Stephen Buss
Environmental Consulting Ltd

18A Frognal Gardens: Hydrology and Sub-surface Flow Screening

Basement Impact Assessment

Version control log

Document number	Date	Issued by	Issued to	Comments
2019-003-059-002	17/09/19	Steve Buss	Soil Consultants	Final draft
2019-003-059-001	09/09/19	Steve Buss	Soil Consultants	First draft

Client: Roger Pilgrim and Nadine Majaro

Dated: September 2019

www.hydro-geology.co.uk
32 Port Hill Road, Shrewsbury SY3 8SA
Registered in England and Wales number 08595273

DISCLAIMER

This report has been prepared by Stephen Buss Environmental Consulting Ltd (SBEC) in its professional capacity as hydrogeologist, in a manner consistent with the level of care and skill ordinarily exercised by members of the geological and engineering professions practising at this time, within the agreed scope and terms of contract, and taking account of the manpower and resources devoted to it by agreement with its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole. As with any environmental appraisal or investigation, the conclusions and observations are based on limited data. The risk of undiscovered environmental impairment of the property cannot be ruled out. SBEC cannot therefore warrant the actual conditions at the site and advice given is limited to those conditions for which information is held by SBEC at the time. The findings are based on the information made available to SBEC at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time.

This report is provided to the client addressed above. Should the client wish to release this report to any other third party for that party's reliance, SBEC accepts no responsibility to any third party to whom this report or any part thereof is made known. SBEC accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against SBEC except as expressly agreed with SBEC in writing.

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.

TABLE OF CONTENTS

Figures

Figures

1. Introduction

1.1 Background

This report presents the screening and scoping 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 18A Frognal Gardens, London NW3 6XA (Figure 1.1, national grid reference TQ 2616 8577). The local planning authority is Camden Borough Council.

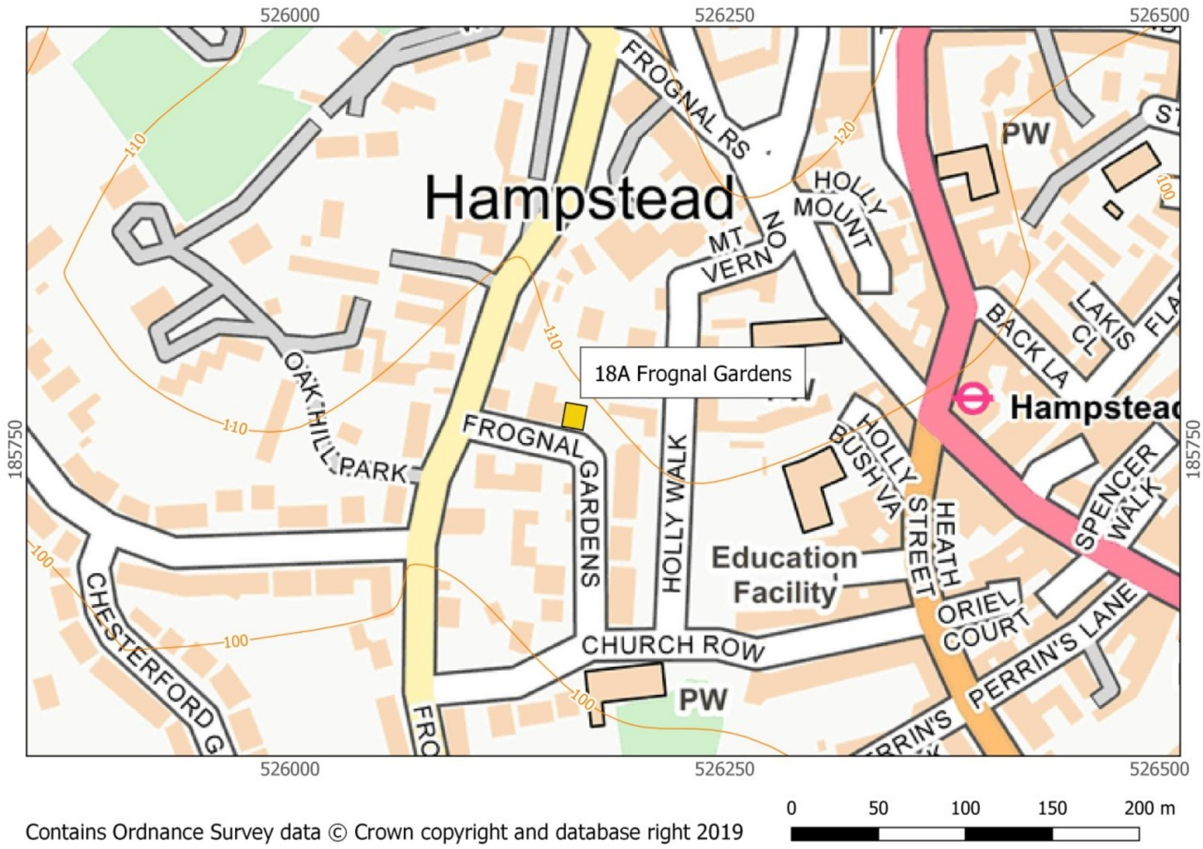


Figure 1.1 Location of 18A Frognal Gardens

1.2 The Site

The site at 18A Frognal Gardens currently comprises a residential semi-detached dwelling. The ground level on site rises by about 3 m from the front to the back of the property and as a result, at the front of the property the building consists of three-storeys with a garage, utility/boiler room and bedroom on the lower floor, whereas at the back of the premises, the building consists of two storeys with the ground floor level with the rear garden.

The surrounding area is predominantly residential. A private road runs alongside the east of the site to number 18 Frognal Gardens. The garden at 18A backs onto the garden surrounding number 18. Number 18B Frognal Gardens, to the west, is attached to the current property and of a similar age and construction. Other houses on the street consist of large detached and semi-detached properties built in the late 18th Century.

Moreton House, to the east, is a Grade II listed building situated on Holly Walk and consists of flats. The gardens of properties number 16, 17 and 18 on Holly Walk back onto the private alleyway leading to number 18.

Hampstead Heath is around 675 m to the north-east, and Hampstead tube station is 220 m to the east.

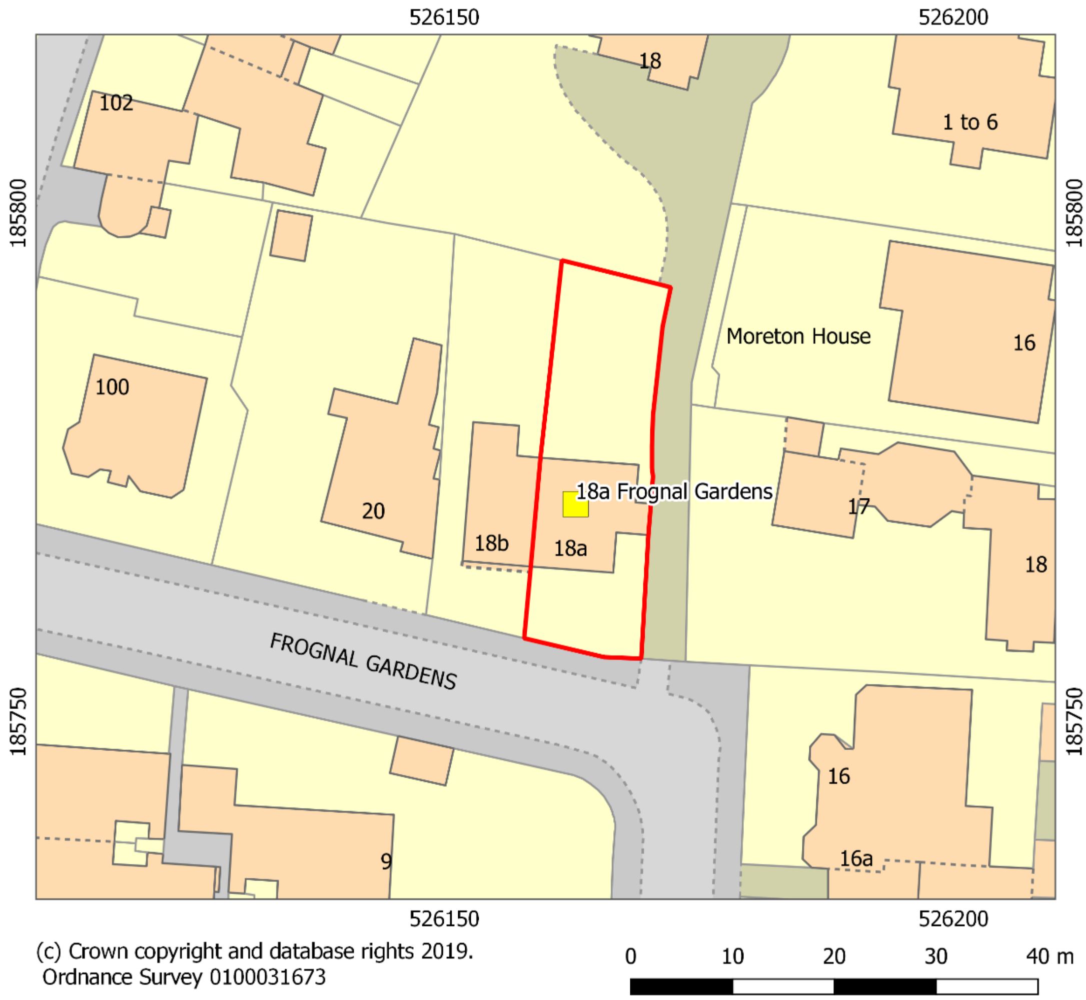


Figure 1.2 Local area (18A Frognal Gardens, outlined in red)

1.3 Proposed basement works

It is intended that the site will be redeveloped by demolishing the current property at the site and constructing a new dwelling. The new dwelling will include a lower ground floor level that extends along the entire footprint of the property and will involve deepening and extending the current lower ground floor level to the rear of the dwelling. A plunge pool will be built at the back of the house.

Proposed works, as drawn by Alison Brooks Architects, and plans of the current dwelling, as drawn by A D Horner Ltd, are shown in Figure 1.3 and 1.4.

Based on the site topographic survey by A D Horner Ltd (drawing number 5594-14JAN19-01), ground level at the street on the south-eastern corner of the site is 108.2 m above Ordnance Datum (AOD), and 109.0 m AOD on the south-western corner. Ground level at the front of number 18A is 108.7 m AOD, and at the rear is 111.4 m AOD. The rear garden rises to 112.9 m AOD at its north-eastern corner.

(Ground levels around the attached building, number 18B Frognal Gardens, are generally 1.0 m lower than around 18A, with the front of 18B at c. 107.8 m AOD and the rear at c. 110.3 m AOD.)

Proposed plans by Alison Brooks Architects (drawing number ABA-2473-20-023) show that the proposed level of the lower ground floor is at 108.4 m AOD, which is approximately 0.3 m below the current ground level at the front of the property and approximately 3.0 m below the ground level at the back of the proposed development. The plunge pool is expected to extend to a further depth of 2.0 m below ground level to circa 106.4 m AOD.

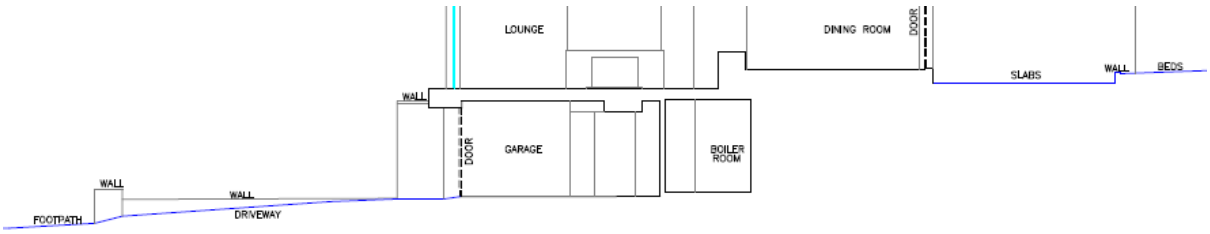


Figure 1.3 Cross-section of current dwelling at 18A Frognal Gardens

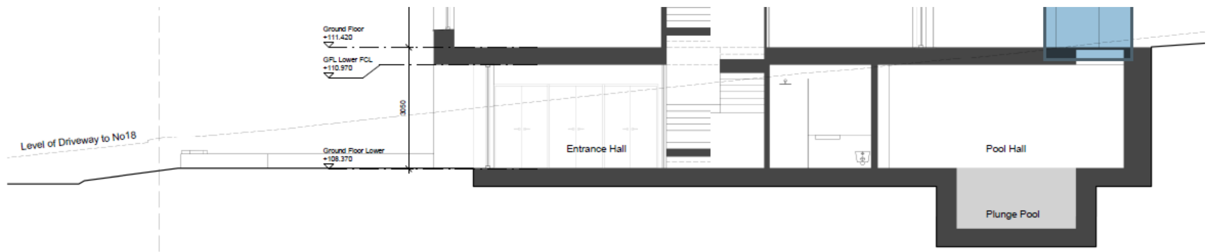


Figure 1.4 Cross-section of proposed works at 18A Frognal Gardens

1.4 Scope of Report

Stephen Buss Environmental Consulting Ltd was instructed in August 2019 to complete this report. This report presents the subsurface flow (groundwater) and surface water components of the basement impact assessment for the development, complies with Camden Planning Guidance: Basements (2018)[1] screening, scoping and site investigation stages, and makes reference to the basement impact assessment guidance of ARUP (2010)[2].

1.5 Authorship of Report

This report has been completed by Dr Stephen Buss MA MSc CGeol. Dr Buss is a UK-based independent hydrogeologist with more than 19 years' consulting experience in solving groundwater issues for regulators, water companies and other private sector organisations. **Dr**

THE GEOLOGICAL SOCIETY CGeol CHARTERED GEOLOGIST Fellow No. 10004065

[1] The London Borough of Camden, 2018. Camden Planning Guidance: Basements.
[2] ARUP, 2010. Camden geological, hydrogeological and hydrological study. Guidance for subterranean development.

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 1830 1:2500 County Series map the site is shown to be on a small road linking The Mansion to Holly Walk. Two wells are shown about 30 m to the south-east of the current location of 18A Frognal Gardens.

These wells are shown on maps until the 1896 1:2500 map, where the first properties on Frognal Gardens are shown to have been built over them. A small building was built on the site of 18 Frognal Gardens at this time.

Houses to the east on Holly Walk are first shown on historical maps from 1870. Number 18 Frognal Gardens (Frognal End) is a substantial house built in 1892 for the novelist Sir Walter Besant. Numbers 18A and 18B were built in the front garden of number 18 in the mid-1960s.

2.2 Drainage and Topography

Elevation of the plot, 18A Frognal Gardens, is between about 108.2 and 112.9 m AOD according to the site topographic survey. Ground surface around the site slopes down to the south west; the gradient calculated from Environment Agency LIDAR data is about 0.1.

The site is in the vicinity of three 'lost rivers' which are now culverted beneath the city and incorporated into the sewer network[3] (Barton and Myers, 2016). Most significantly, the site was in the upper catchment of one of the two main tributaries of the former River Westbourne. The East Westbourne East Branch tributary, as mapped by Arup (2016)[4], is believed to have risen around 80 m north-east of the site, and to have continued southwards along the line of the current road, Frognal, until it reached the River Westbourne. At its closest point, it flowed circa 60 m west of the site.

A tributary of the former River Fleet rose 430 m to the north-east-east, and the headwaters of the River Tyburn were 700 m to the south-east.

The nearest current surface water feature is Whitestone Pond, at the southern end of Golders Hill Park about 540 m north of the site. The elevation of Whitestone Pond is 133 m AOD and is up-gradient of the site.

The closest pond within the pond chains on Hampstead Heath is the Vale of Heath Pond, at around 780 m to the north east, and at about 105 m AOD, lower than the elevation of the site.

2.3 Local basements

Details of any recent basement developments in adjacent properties have been searched for via the Camden Planning Portal. Several properties have been identified as having basements: Moreton House and 16 Holly Walk, and there is an application in progress for 16 Frognal Gardens.

---

[3] Barton, N. and Myers, S., 2016. The Lost Rivers of London 3rd Edition. BCA, London.
[4] Arup, 2016. Redington Frognal Neighbourhood Forum, Red Frog Sub-surface Water Features Mapping, Summary Report.

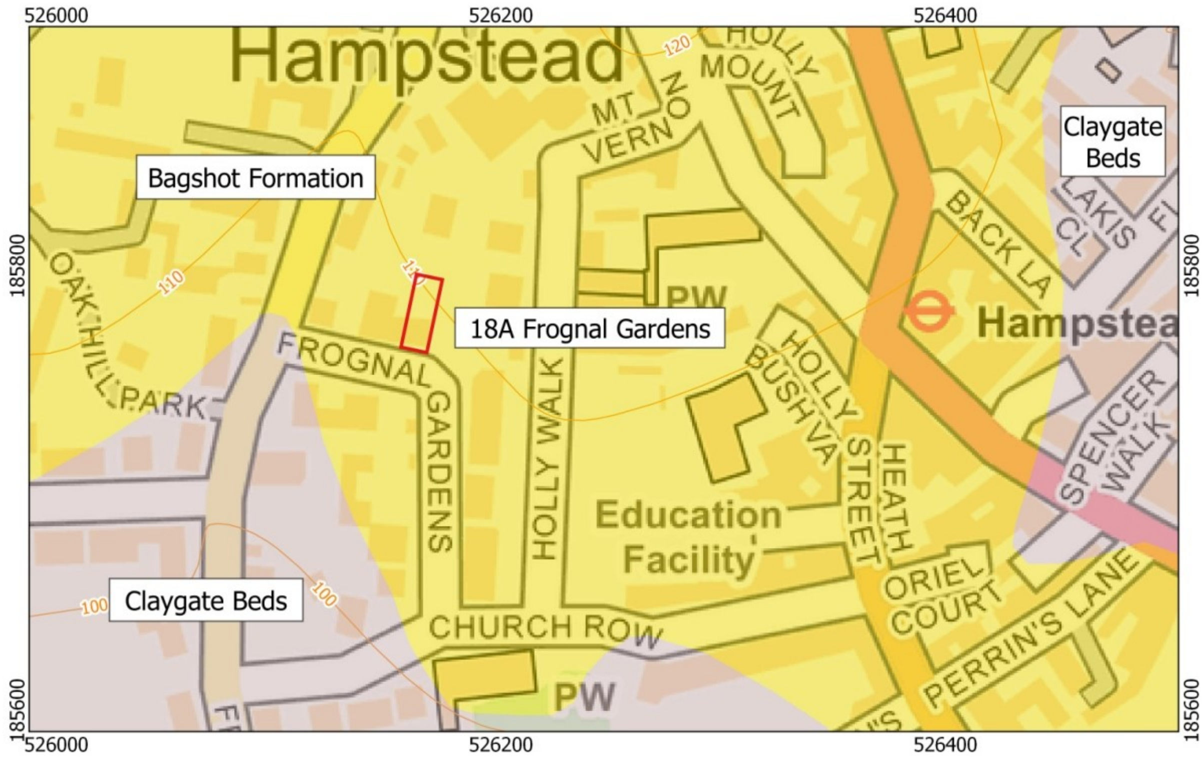
- At Flat 2 Moreton House, planning permission (2011/6231/P) was granted to create access to the basement flat from the lightwell at the side of the property. The development involved lowering a small amount of the floor of the lightwell by just under 1 m. It did not involve structural alteration to the existing basement.
- At number 16 Holly Walk, planning permission (2005/1055/P) was granted for the demolition of the existing building and erection of a two storey detached house with a single-storey basement. Final floor level (FFL) for the basement was 114.15 m AOD, with a pool on the northern side of the building (against its boundary with Moreton House) at approximately 112.55 m AOD.
- The application for 16 Frognal Gardens (2018/2440/P) is for erection of a single storey detached house with a single-storey basement in the rear of the property, i.e. on Holly Walk. The basement is to be constructed at a depth of 2 to 4 m bgl, which is about 108.3 to 110.3 m AOD (assuming ground level from Environment Agency LIDAR data).

