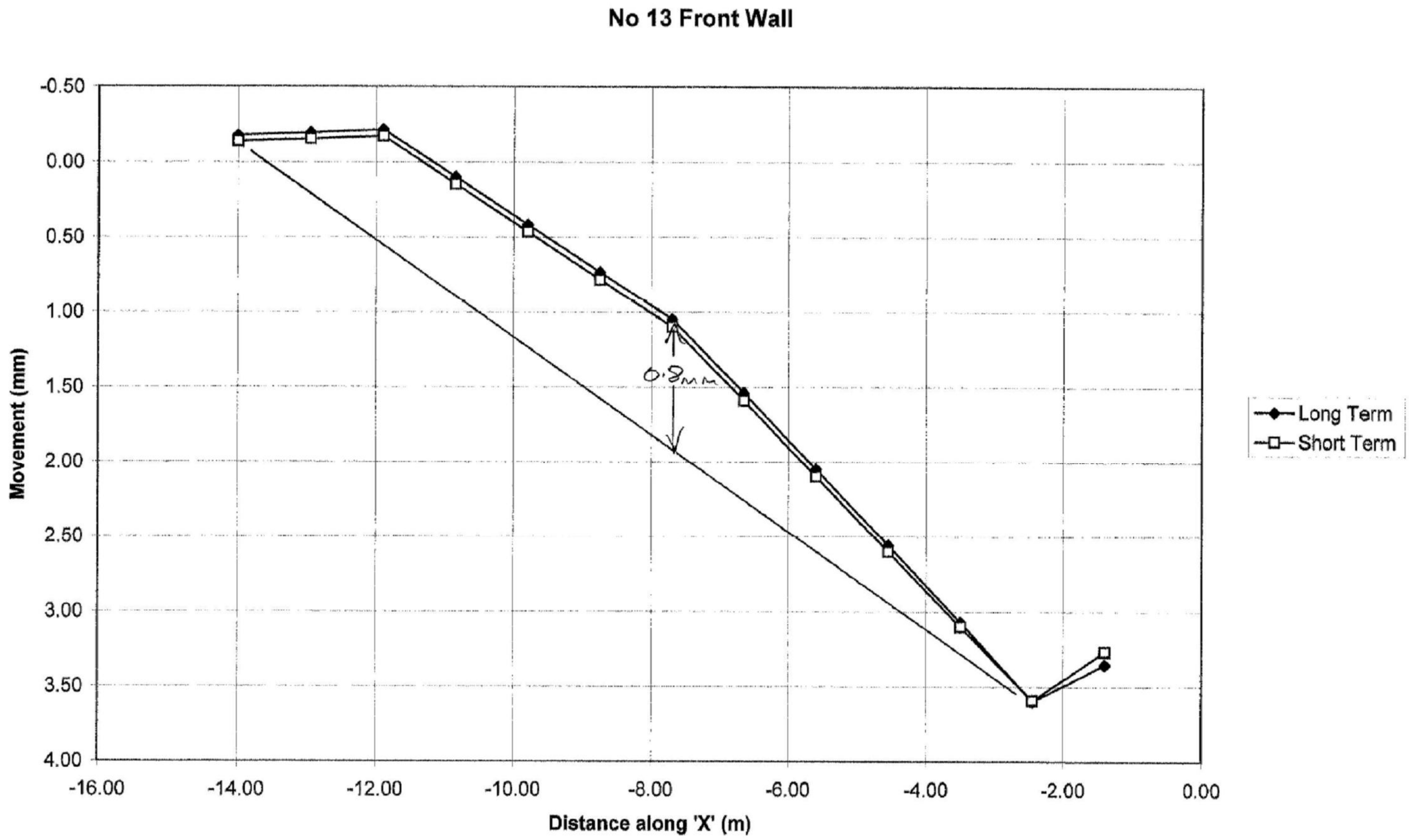
2 Burland JB (1997). ‘Assessment of risk of damage to buildings due to tunnelling and excavation’. In ‘Earthquake Geotechnical engineering’ Ishihara (Ed). Balkema pub.

3 Gaba A R, Simpson B, Powrie W, Beadman D R (2003) Embedded retaining walls - guidance for economic design, CIRIA Report C580, London. ISBN: 978-0-86017-580-3.

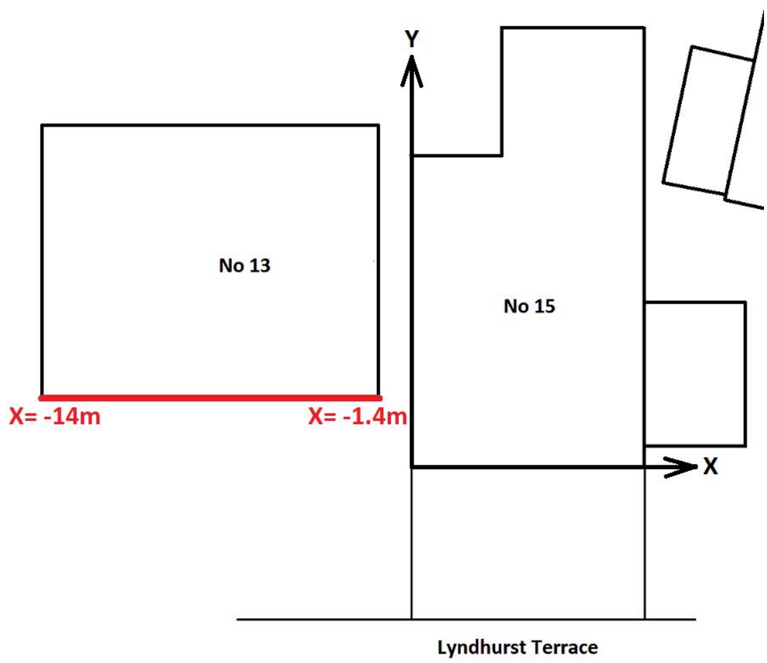
4 Fuentes, R. and Devriendt, M (2010). ‘Ground movements around the corners of excavations: empirical calculation method’. Journal of geotechnical and geoenvironmental engineering, ASCE v136 Issue 10 pp1414-1424.

5 Hellings J, Burland JB, and Symons IF (1990). ‘Testing of soil samples from Bell Common Tunnel’. TRRL Contractor Report 172.

