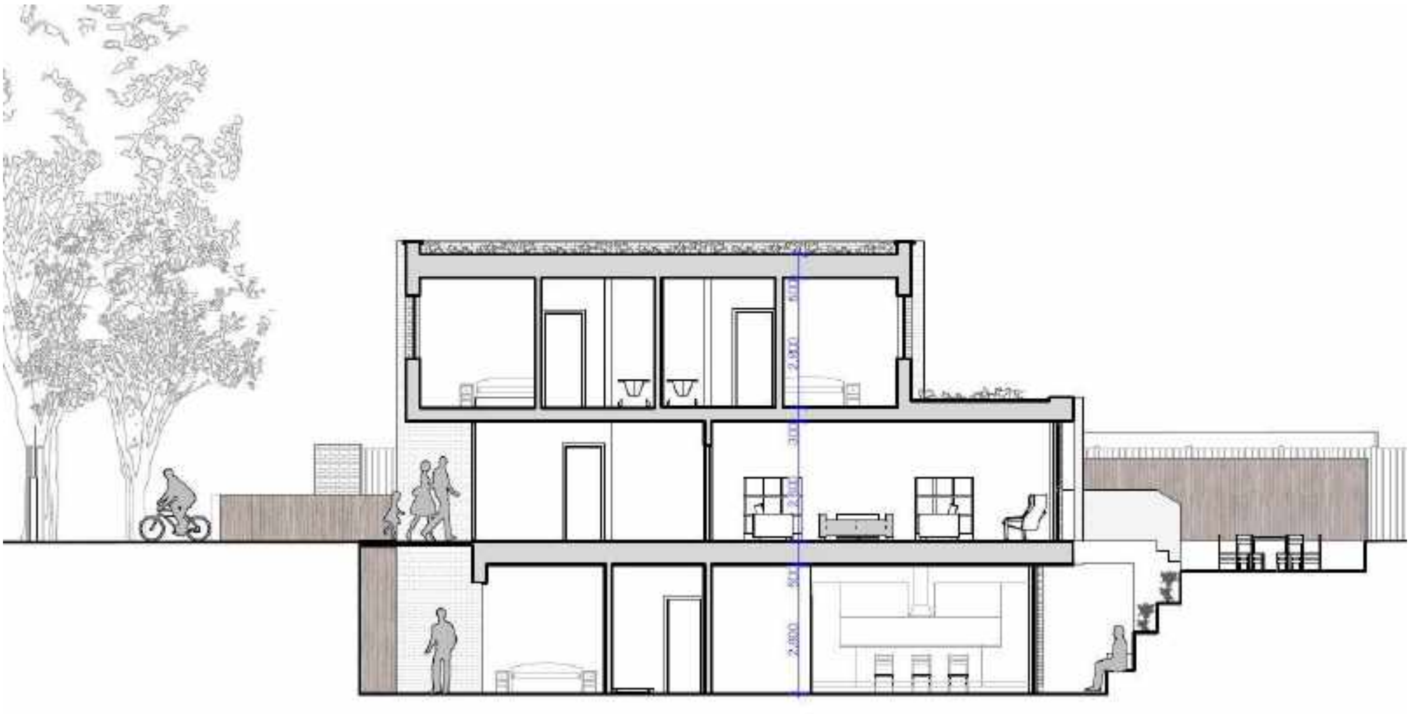
Basement Impact Assessment Report



Site | Parsifal Road Garages,
London,
NW6 1UG,

Client | Gary Sugarman
Date | August 2020
Our Ref | BIA/11384

Chelmer Global Ltd
Unit 7 Hall Road Industrial Estate, Hall Road, Southminster, Essex CM0 7DA
Essex: 01245 400930 | info@siteinvestigations.co.uk | www.siteinvestigations.co.uk

Basement Impact Assessment

Site: **Parsifal Road Garages**
London, NW6 1UG
(behind 521 Finchley Road, NW3 7BT)

Client: **Gary Sugarman**

Report Status: **FINAL**		
Role	**By**	**Signature**
Report prepared by:	Keith Gabriel MSc DIC CGeol FGS UK Registered Ground Engineering Adviser	K.R. Gabriel
Slope/ground stability aspects approved by: Surface flow and flooding aspects approved by:	Mike Summersgill MSc CEng MICE C.WEM FCIWEM	[signature]
Subterranean (Groundwater) flow aspects approved by:	Keith Gabriel MSc DIC CGeol FGS UK Registered Ground Engineering Adviser	K.R. Gabriel

Foreword

This report has been prepared in accordance with the scope and terms agreed with the Client, and the resources available, using all reasonable professional skill and care. The report is for the exclusive use of the Client and shall not be relied upon by any third party without explicit written agreement from Chelmer Global limited (CGL).

This report is specific to the proposed site use or development, as appropriate, and as described in the report; CGL accept no liability for any use of the report or its contents for any purpose other than the development or proposed site use described herein.

This assessment has involved consideration, using normal professional skill and care, of the findings of ground investigation data obtained from the Client and other sources. Ground investigations involve sampling a very small proportion of the ground of interest as a result of which it is inevitable that variations in ground conditions, including groundwater, will remain unrecorded around and between the exploratory hole locations; groundwater levels/pressures will also vary seasonally and with other man-induced influences; no liability can be accepted for any adverse consequences of such variations.

This report must be read in its entirety in order to obtain a full understanding of our recommendations and conclusions.

Contents Page

1. INTRODUCTION

1.1 This Basement Impact Assessment (BIA) has been prepared in support of a planning application to be submitted to the London Borough of Camden (LBC) for demolition of the existing garages to the rear of Parsifal House, No.521 Finchley Road and construction of a pair of two-storey houses with basements. Vehicular access to the site is via a driveway off Parsifal Road which passes along the north-east side of No.1 Parsifal Road. Further details of the proposed works are given in Section 3. This assessment is in accordance with the requirements of the London Borough of Camden (LBC) Local Plan 2017, Policy A5 in relation to basement construction, and follows the requirements set out in LBC's guidance document 'CPG Basements' (March 2018).

1.2 This assessment has been undertaken by Keith Gabriel, a Chartered Geologist with an MSc degree in Engineering Geology (who has specialised in slope stability and hydrogeology), and reviewed by Mike Summersgill, a Chartered Civil Engineer and Chartered Water and Environmental Manager with an MSc degree in Soil Mechanics (geotechnical and hydrology specialist). Both authors have previously undertaken many assessments of basements in several London Boroughs.

1.3 **Desk Study**: A site inspection (walk-over survey) of the site was undertaken and a selection of photographs are presented in Appendix A. Desk study data has been collected from various sources including borehole/well logs from the area around the site (Appendix B), flood reports and flood modelling specific to the borough, historic maps (Appendices C & D), and environmental & geological data in Groundsure's Insight report (Appendix E). Relevant information from the desk study and site inspection is presented in Sections 2–6.

1.4 **Ground Investigation:** Sitework for the ground investigation (boreholes and trial pits) was undertaken on 21st May 2020, the findings from which are presented in Section 9 and Appendix F.

1.5 The Screening, Scoping and basement impact assessments in accordance with CPG Basements, Stages 1-4, are presented in Sections 7, 8 & 10 respectively.

1.6 The following site-specific documents in relation to the proposed extension and planning application have been considered:

Granit Architecture + Interiors:

- Drg No.1850/EX/001 Existing Location Plan
- Drg No.1850/EX/002 Existing Site Plan
- Drg No.1850/P/100/1 Site Plan (Proposed)
- Drg No.1850/P/100/2 Site Plan – Existing Garages vs Proposed
- Drg No.1850/P/100/3 Basement Floor Plan
- Drg No.1850/P/100/4 Basement Floor Plan (OVERLAY)
- Drg No.1850/P/100/5 Ground Floor Plan
- Drg No.1850/P/100/6 First Floor Plan
- Drg No.1850/P/100/7 Roof Plan

Granit Architecture + Interiors (continued)**:**

- Drg No.1850/P/100/8 Front Elevation
- Drg No.1850/P/100/9 Rear Elevation
- Drg No.1850/P/100/10 Side Elevation 1 (South-east)
- Drg No.1850/P/100/11 Side Elevation 2 (North-west)
- Drg No.1850/P/100/12 Section AA
- Drg No.1850/P/100/13 Contextual Front Elevation

Spatial Dimensions (Surveyors):

- Drg No.18301_01 Topographical Survey

Mitchinson Macken (Structural Engineers):

- Drg No.19313/101 Temporary Works
- Drg No.19313/102 Rev.A Ground Floor Plan showing Foundation Layout (with load takedown)
- 19313 Sheet 101 Load Take Down (flank wall calculation)
- 19313 Calc'n Sheets 1-11 Retaining Wall A-A Analysis (Cantilever RC 3250)
- 19313 Method Statement for Construction of Retaining Wall

This report should be read in conjunction with all the documents and drawings listed above.

2. THE PROPERTY, TOPOGRAPHIC SETTING AND PLANNING SEARCHES

2.1 The site is currently occupied by three rows of garages, two of which are adjoined back-to-back (see Figure 1 below and Photos 1 to 5 in Appendix A). The site is bordered to the north-west by No.1g and to the south-east by the recently constructed No.1e and the shared forecourt with No.1f. Between the garages and Parsifal House there is a small garden which includes lawns, flower beds and paved paths. The garden to the south-west of the driveway (No. 1 Parsifal Road) included the felled/fallen trunk of a substantial Copper Beech tree.

2.2 The garages are built of brick with shallow-pitched, felt roofs and up-and-over metal doors. An access driveway which is shared with No’s 1e & 1f is surfaced with asphalt. With the exception of a path surfaced with paving slabs and a gravelled edge strip along the north-west boundary, the whole of the remainder of the site for the proposed houses (within the area of the existing garages) is surfaced with concrete.

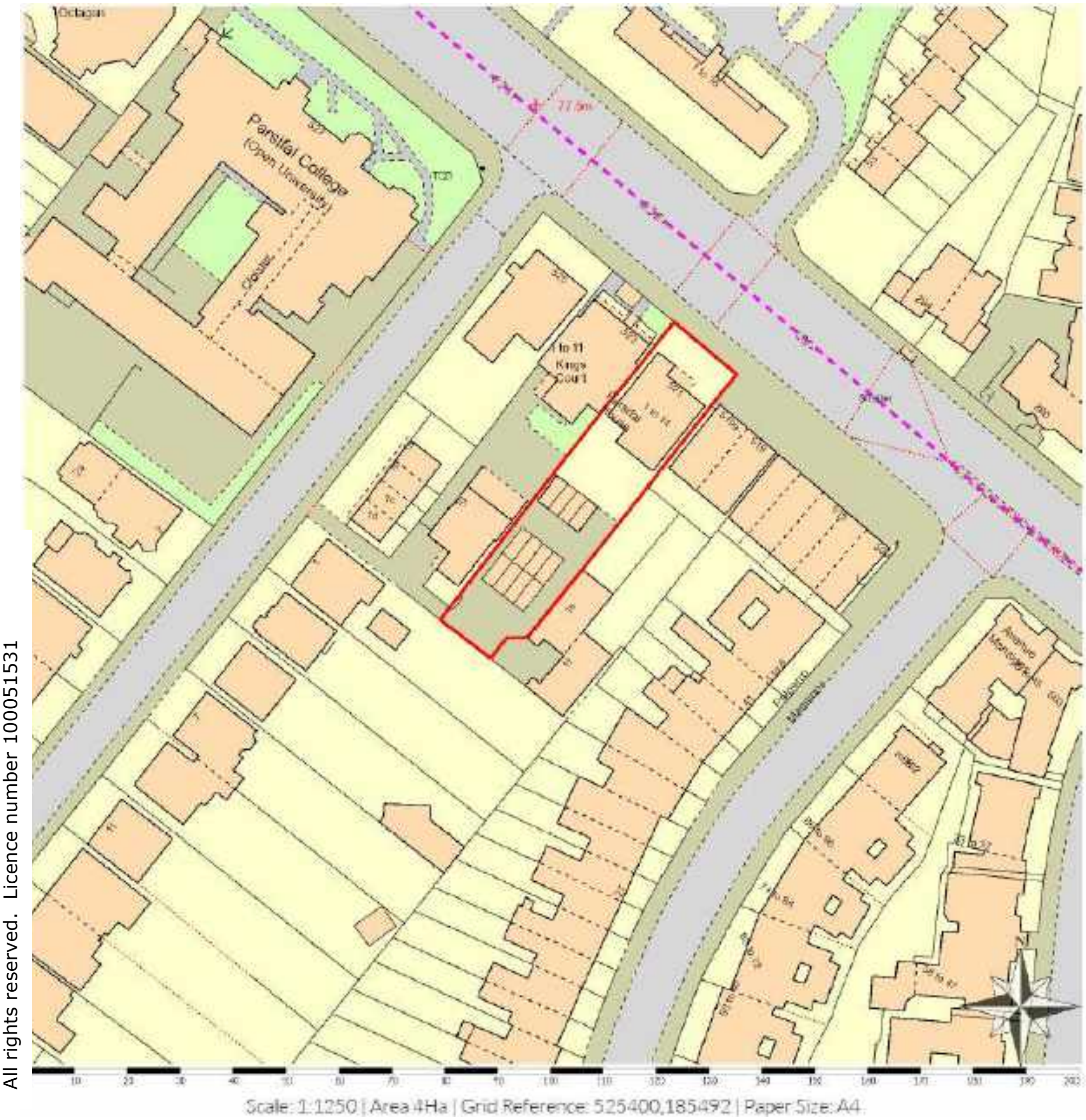


Figure 1: Extract from 1:1,250 OS map (not to scale) with indicative site outline in red.

2.3 The first available historic Ordnance Survey (OS) map with coverage of this area, dated 1870 (1:2,500 scale, as presented in Appendix C) shows that the area remained undeveloped farmland, with the rear driveway to West End Farm/House crossing the south-west end of the site. Finchley Road and Fortune Green Lane were present to the north-east and south-west respectively. By 1896 Parsifal Road was present, Finchley Road had been widened and formalised, and a large detached house had been built on the site, linked to similar houses on both sides. No's 1, 3 & 5 Parsifal Road had also been built by 1896.

2.4 By publication of the 1915 map, the surrounding area was almost fully developed. The most notable change on the 1953 1:1,250 scale OS map was the demolition of five large houses on the opposite side of Finchley Road, leaving a large vacant plot. The London County Council Bomb Damage Map for this area (London Topographical Society, 2005) records "*Blast damage, minor in nature*" for the south-eastern of these houses, but no other damage attributable to bombing during WW2 in the vicinity of the site (see also paragraph 2.7). Also, on the 1953 map, No.1 Parsifal Road was labelled 'Vicarage', No.1a had been built in the former rear garden of No.519 Finchley Road, and No.519 had been replaced by No's 519 & 519a.

2.5 By 1973, Parsifal House (14 flats) and the existing garages had been built on the site of current interest. In the rear garden of the adjoining No.523 a large extension had been added (labelled "*Moadon Habonim Jewish Youth Centre*") and a separate building had appeared alongside the driveway to the site. The existing No's 1a-1d Parsifal Road first appeared on the 1981 OS map, in the former rear garden to No.525 Finchley Road, while No's 1e & 1f first appeared (where No.1a had been) on the 1991 map, though they were probably built much earlier, as planning approval was granted in February 1978 (and those parts of the 1979 and 1981 maps were not available in Groundsure's map pack).

