OD Camden Hotel Ltd

Haverstock Hill

Site Investigation and Basement Impact Assessment Report

HH-ARP-REP-301

Issue 2 | 10 November 2020

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Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

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Appendices

Foreword

This document has been prepared by Arup for OD Camden Hotel Ltd to support the proposed planning application for the site at 5-17 Haverstock Hill, London, NW3.

The proposed development will consist of the demolition of existing building and erection of a part-six, part-seven storey development comprising residential (Use Class C3), Hotel (Use Class C1) and associated commercial, business and service (Class E) use with associated works.

The document is a development of the BIA presented by Geotechnical and Environmental Associates (GEA) for Cambridge Gate Properties dated May 2016 and as submitted for an earlier ["Granted Subject to a Section 106 Legal Agreement"] planning application number 2016/3975/P for the same site. The document has been provided in Appendix A for reference.

The interpretative work presented herein is by Arup and no reliance has been placed on the work by GEA; where factual information has been presented by GEA this information has been reviewed and included in this report where found appropriate. The report follows the same structure as the GEA report to allow those reviewing the report to readily identify the differences between the current proposed scheme and the consented scheme.

The main changes to the scheme from the previous planning application are the following:

- Change of proposed use for the building,
- Modifications to the piling foundation layout; and,
- Modifications to the proposed basement footprint and depth.

Executive summary

Arup have produced this Site Investigation and Building Impact Assessment report for OD Camden Hotel Ltd.

The proposed works comprise:

- Demolition of existing building; and,
- Construction of a part-six, part-seven storey development comprising residential (Use Class C3), Hotel (Use Class C1) and associated commercial, business and service (Class E) use with associated works. A basement will cover part of the footprint of the site towards the north.

Part 1 of this report provides a desk study of the site and the screening assessment suggested by the LBC guidance for any proposed development that includes a subterranean basement. A summary of the ground investigations carried to date on the site is also provided.

Part 2 of this report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, contamination assessment and then provides advice and recommendations with respect to foundation options. An additional site investigation is planned to:

- Provide deeper information on the London Clay for pile design;
- Provide additional information on the existing foundations and boundary conditions; and
- Provide additional environmental samples.

It is planned that this ground investigation will take place before January 2020.

In Part 3 of this report a ground movement assessment is presented. An analysis has been carried out to calculate the movements arising from the proposed basement excavation and the results of this analysis have been used to calculate the effect of these movements on surrounding structures including buildings and LUL infrastructure.

The analysis has predicted that the proposed installation of the retaining walls and excavation of the proposed basement may generally result in a building damage for sensitive structures of Category 0 (negligible), which falls within acceptable limits according to the Camden Planning Guidance (CPG4).

The impact on the LUL infrastructure (tunnels, shafts and adits) has been found to be acceptable. However, a pre and post condition survey for the calculated zone of influence is recommended to:

- Provide OD Camden Hotel Ltd and LUL with a baseline of the current condition; and,
- Confirm the assumptions in this report.

No further mitigations measures are proposed at this stage.

Part 1: Investigation

This section of the report provides a desk study of the site and the screening assessment suggested by the LBC guidance for any proposed development that includes a subterranean basement. A summary of the ground investigations carried to date on the site is also provided. Interpretation of the findings is presented in Part 2.

1 Desk study

1.1 Site location and description

The site is located in the London Borough of Camden, NW3, in a mixed residential and commercial area. The site is located at the National Grid reference TQ 28144 84418, and its location is shown in Figure 1.

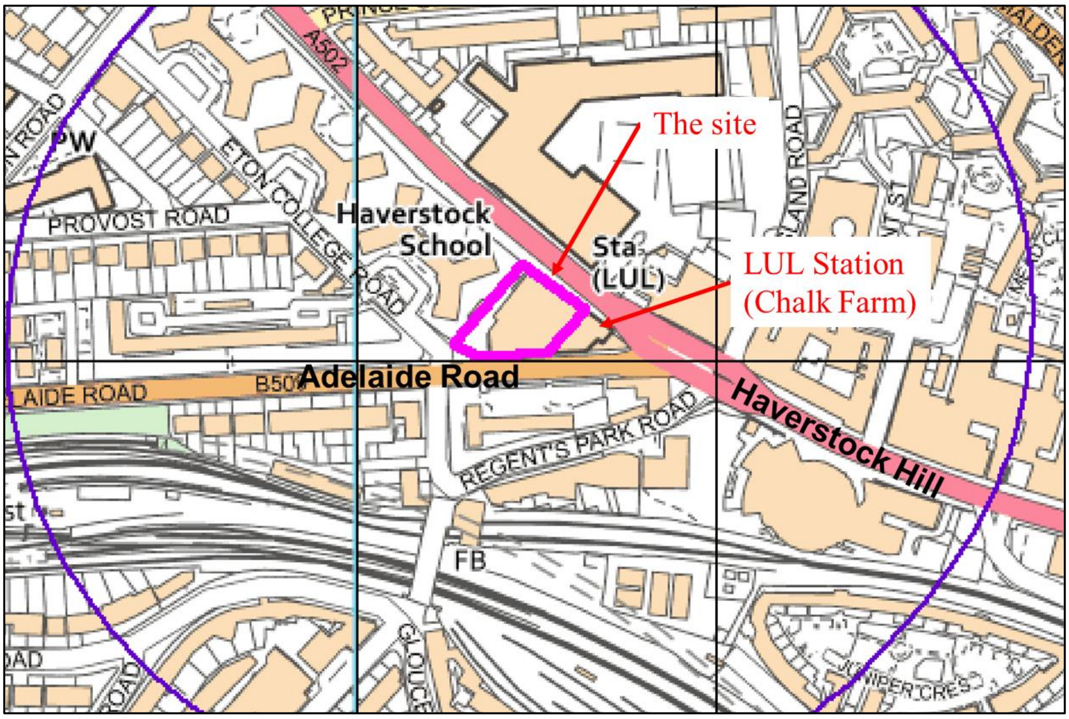


Figure 1: Site location plan (Envirocheck, 2020)

The site is bounded by Haverstock Hill to the northeast and Adelaide Road to the south. It is adjoined to the southeast by Chalk Farm London Underground station, a two-storey Grade II listed building, and is bordered to the northwest by Eton Place, a six-storey apartment block, which fronts onto Eton College Road to the southwest.

Associated with Chalk Farm Underground Station is the Northern Line, with tunnels running beneath Haverstock Hill. Access to the tunnel is via vertical shafts from the station at ground level and horizontal cross passages to the tunnel platform(s). Further details of the tunnels are presented in Section 1.3.

The local topography slopes down towards the southeast with a typical slope between 4 and 5%. The site is typically flat with a ground level rising from approximately +31.6mOD to +32.5 mOD along Haverstock Hill. In terms of hydrology the site is located between the River Fleet to the east and the River Tyburn to the west and between the higher areas of Primrose Hill to the west and Dartmouth Park to the east. The path of the River Fleet passes some 250m east of the site along Malden Street. The Fleet in this area is in culvert/sewer and is not visible at the surface.

The site is quadrilateral in shape, measuring a maximum of approximately 60m (parallel to Eton Place) by approximately 40m (parallel to Haverstock Hill). A site walkover was carried out by Arup on 20th August 2020 and selected photographs are included in Figure 2.

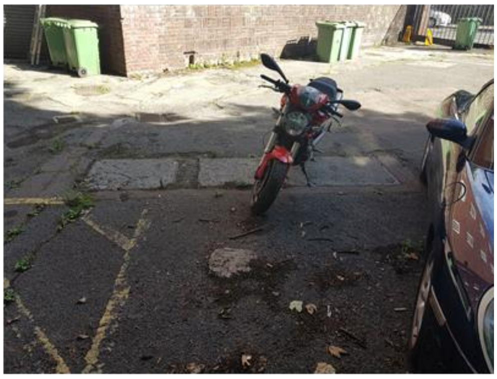
(a) Haverstock Hill Road frontage

(b) Adelaide Road frontage

Figure 2: Adelaide Road and Haverstock Hill Road frontages

(a) Adelaide Road frontage (entrance to backyard)

(b) Backyard (looking west towards Haverstock Hill)



(c) Backyard (inspection chambers and drainage)

(d) Backyard (single story shed)

Figure 3: Site backyard

The central and southern parts of the site are occupied by a brick building, comprised of up to six-storeys with a partial basement extending to a depth of roughly 0.9m below existing ground level to a level of approximately +31mOD. The partial basement houses the lowest level of car park and is located beneath the central part of the site (see Figure 4).

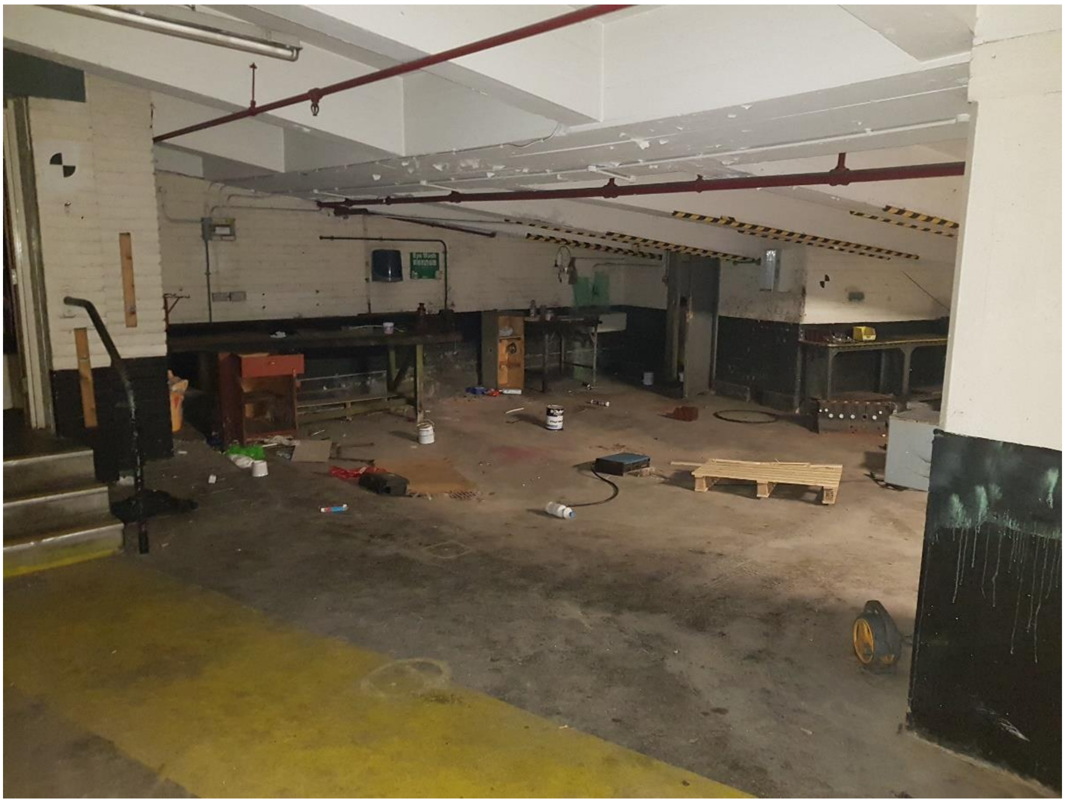


Figure 4: Basement of the existing building.

A shutter door is present along the north-western elevation of the six-storey building, which leads to the ground floor. Two ramps are present, one leads to the basement and the other to the first floor.

An area of hardstanding is present in the northwest of the site, which can be accessed from Haverstock Hill via two sets of double gates or from Adelaide Road via a double gate. This area contains numerous services, which are evident from surface scarring and also shown on the service plans. In this area, a vent was noted along with a manhole cover, which was lifted and found to have be infilled. A further three chambers were noted in this area and are understood to have been interceptors.

In the central northern part of the hardstanding area, a single storey detached building is present and along the northern boundary is a brick wall. Cracks were noted in both of these structures, up to 40 mm in width and monitoring points were observed.

Mature trees, up to 20m in height are present in the grounds of Eton Place along the north-western perimeter of the site. Semi-mature trees, ranging from 6 m to 8 m in height, are present along the pavement adjacent to Haverstock Hill. The site itself is however essentially devoid of vegetation. A tree survey has been carried out by Greengage on August 2020, the survey identified 15 trees either within or directly adjacent to the proposed development area (Refer to Appendix B for the Tree Constraints Assessment).

1.2 Site history

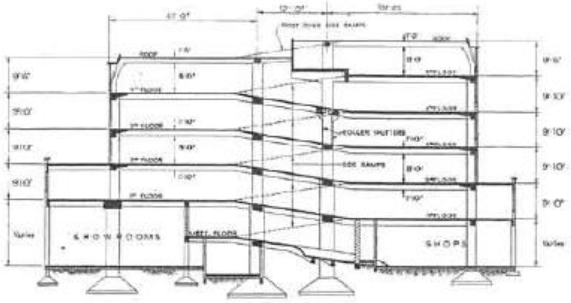
The site history has been summarised below in Table 1. The information was sourced predominately from historical Ordnance Survey (OS) maps from the Envirocheck report (2020), Layers of London and Google Earth. A full copy of the Envirocheck report is provided in Appendix C.

Table 1 Summary of site history.

Year	*Observation*	*Source*
1646	*Area north of Marybon Park (to be renamed Regents Park shown as undeveloped land with "village" of Chalnot (?) nearby.* 	*Joan Blaeu, 1646.*
1746	*Area of site appears not to be developed. Haverstock Hill shown (not named) linking London to Hampstead*	*John Rocque, 1746.*

Year	***Observation***	***Source***
1800	*Chalk Farm, Haverstock Hill and Primrose Hill all mentioned. Exact site location not shown. Haverstock Hill road clearly shown.* 	*Fairburn Edition, 1800,*
1870 / 1896	*Site is shown to be developed with likely residential housing blocks spanning between Haverstock Hill and Adelaide Road / [Eton} College Road. The site of the Chalk Farm Station is occupied by a pair of seemingly substantial semi-detached houses.* *A school is located off Haverstock Hill to the north of the site (north side of Haverstock Hill).* 	*OS map published 1875 Surveyed 1870*
1907	*Chalk Farm Station and Northern Line tunnels opened under the name of Charing Cross, Euston & Hampstead Railway (CCE&HR). LU tunnels run beneath Haverstock Hill.*	*LU plan*
1916	*The school to the north of Haverstock Hill has expanded into "Schools"*	*OS map*

<table>
<tr><th>Year</th><th>Observation</th><th>Source</th></tr>
<tr><td>1930's</td><td>Eton Place and Eton Garage built at the same time by 1939 for Messrs Bell Property Trust Ltd (completion by 1939).



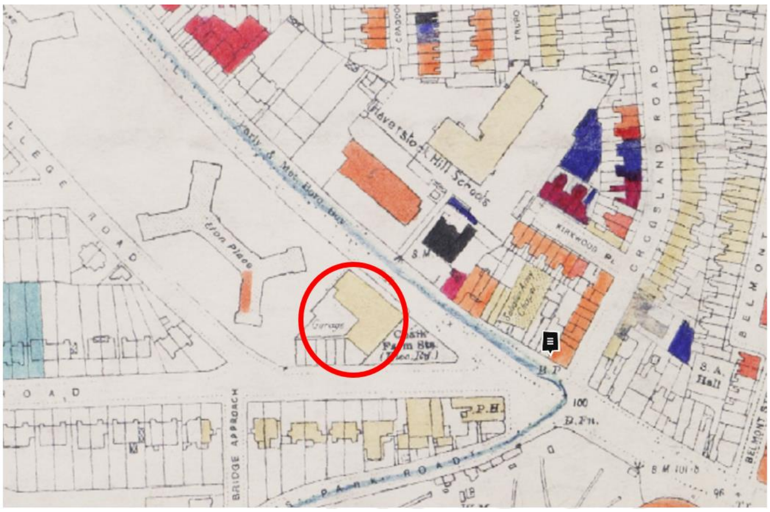
Eton Garage, Chalk Farm Road, Section</td><td></td></tr>
<tr><td>1939-1945</td><td>Site is shown to be developed with a garage to the north of the site and a terrace of units to the south (adjacent to Adelaide Road).

