APPENDIX B

- Stephen Buss Environmental Consulting Ltd "Hydrology and Sub-surface Flow Screening Basement Impact Assessment" (Ref: 2019-003-065-002, 09/10/19)

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8 Daleham Gardens: Hydrology and Sub-surface Flow Screening Basement Impact Assessment

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The findings do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

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1. Introduction

1.1 Background

This report presents the screening stage of a basement impact assessment, focussed on hydrology and sub-surface flow, to be submitted in support of a planning application for the basement development at 8 Daleham Gardens, NW3 5DA (Figure 1.1, national grid reference TQ 2672 8480). The local planning authority is Camden Borough Council.

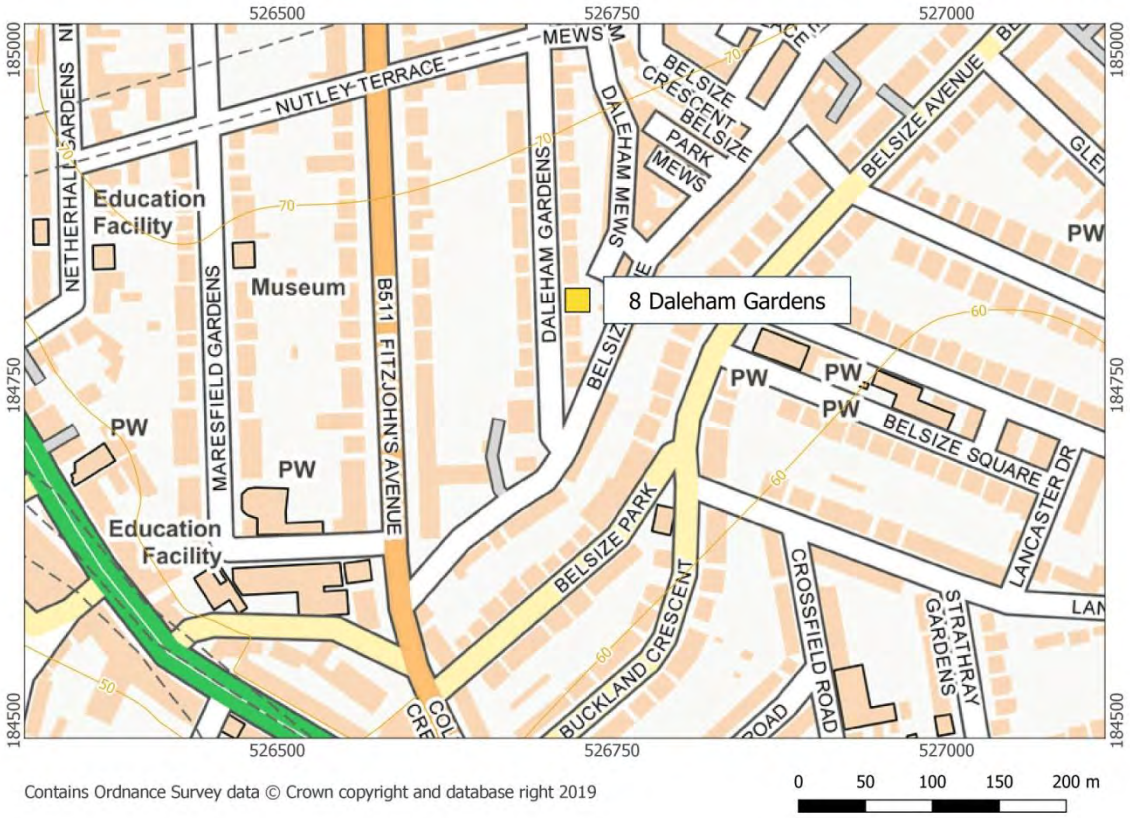

Figure 1.1 Location of 8 Daleham Gardens

1.2 The Site

The site at 8 Daleham Gardens currently comprises of a three-storey detached dwelling with a lower ground floor across part of the footprint. An undercroft is present beneath the north west corner of the building.

Daleham Gardens is a residential street consisting of large detached properties all constructed during the same period. The A41 (and Finchley Road underground station) is about 450 m to the west of the site and the Royal Free Hospital on the A502 is about 650 m to the north-east.