2.6 No further changes were evident from the appended historic maps; the current 1:1,250 scale OS map (Figure 1) shows the new footprints for No's 1e & 1f, and the re-development of No.523's site with Kings Court (11 flats) and the newer No.1g.

2.7 The Hampstead bomb map shows that the nearest recorded high explosive bomb fell at the junction of Heath Drive with Finchley Road (probably in the garden of No.38 Heath Drive). That was the western of a line of three bombs; these bomb lines often have five or six recorded explosions, so if there were two or three unexploded bombs extending west from this string then one could have fallen in the garden of No.521. Accordingly, it is recommended that an unexploded ordnance (UXO) screening report should be obtained from a suitably experience specialist before excavations are undertaken.

2.8 The topographic survey that was undertaken in 2018 shows a 20m high Willow tree in the site, close to the north-east corner of the garages. That tree had been removed prior to the site inspection, together with two smaller Silver Birch trees; the Willow's former location is shown in Photo 2.

Topographic Setting:

2.9 The site is located on a broadly south-facing slope which leads up to Hampstead Heath. A former branch of the River Westbourne, one of the 'lost' rivers of London (see Section 5), passes to the east of the site, close to Heath Drive and Cannon Hill, as illustrated by the contours on Figure 2. Those contours indicate a maximum overall slope angle between the 80m and 75m contour lines in the vicinity of the site of approximately 2.3°, increasing between the 75m and 70m contours to 3.3°.

2.10 The topographical survey by Spatial Dimensions (Drg No.18301_01) shows that the site has a very gentle fall towards the south across the site. Within the footprint of the proposed houses the existing ground is almost level, falling from 75.02m to 74.79m AOD. From the rear wall of Parsifal House to the southernmost point of the site, the range is 75.83m to 74.71m AOD which, over a distance of 50.6m, represents a slope angle of 1.3°.

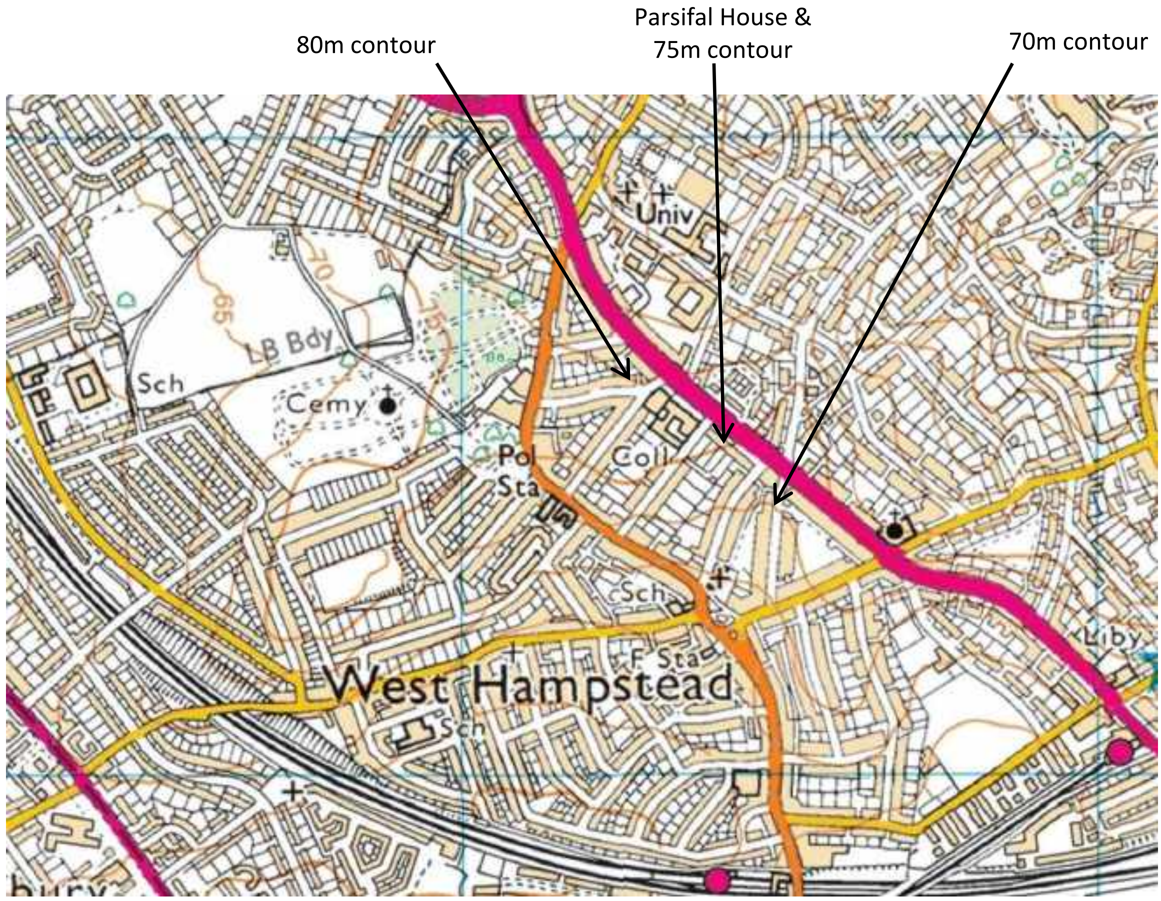


Figure 2: Extract from 1:25,000 scale Ordnance Survey map showing site location.

Planning Searches:

2.11 Searches were made of planning applications on Camden council's website (on 15th June and 4th August 2020) in order to obtain details of any other basements which have been constructed, or are planned, in the vicinity of the property. Plans of the immediately adjacent properties were also sought and were downloaded where available. These searches found:

- **Parsifal House:** Current application (2019/5709/P) concerns an earlier, slightly different version of the currently proposed development; specifically: "*Erection of two storey plus basement building, to provide 2 x 3 bed residential units (Class C3). Excavation for basement extension with front light well and rear sunken garden. Provision of 5 x off-street parking spaces to rear of new dwellings. Demolition of 12 x garages*".
- **Adjacent No.1e Parsifal Road:** Application (2013/5125/P) involving "*Basement extension with front and rear lightwells, rear single-storey conservatory extension, front extension with timber cladding to match neighbouring property, translucent glass privacy screens to new rear terrace and new translucent window to North-West Elevation*" was granted planning permission on 6th January 2014. Visual evidence at surface and from aerial photos indicates that these works have been completed. The finished floor level (FFL) in the basement is shown as 3.80m below the front entrance threshold.
- **Adjacent No.1g Parsifal Road:** Application (2012/5533/P) involving "*Erection of conservatory at rear ground floor level in connection with existing dwellinghouse (Class C3)*" was granted planning permission on 10th December 2012. Plans and elevations of the scheme were provided but no details were given of the parking beneath the property's rear garden (see Photo 7).
- **Adjacent No.523 Finchley Road:** Application 2006/5903/P for "*Demolition of existing building and outbuildings and erection of a 5 storey building comprising 11 flats (1 x 1bed, 7 x 2-bed and 3 x 3-bed) fronting onto Finchley Road and a 2 storey detached dwelling house to the rear of the site and provision of 10 car parking spaces and 16 cycle spaces accessed via Parsifal Road*" was granted planning permission on 3rd April 2007. Plans and sections of the proposed scheme were downloaded. Eleven related applications concerning the conditions applied to this consent were subsequently granted approval, including:
    - Application 2007/6200/P for "*Details of slab levels in relation to surrounding land pursuant to part of condition 2 attached to the planning permission granted subject to a section 106 Legal Agreement dated 03 April 2007 (ref: 2006/5903/P) for demolition* …". A useful drawing with details of the levels of the underground parking adjacent to No.521's garages was obtained.
- **No.519 Finchley Road:** No relevant applications, and none since 1961.
- **No.1 Parsifal Road:** The only granted applications (or 'no objections') concern tree works in the rear or side gardens. The latest application (Ref: 2016/4483/T) is relevant as it concerned the large Copper Beech tree in the rear garden, which has since fallen; the Council objected to reduction of the crown of the Beech by 2-3m (and placed a TPO on the tree).

3. PROPOSED BASEMENT

3.1 The basements beneath the proposed pair of houses for which planning permission will be sought, as shown in the scheme drawings by Granit (see paragraph 1.6), will comprise:

- Adjoined single-storey basements beneath the entire footprint of both houses. Each basement includes a Kitchen/Diner, Utility, Bedroom, WC and stairs up to the ground floor.
- Full depth front lightwells with grilles over.
- Rear lightwells with tiered flower beds and steps up to private rear gardens (see Granit's Section AA, as reproduced on the front cover of this report).

3.2 Both houses will also have landscaped amenity gardens at the front of the house, at ground floor level, with cycle stores and refuse/recycling bin stores. Green roofs have been specified above both the ground floor rear projection and first floor.

3.3 The Section AA drawing by Granit shows that the finished floor level (FFL) in the basement will be **3.30m** (2.80 + 0.50m) below the ground floor's FFL which is shown flush with the ground level at the front of the property. The retaining wall analyses by Mitchinson Macken show that the underpin bases will be **350mm thick**; with an allowance of **200mm** for insulation, cavity drainage and floor structure the founding level (formation) of the underpins and slab will be approximately **3.85m** below the ground floor's FFL.

3.4 Mitchinson Macken's basement plan (Drg No. 19313/102 Rev.A) shows that the central basement slab will be **250mm thick** reinforced concrete.

3.5 The existing ground levels within the two plots range from 74.79-74.86m above Ordnance Datum (AOD) along the frontage of the plots onto the shared driveway to 75.00-75.02m AOD at the rear boundaries. The proposed ground floor FFL for both houses has therefore been assumed to be **74.90m AOD**, which gives a formation level at approximately **71.05m AOD**. Excavation depths for the proposed basement are therefore expected to range from **3.74m** to **3.97m**.

3.6 The proposed pair of houses and their gardens will not extend beneath the footprint of the northern block of garages. However, those garages will be demolished and five new garages will be built closer to Parsifal House, leaving a vehicle manoeuvring space of 6.0m between the basement and the new garages.

4. GEOLOGICAL SETTING

4.1 Mapping by the British Geological Survey (BGS) indicates that the site is underlain by the London Clay Formation. Figure 3 shows an extract from Figure 16 of the Camden GHHS (Camden Geological, Hydrogeological and Hydrological Study by Arup, November 2010) which illustrates the site geology of the Hampstead area.

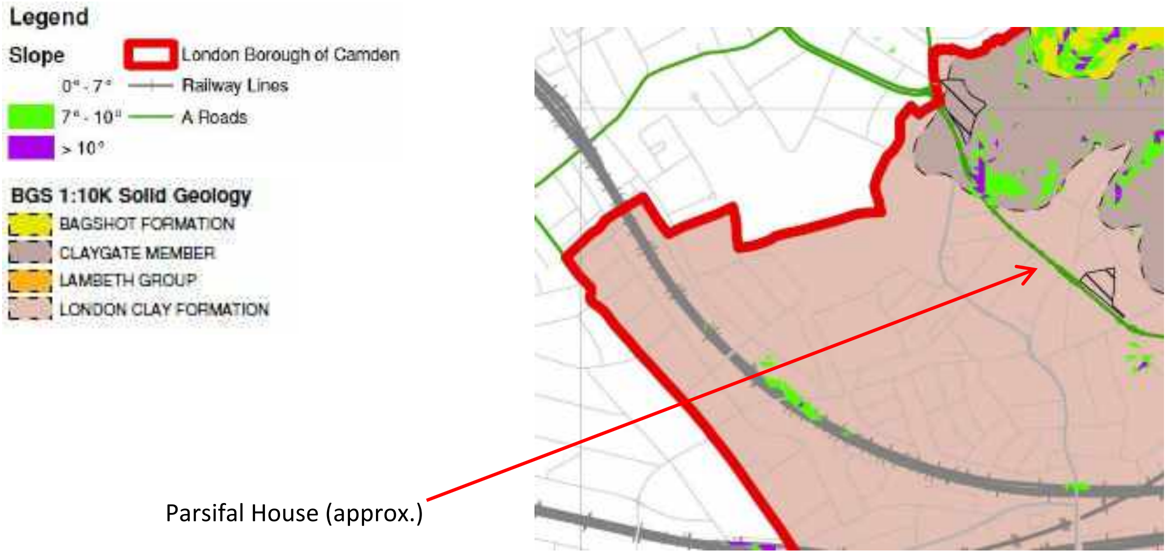


Figure 3: Extract from Figure 16 of the Camden GHHS showing geology and slope angles >7° (Arup, 2010)

4.2 In urban parts of London, the London Clay is typically overlain by Made Ground. A thin superficial layer of natural, locally-derived re-worked soils called Head deposits may also be present (because these are not mapped by the British Geological Survey where they are expected to be less than 1.0m thick). In the areas which have been excavated, some or all of these deposits may have been removed.

4.3 The London Clay is well documented as being a firm to very stiff over-consolidated clay which is typically of high or very high plasticity and high volume change potential. As a result, it undergoes considerable volume changes in response to variations in its natural moisture content (the clay shrinks on drying and swells on subsequent rehydration). These changes can occur seasonally, in response to normal climatic variations, to depths of up to 1.50m and to much greater depths in the presence of the trees whose roots abstract moisture from the clay. The clay will also swell when unloaded by excavations such as those required for the construction of basements.

4.4 The results of the BGS natural ground subsidence hazard classifications are provided in the Groundsure Insight report (Appendix E, Section 17); all indicated 'Negligible' or 'Very Low' hazard ratings with the exception of 'Shrink swell clays' for which a 'Moderate' hazard rating was given, which reflects the outcrop of the London Clay Formation at surface.

4.5 The Groundsure GeoInsight report (Appendix E, Section 18) records:

- Historical surface ground working features, the closest of which were gravel pits located 138m and 148m to the south of the site on the 1873 1:10,560 OS map though they are not evident on the appended map (see App.E, Section 18.3).
- 12 records of historical underground workings within 1000m of the site, all of which relate to the London Overground line's tunnel to the east of the 'Finchley Road & Frognal' station (see App.E, Section 18.4).
- No historical 'non-coal mining' features or 'mining cavities' recorded within 1000m of the site (see App.E, Sections 18.6 & 18.7).
- No records of mining on site for five specific mineral deposits (see App.E, Sections 18.9 to 18.13).

It should be noted that these databases are based on mapping evidence, so inevitably will provide an incomplete record of underground workings.

4.6 A search of the BGS borehole database was undertaken for information on previous ground investigations and any wells in the vicinity of the site; the locations of the few available are presented on the location plan in Appendix B. The strata depths in a selection of these boreholes are summarised in Table 1. For full strata descriptions, reference should be made to the logs in Appendix B. General points of note from these boreholes were:

- BGS Boreholes TQ28NE/119 (BHs 1-4) were all drilled by Soil Mechanics Ltd, as part of a ground investigation at Kidderpore Avenue, to the north-east of the site. The boreholes display similar information; thus in Table 1, only the minimum and maximum depths are recorded, giving the range of depths found across these four boreholes.
- BGS Borehole TQ28NW/32: This shallow (1.28m deep) pit was dug to assess the founding conditions for the West Hampstead Fire Station (and found 'Hard yellow CLAY' below 0.67m). Identical strata depths, strata descriptions and ground level are given for borehole TQ28NW/21, the location of which is shown further to the north-east (see Figure B1), so that record is believed to be a mis-plotted duplicate. The record for TQ28NW/21 does indicate that the hard yellow CLAY was considered by the BGS to be Weathered London Clay.