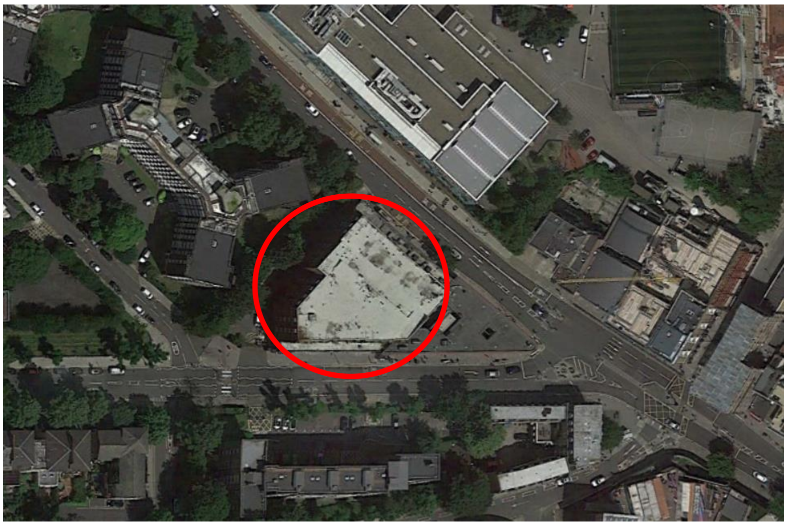
Eton Place to the north (mansion block of flats) has been constructed.

Total destruction of building north of Haverstock Hill, due to bomb damage. Partial damage to adjacent structures.

Small damage to the south east wing of Eton Place.

No damage shown to the development site or the Chalk Farm Station.


</td><td>Layers of London, Bomb damage maps.</td></tr>
</table>

Year	***Observation***	***Source***
1946	*Site is developed to its current status with a single building occupying the site. This is different to the layout shown in the Bomb Damage Map records from WW2.*	*OS Map.*
> 1946	*Anecdotal information: the site was occupied by a garage used for parking, a motor showroom and offices, along with a petrol station, workshop, washing bays, store, battery charging rooms and shops.*	*GEA report 2016.*
2003/ 2005	*Site across Haverstock Hill redeveloped with large school (2003 not present, 2005 present) (image 7/2005).*  	*Google Earth imagery.*
2019	*Present day.* 	*Google Earth imagery.*

An enquiry was made by GEA in 2016 (GEA, 2016) with regard to the presence of buried fuel tanks. No information was held by the local petroleum officer regarding fuel storage tanks below the site.

1.3 Tunnels and underground features

The LUL Northern Line Tunnel is located beneath Haverstock Hill as it passes close to the site. The nearest tunnel to the site is the northbound tunnel which has been surveyed relative to the development site as per Figure 5. The survey shows the tunnel soffit (inside level of the top of the tunnel) at a level of +21.4 rising to +21.9mOD (marked as 121.4 to 121.9mTD on the plan) as it passes the site. The ground (footpath) level is at +31.6 rising to +32.4mOD, i.e. some 10m above the soffit level of the tunnel (the soffit level of the tunnel is the top of the tunnel as measured from inside the tunnel, the tunnel lining thickness is 0.12m). The tunnel diameters are 3.81m (12 foot 6 inch). The tunnel extrados is approximately 4.5 to 5.1m (south to north from the property ownership line).

Contact has been made with London Underground Limited (LUL) regarding their assets beneath the site and their response is included in the Appendix D, regarding permission to undertake site investigation. Further liaisons will need to be made with LUL to ensure that the development proposals do not impact upon their assets.

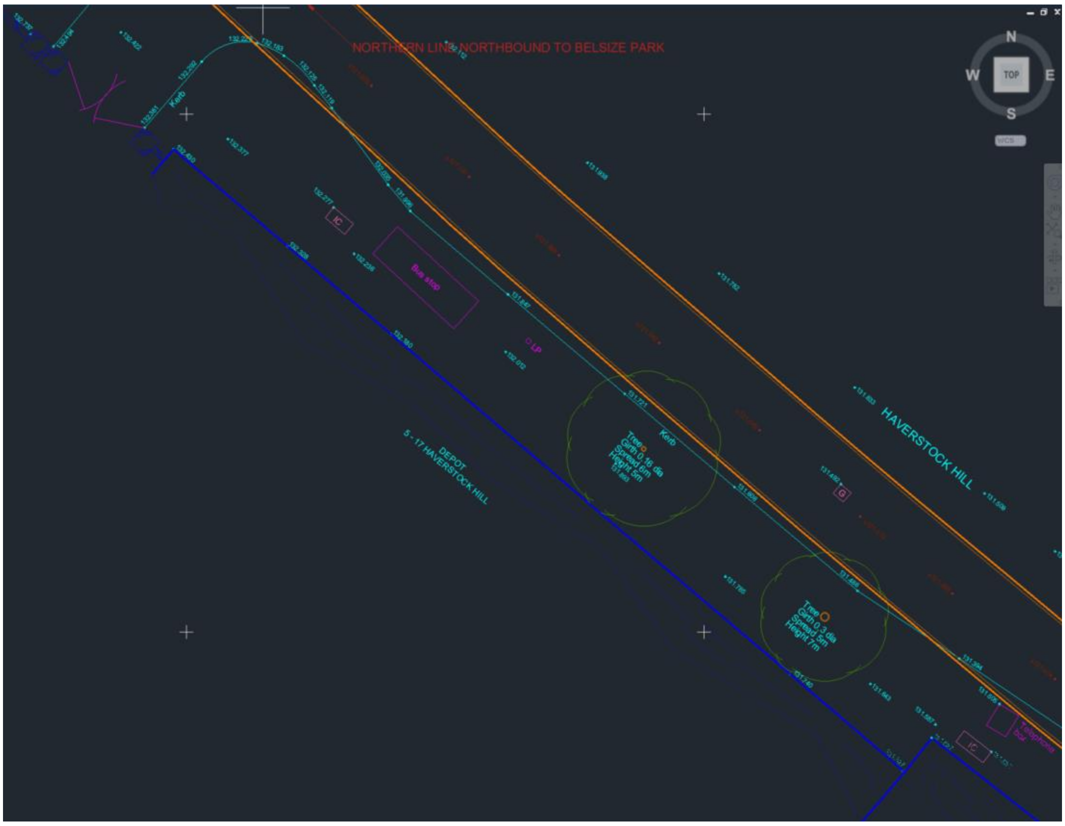


Figure 5: LU survey dated 19/11/2015 “Correlation survey of 5-17 Haverstock Hill with Northbound Northern line”.

1.4 Preliminary UXO Risk Assessment

A desk based preliminary Unexploded Ordnance (UXO) risk assessment has been carried out by 1st Line Defence on behalf of GEA (OPN2876) and the report is included in full in Appendix E.

The UXO assessment provided the following conclusions:

- There were no known military uses close or on site;

- There was evidence of bomb strikes near the site including the adjacent school and buildings to the north west, although no direct hits to the site;
- The adjacent school was recorded as being destroyed;
- The garage and depot were observed to have survived the second world war intact and unchanged based on available mapping; and
- There is a minimal risk of encountering ordnance at the site and additional research would not cause a significant change to the assessed minimal level of risk.

1.5 Geology

The British Geological Survey (BGS) map of the area at 1:10,000 scale indicates that the site is directly underlain by the London Clay Formation; Figure 6.

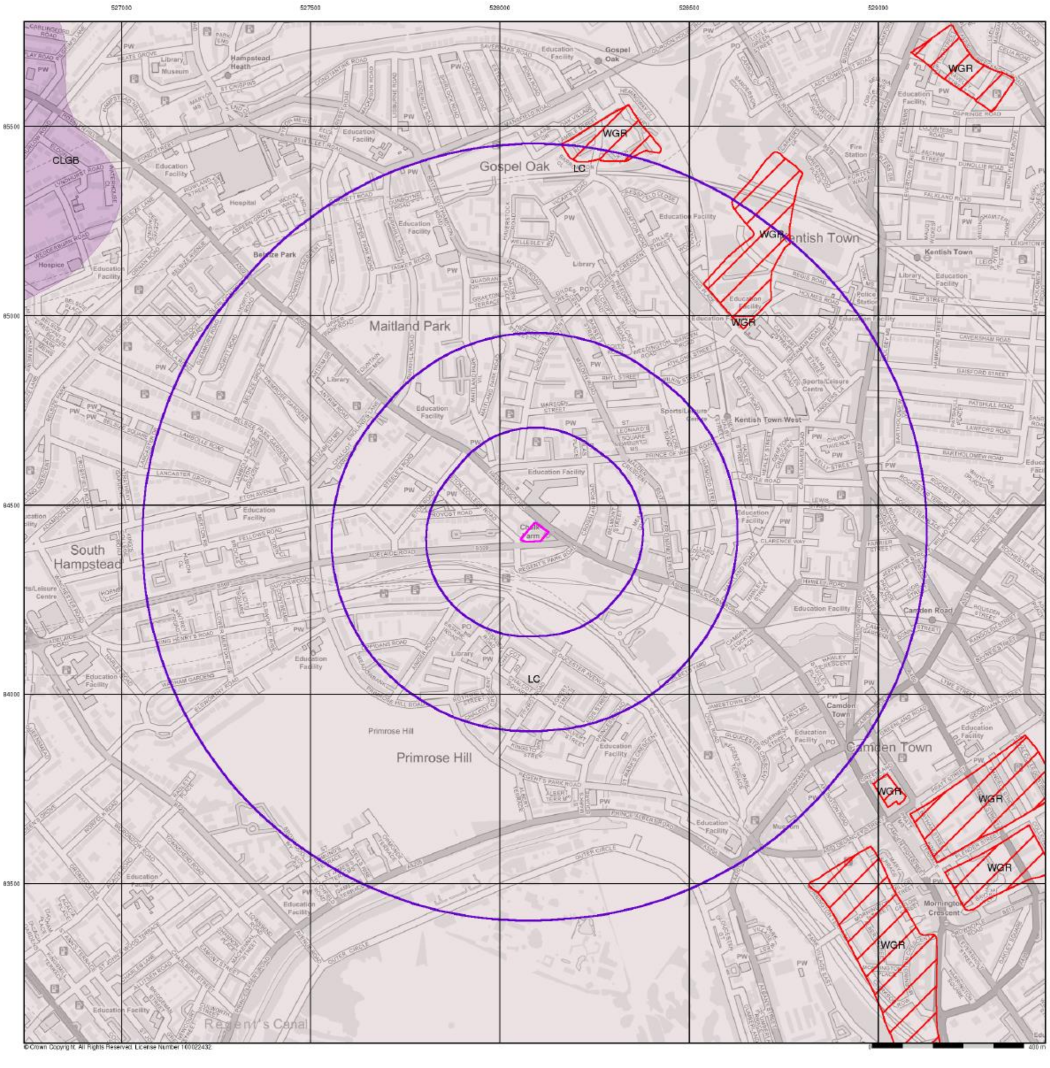


Figure 6: Geological Map 10,000 (Envirocheck, 2020).

The site is in a wide area of London Clay Formation (LC) dating to the Eocene age; to the northwest an outcrop of the Claygate Member (CLGB) can be seen as one approaches the upper part of the hill at Hampstead Village. Areas of Worked

Ground (WGR) can also be seen around the site but not directly at the site. The London Clay Formation is described in the BGS data base as:

> *The London Clay mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand, which commonly increase towards the base and towards the top of the formation. At the base, and at some other levels, thin beds of black rounded flint gravel occur in places. Glauconite is present in some of the sands and in some clay beds, and white mica occurs at some levels.*
>
> *The base of the London Clay formation was redefined by Ellison et al. (1994) to correspond to the base of the Walton Member (Division A2) of King (1981). It is usually marked by a thin bed of well-rounded flint gravel or a glauconitic horizon, or both, typically resting on a sharply defined planar surface, although locally uneven. The London Clay Formation overlies the Harwich Formation or, where the Harwich Formation is absent, the Lambeth Group.*

Further information from the BGS Geoindex provides the thickness of the London Clay in this area. Encountered geology from historic nearby boreholes is summarised below in Table 2.

Table 2: Nearby BGS boreholes.

Reference	**Geology**	**Comment**
TQ28SE/411 350m east of site	Fill to 2.44m (+25.6mOD) London Clay proven to 31.5m (-3.4mOD)	Seepage and Claystone at +0.9 to +0.3mOD London clay base not proven.
TQ28SE6 280m south of site	Made Ground to 4.5m (+26mOD) Loam and Brick Earth to 5.5m (+25mOD) London Clay to 49.4m (-18.9mOD) Woolwich and Reading Beds to 69m (-38.4 mOD) Thanet Sand to 71.3m (-40.9mOD) Chalk proven	-
TQ28SE1490 550m north of site	London Clay to 68m (-15mOD) Reading Beds to 86.5m (-33.5mOD) Thanet Sand to 95.1 m (-38.5mOD) Chalk Proven	Ground level assessed from Google Earth to be circa +53mOD
TQ28SE299 At Chalk Farm Station	[Made Ground not mentioned] London Clay proven to 10.36 m.	-

Reference	Geology	Comment
TQ28SE217 and TQ28SE217/A-B 60m north of site (at school)	Made Ground to up to 1.22 m Brown clay [London Clay] proven to 5.0m.	-

Based on the above BGS boreholes the preliminary ground model is as per Table 3 and is summarised below. For further description see section 3.2 and 4.

- Made ground including hard standings and fill materials at surface to circa 2-4m depth;
- London Clay formation to circa 50m depth (-19mOD). Potential for clay stones and water seepages within the stratum. The likely sub-units of London Clay that are to be encountered are B2 at the surface followed by B1 extending to circa 25m depth. Below 25m depth it is likely that sub-unit A2 will be encountered. The defining characteristics of these divisions; notable B2 for shallow engineering and B1 for piles is high and reasonably uniform plasticity with potential for laminae of sand at the top and base of B1 moderately. The top of sub-unit B2 may also have sandy horizons but this zone is likely to be weathered masking the original structure.
- Lambeth Group (Reading Formation, predominantly clay rich) over Thanet Sand and Chalk.

Table 3: Ground Model.

Stratum	Top level (mOD/mTD)	Comment
Made Ground	+32mOD /132mTD	Variable, reworked London Clay
London Clay	+29mOD / 129mTD	Firm becoming Stiff Silty Clay, may have sand layers towards base.
Lambeth Group	-19mOD / 81TD	Interbedded silty clay and sand layers
Thanet Sand	-38mOD / 62mTD	Very dense silty fine sand.
Chalk	-40 mOD / 60mTD	Weak rock

1.6 Hydrology and hydrogeology

Based on the geological assessment above the ground conditions for hydrology and hydrogeology will be dominated by the London Clay. The London Clay is classified by the Environment Agency as unproductive strata, which refers to deposits that have low permeability and negligible significance for water supply or river base flow.