  As part of the ground investigation at 16 Frognal Gardens two boreholes were constructed. Both encountered clayey sand/sandy silt of the Bagshot Beds, with no base identified. In the deepest borehole there was a groundwater strike at 6.0 m depth (c. 106.3 m AOD) but the standpipe that was installed to 5.0 m depth (c. 107.3 m AOD) remained dry during subsequent monitoring.

All known basements are at least 30 m from the proposed development at 18A Frognal Gardens.

2.4 Geology and Hydrogeology

Mapped bedrock at the site comprises the Bagshot Formation, and beneath these are the Claygate Beds (Figure 2.1). The mapped boundary of the two deposits is approximately 50 m south-west of the site. No superficial deposits are mapped at the site's location.



0 50 100 150 200 m

Figure 2.1 Bedrock Geology

The Bagshot Formation can be up to 45 m thick and consists of sandy layers with clayey horizons. The sand layers will often form localised aquifers. Beneath the Bagshot Formation lies the Claygate Beds, a silty clay unit at the top of the London Clay Formation.

Below the Claygate Beds the London Clay is about 105 m thick (at the former Hampstead Brewery borehole[5] (about 620 m to the east of the site) and isolates the main aquifer of the London Basin from the surface.

One borehole[6] was drilled, in 1969, on Back Lane, about 270 m north-east of the site. Ground level at the borehole was 112 m AOD so the stratigraphic sequence in the borehole is similar to that which will be penetrated by the basement. Water was first encountered within the clayey layer at 5.5 m depth (106.5 m AOD), but the rest water level is not recorded in the log on the BGS website.

[5] http://scans.bgs.ac.uk/sobi_scans/boreholes/590586
[6] http://scans.bgs.ac.uk/sobi_scans/boreholes/590682

2.5 Site Investigation Results

Two window sample boreholes and one auger borehole were constructed by Soil Consultants in August 2019. A map of the borehole locations is shown in Figure 2.2, and schematic logs of the boreholes are presented in Figure 2.3.

The upper layer consisting of clayey very silty sand with bands of sandy very silty clay is considered to be the Bagshot Formation, with silty clay of the Claygate Beds or London Clay below.

Standpipes were installed in BH1 and WS1. Water observations are shown in Table 2.1. WS2 was dry, probably because it did not penetrate to the depth of the water strike at adjacent BH1.

Table 2.1 Water observations (m | *m AOD*)

	Ground level (m AOD)	Borehole depth	Water strike	RWL 8/8/19 & 12/8/19	RWL 22/8/19	RWL 4/9/19
WS1	*108.70*	4.0 | *104.7*	3.00 | *105.70*	2.78 | *105.92*	2.37 | *106.33*	2.70 | *106.00*
WS2	*111.45*	5.0 | *106.45*	Dry	No standpipe	No standpipe	No standpipe
BH1	*111.45*	15.0 | *96.45*	5.45 | *106.00*	4.65 | *106.80*	4.67 | *106.78*	4.69 | *106.76*

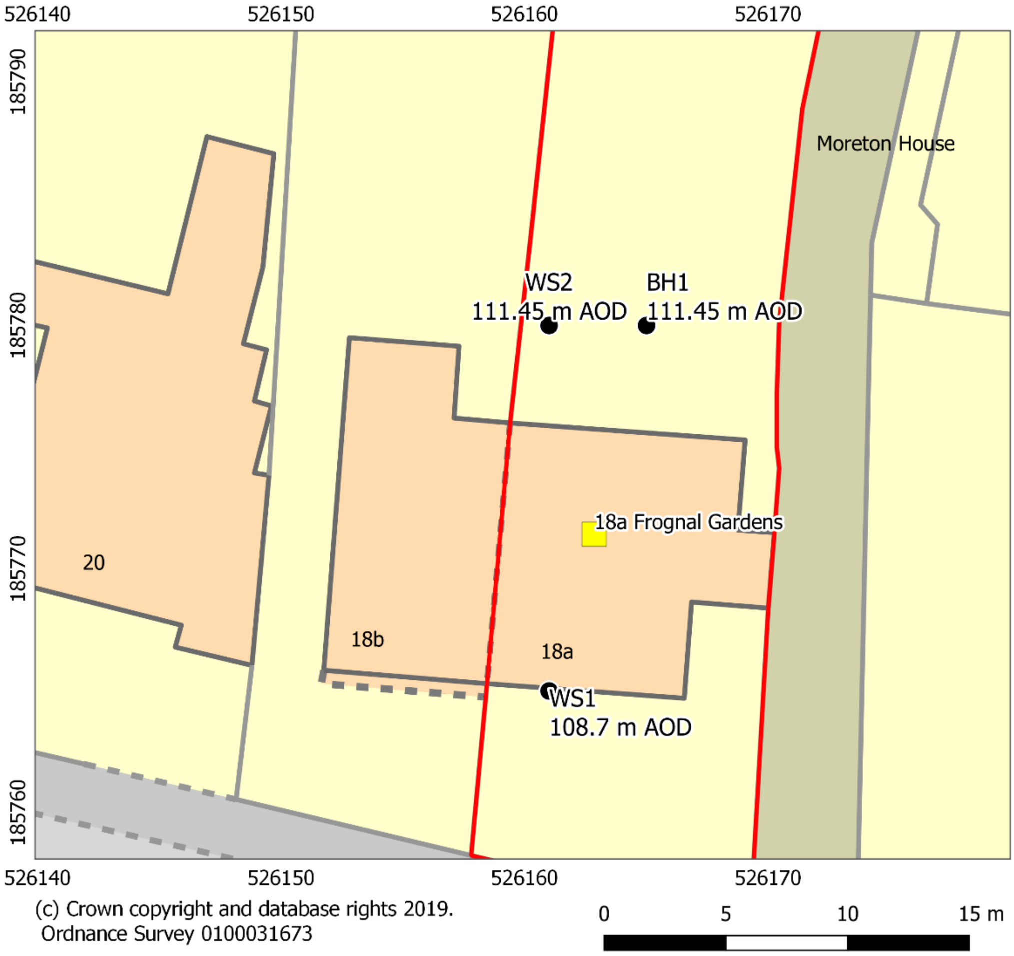


Figure 2.2 2019 borehole locations

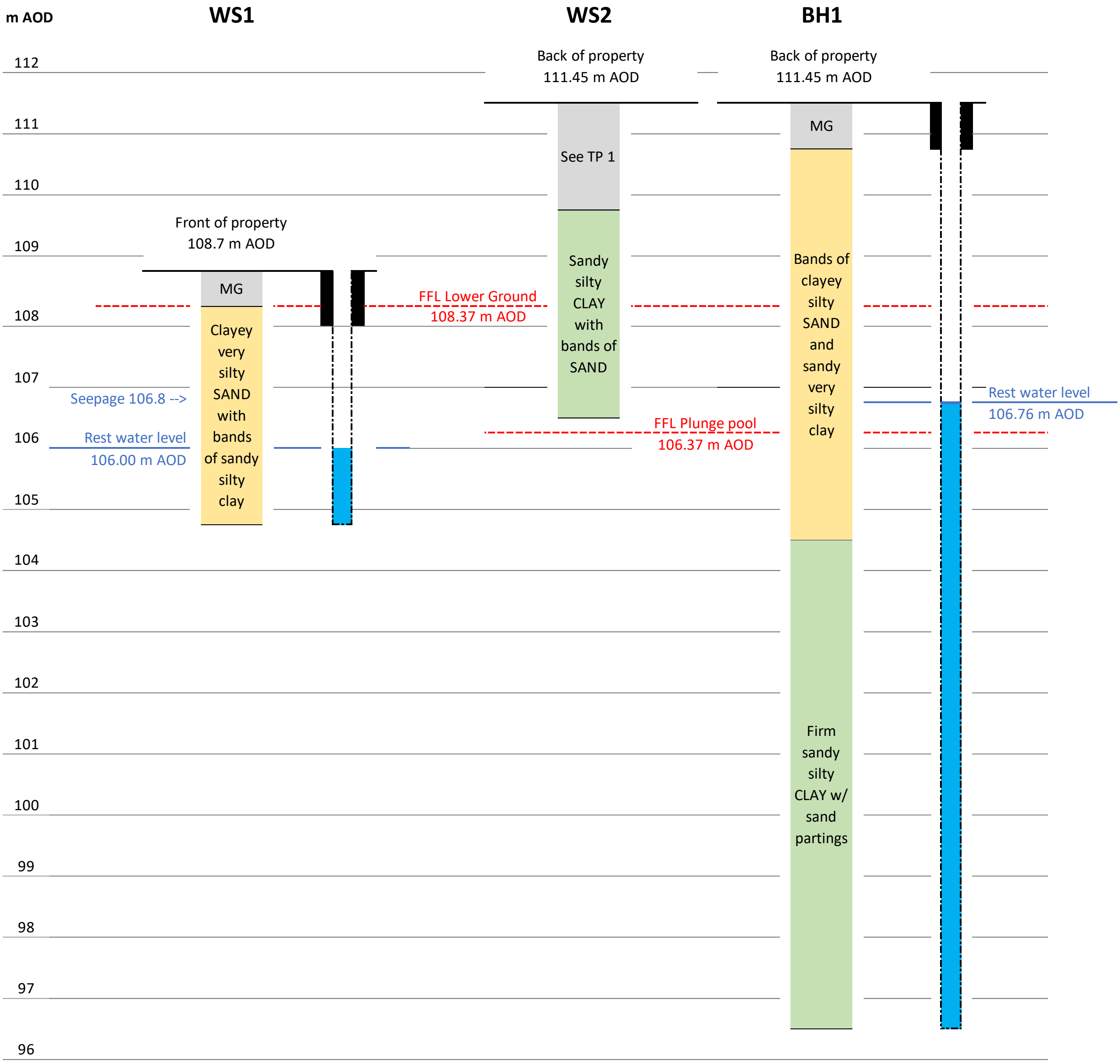


Figure 2.3 Schematic borehole logs

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?*

YES. The site boreholes indicate that the basement will be constructed within a permeable formation. This is discussed further in Section 5.

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

YES. Rest water levels in borehole BH1 is above the likely base of the plunge pool, but not the main part of the basement. This is discussed further in Section 5.

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

YES. Historical mapping shows the presence of two wells within 100 m to the south-east of the site. It is also believed that the course of a tributary of the lost river Westbourne is within 100 m to the west of the site. This is discussed further in Section 5.

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 the Vale of Heath Pond is at about 105 m AOD, lower than the elevation of the site. There is also a ridge feature between them, and so the site is not within the chain's catchment.

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

YES. There will be a minor increase in impermeable area at the rear of the site, but the FRA proposes that paving at the front be permeable, so that there is overall no significant change in infiltration across the site, so the surface water flow regime will be unchanged.

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 Whitestone Pond about 540 m north of 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 largely be beneath the footprint of the building hence the 1 m 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 rear, 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?*

   YES. Much of the area to the rear of the building that will be replaced by roof and/or underlain by basement currently comprises an existing hard surface beneath a shallow layer of accumulated leaf litter and topsoil). There will be some encroachment of the building onto current green space. However the FRA proposes that paving at the front be permeable, so that there should be overall no significant change in infiltration across the site, so the surface water flow regime will be unchanged.

   The lower ground floor will entirely be beneath the footprint of the future building/hardstanding, therefore the 1m distance between the roof of the lower ground floor and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.

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?*

   YES. There will be a minor increase in impermeable area at the rear of the site, but the FRA proposes that paving at the front be permeable, so that there is overall no significant change in infiltration across the site, so the surface water flow regime will be unchanged.

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?*

   NO. The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013 and Figures 3iii, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a very low flooding risk from surface water, sewers, reservoirs (and other artificial sources), and fluvial/tidal watercourses.

   It is possible that the basement will be constructed within pockets of groundwater in the Bagshot Beds, 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 clayey very silty sand with bands of sandy very silty clay, considered to be the Bagshot Formation, with a silty clayey stratum below that is considered to comprise either the Claygate Beds or London Clay (Section 0).

The Bagshot Formation and Claygate Beds are designated as secondary aquifers by the Environment Agency[7]. This describes the sands in the formation as having low permeability, but high storage capacity. As a result, although water abstraction from the formation is reliable, yields are not high.

The sandy horizons of the Bagshot Formation beneath the site are water-bearing. Groundwater level in the Bagshot Formation has been c. 106.8 m AOD at the rear of 18A Frognal Gardens, over the summer of 2019. Groundwater level falls to 106.0 m AOD towards the front of the property, so the hydraulic gradient is approximately southwards, with the slope of the ground.

Groundwater levels were measured at the end of a dry summer, so winter levels are likely to be somewhat higher: ARUP (2010) suggests that the seasonal range of groundwater level fluctuation in the Bagshot Formation is likely c. 0.50 m.

(The presence of local historical wells and the source of a tributary of the River Westbourne is consistent with the groundwater level observations made, i.e. that there are water-bearing horizons in the permeable Bagshot Formation here.)

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 18A Frognal Gardens falls towards the south, with the ground surface.

The FFL of the plunge pool is to be 106.37 m AOD, so this part of the basement will be excavated below the groundwater level. The summer groundwater level at the rear of the property, where the plunge pool is to be constructed is 106.8 m AOD but winter levels might be up to 107.3 m AOD.

Where the basement intersects with the groundwater level, the water table level will rise closest to the northern edge of the proposed basement. Typically, if the system were to be modelled, the rise in groundwater level might be expected[8] to be no more than 0.05 m at a distance of a few metres from the basement.

The rise in groundwater will occur beneath the garden of the property. Number 18B Frognal Gardens has a lower ground floor the same as number 18A at present. This is, like the floor level at 18A, several metres above the water table. Other deeper basements are beneath 16 Holly Walk

---

[7] BGS and Environment Agency (2000). The physical properties of minor aquifers in England and Wales http://nora.nerc.ac.uk/id/eprint/12663/

[8] 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.'

(about 30 m to the north-east) and Moreton House (about 40 m to the north-east). At these distances, and not directly up-the hydraulic gradient of the new basement, any rise in groundwater level will be negligible.

While there are some single-storey basements nearby, that may be constructed below the water table, they are separated sufficiently that there is no risk of a cumulative impact.

There may be a slight drop in groundwater level to the south of the new basement. The historical wells were, roughly, to the south but are no longer present and are not considered to be receptors for any change in groundwater level.

The source of the historical River Westbourne tributary is uphill of the site, and considerably above the observed rest water levels (at a horizontal distance of 80 m from 18A Frognal Gardens, the level of the historical spring is likely to have been about 111 m AOD). 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 18A Frognal Gardens have been considered. The following summary conclusions are made:

- There will be a minor increase in man-made impermeable area, but it is proposed that this is compensated for by the use of permeable paving. Therefore the amount, timing and quality of surface water runoff will not be affected by the development. No additional water will go to ground as a result of the basement development.
- Available geological and hydrogeological information indicates there is an aquifer layer, the Bagshot Formation, beneath the site that water-bearing.
- Basement excavation is likely to intercept the water table, and construction of the plunge pool (though not the main basement structure) will intercept the water table permanently. A slight rise in groundwater level up-gradient of the new basement is therefore to be expected.
- Potential receptors for changing groundwater levels have been identified but a) the impact on groundwater level at a distance more than 5 m is likely to be un-measurable, and b) all potential receptors are either above the water table or several tens of metres from the new basement. Therefore there is negligible risk of impacting any of the identified receptors.

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

PROPOSED REPLACEMENT DWELLING AND BASEMENT LEVEL AT NUMBER 18A FROGNAL GARDENS, CAMDEN, LONDON

FLOOD RISK ASSESSMENT

SEPTEMBER 2019

REF: 2351/RE/08-19/01 REVISION A

Evans Rivers and Coastal Ltd
T: 07896 328220
E: Enquiries@evansriversandcoastal.co.uk
W: www.evansriversandcoastal.co.uk

CONTRACT

Evans Rivers and Coastal Ltd has been commissioned by Stephen Buss Environmental Consulting Ltd to carry out a Flood Risk Assessment for a proposed redevelopment at number 18A Frognal Gardens, Camden, London.

QUALITY ASSURANCE, ENVIRONMENT AND HEALTH AND SAFETY

Evans Rivers and Coastal Ltd operates a Quality Assurance, Environmental, and Health and Safety Policy.

This project comprises various stages including data collection; depth analysis; and reporting. Quality will be maintained throughout the project by producing specific methodologies for each work stage. Quality will also be maintained by providing specifications to third parties such as surveyors; initiating internal quality procedures including the validation of third party deliverables; creation of an audit trail to record any changes made; and document control using a database and correspondence log file system.

To adhere to the Environmental Policy, data will be obtained and issued in electronic format and alternatively by post. Paper use will also be minimised by communicating via email or telephone where possible. Documents and drawings will be transferred in electronic format where possible and all waste paper will be recycled. Meetings away from the office of Evans Rivers and Coastal Ltd will be minimised to prevent unnecessary travel, however for those meetings deemed essential, public transport will be used in preference to car journeys.

The project will follow the commitment and objectives outlined in the Health and Safety Policy operated by Evans Rivers and Coastal Ltd. All employees will be equipped with suitable personal protective equipment prior to any site visits and a risk assessment will be completed and checked before any site visit. Other factors which have been taken into consideration are the wider safety of the public whilst operating on site, and the importance of safety when working close to a water source and highway. Any designs resulting from this project and directly created by Evans Rivers and Coastal Ltd will also take into account safety measures within a "designers risk assessment".