Table 1: Summary of Strata in BGS Boreholes

Strata (abbreviated descriptions)	**Depths (m) and levels (m AOD) to base of strata in BGS Boreholes**		
	TQ28NE/119 (BH1-BH4)	**TQ28NE/32 (and ~/21)**	
GL (mAOD)	Depth	Depth	**Level** **60.15**
Surfacing/ Made Ground	0.15-0.53	0.67	**59.48**
Soft/firm becoming firm/stiff, grey and brown mottled, sandy clayey SILT (Claygate Member)	4.27-5.79	-	**-**
Firm-very stiff fissured brown silty CLAY with crystals (Weathered London Clay Fm)	-	>1.28	**<58.20**
Firm-very stiff, fissured, grey/dark grey silty CLAY with crystals (London Clay Formation)	>10.67-15.39	-	
Seepage/Strike	-	-	**-**
Groundwater standing level	1.27-7.47	-	**-**

5. HYDROLOGICAL SETTING (SURFACE WATER)

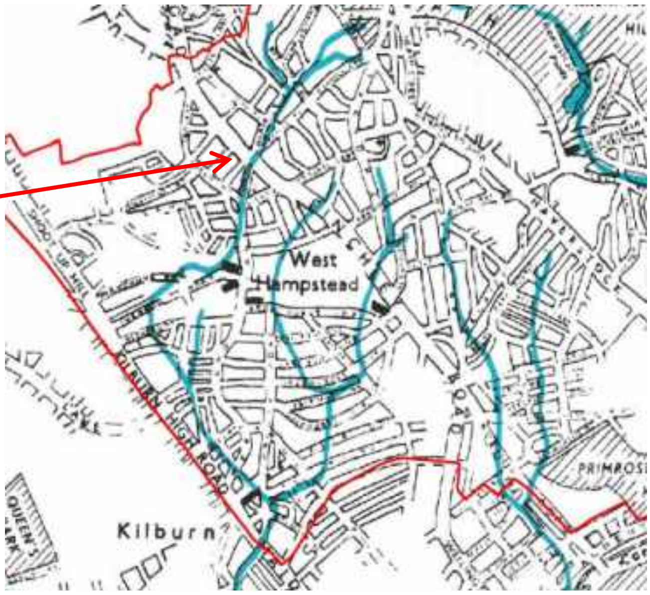


Figure 4: Extract from Figure 11 of the Camden GHHS (Arup, 2010) showing former watercourses, based on Barton (1992).

5.1 The site lies to the west of a tributary to the river Westbourne, one of the 'lost' rivers of London, as shown in Figure 4. Most of these 'lost' rivers now run in dedicated culverts or the sewer system. The location of this tributary is confirmed by the 1865/1873 historic OS map (small scale), which shows two streams merging, then crossing Finchley Road just over 100m to the south-east of the site and continuing downhill to pass beneath the Mill Lane-West End Lane junction. This tributary was most likely culverted when the area was developed.

5.2 The gentle southerly fall across the site, ensures that surface water drains away from Parsifal House to the gullies within the site and to the south-west boundary where excess run-off is able to seep under the fence into the rear garden of No.1 Parsifal Road (Photos 1 & 8). Surface water also drains south-eastwards along the shared driveway to the lower end for the site where it either also runs-off into No.1's garden or continues into the forecourt of No's 1e & 1f.

5.3 No run-off into the site is expected from the 'upslope' site of No.523 Finchley Road/No.1g Parsifal Road owing to the lower level of that site (supported by a retaining wall) and the (assumed) positive drainage from No.1g's rear garden, which is underlain by the concrete roof slab to the covered parking bays. Therefore, the surface water catchment for the site of the proposed houses is expected to be restricted to the site itself.

5.4 Figure 5 shows that Parsifal Road did not flood in either of the 1975 or 2002 events. Finchley Road, along with the Lyncroft Road to the east of the site, were subject to surface water flooding in 2002, but not in the 1975 floods (as confirmed by the more detailed map in the 2003 'Floods in Camden' report). The implications of those historical events are addressed in Section 10.8. While the whole length of the affected roads is recorded as having flooded, those floods generally affected only a short length of these roads (usually around the 'low points').

Parsifal Road

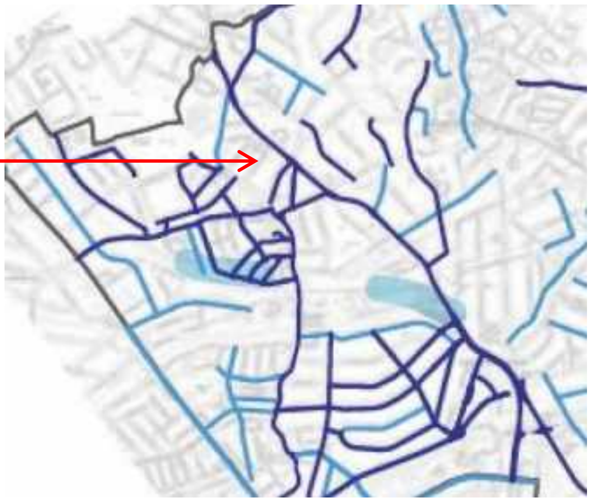


Figure 5: Extract from Figure 15 of the Camden GHHS (Arup, 2010) showing roads which flooded in 1975 (light blue), in 2002 (dark blue), and 'Areas with potential to be at risk of surface water flooding' (wide light blue bands).

5.5 The Environment Agency's classifications for the risk of flooding from rivers and sea (available on the GOV.UK website), have shown that the site is:

- Within Flood Risk Zone 1, so has less than 1 in 1000 annual probability of river or sea flooding (<0.1% in any given year), **not** taking into account the presence of any flood defences;
- Classified under the Environment Agency's Risk of Flooding from Rivers or Seas (RoFRaS) dataset, which **does** allow for the beneficial effects of any flood defences (though irrelevant in this part of Camden), with a 'Very Low' probability of flooding, which is once again defined as "*each year this area has a chance of flooding of less than 0.1%*" (<1 in 1,000).

These are all as expected, given the remote position of the site relative to the River Thames floodplain, and the former course of the nearest of the 'lost' rivers (see paragraph 5.1).

5.6 The Environment Agency's modelling also shows that this area does not fall within an area at risk of reservoir flooding; with the nearest potentially affected area (the "maximum extent of flooding") being from the Hampstead Pond Chain over 1.8km to the east of the site.

5.7 Some hydrological data for the site has been obtained from the Groundsure Enviro+Geo Insight report (see Appendix E), including:

- There are no Water Network records (of rivers, streams, lakes or canals, from 'OS MasterMap' data) within 250m of the site (App.E, Section 6.1);
- No surface water features were identified within 250m of the site (App.E, Section 6.2);
- Under the EU's Water Framework Directive, the site is in a Coastal catchment, draining to the Thames, and does not fall within a 'River Water Body' catchment (App.E, Sections 6.3 & 6.4);
- There are no surface water abstraction licences within 2000m of the site (for more than 20m^3 per day; App.E, Section 5.7).
- The Environment Agency have no records of historical flooding within 250m of the site since 1946 (App.E, Section 7.2);
- There are no flood defences, no areas benefiting from flood defences, and no flood storage areas within 250m of the site (App.E, Sections 7.3, 7.4 & 7.5).
- Flood modelling by Ambiental Risk Analytics gives a '1 in 1,000 years' risk of 0.1-0.3m deep surface water flooding, where two overlapping pixels result in tiny areas within the site at the front end of the 521-519a boundary; as there is a brick boundary wall there and No.519a is downslope of No.521, the actual risk of natural surface water flooding there is probably negligible. The terrace of shops which includes No's 519/519a, plus No's 1e & 1f Parsifal Road, are shown as being at a higher risk of surface water flooding since Ambiental's model has them on the revised flow route of the former Westbrook tributary, especially the garden to No.1f which is lower than No.1e (App.E, Section 8).

5.8 The Environment Agency (EA) published a new map of 'Flood Risk from Surface Water' in January 2014, and a more detailed version has since become available on the 'Check your Long Term Flood Risk' pages of the GOV.UK website, an extract from which is presented in Figure 6 below. This map identifies four levels of risk (high, medium, low and very low), and is based primarily on topographic levels (from LiDAR data), flood depths and flow paths. The EA's definitions of these risk categories are:

'Very low' risk:	Each year, these areas have a chance of flooding of less than 1 in 1000 (<0.1%).
'Low' risk:	Each year, these areas have a chance of flooding of between 1 in 1000 (0.1%) and 1 in 100 (1%)
'Medium' risk:	Each year, these areas have a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3%).
'High' risk:	Each year, these areas have a chance of flooding of greater than 1 in 30 (>3.3%).

5.9 The EA's modelling presented in Figure 6 shows the site and the adjoining properties, including No's 219/219a, No's 1e & 1f Parsifal Road and the adjacent part of the Finchley Road carriageway, all have a 'Very Low' risk of flooding from surface water; this is the national background level of flood risk. The degree of difference between this modelling and that by Ambiental Risk Analytics (see Appendix E, Section 8) is unusual and striking.

Figure 6: Extract from the Environment Agency's 'Flood Risk from Surface Water'.

5.10 Surface water flood modelling has also been undertaken by URS as part of a Strategic Flood Risk Assessment for the London Borough of Camden, and was published in July 2014; an extract from their model is presented in Figure 7. As per the Environment Agency's modelling, this map identifies the same four levels of risk (high, medium, low and very low). This modelling is less clear than the EA's, though it also shows that the site, the adjoining properties and the adjacent part of the Finchley Road carriageway are classified as being at 'Very Low' risk of flooding from surface water.

5.11 Figure 7 also shows that the site falls within the Group3_010 Critical Drainage Area, but is just outside the Cannon Hill Local Flood Risk Zone (see Camden SFRA Figure 6, Rev.2).

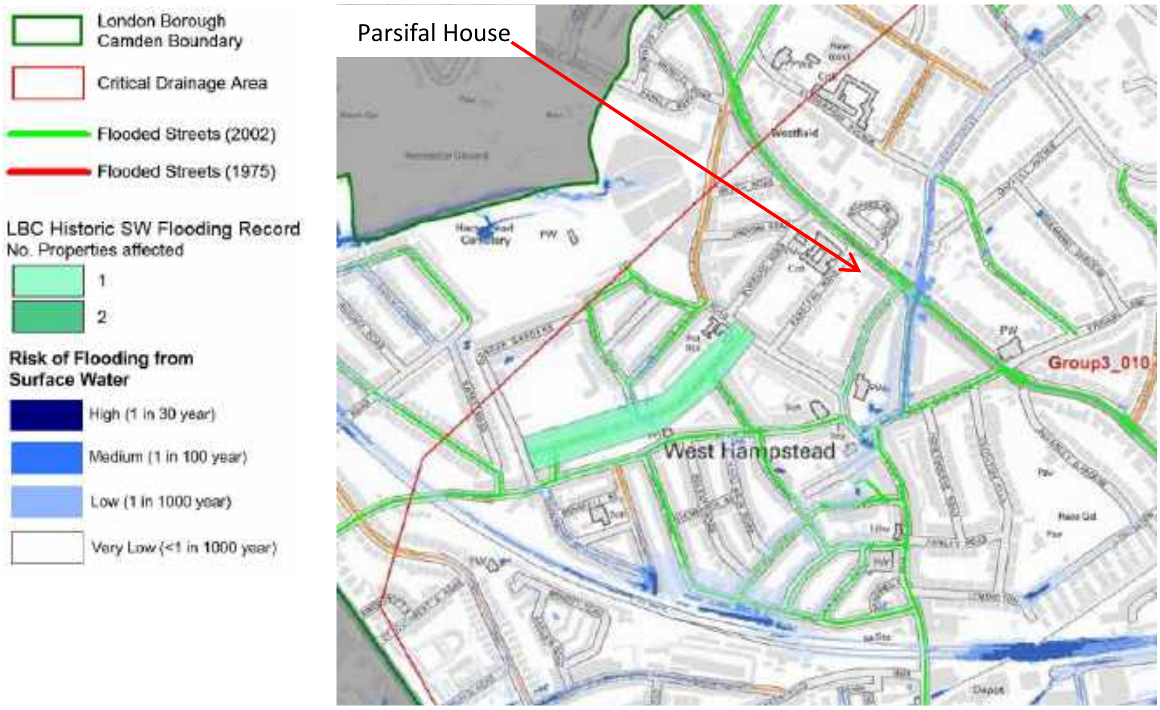


Figure 7: Extract from Figure 3v of the Camden Strategic Flood Risk Assessment (SFRA) (URS, July 2014) showing risk of flooding from surface water.

5.12 The implications from these flood models are discussed in Section 10.8.

5.13 Figures 5a & 5b of the Camden Strategic Flood Risk Assessment present historic records of internal and external sewer flooding respectively, based on Thames Water's DG5 Flood Register. These figures show that, when the Camden Strategic Flood Risk Assessment was written (July 2014), only one property within postcode 'NW6 1' (and none in 'NW3 7') was recorded by Thames Water as having been affected by internal sewer flooding in the previous 10 years, and none were recorded in either of these postcodes as having been affected by external sewer flooding in the previous 10 years.

6. HYDROGEOLOGICAL SETTING (GROUNDWATER)

6.1 The London Clay Formation is classified by the Environment Agency as an 'Unproductive Stratum', as indicated by Figure 8. .

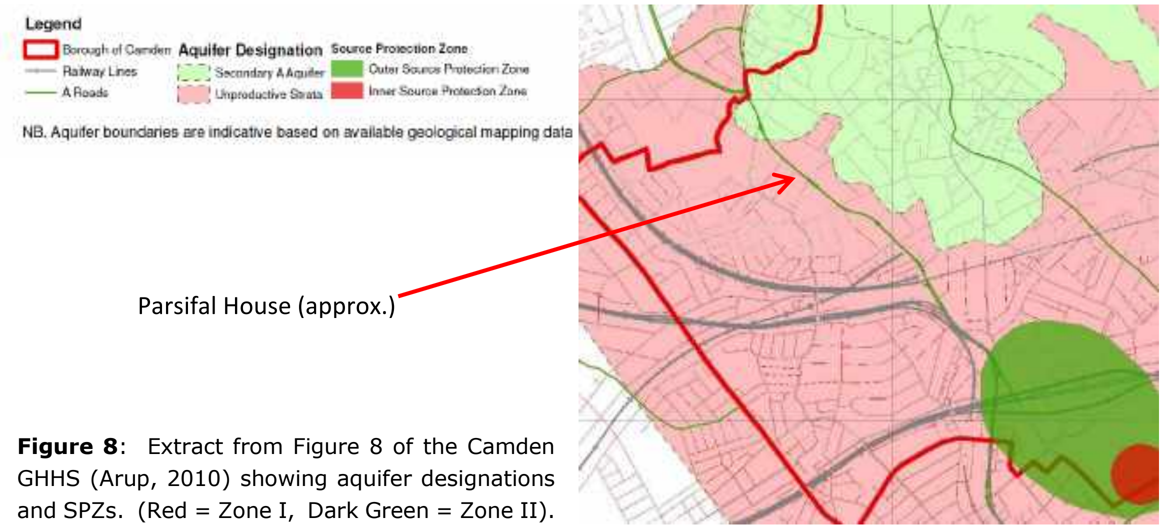


Figure 8: Extract from Figure 8 of the Camden GHHS (Arup, 2010) showing aquifer designations and SPZs. (Red = Zone I, Dark Green = Zone II).