A deep aquifer is present within the lower permeable layers of the Lambeth Group, the Thanet Sand Formation and the Chalk. This is often referred to as the chalk-basal sands aquifer of the London Basin. The Chalk is classified as a principal aquifer, described as layers of rock or drift deposits with high intergranular or fracture permeability providing a high level of water storage. The lower Lambeth Group and Thanet Sand Formation are classified as secondary A aquifers.

There are no Environment Agency designated Groundwater source protection zones (SPZs) on the site however a SPZ is located to the south west with the SPZ Zone 2 388m and the SPZ Zone 1 597m from the site boundary. There are no listed groundwater or surface water abstraction points within 500 m of the site.The nearest surface water feature is Regents Canal, located 530 m southeast of the site. The site lies outside the catchment of the Hampstead Heath chain of ponds to the north.

Due to the predominantly cohesive nature of the soils, the groundwater flow rate is likely to be negligible. Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1 x 10-10 m/s and 1 x 10-8 m/s, with an even lower vertical permeability.

The site is not at risk of flooding from rivers or sea, as defined by the Environment Agency. Haverstock Hill and Adelaide Road have been identified as low to medium risk of surface water flooding (see Figure 7).

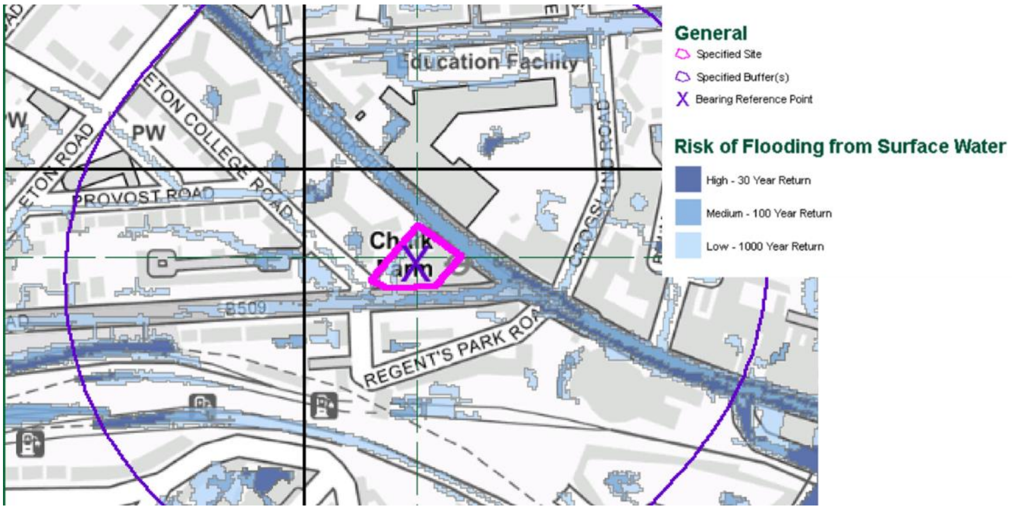


Figure 7: Risk of flooding from surface water (Envirocheck, 2020).

Historically a tributary of the River Fleet flowed in a roughly south-easterly direction, about 250 m to the east of the site close to Malden Road. It is understood that the River Fleet is now covered and culverted and forms part of the surface water sewerage system.

The site is largely covered by the existing building and hardstanding and as such infiltration of rainwater into the ground beneath the site is limited and therefore the majority of surface runoff is likely to drain into combined sewers in the road.

It is considered that the risk of flooding to the site is low with chalk farm road to the southeast continuing to fall away gently. Detailing of basement entrance levels (access and services) will need to accommodate shallow on pavement water and a possible ground water table at ground level due to the low permeability of the London Clay and fill (dominated by clay) at shallow depth.

1.7 Contamination Potential

A Land Contamination Preliminary Risk Assessment has been completed by Arup (ref: HH-ARP-REF-401) to support the proposed planning application. The report reviews desk-based information concerning historical and current uses and provides a conceptual site model that assesses the potential for ground contamination and the implications to the proposed development.

A summary of the desk-based findings are presented below with a summary of the risk assessment presented in Section 5

- The historical review identified the site as a garage from 1939 to 1963 where it is denoted as a depot;
- Camden Goods Depot which has included a coal depot, engine sheds and large-scale rail infrastructure located approximately 100m to the south east. The area closest to the site is shown to have been redeveloped into a car park during the late 1980s and early 1990s;
- A petrol station was present 130m east of the site, however this is shown to have been redeveloped and is no longer shown on the 1991 historical maps;
- An enquiry was made to the London Fire and Emergency Planning Authority by GEA (GEA, 2015) for records of above ground and underground storage tanks. The response indicated that there was no specific information on tanks held on file;
- There are no current or historic landfill sites, waste transfer or treatment sites within 500m of the site;
- No active or historic discharge consents to groundwater or surface water are located within 500m of the site;
- Adelaide local nature reserve is 400m to the south west. There are no other environmentally sensitive sites within 500m of the site;
- The site is within a lower probability radon area where less than 1% of homes are estimated to be at or above the action level (200Bq/m3). No radon protection measures are necessary in the construction of new dwellings or extensions

A request for a search for environmental information related to the site was submitted to Camden Council in August 2020. The following information was provided for the site:

- The site has not been classified as ‘contaminated land’ under Part 2A of the Environmental Protection Act 1990;
- There are no records of current or former landfills under the local authority on-site or within 250m of the site boundary;
- The site is recorded as being formerly used as a motor garage and repair workshop;
- Land uses within 100m of the site include coal and coke merchants (1923 to 1961), plumbing and sanitary engineers (1971), numerous plots of railway

land (1894 to 1971), three unspecified works (1934 to 1939 and 1952 to 1954), garages (1952 to 1954) and a coal depot (1952 to 1955);

- No current Part A or Part B environmental permitted industrial processes are present within 100m of the site;
- There are no private water supplies within 2km of the site, and;
- Camden Council has provided a moderate risk score of contamination being present at the site.

2 Screening

2.1 Context

The LBC guidance suggests that any development proposal that includes a subterranean basement should be screened to determine whether or not a full BIA is required.

2.2 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to Appendices E1, E2 and E3 which include a series of questions within screening flowcharts for surface flow and flooding, subterranean (groundwater) flow and land stability. The flowchart questions and responses to these questions are tabulated below.

2.2.1 Subterranean (groundwater) Screening Assessment

Question	Response for 5-17 Haverstock Hill
1a. Is the site located directly above an aquifer?	No. The Site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit water. Deep strata are excluded from this assessment as they are not impacted by the basement or the building foundations
1b. Will the proposed basement extend beneath the water table surface?	The basement will cut into the London Clay. It will penetrate the made ground layer with local perched water tables. It will not impact on a recognisable water table as would be found in a terrace gravel layer.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. The nearest “river” is the now “sewerised” River Fleet to the >100m east of the site.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No.
5. As part of the 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. The London Clay is not suitable for SUDS based soakaways.
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. There are no groundwater dependent ponds or spring lines within 1 km of the proposed development.

The above assessment has identified no potential issues that need to be addressed.

Any potential issues that need to be addressed, along with the possible effects of the basement construction on the local hydrology and hydrogeology and are discussed further in Part 2 of this report.

2.2.2 Stability Screening Assessment

Question	**Response for 5-17 Haverstock Hill**
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No.
5. Is the London Clay the shallowest strata at the site?	Yes.
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	Possibly.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Yes. The area is prone to these effects as a result of the presence of shrinkable clay soils, such as London Clay and cracking was noted during the site walkover along the northern boundary wall and in the single storey shed.
8. Is the site within 100 m of a watercourse or potential spring line?	No.
9. Is the site within an area of previously worked ground?	No.
10. Is the site within an aquifer?	No. The site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit usable amounts of water.
11. Is the site within 50 m of Hampstead Heath ponds?	No.
12. Is the site within 5 m of a highway or pedestrian right of way?	Yes. The site fronts onto Haverstock Hill and Adelaide Road with Eton College Road at the west corner.

Question	Response for 5-17 Haverstock Hill
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No. The proposed new partial basement is not adjacent to the perimeter of the site close to Chalk Farm Station to with south extending deeper than the existing.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. The Northern Line northbound Tunnel is located to the north of the site, beneath Haverstock Hill, with the crown levels at a depth of roughly 10 m (+21.90 m OD) below ground level but offset by over 4.5m from the property boundary. No construction is proposed within the exclusion zone of the LU tunnels. LU ground movement assessment will nevertheless be carried out in the next stage of design.

The above assessment has identified the following potential issues that need to be assessed:

Q5. London Clay is the shallowest stratum at the site.

Q6. The proposal may be within tree protection zones.

Q7. The site is within an area of seasonal shrink-swell.

Q12. The site is within 5 m of a public highway.

Q14. The site is located within the exclusion zone of a tunnel.

The potential issues that need to be assessed, along with the possible effects of the basement construction on the local hydrology and hydrogeology, are discussed further in Part 2 of this report.

2.2.3 Surface Flow and Flooding Screening Assessment

Question	Response for Response for 5-17 Haverstock Hill
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.

Question	**Response for Response for 5-17 Haverstock Hill**
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. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the existing hardstanding/building footprint, therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. There will not be an increase in impermeable area across the ground surface above the basement. There will be no surface expression of the basement development.
4. Will the proposed basement development 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. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the existing hardstanding/building footprint, therefore the 1m distance
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposed basement is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses as the surface water drainage regime will be unchanged.

Question	Response for Response for 5-17 Haverstock Hill
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 of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No. The Camden Flood Risk Management Strategy dated 2013, together with Figures 3ii, 4e, 5a and 5b of the SFRA dated 2014, and Environment Agency online flood maps show that the site has a very low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses. In accordance with paragraph 5.11 of the CPG a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding. The BIA notes that surface perched water tables may exist, the basement will be designed to accommodate a water pressure uplift on the basement walls and slab with a head of 1m below ground level as per CIRIA C760 guidance. The site is located within the Critical Drainage Area number GROUP3-003, but is not in a Local Flood Risk Zone, as identified in the Camden SWMP and Updated SFRA Figure 6/Rev 2.

The above screening has identified no potential issues that need to be assessed.

2.2.4 Potential Impacts

The following potential impacts have been identified by the screening process.

Potential Impact	Consequence
London Clay is the shallowest stratum on the site.	The London Clay is prone to seasonal shrink-swell and can cause structural damage.
Proposed new building may be located within tree protection zone	Damage to tree roots.
Seasonal shrink-swell	If a new basement is not dug to below the depth likely to be affected by tree roots this could lead to damaging differential movement between the subject site and adjoining properties. NHBC Specification Clause 4.2 suggest that the depth of shrink-swell in high plasticity clay for high water demand trees should be engineer designed. A basement of 5m construction depth will penetrate below the depth of significant tree root effect.
Site within 5 m of a public highway.	Excavation of a basement may result in structural damage to the road or footway. Assessment of services within the road will also need to be assessed.

Potential Impact	Consequence
The location of the Northern Line Underground tunnel	While the works are beyond the LU Tunnel exclusion zone an assessment of the works (demolition, excavation and construction) on the LU assets will be carried out for LU agreement.

These potential impacts have been investigated through the site investigation and design assessment, as detailed in the Building Impact Assessment.

3 Ground investigations

3.1 Previous ground investigations

This section reviews the available Ground Investigation data obtained by the client to provide a summary of the available relevant data. During the previous design stage, a site investigation was recommended and was specified by Conisbee, with input from GEA and comprised of the following (see Figure 8):

- Two boreholes advanced to depths of 15m and 24.7m from ground level by means of a standard cable percussion drilling rig;
- A total of five open-drive sampler boreholes advanced to depths of 4m and 5.2m below ground level and to depths of 3m and 10m below the existing lower car park level;
- Standard penetration tests (SPTs), carried out at regular intervals in the cable percussion boreholes and a single open-drive sampler borehole, to provide quantitative data on the strength of the soils;
- A soil vapour survey carried out within the existing lower level car park and from internal ground level, using a photo-ionisation detector (PID);
- Headspace testing on all samples of recovered soils from the open-drive sampler boreholes;
- Installation of three groundwater monitoring standpipes to depths of 6m and two subsequent monitoring visits, roughly two weeks and six weeks after installation;
- A single hand-dug trial pit excavated to a depth of 1.2m to expose the footings shared with Chalk Farm LUL station;
- Testing of selected soil samples for contamination and geotechnical purposes.

Figure 8: Existing ground investigation (GEA, 2016)

3.2 Ground conditions

3.2.1 Made Ground

The concrete hardstanding in the external car park extended to depths of between 0.2m and 0.35m, over a layer of metal square mesh and the existing ground floor slab and lower ground floor slab were between 0.15m and 0.19m in thickness.

The made ground extends to depths of 0.8m and 2.6m below ground level and generally comprised brown clay with flint gravel and sand partings, fragments of concrete and brick and rootlets.

The thickness of made ground appeared to be greatest in the northern part of the site, towards Eton Place.

In Borehole No 2, a layer of concrete was noted from 2.5m to 2.6m, which may possibly represent an old basement slab from the former houses.

The base of the made ground was not proved in Borehole Nos 3 and 3A. In Borehole No 3, metal was encountered at a depth of 0.14m, along one edge of the service pit, so the borehole was relocated 1m to the northeast. At a depth of 0.56m rusty metal was noted across the entire base of the service pit and the borehole location was relocated3 m to the northeast. It is possible that the metal encountered within Borehole No 3A, located close to the chambers within the external car park, may be a buried fuel tank from the former fuel station.

At lower car park level, the floor slab comprised screed over concrete, extending to depths of 0.15m and 0.19m, with no reinforcement noted in the recovered cores. In Borehole No 6, a layer of cobbly gravel with brick fragments was noted beneath the slab, which was in turn underlain by soft dark grey mottled black silty sandy clay with decayed wood and an organic odour, extending to a depth of 0.45m.

No vapours were detected with the PID during headspace analysis on recovered samples.

At existing lower car park level, the slab is generally directly underlain by natural soils.

Apart from the presence of fragments of extraneous material noted above, no visual or olfactory evidence of contamination was observed during the fieldwork.

3.2.2 London Clay

The London Clay initially comprised firm becoming stiff brown mottled grey silty fissured clay with occasional partings of orange-brown fine sand and silt and selenite crystals, which extended to depths of 9.6m and 9.8m from ground level and to a depth of 8.3m below existing basement level. Below this depth, unweathered London Clay comprised of stiff becoming very stiff grey silty fissured clay with rare grey burrows was encountered and proved to the maximum depth investigated of 24.7m.

Claystones were encountered at various depths within the London Clay and Borehole No 1 was terminated on a claystone at a depth of 24.7m.

In Borehole No 2 a pyrite nodule was encountered at a depth of 14.5m.

Live rootlets were noted to depths of 2.1m and 2.6m and dead rootlets to a maximum depth of 4.80m below ground level. Below existing lower car park level dead rootlets were noted to a depth of 2.6m. In Borehole No 3B, the clay was noted to be ‘stiff’ and desiccated to a depth of about 2.3m, in close proximity to existing mature trees and it is possible the clay was also potentially desiccated in Borehole No 5 to a similar depth.

Atterberg limit tests indicate the clay to be of high-volume change potential. The results of the undrained triaxial tests generally indicate an increase in strength with depth. The results indicate the clay to be of high strength to extremely high strength.

3.2.3 Groundwater

A seepage was noted from within the base of the made ground at a depth of 2.5m in Borehole No 2. Perched water was encountered around a claystone in Borehole No 3B at a depth of 3.43m. Perched water was also encountered at the base of the trial pit excavated to expose the footings of Chalk Farm London Underground Station and water was measured at a depth of 0.98m below floor level on completion of the trial pit.