Report carried out by:

Rupert Evans, BSc (Hons), MSc, CEnv, C.WEM, MCIWEM, PIEMA

DISCLAIMER

This report has been written and produced for Stephen Buss Environmental Consulting Ltd. No responsibility is accepted to other parties for all or any part of this report. Any other parties relying upon this report without the written authorisation of Evans Rivers and Coastal Ltd do so at their own risk.

COPYRIGHT

CONTENTS

1. INTRODUCTION

1.1 Project Scope

1.1.1 Evans Rivers and Coastal Ltd has been commissioned by Stephen Buss Environmental Consulting Ltd to carry out a Flood Risk Assessment for a proposed redevelopment at number 18A Frognal Gardens, Camden, London.

1.1.2 It is understood that this Flood Risk Assessment will be submitted to the Planning Authority as part of a planning application. Specifically, this assessment intends to:

a) Review any literature and guidance specific to this area;

b) Assess the risks to people and property and propose mitigation measures accordingly;

c) Review existing evacuation and warning procedures for the area;

d) Carry out an appraisal of flood risk from all sources as required by NPPF;

e) Report findings and recommendations.

1.1.3 This assessment is carried out in accordance with the requirements of the National Planning Policy Framework (NPPF) dated 2019. Other documents which have been consulted include:

- DEFRA/EA document entitled *Framework and guidance for assessing and managing flood risk for new development Phase 2 (FD2320/TR2)*, 2005;
- DEFRA/Jacobs 2006. *Groundwater flooding records collation, monitoring and risk assessment (ref HA5)*.
- National Planning Practice Guidance – Flood Risk and Coastal Change.
- Woods-Ballard., et al. 2015. *The SUDS Manual, Report C753*. London: CIRIA.
- National SUDS Working Group. 2004. *Interim Code of Practice for Sustainable Drainage Systems*.
- London Borough of Camden Preliminary Flood Risk Assessment (PFRA) Version 0.2 dated 2011.
- London Borough of Camden Strategic Flood Risk Assessment (SFRA) dated 2014.
- London Borough of Camden Surface Water Management Plan (SWMP) Version 1 dated 2011.
- London Borough of Camden flood risk management strategy (FRMS) dated 2013.
- *Camden Planning Guidance – Water and Flooding* dated 2018.
- *Camden Planning Guidance – Basements* dated 2018.

2. DATA COLLECTION

2.1 To assist with this report, the data collected included:

- 1:250,000 *Soil Map of South East England* (Sheet 6) published by Cranfield University and Soil Survey of England and Wales 1983.
- Ordnance Survey 1:10,000 street view map obtained via Promap (Evans Rivers and Coastal Ltd OS licence number 100049458).
- 1:625,000 *Hydrogeological Map of England and Wales*, published in 1977 by the Institute of Geological Sciences (now the British Geological Survey).
- Filtered LIDAR data at 1m resolution.
- British Geological Survey, *Online Geology of Britain Viewer*.
- British Geological Survey, *Groundwater Susceptibility Map*.
- Borehole logs undertaken by Soil Consultants.
- Topographical survey of the site as shown on Drawing Number 5594-14JAN19-01.

3. SITE CHARACTERISTICS

3.1 Existing Site Characteristics and Location

3.1.1 The site is located at number 18A Frognal Gardens, Camden, London. The approximate Ordnance Survey (OS) grid reference for the site is 520773 183953 and the location of the site is shown on Figure 1.

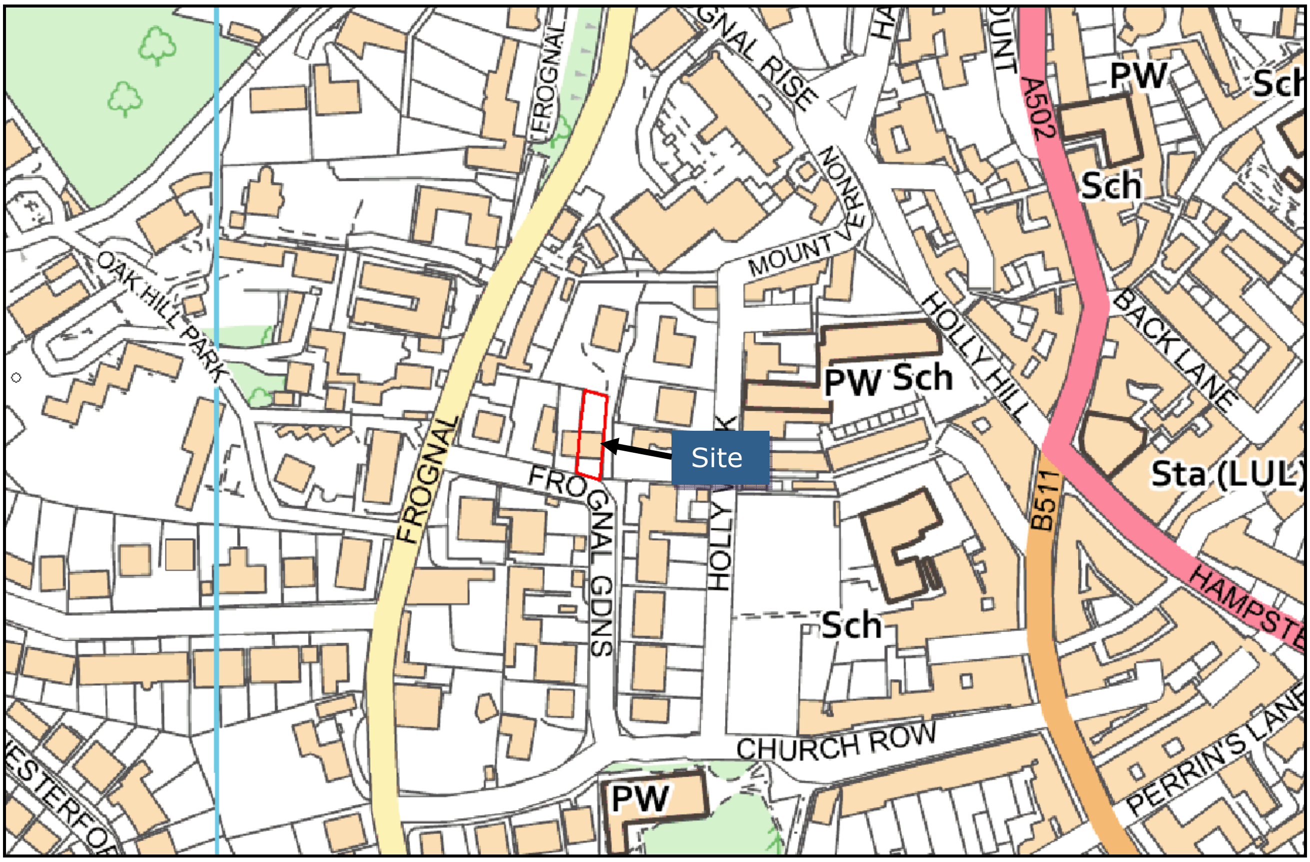


Figure 1: Site location plan (Source: Ordnance Survey)

3.1.2 The site comprises a three-storey dwelling with garage, bedroom, utility and boiler room across lower ground floor areas and living/sleeping areas across upper floors. As the site rises in a northerly direction the ground floor is cut into the ground slope which provides level access onto the rear garden from the upper ground floor.

3.1.3 The rear garden is partially paved and a driveway exists at the front of the property which leads onto Frognal Gardens. The existing site layout can be seen on Drawing Numbers 5594-14JAN19-01, 5594-14JAN19-02 and 5594-14JAN19-08.

3.1.4 A topographical survey of the site is shown on Drawing Number 5594-14JAN19-01. Filtered LIDAR data at 1m resolution has also been obtained to determine and illustrate the topography of the site and surrounding area (Figure 2).

3.1.5 By reviewing the site layout and LIDAR data it can be seen that ground levels rise in a northerly direction.

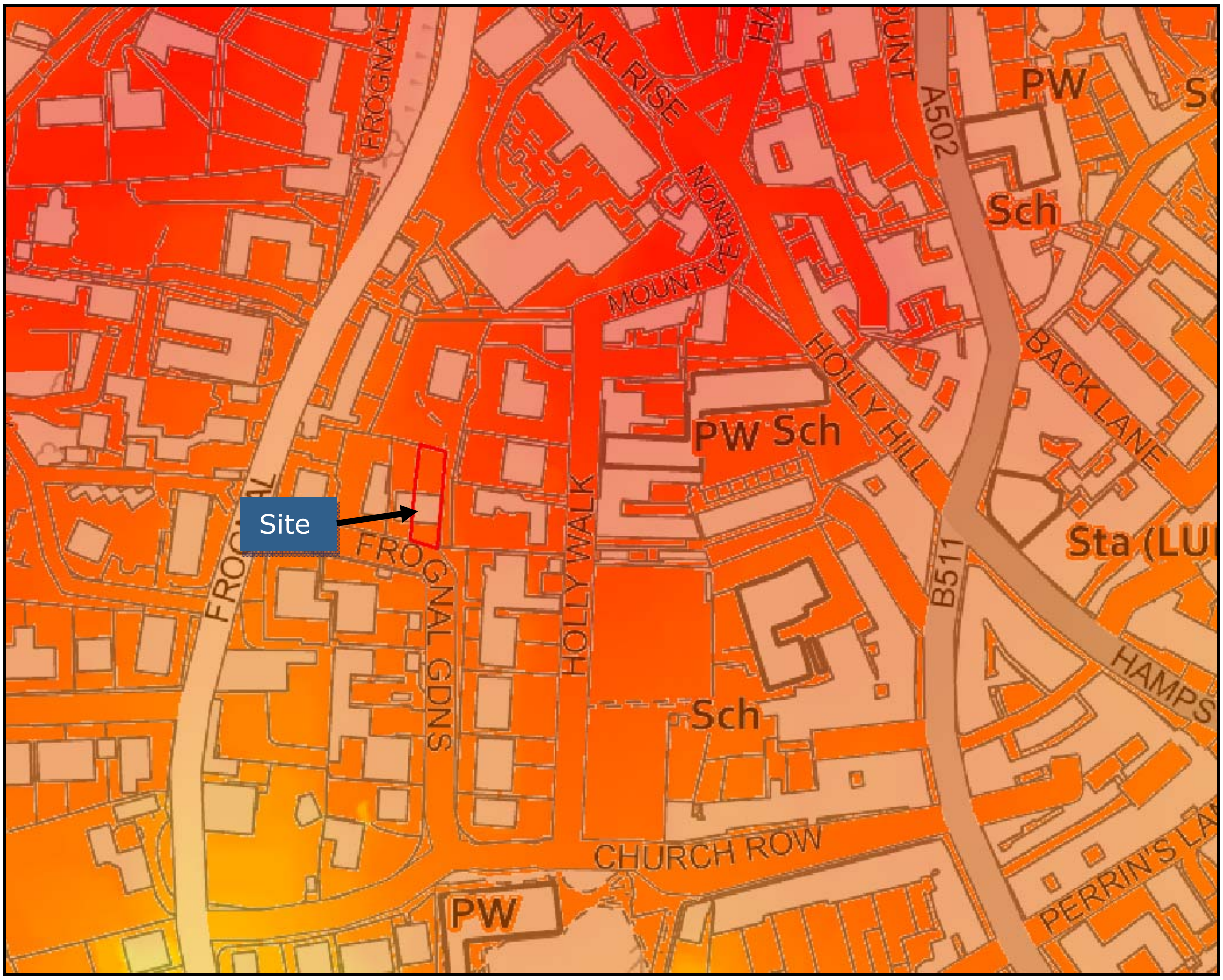


Figure 2: LIDAR survey data where higher ground is denoted as red, orange and yellow colours and lower areas denoted by blue and green colours

3.2 Site Proposals

3.2.1 It is the Client's intention to redevelop the site by demolishing the existing building and erecting a new dwelling together with a lower ground floor which will extend further below ground level into the rear garden and front driveway.

3.2.2 The site proposals can be seen on Drawing Number ABA-2473-20-023 and ABA-2473-20-099.

4. SOURCES OF FLOODING

4.1 Fluvial

4.1.1 The Environment Agency Flood Map shows that the site is located within the NPPF Flood Zone 1, 'Low Probability' which comprises land as having less than a 1 in 1000 year annual probability of fluvial or tidal flooding (i.e. an event more severe than the extreme 1 in 1000 year event). NPPF states that all uses of land are appropriate in this zone.

4.1.2 The SFRA also states that there has been no historical flooding within the Borough from fluvial or tidal sources.

4.1.3 The SFRA and SWMP states that all main rivers historically located within the Borough are now culverted and incorporated into the sewer network. The SWMP discusses the River Fleet which is one of London's "lost rivers" and which historically originates from springs on Hampstead Heath and drains to the Thames through the Borough. The Fleet is entirely incorporated within the sewer network.

4.1.4 The SFRA continues to discuss the Borough's historic rivers and in addition to the Fleet, the Tyburn, Kilburn and Brent were also located in the area of Hampstead Heath. All of these "lost rivers" are also now incorporated into the local sewer system maintained by Thames Water. It is for these reasons that the Borough is located entirely within Flood Zone 1.

4.2 Critical Drainage Areas (CDA)

4.2.1 Despite the site being located within Flood Zone 1, it is understood from Figure 6/Rev 2 of the SFRA and Figure 3.1 of the SWMP, that the site is located within the Group3-010 Critical Drainage Area (CDA).

4.2.2 The SWMP defines the CDA as:

"A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure."

4.2.3 The site is also located adjacent to, and possibly partially within, the Frognal Lane Local Flood Risk Zone (LFRZ).

4.2.4 The SWMP defines the LFRZ as:

"…discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location."

4.3 Groundwater Flooding

4.3.1 In addition to the information provided in the SFRA and SWMP, in order to assess the potential for groundwater flooding, the Jacobs/DEFRA report entitled *Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study*, published in May 2004, was consulted, together with the guidance offered within the document entitled *Groundwater flooding records collation, monitoring and risk assessment (ref HA5)*, commissioned by DEFRA and carried out by Jacobs in 2006.

4.3.2 The various soil and geological data outlined in Chapter 2, together with Figure 4b/Rev 1 of the SFRA indicates that the soils beneath the site comprise made ground overlying clay, silt and sand.

4.3.3 Figure 4e/Rev 1 of the SFRA shows that the site has not been affected in the past from groundwater flooding incidents (although there has been an incident 136m south east of the site), and that the site is not located within an area of increased susceptibility to elevated groundwater.

4.3.4 Paragraphs 2.10.4 and 2.10.6 of the SFRA states that the Claygate Member has a low permeability but is likely to permit moderate infiltration. The borehole logs indicate that perched water is present at a depth of between 2.78m bgl and 5.45m bgl with some seepage at 1.90m bgl.

4.3.5 The lower ground floor will need to be designed to achieve a Grade 3 level of waterproofing protection as outlined in BS8102:2009. A new reinforced concrete lining wall and ground-bearing concrete slab should be constructed using water resistant concrete to form the primary barrier. Appropriate groundwater control such as sump pumping may be required especially during the construction phase.

4.4 Surface Water Flooding and Sewer Flooding

4.4.1 Surface water and sewer flooding across urban areas is often a result of high intensity storm events which exceed the capacity of the sewer thus causing it to surcharge and flood. Poorly maintained sewer networks and blockages can also exacerbate the potential for sewer flooding.

Surface Water Flooding

4.4.2 It has been established that the site lies within the Group3-010 Critical Drainage Area. The SFRA notes that the surface water mapping indicates that the surface water flood extent broadly follows the natural topography of the borough and man-made features such as roads and rail lines. During extreme modelling scenarios, the SFRA states that there is increased ponding in areas of properties.

4.4.3 The SFRA discusses the two large surface water flooding events in the Borough, which occurred in 1975 and 2002 and caused widespread damage. It is understood that during these events the sewers reached maximum capacity. Figure 3iii/Rev 1 of the SFRA shows that Frognal Gardens was affected during the 1975 event but not the site.

4.4.4 Figure 3iii/Rev 1 of the SFRA and the Agency's Surface Water Flooding Map (Figure 3) indicates that there is a very low surface water flood risk across the site and Frognal Gardens (i.e. chance less than 1 in 1000 years).

4.4.5 It is generally accepted that the low risk flood event (i.e. between 1 in 1000 years and 1 in 100 years) on the Agency's map is used as a substitute for the climate change 1 in 100 year event to provide a worst-case scenario.

4.4.6 People should make a judgment on leaving or accessing the site before, during or after the event in relation to any external flood hazard. The data across the wider area indicates that the preferred evacuation route away from the site is in a southerly direction along Frognal Gardens (Figure 4).