6.2 New groundwater vulnerability mapping has been undertaken jointly by the BGS and Environment Agency; this mapping presents an assessment of the vulnerability of groundwater to a pollutant discharged at ground level based on the hydrological, geological, hydrogeological and soil properties within a one kilometre square grid. Groundwater vulnerability is described as High, Medium or Low based on the leachability and permeability of the soils concerned, with superficial and bedrock aquifers classified separately. Unproductive aquifers such as the London Clay Formation are also classified as having 'unproductive' vulnerability. The 'Low' leaching class and 40-70% Infiltration Value within 50m of the site (see Groundsure's Enviro+Geo Insight report in Appendix E, Section 5.3) are largely irrelevant given that the site is fully paved or built over with the exception of the gravel strip along much of the western site boundary.

6.3 The Chalk Principal Aquifer which occurs at depth beneath the London Clay is not considered relevant to the proposed basement, so is not considered further.

6.4 While the London Clay Formation is classified as an 'Unproductive Stratum', it can still be water-bearing. The water pressures within the clay in the depths of current interest are likely to be hydrostatic, which means they increase linearly with depth, except where they are modified by tree root activity or the influence of man-made changes such as utility trenches (which can act either as land drains or as sources of water and high groundwater pressures). Any silt or sand partings, laminations or thicker beds are likely to contain free groundwater and, where these are laterally continuous, they can give rise to moderate water entries into excavations. In most cases, there will be only very limited or no natural flow in these silt/sand horizons.

6.5 Perched groundwater would typically be expected in any Made Ground, and possibly also in any Head deposits which overlie the London Clay, in at least the winter and early spring seasons. Variations in groundwater levels and pressures will occur in response to seasonal climatic changes and with other man-induced influences.

6.6 The groundwater catchment areas upslope of the site are likely to differ for each of the main stratigraphic units:

- Made Ground: The catchment for any perched groundwater in the Made Ground is probably limited to the immediately adjoining areas of Made Ground, except where the trenches for drains and other services provide greater interconnection.
- London Clay Formation: The catchment for the underlying London Clay will comprise recharge from the overlying soils in the vicinity of the site, plus potentially a wider area determined by the lateral extent of any interconnected silt/sand horizons.

6.7 Other hydrogeological data obtained from the Groundsure Enviro+Geo Insight report (Appendix E) include:

- There are no Source Protection Zones (SPZs) within 500m of the site (App.E, Sections 5.9 & 5.10, and Figure 8 above).
- There are no licensed groundwater or potable water abstractions (of greater than 20 cubic metres per day) within 1800m of the site (App.E, Sections 5.6 & 5.8).
- For the site and an area within 50m of the site, Ambiental Risk Analytics has classified the susceptibility to groundwater flooding as '**Negligible'** for a 1 in 100 year return period (App.E, Section 9.1).

6.8 Groundwater flooding incidents were presented on Figure 4e of the Camden SFRA (see Figure 9 below). Camden Council had 21 records of historic flooding in houses in four roads, seven of which were in Lyncroft Gardens, the closest road to the south-east of the site. The Environment Agency had records of 23 groundwater flooding incidents in the borough, the closest of which was around 470m to the south-west of the site, on the north side of Hillfield Road. Some of these records may relate to misidentified surface water flooding.

6.9 Details of what was found by the site-specific ground investigation in May 2020 are presented in Section 9.

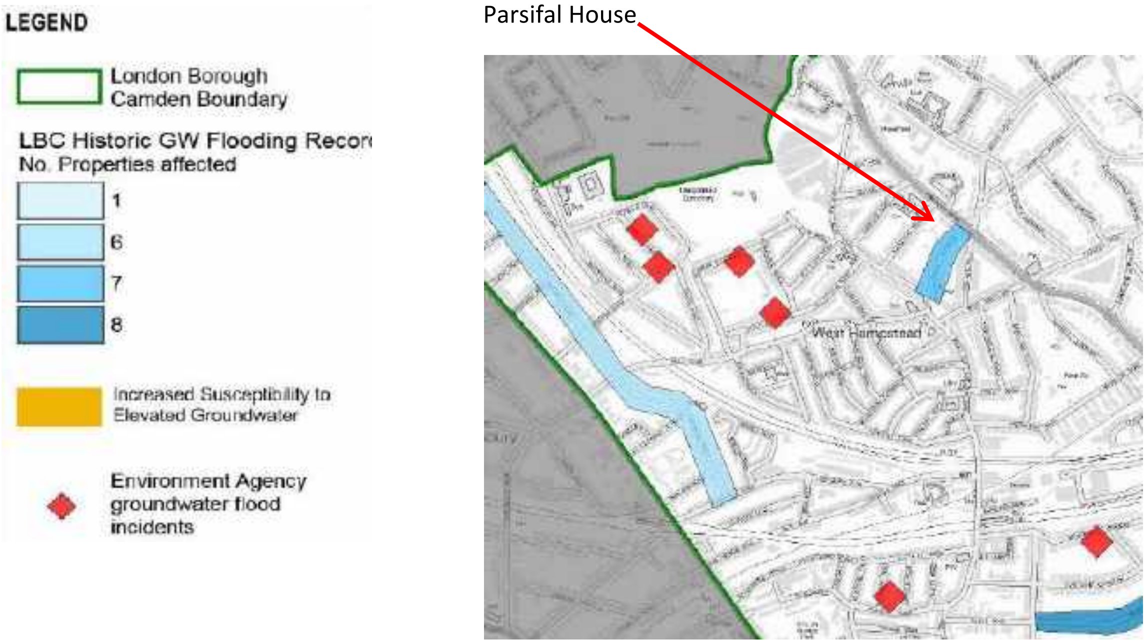


Figure 9: Increased Susceptibility to Elevated Groundwater – extract from Figure 4e of the SFRA. Ordnance Survey © Crown copyright 2014. All rights reserved. Licence No.100051531.

7. STAGE 1 - SCREENING

7.1 The screening has been undertaken in accordance with the three screening flowcharts presented in LBC's CPG Basements (2018) guidance document. Information to assist with answering these screening questions has been obtained from various sources including the site-specific ground investigation, the Camden geological, hydrogeological and hydrological study (Arup, 2010), borough-specific flood studies, historic maps and data obtained from Groundsure (see Appendices C, D & E) and other sources as referenced.

7.2 Subterranean (groundwater) flow screening flowchart:

Question		**Response, with justification of 'No' answers**	**Clauses where considered further**
1a	Is the site located directly above an aquifer?	No – Site underlain by London Clay	4.1 & Figure 3
1b	Will the proposed basement extend beneath the water table surface?	No, not beneath the water table in an aquifer, though it will extend below the phreatic surface of the groundwater in the London Clay.	9.5, 9.6, and Sections 10.2 & 10.3
2	Is the site within 100m of a watercourse?	No – There are no surface water features within 250m of site.	5.1 & 5.7
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No – Site is approx 820m to the south of the nearest pond chain catchment (Golders Hill Pond Chain).	
4	Will the proposed basement development result in a change in the proportion of hard surfaced/ paved areas?	Yes – the green roofs will cause a beneficial reduction, but they are remote from and irrelevant to groundwater flow, so **not** carried forward to Scoping.	2.5 & 3.2
5	As part of the site drainage, will more surface water (eg: rainfall and run-off) than at present be discharged to the ground (eg: via soakaways and/or SUDS)?	No – Soakaways would be inappropriate in London Clay.	
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 (not just the pond chains on Hampstead Heath) or spring line?	No – There are no surface water features within 250m of the site. Nearest springs are likely to be around 157m to the north (at the London Clay-Claygate Member interface).	5.7, Figure 3 & Appendix E, Section 14.3

While the answer to question Q1b above was no, the design of the basement must allow for the presence of groundwater in the Made Ground, which was found to be predominantly clayey, and the London Clay. The Council's historic records of nearby groundwater flooding (see Figure 9) reinforces this requirement. The temporary works during construction must also allow for the presence of groundwater. These matters are considered in Sections 10.1 to 10.3.

7.3 Slope/ground stability screening flowchart:

Question		**Response, with justification of 'No' answers**	**Clauses where considered further**
1	Does the existing site include slopes, natural or man-made, greater than 7°? (approximately 1 in 8)	No – The slope angle across the site, to the rear of Parsifal House is 1.3°, and even less within the plots for the proposed houses.	2.10 and Figure 3
2	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°?	No – No re-profiling is proposed.	Section 3
3	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No – Figure 16 in the Camden GHHS shows no land greater than 7° in the vicinity of this property.	2.9 & Figure 3
4	Is the site in a wider hillside setting in which the general slope is greater than 7°?	No – The contour intervals indicate maximum overall slope angles of 2.3° to 3.3° and Figure 16 in the Camden GHHS shows no slopes greater than 7° in the vicinity of this property	2.9 & Figure 3
5	Is the London Clay the shallowest strata at the site?	Yes, it is the shallowest stratum mapped by the BGS (though it may be overlain by Head Deposits).	Carried forward to Scoping: 4.1, 8.2, Section 9
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree root protection zones where trees are to be retained?	No – There is no vegetation in the footprint of the proposed houses, but a 20m high Willow has been removed since 2018 and a large fallen Copper Beech was present in the rear garden of No.1 Parsifal Rd.	Carried forward to Scoping: 8.2, Section 10.4
7	Is there a history of seasonal shrink/swell subsidence in the local area, and/or evidence of such effects at the site?	No evidence (all neighbouring properties are relatively modern, and this is a new build project)	Sections 2 & 3
8	Is the site within 100m of a watercourse or potential spring line?	No – see Q2 & Q6 in subterranean flow screening above. No springs in the vicinity.	
9	Is the site within an area of previously worked ground?	No – See BGS map extract (Figure 3 herein) and maps on pages 73 & 85 of the Enviro+ GeoInsight report (in App.E).	4.1 & Figure 3
10	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No – London Clay Formation is classified as an 'Unproductive Stratum'.	6.1
11	Is the site within 50m of the Hampstead Heath ponds?	No – Site is approx 820m southwest of the nearest pond chain (Golders Hill).	
12	Is the site within 5m of a highway or a pedestrian right of way?	No, though does adjoin a shared driveway.	Carried forward to Scoping: 8.2, Section 10.4
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	Yes	Carried forward to Scoping: 8.2, Section 10.4
14	Is the site over or within the exclusion zone of any tunnels, eg railway lines.	Unknown	Carried forward to Scoping: 8.2, 10.1.3

7.4 Surface flow and flooding screening flowchart:

Question		**Response, with justification of 'No' answers**	**Clauses where considered further**
1	Is the site within the catchment of the pond chains on Hampstead Heath?	No – Site is approx 820m southwest of the nearest pond chain (Golders Hill).	
2	As part of the proposed site drainage, will surface water flows (eg volume of rainfall and peak run-off) be materially changed from the existing route?	No –Surface water will continue to be discharged to mains drainage, though the green roofs will provide beneficial interception. Surface water from the lightwells will have to be pumped into the drainage system.	5.2, Section 10.8
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes – A beneficial reduction from the proposed green roofs.	3.2, (Carried Forward to Scoping: 8.3 & Section 10.8)
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by the adjacent properties or downstream watercourses?	Yes – there is likely to be a slight reduction in surface water run-off to the rear garden of No.1 Parsifal Rd. There are no watercourses within 250m.	5.2, 5.3 & 5.7 (Carried Forward to Scoping: 8.3 & Section 10.8)
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No – There should be no significant change in surfaces generating run-off. None of the run-off from this property goes directly to a surface watercourse.	5.2 & 5.7
6	Is the site in an area known to be at risk from surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	Yes – Finchley Road did flood in 2002 (though probably only at localised low points or at reductions in gradient).	5.4 & Figure 5. Carried forward to Scoping: 8.3 & Section 10.8

7.5 <u>Non-technical Summary – Stage 1:</u>

The screening exercise in accordance with 'CPG Basements' has identified eight issues which need to be taken forward to Scoping (Stage 2); five are related to ground stability and three are related to flooding potential, although two of those are beneficial. In addition, the presence of groundwater in the Made Ground and the London Clay must also be allowed for in the design of the basement and the associated temporary works; these matters are considered in Sections 10.2 and 10.3.

8. STAGE 2 – SCOPING

8.1 The scoping stage is required to identify the potential impacts from the aspects of the proposed basement which have been shown by the screening process to need further investigation. A conceptual ground model is usually compiled at the scoping stage; however, because the ground investigation has already been undertaken for this project, the conceptual ground model including the findings of the ground investigation is described under Stage 4 (see Section 10.1).

8.2 Slope/ground stability scoping:

Issue (= Screening Question)		**Potential impact and actions**
5	Is the London Clay the shallowest strata at the site?	**Potential impact:** Heave in response to the unloading caused by the basement excavations, and as Q7 below. **Action:** Ground investigation required, followed by appropriate design**.**
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree root protection zones where trees are to be retained?	**Potential impact:** Heave from removal of trees (within area of root growth); slope(s) become less stable; damage to trees to be retained including possible loss of stability. **Action:** Basement design to take into account likely heave following removal of the large Willow and Copper Beech trees. Revise the scheme if required to prevent unacceptable impacts.
12	Is the site within 5m of a highway or a pedestrian right of way?	**Potential impact:** Construction of basement causes loss of support to footway/highway (or, in this case, the shared driveway) and damage to the services beneath them**.** **Action:** Ensure adequate temporary and permanent support by use of best practice underpinning methods**.**
13	Will the proposed basement substantially increase the differential depth of foundations relative to neighbouring properties?	**Potential impact:** Loss of support to the ground beneath the foundations to No.1g Parsifal Road, if basement excavations are inadequately supported. Possible long term differential movement. **Action:** Ensure adequate temporary and permanent support by use of best practice underpinning methods.
14	Is the site over or within the exclusion zone of any tunnels, eg railway lines.	**Potential impact:** Stress changes on any tunnel lining. Piles or boreholes penetrating the tunnel (though no piles in this scheme)**.** **Action:** Undertake services search to check that there are no tunnels / deep services in the vicinity.

8.3 Surface flow and flooding scoping:

Issue (= Screening Question)		**Potential impact and actions**
3	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	**Potential impact:** In general, may increase flow rates to sewer, and thus increase the risk of flooding (locally or elsewhere). May change infiltration. In this case, the inclusion of extensive green roofs is beneficial. **Action:** Ensure appropriate specification of the green roofs (a type of SuDS).
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by the adjacent properties or downstream watercourses?	**Potential impact:** In general, increased run-off might cause flooding (locally or elsewhere); a significant decrease might be detrimental to plants. In this case, run-off will continue down the shared access drive and the driveway between the proposed houses and No.1e, and the slight reduction in run-off is likely to be beneficial. **Action:** None.
6	Is the site in an area known to be at risk from surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	**Potential impact:** Flooding of the basement. **Action:** Review flood risk and provide flood resistance measures as appropriate.