Three standpipes were installed to a depth of 6m and have been monitored on two occasions to date, roughly two weeks and six weeks after installation. The results of the monitoring visit are shown in Table 4. The second monitoring visit was undertaken after a period of heavy sustained rainfall.

Table 4: Groundwater monitoring

Date	Borehole No	Depth to water (m)
18/12/2015	1 (tip at 6m depth)	2.08
	2 (tip at 5m depth)	1.88
	6 (tip at 6m depth)	DRY
13/01/2016	1 (tip at 6m depth)	2.05
	2 (tip at 5m depth)	1.87
	6 (tip at 6m depth)	3.72

3.3 Chemical Testing

GEA scheduled only four samples of Made Ground and eleven samples of London Clay for the following chemical testing:

- General inorganics;
- Metals and metalloids;
- Speciated banded TPH;
- Speciated PAH; and
- Total phenol.

Three of the four Made Ground samples were scheduled for asbestos testing.

No ground gas monitoring, soil leachability tests or groundwater sampling was undertaken as part of the investigation. Chemical testing of soils has been assessed as part of the Arup Land Contamination Preliminary Risk Assessment Report (doc ref HH-ARP-REF-401).

3.3.1 Soil Vapour Survey

GEA undertook a soil vapour survey (SVS) within the existing lower level car park in the area of the manhole covers which are understood to have been interceptor tanks. The SVS comprised 32 probe holes in a uniform grid at lower car park level and three positions at internal ground level to a depth of 1.00m bgl.

GEA conclude that no vapours were detected during the survey.

3.4 Existing foundations

The findings of the trial pit are summarised in the table below. Sketches and photographs of the pit are included in the Appendix.

Trial Pit No	Structure	Foundation detail	Bearing Stratum
1	Chalk Farm London Underground station	Concrete Top 0.16 m Base of footing not proved, extends at least to a depth of 1.20 m Lateral projection 0.16 m	Not proved

Perched water was encountered at the base of the trial pit and was at a depth of 0.98m below floor level on completion of the trial pit.

Part 2: Design Basis

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to foundation options.

4 Ground interpretation

4.1 General

This section interprets the available Ground Investigation data obtained by the client to provides an interpretation of the ground conditions and material properties suitable for design.

The desk study has revealed that the site has had a potentially contaminative history, given that it was used a filling station and garage, and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- Below a moderate to significant thickness (0.5 to 2.6m thick) of made ground below ground level or nominal thickness below existing lower car park level, the London Clay was encountered and proved to the maximum investigated depth of 24.70m. The likely depth to the base of the London Clay at the site is around 50m below ground level;
- The concrete hardstanding in the external car park extends to depths of between 0.20 m and 0.35 m, over a layer of metal square mesh and the existing ground floor slab and lower ground floor slab were between 0.15m and 0.19 m in thickness;
- The made ground extends to depths of 0.50 m and 2.60 m below ground level and generally comprises brown clay with flint gravel and sand partings, fragments of concrete and brick and rootlets, with the greatest thickness in the north of the site;
- Metal was encountered at a depth of 0.56 m across the entire base of the services inspection pit located close to the chambers within the external car park may be a buried fuel tank from the former fuel station;
- A layer of concrete was encountered from 2.50 m to 2.60 m below ground level at a single location, and may represent the base of a former backfilled basement;
- At existing lower car park level the slab is generally directly underlain by natural soils;
- Soft dark grey mottled black silty sandy clay with decayed wood was noted at a single location extending to a depth of 0.45 m below existing lower car park level;
- the London Clay initially comprises firm becoming stiff fissured high strength and very high strength brown mottled grey silty clay with occasional partings of orange- brown fine sand and silt and selenite crystals, which extends to

depths of 9.6m and 9.8m from ground level and to a depth of 8.3m below existing lower level car park.

- Below this depth, stiff becoming very stiff fissured high strength to extremely high strength grey silty clay with rare grey burrows was encountered and proved to the maximum depth investigated of 24.70m;
- Claystones were encountered at various depths across the site within the London Clay;
- The clay was noted to be desiccated to a depth of 2.3m below ground level;
- Seepages were encountered in the made ground locally and locally around claystones in the London Clay. Subsequent monitoring has measured groundwater at depths below ground level of between 1.87m and 3.72m; and
- Contamination testing has revealed elevated concentrations of lead and arsenic within the made ground and a slightly elevated concentration of lead within a single sample of London Clay.

4.2 Assumed stratigraphy

The assumed soil stratigraphy based on existing GI and BGS data is summarised in Table 5.

Table 5: Summary of assumed stratigraphy

Stratum	Top level (mOD/mTD)	Comment
Made Ground	+32mOD /132mTD	Variable, reworked London Clay
London Clay	+29mOD / 129mTD	Firm becoming Stiff Silty Clay, may have sand layers towards base.
Lambeth Group	-19mOD / 81TD	Interbedded silty clay and sand layers
Thanet Sand	-38mOD / 62mTD	Very dense silty fine sand.
Chalk	-40 mOD / 60mTD	Weak rock

4.3 Assumed ground parameters

Table 6 shows the soil parameters assumed for this stage of design of the geotechnical elements of the new proposed scheme.

Table 6: Summary of assumed parameters

Stratum	Bulk unit weight γ (kN/m^3)	Angle of shear resistance φ' (deg)	Cohesion c' (kPa)	Undrained shear strength c_u (kPa)	Soil stiffness profile E (kPa) (2)			
					$E_{u,v}$	E'_v	$E_{u,h}$	E'_h
Made Ground	17	20	0	N/A	20,000	20,000	N/A	5,000
London Clay	19.5	25	5	40+11.2z (1) (3)	400c_u	250c_u	1000c_u	750c_u

Stratum	**Bulk unit weight γ (kN/m^3)**	**Angle of shear resistance φ' (deg)**	**Cohesion c' (kPa)**	**Undrained shear strength c_u (kPa)**	**Soil stiffness profile E (kPa) (2)**			
					$E_{u,v}$	**E'_v**	**$E_{u,h}$**	**E'_h**
Lambeth Group	19.5	25	5	350 (4)	400c_u	250c_u	1000c_u	750c_u
Thanet Sand	20	35	N/A	N/A	N/A	400,000	N/A	400,000
Chalk	Assumed as rigid boundary in PDisp models							

Notes:

(1) z is depth below top of London Clay

(2) Based on typical correlation between E and c_u derived from back analysis of case histories within the London Clay in central London.

(3) c_u limited to 350 kpa

(4) As per base of London Clay

5 Contamination Assessment

A Land Contamination Preliminary Risk Assessment has been completed by Arup (ref: HH-ARP-REF-401) to support the proposed planning application and should be reviewed for full context of the summary contained within this section.

The report reviews desk-based information concerning historical and current uses and provides a conceptual site model that assesses the potential for ground contamination and the implications to the proposed development. The report has been prepared with consideration of relevant guidance including BS10175:2011+A2:2017 Investigation of potentially contaminated sites, Code of Practice (British Standards Institution (2017)) and Environment Agency guidance (Land Contamination: Risk Management) (Environment Agency. (2019), n.d.)

5.1 Summary of findings

The site has had limited history of potentially contaminative land-uses. The site is recorded as being a private garage and car showroom, with a small petrol station and workshop from the 1930s prior to becoming a depot for vehicle storage in the 1950s.

The previous ground investigation undertaken by GEA in 2016 (GEA (2016)) demonstrates the geological sequence comprises of Made Ground, which is thickest towards the west of the site up to 2.6m. which overlies the London Clay formation, which was encountered to a depth of 24.7m bgl. Localised groundwater is recorded to be perched at the base of the Made Ground.

Nearby BGS boreholes show the Lambeth Group, Thanet Formation and Chalk to underly the London Clay, although these were not encountered during the investigation. The London Clay is not designated as an aquifer while the underlying Thanet Formation and Lambeth Group are designated as secondary A aquifers and the Chalk as a principal aquifer.

Potential sources of contamination are limited to onsite Made Ground and potential underground storage tanks. An underground tank, or tanks, and associated infrastructure are suspected to be present within the south western extent of the site based a metal obstruction encountered during previous investigations. However, there are no formal records of the presence or of decommissioned tanks at the site.

The previous contamination assessment undertaken by GEA was reviewed in context of the proposed development with chemical testing of soils re-assessed. Arsenic and lead were above residential GAC.

A summary of the risk ratings from the contamination risk assessment and conceptual site model is presented in Table 7.

Table 7 Summary of the preliminary risk assessment

Receptor	Risk rating
Risk to human health; construction workers and	Moderate to low
Risk to human health; adjacent site users	Low
Risk to human health; end users	Moderate to very low
Risk to controlled waters; underlying chalk aquifer	Low
Risk to controlled waters; Regent's Canal	Negligible
Ecology and soft landscaped areas	Negligible
Risk to the built infrastructure	Very low

During construction works, the presence of potential underground tanks, pipework and interceptors and any surrounding contamination should be investigated and removed if encountered. Due to the underlying clay deposits, potential contamination (if present) is likely to be localised in depth and area.

Whilst some results from the previous investigation were above, GAC there is no soft landscaping areas at ground level and the form of construction will prevent exposure to end users. All the identified contaminant linkages can be managed through construction and design.

5.2 Summary of recommendations

The recommendations from the PRA are summarised below. Additional details are included in Arup report ref HH-ARP-REF-401:

- The number, integrity and contents of tanks are unknown. It is recommended that management of possible USTs is addressed during construction under an advanced investigation works and remediation strategy;
- A verification report should be completed to demonstrate that works have been undertaken in accordance with the aforementioned best practice and the advanced works remediation strategy;
- Depending on the final design a foundation works risk assessment may be required to assess the risks of piling through brownfield sites.
- The foundation works risk assessment should be a standalone document and prepared in accordance with the relevant Environment Agency guidance (Environment Agency (2001)). This is likely to be a requirement if piles are proposed to fully penetrate the London Clay and create preferential pathways to underlying principal aquifers;
- Aggressive ground poses a risk to the built infrastructure which can be mitigated through design. Concrete should be designed in accordance with BRE SD1 (Building Research Establishment (2017)) to resist aggressive ground conditions;
- Water supply pipes should be designed in accordance with UKWIR guidance (UK Water Industry Research (UKWIR), (2011)) using materials that are suitably resistant to permeation and chemical attack;

6 Design basis

6.1 General

Piles will be required to withstand the vertical loads from the superstructure of the proposed scheme.

Excavations for the proposed basement structure will require temporary support to prevent any excessive ground movements and the stability of the adjacent Haverstock Hill, and to a lesser extent (due to distance from the basement) of the LU building.

6.2 Basement construction

It is understood that it is proposed to form a partial basement, which will extend to a depth of approximately 4.5m (plus construction thickness, total thickness ~6m) below existing ground level. On this basis, formation level is likely to be within the upper metres of the weathered London Clay.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by whether it is to be incorporated into the permanent works and have a load bearing function. The final choice will depend to a large extent on the need to protect nearby structures from movements, the required overall stiffness of the support system, and the need to control groundwater movement through the wall in the temporary condition. The permanent basement box would been an internal structure.

Consideration of the LU assets (tunnels, building and shafts) is a key consideration in defining the basement construction and stiffness. Use of a pile wall for basement support adjacent to the LU tunnels is a likely solution to support Haverstock Hill road and services whilst not impacting on the LU tunnels as would be the case when using driven sheet piles (these being precluded within 15m of LU structures as per Clause 3.9.1 of LU document "Civil Engineering - Common Requirements" (S1050, Issue no: A9, date: April 2016)

All piles would be constructed beyond the LU Piling Exclusion Zones as per Clause 3.9.3 in S1050, pile location relative to the exclusion zone would allow for construction tolerances and the known accuracy of the LU asset positioning. On the basis of the understanding of the ground conditions to date, it should be possible to adopt a contiguous pile wall, with the use of localised grouting and / or pumping if necessary in order to deal with groundwater inflows, subject to the results of the further testing and investigation to assess the rate of groundwater inflow as noted above.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition.

The stability of the adjacent foundations of the LU station will need to be considered, but given the distance from the proposed basement and the likely choice of a piled solution for the new building, the impacts of the proposed construction works will be small – no intervention underpinning works is proposed.

Formation level of the approximately 0.9m deep semi-level basement is likely to be within the firm weathered London Clay and will result in a net unloading of up to approximately 18 kN/m^2. The proposed excavations will result in elastic heave and long term swelling of the London Clay. The effects of the longer-term swelling movement will to a certain extent be counteracted by the applied loads from the development. Further consideration is given to heave movements in Part 3 of this report.

6.3 Piled foundations

For the ground conditions at this site, some form of bored pile is likely to be the most appropriate type. A conventional rotary augered pile may be appropriate but consideration will need to be given to the possible instability and water ingress in the made ground and within any silty or sandy zones within the London Clay. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

Preliminary pile charts for the Harvestock Hill site area are provided in Figure 9. A total stress approach has been used to derive the pile resistance in the London Clay. The key assumptions for deriving the preliminary design pile charts are summarised below:

- EC7 partial factors are based on no load tests being carried out;
- An adhesion factor (α) of 0.5 has been taken for the London Clay;
- Design chart is for single piles. Group effects should be considered if the piles are closely spaced (i.e. less than 3D); and,
- Superficial deposits (i.e. Made Ground) have not been relied upon providing any pile resistance.

It should be noted that the building is currently proposed to be founded on 900mm piles. However, further value engineering work will be undertaken in the next stages in order to reduce the amount of piles and their diameter in order to be more cost effective, sustainable and optimize the construction programme. It is envisaged that this value engineering exercise will not change the outcome of the Ground movement assessment presented in Part 3.

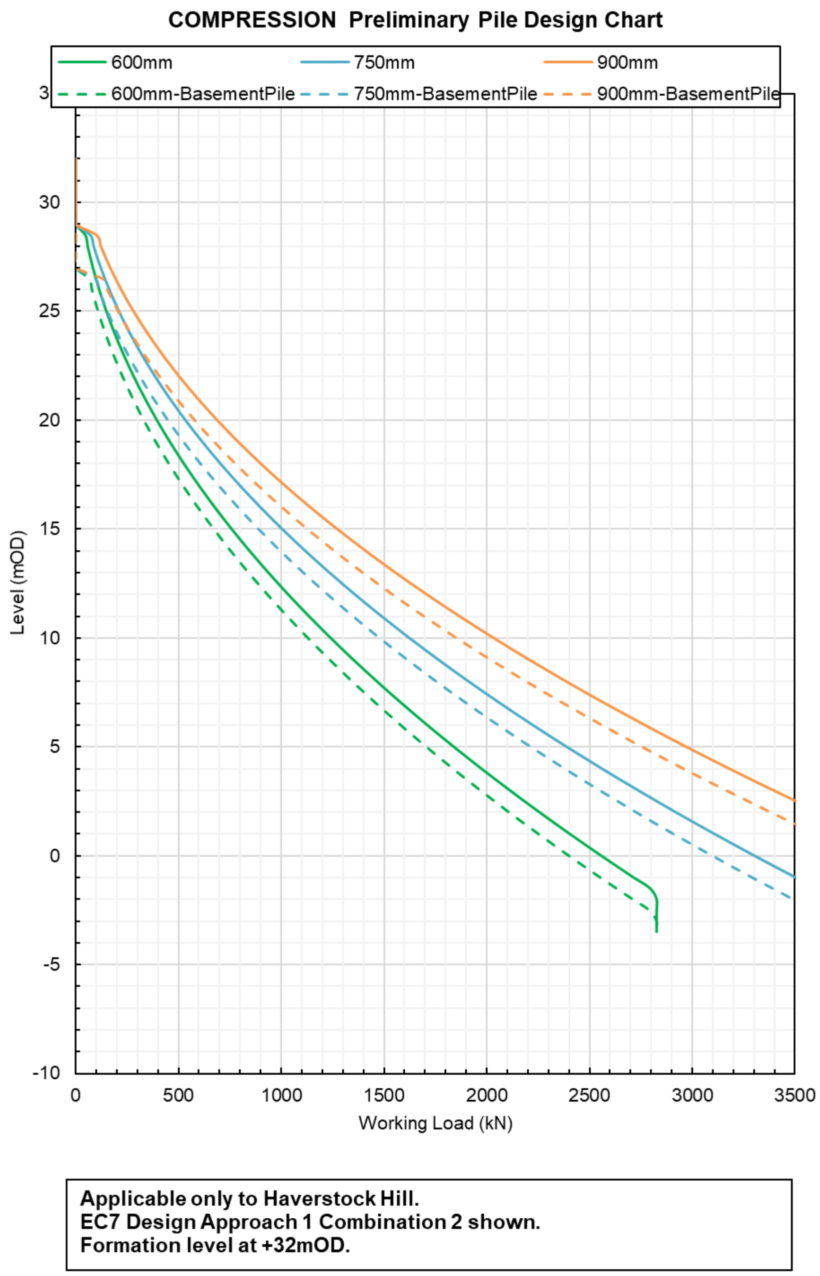


Figure 9: Preliminary pile design chart

6.4 Ground and basement floor slabs

Following the excavation, the ground floor and basement floor slabs will need to be suspended over a void in accordance with NHBC guidelines within the zone of influence of any existing or proposed trees. Outside the zone of influence of trees and following the removal of the made ground and a proof rolling exercise it should be possible to adopt a piled raft to withstand the vertical loads.