(Figures 6-15 follow below)

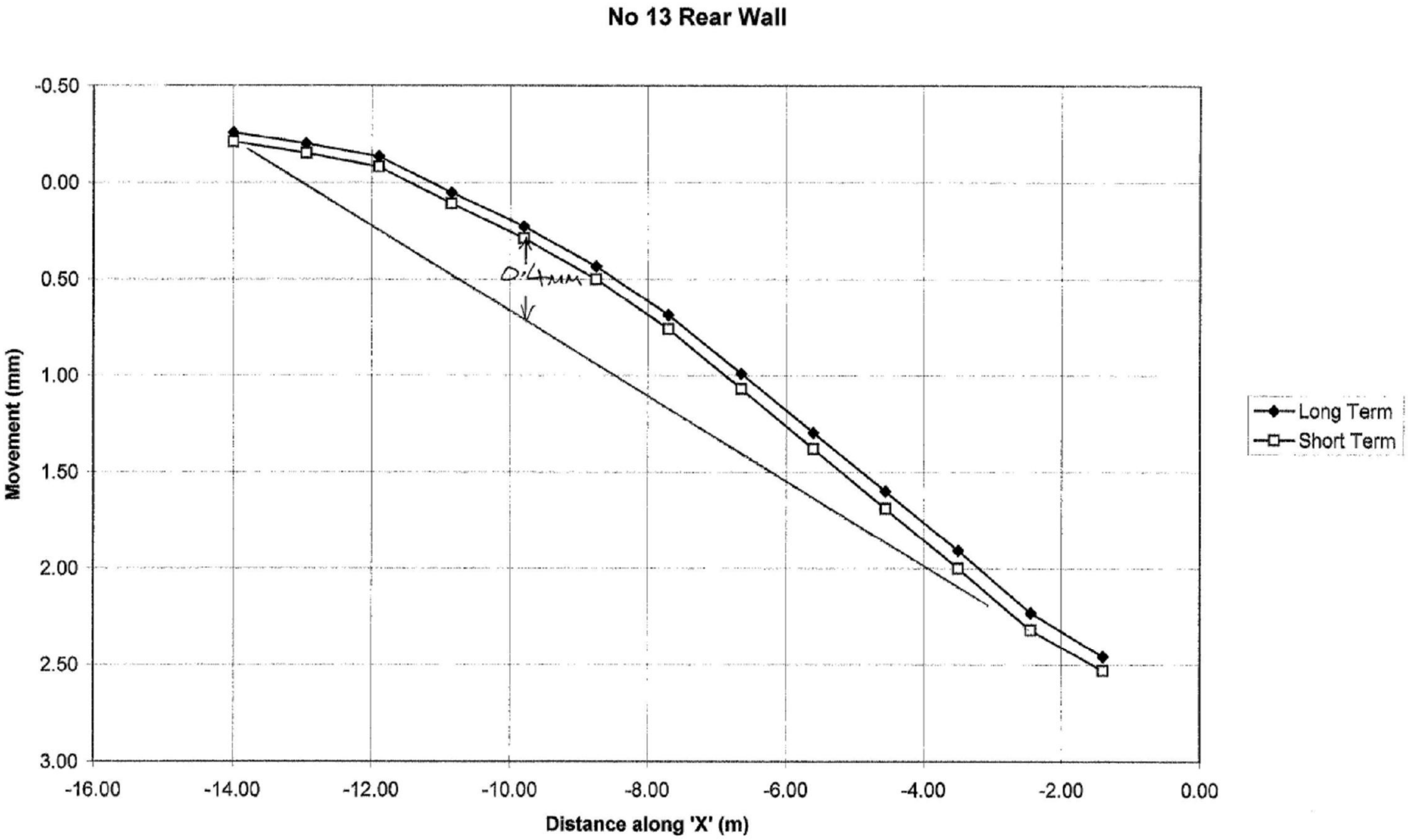


No 13 Front Wall
Movement (mm)
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
-16.00
-14.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
Distance along 'X' (m)
0.8mm
Long Term
Short Term