8.4 Non-technical Summary – Stage 2:

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

- A ground investigation is required (which has already been undertaken).
- Designer and contractor to take account of the potential heave from the recent removal of two large trees (Willow, upslope of the garages, and Copper Beech adjacent to shared driveway).
- Ensure adequate temporary and permanent support by use of best practice underpinning methods.
- Undertake a services search to check whether there are any deep services/ tunnels which might be affected by the basement.
- Ensure appropriate specification of the green roofs (and any other SuDS).
- Review flood risk and include appropriate flood resistance and mitigation measures in the scheme's design.

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

9. STAGE 3 – GROUND INVESTIGATION

9.1 The ground investigation sitework was carried out on 21st May 2020, and consisted of two continuous flight auger borehole (BH1 & BH2) drilled to a depth of 8.0m below ground level (bgl), and six hand dug trial pits (TP1 to TP6). One pit (TP4) was also extended to a depth of 3.0m by hand augering. The factual findings from the investigation are presented in Appendix F, including a site plan, trial pit logs and borehole logs; reference should be made to the logs for full details of the strata descriptions and footing geometries. Results from the subsequent laboratory testing on the samples recovered from the boreholes and trial pits are also presented in Appendix F.

9.2 The trial pits were dug in order to investigate the foundations to Parsifal House and the boundary wall with No.1e Parsifal Road, or the thickness of the garage slabs, and to assess the type and condition of the soils beneath the footings/slabs at their respective locations.

TP1:	Location:	Rear wall of Parsifal House
	Ground level:	c. 75.7m AOD
	Footing depth:	>1.60m bgl; projection = 0.25m/0.80-0.85m
	Materials:	Concrete (0.50m thick) over suspected underpin concrete
	Surfacing:	Topsoil
	Geology under footing:	Not found (MADE GROUND to base of pit: Sandy clayey SILT with numerous brick and concrete fragments).
	Roots:	Numerous, <8mm near surface, reducing to <3mm.
TP2:	Location:	Driveway, alongside No.1e.
	Ground level:	c. 74.85m AOD
	Surfacing:	0.25m concrete
	Geology:	MADE GROUND to base of pit: Soft, sandy, very silty CLAY/clayey SILT with numerous pieces of concrete and brick rubble.
	Roots:	None observed
TP3:	Location:	Flower bed alongside boundary wall with No.1e's garden.
	Ground level:	Approx. 75.0m AOD
	Footing depth:	0.80m bgl; projection = 0.20m
	Materials:	Concrete (0.50m thick)
	Surfacing:	Topsoil
	Geology under footing:	"Stiff" silty CLAY with partings of silt and fine sand. Hand vane readings: 78kPa, 86kPa.
	Roots:	Numerous, <20mm near surface, reducing to <3mm.

Continued…

TP4:	Location:	Flower bed in Parsifal House garden (to north of garages).
	Ground level:	c. 75.0m AOD
	Surfacing:	Topsoil
	Geology:	0.1-1.0m: MADE GROUND: Soft, sandy, very silty CLAY with numerous concrete and brick fragments; over 1.0 - >3.0m: Firm to stiff, becoming stiff, silty CLAY with partings of silt and fine sand. (Hand vane readings increased from 76kPa to 132 kPa - see appended log).
	Roots:	Numerous down to 1.50m depth, <3mm near surface, reducing to 1-2mm
TP5:	Location:	In northern block of garages.
	Ground level:	c. 75.05m AOD
	Surfacing:	0.10m concrete slab over polythene membrane (dpm)
	Geology:	0.1-1.0m: MADE GROUND: 'Loose', sandy, clayey SILT/ silty CLAY with numerous concrete and brick fragments; over 1.0->1.5m: Firm to stiff, silty CLAY with partings of silt and fine sand. (Hand vane readings increased from 78kPa to 96kPa - see appended log).
	Roots:	None observed.
TP6:	Location:	In southern block of garages.
	Ground level:	c. 74.9m AOD
	Surfacing:	0.20m concrete slab
	Geology:	0.2-1.0m: MADE GROUND: Pungent, 'loose', very silty CLAY/clayey SILT with numerous concrete and brick fragments; over 1.0->1.5m: Pungent, firm to stiff, silty CLAY with partings of silt and fine sand. (Hand vane readings at base of pit: 82kPa, 86kPa).
	Roots:	None observed.

9.3 The geological sequence as found by the boreholes may be summarised as follows:

- Made Ground: To 1.20m bgl: Medium compact to compact (BH1), or 'loose' (BH2), slightly gravelly to gravelly, sandy, clayey SILT locally becoming very silty CLAY with numerous concrete and brick fragments or rubble.
- Weathered London Clay Formation: Recorded from the base of the Made Ground (1.20m bgl) to the base of both boreholes. The Weathered London Clay was recorded as "*Stiff, mid brown orange grey veined, silty CLAY with partings of orange brown silt and fine sand*". Its consistency was recorded as "*very stiff*" below 2.50m in BH1 and below 3.80m in BH2, at which levels the hand vane readings exceeded 140kPa.

9.4 Roots were recorded to a maximum depth of 3.40m bgl in BH1, which was 7.0m from a large Plane pavement tree. No roots were recorded in BH2, despite that being near the fallen Copper Beech.

9.5 No groundwater entries were recorded in any of the exploratory holes during drilling/ digging.

9.6 Standpipes were installed to the base of both boreholes, comprising 1.0m of plain pipe at top, then 7.0m of slotted pipe. Water level readings were recorded on two occasions; the results during this short monitoring period are presented in Table 2 below.

Table 2: Water levels from Groundwater Monitoring

Date	Depth to Water (m bgl / m AOD)	
	BH1	BH2
03-06-2020	Dry	6.62 / 69.47
10-06-2020	Dry	6.00 / 68.85

Laboratory Testing:

9.7 Geotechnical laboratory tests on samples recovered from borehole BH1 and trial pit TP1 were carried out by Chelmer Laboratories and i2 Analytical Ltd. The testing comprised classification tests (including water content and plasticity) and chemical testing to assess the potential for acid or sulphate attack on buried concrete. The test reports are presented in Appendix F.

9.8 Plasticity tests were performed on thirteen samples of Weathered London Clay. All the samples tested, with one exception, were found to be of Very High Plasticity (one on the borderline with High plasticity), as classified by BS5930 (2015), while the sample from 1.50m bgl in BH1 was found to be of High Plasticity; these results are displayed in a plasticity chart on page 20 of Chelmer's Factual report (Appendix F). All the samples tested were found to be of High Volume Change Potential, as defined by the NHBC (NHBC Standards, 2020, Chapter 4.2, Building near Trees).

9.9 Water Contents were determined for the same samples as were tested for plasticity. The results ranged from 27% to 37%. Profiles of Water Content against depth have been plotted on page 19 of Chelmer's Factual report; these show significantly lower Water Contents in BH1 and TP3, to a depth of at least 4.0m, relative to the values obtained from TP4 and BH2. BH1 and TP3 were near existing/felled substantial trees. The low Water Content reading from the bottom of BH1 is anomalous, as that would be expected to be similar to the Water Contents in the lower part of BH2.

9.10 Comparison of the Water Contents with the Plastic Limit values from the same samples confirmed the presence of significant desiccation down to at least 4.0m in BH1 and in TP3 (where Water Contents were between 1% below and 1% above Plastic Limit). In contrast, over the same depth range in BH2, the Water Contents were 4-7% above Plastic Limit. This desiccation is attributed to the action of tree roots which, in the case of TP3, was probably caused primarily by roots from the recently removed/fallen Willow.

9.11 The chemical tests were undertaken on a total of five samples in order to assess the potential for acid or sulphate attack on buried concrete. The samples tested included two samples of Made Ground (from BH1 at 0.50m bgl and BH2 at 1.00m bgl) while the remainder were from the Weathered London Clay. The following ranges of results were recorded:

pH value:	7.6 – 8.2	
Water-soluble sulphate:	89 - 3430mg/L	
Total acid-soluble sulphate:	0.054 – 0.926%	(London Clay only)
Total sulphur:	0.023 - 0.419%	(London Clay only)

Calculations following BRE Digest SD1 (2005) gave 'derived' values for the London Clay:

Total Potential Sulphate (TPS):	0.069 – 1.257%
Oxidisable sulphides:	0.015 - 0.331%

These results indicated that the samples fell within the following Design Sulphate Classes, as defined by BRE Special Digest 1 (2005):

Made Ground:	**DS-1**
Weathered London Clay:	**DS-1** at 1.0m and 2.5m bgl
	DS-4 at 6.0m bgl

Pyrite was also probably present in the sample from 6.00m in BH1, because its oxidisable sulphides value exceeded 0.3%.

<u>Non-technical Summary – Stage 3:</u>

9.12 The site-specific ground investigation at the Parsifal Road garages confirmed the presence of London Clay at shallow depth below the site. This is consistent with mapping by the British Geological Society (BGS). The rear wall of Parsifal House appeared to have been underpinned.

9.13 No groundwater entries were recorded in any of the boreholes or trial pits, though this does not mean that groundwater is absent. Standpipes were installed in both boreholes to enable recording of groundwater levels/pressures. The highest water level recorded during the short monitoring period was 6.0m below ground level; this is very unlikely to represent the correct groundwater pressure/level in these clays.

10. STAGE 4 – BASEMENT IMPACT ASSESSMENT

10.1 Conceptual Ground Model

10.1.1 The desk study evidence, together with the ground investigation findings, suggest a conceptual ground model for the site characterised as follows. For further details of the geology found by the ground investigation, and the results of in-situ and laboratory testing, reference should be made to Section 9 and Appendix F.

- Made Ground: Made Ground was present in all the exploratory holes. The thickness appeared to be quite uniform at 0.8m to 1.20m, with a notable exception alongside the rear wall of Parsifal House where the base of the Made Ground was not found within the 1.60m depth of trial pit TP1; that Made Ground might be backfill to an access trench for the suspected underpinning. The Made Ground was generally described as sandy, clayey SILT to silty CLAY with numerous concrete and brick fragments; the latter became "rubble" in a couple of locations. The consistency, where noted, was generally soft or locally 'loose'. Beneath the southern garage block, the Made Ground was noted to be pungent and "dark brown grey-black" in colour (TP6).
  Numerous roots were noted in the front garden of Parsifal House (BH1, close to a large Plane tree and a conifer/evergreen hedge), and in the small garden behind Parsifal House (TPs 1, 3 & 4), where a 20m high Willow and two Silver Birch trees have been removed since 2018.
  Other materials, as well as other soil types and greater thicknesses/depths, are also likely to be present on site, owing to the inherent variability of Made Ground.
- Weathered London Clay: Silty CLAYS attributed to the in-situ London Clay are expected to underlie the whole site and will be the founding soils for the proposed basements. Hand vane readings indicated that the consistency of these clays in the upper part of the weathered London Clay sequence was firm to stiff in the trial pits, which the borehole vane tests indicated became stiff below 1.50m. The colour of these clays had weathered to mid brown/orange with grey veining to the full depth of the boreholes; the partings of silt and fine sand were also orange and brown.
  The shear vane readings typically give over-estimates of the 'mass' shear strengths of such clays because of the presence of fissures/shears, so should NOT be used for design purposes without a compensating reduction factor (in addition to design partial factors in accordance with Eurocode 7). The fissures/ shears also make such clays less stable in excavations than would otherwise be expected.
  Selenite (a form of gypsum, which is aggressive to buried concrete) was not recorded but is likely to be present, given that chemical testing indicated the probable presence of pyrite at 6.0m depth. These clays also often contain claystone nodules/horizons which can obstruct boreholes and piles.

The logs of other boreholes, in the wider area, indicate that the base of the Weathered London Clay can be found at depths ranging from 6.7m to 8.2m bgl, increasing locally to 10-12m bgl.

- London Clay Formation ('un-weathered'): Wasn't encountered by the site-specific ground investigation, or the investigation for No.1e's basement. Very stiff, grey CLAY of the London Clay Formation is expected to be present beneath the entire site, and is likely to extend to a depth of more than 65m based on the finding from BGS borehole TQ28SW/74. Like their weathered derivatives, these clays are expected to be fissured/sheared, to contain pyrite and claystones, and will undergo heave movements in response to any net unloading by basement excavations.

- Hydrogeology
    - Perched groundwater should be expected in the Made Ground during at least the winter and spring seasons, though it may be present only locally and little or no flow is anticipated through the silty CLAYS and sandy clayey SILTS.
    - Groundwater pressures are expected to be essentially hydrostatic within the depth of current interest in the London Clay. Groundwater flow through these clays is likely to be minimal, in practice being limited to seepage through any of the silt/sand partings which are sufficiently interconnected. The slow groundwater entry into the standpipes indicates that there is minimal or no flow through these partings.
    - The hydrogeology may be complicated further by the backfill in service trenches and granular pipe bedding (where present) forming preferential groundwater flow pathways within the strata they pass through.

10.1.2 The hydrogeological regime outlined above will be affected by long-term climatic variations as well as seasonal fluctuations, all of which must be taken into account when selecting a design water level for the permanent works. No multi-seasonal monitoring data are available, so a conservative approach will be needed, in accordance with current geotechnical design standards which require use of 'worst credible' groundwater levels/pressures. See paragraph 10.2.8 for the recommended design groundwater level.

10.1.3 A services search has been undertaken and should be referred to for details of adopted services beneath the site. These searches do not consider private services, such as the drains serving the gullies within the driveway and the electricity supply to the lights on the garages, so tracing of all private services should be undertaken before the garages are demolished.

10.2 Subterranean (Groundwater) Flow – Permanent Works

10.2.1 The Made Ground comprises sandy clayey SILTS through to sandy silty CLAYS with artificial debris. These are likely to be of low permeability so seepage of any groundwater perched above the in-situ Weathered London Clay (of even lower permeability) is expected to be minimal. No perched water was found in the Made Ground during the site-specific ground investigation, though perched water may develop locally at times, at least during wetter winter and spring seasons.

10.2.2 The common lack of groundwater entries into boreholes while drilling through the London Clay is caused by the low permeability of the clays and the temporary sealing of any slightly more permeable layers by the drilling process, rather than by an absence of water.

10.2.3 The highest groundwater standing level (phreatic surface) recorded during the brief monitoring period was 6.00m below ground level (bgl); this was very unlikely to be representative of the water pressures/levels in the surrounding clays, so higher water levels must be expected and allowed for in the design analyses.

Existing Basements:

10.2.4 No.523 Finchley Road has a lower ground floor which continues through to the parking area under the rear garden of No.1g Parsifal Road (see Photo 7 in Appendix A). The ground level in that parking area is 73.20-73.25m AOD, so the retaining wall along the boundary with the garages site is likely to be founded at or below 72.8m AOD. No.1e Parsifal Road has a full footprint basement with a finished floor level at 71.00m AOD (the 4.800m ground floor threshold level on the architect's drawings for No.1e corresponds with the 74.80m AOD level on the topographic survey of the garages by Spatial Dimensions), so that basement is likely to be founded at or below 70.50m AOD, which is below the level of the currently proposed basement.

Other Proposed Basements:

10.2.5 No other current or recent applications were found on Camden's planning website for modern basements beneath the other adjacent properties (No's 519/519A Finchley Road or No.1g Parsifal Road).