Ground in the area around 8 Daleham Gardens slopes to the south east, but the ground within the property boundaries slopes roughly eastwards. Based on Environment Agency LIDAR data at 1 m spatial resolution ground level at the western boundary of the property is 65.8 m AOD (adjoining the street). There is a lower lying terrace/patio area to the rear of the house at approximately 62.8 m AOD, which is level with the existing lower ground floor level.

1.3 Proposed Basement Works

According to architectural drawings from GL Studio, it is intended that the site will be developed by deepening the existing basement underneath the north-western corner of the current dwelling at 8 Daleham Gardens (Figure 1.2).

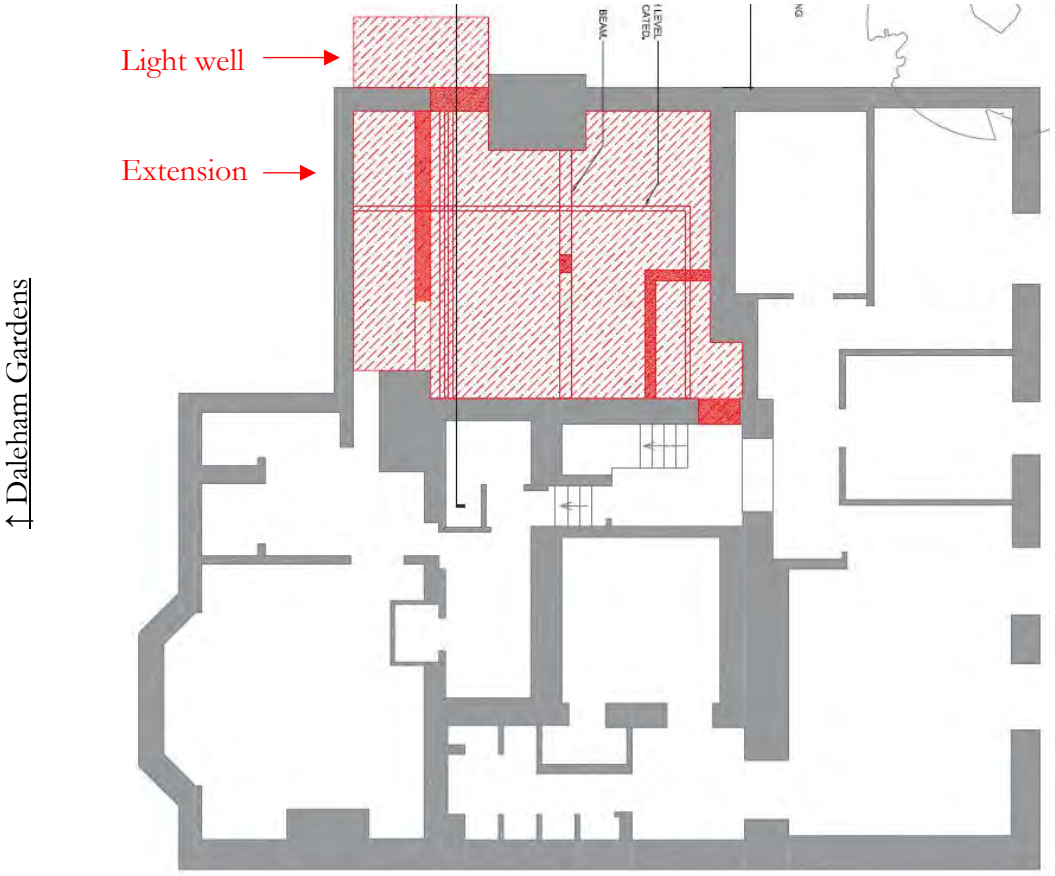

Figure 1.2 Site plan

Sections drawn by GL Studio (A100 and A300) show how the current undercroft floor is to be lowered by c. 1.4 m (Figure 1.3). An extension northwards outside the existing building footprint will be used to create a new external lightwell.