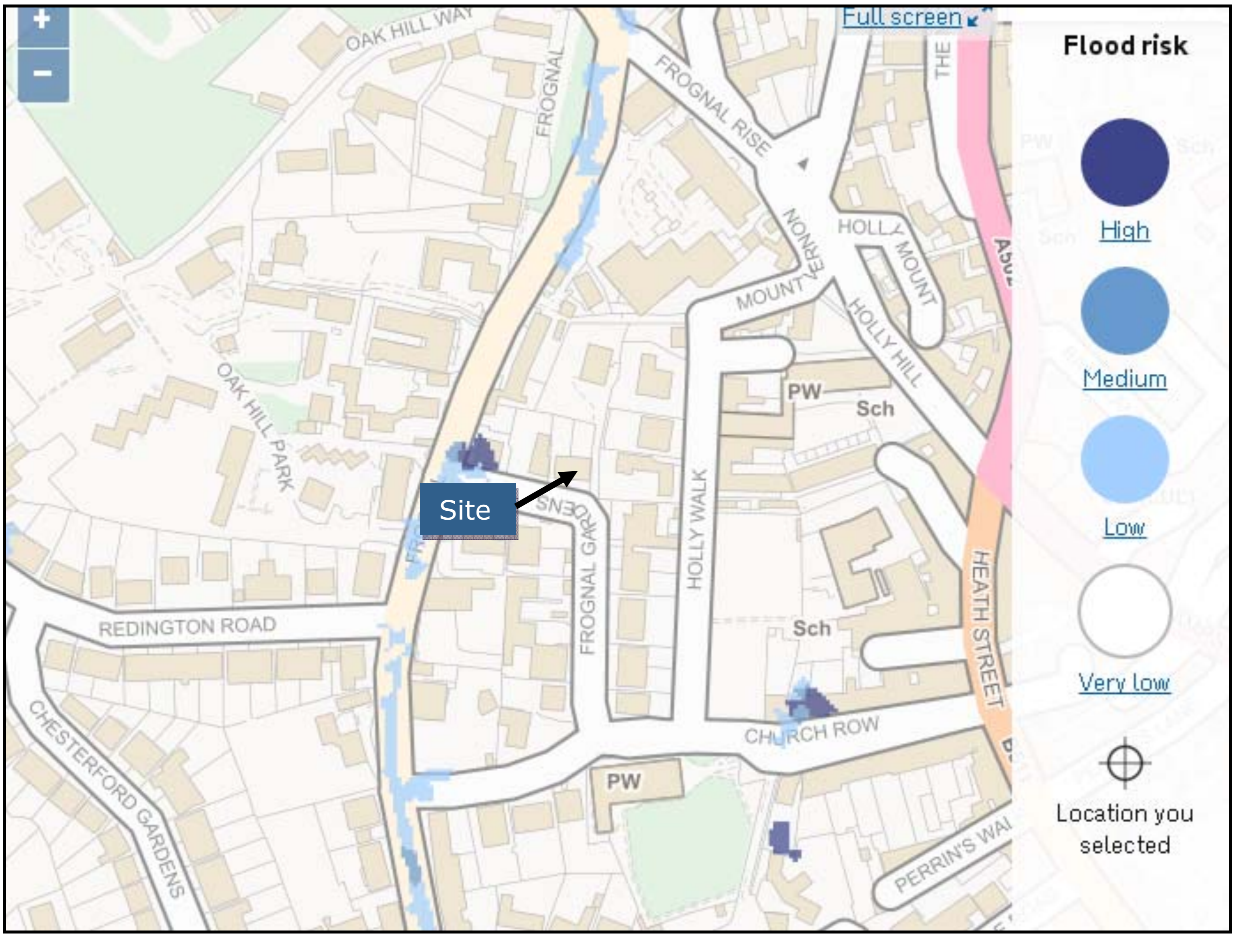


Figure 3: Environment Agency Surface Water Flooding Map (Source: Environment Agency, 2019)

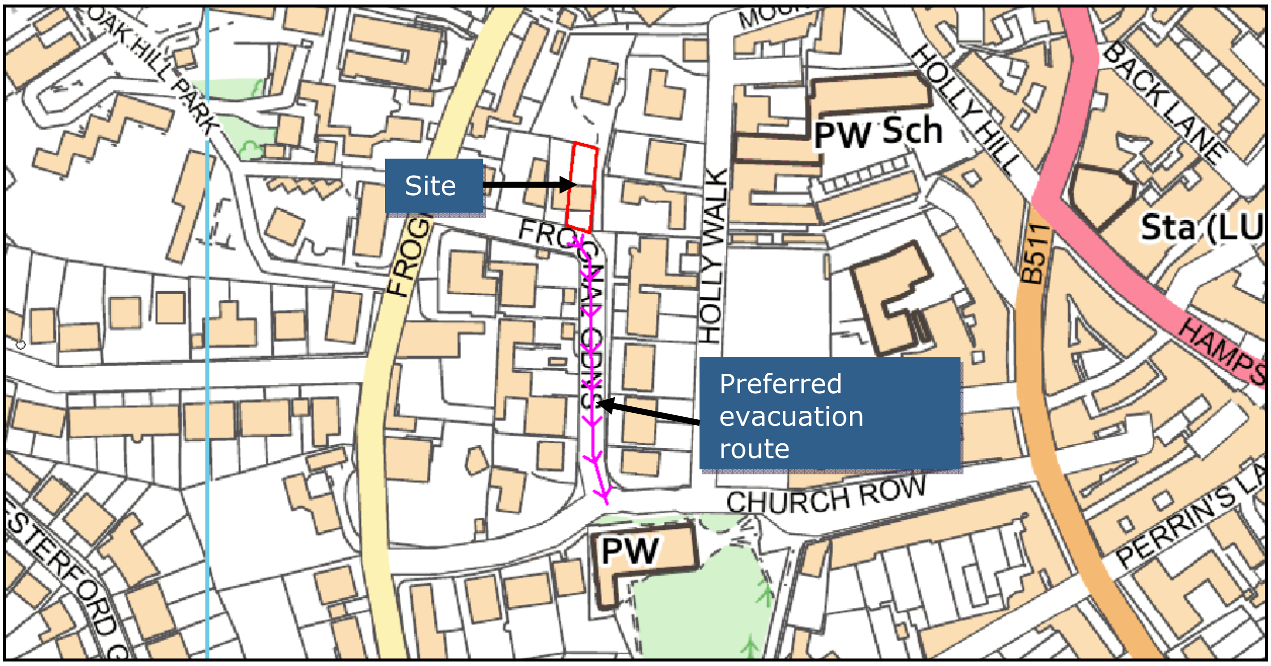


Figure 4: Preferred evacuation route

Sewer Flooding

4.4.7 Figure 5a/Rev 1 of the SFRA indicates that the site is located across an area which has had no internal recorded sewer flooding incidents. Figure 5b/Rev 1 of the SFRA that the site is located across an area which has had no external sewer flooding incidents.

4.4.8 It is considered that there is an overall low risk of sewer flooding at the site.

4.4.9 It is considered that the site should be fitted with a positive pumped device so that it will be protected further from sewer flooding.

4.4.10 In addition to the pumped device there should be a non-return valve (e.g. http://www.forgevalves.co.uk/) installed so that if the sewers become completely full during a heavy storm, foul water does not backflow into the property.

4.4.11 This approach is recommended in section 6.16 of the *Camden Planning Guidance – Basements* dated 2018.

4.5 Reservoirs, Canals And Other Artificial Sources

4.5.1 The failure of man-made infrastructure such as flood defences and other structures can result in unexpected flooding. Flooding from artificial sources such as reservoirs, canals and lakes can occur suddenly and without warning, leading to high depths and velocities of flood water which pose a safety risk to people and property.

4.5.2 The Environment Agency's "Risk of flooding from reservoirs" map suggests that the site is not at risk from reservoirs.

5. SURFACE WATER DRAINAGE AND SUDS

5.1 Policy 5.13 in Chapter 5 of the London Plan dated March 2015, requires sustainable drainage systems (SUDS) to be installed where appropriate and in line with the drainage hierarchy in order for runoff to be managed as close to its source as possible. The London Plan states that SUDS should be utilised unless there are practical reasons for not doing so.

5.2 There will be a slight increase in impermeable area as a result of the proposed lower ground floor extending into the rear garden.

5.3 Opportunities for incorporating SUDS across the site have been identified and consist of the replacement of existing impermeable surfaces at the front of the site with permeable paving (i.e. across the driveway), together with additional planting across part of the lower ground roof area at the front of the property.

5.4 This will result in an overall net reduction in impermeable area across the site. Therefore, there will not be an increase in runoff rate or runoff volume as a result of the proposed development.

6. CONCLUSIONS

- The site is located within Flood Zone 1.

- This assessment has investigated the possibility of groundwater flooding and flooding from other sources at the site. It is considered that there will be a moderate risk of groundwater flooding which will be mitigated by tanking of the lower ground floor.

- There is a very low surface water flood risk across the site and along Frognal Gardens.

- There is a low sewer flooding risk, however, it is considered that the site should be fitted with a positive pumped device so that it will be protected further from sewer flooding. In addition to the pumped device there should be a non-return valve (e.g. http://www.forgevalves.co.uk/) installed so that if the sewers become completely full during a heavy storm, foul water does not backflow into the property.

- There will not be an increase in surface water runoff from the site and there will be no overall net increase in impermeable area. Existing impermeable hardsurfaces at the front of the property will be retrofitted using SUDS permeable paving which will lead to a net reduction in impermeable area and runoff.

7. BIBLIOGRAPHY

i. *Camden Planning Guidance – Basements* dated 2018.

ii. *Camden Planning Guidance – Water and Flooding* dated 2018.

iii. Communities and Local Government 2018. *National Planning Policy Framework.*

iv. DEFRA/EA 2005. *Framework and guidance for assessing and managing flood risk for new development, Phase 2, Flood and Coastal Defence R&D Programme, R&D Technical Report FD2320/TR2*. Water Research Council.

v. DEFRA/Jacobs 2004. *Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study (LDS), Final Report, Volumes 1 and 2*.

vi. Geological Society of London 2006. *Groundwater and Climate Change.* Geoscientist magazine, Volume 16, No 3.

vii. Institute of Geological Sciences 1977. *Hydrogeological Map of England and Wales,* 1:625,000. NERC.

viii. London Borough of Camden Preliminary Flood Risk Assessment (PFRA) Version 0.2 dated 2011.

ix. London Borough of Camden Strategic Flood Risk Assessment (SFRA) dated 2014.

x. London Borough of Camden Surface Water Management Plan (SWMP) Version 1 dated 2011.

xi. London Borough of Camden flood risk management strategy (FRMS) dated 2013.

xii. Water UK 2012. *Sewers for Adoption 7th Edition, A design and construction guide for developers*. Water Research Council.

EVANS

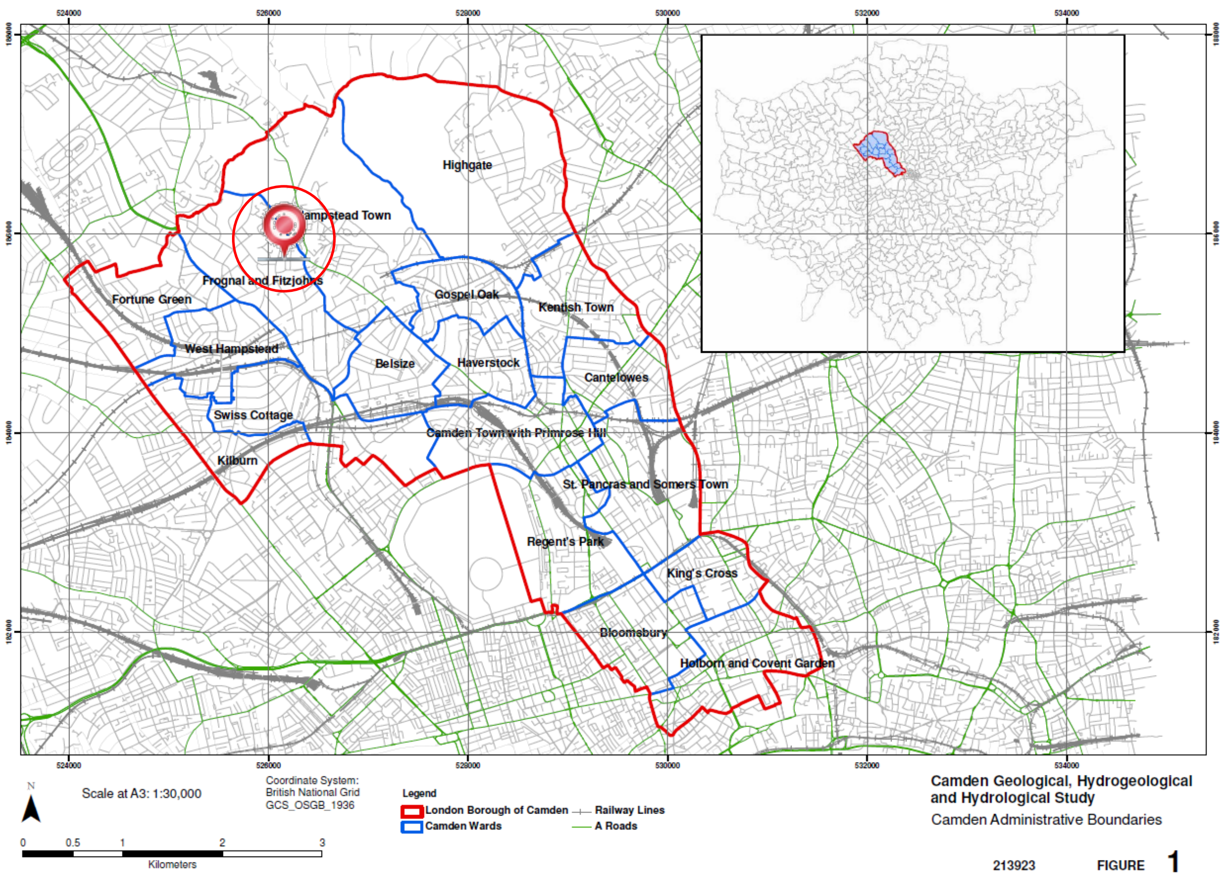
Rivers and Coastal

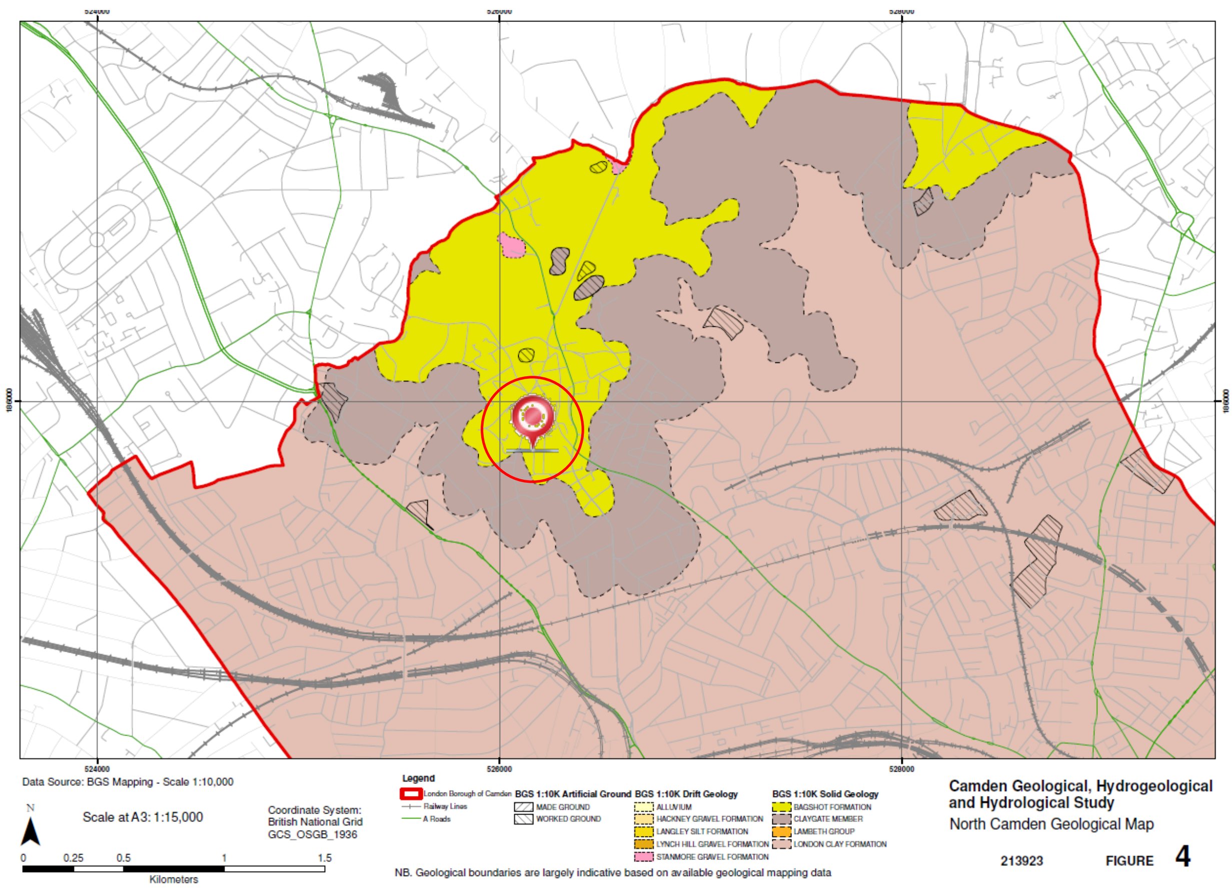
Site & Location

18A Frognal Gardens
Hampstead, London, NW3 6XA

Report No:
10402/SC

Arup Figs for BIA

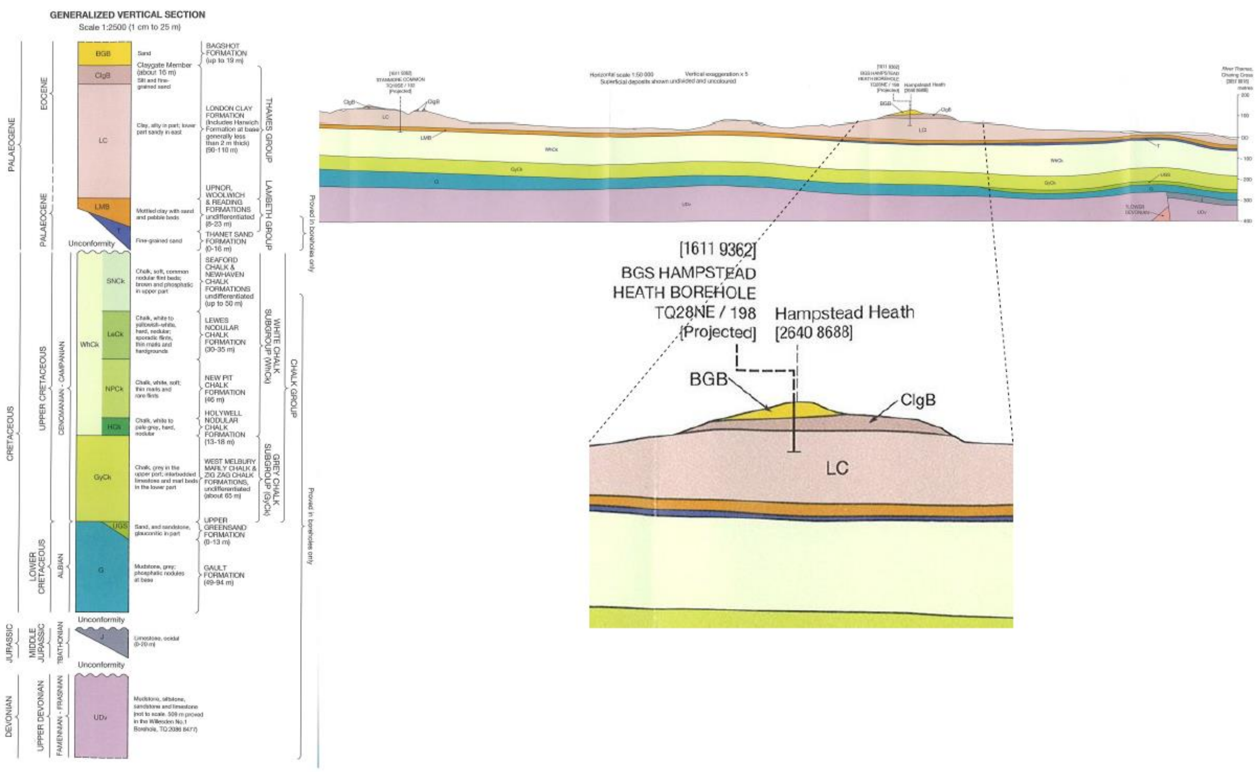




SoilConsultants

Site & Location	18A Frognal Gardens Hampstead, London, NW3 6XA	Report No: 10402/SC