Proposed Basement at Parsifal Road Garages:

10.2.6 Details of the proposed works are given in Section 3. The proposed basement is expected be founded at approximately **71.05m AOD** (the formation level; see paragraph 3.5). Based on the strata levels in BH2, the basement's formation level will be in the Weathered London Clay, at the level where the clays were noted to become very stiff. The basement will therefore obstruct any seepage of perched groundwater but it is not expected to create any significant impact, locally or cumulatively, because of the naturally very low permeability of the London Clay and because the existing footings to Parsifal House, the lower ground floor to No.523 and the retaining walls around its rear parking areas must already block almost all downslope seepage in the Made Ground. The drain trenches between these buildings and between Parsifal House and No.519A may provide the only seepage/flow paths past them, but that drain will remain in place passing to the east of the proposed basement. Thus, the proposed basement is considered acceptable in relation to groundwater flow.

10.2.7 In the unlikely event that the basement excavations encounter, and would completely obstruct, a local deposit of more permeable soils containing mobile groundwater which has remained undetected within the London Clay (or Head deposits), of sufficient thickness and extent to permit significant flow, then it is possible that an engineered groundwater bypass might be required. This bypass would have to be detailed once the geometry of the permeable soil unit is known. Water-bearing claystone horizons in the London Clay can also permit significant seepage/flow and might require similar treatment if encountered.

10.2.8 Current geotechnical design standards require use of a 'worst credible' approach to selection of groundwater pressures. On sites such as this where high plasticity clays are present close to surface, the groundwater table (or phreatic surface) may rise to surface, or at least into the overlying Made Ground in the wettest winters, unless mitigation measures such as land drainage can be installed. No acceptable disposal location exists for such water (because there is no accessible watercourse nearby, and Thames Water will not allow long-term disposal of groundwater to the mains drainage system). As a result, use of a design groundwater level at ground level is recommended for the whole basement, for both short-term and long-term situations (in accordance with Eurocode 7, BS EN 1997-1).

10.2.9 The basement structure should be designed to resist buoyant uplift pressure that would be generated by the 'worst credible' groundwater levels. For the design groundwater level suggested above, buoyant uplift pressures of up to **40kPa** (un-factored) would have to be accommodated.

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

10.2.11 The National House Building Council published new guidance on waterproofing of basements in November 2014 (now NHBC Standards, 2020, Chapter 5.4). Compliance would be compulsory if an NHBC warranty is required, otherwise it may provide a useful guide to best practice.

10.3 Subterranean (Groundwater) Flow – Temporary Works

10.3.1 Local groundwater entries/seepages may occur into the excavations for the basement though, on current evidence, if any do occur they are likely to be minor and should be manageable by sump pumping, provided that they are not being fed by defective drains or water supply pipes. An appropriate discharge location must be identified for the groundwater removed by sump pumping.

10.3.2 All groundwater control measures should be supervised by an appropriately competent person. A careful watch should be maintained to check that fine soils are not removed with the groundwater; if any such erosion/removal of fines is noticed, then pumping should cease and the advice of a suitably experienced and competent ground engineer should be sought.

10.3.3 The unloaded clays at/beneath formation level will readily absorb any available water which would lead to softening and loss of strength. It will therefore be important to ensure that the clays at formation level (onto which the underpins and the basement slab will bear) are protected from all sources of water, with suitable channelling to sumps for any groundwater seeping into the excavations. The formation clays should be inspected and then blinded with concrete immediately after completion of final excavation to grade. Any unacceptably soft/weak areas must be excavated and replaced with concrete.

10.4 Slope and Ground Stability

10.4.1 With an overall slope angle of 1.3° across the site (and development plots which are almost level) and slopes of up to 3.3° in the surrounding area (see paragraphs 2.9 & 2.10), the proposed basement excavation raises no concerns in relation to slope stability.

Basement Retaining Wall Construction:

10.4.2 Use of reinforced concrete (RC), cantilevered, 'L' shaped retaining walls is anticipated for construction of the perimeter walls of the proposed basement. These are proposed to be constructed in traditional underpinning sequence, in panels not exceeding 1.0m in width, as shown on the basement plan by Mitchinson Macken (Drg No.19313/102 Rev.A), subject to agreement under Party Wall Act protocols. The estimated founding (formation) levels and excavation depths of the retaining walls and basement slab are explained in paragraphs 3.3 and 3.5.

10.4.3 Underpinning sequence methods involve excavation of the ground in short lengths (not exceeding 1.0m is recommended) in order to enable stresses in the ground to 'arch' onto the ground or completed underpinning on both sides of the excavation.

10.4.4 Some ground movement is inevitable when basements are constructed. When underpinning sequence methods are used, the magnitude of the movements in the ground being supported by the new basement walls is dependent primarily on:

- the geology;
- the adequacy of temporary support to both the underpinning excavations and partially complete underpins, prior to installation of full permanent support;
- the quality of workmanship when constructing the permanent structure.

A high quality of workmanship and use of best practice methods of temporary support are therefore crucial to the satisfactory control of ground movements alongside basement excavations (see 10.4.5 to 10.4.7 below).

10.4.5 The minimum temporary support requirements recommended for the excavations for the proposed RC retaining walls, subject to inspection and review as described in 10.4.6 and 10.4.7 below, are:

- Full face support must be installed as the excavations progress for all excavations through the Made Ground and in any firm clay which is present at the top of the London Clay/Head deposits.
- Closely-spaced temporary support may be adequate in the stiff or very stiff clays of the weathered London Clay Formation, depending on the degree of fissuring.
- Temporary support must also be installed to support all the new underpins, and must be maintained until the full permanent support has been completed, including allowing time for the concrete to gain adequate strength.

All temporary support should use high stiffness systems, installed in accordance with best practice, in order to minimise the ground movements.

10.4.6 In accordance with normal health and safety good practice, the requirements for temporary support of any excavation must be assessed by a competent person at the start of every shift, and at each significant change in the geometry of the excavations as the work progresses. The London Clay is likely to be fissured; such fissures can cause seemingly strong, stable excavations to collapse with little or no warning. Thus, in addition to normal monitoring of the stability of the excavations, a suitably competent person should check whether such fissuring is present and, if encountered, should assess what support is appropriate.

10.4.7 Under UK standard practice, the contractor is responsible for designing and implementing the temporary works, so it is considered essential that the contractor employed for these works should have completed similar schemes successfully. For this reason, careful pre-selection of the contractors who will be invited to tender for these works is recommended. Full details of the temporary works should be provided in the contractor's method statements.

10.4.8 The unloaded clays at/beneath formation level will readily absorb any available water which would lead to softening and loss of strength. It will therefore be important to ensure that the clays at formation level are protected from all sources of water as described in paragraph 10.3.3.

10.4.9 A provisional 'bottom-up' construction sequence has been provided by Mitchinson Macken (see Drg No.19313/101). Multi-level propping must be maintained in Stage 5 of that sequence and full width lower props should be included in Stages 6 to 8, in addition to the high level props, in order to minimise forward movement of the retaining walls (and thereby minimise potential damage to the adjacent properties, in particular to No.1g Parsifal Road). This methodology can only be preliminary, because the appointed contractor will be responsible for the temporary works and preparation of the final Construction Phase plan.

<u>Geotechnical Design - Retaining Walls:</u>

10.4.10 Design of the retaining walls for the basement must include all normal design scenarios (sliding, over-turning and bearing failure), and must take into consideration:

- Earth pressures from the surrounding ground (see paragraph 10.4.11 below);
- Dead and live loads from the superstructure;
- Loads from all adjacent walls in No.1g Parsifal Road which are founded within the relevant active earth pressure zone;
- Vehicle loads on the driveway around three sides of the basement and normal surcharge allowances elsewhere;
- Swelling displacements/pressures from the underlying clays;
- Lateral heave forces resulting from the loss of the Willow and Copper Beech trees;
- Design groundwater levels and hydraulic uplift forces on the basement structure, as described more fully in paragraphs 10.2.8 and 10.2.9;
- Precautions to protect the concrete from sulphate attack.

10.4.11 The following geotechnical parameters should be used when calculating earth pressures:

Made Ground (clays):	Unit weight, γ_b:	18.0 kN/m^3
	Effective cohesion, c':	0 kPa
	Angle of internal friction, φ':	25°
London Clay Fm:	Unit weight, γ_b:	20.0 kN/m^3
	Effective cohesion, c':	0 kPa
	Angle of internal friction, φ':	22°

Coefficient of earth pressure at rest, k_0: up to 2.5-3.0 where undisturbed (varies with depth); the extent to which this stress is released when the retaining walls are excavated depends on the stiffness of the temporary and permanent support, but might typically reduce to around k_0 = 1.0.

These parameters should be used in conjunction with appropriate partial factors, dependent upon the design method selected.

Geotechnical Design - Bearing Capacity:

10.4.12 Stiff to very stiff silty CLAYS are expected at the founding level (formation) of the retaining walls and basement slab. Shear strengths for these soils measured in-situ using a hand shear vane were in excess of the 140kPa maximum range of the vane, however shear vane readings do not reflect the influence of fissures/shears in these clays. Accordingly, it is recommended that a conservative undrained cohesion, Cu, value of 100kPa should be adopted for design purposes.

10.4.13 Based on the derived undrained cohesion value given above, the maximum allowable bearing pressure for the retaining structures would be **170kPa** for up to 25mm settlement (long-term) based on a bearing capacity factor, N_c = 5.2 (after Skempton, 1951, for a strip footing with no adjacent surcharge) and a factor of safety, F = 3. This allows for the temporary situation when the central area within the underpins is excavated prior to casting the central basement slab.

Trees:

10.4.14 Significant desiccation has been identified in TP3, which was located close to where a 20m high Willow tree had recently been removed, and where trees remained within 4+ m. The Willow was approximately 8.0m from the nearest corner of the proposed basement; guidance from the NHBC (NHBC Standards, 2020, Chapter 4.2) indicates that engineer-designed foundations greater than 2.5m deep are required at that distance from the Willow. As the basement will be founded at 3.95m below ground level at that corner, it is unlikely that removal of the Willow will result in heave forces underneath the basement, though lateral heave pressures are likely and these must be allowed for.

10.4.15 The exact former location of the fallen Copper Beech tree in the rear garden of No.1 Parsifal Road is not known, but it could have been only 6.0-6.5m from the front wall of the proposed basement. As Beech trees are a Moderate water demand species, NHBC guidance would require a 1.85m founding depth at this distance from the tree, so once again it is unlikely that heave forces will develop underneath the basement, though lateral heave pressures are likely and must be allowed for.

10.5 PDISP Heave/Settlement Assessment

Basement Geometry and Stresses:

10.5.1 Analyses of the vertical ground movements (heave or settlement) have been undertaken using PDISP software in order to assess the potential magnitudes of movements which may result from the changes in vertical stresses caused by excavation of the basement. The horizontal forces acting on the retaining walls have not been modelled, so the stress regime has been simplified.

10.5.2 Figure G1 in Appendix G illustrates the layout of the PDISP zones used to model the proposed underpins, lightwell and basement slab overlaid on the proposed basement foundation layout from Mitchinson Macken's drawing No.19313/102 rev.A. The load takedown data for the proposed building are given on the same drawing which, for clarity, is reproduced in Figure G2.

10.5.3 The overall dimensions of the basement excavations are approximately 11.85m wide by 19.1m long (both including 200mm heels to the retaining walls, as per Michinson Macken's preliminary design). The founding depth of the underpins was taken as **71.05m AOD**, the basis for which is set out in paragraphs 3.3 to 3.5. The existing ground levels within the footprint of the proposed basement vary by only 0.23m and do not follow a regular pattern, so a single average depth of excavation was used in calculations of net bearing pressures (see paragraph 3.5).

10.5.4 Table 3 presents the **net** bearing pressures which will result from the basement works for all the primary PDISP zones during the four major stress states associated with these works (see 10.5.7 below for details), and the **gross** loading values for the superimposed zones. All applied pressures were calculated from Mitchinson Macken's load takedown, together with the calculated self-weight of the retaining walls and the internal columns/piers and party wall. The loads/pressures acting on the top of the basement slab (with excavation dimensions applicable to the stems of the retaining walls) were applied over the larger areas of the basement slab in order to allow for the proposed retaining wall heels (together with the net load from the slab itself). As this is a new build project, a 'bottom-up' construction sequence has been assumed to apply, so the superstructure loads were only added to the model in Stages 3 & 4.

Table 3: Bearing pressure changes for PDISP Zones				
ZONE #	TYPE	Change in vertical pressure (kPa)		
		Stage 1	Stage 2 (Full excv'n)	Stages 3 and 4
1	Retaining wall base	-44.00	-44.00	-44.00
2	Retaining wall base	-51.83	-51.83	-42.19
3	Retaining wall base	-51.02	-51.02	-38.52
4	Retaining wall base	-52.20	-52.20	-40.77
5	Retaining wall base	-44.37	-44.37	-44.37
6	Retaining wall base	-51.02	-51.02	-38.52
7	Retaining wall base	-51.83	-51.83	-42.19
1A	Ret'ng wall stem & Excv'n	-50.99	-50.99	-50.99
2A	Ret'ng wall stem & Excv'n	-56.29	-56.29	-46.17
3A	Ret'ng wall stem & Excv'n	-56.29	-56.29	-42.96
4A	Ret'ng wall stem & Excv'n	-57.22	-57.22	-45.10
5A	Ret'ng wall stem & Excv'n	-51.65	-51.65	-51.65
6A	Ret'ng wall stem & Excv'n	-56.29	-56.29	-42.96
7A	Ret'ng wall stem & Excv'n	-56.29	-56.29	-46.17
8	Basement slab	0.00	-65.00	-65.00
9	Basement slab	0.00	-65.00	-65.00
10	Basement slab	0.00	-65.00	-65.00
11	Superimposed load	0.00	0.00	39.44
12	Superimposed load	0.00	0.00	31.66
13	Superimposed load	0.00	0.00	58.66
14	Superimposed load	0.00	0.00	37.08

(light blue) : Equivalent pressures at top of slab - NOT used in PDISP analyses.
(light orange) : Only self-weight applied where building superstructure will be constructed after the basement retaining walls.

<u>Ground Conditions:</u>

10.5.5 The ground profile was based on the site-specific ground investigation, as presented in Sections 9 and 10.1 above, and the desk study information in Section 4.

10.5.6 The short-term and long-term geotechnical properties of the soil strata used for the PDISP analyses are presented in Table 4, based on this investigation and data from other projects.

Table 4: Soil parameters for PDISP analyses				
Strata	**Level** (m AOD)	**Undrained Cohesion,** Cu (kPa)	**Short term, undrained Young's Modulus,** Eu (MPa)	**Long term, drained Young's Modulus,** E' (MPa)
Weathered London Clay & London Clay	71.05 47.00	100 244	50 122	30 73

Where:

For Weathered London Clay and London CLAY:

Undrained Shear Strength, Cu at top of stratum (100 kPa) is based on conservative interpretation of 140+ kPa shear vane readings.
Undrained Shear Strength within stratum assumed to increase linearly at 6z kPa/m
where z = depth below the top of the stratum.
Undrained Young's Modulus, Eu = 500 * Cu
Drained Young's Modulus, E' = 0.6 * Eu

PDISP Analyses:

10.5.7 Three dimensional analyses of vertical ground movements in response to construction of the proposed basement extension have been undertaken using PDISP software and the basement and ground floor geometries, loads/stresses and ground conditions outlined above. PDISP analyses have been carried out as follows:

- Stage 1: Excavation for and construction of all perimeter retaining walls – Short-term (undrained) condition
- Stage 2: Excavation of central area of basement and construction of basement slab – Short-term condition
- Stage 3: Construction of internal basement walls/columns/piers and all superstructure (ie: completion of the development) – Short-term condition
- Stage 4: As Stage 3, except – Long-term (drained) condition

10.5.8 The results of the analyses for Stages 1-4 are presented as contour plots on the appended Figures G3 to G6 respectively.