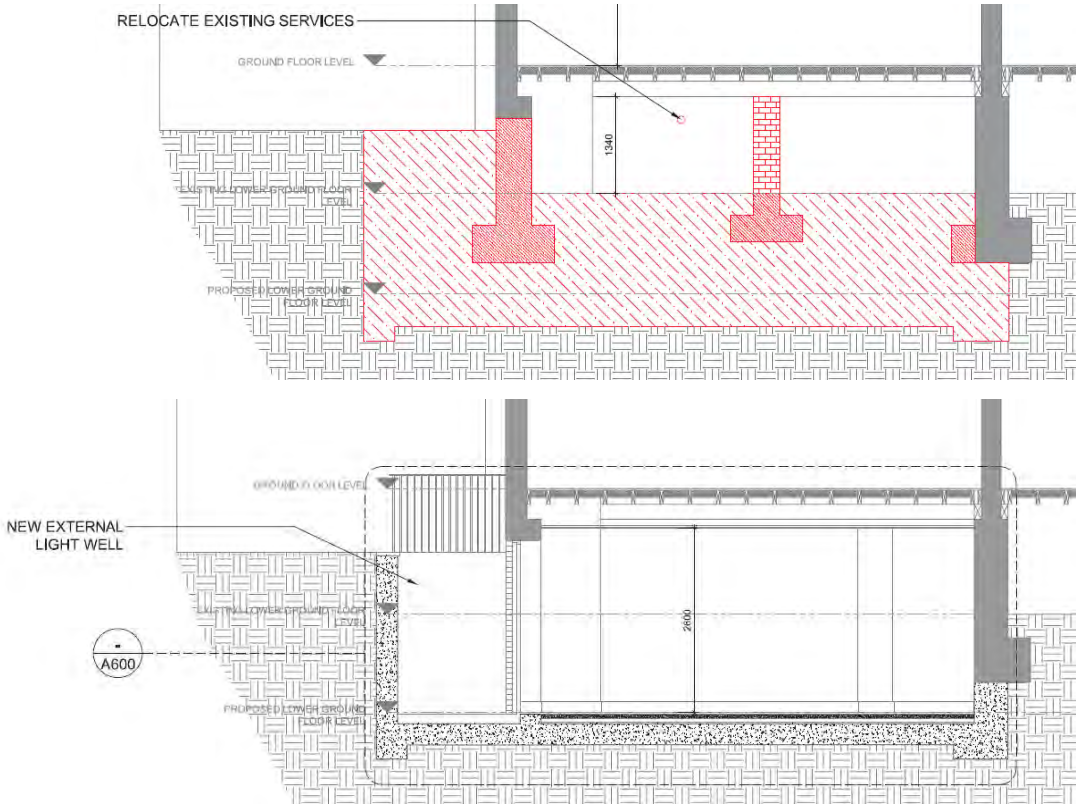

Figure 1.3 Draft cross-sections of existing (top) and proposed (bottom) basement works

1.4 Scope of Report

Stephen Buss Environmental Consulting Ltd was instructed in October 2019 to complete this report. This report presents the subsurface flow (groundwater) and surface water components of the basement impact assessment for the development that complies with CPG Basements screening, scoping and site investigation stages, and makes reference to the basement impact assessment guidance of ARUP (2010)[1].

[1] ARUP, 2010. Camden geological, hydrogeological and hydrological study. Guidance for subterranean development.

1.5 Authorship of Report

This report has been prepared by Dr Stephen Buss MA MSc CGeol. Dr Buss is a UK-based independent hydrogeologist with more than 18 years' consulting experience in solving groundwater issues for regulators, water companies and other private sector organisations. **Dr Buss is a Chartered Geologist with the Geological Society of London.** Dr Buss's CV and publications list is available at www.hydro-geology.co.uk.

Rupert Evans MSc CEnv C.WEM MCIWEM AIEMA is a UK-based independent hydrologist with more than 12 years' consultancy experience in flood risk assessment, surface water drainage schemes and hydrology/hydraulic modelling. **Mr Evans is a Chartered Water and Environmental Manager (C.WEM) and a Member of the Chartered Institution of Water and Environmental Management.**

2. Conceptual Site Model

2.1 Site History

On the earliest OS London Town Plan maps dating back to 1850-1851, the site of 8 Daleham Gardens is open land.