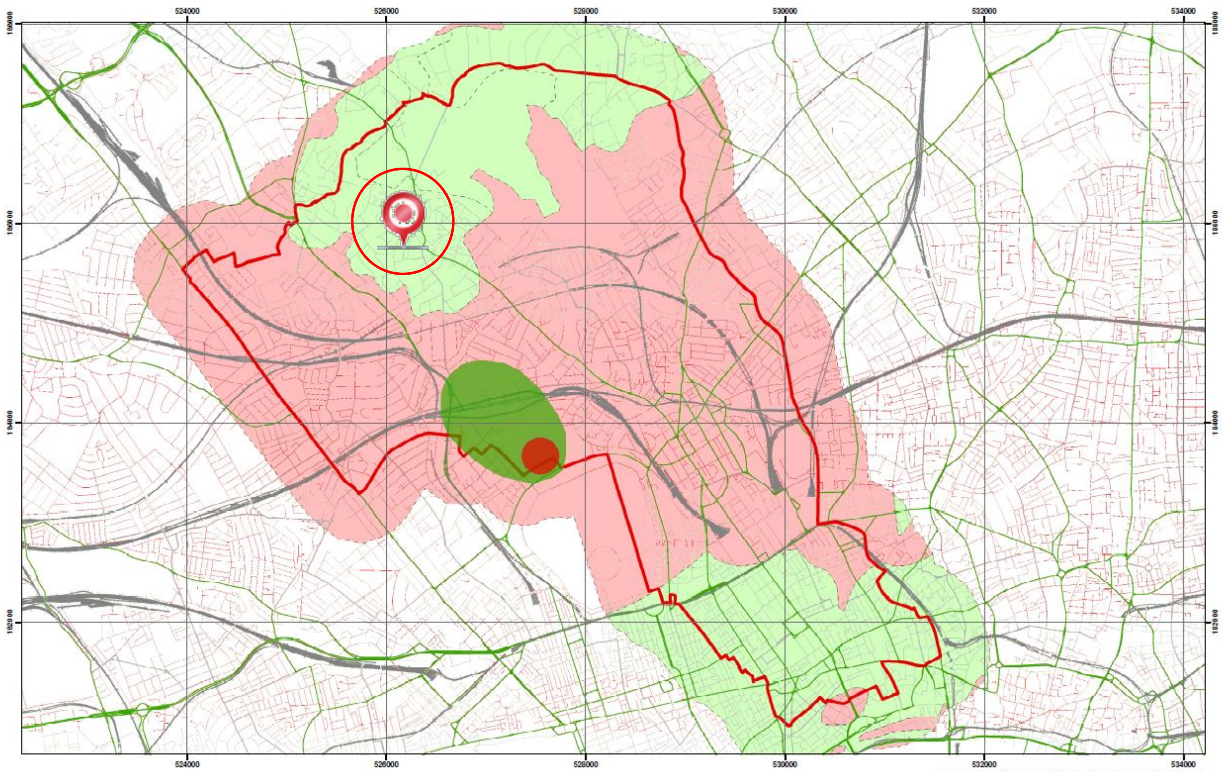
Arup Figs for BIA



Source - British Geological Society, 1:50,000 Series
England and Wales Sheet 256 – North London

Camden Geological, Hydrogeological and Hydrological Study
Geological Long Section (NW – SE)

213923 FIGURE 7



Environment Agency Aquifer Designation based on BGS Mapping

Scale at A3: 1:30,000

Coordinate System: British National Grid GCS_OSGB_1936

0 0.5 1 2 3
Kilometers

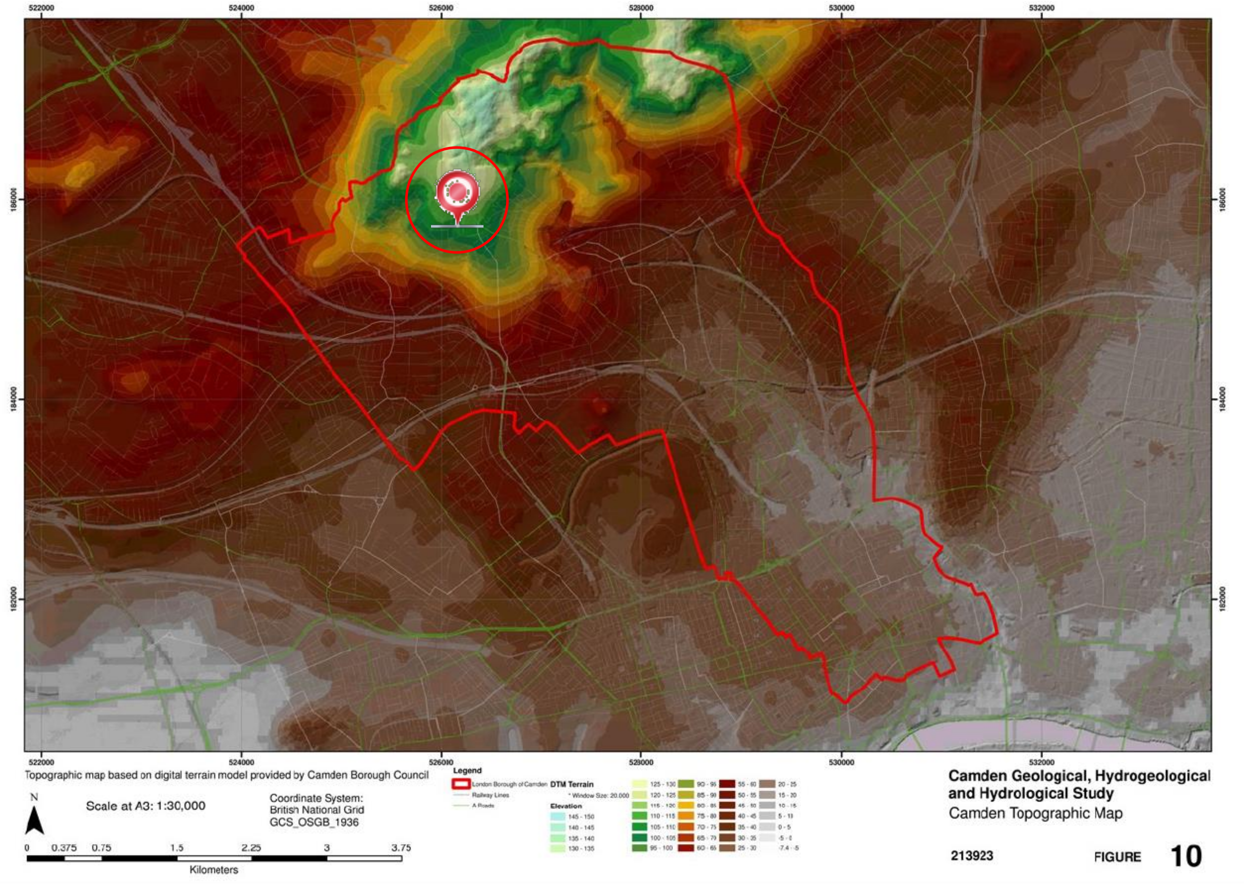
Legend
Borough of Camden
Railway Lines
A Roads
Aquifer Designation
Secondary A Aquifer
Unproductive Strata
Source Protection Zone
Outer Source Protection Zone
Inner Source Protection Zone

NB. Aquifer boundaries are indicative based on available geological mapping data

Camden Geological, Hydrogeological and Hydrological Study
Camden Aquifer Designation Map

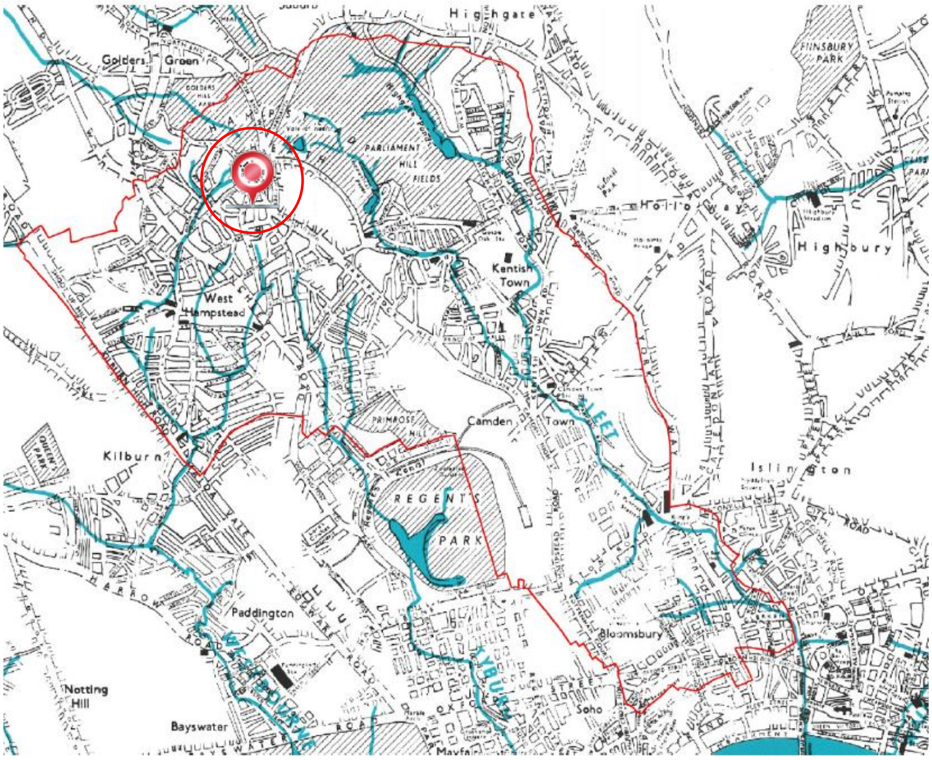
213923 FIGURE 8

Arup Figs for BIA



Site & Location	18A Frognal Gardens Hampstead, London, NW3 6XA	Report No: 10402/SC

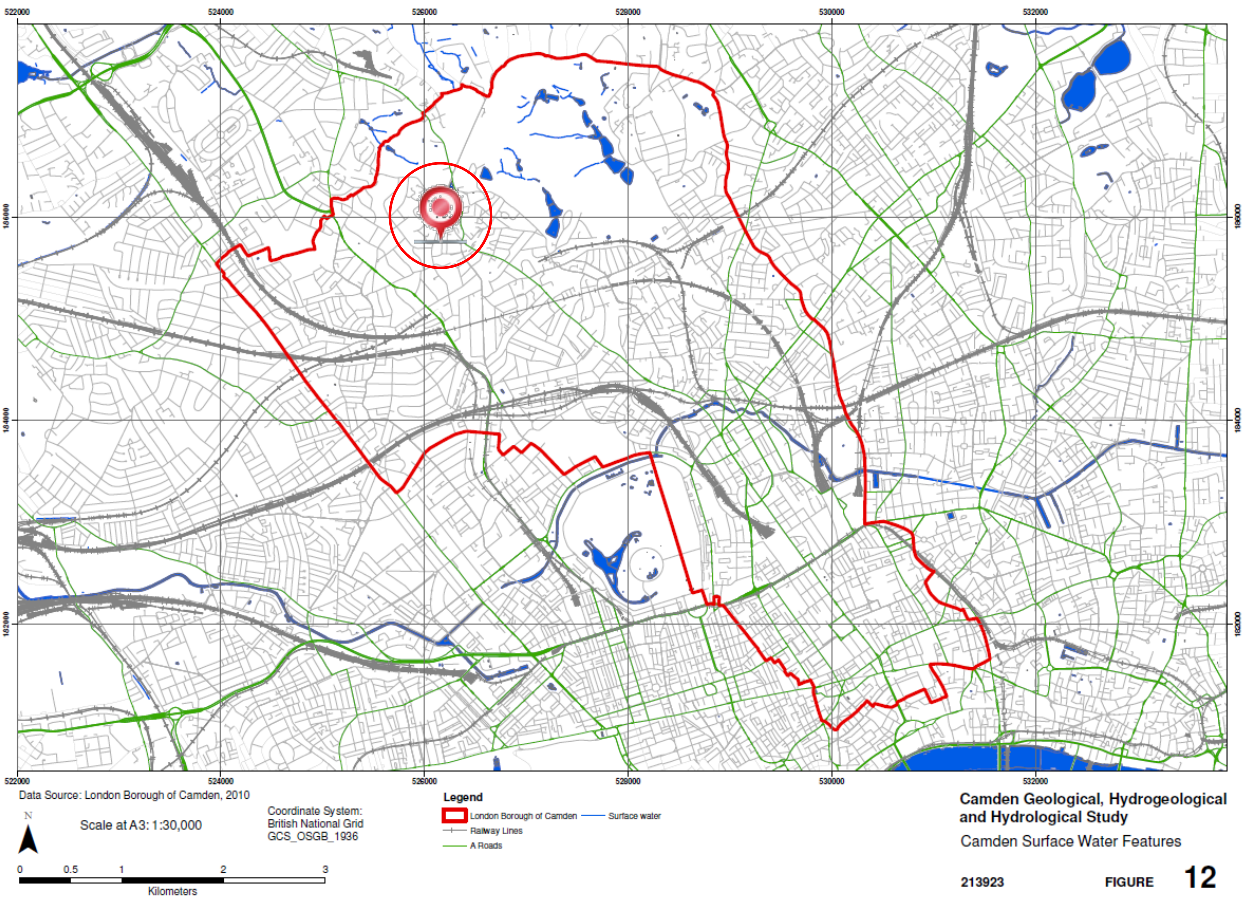
Arup Figs for BIA



Source – Barton, Lost Rivers of London

Camden Geological, Hydrogeological and Hydrological Study
Watercourses

213923 FIGURE 11



Camden Geological, Hydrogeological and Hydrological Study
Camden Surface Water Features

213923 FIGURE 12

Site & Location	18A Frognal Gardens Hampstead, London, NW3 6XA	Report No: 10402/SC

Arup Figs for BIA

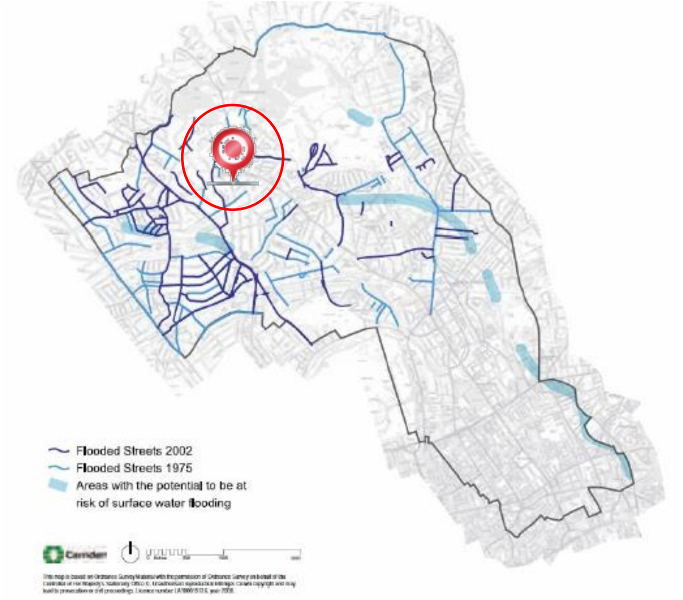
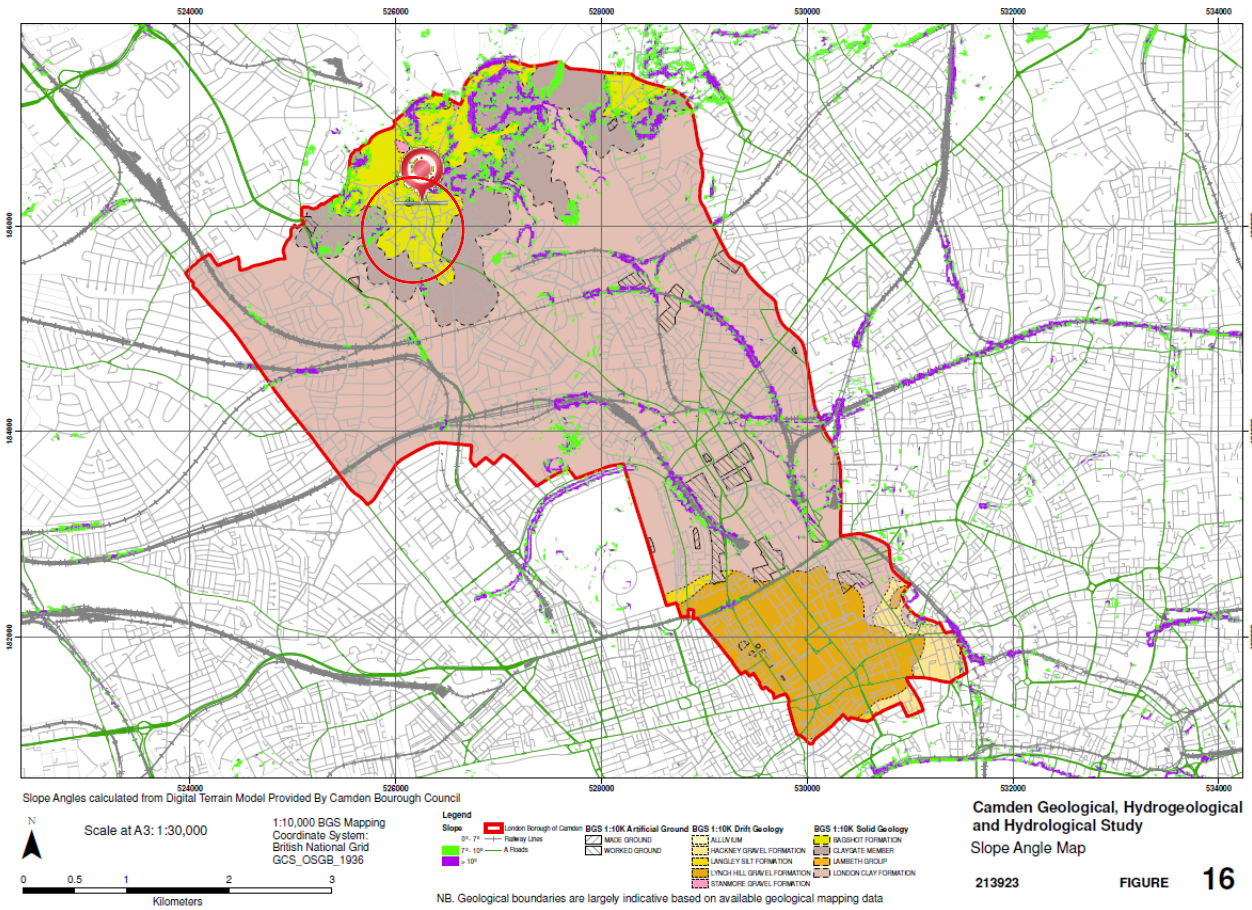