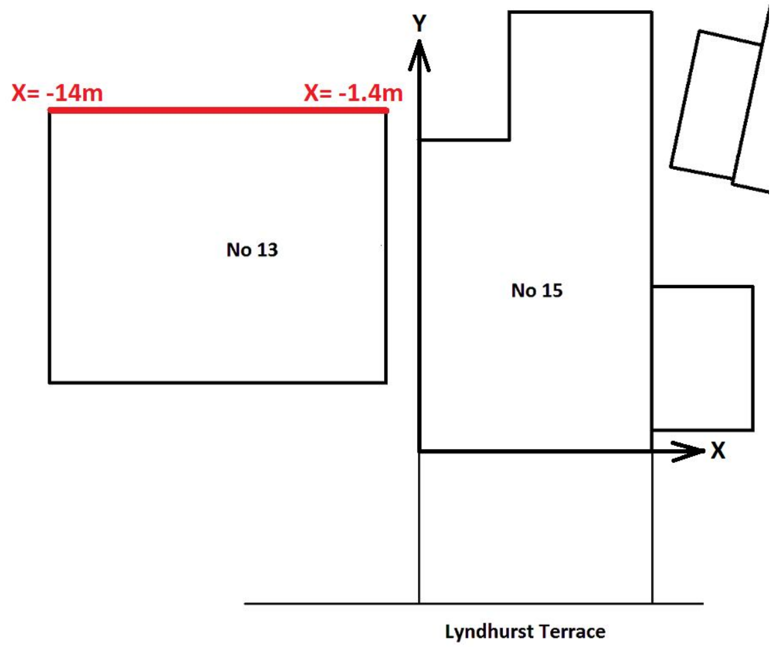


Y
No 13
No 15
X= -14m
X= -1.4m
X
Lyndhurst Terrace

Figure 6

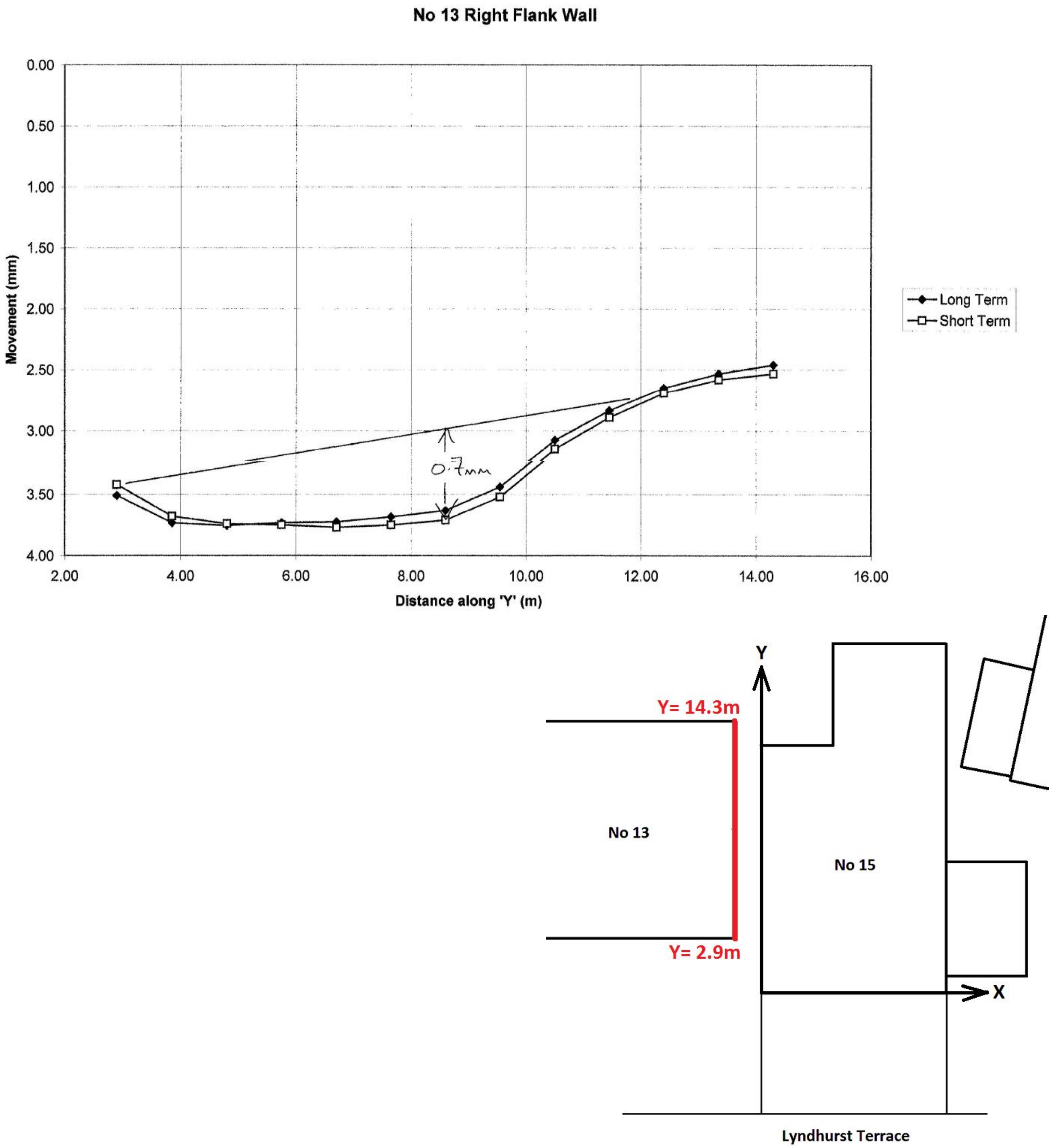


No 13 Rear Wall
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Movement (mm)
-16.00
-14.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
Distance along 'X' (m)
0.4mm
Long Term
Short Term



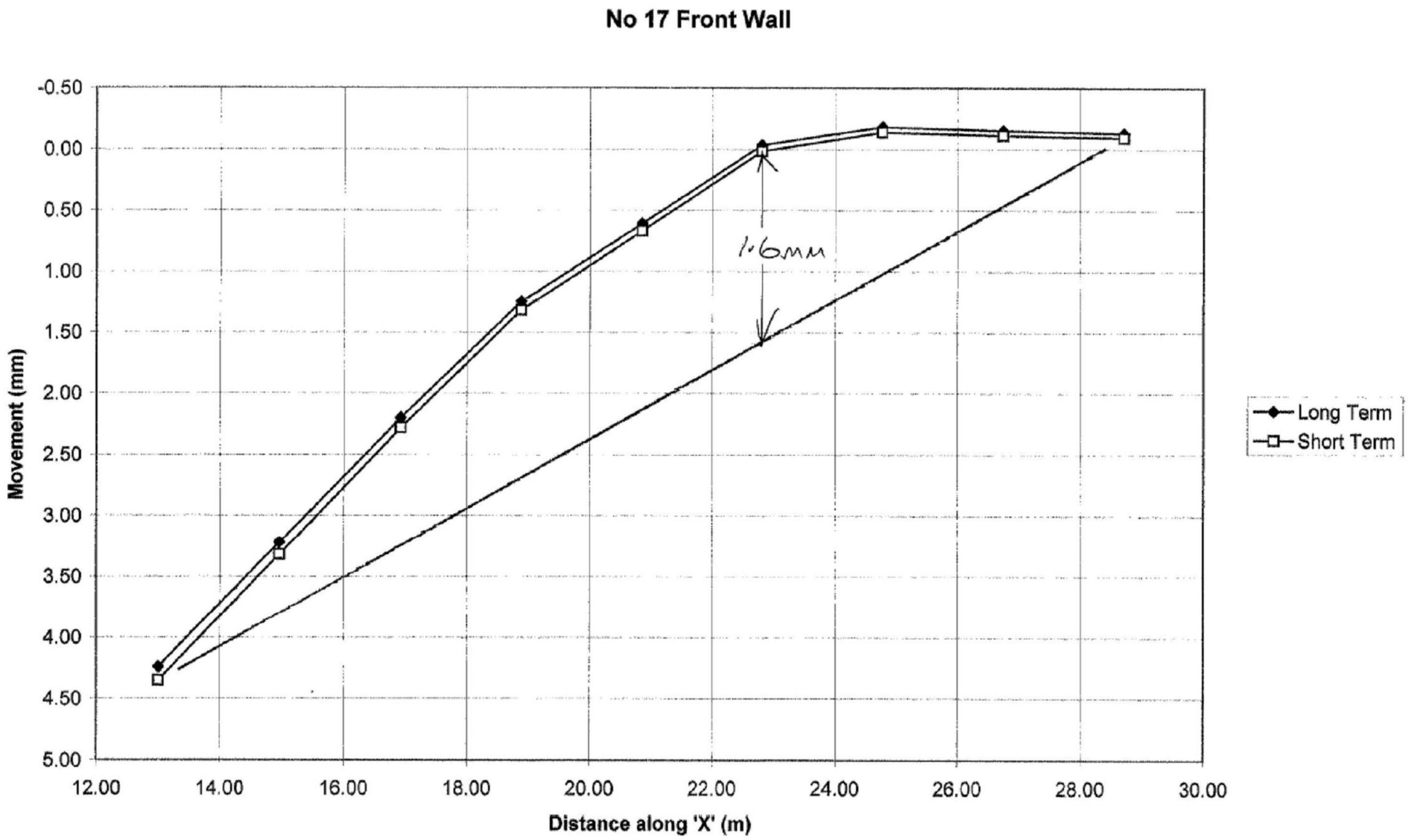
Y
X= -14m
X= -1.4m
No 13
No 15
X
Lyndhurst Terrace