Part 3: Ground movement assessment

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

7 Ground movement assessment

7.1 General

An analysis has been carried out to calculate the movements arising from the proposed basement excavation and the results of this analysis have been used to calculate the effect of these movements on surrounding structures.

The existing building, which is understood to be supported on ground bearing foundations (GEA Ground Investigation 2016) and will be demolished to ground level. It is anticipated that the existing basement walls may require temporary propping to prevent them failing once the existing ground slab is removed. The existing basement structure can then be safely excavated with its foundations broken out.

The extent of the new basement construction largely overlaps with the existing. In areas where it is extended this is adjacent to a boundary where existing buildings are a significant distance away.

Beyond the areas described above the existing ground slab can be removed and the existing foundations grubbed out without compromising the stability of adjoining buildings or public footpaths. There are only nominal existing retaining features at the perimeter of the existing buildings. The new piled foundations can then be installed using traditional ground support techniques to local excavations (e.g, for the pile caps and ground beams). The new structure can then be constructed above this.

7.2 Information used in the assessment

The information presented in Table 8 has been used to undertake the ground movement assessment.

Table 8: Drawings references used in the ground movement assessment

Drawing Reference	Purpose of Information
Proposed development	
HH-ARP-SKE-S-011 Estimated Column Loads	Estimated column loads plan
6432_HH_00G pln	Ground floor plan
6432_HH_00LG pln	Lower ground floor plan
LU asset drawings	

Drawing Reference	Purpose of Information
N046-TLL-S-1MA001	Survey drawing of the Northbound tunnel alignment. Provides soffit levels of crown of northbound tunnel (centreline) Extrados and intrados of tunnel
SR20_081	Survey drawing (including spot levels) of surface infrastructure, Chalk farm station vertical shaft, horizontal passageways and northbound and southbound tunnel alignments. Provides soffit levels of crown of both tunnels (centreline) Provides track levels for both tunnels
TLL-N001-P101-DTAOAP1-TUN-RPT-00001 Rev 3 Edited.pdf	Internal tunnel diameter is 11ft 8.25inch=3.56m (Agrees with existing BIA & N046-TLL-S-1MA001) External tunnel diameter is 12ft 6inch=3.81m (Agrees with existing BIA & N046-TLL-S-1MA001)
Chalk Farm Station Existing Drawings_1.0.pdf	Position of chalk farm station and tunnel alignment Chalk farm station drawings, including vertical shafts and pedestrian access tunnel to main tube line Alignment drawings
Existing structure	
200717_Load Takedown_Existing Building	Estimate of existing building footing loaciton and size
DAS complete (includes Existing & Consented Building Drawings)	Existing building plans
33507a_01-14_PE	Survey
Site photographs	
SI & Basement Impact Assessment	Existing building foundation location and size
General	
103307T-01.dwg	Survey (date tbc)

7.3 Assumptions

The key assumptions adopted for calculating the ground movements are summarised below:

- The existing basement on the site was assumed to be 0.9 m deep, in line with the previous 2016 Site Investigation & Basement Assessment Report GEA
- Ground level assumed to be uniform at +32mOD (+132mTD)
- No evidence of lower ground floor of Eton Place on planning portal or street view, therefore foundations are conservatively assumed to be 0.6m deep.

- Foundations of Chalk Farm station are assumed to extend to 1.2 m below ground level GEA 2016 GI did not prove foundation depth at this location).
- Chalk farm station box and vertical shafts assumed to extend to +22.4mOD, 122.4mTD as per *SR20_081*.
- Passenger tunnels – invert assumed at +22.4mOD, +122.4mTD as per *SR20_081*. Tunnel height assumed to be 2.5 m.
- Tunnel alignment, depth and track levels as per *N046-TLL-S-1MA001 and SR20_081*. From the edge of Chalk Hill Farm Station to the northern edge of the site; Northbound tunnel crown soffit level and track levels are approximately s121.25 to 121.97mTD and 118.25-118.93mTD respectively. Southbound tunnel crown soffit levels and track levels are approximately s121.27-122.00mTD and 118.24-119.0mTD.
- Tunnel diameters taken *TLL-N001-P101-DTAOAP1-TUN-RPT-00001 Rev 3 Edited.* Internal diameter 11ft 8.25inch=3.56m, *External tunnel diameter 12ft 6inch=3.81m*

The following construction sequence has been assumed to enable analysis of the ground movements around the proposed basement both during and after construction:

1. Demolish the existing six-storey building;
2. Construct new retaining walls;
3. Fully excavate new basement;
4. Construct new foundation piles and construct super-structure.

It is assumed that excavations for the proposed basement structure will require temporary support to prevent any excessive ground movements and the stability of the adjacent Haverstock Hill, and to a lesser extent (due to distance from the basement) of the LU building.

When the final excavation depths have been reached the permanent works will be formed, which are likely to comprise reinforced concrete walls with a drained cavity lining the inside of the retaining walls. Reinforced concrete will be used for floor slabs at basement and ground level and it is anticipated that heave protection may be installed beneath the basement slab.

7.4 Methodology

7.4.1 Ground movement sources

The primary sources of ground movement from the Haverstock Hill development include the following

- Unloading the ground resulting in heave (i.e. demolitions);
- Basement construction; and,

- Loading the ground resulting in settlement (i.e. transfer the building load to the ground).

The ground movements have been calculated using the Oasys software XDisp and PDisp.

7.4.2 Vertical unloading and reloading ground movements

At this site unloading of the London Clay will take place as a result of the proposed existing building demolition and basement excavation; the reduction in vertical stress in the short term will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the "immediate" or elastic movements as a result of the net unloading caused by the demolition and basement excavation.

Following the short-term unloading stage inclusion of the new building loads will be included. Drained parameters have been used to provide an estimate of the total long-term movement which includes loads from the new building as well as the demolition and basement excavation unloading. In this way bounds of movement are calculated (maximum heave and maximum settlement).

Oasys PDisp has been used to calculate the movements arising from vertical unloading and loading. This program calculates soil displacements associated with loading or unloading based on elastic assumptions. The soil stiffness parameters used in the assessment are presented in Table 6. These are based on typical correlations between E and c_u that have been derived

A rigid boundary for the analysis has been set at the top of the Chalk (i.e. –40mOD), where nearby BGS records indicate that the base of these formations is likely to be present.

7.4.3 Wall installation and retained cut excavation

For at-grade structures, horizontal and vertical ground movements arising from retaining wall installation and basement excavation have been assessed using the empirical methods proposed in CIRIA C760, these movement will be used to assess adjacent building damage classification according to the Burland method.

Oasys Xdisp has been used to calculate the movements arising from wall installation and retained cut excavation. CIRIA C760 curves for 'excavations in front of a high stiffness wall in stiff clay' have been adopted as being considered most appropriate for the proposed excavation and its support at this site as the walls will be generally supporting cohesive soils.

7.4.4 Piled foundations

The proposed pile layout and loads were provided by Arup Structural Engineers. Oasys Pile was used to model the pile settlement using total stress parameters as outlined in Table 6. Capacity provided by the made ground was conservatively ignored.

To simplify the analysis two Oasys Pile models were used to bound the analysis. One for the column piles, where the the highest SLS load was 1850kN and one for the core piles where the highest load was approximately half that of the core piles (925kN).

Traditionally to determine surface settlements for pile groups an equivalent raft method approach is typically adopted where the load from the pile group is modelled at a depth of two-thirds of the pile length with a load distribution of 1H:4V. However, for a tunnel impact assessment where the assets are located at higher levels (i.e. above two-thirds of the pile length) consideration needs to be given in more detail to the load shed from pile to ground.

To account for this the load distribution down the piles was broken up into a series of discrete levels to represent the load being shed from the pile over these intervals.

This was modelled in Oasys Pile by conservatively assuming all load is shed via shaft friction to the surrounding soil. This gave the pile stress distribution down the pile. The load being shed from the pile at each discrete interval (in this case 2m intervals) was then divided by an equivalent load area using the same principles as the equivalent raft method mentioned above. This gave a series of load ‘discs’ down the pile which were modelled in PDisp. This pile load distribution is shown in Figure 19.

8 Damage assessment

8.1 General

The ground movement assessment is initially based on greenfield ground movements imposed on to the existing assets. Resulting strains on the existing neighbouring buildings are appraised with the Burland method. The resulting strains and stresses on the LUL tunnel lining are also appraised and compared with the LUL criteria and methodology (Refer to LU S1055).

8.2 Building damage assessment

Movements arising from the wall installation and basement excavation phases, have been calculated using the methodology outlined in Section 7.4. Oasys Xdisp uses the methodology outlined by Burland (1995) to calculate the likely damage induced to the adjacent properties.

The potential heave movements calculated for the unloading stage have not been included in this assessment, which can therefore be considered as conservative, as these movements are likely to have a mitigating effect on the downward settlement predicted by XDisp. The resultant total stress and strain due to the proposed development on the nearby LU tunnel is addressed in Section 8.3.

Table 9: Building Damage Assessment results in surrounding buildings

Building	Elevation reference in PDisp and XDisp models	Maximum Category of Damage (1)
Eton Place	A to H	Category 0 - Negligible
Chalk Farm Station	I to K	Category 0 – Negligible (excavation + contiguous pile wall)
Notes: (1) From Table 6.4 of C760: Classification of visible damage to walls.		

The proposed basement is ca. 20m away from the Chalk Farm Station closest façade. The calculated horizontal movements in the Chalk Farm Station along station elevations are less than 2.5mm and therefore not considered to have a material effect on the LUL station.

The analysis was based on using the following CIRIA curves: excavation in front of high stiffness wall in stiff clay and CIRIA curve for installation of contiguous pile wall in stiff clay. The analysis has predicted that the proposed installation of the retaining walls and excavation of the proposed basement may generally result in a building damage for adjacent structures of Category 0 (negligible), which falls within acceptable limits according to the Camden Planning Guidance (CPG4). Further investigation and design work may result in this category of damage extending toward / into Category 1 (very slight) which also conforms to CPG4 criteria; this observation is mainly applied to Chalk Farm Station which is closest to the proposed development.

8.3 LUL tunnels assessment

The proposed basement extension will be in close proximity to the Northern Line of the London Underground which runs below Haverstock Hill, adjacent to the site. Chalk Farm London Underground station is located adjacent to the south-eastern boundary of the site. The Northern Line tunnels are circular in cross section, with external diameters of approximately 3.8 m. The tunnels have been modelled from LU drawings.

There are two passenger tunnels that lead from the station box horizontally over the two Northern Line Tunnels to provide pedestrian access to the platforms. These tunnels have been modelled at a depth of 5 m below ground level (to the crown of the tunnel) and are assumed to be rectangular in shape, with a width and height of roughly 3 m and 2.5 m respectively.

The assessment has been carried out in accordance with LU Category 1 Standard S1055 Civil Engineering – Deep Tube Tunnels and Shafts Issue A2, December 2011 (LU S1055).

8.3.1 Unloading stage calculated movements

The assumptions adopted for the calculations of the demolition and excavation ground movements are:

- Demolition of the existing building is undertaken with unloading occurring at the estimated shallow footing levels, assumed to be +31mOD for the shallow footings;
- The weight of the existing building has been estimated by Arup Structural Engineers to determine approximate loads on the foundations (Figure 10). The estimated loads were used to approximate shallow footing sizes (Figure 11);
- The excavation of the remainder of the new proposed basement. Unit weight of the excavated material was conservatively assumed to be 20kN/m^3;
- To account for the area where the existing basement will be temporarily backfilled an allowance for a 15 kPa reload was provided; and
- Short term ground parameters have been assumed given the sequence of works will be followed by the construction of the new foundations of superstructure of proposed development building.