Figure 5 from Core Strategy, London Borough of Camden

Camden Geological, Hydrogeological and Hydrological Study
Flood Map

213923 FIGURE **15**

:

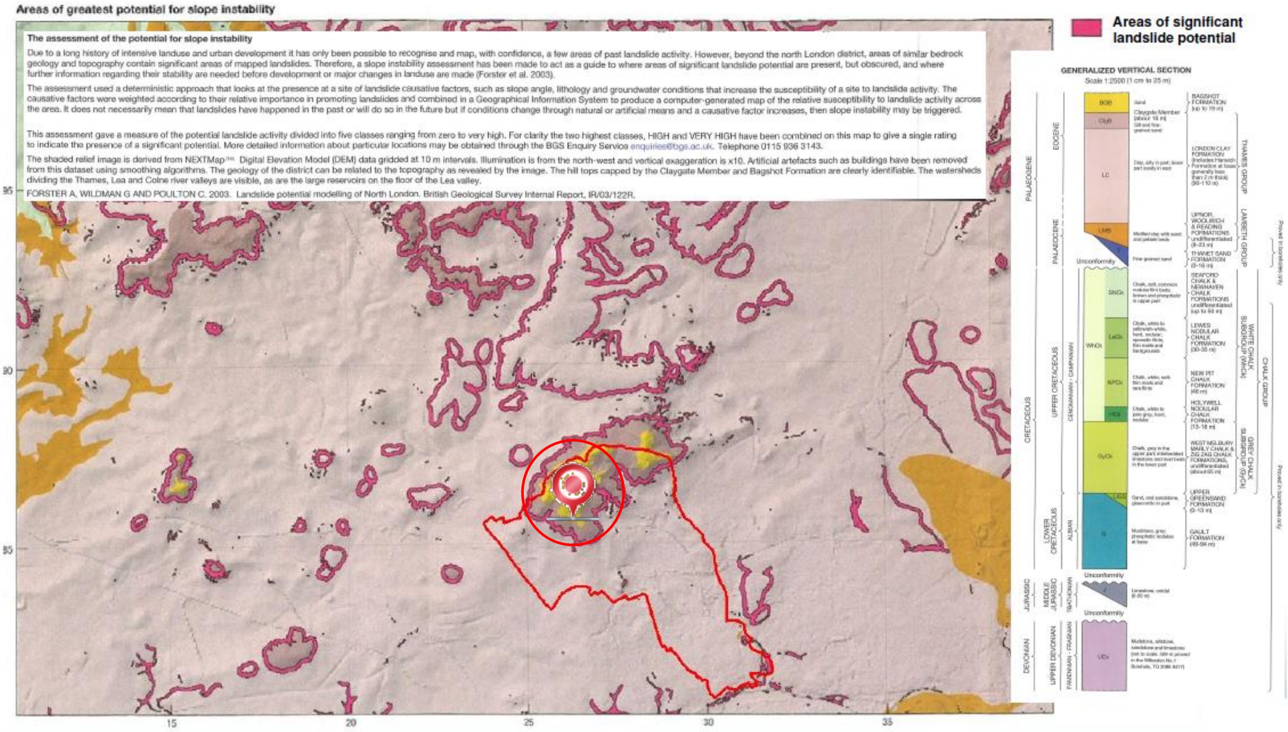


Camden Geological, Hydrogeological and Hydrological Study
Slope Angle Map

213923 FIGURE **16**

SoilConsultants

Arup Figs for BIA



Source - British Geological Society, 1:50,000 Series England and Wales Sheet 256 – North London

Camden Geological, Hydrogeological and Hydrological Study
Areas of landslide potential

213923 FIGURE **17**

Source - London Borough of Camden, January 2010. *Camden Core Strategy Proposed Submission.*

Camden Geological, Hydrogeological and Hydrological Study
Transport Infrastructure

213923 FIGURE **18**

18a Frognal Gardens

Drainage Report

September 2019

EEP Ref: 3849

Environmental Engineering Partnership

Consulting Engineers

The Chapel House,
High Street, West Wycombe,
Buckinghamshire.
HP14 3AG
Telephone: 01494 464544
Facsimile: 01494 464282
e-mail: consulting@eep.co.uk
Website: eep.co.uk

EEP Project Services Ltd trading as
Environmental Engineering Partnership

Company Registration No. 02584221
Registered in England
VAT Number GB 314 0971 80

Contents

Introduction

Where projects are proposing to incorporate a below ground level basement, in accordance with the Camden Local Plan these projects are required to submit a drainage report where the following information is required:

- Identification of flood risk (by Akera Engineers)
- Assessment of existing run-off rates
- Calculation of greenfield run-off rates
- Identification of measures, in line with the drainage hierarchy, to reduce run-off rates
- Calculation of proposed run-off rates

Existing Drainage Connection

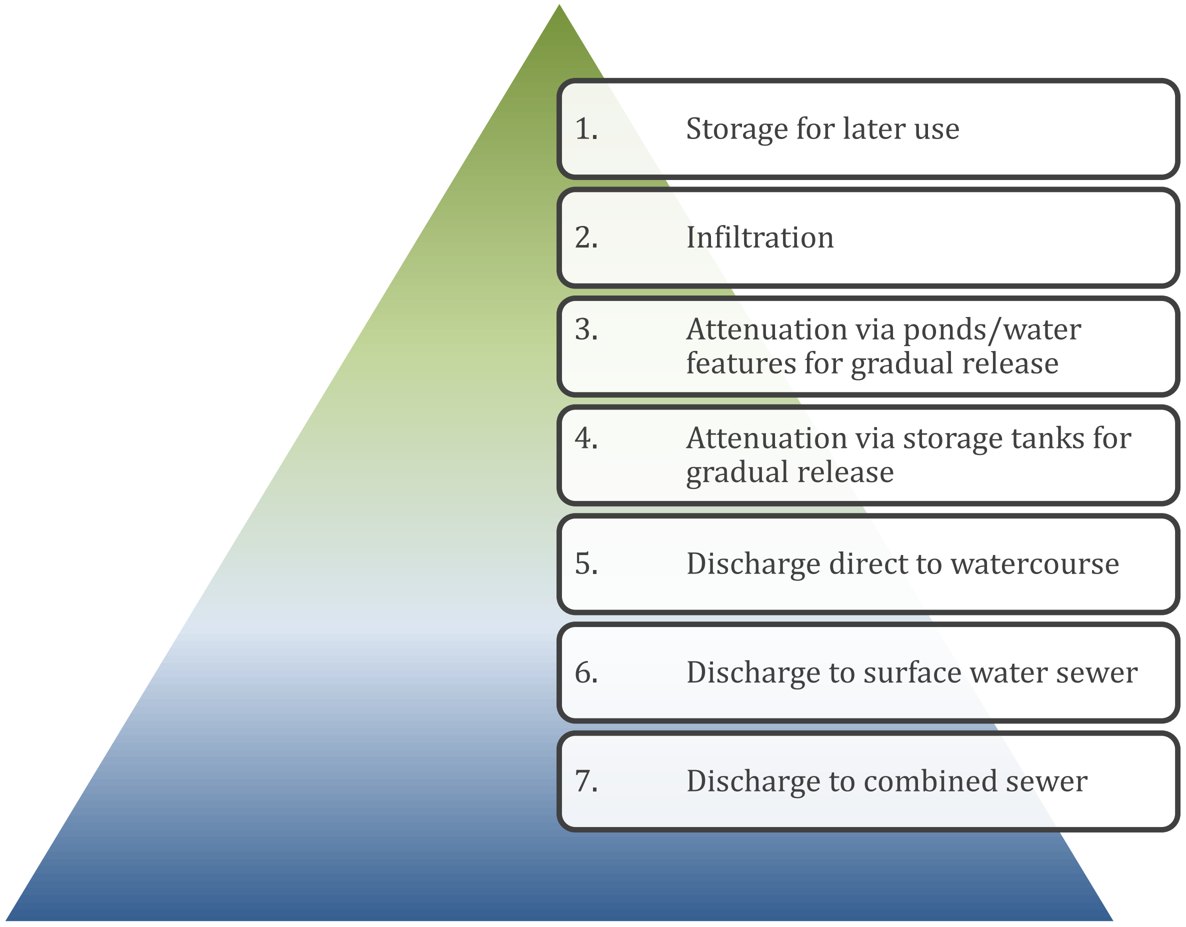
Currently, the rainwater drainage plus the soil and waste drainage from the building are combined and discharge directly to the Thames Water Sewer located beneath the Frognal Gardens road, the drainage combines within an existing manhole located within the front of house private drive/car parking area.

Accordingly, as it is known that the existing connection to the sewer is via a 'combined' drain, which has been confirmed to be Ø150 mm. However, the drainage connection from 18A connects to the drainage from 18B (Ø100 mm pipework) before connecting to the sewer. The connection between the two buildings can be seen at the manhole located on the property of 18B.

Please see a recent CCTV report of the existing drainage system in the Appendix of this report.

It is assumed that the existing rainwater drainage system would have been designed using a rainfall intensity of 75mm/hour.

Drainage Hierarchy



SURFACE AREA CALCULATION ñ EXISTING AND PROPOSED

Existing Areas m²		
GF	18.8	Drains to garden
	131.0	Garden
	47.9	
	71.1	Drains to street
	30.2	Garden
Roof	104.6	
Total	403.6	

161.2m² Garden

Impermeable	152.5
Permeable	180.0
To street	71.1

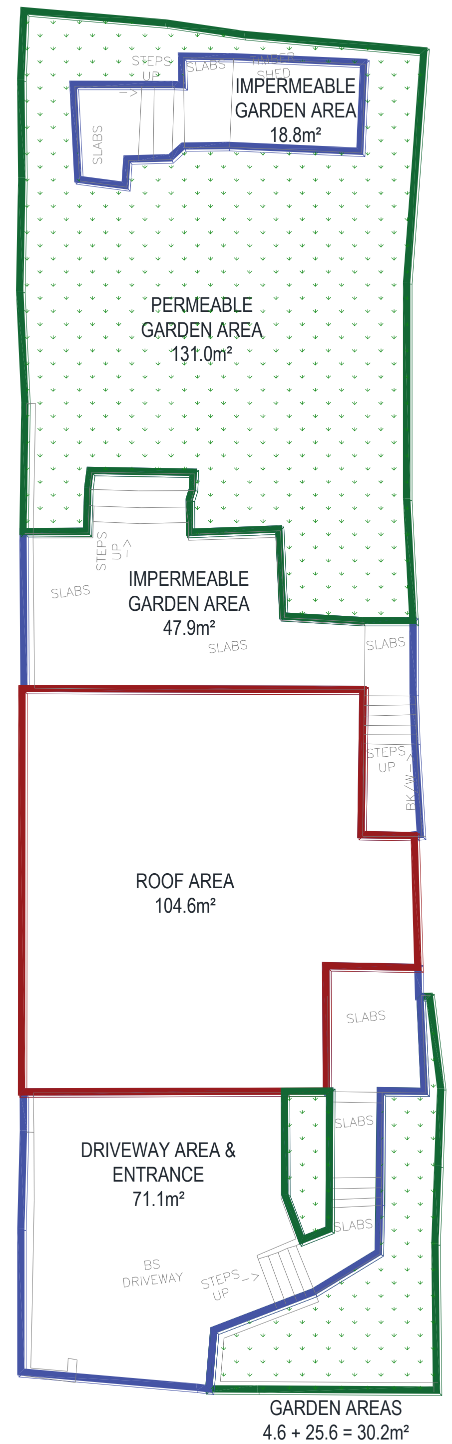
Proposed Areas m²		
GF Lower	43.5	Drains to street
	11.4	Garden
GF Upper	131.1	Garden
	28.0	
	29.9	13.0m² Green Roof
01	12.9	
02	33.1	15.8m² Green Roof
	11.5	
Roof	102.2	
Total	403.6	

142.5m² Garden

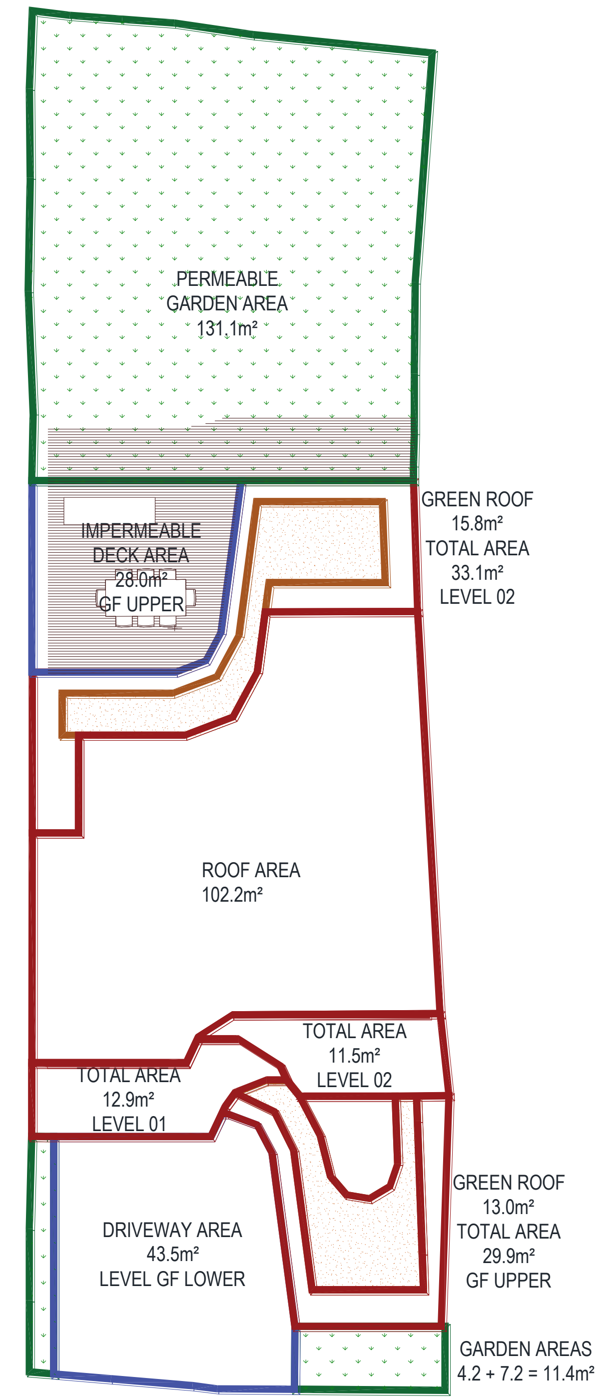
28.8m² Green Roof

Impermeable	154.6
Permeable	142.5
Semi Permeable	63.0
To street	43.5

Existing



Proposed



SURFACE AREA CALCULATION ñ EXISTING AND PROPOSED

Existing Building:

a) Impermeable area = 152.5m^2

b) Permeable area = 180.0m^2

c) Discharges to street = 71.1m^2

Total **403.6m^2**

Proposed Building:

c) Impermeable area = 154.6m^2

d) Permeable area = 142.5m^2

e) Semi-permeable Green Roof area = 63.0m^2

f) Discharges to street = 43.5m^2

Total **403.6m^2**

As can be seen from table 6 within the CIBSE Guide KS11 the rainfall water retention will be 50% (TBC) which affectively increases the "permeable area" by 38 m^2 (63 m^2 ÷ 2 = 31.5 m^2 or 50%), therefore the new site areas simplified for run-off calculation purposes we can adjust the areas as follows:-

Proposed Building (Simplified):

f) Impermeable area = 186.1m^2 (154.6 + 31.5)

g) Permeable area = 174m^2 (142.5 + 31.5)

h) Discharges to street = 43.5m^2

Total **403.6m^2**

Substrate depth / mm	Vegetation	Average annual water retention / %	Average annual rainfall run off / %
20–40	Moss, sedums	40	60
40–60	Sedums and moss	45	55
60–100	Sedums, moss and herbs	50	50
100–150	Sedums, herbs and grass	55	45
150–200	Grass and herbs	60	40

Water retention in extensive green roofs (based on 650–800 mm annual rainfall).
CIBSE KS11 – Green Roofs, Table 6.

Run-off rate calculations

The rainfall intensity stipulated within Clause 3.8 of the March 2019 version of the 'Camden Planning Guidance – Water & Flooding' for a residential development the required 'Protection Years' are for a 100 year return period, using BS EN 12056-3 this results in a design intensity of 250mm/hour (0.069 litres/second/metre^2).

Run-off Calculations

		Area m^2	Run-off l/s		
Existing	Impermeable	152.5	10.52		
Existing	Permeable	180.0	12.42		
Proposed	Impermeable	186.1	12.84	22%	% Change
Proposed	Permeable	174	12.01		

Rainfall intensity calculations for **18a FROGNAL GARDENS, LONDON.**

Based on Category 2 values from BS EN 12056 part 3

BASIC DATA

Nearest geographical town	London	
Building life span required	100	years

Calculations data based on BS EN 12056 part 3 Category 2

Protection years (T) (1.5 x life span)	150	years				
Fig. NB.6 value (return period in years)	4.5	(based on 2min M5)				
From Table NB.1, fraction for 2 min. storm = 1.00						
Therefore 2 min. M5 rainfall =	4.5	X	1	=	4.5	
Factor from Fig. NB.7 using protection years	150	(M5=2)		=	1.9	
Using return period year factor for 2 min M5 =	1.85	X	4.5	=		8.325

Calculated Flowrates

Rainfall intensity in mm/hour	30	X	8.325	=	250	mm/hour
Run off in litres per second	0.069	per square metre				

ATTENUATION TANK CAPACITY CALCULATIONS

In order to maintain the building's original rainwater discharge to the sewer any design for the attenuation and controlled release of rainwater shall not exceed the discharge rate of the original design. It is assumed that the rainfall intensity used for the original design was based on 75mm per hour/m².