Figure 7

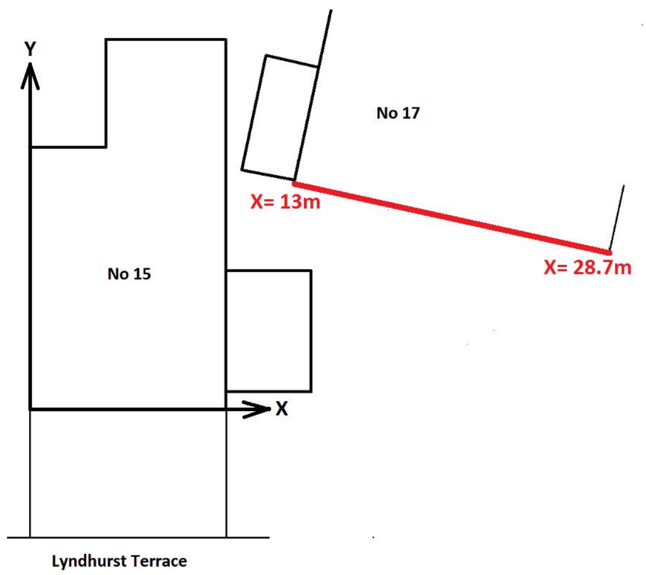


No 13 Right Flank Wall
Movement (mm)
Distance along 'Y' (m)
Long Term
Short Term
0.7mm
Y
X
Y= 14.3m
Y= 2.9m
No 13
No 15
Lyndhurst Terrace

Figure 8

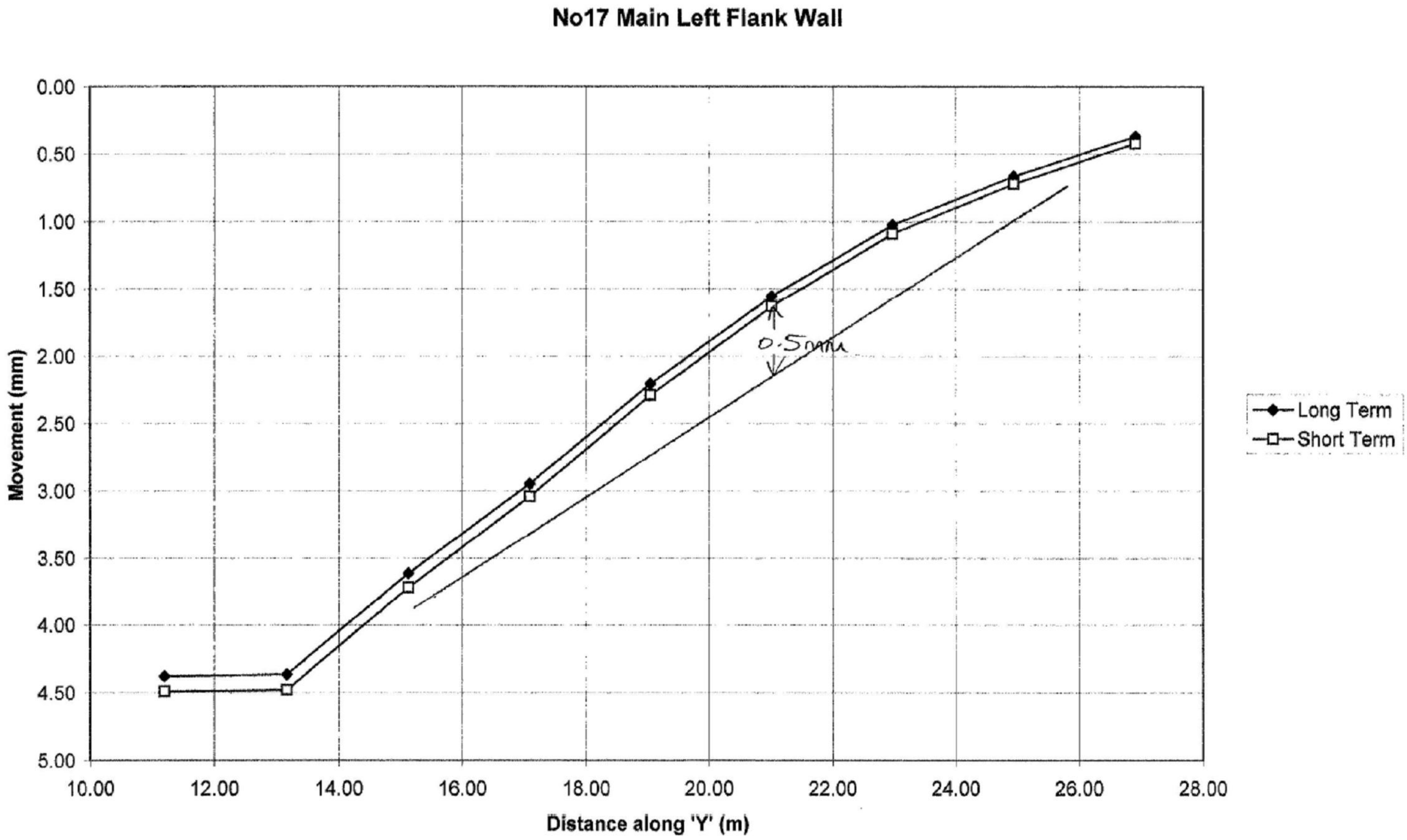


No 17 Front Wall
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Movement (mm)
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
30.00
Distance along 'X' (m)
1.6mm
Long Term
Short Term



Y
No 17
X= 13m
X= 28.7m
No 15
X
Lyndhurst Terrace

Figure 9


No17 Main Left Flank Wall
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Movement (mm)
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
Distance along 'Y' (m)
0.5mm
Long Term
Short Term