Heave/Settlement Assessment:

10.5.9 The proposed works will cause immediate elastic displacements (settlement/heave) in response to the stress changes, followed by long-term plastic deformations (primarily swelling in this case) as the pore water pressures in the over-consolidated clays, which underlie the site, adjust to the stress changes. The rate of plastic swelling will be determined by the availability of water and the permeability of the soils concerned; the low permeability of the London Clay typically results in these adjustments taking many decades to reach full equilibrium. The retaining walls and basement slab will need to be designed so as to enable them to accommodate the swelling displacements/pressures developed beneath them and the resultant distortions.

10.5.10 The ranges of predicted short-term and long-term movements for each of the main parts of the proposed basement are presented in Table 5 below. The predicted displacements have been rounded to the nearest 0.5mm. These analyses predicted heave beneath the entire basement in all stages, with displacements of up to 8.5mm being predicted, and differential displacements up to 7mm. The load takedown did not provide separate loadings for the columns/piers which will form part of the front and rear walls, so it remains possible that local settlements and greater differential movements will be experienced along these walls.

10.5.11 The range of displacements quoted in Table 5 cover approximately the full range of predicted deflections, however the stiffness of the retaining structures is likely to reduce the range of displacements actually experienced.

10.5.12 The findings show that the 'bottom-up' construction sequence will result in the initial heave, which occurs during Stages 1 & 2, being reversed as the superstructure is built and generates elastic settlements (Stage 3) before the long-term plastic swelling results in renewed heave movements (Stage 4).

Table 5: Summary of predicted displacements

Location	**Stage 1 (Figure G3)**	**Stage 2 (Figure G4)**	**Stage 3 (Figure G5)**	**Stage 4 (Figure G6)**
Front lightwells (Zone 1)	1 – 3.5mm Heave	1.5 – 4.5mm Heave	1 – 3mm Heave	2 – 5mm Heave
Front wall (Zones 11 & 12)	Not present	Not present	2 – 3mm Heave	2 – 5mm Heave
NW flank wall (left side) (Zones 2-4)	1.5 – 3.5mm Heave	2 – 6mm Heave	1.5 – 4.5mm Heave	2.5 – 7.5mm Heave
SE flank wall (right side) (Zones 6 & 7)	1.5 – 3.5mm Heave	1.5 – 6mm Heave	1 – 4.5mm Heave	2 – 7.5mm Heave
Rear lightwells (Zone 5)	1 – 3.5mm Heave	1 – 5mm Heave	1 – 4.5mm Heave	1.5 – 7mm Heave
Party wall (Zone 13 & part of Zones 12 & 14)	Not present	Not present	2.5 – 4.5mm Heave	4.5 – 7mm Heave
Central basement slab (Zones 8-10)	Not present	4.5 – 6.5mm Heave	3 – 5mm Heave	5 – 8.5mm Heave

10.6 Damage Category Assessment

10.6.1 When retaining walls are built in traditional underpinning sequence, it is inevitable that the ground will be un-supported or only partially supported for a short period during the excavation of each pin, even when temporary support is installed sequentially as the excavation progresses. This means the behaviour of the ground will depend on the quality of the workmanship and suitability of the methods used, so rigorous calculations of predicted ground movements are not practical. However, provided that the temporary support follows best practice as outlined in Section 10.4, then extensive past experience has shown that the bulk movements of the ground alongside a single-storey basement (typical depth 3.5m) should not exceed 5mm horizontally.

10.6.2 In order to relate these typical ground movements to possible damage which adjoining properties might suffer, it is necessary to consider the strains and angular distortion (as a deflection ratio) which they might generate using the method proposed by Burland (2001, in CIRIA Special Publication 200, which developed earlier work by himself and others).

10.6.3 The potentially critical locations will be determined by the displacements predicted by the PDISP analyses and the geometries of the adjoining buildings. For these damage category assessments, we are interested in the ground movements at the foundation level of the neighbouring buildings, whereas the empirical data for ground movements alongside excavations presented in CIRIA Report C760 (Gaba et al, 2017) concerns movements at ground surface (and presents data for embedded retaining walls, but, as no equivalent data exist for underpins, this data is deemed the best available, though it must be interpreted very cautiously).

10.6.4 The neighbouring No.1e obtained planning consent for a full footprint basement in 2014 (application No.2013/5125/P). The associated superstructure works all appear to have been completed, so it is reasonable to assume that the basement has also been constructed (which should be confirmed during detailed design). The planned depth of No.1e's basement was greater than the depth of the one currently proposed (see paragraph 10.2.4), and the two buildings will be separated by the width of the driveway, so the proposed basement works are not expected to cause any ground movements beneath No.1e.

10.6.5 The proposed houses will be approximately 1.15m from the south-east flank wall of No.1g Parsifal Road, so the heel of the basement retaining wall will be approximately 0.95m from No.1g. On the assumption that No.1g has typical 0.6m wide, 1.0m deep footings then the gap between the two structures would be 0.8m. The worst-case wall geometry in No.1g applies to all three of the transverse walls which extend into the single-storey section, with the upper (first floor) part of those walls ignored. Heave movements around a basement excavation are beneficial because they offset (either partly or wholly) the settlements caused by relaxation of the ground around the basement, so the rear wall of No.1g represents the critical location for that house.

10.6.6 The rear wall of the proposed houses would be slightly forward of the retaining wall at the rear of the car parking bays beneath No.1g's garden (the centreline of that wall is approximately 2.25m behind the rear wall of No.1g). That retaining wall has been estimated to be founded at or below 72.8m AOD (see paragraph 10.2.4), which is above the level of the currently proposed basement, so potential damage to that wall also needs to be considered. However, the greater height of the wall and the reduced depth of excavation required relative to the parking bays means that, by inspection, it is apparent that this retaining wall would be significantly less vulnerable to damage than the rear wall of No.1g.

10.6.7 The rear wall of Parsifal House is approximately 22.5m/25.0m from the proposed basement, so, based on the case-history data published in CIRIA Report C760, Parsifal House is beyond the range of predicted ground movements associated with the proposed basement.

10.6.8 Thus, a single damage category assessment has been undertaken for the critical rear wall of No.1g as identified above. This assessment considered:

- ground movements alongside the proposed retaining wall caused by relaxation of the ground in response to the excavations, using empirical data from monitoring of large retaining walls during construction, as presented in CIRIA Report C760 (see 10.6.3 above);
- ground movements arising from the vertical stress changes, as assessed by the PDISP analyses (see Section 10.5), including an allowance for the stiffness of the foundations. Only the post-construction displacements (between Stages 3 & 4 of the PDISP analyses) have been considered, because the CIRIA data includes all movements during construction.

Ground movements associated with the construction of retaining walls in clay soils have been shown to extend to a distance up to 3.5 to 4 times the depth of the excavation.

<u>Rear wall of No.1g Parsifal Road:</u>

10.6.7 The relevant geometries, based on information in Section 3, the site-specific ground investigation (see Section 9 and Appendix F), and the relevant drawings for No.1g (see 2.11) are:

Depth of excavation alongside rear wall = **4.125m** (from the 75.175m AOD ground level at rear of No.1g – see plan attached to No.523 Finchley Road's planning application 2007/6200/P).

Width, horizontal movement = 4.125 x 4 = **16.5m**, so will extend beyond this 10.4m long wall. Horizontal movements are typically linear, so generate no deflection.

Width, settlement = 4.125 x 3.5 = **14.4m**, so will also extend beyond the far end of this wall.

Width (L) of rear wall of No.1g = **10.4m**, at 0.8-11.2m from the basement
Depth of foundations = **1.0m** (assumed, as this is a modern house founded on clays)
Height (H) = 3.6 (to upstand around roof terrace) + 1.0 = **4.6m**
Hence L/H = **2.26**

10.6.8 The typical horizontal displacement value becomes 5.9mm once adjusted for the additional depth of excavation. When combined with the geometry recorded above, indicates that the horizontal strain beneath No.1g is likely to be in the order of ε_h = 3.58 x 10^{-4} (0.036%).

10.6.9 The settlement caused by relaxation of the ground alongside the basement, in response to excavation of the retaining wall, can be estimated using the settlement profile for the worst case (low stiffness) scenario presented in Figure 6.15b of CIRIA Report C760. This CIRIA data should be combined with the long-term movements predicted by the PDISP analysis, between Stage 3 (short-term) and Stage 4 (long-term); the settlement profiles are then summed to find the maximum deflection, Δ. Figure 10 presents these settlement profiles for the rear wall of No.1g. The maximum Δ = 0.7mm, which represents a deflection ratio, Δ/L = 6.7 x 10^{-5} (0.007%).

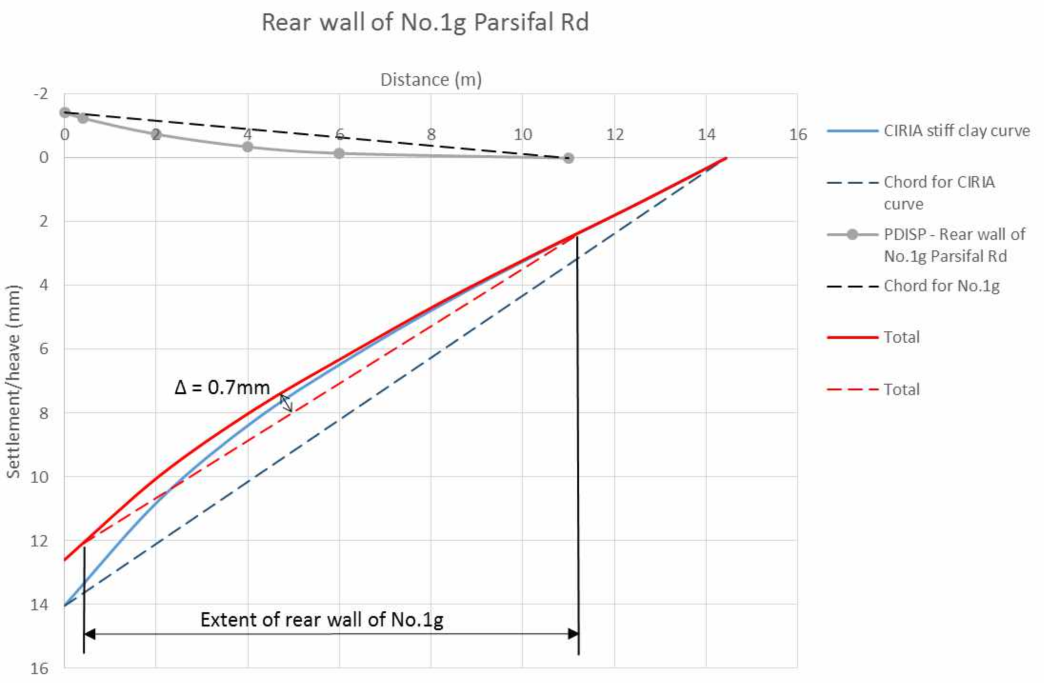


Figure 10: Displacement profile for rear wall of No.1g Parsifal Road.

10.6.10 Using the graphs for L/H = 2.0 these deformations represent a damage category of 'negligible' (Burland Category 1, ε_{lim} = <0.05%), as given in CIRIA SP200, Table 3.1, and illustrated in Figure 11 below.

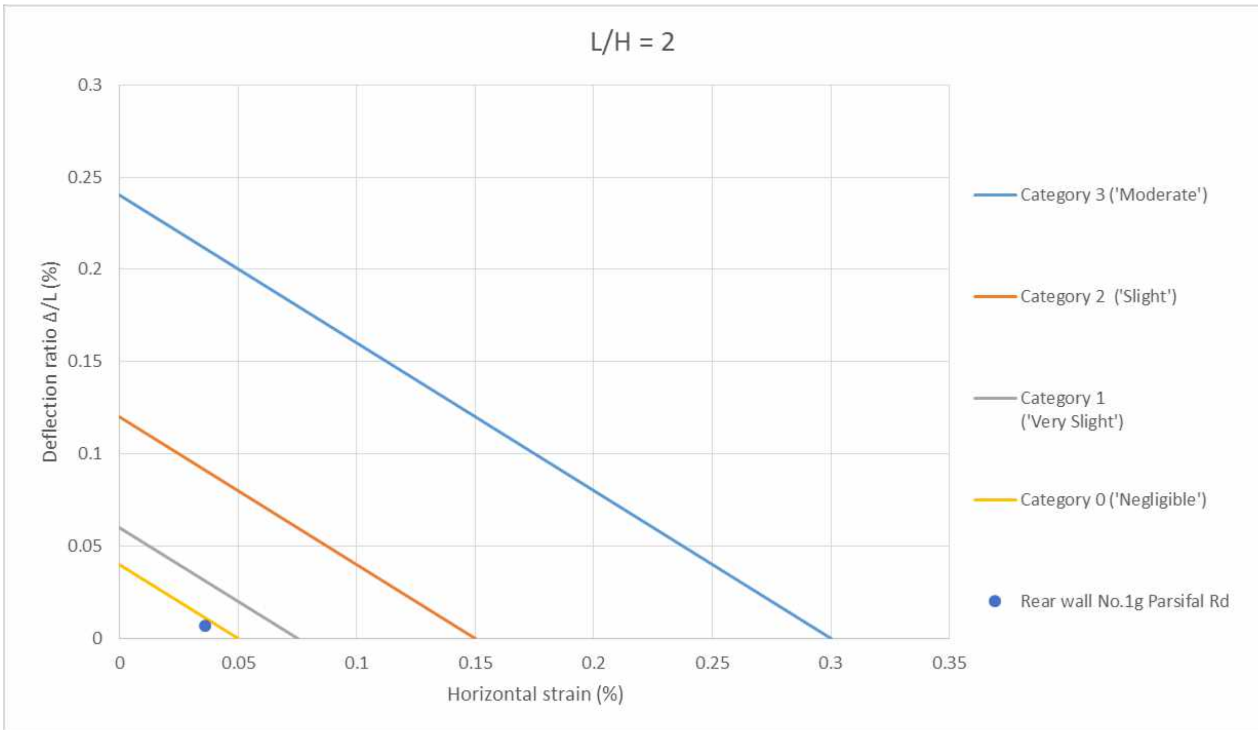


Figure 11: Damage category assessment for rear wall of No.1g Parsifal Road.

10.6.15 Use of best practice construction methods, as outlined in Section 10.4, will be essential in order to ensure that the ground movements are kept in line with the above predictions. In particular, the provisions of Section 10.4.9, in relation to propping of the excavation during 'bottom-up' construction, need to be observed.

10.7 Monitoring

10.7.1 A condition survey should be undertaken for No.1g Parsifal Road, the only potentially vulnerable neighbouring property, before the works commence, in order to provide a factual record of any pre-existing damage. No.1e is not considered to be vulnerable because its full footprint basement is already founded deeper than the currently proposed new basement (see 10.2.4). Such surveys are usually carried out while negotiating the Party Wall Award and are beneficial to all parties concerned.