Therefore, following the guidance from the Camden Planning Guidance documents and methodology provided in the BRE Digest 365 – Soakaway Design, and The Wallingford Procedure, the following equations can be used to size the rainwater attenuation tank:

Run-off Calculations Based on original building design (75mm/Hr/m²)	Area m²	Run-off l/s	
Impermeable	152.5	3.20	maximum allowable discharge to sewer

NOMENCLATURE

$MX\text{-}D_{min} : {}^{X=return\ period\ (years)}_{D=storm\ duration\ (min)}$

$Z1: rainfall\ factor\ taken\ from\ figure\ 1\ and\ table\ 1 - BRE\ Digest\ 365$

$Z2: growth\ factor\ taken\ from\ table\ 2 - BRE\ Digest\ 365$

$d = discharge\ rate (l/s)$

$T = time\ (s)$

$I = inflow\ (m^3)$

$O = outflow\ (m^3)$

$S = storage\ (m^3)$

EQUATIONS

$M5\text{-}D_{min} = M5\text{-}60_{min\ rainfall} \times Z1$

$M10\text{-}D_{min} = M5\text{-}D_{min} \times Z2$

$O = d \times M10\text{-}D_{min}$

$I = d \times T$

$I_{140\%} = I \times 1.4$

$S = I_{140\%} - O$

Area m²	Duration	Rainfall factor Z1	M5 rainfalls mm	Growth factor Z2 (M10)	M10 year rainfall mm	Growth factor Z2 (M100)	M100 year rainfall mm	M100 year rainfall + 40% mm	Inflow m³	Inflow (@140%) m³	Outflow m³	Storage required m³
186.1	5 mins	0.38	7.6	1.19	9.0	1.96	14.9	20.9	2.8	3.9	1.0	2.9
	10 mins	0.53	10.6	1.22	12.9	2.00	21.2	29.7	3.9	5.5	1.9	3.6
	15 mins	0.64	12.8	1.24	15.9	1.96	25.1	35.1	4.7	6.5	2.9	3.7
	30 mins	0.81	16.2	1.24	20.1	2.00	32.4	45.4	6.0	8.4	5.8	2.7
	1 hour	1.00	20	1.24	24.8	2.03	40.6	56.8	7.6	10.6	11.5	0.0
	2 hours	1.20	24	1.22	29.3	2.01	48.2	67.5	9.0	12.6	23.1	0.0
	4 hours	1.42	28.4	1.19	33.8	1.97	55.9	78.3	10.4	14.6	46.1	0.0
	6 hours	1.57	31.4	1.17	36.7	1.96	61.5	86.2	11.5	16.0	69.2	0.0
	10 hours	1.74	34.8	1.14	39.7	1.92	66.8	93.5	12.4	17.4	115.3	0.0
	24 hours	2.16	43.2	1.13	48.8	1.86	80.4	112.5	15.0	20.9	276.7	0.0

Protected tree root zone

At 18A Frognal Gardens at the rear of the property are a number of fully established trees, a soakaway, if used, must be located outside of the root protection zone.

Building Regulations Part H and good practice requires that any soakaway be located not closer than 5m to the nearest building and section 3.20 within the 'Camden Planning Guidance – Water & Flooding' states any infiltration measures located within 5m must be designed to avoid harm to the building, in accordance with the Building Regulations.

A survey of the existing root area shows that distance of the building from the root protection zone varies from approximately 2.4m to 5.2m, this provides little or no room for the inclusion of a soakaway system of any meaningful size.

Therefore, rainwater run-off and drainage shall be addressed using a combination of solutions to be discussed in the sections to follow.

Rainwater Infiltration & Attenuation

The proposed architectural design shows extensive green roofing to be installed to some terrace and roof areas, however, it is noted that section 3.14 within the 'Camden Planning Guidance – Water & Flooding' states:

However, green roofs cannot be considered a permeable soil and should be assumed to be saturated at the point of intense storms (i.e. storms that are more intense than a 1 in 10 year storm). Due to the sporadic nature of water consumption, rainwater harvesting tanks should also be assumed to be full at the point of a storm event. Both of these systems are generally not intended to control peak run-off rate during critical events, and are mainly useful during medium and small events to capture run-off and thus reduce the volume of water entering the drainage system during these smaller events.

But section 3.15 also states:

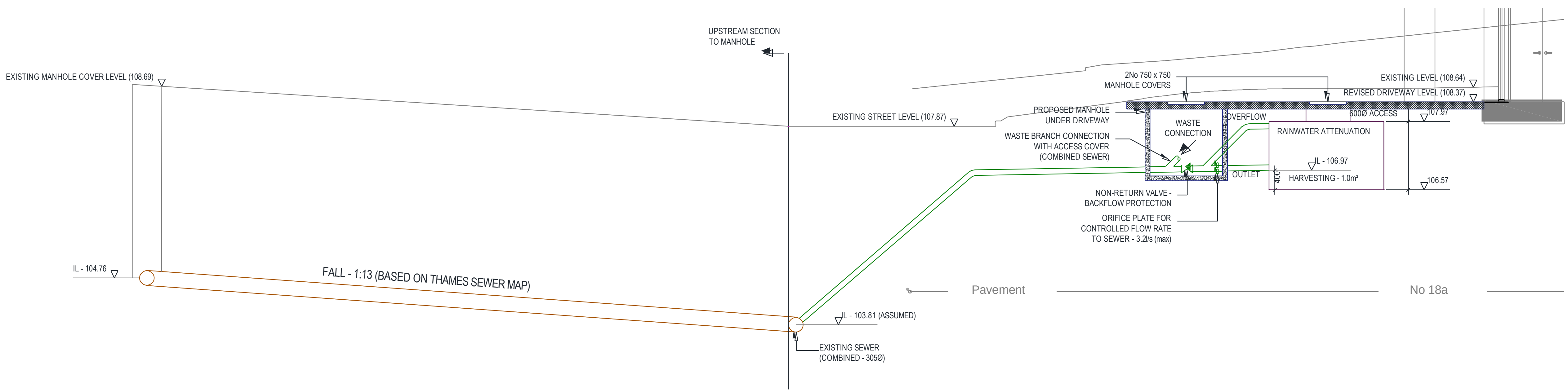
Some rainwater harvesting tanks can incorporate an attenuation chamber/ overflow with controlled release, and green roofs can incorporate an attenuation layer ("blue roof") or be designed to be substantially thick, allowing the associated attenuation volume to be included within the modelling. The Council will consider inclusion of these SuDS in developments favourably due to their additional environmental benefits.

Therefore, the proposal for mitigating the impact of the proposed development to the local sewer network shall be through the attenuation and controlled release of surface water to the sewer. The discharge to the sewer shall be designed to meet the criteria used for the original building, therefore, any additional impact due to climate and increased surface run-off shall be dealt with on site.

The inclusion of several areas of "green roofing" shall serve to provide additional attenuation to the sewer, with the guidance provided in CIBSE Guide KS11, 50% of these areas have been included in the sizing of the attenuation tank.

In order to facilitate the sustainability ambitions of the project, and in line with the drainage hierarchy, it is proposed to maintain a level of water at the bottom of the tank for the provision of harvested rainwater to be reused for irrigation of the green roofs and landscape gardens.

This will require the addition of submersible pumps to the tank that will be serviceable from the manhole cover provided. The tank shall not include a mains water backup, therefore, at times when the tank is empty irrigation will need to come from a Category 5 protected mains water supply.



Conclusions

Due to the revised layout of 18A Frognal Gardens the surface water run-off is expected to increase by 22% when compared with the volume currently coming from the building.

Due to this increase and in order to meet the expectations of the Camden Policy Guidance documents the following measures are proposed to relieve pressure on the local drainage system:

- Green roof attenuation – to control the flow of rainwater from the building

- Rainwater attenuation and controlled release – a hybrid underground system located to the front of the building that will be used to control the flow discharging to the combined sewer with additional harvesting capacity for reuse through irrigation.

With these measures in place we expect to mitigate the impact of any changes to the impermeable run-off surfaces whilst also addressing the future demands owing to climate change. The discharge rate from the attenuation tank shall be designed to be no worse than the original peak discharge for the current building's original design (based on $75mm/Hr/m^2$).

ENVIRONMENTAL
ENGINEERING
PARTNERSHIP

CONSULTING ENGINEERS

APPENDIX ñ CCTV SURVEY REPORT

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Table of Contents

Project Name	Project Number	Project Date
04.09.19 18A Frognal Gardens, London		04/09/2019

Project Information

Project Name	Project Number	Project Date
04.09.19 18A Frognal Gardens, London		04/09/2019

Client

Company: Environmental Engineering Partnership
Street: The Chapel House, High Street
Town or City: West Wycombe, HP14 3AG

Site

Company: EEP
Street: 18A Frognal Gardens
Town or City: London, NW3 6XA

Contractor

Company: Aqua-Jet Specialist Drainage Contractors Ltd
Contact: Rob Wilkinson
Street: Yard 21 Hilton Ind Est, Sutton Lane
Town or City: Hilton, Derbyshire, DE65 5FE
Phone: 01283 730333
Email: aquajetltd@aol.com

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Inspection - 04/09/2019 - MH1X

Section	Inspection	Date	Time	Client`s Job Ref	Weather	Pre Cleaned	PLR
1	1	04/09/19		Not Specified	No Rain Or Snow	Y	MH1X

Operator	Vehicle	Camera	Preset Length	Legal Status	Alternative ID
RR/MD	FJ17 ZDS	Flexi	Not Specified	Not Specified	Not Specified

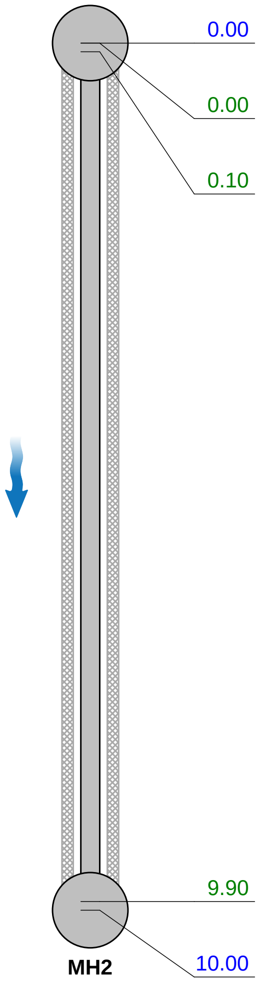
Town or Village:	London	**Inspection Direction:**	Downstream	**Upstream Node:**	MH1
Road:	18A Frognal Gardens	**Inspected Length:**	10.00 m	**Upstream Pipe Depth:**	
Location:		**Total Length:**	10.00 m	**Downstream Node:**	MH2
Surface Type:		**Joint Length:**	0.00 m	**Downstream Pipe Depth:**	

Use:	Combined	**Pipe Shape:**	Circular
Type of Pipe:	Gravity drain/sewer	**Dia/Height:**	100 mm
Year Constructed:		**Pipe Material:**	Cast iron
Flow Control:	No flow control	**Lining Type:**	No Lining
Inspection Purpose:		**Lining Material:**	No Lining

Comments:
Recommendations:

Scale: 1:87

Depth: m
MH1



Position [m]		Code	Observation	MPEG	Photo	Grade
0.00		MH	Start node type, manhole, reference number: MH1	00:00:00		
0.00		WL	Water level, 0% of the vertical dimension	00:00:01		
0.10	S01	DEE	Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, start: RUST / CORROSION	00:00:06		
9.90	F01	DEE	Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, finish: RUST / CORROSION	00:01:22		2
10.00		MHF	Finish node type, manhole, reference number: MH2	00:01:23		

MH2

Depth: m

Structural Defects					Construction Features				
Service & Operational Observations					Miscellaneous Features				
STR No. Def	**STR Peak**	**STR Mean**	**STR Total**	**STR Grade**	**SER No. Def**	**SER Peak**	**SER Mean**	**SER Total**	**SER Grade**
0	0.0	0.0	0.0	1.0	1	1.0	1.0	10.0	2.0

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Pictures - 04/09/2019 - MH1X

Section	Inspection Direction	PLR	Client`s Job Ref	Contractor`s Job Ref
1	Downstream	MH1X		

MH1X_697d6ba7-1a86-43ea-9b00-4985f68a1723_20190906_095824_558.jpg, 00:00:06, 0.10 m
Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, start

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Inspection - 04/09/2019 - A/MH1X

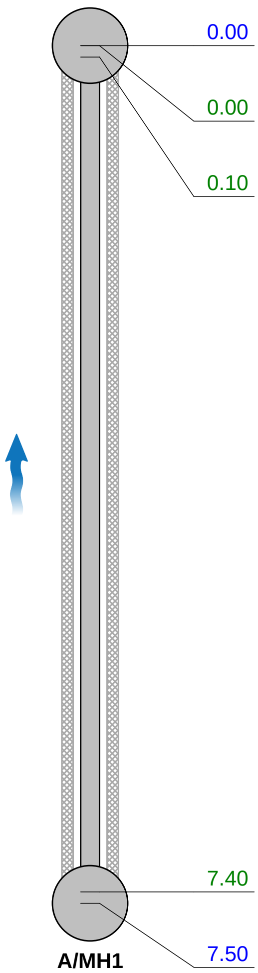
Section	Inspection	Date	Time	Client`s Job Ref	Weather	Pre Cleaned	PLR
2	2	04/09/19		Not Specified	No Rain Or Snow	Y	A/MH1X

Operator	Vehicle	Camera	Preset Length	Legal Status	Alternative ID
RR/MD	FJ17 ZDS	Flexi	Not Specified	Not Specified	Not Specified

Town or Village:	London	**Inspection Direction:**	Upstream	**Upstream Node:**	A/MH1
Road:	18A Frognal Gardens	**Inspected Length:**	7.50 m	**Upstream Pipe Depth:**	
Location:		**Total Length:**	7.50 m	**Downstream Node:**	MH1
Surface Type:		**Joint Length:**	0.00 m	**Downstream Pipe Depth:**	

Use:	Combined	**Pipe Shape:**	Circular
Type of Pipe:	Gravity drain/sewer	**Dia/Height:**	100 mm
Year Constructed:		**Pipe Material:**	Cast iron
Flow Control:	No flow control	**Lining Type:**	No Lining
Inspection Purpose:		**Lining Material:**	No Lining

Comments:
Recommendations:



Scale: 1:66 Position [m]		Code	Observation	MPEG	Photo	Grade
0.00		MH	Start node type, manhole, reference number: MH1	00:00:00		
0.00		WL	Water level, 5% of the vertical dimension	00:00:01		
0.10	S01	DEE	Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, start: RUST / CORROSION	00:00:03		
7.40	F01	DEE	Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, finish: RUST / CORROSION	00:01:22		2
7.50		MHF	Finish node type, manhole, reference number: A/MH1	00:01:22		

Structural Defects					Construction Features				
Service & Operational Observations					Miscellaneous Features				
STR No. Def	**STR Peak**	**STR Mean**	**STR Total**	**STR Grade**	**SER No. Def**	**SER Peak**	**SER Mean**	**SER Total**	**SER Grade**
0	0.0	0.0	0.0	1.0	1	1.0	1.1	8.0	2.0

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Pictures - 04/09/2019 - A/MH1X

Section	Inspection Direction	PLR	Client`s Job Ref	Contractor`s Job Ref
2	Upstream	A/MH1X		

A_MH1X_7069cf84-8557-4d21-aaf6-a844871a4e0a_20190906_100331_033.jpg, 00:00:03, 0.10 m
Attached deposits, encrustation from 12 o'clock to 12 o'clock, 5% cross-sectional area loss, start

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Inspection - 04/09/2019 - MH2X

Section	Inspection	Date	Time	Client`s Job Ref	Weather	Pre Cleaned	PLR
3	3	04/09/19		Not Specified	No Rain Or Snow	Y	MH2X

Operator	Vehicle	Camera	Preset Length	Legal Status	Alternative ID
RR/MD	FJ17 ZDS	Flexi	Not Specified	Not Specified	Not Specified

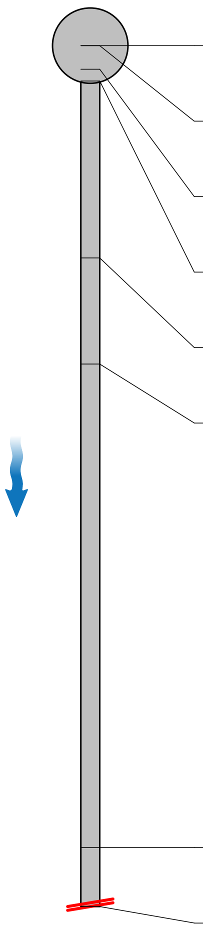
Town or Village:	London	**Inspection Direction:**	Downstream	**Upstream Node:**	MH2
Road:	18A Frognal Gardens	**Inspected Length:**	7.30 m	**Upstream Pipe Depth:**	
Location:		**Total Length:**	7.30 m	**Downstream Node:**	D/S MH2
Surface Type:		**Joint Length:**	0.00 m	**Downstream Pipe Depth:**	

Use:	Combined	**Pipe Shape:**	Circular
Type of Pipe:	Gravity drain/sewer	**Dia/Height:**	100 mm
Year Constructed:		**Pipe Material:**	Vitrified clay pipe (i.e. all clayware)
Flow Control:	No flow control	**Lining Type:**	No Lining
Inspection Purpose:		**Lining Material:**	No Lining

Comments:
Recommendations:

Scale: 1:64

Depth: m
MH2



Position [m]	Code	Observation	MPEG	Photo	Grade
0.00	MH	Start node type, manhole, reference number: MH2: SURVEY THROUGH TOP ACCESS HOLE OF TRAP	00:00:00		
0.00	WL	Water level, 5% of the vertical dimension	00:00:01		
0.20	JN	Junction at 6 o'clock, diameter: 100mm: BOTTOM OUTLET OF TRAP	00:00:09		
0.30	SC	Size changes, new size(s), 150mm high	00:00:15		
1.80	CCJ	Crack, circumferential at joint from 8 o'clock to 3 o'clock	00:00:33		2
2.70	LD	Line deviates down	00:00:41		
6.80	LR	Line deviates right	00:01:23		
7.30	SA	Survey abandoned: JOINS MAIN BLIND	00:01:28		

Structural Defects					Construction Features				
Service & Operational Observations					Miscellaneous Features				
STR No. Def	**STR Peak**	**STR Mean**	**STR Total**	**STR Grade**	**SER No. Def**	**SER Peak**	**SER Mean**	**SER Total**	**SER Grade**
1	10.0	1.4	10.0	2.0	0	0.0	0.0	0.0	1.0

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Pictures - 04/09/2019 - MH2X

Section	Inspection Direction	PLR	Client`s Job Ref	Contractor`s Job Ref
3	Downstream	MH2X		

MH2X_99a95e93-e9bd-4658-b633-a5a8b0b76c35_20190906_101510_209.jpg, 00:00:33, 1.80 m
Crack, circumferential at joint from 8 o'clock to 3 o'clock