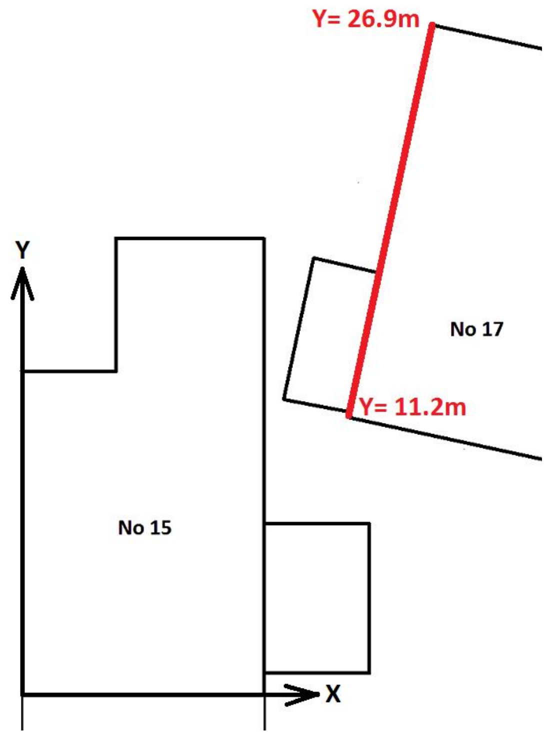
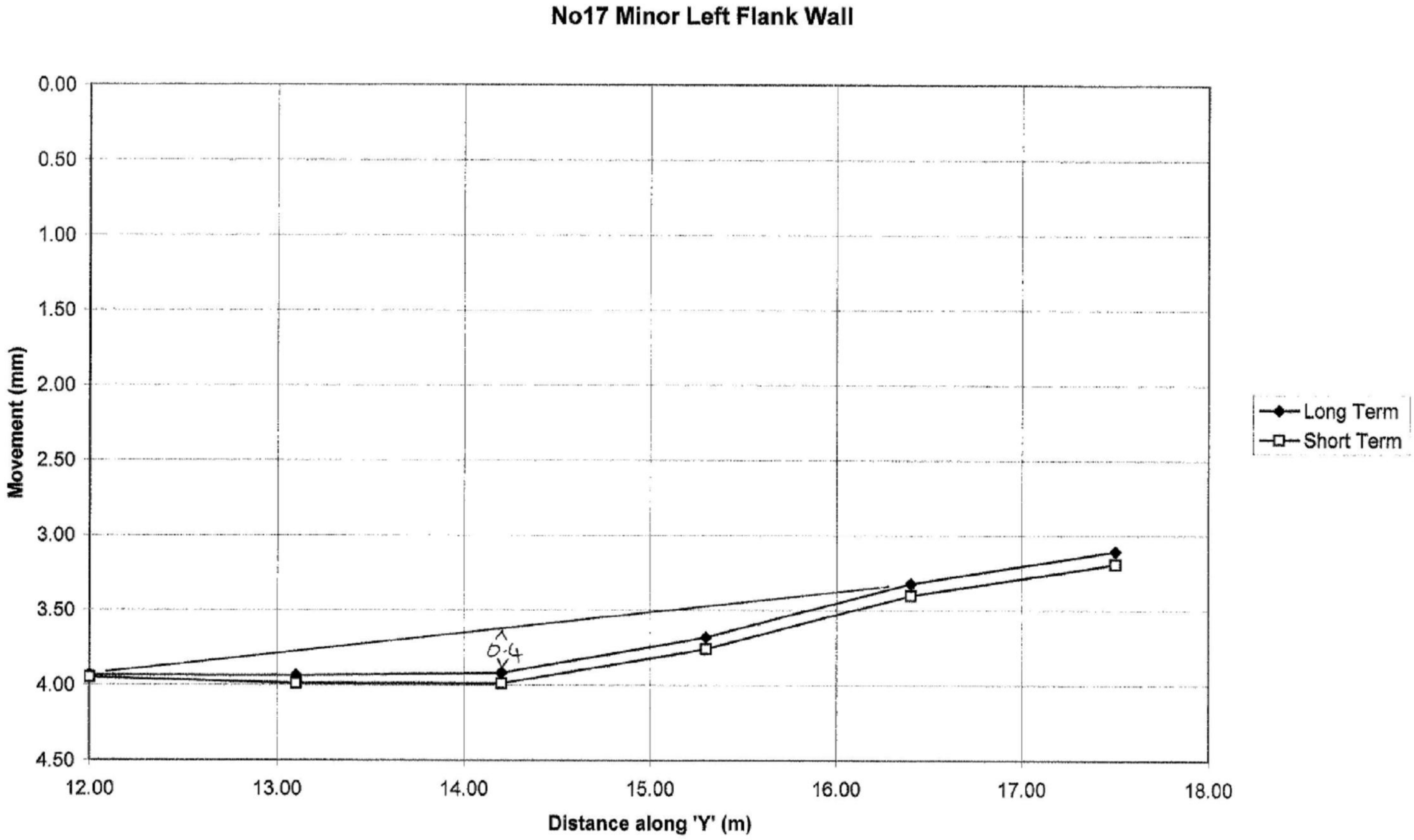
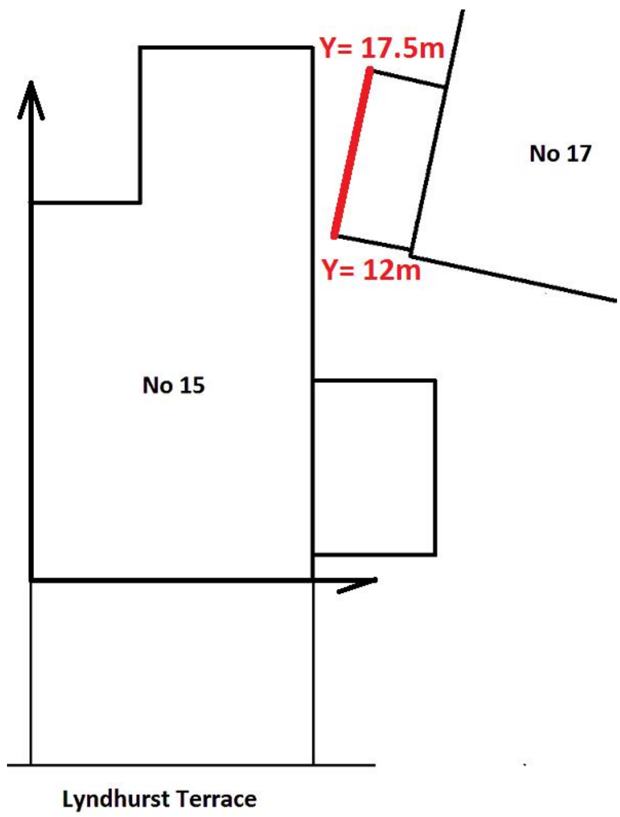