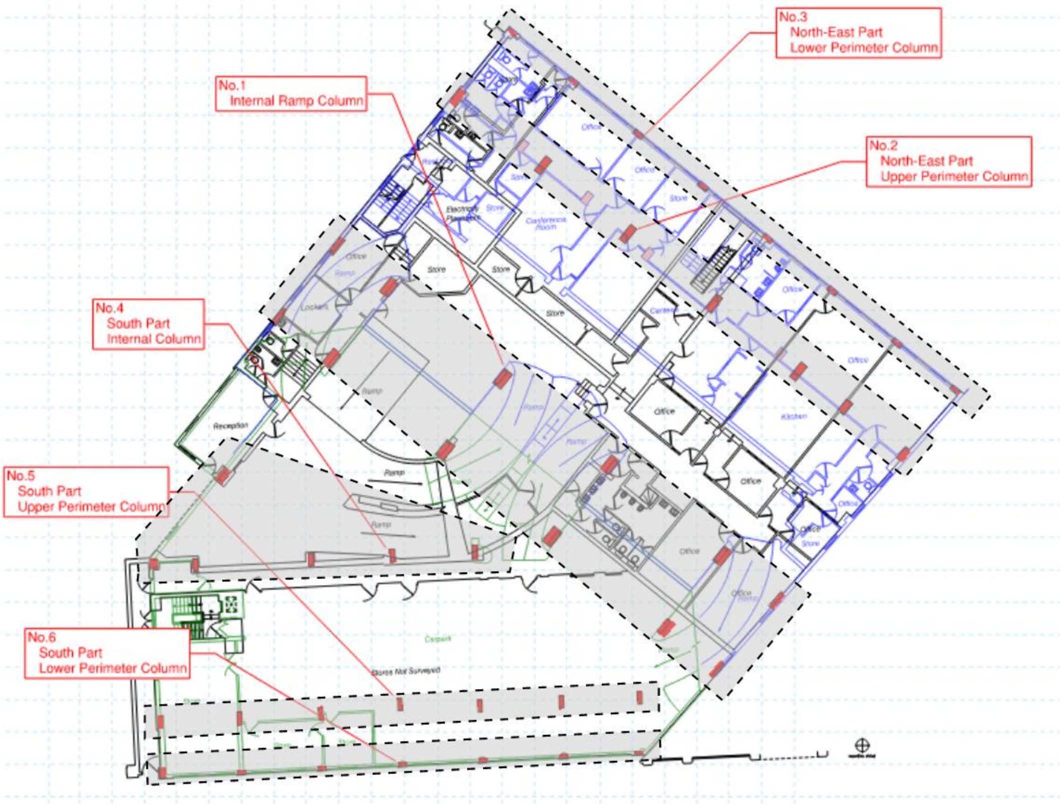


Figure 10: Load takedown of existing structure

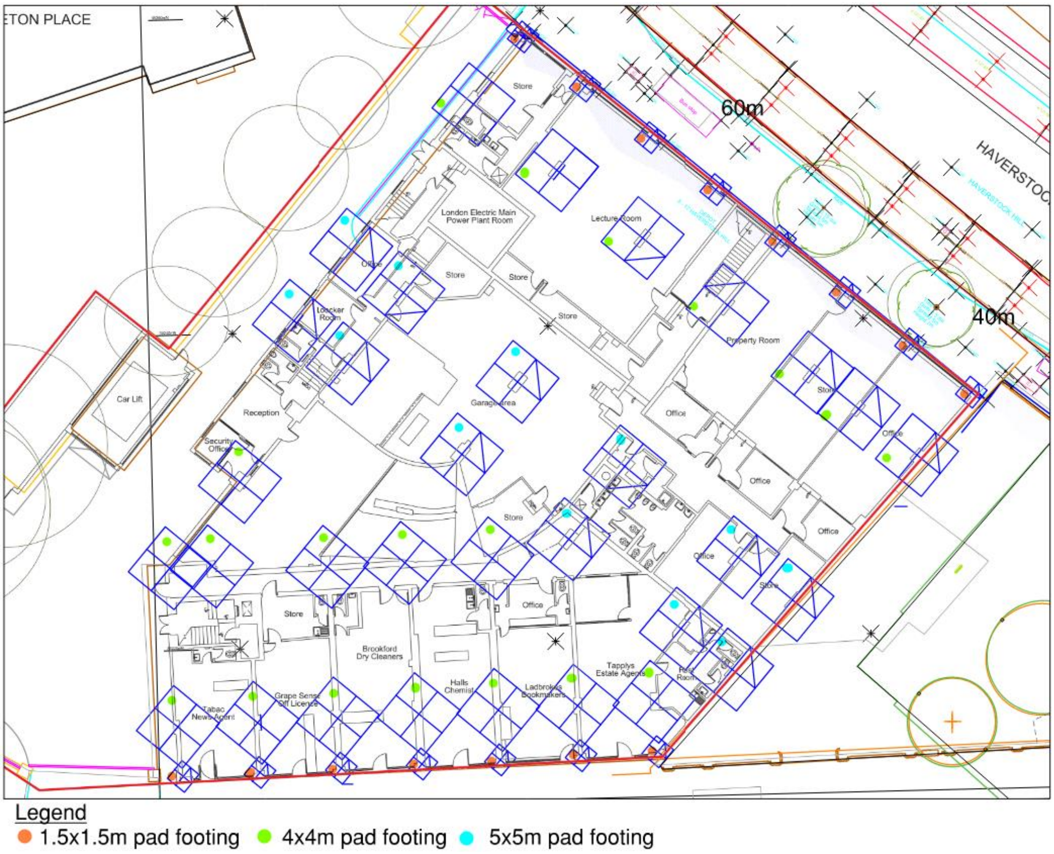


Figure 11: Assumed footing sizes based on load takedown

PDisp was used to estimate the vertical ground movements. A screenshot from PDisp showing the layout for the undrained stage is shown in Figure 12 below. The approximate chainage points are included on the mainline tunnels and passenger cross passages.

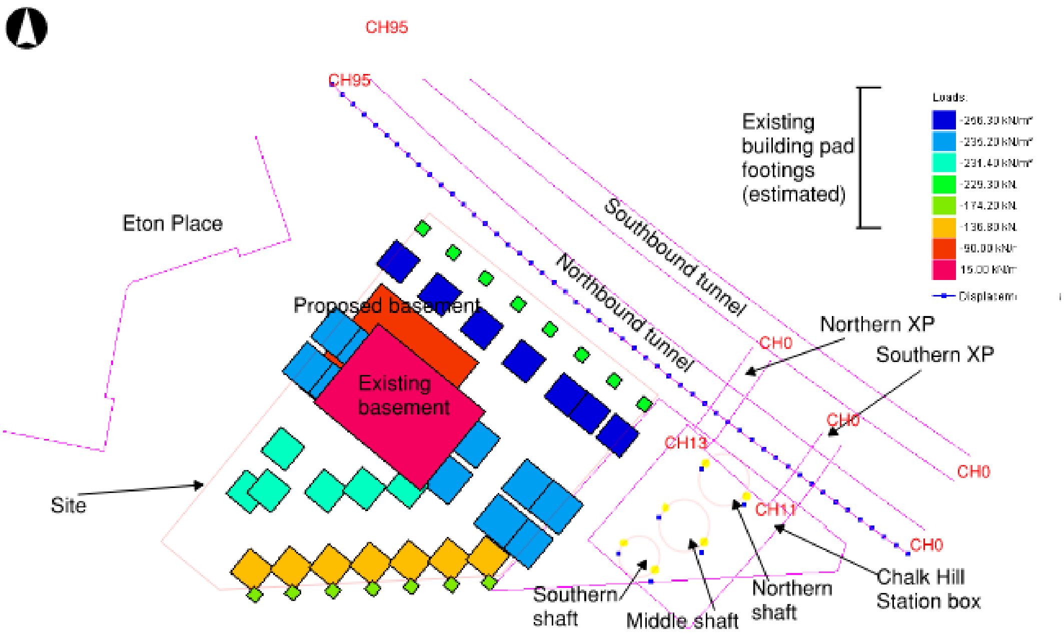


Figure 12: PDisp input. Unloading stage

Mainline tunnel

Figure 13 below shows the vertical ground movements along the northbound mainline tunnel (tunnel closest to the development) at crown, invert, left and right axis levels respectively, due to unloading from building demolition and excavation of the proposed basement. Maximum movements are 5.5mm (heave), located at the left axis of the tunnel in line with the proposed basement excavation. The maximum differential settlement between the crown and invert is less than 1mm.

As no track survey is available at the time of writing this report, the cant and twist has not been calculated. However, a rough estimation of the maximum change in cant can be conservatively assessed with calculated as the maximum “tilt” across the tunnel axis which was approximately 1.7mm (across 3.8m diameter).

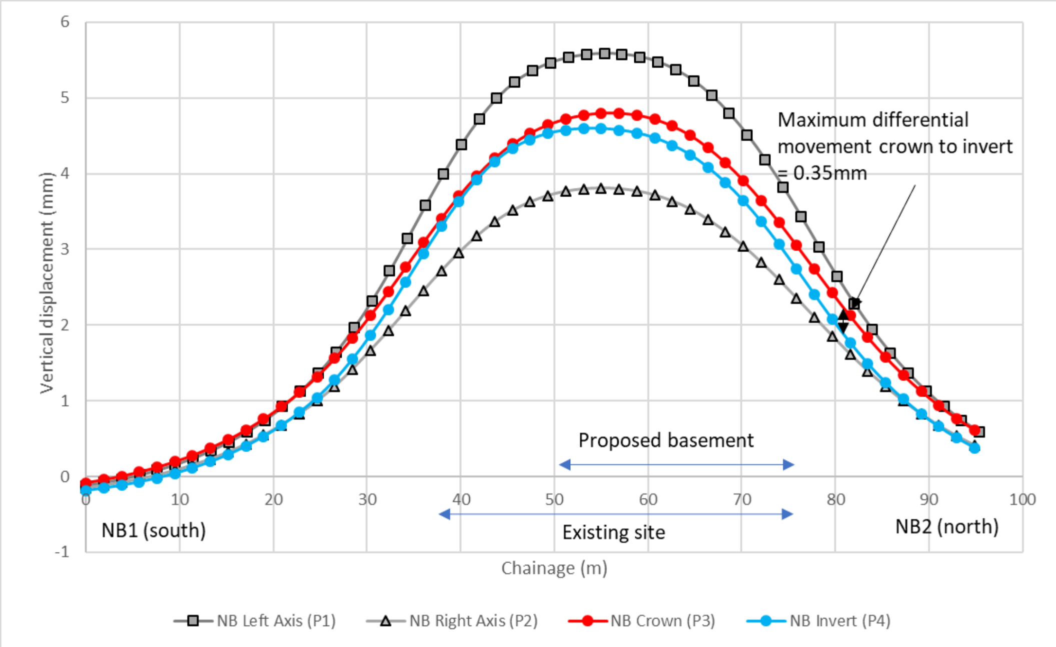


Figure 13: Vertical ground movements along the northbound tunnel at crown, invert, left and right axis due to unloading.

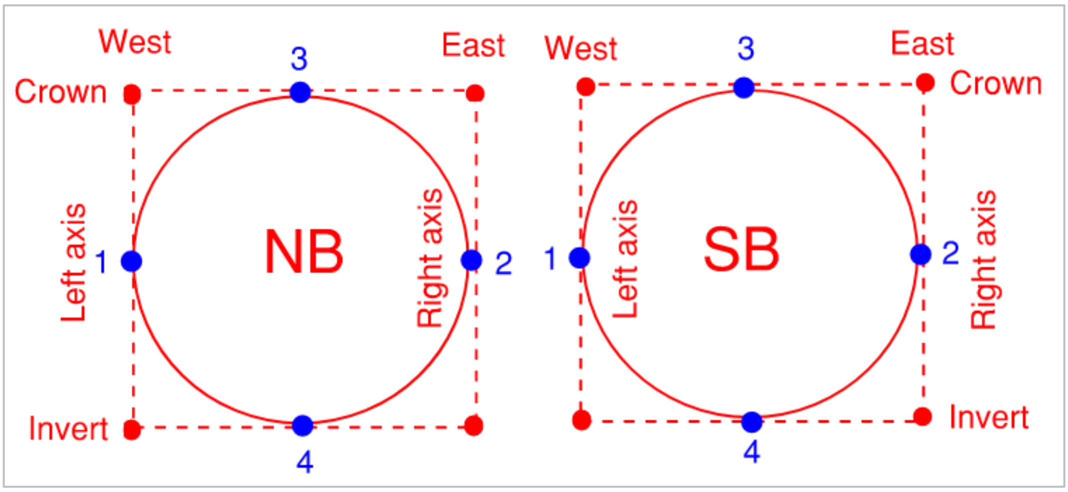


Figure 14: Indicative cross section sketch of mainline tunnels showing points where displacement lines were calculated.

Cross passage tunnel

Figure 15 below shows the vertical ground of the northern passenger tunnel (cross passage closest to the development) at crown and invert levels, due to unloading from building demolition and excavation of the proposed basement. Maximum movements are less than 3.1mm (heave), located at the invert level of the west edge of the northern cross passage tunnel, in line with the Chalk Farm station box.

Maximum vertical ground movements (heave) in the southern cross passage tunnel were less than 1mm

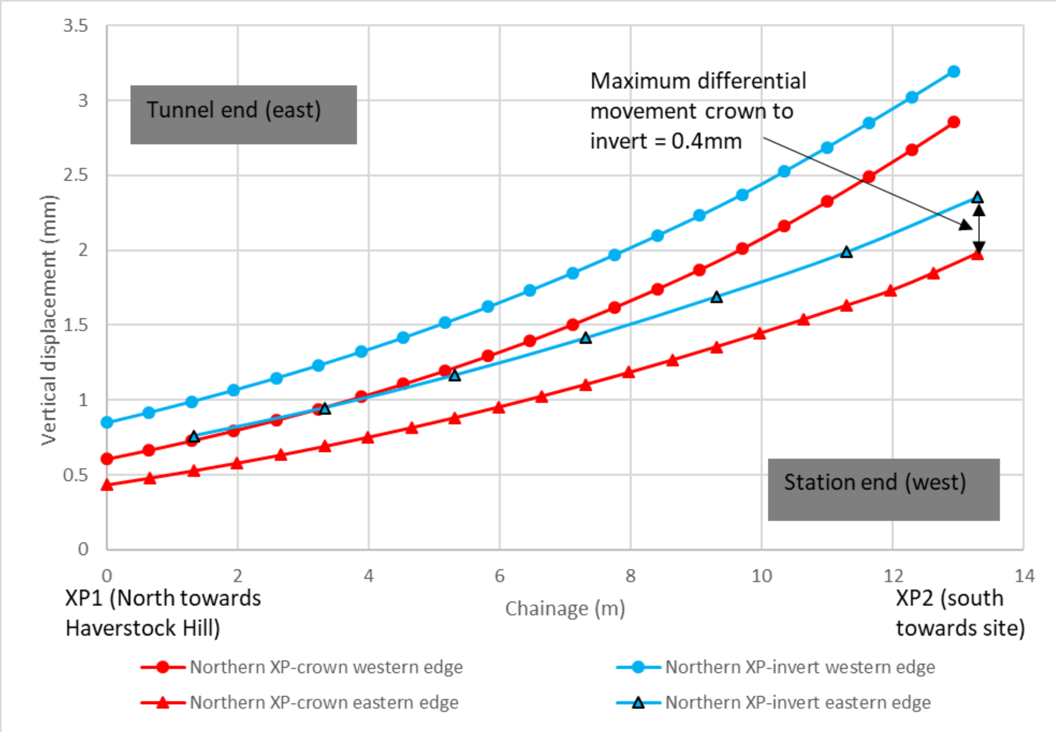


Figure 15: Vertical ground movement along the northern passenger tunnel at crown and invert level due to unloading.

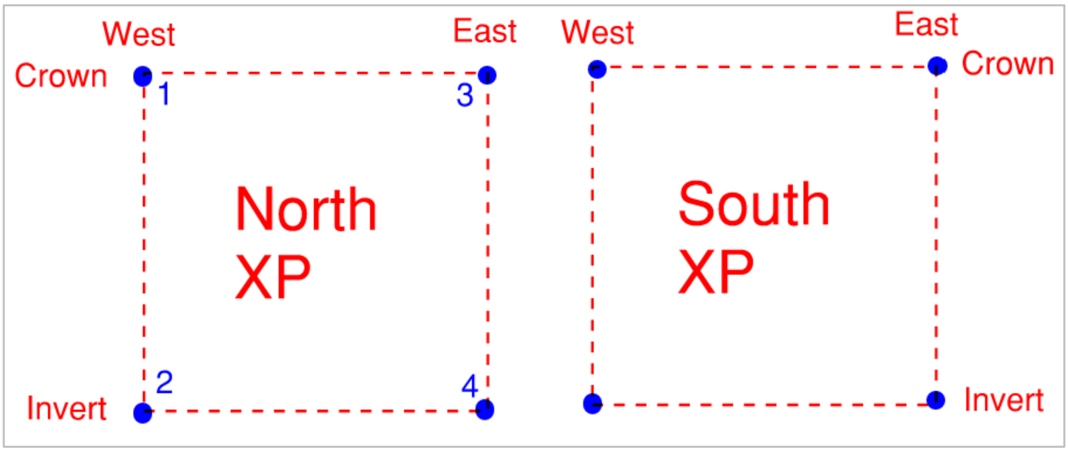


Figure 16: Indicative cross section sketch of cross passage tunnels showing points where displacement lines were calculated.

Vertical shafts and station box

A screenshot from PDisp (plan view) is included below in Figure 17. The figure shows the points (highlighted yellow) adopted for the displacement lines for the three vertical shafts.