10.7.2 Precise movement monitoring should be undertaken weekly throughout the period during which the basement retaining walls and slab are constructed, with initial readings taken before excavation of the basement starts. Readings may revert to fortnightly once all the perimeter walls and the base slab have been completed, and may terminate three months after the new basement slab has reached working strength, the formwork has been struck and all temporary support has been removed, provided that there are no progressive on-going movements. This monitoring is commonly undertaken with a total station instrument and targets attached at a minimum of two levels; the following locations are recommended:

- externally, at three equally spaced locations on the south-east flank wall of No.1g Parsifal Road;
- externally, at three locations (both ends and middle) on the upstand above the boundary retaining wall which supports No.1g's raised rear garden over No523's covered parking (one target at each location);
- at the client's discretion, since outside the Party Wall Agreements, if the replacement garages have been built before the basement is excavated, then monitoring could also be installed on the front end of two or three of those garage walls.

10.7.3 The wall movements detected by the monitoring exercise may be caused by rotation, flexing without cracking, or lateral movements transverse to the plane of the wall. Movements such as these which occur without cracking would all fall within Burland's Category 0, so a twin-track approach to the monitoring will be required, combining both the target monitoring as proposed above and visual observations. Daily inspections of the subject property and external walls of the adjoining buildings should be made and recorded by a member of the contractor's staff. If any new structural cracks appear in the main load-bearing walls, then the appointed Structural Engineer should be informed and those cracks should be monitored using the Demec system (or similar) on the same frequency as the target monitoring. Additional targets might also be installed, at the engineer's discretion, depending on the location of the cracks.

10.7.4 While monitoring readings from this system are typically presented to the nearest 0.1mm, the accuracy (repeatability) is usually quoted as +/-2mm or +/-1.5mm. Thus, if recorded movements in either direction reach 5mm (amber trigger level), then the frequency of readings should be increased as appropriate to the severity of the movement, and consideration should be given to installing additional targets. If recorded movements in either direction reach 8mm (red trigger level), then work should stop until new methods statements have been prepared and approved by the appointed Structural Engineer. Local temporary backfilling of the excavation adjacent to the movement of concern may be required.

10.8 Surface Flow and Flooding

Flooding from Rivers, Sea & Reservoirs:

10.8.1 The evidence presented in Section 5 has shown that:

- the site lies within the Environment Agency's Flood Zone 1, which means that it is considered to be at negligible risk of fluvial flooding (from rivers or sea), and is classified as having a Very Low risk of fluvial/tidal flooding under the Environment Agency's Risk of Flooding from Rivers or Seas (RoFRaS) dataset (paragraph 5.5);
- the site is not at risk of flooding from reservoirs, as mapped by the Environment Agency (paragraph 5.6);
- there are no flood defences, no areas benefitting from flood defences and no flood storage areas within 250m of the site.

Surface Water (Pluvial) Flooding:

10.8.2 There are no natural surface water features within 250m of the site (paragraph 5.7).

10.8.3 The *'Floods in Camden'* report (LBC Floods Scrutiny Panel, 2003) and Arup's 2010 guidance document (Camden GHHS) record that Finchley Road was flooded in the 2002 local pluvial flood event, but not in 1975, although the extent of the road affected was probably limited and remote from these properties (see Figure 5 above).

10.8.4 The Camden Strategic Flood Risk Assessment (SFRA, by URS, 2014) shows that the site is within Critical Drainage Area 'Group3_010' (see Figure 7) though it is (just) outside the Cannon Hill Local Flood Risk Zone. CDAs include both source areas and flood-prone areas; the evidence presented above and below indicates that the site is in a source area for flooding elsewhere and is **not** in a flood-prone area.

10.8.5 The current risk of surface water (pluvial) flooding within the site and the adjoining properties is indicated to be 'Very Low' by the Environment Agency's latest modelling (see Figure 6 and paragraph 5.7). This is the lowest category which represents the national 'background' level of risk. Surface water flood risk on the adjacent part of Finchley Road is also shown as 'Very Low' (increasing to 'Low' risk immediately to the east of Parsifal House, from where the run-off drains down Lyncroft Gardens and, primarily, Cannon Hill (which follows the former alignment of the Westbrook tributary), though that is irrelevant for the proposed basement). The modelling by Ambiental Risk Analytics also shows the site to be at no elevated risk of flooding by surface water, but, in complete contrast to the Agency's modelling, Ambiental's model has the flow route of the former Westbrook tributary aligned with the terrace of shops which includes No's 519/519a and No's 1e & 1f Parsifal Road, with the highest flood risk in the garden to No.1f, which is lower than No.1e (Appendix E, Section 8). The degree of difference between these models is unusual, but does not affect the 'Very Low' risk for the proposed basement's site.

10.8.6 The following flood resistance measures should be implemented in order to enable the site's current 'Very Low' risk rating to be retained:

- Provision of upstands to the retaining walls which will form the front and rear lightwells in order to prevent surface water draining into the lightwells. The height of this upstand could be nominal (say 50mm) for the front lightwell where the ground slopes away from the lightwells, and could be achieved with ramps rather than vertical steps up. For the rear lightwells the upstands should be at least 100mm high, unless the dwarf walls as described below are also provided.
- Provision of dwarf walls beneath the fences around the rear gardens, in order to prevent runoff from the driveway to the new garages entering the 'new' properties' gardens.

Change to Hard Surfacing & Surface Water Run-off:

10.8.7 The plots for the two houses are currently fully paved or built over, with the exception of a narrow strip of gravel surfacing alongside the boundary with No.1g (see Photo 4). The inclusion of extensive green roofs, an important Sustainable Drainage Systems (SuDS), will, by inspection, more than offset the small area of gravel surfacing, so there will be a beneficial net reduction in paved surface area.

Sewer Flooding:

10.8.8 The Camden SFRA noted that Thames Water's DG5 Flood Register had only one record of flooding from public sewers affecting this post code area ('NW6 1', and none in 'NW3 7', see 5.11). However, no drainage system can be guaranteed to have adequate capacity for all storm eventualities and all drainage systems only work at full capacity when they are properly maintained, including emptying gullies and regular checks of the sewers themselves for condition and blockages. Maintenance of the adopted sewers is the responsibility of Thames Water, so is outside the Applicant's control and largely outside of the Council's influence. The probability of future sewer flooding affecting the proposed basement is considered to be very low, provided that the sewer system is well maintained and appropriate flood resistance measures are implemented, as set out below.

10.8.9 Drainage systems are designed to operate under 'surcharge' at times of peak rainfall, which means that the level of effluent in the sewers may rise to ground level. When this happens, the effluent can back-up into un-protected properties with basements and lower ground floors. During major rainfall events, it is possible for some sewers to overflow at ground level, although this is rare.

10.8.10 Camden's CPG Basements requires all basements to be "*protected from sewer flooding by the installation of a positive pumped device*" (paragraph 6.16 in CPG, 2018). Non-return valves and pumped loop systems must therefore be fitted on the drains serving the basements and lightwells, in order to ensure that water from the mains sewer system cannot enter the basements when the adjacent sewer is operating under surcharge. All drains which discharge via the same outfall as the basements must be protected, including those carrying foul water, roof water, and surface water from the lightwells. A battery-powered reserve pump should be fitted to ensure that the system remains functional during power cuts.

10.8.11 The pumped loops must rise high enough to create sufficient pressure head to open the non-return valves when the mains sewer flow is surcharged to ground level, otherwise the basement would once again be vulnerable to flooding while the surcharged flow continues. If it is not possible to achieve a sufficient rise of the loop then temporary interception storage would be required, to hold temporarily the predicted maximum volume of water from all relevant sources which discharge via the valve-protected outfall(s) (including surface water from the various roofs, lightwells, and foul water), for the duration of the predicted surcharged flows in the sewer. This temporary interception storage would require formal design to ensure satisfactory performance.

10.9 Mitigation

10.9.1 The following mitigation measures should be implemented as appropriate:

- In the unlikely event that the basement excavations encounter, and would completely obstruct, a local deposit of more permeable soils containing mobile groundwater, then an engineered groundwater bypass might be required (10.2.7).
- Provision of upstands to the retaining walls around the lightwells (10.8.6).
- Optionally, provision of dwarf walls beneath the perimeter fences around the rear gardens (10.8.6).
- Inclusion in the scheme, as already proposed, of green roofs which are a widely used type of sustainable drainage system (SuDS) (10.8.7).
- Non-return valves and pumped above-ground loop systems should be fitted to the drains serving the basements and lightwells, in order to ensure that water from the sewer system cannot enter the basements when the mains sewer is operating under surcharge (10.8.10 & 10.8.11).

11. NON-TECHNICAL SUMMARY – STAGE 4

11.1 This summary considers only the primary findings of this assessment; the whole report should be read to obtain a full understanding of the matters considered.

11.2 Private services within the site should be located before the garages are demolished (10.1.3).

11.3 The proposed basement is considered acceptable in relation to the likely limited seepage of groundwater through the essentially clayey Made Ground and the weathered London Clay, especially as the Made Ground is already substantially obstructed by No.523's lower ground floor and parking area retaining walls, and the foundations to Parsifal House. There are no basements close enough to create any additional cumulative effect (10.2.1 to 10.2.6). In the unlikely event that the excavations encounter a local deposit of more permeable soils which has remained undetected, then it is possible that an engineered groundwater bypass might be required (10.2.7).

11.4 A design groundwater level equal to ground level is recommended, which means that the basement must be able to resist buoyant uplift pressures (un-factored) of up to 40kPa (10.2.8, 10.2.9). The basement will need to be fully waterproofed (10.2.10, 10.2.11).

11.5 Water entries into the basement excavations are likely to be manageable by sump pumping (10.3.1). The clays onto which the underpins and the basement slab will bear must be blinded with concrete immediately following excavation and inspection (10.3.3).

11.6 There are no concerns regarding slope stability (10.4.1).

11.7 The basement's perimeter RC retaining walls will be constructed using a 'bottom-up' underpinning methodology in panels of limited width. Use of best practice methods and high stiffness temporary support systems, installed in a timely manner, will be crucial to the satisfactory control of ground movements around the basement (10.4.2 to 10.4.8). Additional propping should be incorporated in Mitchinson Macken's provisional construction sequence (10.4.9).

11.8 Various other guidance is provided in relation to the geotechnical design of the basement's perimeter walls (10.4.10, 10.4.11).

11.9 A net bearing pressure of 170kPa may be used for the underpins and RC retaining walls (10.4.12, 10.4.13).

11.10 Desiccation attributed to a recently removed Willow tree is not expected to cause heave beneath the basement, but is likely to generate lateral heave pressures on the adjacent part of the basement retaining walls. Similar lateral pressures may affect the front wall of the basement as a result of the loss of the Copper Beech from the rear garden of No.1 Parsifal Road (10.4.14).

11.11 The basement slab must be designed to accommodate swelling displacements/ pressures generated by heave of the underlying clays. A preliminary heave/ settlement assessment has been undertaken (using PDISP software) which predicted heave beneath the entire basement in all stages, with displacements of up to 8.5mm and differential displacements up to 7mm. The load takedown did not provide separate loadings for the columns/piers which will form part of the front and rear walls, so it remains possible that local settlements and greater differential settlements will be experienced there. (Section 10.5).

11.12 A single damage category assessment was undertaken for the rear wall of No.1g Parsifal Road, which was assessed to be the potentially most vulnerable wall in the adjacent properties. The results indicated that, provided best practice construction methods are employed, the worst case predicted deformation affecting No.1g is likely to fall within Burland Category 0, termed 'negligible' (Section 10.6).

11.13 A condition survey of the neighbouring No.1g should be commissioned and a programme of monitoring that house, and the canopy which supports its garden over the covered parking bays to No.523 Finchley Road, should be established before the works start (Section 10.7).

11.14 The Environment Agency's maps show that the site is at negligible risk of flooding from rivers or the sea, and at no risk of flooding from reservoirs (10.8.1).

11.15 Finchley Road is recorded as having flooded during the 2002 event, but not in 1975, and that flooding was probably remote from Parsifal House (10.8.3). The Camden SFRA shows that Parsifal Road is within Critical Drainage Area 'Group3_010'; and just outside the Cannon Hill Local Flood Risk Zone. Other evidence presented herein indicates that the site is **not** in a flood-prone area (10.8.4).

11.16 The Environment Agency's modelling of risk of flooding from surface water predict a Very Low flood risk for the site and the neighbouring properties. Modelling by Ambiental Risk Analytics also gave no elevated risk of surface water flooding for the site (other than two tiny areas at the front of Parsifal House which are considered inappropriate), but predicted a completely different alignment of the flow route down the 'valley' feature, and affecting No's 1e & 1f Parsifal Road but not the plots for these proposed houses (10.8.5). Recommendations are given for flood resistance mitigation measures to maintain the site's Very Low risk of surface water flooding (10.8.6).

11.17 The development will result in a significant net beneficial decrease in paved surface area, owing to the inclusion of extensive green roofs (10.8.7).

11.18 Thames Water had have only a single record of flooding from public sewers affecting postcode area 'NW6 1' and none in 'NW3 7', so the probability of future sewer flooding affecting the proposed basements is considered to be very low, provided that the sewer system is well maintained and appropriate flood resistance measures are implemented (10.8.8).

11.19 Non-return valves and pumped above-ground loop systems should be fitted to the drains serving the basements and lightwells. Temporary interception storage may also be required, with sufficient capacity for the predicted maximum volume of discharges (from all sources) via the 'protected' outfall pipe(s), for the duration of the predicted surcharged flows in the sewer; formal design would be required (10.8.9 to 10.8.11).

11.20 Mitigation measures which have been recommended in Sections 10.2-10.8 are summarised in Section 10.9.

References

Arup (November 2010) Camden geological, hydrogeological and hydrological study – Guidance for subterranean development. Issue 01. London.

Barton N (1992) The Lost Rivers of London. Historical Publications Ltd, London.

Barton N & Myers S (2016) The Lost Rivers of London. 3rd Edition. Historical Publications Ltd, London.

BS 1377-2 (1990) Methods of test for Soils for civil engineering purposes – Part 2: Classification Tests. British Standards Institution, London.

BS 5930 (2015) Code of practice for ground investigations. British Standards Institution, London.

BS 8002 (2015) Code of Practice for earth retaining structures. British Standards Institution, London.

BS 8102 (2009) Code of practice for protection of below ground structures against water from the ground. British Standards Institution, London.

BS EN 1997-1 (2004) +A1 (2013) Eurocode 7: Geotechnical Design – Part 1: General rules. British Standards Institution.

Ellison RA et al (2004) Geology of London. Special Memoir for 1:50,000 Geological sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales). British Geological Survey, Keyworth.

Gaba, A.R., Simpson, B., Powrie, W. and Beadman, D.R. (2003) CIRIA Report C580: 'Embedded retaining walls – guidance for economic design'. CIRIA, London.

Gaba, A.R., et al (2017) CIRIA Report C760: 'Guidance on embedded retaining wall design'. CIRIA, London.

London Borough of Camden (2003) Floods in Camden, Report of the Floods Security Panel.

London Topographical Society (2005) The London County Council Bomb Damage Maps 1939-1945. LTS Publication No.164.

NHBC (2020) NHBC Standards, Chapter 4.2, Building Near Trees.

NHBC (2020) NHBC Standards, Chapter 5.4, Waterproofing of basements and other below ground structures.

URS (2014) London Borough of Camden SFRA – Strategic Flood Risk Assessment. Final Report.