Y= 26.9m
Y
No 17
Y= 11.2m
No 15
X

Figure 10

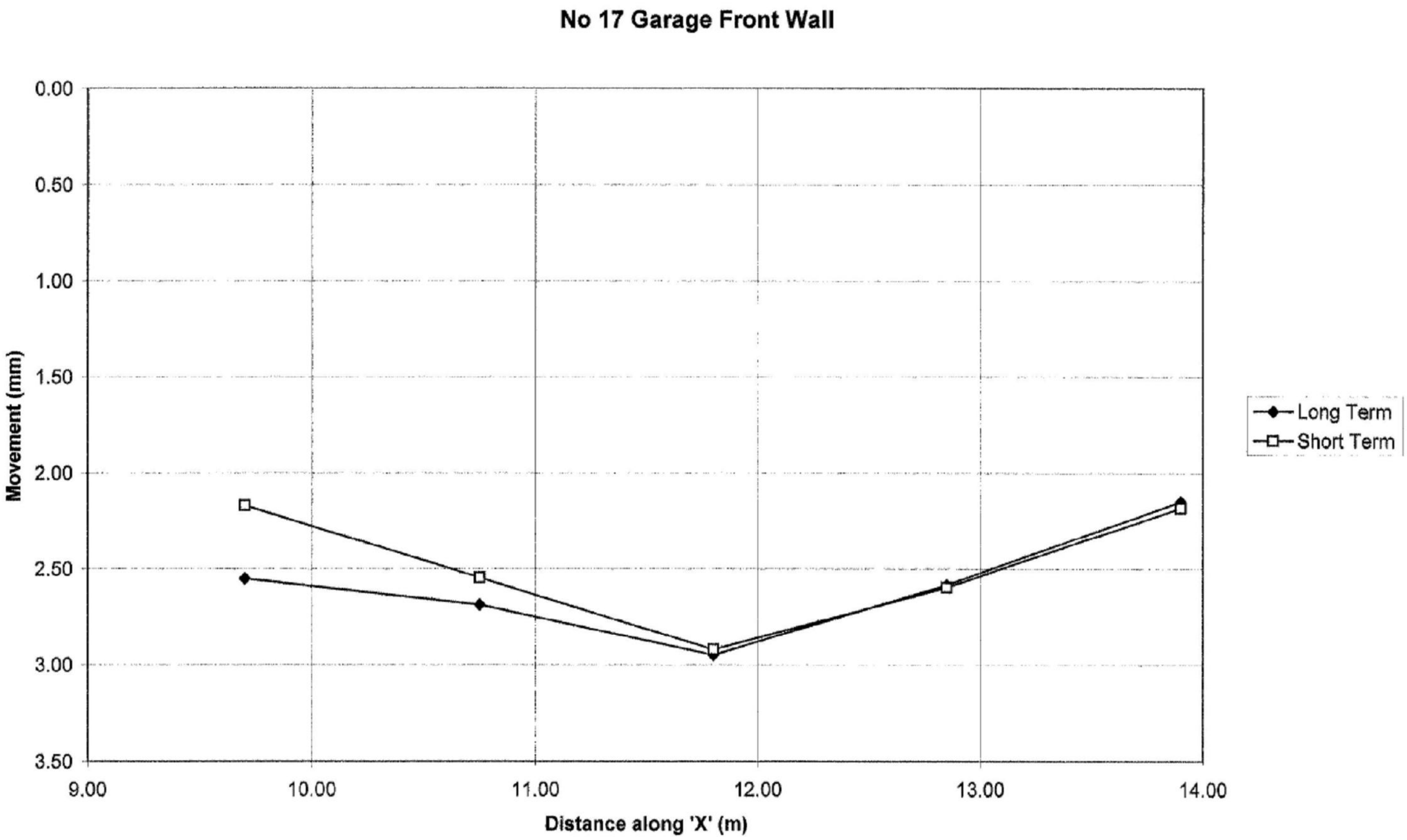


No17 Minor Left Flank Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
12.00
13.00
14.00
15.00
16.00
17.00
18.00
Distance along 'Y' (m)
Long Term
Short Term
0.4