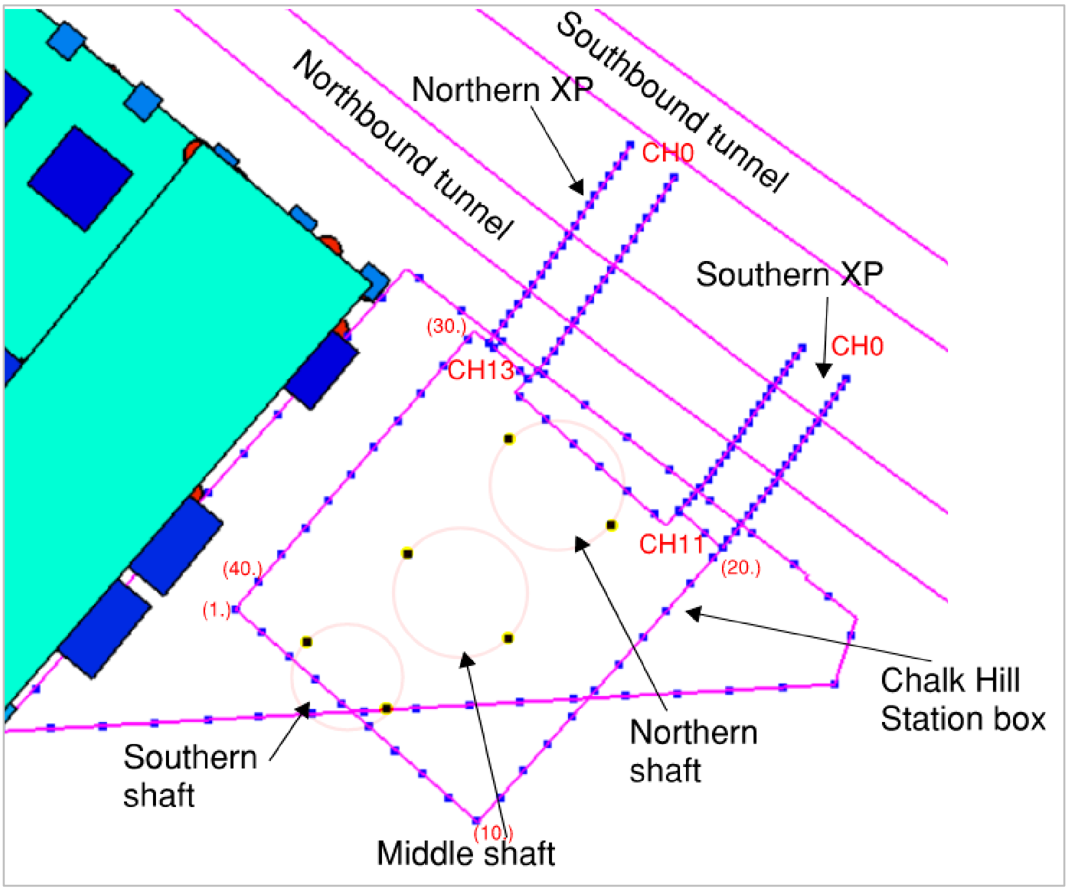


Figure 17: PDisp screenshot of Chalk Hill Station

Figure 18 summarises the average vertical ground movement along each shaft displacement line, and the vertical ground movements at the Chalk Farm Station ‘box’ and cross passages at the invert and crown levels respectively. Movement is due to unloading from building demolition and excavation of the proposed basement.

Maximum movements are less than 3.7mm (heave), located along the western edge of the southern shaft and less than 8.8mm (heave) at the western corner of the Chalk Farm Station ‘box’.

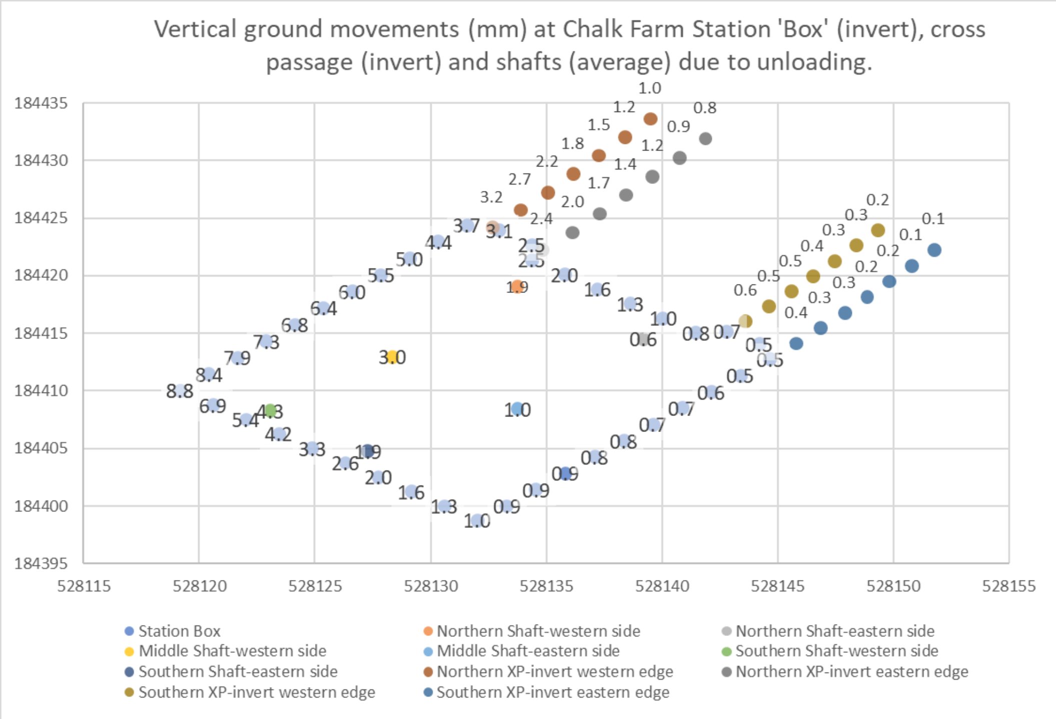


Figure 18: Summary of vertical ground movements at the invert of the Chalk Farm Station box, cross passages and shafts (average level) due to unloading.

8.3.2 Reloading stage calculated movements

The assumptions adopted for the calculation of the reloading cumulative ground movements are:

- Unloading conditions as per section 8.3.1
- The load of the new proposed building is transmitted to the ground assuming the methodology outlined in Section 7.4.4;
- The pile loads assumed in the assessment are shown 1850kN for all column piles and 925kN for all core piles
- Soil conditions were modelled in the short term (undrained) and the long term (drained). The results presented in this report correspond to the long term (drained) conditions of the ground.

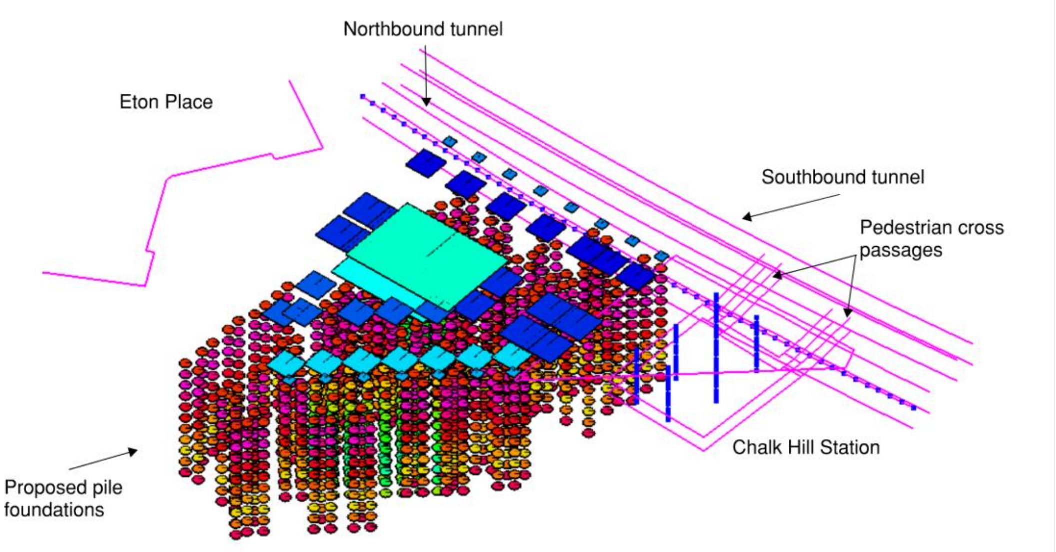


Figure 19: PDisp input. Reloading stage

Mainline tunnel

Figure 20 below shows the vertical ground movements along the northbound tunnel at crown, invert, left and right axis levels, due to unloading from building demolition and excavation of the proposed basement and the reloading from the new proposed building. Maximum movements are less than 7.6mm (settlement), located at the left axis of the northbound tunnel in line with the proposed basement excavation (point closer to the proposed development). These are long-term movements using drained soil parameters.

As no track survey is available at the time of writing this report, the change of cant and twist has not been calculated. However, a rough estimation of the maximum change of cant can be conservatively assessed as the maximum “tilt” across the tunnel axis which was approximately 3.2mm (across 3.8m diameter).

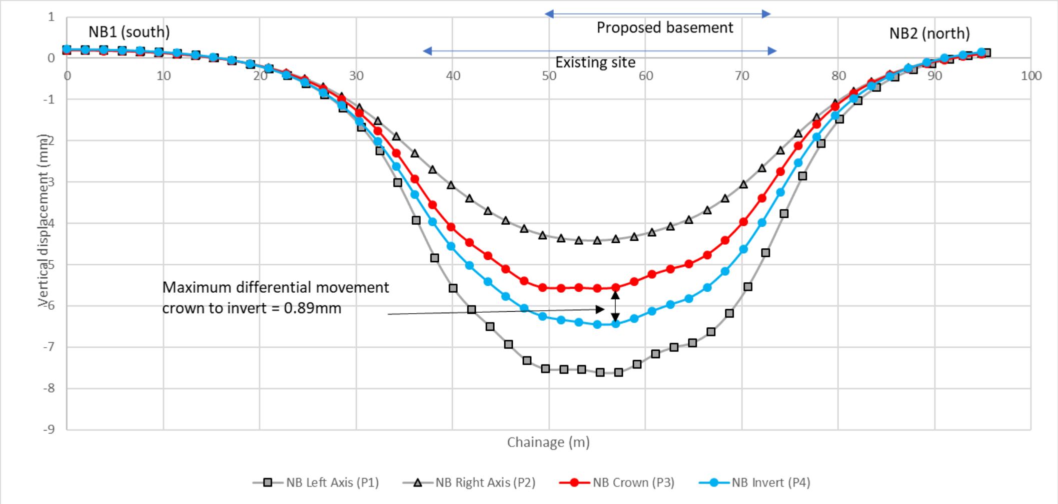


Figure 20: Vertical ground movements along the northbound tunnel at crown, invert, left and right axis levels due to unloading and reloading.

Cross passage tunnel

Figure below shows the vertical ground of the northern passenger tunnel (cross passage closest to the development) at crown and invert levels, due to reloading. Maximum movements are less than 1.9mm (settlement), located at the invert level of the west edge of the northern cross passage tunnel, in line with the Chalk Farm station box.

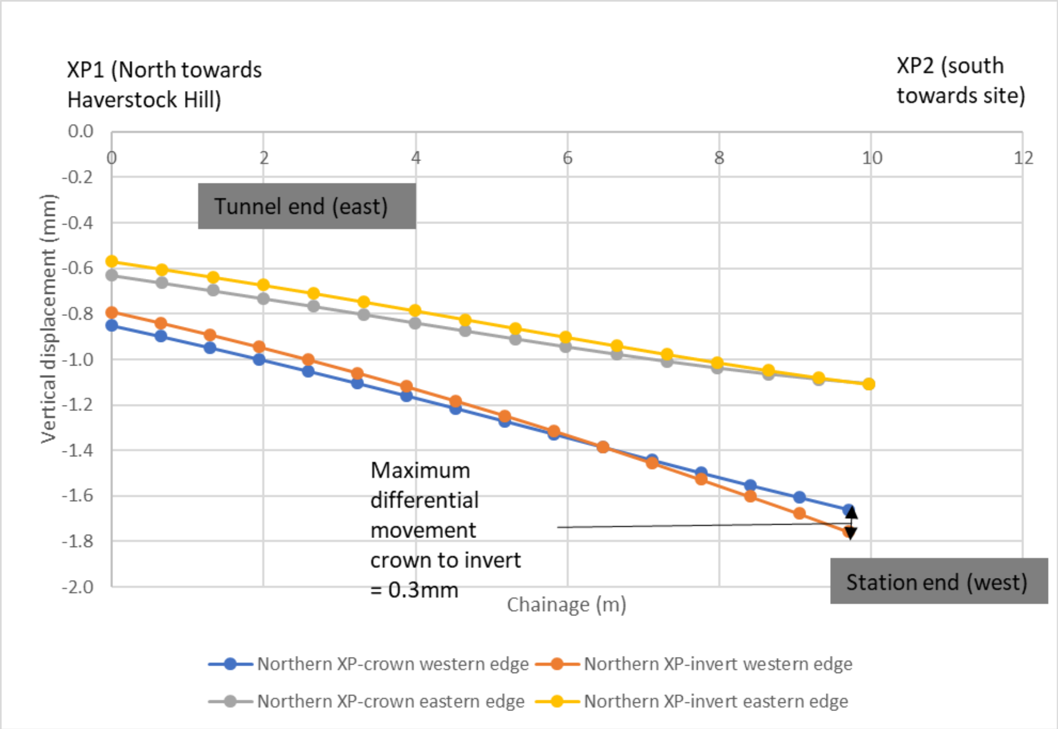


Figure 21: Vertical ground movements along the northern passanger tunnel at crown and invert level due to unloading

Vertical shafts and station box

Figure 22 summarises the average vertical ground movement along each shaft displacement line, and the vertical ground movements at the invert of the Chalk Farm Station 'box' and cross passages. Movements are due to unloading from building demolition and excavation of the proposed basement and the reloading from the new proposed building.

Maximum movements are less than 3.9mm (heave), located along the western edge of the southern shaft and less than 3mm (settlement) at the northern edge of the Chalk Farm Station ‘box’…………..