On the OS County Series 1:2500 map from 1871, the site is still undeveloped, but a stream (believed to be the River Tyburn) is marked running approximately north-south around 100 m to the west of the site, roughly along the line of the present Fitzjohns Avenue. The stream rises from a pond approximately 300 m to the north of 8 Daleham Gardens, at an elevation of about 82 m AOD. Approximately 100 m north of the pond, and at an elevation of about 88 m AOD is a 'conduit well'. This is now known as Shepherds Well, and is located on the junction between Akenside Road and Fitzjohn's Avenue and is considered to be the original source of the River Tyburn.[2,3]

The properties on Daleham Gardens, including the site at number 8, are all shown on the OS Town Plan of 1895. The stream and ponds shown on earlier maps are no longer marked. Since this time, the general environs of the site have not substantially changed.

2.2 Drainage and Topography

Based on Environment Agency LIDAR data elevation of the plot at 8 Daleham Gardens is between 65.8 m AOD at the western boundary of the property fronting the street and 62.8 m AOD at the back of the property on the eastern wall. Ground elevation to the north and south of the property is between 64.8 – 65.0 m AOD. The ground surface slopes roughly eastwards; the gradient calculated from the LIDAR data is about 0.15.

The area is in the upper catchment of the former River Tyburn (Figure 2.1 Locations of lost rivers around Daleham Gardens). The western tributary of the river lies approximately 130 m west of the site, where it flowed from Shepherds Well down Fitzjohn's Avenue. A second tributary of the River Tyburn flowed to the east of the site, along Belsize Avenue, originating approximately 650 m to the north-east behind Hampstead Town Hall[4]. The River Tyburn is now a 'lost river' and is largely culverted beneath the city[5] (Barton and Myers, 2016).

The nearest current surface water feature is the Hampstead Ponds chain, the closest of which is the Number 1 Pond, about 1.14 km to the north-east of the site. The former River Fleet flows from these ponds towards the south-east. The elevation of the Number 1 Pond is about 70 m AOD, so higher than the elevation of the site, but the land slopes down to the south-east, and so the former River Fleet flowed to the south-east, rather than towards the site.

[2] https://www.londonslostrivers.com/river-tyburn.html
[3] Arup, 2016. Redington Frognal Neighbourhood Forum, Red Frog Sub-surface Water Features Mapping, Summary Report.
[4] https://www.camden.gov.uk/documents/20142/1458280/Rivers+in+Camden.pdf/559155f8-645b-2e39-2669-3faacce135e6
[5] Barton, N. and Myers, S., 2016. The Lost Rivers of London 3rd Edition. BCA, London.

Figure 2.1 Locations of lost rivers around Daleham Gardens

2.3 Local basements

Details of recent basement developments in adjacent properties have been searched for via the Camden Planning Portal but none have been identified. However, it is considered that due to the comparable construction of properties along Daleham Gardens, neighbouring properties will have similar existing cellars to that found at the number 8.

In 2008, a planning application for 15 Daleham Gardens (opposite number 8) for the excavation of a basement level extension below rear garden was withdrawn. No drawings or ground investigations exist for this application (2008/2464/P).

Drawings from planning permission (TP/704/W/6114) granted with conditions in 1962 to sub-divide 13 Daleham Gardens into flats show the presence of a lower ground floor.

2.4 Geology and Hydrogeology

Mapped bedrock beneath the site comprises London Clay, although the Claygate Member crops out about 250 m to the north. The mapped boundary approximately follows a contour of c. 80 m AOD around the local hillside. The London Clay Formation comprises of poorly laminated blue-brown and grey-brown silty clay with some layers of sandy clay.