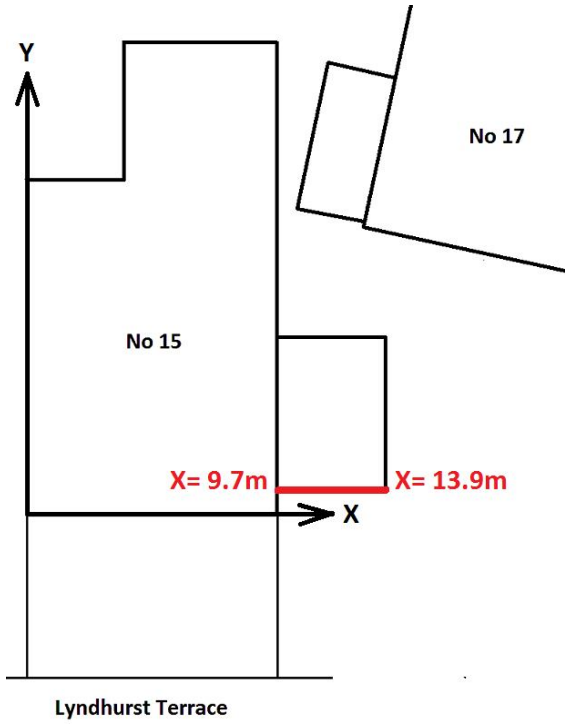


Y= 17.5m
Y= 12m
No 17
No 15
Lyndhurst Terrace

Figure 11

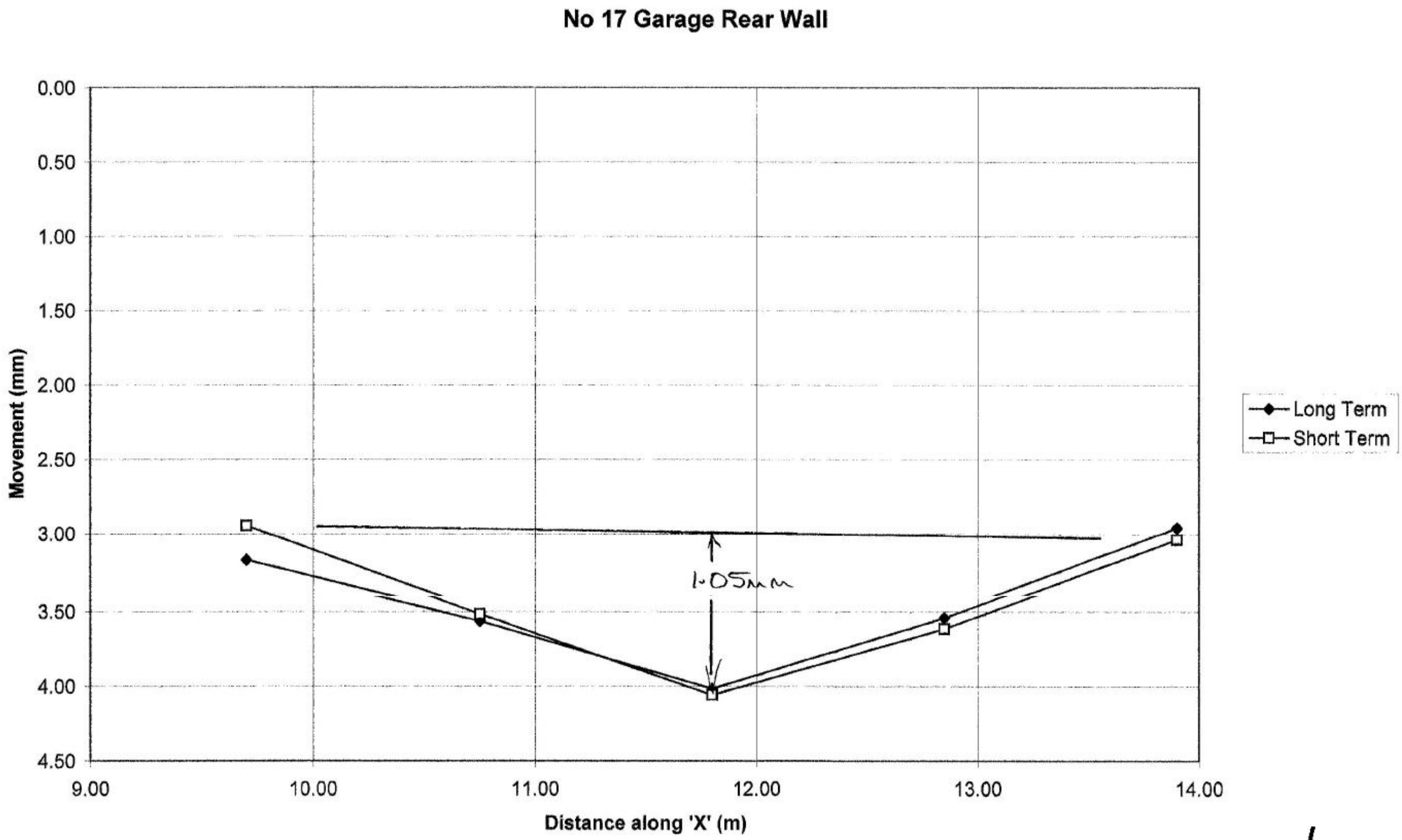


No 17 Garage Front Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
9.00
10.00
11.00
12.00
13.00
14.00
Distance along 'X' (m)
Long Term
Short Term



Y
No 17
No 15
X= 9.7m
X= 13.9m
X
Lyndhurst Terrace

Figure 12


No 17 Garage Rear Wall
Movement (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
9.00
10.00
11.00
12.00
13.00
14.00
Distance along 'X' (m)
1.05mm
Long Term
Short Term

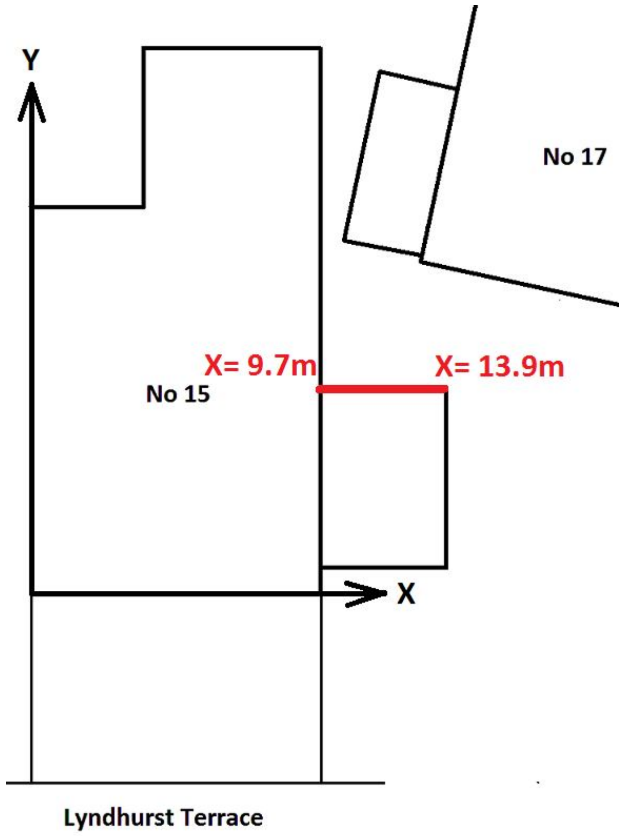
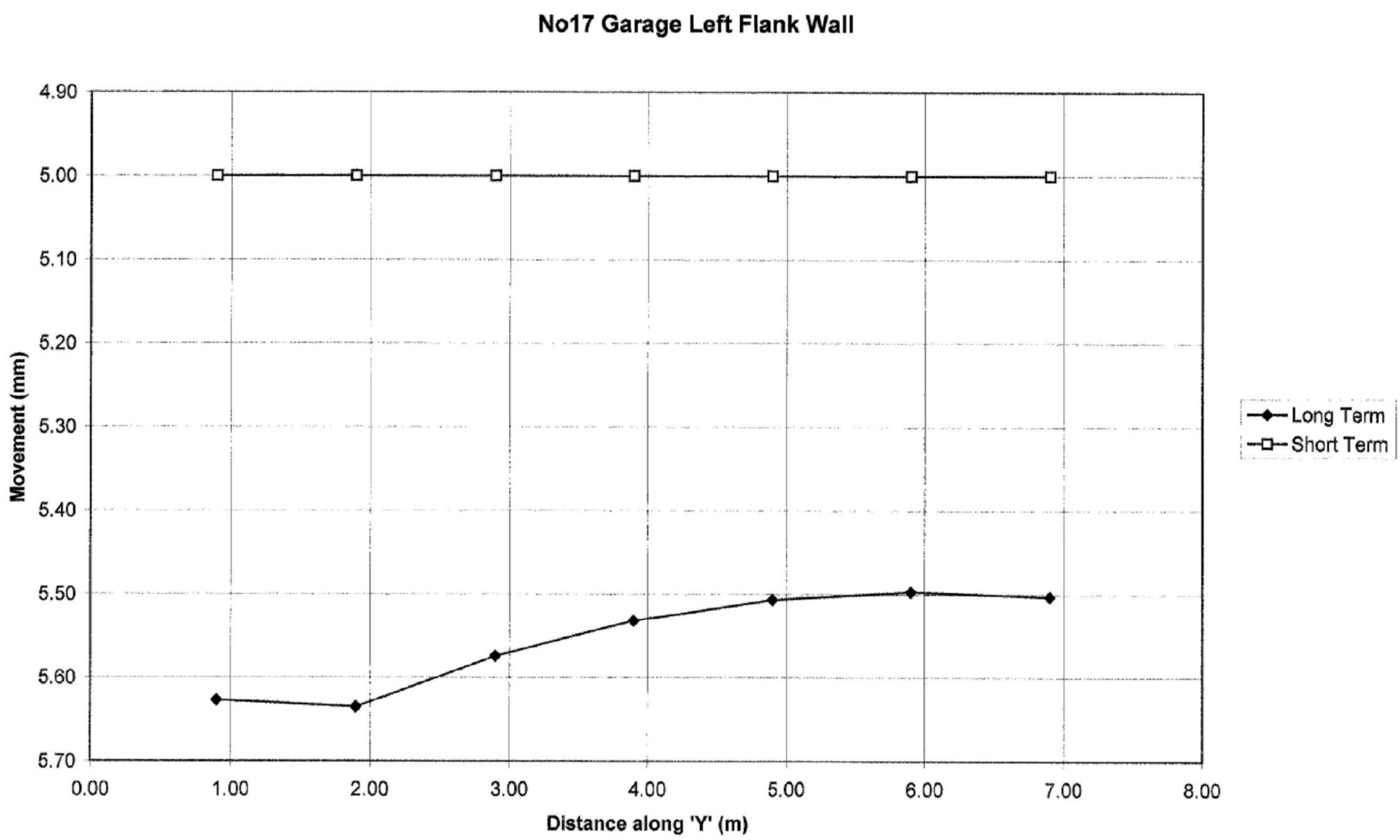
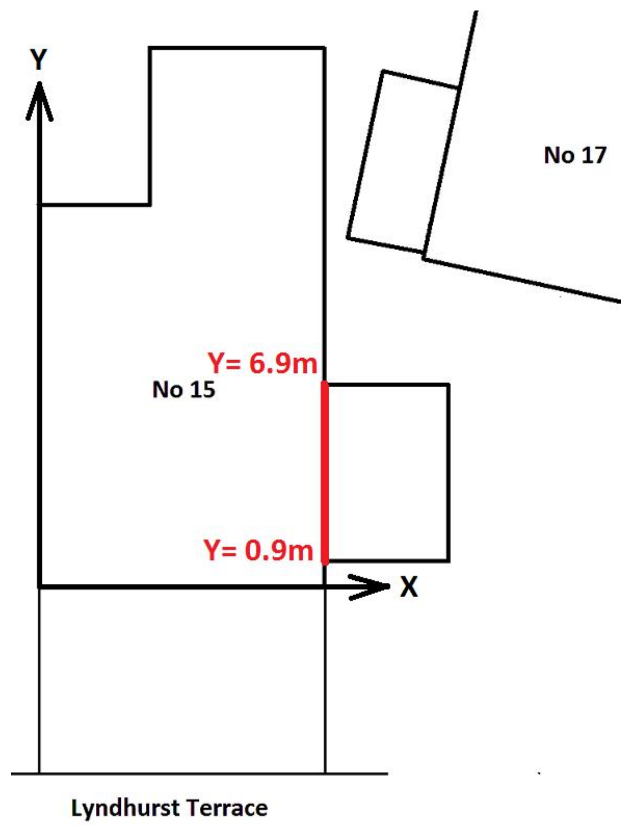