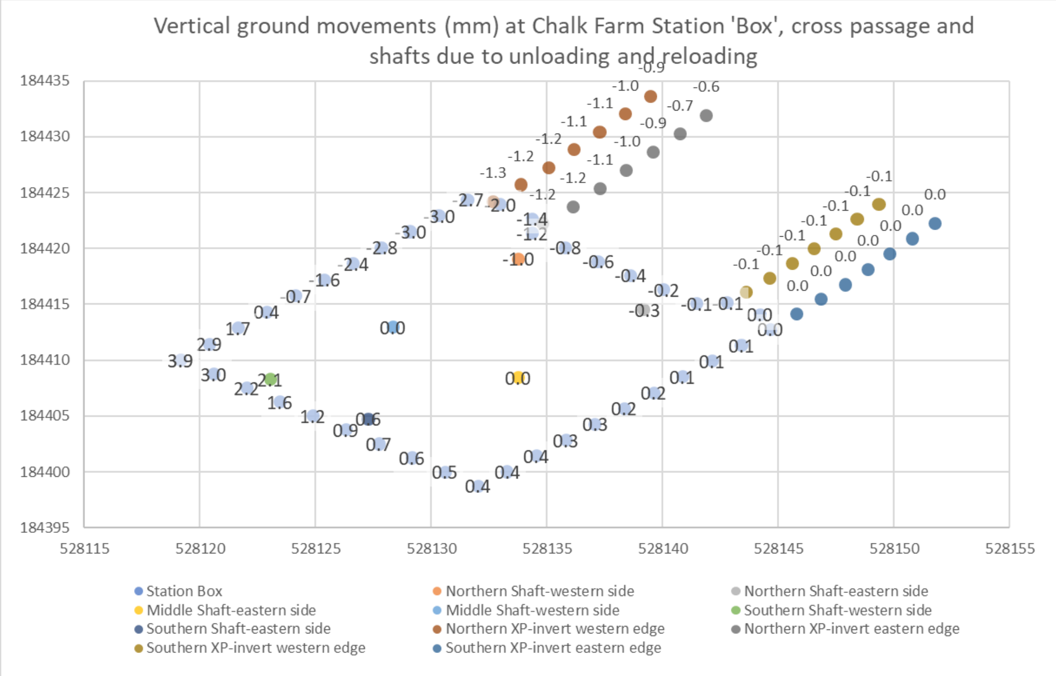
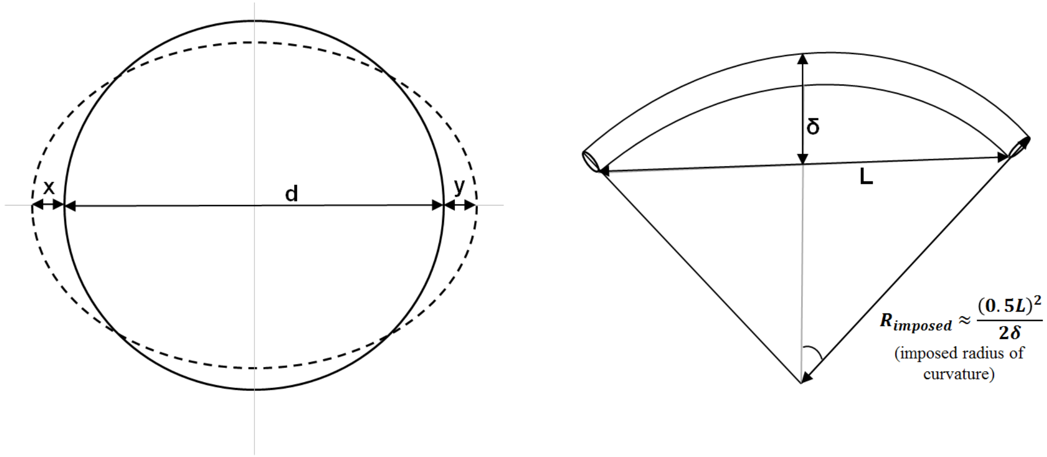


Figure 22: Summary of vertical ground movements at the invert of the Chalk Farm Station box, cross passages and shafts due to unloading and reloading.

8.3.3 Running tunnels structural assessment

A structural check on the tunnels has been carried out considering both radial and longitudinal deformation of the running tunnels. Radial deformation is considered in terms of ovalisation of the tunnel lining and longitudinal deformation is considered in terms of radius of curvature. These deformations are illustrated in Figure 23.



Radial deformation and calculation of squat
Ovalisation = (x + y) / tunnel diameter *(d)*
Where x & y are positive, referred to in this report as *squatting*
where x & y are negative, referred to in this report as *elongation*

Longitudinal deformation and calculation of imposed radius of curvature

Figure 23: Tunnel deformation due to imposed ground movements

8.3.3.1 Radial deformation

The radial distortion in the lining is assessed by considering the displacements in the crown and in the invert of the tunnel. Based on the calculated displacements and ovalisation values the following is found.

During the unloading stage:

- A displacement of 4.8mm (heave) at the crown and 4.6mm (heave) at the invert is anticipated for the Northbound tunnel at Chainage 55.
- The maximum differential radial displacement is calculated at 0.4mm (squatting) at Chainage 81 for the Northbound tunnel.

During the reloading stage:

- A displacement of 5.6 (settlement) at the crown and 6.4mm (settlement) at the invert is anticipated for the Northbound tunnel at Chainage 55.
- The maximum differential radial displacement is calculated at 0.9mm (elongation) is anticipated for the Northbound tunnel at Chainage 59.

These movements are considered negligible in the context of the radial distortion of the tunnel.

8.3.3.2 Longitudinal deformation

The radius of curvature between points of inflexion has been assessed along the tunnel. Based on the calculated displacements the following is found:

During the unloading stage:

- A displacement of 1.8mm (heave) over 38m, corresponding to an imposed radius of curvature of 100km.

During the reloading stage:

- A displacement of 2.5mm (settlement) over 32m, corresponding to an imposed radius of curvature of 51km.

8.3.4 Passenger passageways and vertical shafts structural assessment

The calculated displacements demonstrate that the vertical displacement of the vertical shafts, tunnel passageways and the station box structure have all the similar magnitude and therefore are compatible.

The induced differential settlements displacements between these structures are anticipated to lead in changes of the internal forces (bending moments, shear and normal forces) of the elements of these structures. However, due to the very low magnitude and provided that there is compatibility between the structures these changes of the internal forces are anticipated to be minimal and therefore their structural integrity will be maintained.

Regarding the shafts' differential deformation, both during the unloading stage and reloading stage, the angular distortion is calculated less than 0.1%. The differential displacements are limited and therefore the impact on the existing infrastructure will be negligible.

8.4 Conclusions

The analysis has predicted that the proposed installation of the retaining walls and excavation of the proposed basement may generally result in a building damage for sensitive structures of Category 0 (negligible), which falls within acceptable limits according to the Camden Planning Guidance (CPG4).

Calculated ground movements at the running tunnels are ca. 5.5mm (heave) for the unloading stage and 7.6mm (settlement) for the reloading case in the long term.

The worst-case running tunnel ovalisation is calculated 0.9mm (elongation) for the Northbound tunnel at Chainage 59 during the reloading stage. The minimum radius of curvature is calculated as 51km during the reloading stage. From similar assessments previously undertaken for LUL it is known that a radius of curvature greater than 9km is generally not considered to be of concern or to require further assessment.

Assuming that the vertical shafts and associated passageways connecting from the shafts to the tunnels are in a serviceable condition, the impact of the Haverstock Hill development works on these assets is considered to be negligible.

A pre and post condition survey for the calculated zone of influence is recommended to:

- Provide OD Camden Hotel Ltd and LUL with a baseline of the current condition; and,

- Confirm the assumptions in this report.

No further mitigations measures are proposed at this stage.

Further to the above, it should be noted that the interface between the existing building and Chalk Farm Station listed building will have to be carefully considered in the next stages to safely manage the demolition and reconstruction without damaging the façade or impacting upon the station finishes and operational equipment. A Party Wall surveyor will be appointed by the client and further engagement with TfL will be required.

9 Basement Impact Assessment summary

9.1 General

The screening identified a number of potential impacts. The desk study and existing ground investigation information has been used below to review the potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

Table 10 below summarises the previously identified potential impacts and the additional information that is now available from the site investigation in consideration of each impact.

Table 10: Potential impacts previously identified in the site investigation section

Potential Impact	Site Investigation Conclusions
Seasonal shrink-swell can result in foundation movements	The London Clay is the shallowest stratum at the site and laboratory testing has indicated a high low volume potential change. Shrinkable clay is present within a depth that can be affected by tree roots and desiccation of the clay soils was noted and should be bypassed. New foundations will need to be designed in accordance with NHBC guidelines to protect from future shrinking and swelling associated with tree removal / growth. Subject to inspection of foundation excavations in the normal way.
Damage to trees – heave of clay soils	Damage to tree roots during construction works may lead to the death of trees, which would result in long term swelling of the clay. A tree survey has been carried out by Greengage on August 2020, the survey identified 15 trees either within or directly adjacent to the proposed development area (Refer to Appendix B for the Tree Constraints Assessment).
Site within 5 m of a highway – excavation of basement could lead to damage	The investigation has not indicated any specific problems, such as weak or unstable ground, voids or a high-water table that would make working within 5m of public infrastructure particularly problematic at this site. A retention system will be adopted that maintains the stability of the excavation at all times.
Location of the Northern Line tunnels & Chalk Farm London Underground station.	A ground movement assessment has been carried out to confirm movements that may affect the tunnel as a result of demolition of the existing building and construction of a new building and the results are discussed in Part 3 (Sections 7 and 8) of this report.

It is proposed to construct two new buildings, up to seven storeys, plus a single-level basement, extending to a depth of approximately 5m below ground level in the northern part of the site. The proposed basement will be within the London Clay. Monitored water levels in the standpipes have been measured between 0.98m and 3.72m depth in the upper part of the London Clay / made ground veneer. Shallow monitored groundwater levels within standpipes is a common feature of low permeability clay strata and is not necessarily indicative of a consistent water table as would be the case within a permeable water bearing strata. Thus, although the basement may extend below the monitored water levels in standpipes it is not the case that it extends below a general and continuous groundwater table. Nevertheless, the basement will need to be designed for water level close to ground level due to the low permeability nature of the London Clay and the potential for perched water tables in the made ground providing uplift to the basement.

The London Clay is classified by the Environment Agency as Unproductive Strata; not capable of storing and transmitting groundwater in sufficient quantities to support baseflow to watercourses or private supplies.

On the basis of the results of the ground investigation, 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 or on the amount of annual recharge into the London Clay. This is due to its very low permeability and its inability to conduct groundwater flow.

The results of the existing site investigation have been used below to review the remaining potential impacts[1], to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

<u>Shrink / swell potential of / London Clay</u>

Shrinkable clay is present below the site and damage is noted on site to some structures, in close proximity to existing trees. Numerous trees are present on the site and desiccation was noted within two boreholes, drilled in close proximity to existing trees. The proposed single level basement is likely to extend well below the potential depth of root action, but this should be confirmed once proposals have been finalised.

<u>Tree protection orders</u>

A tree survey has been carried out by Greengage on August 2020, the survey identified 15 trees either within or directly adjacent to the proposed development area (Refer to Appendix B for the Tree Constraints Assessment). Foundations of the proposed basement should extend beyond the zone of tree root activity.

<u>Location of public highway</u>

A retention system will be adopted that maintains the stability of the excavation at all times.

[1] An additional site investigation is planned to a) provide deeper information on the London Clay for pile design; b) to provide additional information on the existing foundations and boundary conditions; and c) provide additional environmental samples.

9.2 Non-Technical Summary of Evidence

This section provides a short summary of the evidence acquired and used to form the conclusions made within the BIA.

9.2.1 Screening

The following table provides the evidence used to answer the surface water flow and flooding screening questions.

Table 11: Surface water flow and flooding screening questions

Question	Response for Response for 5-17 Haverstock Hill
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.
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. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the existing hardstanding/building footprint, therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. There will not be an increase in impermeable area across the ground surface above the basement. There will be no surface expression of the basement development.
4. Will the proposed basement development 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. There will not be an increase in impermeable area across the ground surface above the basement, so the surface water flow regime will be unchanged. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will entirely be beneath the existing hardstanding/building footprint, therefore the 1m distance

Question	Response for Response for 5-17 Haverstock Hill
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposed basement is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses as the surface water drainage regime will be unchanged.
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 of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No. The Camden Flood Risk Management Strategy dated 2013, together with Figures 3ii, 4e, 5a and 5b of the SFRA dated 2014, and Environment Agency online flood maps show that the site has a very low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses. In accordance with paragraph 5.11 of the CPG a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding. The BIA notes that surface perched water tables may exist, the basement will be designed to accommodate a water pressure uplift on the basement walls and slab with a head of 1m below ground level as per CIRIA C760 guidance. The site is located within the Critical Drainage Area number GROUP3-003, but is not in a Local Flood Risk Zone, as identified in the Camden SWMP and Updated SFRA Figure 6/Rev 2.

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Table 12: Subterranean (groundwater flow) screening questions

Question	Response for 5-17 Haverstock Hill
1a. Is the site located directly above an aquifer?	No. The Site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit water. Deep strata are excluded from this assessment as they are not impacted by the basement or the building foundations
1b. Will the proposed basement extend beneath the water table surface?	The basement will cut into the London Clay. It will penetrate the made ground layer with local perched water tables. It will not impact on a recognisable water table as would be found in a terrace gravel layer.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. The nearest "river" is the now "sewerised" River Fleet to the >100m east of the site.

Question	Response for 5-17 Haverstock Hill
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No.
5. As part of the 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. The London Clay is not suitable for SUDS based soakaways.
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. There are no groundwater dependent ponds or spring lines within 1 km of the proposed development.

The following table provides the evidence used to answer the stability assessment screening questions.

Table 13: Stability assessment screening questions.

Question	Response for 5-17 Haverstock Hill
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No.
5. Is the London Clay the shallowest strata at the site?	Yes.
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	Possibly.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Yes. The area is prone to these effects as a result of the presence of shrinkable clay soils, such as London Clay and cracking was noted during the site walkover along the northern boundary wall and in the single storey shed.
8. Is the site within 100 m of a watercourse or potential spring line?	No.
9. Is the site within an area of previously worked ground?	No.

Question	Response for 5-17 Haverstock Hill
10. Is the site within an aquifer?	No. The site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit usable amounts of water.
11. Is the site within 50 m of Hampstead Heath ponds?	No.
12. Is the site within 5 m of a highway or pedestrian right of way?	Yes. The site fronts onto Haverstock Hill and Adelaide Road with Eton College Road at the west corner.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No. The proposed new partial basement is not adjacent to the perimeter of the site close to Chalk Farm Station to with south extending deeper than the existing.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. The Northern Line northbound Tunnel is located to the north of the site, beneath Haverstock Hill, with the crown levels at a depth of roughly 10 m (+21.90 m OD) below ground level but offset by over 4.5m from the property boundary. No construction is proposed within the exclusion zone of the LU tunnels. LU ground movement assessment will nevertheless be carried out in the next stage of design.

9.2.2 Scoping and Site Investigation

The questions in the screening stage that there were answered ‘yes’, were taken forward to a scoping stage and the potential impacts discussed in Section 3 of this report, with reference to the possible impacts outlined in the Arup report.

A ground investigation has been carried out, which has allowed an assessment of the potential impacts of the basement development on the various receptors identified from the screening and scoping stages. Principally the investigation aimed to establish the ground conditions, including the groundwater level, the engineering properties of the underlying soils to enable suitable design of the basement development and the configuration of foundations of the Chalk Farm LUL station.

An additional site investigation is planned to

- Provide deeper information on the London Clay for pile design;
- Provide additional information on the existing foundations and boundary conditions; and
- Provide additional environmental samples.

9.2.3 Impact Assessment

Section 6 of this report provides recommendations for the design of the proposed development, whilst Part 3 provides the outcomes of a ground movement analysis and building damage assessment, which has also been used to provide a conclusion on any potential impacts to the LUL infrastructure from the proposed basement development.

10 References

[1] 1st Line Defence, Preliminary Risk UXO Assessment, report no: OPN2876, dated 5 November 2015.

[2] British Geological Survey (BGS), 2019. 1:10,000 Geological Map.

[3] British Geological Survey. Geology of Britain Viewer. Online information available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html?

[4] Envirocheck Report, dated 8 July 2020.

[5] 1 Floods in Camden, report of the Floods Scrutiny Panel, June 2003

[6] Geotechnical and Environmental Associates (GEA), 2016. Site Investigation and Basement Impact Assessment Report, 5-17 Haverstock Hill London NW3 2BL, report no. J15316, dated May 2016.

[7] Google Earth Pro, 2020, Current and Historic Aerial Imagery.

[8] Layers of London. Online information available at: https://www.layersoflondon.org/map

[9] Pantelidou, H. & Simpson, B. (2007). Geotechnical variation of London Clay across central London Géotechnique 57, No. 1, 101–112