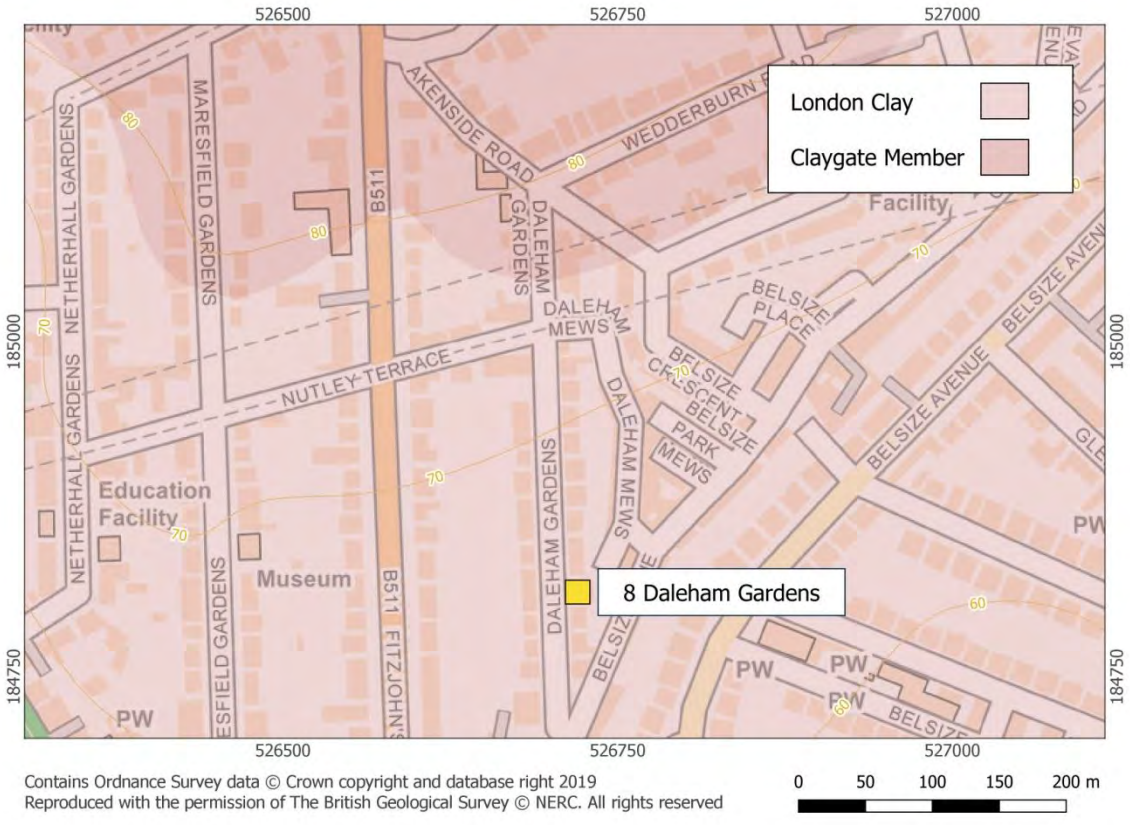

Figure 2.2 Bedrock geology

No superficial deposits are mapped at the site.

A borehole (TQ28NE277[6]) drilled at the Royal Free Hospital, 730 m to the north-east of the site, shows the London Clay to be 69 m thick. Here, the London Clay overlies the Woolwich and Reading Beds Formation, and the Thanet Sands, before penetrating the Chalk aquifer at 101 m.

A 15 m borehole[7] drilled at Holy Trinity Church, 400 m to the west of the site, reported 0.5 m of made ground, followed by 9.8 m of brown fissured clay on top of 4.9 m of dark brown fissured clay. No water was struck during drilling, and no standing water was reported.

A number of boreholes[8] were drilled at 3, 5 and 7 Fitzjohn's Avenue in 2007. Of those 5 m or deeper, made ground was reported to be between 0.8 m to 3 m before penetrating London Clay. All were found to be dry apart from one where groundwater was reported to be struck at 12.1 m[9]. The approximate ground level of the boreholes is 65 m AOD, and so the water level would be at approximately 53 m AOD. No water was observed in the two boreholes with standpipes installed.

2.5 Site Investigation Results

To provide additional information about local geology, two window sample boreholes were constructed at 8 Daleham Gardens in September 2019. Borehole WS1 was constructed to 5.0 m depth at the front (west) of the house and WS2 to 5.0 m to the north side of the house. Schematic logs are presented in Figure 2.3.

WS1, at the front of the property, penetrated 1.7 m of topsoil and made ground before reaching London Clay which was seen until the base of the borehole. It was reported as dry on drilling. WS2, to the north of the property, adjacent to number 10 Daleham Gardens, was also reported as dry. Here, 2.65 m of made ground was seen followed by London Clay.