Y
X
No 17
No 15
X= 9.7m
X= 13.9m
Lyndhurst Terrace

Figure 13



No17 Garage Left Flank Wall
Movement (mm)
4.90
5.00
5.10
5.20
5.30
5.40
5.50
5.60
5.70
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance along 'Y' (m)
Long Term
Short Term



Y
No 17
Y= 6.9m
No 15
Y= 0.9m
X
Lyndhurst Terrace

Figure 14

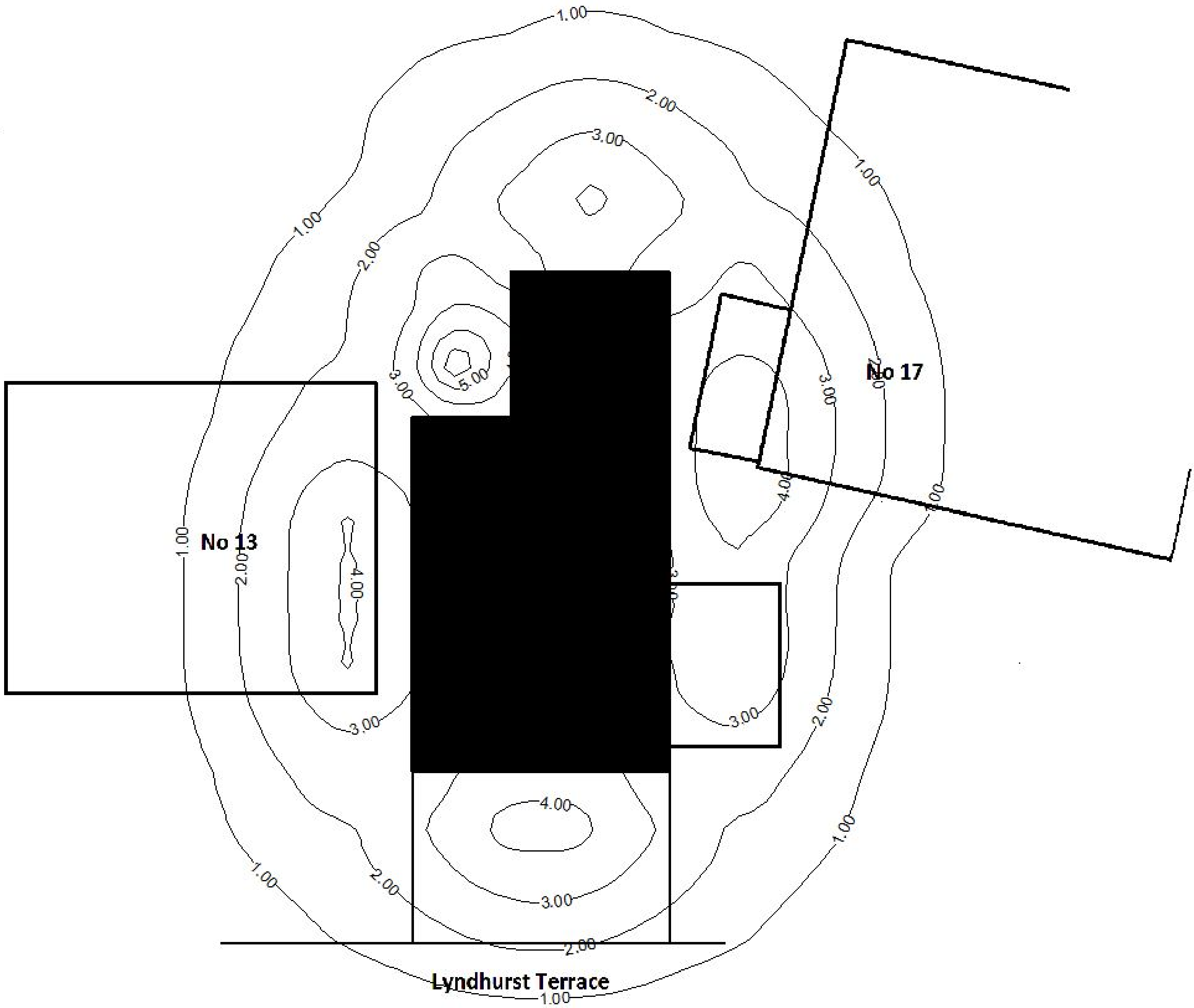


Figure 15 –Predicted short-term settlement (end of excavation) (mm)