Standpipes were installed in both boreholes. Table 2.1 shows monitoring results.

Table 2.1 Groundwater level monitoring results

	Ground level* (m AOD)	Water strike (m | m AOD)	RWL 18/09/19 (m | m AOD)	RWL 25/09/19 (m | m AOD)	RWL 2/10/19 (m | m AOD)
WS1	65.5	Dry	3.06 | 62.44	1.59 | 63.91	1.90 | 63.60
WS2	64.8	Dry	2.59 | 62.21	2.30 | 62.50	2.07 | 62.73

* Using ground level at WS1 at 65.5 m AOD as the datum.

Boreholes have not been surveyed to Ordnance Datum but there was a measured 0.7 m step down from WS1 to WS2. The existing undercroft floor is shown (on the architect's section) to be about 1.6 m below ground level where WS1 was constructed and the proposed basement will be about 3.0 m below ground level at WS1.

[6] http://scans.bgs.ac.uk/sobi_scans/boreholes/590865
[7] http://scans.bgs.ac.uk/sobi_scans/boreholes/592030
[8] http://scans.bgs.ac.uk/sobi_scans/boreholes/18393263, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393269, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393331, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393336, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393301, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393270, http://scans.bgs.ac.uk/sobi_scans/boreholes/18393308
[9] http://scans.bgs.ac.uk/sobi_scans/boreholes/18393269

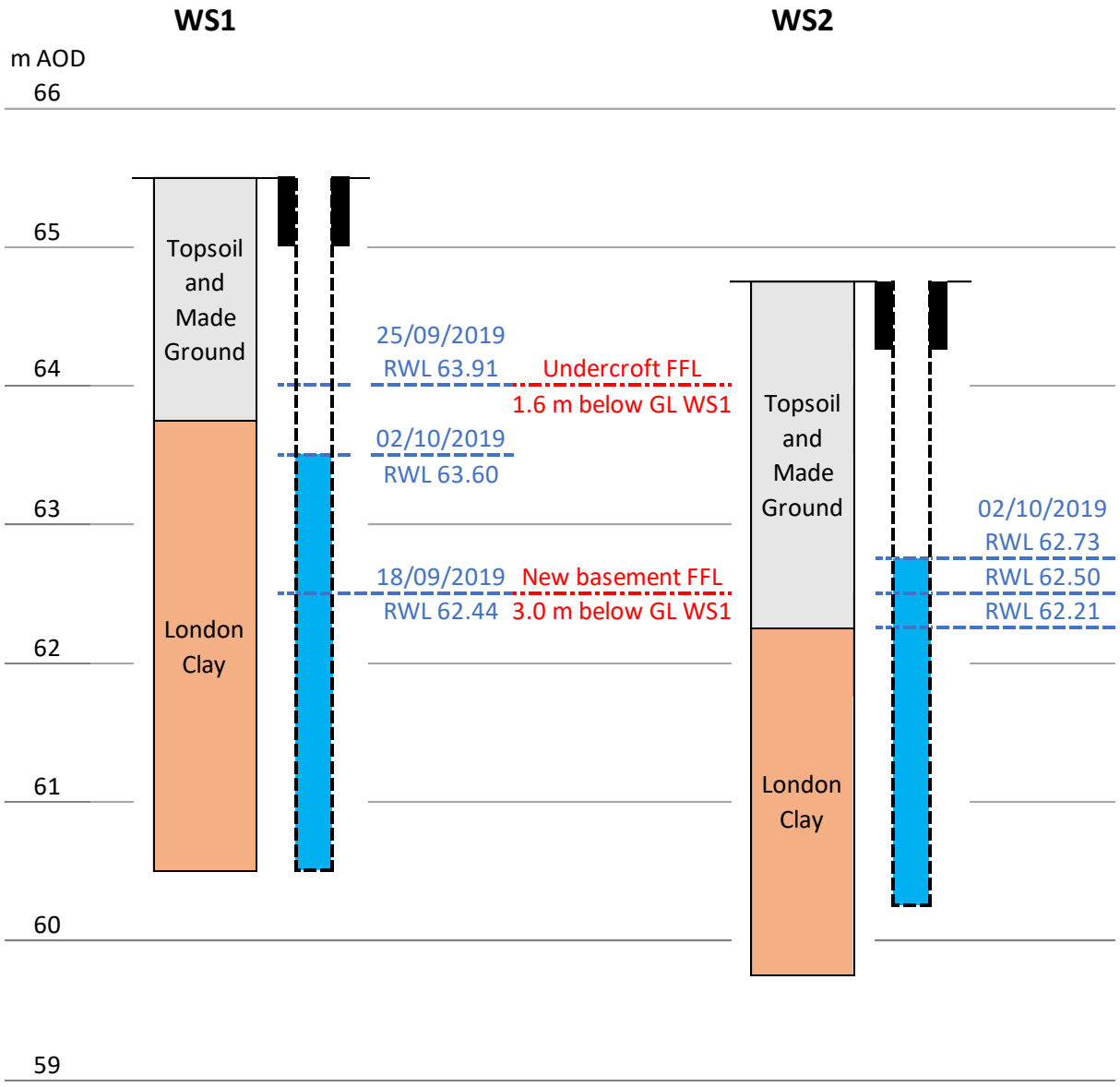

Figure 2.3 Schematic borehole logs

3. Screening Assessment: Groundwater

Subterranean (groundwater) screening follows the procedure outlined in the Camden Planning Guidance: Basements .

1a) Is the site located directly above an aquifer?

NO. The site boreholes indicate that the site sits on London Clay, which does not represent an aquifer. The Claygate Member, a Secondary A aquifer, crops out about 240 m to the north of the site.

1b) Will the proposed basement extend beneath the water table surface?

YES.

2) Is the site within 100m of a watercourse, well (used/ disused) or potential spring line?

NO. Historical mapping shows that the former River Tyburn flowed 100 m to the west of the site, but this is a 'lost river' and culverted through the drainage system.

The nearest potential spring line is approximately 240 m to the north of the site at the boundary between the London Clay and Claygate Member. Shepherd's Well is the closest well 422 m north-north-west of the site.

3) Is the site within the catchment of the pond chains on Hampstead Heath?

NO. The nearest pond within the pond chains on Hampstead Heath is Number 1 Pond. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.

4) Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?

NO. There will not be an increase in impermeable area across the site, so the surface water flow regime will be unchanged. The basement will entirely be beneath the footprint of the building.

5) As part of the site drainage, will more surface water (e.g. rainfall and runoff) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?

NO. Discharge to the ground is not proposed.

6) Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring line?

NO. The nearest surface water body is Number 1 Pond on Hampstead Heath 1.14 km north-east of the site. The closest spring or well is Shepherd's Well, 400 m to the north of the site and at least 13 m above ground level at the site.

4. Screening Assessment: Surface water

Surface flow and flooding screening follows the procedure outlined in Figure 3 (surface flow and flooding screening flowchart) of the Camden Planning Guidance 4 (CPG4) entitled Basements and Lightwells dated 2013.

1) *Is the site within the catchment of the pond chains on Hampstead Heath?*

   NO. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is not located within this catchment area.

2) *As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?*

   NO. There will not be an increase in impermeable area across the site, so the surface water flow regime will be unchanged.

   The basement will entirely be beneath the footprint of the building and the 1m distance between the roof of the basement and ground surface as recommended by section 3.2 of the CPG Basements 2018 does not apply.

   Due to the requirement of a lightwell across parts of the basement which extends outside of the footprint at the side, it is not practical to include the 1m distance.

3) *Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?*

   NO. There will not be an increase in impermeable area across the ground surface above the lower ground floor.

4) *Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?*

   NO. There will not be an increase in impermeable area across the site, so the surface water flow regime will be unchanged.

   The basement will entirely be beneath the footprint of the building and the 1m distance between the roof of the basement and ground surface as recommended by section 3.2 of the CPG Basements 2018 does not apply.

   Due to the requirement of a lightwell across parts of the basement which extends outside of the footprint at the side, it is not practical to include the 1m distance.

5) *Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?*

   NO. The proposed basement is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses as the surface water drainage regime will be unchanged and the land uses will remain the same.

6) *Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?*

YES. The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013 and Figures 3v, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a low flooding risk from sewers, reservoirs (and other artificial sources), and fluvial/tidal watercourses.

There is a very low, low, medium and high risk of surface water flooding across the site. This risk is dealt with in a separate flood risk assessment (FRA).

It is possible that the basement will be constructed within a pockets of groundwater and the recommendations outlined in the BIA with regards to water-proofing and tanking of the basement will reduce the risk to acceptable levels.

In accordance with paragraph 6.16 of the CPG a positive pumped device and non-return valve will be installed in the basement in order to further protect the site from sewer flooding.

5. Impact Assessment: Groundwater

5.1 Baseline Conditions

Sub-surface at the site consists of 1.70 to 2.65 m of gravelly clay made ground beneath which is silty clay of the London Clay (Section 2.5). There are no superficial deposits.

On construction, boreholes were dry but subsequent monitoring yielded measurements of groundwater rising to 63.91 m AOD, or 1.59 m below ground level in WS1 at the front of the building and 62.50 m AOD, 2.30 m below ground level, at WS2 (which is relatively downhill of WS1). This apparent fall in water level is eastwards, like the local slope of the ground.

On the other hand, if this were a genuine water table this is an extremely high hydraulic gradient. It is more realistic to expect that these water level measurements are representative of isolated pockets of groundwater sitting upon the top of the low permeability London Clay. These pockets will have a finite amount of water associated with them, and probably do not extend outside of the site boundary.

The floor of the current undercroft is 1.6 m below ground level at WS1, so is very close to one of the measured groundwater levels in that borehole. Groundwater levels were measured at the end of a dry summer, so winter levels are likely to be somewhat higher. No water ingress problems are known.

5.2 Impact Assessment

Typically, when a basement constructed with impermeable walls is placed into a permeable aquifer with flowing groundwater, groundwater level rises upstream of the basement and drops downstream of the basement. The hydraulic gradient of the water table beneath 8 Daleham Gardens falls towards the east, with the ground surface.

The FFL of the new basement is to be 3.0 m below ground level so it will be extended below the measured groundwater level at WS1, but not the measured level at WS2. Water levels are probably higher in winter and since there are no known issues with groundwater ingress at present it can be expected that there will be no future issues, given that the basement lining is to be renewed. Some dewatering via a sump might be anticipated during construction.

Where the basement intersects with the water levels, the water level will rise closest to the western edge of the proposed basement. Typically, if the water was representative of a continuous groundwater body, and the system were to be modelled, the rise in groundwater level might be expected[10] to be no more than 0.05 m at a distance of a few metres from the basement.

This hypothetical rise in groundwater will occur beneath the front garden of the property and beneath the roadway of Daleham Gardens. Number 10 Daleham Gardens may have a cellar at the same floor level as at number 8. This is to the side of the new basement and at least 4 m away. At this distance, and being not directly up-the hydraulic gradient of the new basement, any rise in groundwater level will be negligible.

[10] For example, in the ARUP (2010) guidance for subterranean development for Camden Borough Council (paragraph 172), it is stated that: 'The change in water levels is in proportion to the increase in the length of the flow path. In the case of a site measuring 10 m in the direction of groundwater flow, the natural difference in groundwater level might be one or two centimetres.'

The source of the historical River Tyburn is uphill of the site, and considerably above the observed rest water levels (Section 2.22.1). Any flow that persists will be diverted into Thames Water sewers, and do not feed any watercourse.

6. Conclusions

Potential environmental impacts of the basement development at 8 Daleham Gardens have been considered. The following summary conclusions are made:

- There will be no increase in man-made impermeable area so the amount, timing and quality of surface water runoff will not be affected by the development. No water will go to ground as a result of the basement development.
- There are no local surface water bodies or water wells that might be impacted by the development.
- While the geological conditions encountered cause springs to emerge elsewhere in Hampstead this is not considered to be an issue at this site (Section 5).
- Available geological and hydrogeological information indicates that there is no permeable aquifer beneath the site that is capable of maintaining a significant groundwater body.
- Water level measurements have been consistently above floor level of the new basement. These are considered to be representative of isolated pockets of water within the sub-surface and not of a continuous water table, and therefore basement construction is expected to have no impact on the water environment outside of the site boundary.

These conclusions are considered to be robust and no further investigations are recommended.