Aqua-Jet Specialist Drainage Contractors Ltd
Yard 21 Hilton Ind Est, Sutton Lane, Hilton, Derbyshire, DE65 5FE
Tel. 01283 730333
aquajetltd@aol.com

Section Inspection - 04/09/2019 - JUNCTIONX

Section	Inspection	Date	Time	Client`s Job Ref	Weather	Pre Cleaned	PLR
4	4	04/09/19		Not Specified	No Rain Or Snow	N	JUNCTIONX
Operator		**Vehicle**		**Camera**	**Preset Length**	**Legal Status**	**Alternative ID**
RR/MD		FJ17 ZDS		Flexi	Not Specified	Not Specified	Not Specified

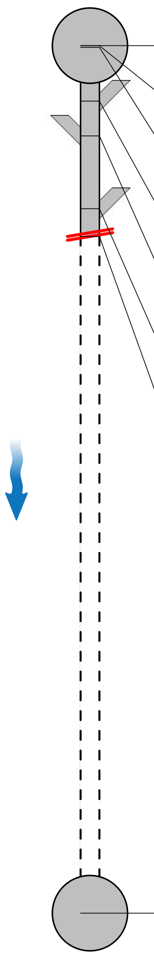
Town or Village:	London	**Inspection Direction:**	Downstream	**Upstream Node:**	JUNCTION
Road:	18A Frognal Gardens	**Inspected Length:**	11.00 m	**Upstream Pipe Depth:**	
Location:		**Total Length:**	50.00 m	**Downstream Node:**	D/S JN
Surface Type:		**Joint Length:**	0.00 m	**Downstream Pipe Depth:**	

Use:	Combined	**Pipe Shape:**	Circular
Type of Pipe:	Gravity drain/sewer	**Dia/Height:**	300 mm
Year Constructed:		**Pipe Material:**	Vitrified clay pipe (i.e. all clayware)
Flow Control:	No flow control	**Lining Type:**	No Lining
Inspection Purpose:		**Lining Material:**	No Lining

Comments:
Recommendations:

Scale: 1:435

Depth: m
JUNCTION



Position [m]	Code	Observation	MPEG	Photo	Grade
0.00	MH	Start node type, manhole, reference number: JUNCTION	00:00:00		
0.00	WL	Water level, 5% of the vertical dimension	00:00:01		
0.10	REM	General remark: POOR VIEW OF PIPE DUE TO SIZE	00:00:07		
3.20	JN	Junction at 9 o'clock, diameter: 150mm	00:00:31		
5.20	JN	Junction at 3 o'clock, diameter: 150mm	00:00:42		
9.40	CN	Connection other than junction at 10 o'clock, diameter: 150mm	00:01:07		
11.00	SA	Survey abandoned: LIMIT OF SURVEY	00:01:17		
50.00		End of pipe			

D/S JN
Depth: m

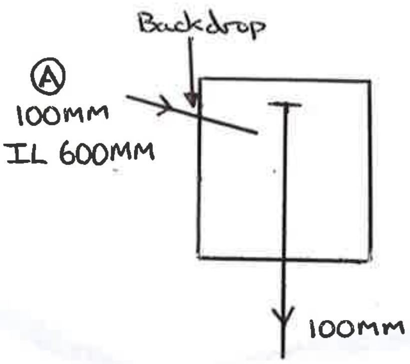
Structural Defects					Construction Features				
Service & Operational Observations					Miscellaneous Features				
STR No. Def	**STR Peak**	**STR Mean**	**STR Total**	**STR Grade**	**SER No. Def**	**SER Peak**	**SER Mean**	**SER Total**	**SER Grade**
0	0.0	0.0	0.0	1.0	0	0.0	0.0	0.0	1.0

AquaJet

Drainage Specialists

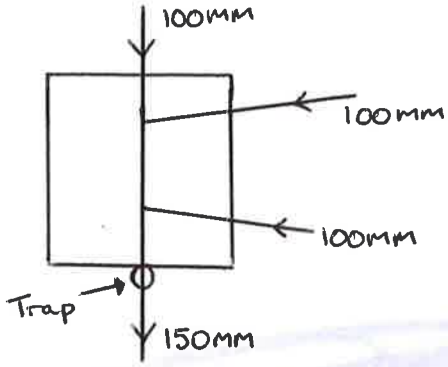
Manhole Information

REFERENCE: MH 1	DUTY: CB
DIAGRAM:	



DEPTH AT OUTLET: 1740MM	
MH SIZE 900MM x 500MM	
MH MATERIAL Brick / Render	
OBSERVATIONS/ COMMENTS:	

REFERENCE: MH2	DUTY: CB
DIAGRAM:	



DEPTH AT OUTLET: 1400MM	
MH SIZE 950MM x 600MM	
MH MATERIAL Brick	
OBSERVATIONS/ COMMENTS:	

REFERENCE:	DUTY:
DIAGRAM:	
DEPTH AT OUTLET:	
MH SIZE	
MH MATERIAL	
OBSERVATIONS/ COMMENTS:	

REFERENCE:	DUTY:
DIAGRAM:	
DEPTH AT OUTLET:	
MH SIZE	
MH MATERIAL	
OBSERVATIONS/ COMMENTS:	

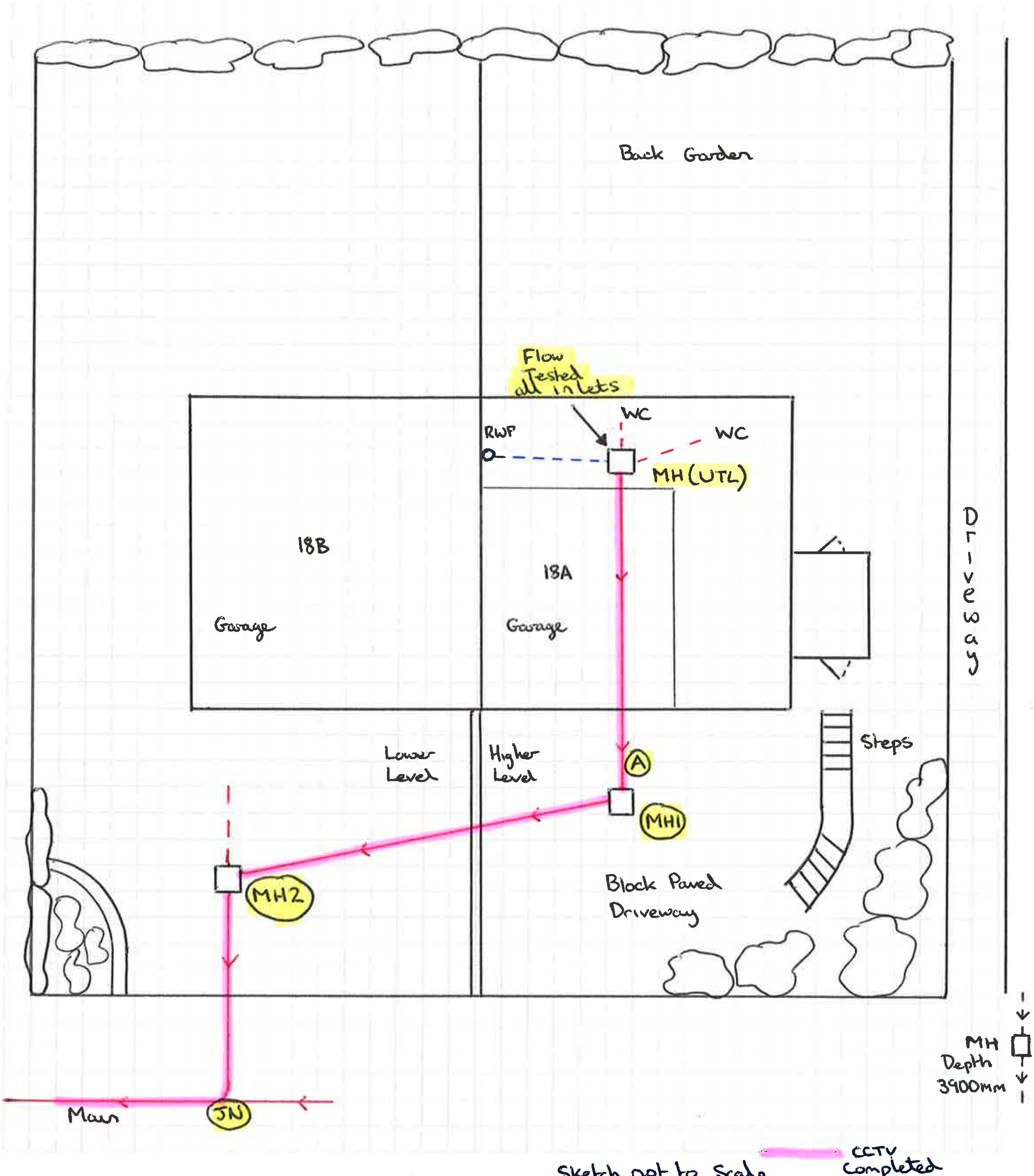
Jetting • Vacuumation • Camera Inspection • Excavation & Repairs • Septic Tanks

Tel 01283 730333 Fax 01283 730444 www.aquajetltd.co.uk aquajetltd@aol.com

Aqua Jet Specialist Drainage Contractors Ltd, Yard 21, Hilton Industrial Estate, Sutton Lane, Hilton, Derbyshire, DE65 5FE

Aqua-Jet

Drainage Specialists



Jetting • Vacuumation • Camera Inspection • Excavation & Repairs • Septic Tanks
Tel: 01283 730333 Fax: 01283 730444 www.aquajetltd.co.uk aquajetltd@aol.com
Aqua-Jet Specialist Drainage Contractors Ltd, Yard 21, Hilton Industrial Estate, Hilton, Derbyshire, DE65 5FE

A-squared Studio

18A Frognal Gardens

Ground Movement Assessment Report

October 2019

1125-A2S-XX-XX-RP-Y-0001-00

Project Name	18A Frognal Gardens
Project Number	1125
Client	Soil Consultants Ltd
Document Name	Ground Movement Assessment Report

A-squared Studio Engineers Limited
One Westminster Bridge Rd
London, SE1 7XW

020 7620 2868
contact@a2-studio.com
www.a2-studio.com

Prepared by	Checked by	Approved by
S. Buensuceso BS, MSc, DIC	H. Shariff MEng(Hons)	A. Nikolic BEng(Hons), MSc, DIC, CEng, MICE, MSt(Cantab)
Graduate Engineer	Engineer	Director

Document Reference	Status	Revision	Issued by	Date
1125-A2S-XX-XX-RP-Y-0001-00	First Issue	00	SB	15.10.2019

Contents

1. Introduction

A-squared Studio Engineers Ltd (A-squared) has been appointed Soil Consultants Ltd (SCL) to undertake a Ground Movement Assessment (GMA) for the 18A Frognal Gardens development in London.

The A-squared scope comprises an assessment of the potential impact of the proposed redevelopment works on the various neighbouring properties.

1.1. Study Aims & Objectives

A ground movement and impact assessment has been carried out in order to estimate the potential damage induced by the proposed redevelopment at 18A Frognal Gardens on the neighbouring properties.

The scheme involves the demolition of the existing two- to three-storey property, excavation of an extended basement, and construction of a proposed four-storey residential structure. The depth of excavation ranges from 1.0m to 5.7m due to sloping ground from the northeast to the southwest and a localised deepening for a pool. Contiguous piled walls have been selected as the ground retention system for the northern and eastern sides of the excavation while mass concrete underpins have been selected for the north-western side.

The assessment encompasses properties located within the zone of influence of the proposed scheme. The GMA assessment is based on *greenfield* ground movements which are unlikely to be exceeded. The adopted assessment methodology provides a robust and conservative assessment representative of current industry best practice, as detailed in Section 4.

The assessment carried out and described herein aims to:

- Assess the impact of ground movements induced by the proposed works on properties adjacent to the development under consideration.
- Inform Party Wall awards.
- Provide performance criteria and inform aspects of substructure construction and design.

This report provides a detailed description of the:

- Site and proposed development.
- Modelling parameters and input.
- Analyses and results.

2. The Site & Development

2.1. Site Location and Proposed Development

The proposed development is located at 18A Frognal Gardens, Hampstead, London, NW3 6XA, as shown in Figure 2.1. The site is approximately located at British National Grid coordinates 526168E,185768N, falling within administrative boundaries of the London Borough of Camden. Hampstead Underground Station is located approximately 220m east of the site.

The site is gently sloping, with elevations ranging from approximately +108.7mOD in the southwest to +112.5mOD in the northeast.

Figure 2.1 18A Frognal Gardens site location

The existing structure occupying the site is a two- to three-storey residence with a lowest level that cuts into the natural topography. This structure will be demolished, and a two- to four-storey residence will be constructed in its place. The proposed development involves several excavations over a large portion of the site footprint to create the lower ground floor and pool area.

The excavation will be supported by contiguous piled walls on the northern and eastern sides and mass concrete underpins installed sequentially in a hit-and-miss fashion on the north-western side. The lower ground floor excavation will extend from a minimum depth of 1.0m on the southern side and maximum depth of 5.7m, representing the pool area in the northern section of the property. The locations of each of the retention systems are shown in Figure 2.2.

Scheme drawings (current at the time of writing) are presented in Appendix A.

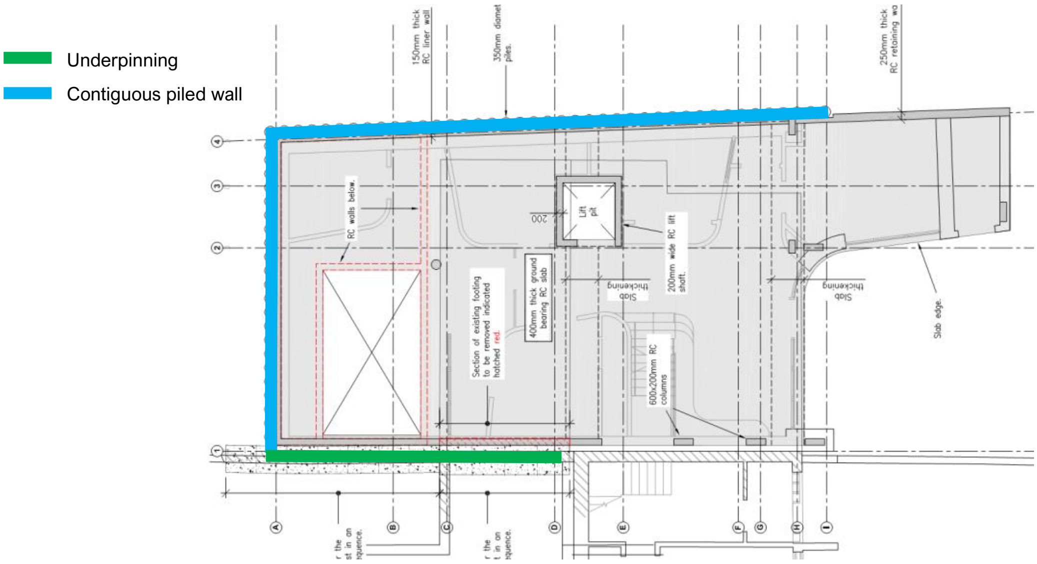


Figure 2.2 Sketch showing the locations of each proposed excavation retention system

3. Geology

Site-specific ground investigation works were carried out on the project site by Soil Consultants Ltd in August 2019. The ground conditions were found to comprise the following (in order of increasing depth):

- Made Ground – anthropogenic deposits of undifferentiated silty clays, sands and gravels.
- Bagshot Formation – loose brown slightly clayey SILT/SAND with occasional clay lenses
- Claygate Beds – firm grey mottled brown sandy silty CLAY with sand horizons
- London Clay Formation – stiff to very stiff fissured brown CLAY with occasional rare bands of silty sand.

The above include the strata of engineering interest and significance, taking cognisance of the scale of the proposed development and zone of influence. The ground model adopted for this assessment is presented in Table 3.1.

Table 3.1 Ground model and geotechncial parameters adopted for analysis purposes

Stratum	Depth (mBGL)	Thickness (m)	Undrained Young's Modulus, E_u [2] (MPa)	Drained Young's Modulus, E' [2] (MPa)
Made Ground	0.0	1.0	-	10.0
Bagshot Formation	1.0	6.0	-	18.0
Claygate Beds + London Clay[3]	7.0	27.0[4]	14.4 + 3.2z[5]	11.5 + 2.5z[5]

1. Ground model based on previous site-specific ground investigation undertaken by Soil Consultants Ltd. This data has been interpreted specifically for the scope of the GMA presented herein.
2. Stiffness data (E_u and E') has been evaluated empirically from in-situ testing data taking into consideration the nature of the geotechnical/soil-structure interaction mechanisms and level of anticipated strain within the soil mass.
3. Claygate Beds and London Clay are assumed to follow a continuous stiffness profile.
4. *Rigid boundary* assumed at 34.0mBGL for analytical purposes.
5. z refers to the depth in metres below the top of the Claygate Beds + London Clay formation.

4. Impact Assessment Methodology

4.1. Assessment Details

The assessment has been undertaken using proprietary spreadsheets and the commercially available software Oasys Pdisp and Xdisp, which consider the three-dimensional ground movement field induced by the proposed excavation works.

Ground movements will arise as a result of various mechanisms which are mobilised as part of the construction works for the proposed scheme. The demolition of the existing building and lower ground floor excavation process will induce ground movements arising from the overburden removal and installation of the proposed retention systems. The permanent condition loading will partially reinstate a portion of the removed overburden, yielding settlements across the foundation system. The induced ground movements will extend over a given zone of influence surrounding the building/excavation footprint

A series of three-dimensional models of the proposed scheme have been developed in Oasys Xdisp / Pdisp and combined by means of superposition in order to enable ground movement assessments to be carried out representing the various construction stages. The ground movement displacement fields were separated in two groups (A & B) based on the approach followed, as detailed below:

Group A – Unloading/loading ground movements

- A1. Building demolition (short term).
- A2. Building demolition and basement excavation (short term).
- A3. Building demolition, basement excavation, and application of the proposed building loading (long term).

Group B – CIRIA-based ground movements

- B1. Contiguous wall and underpin installation and basement excavation.
- B2. Contiguous wall and underpin installation, basement excavation, and application of the proposed building loading (long term)

The Group A assessments are based on *greenfield* ground movements evaluated from linear half-space (Pdisp) analyses and focus on vertical ground movements induced by the overburden removal unloading and reloading processes.

Demolition unloading pressures of 30kPa and 45kPa have been applied over the footprint of the existing building on site, as shown in Figure 4.1 (approximately 15kPa per storey).

Excavation unloading pressures have been modelled at the basement formation level representing the removal of approximately 1.0m (20kPa) and 4.2m (85kPa) of overburden to create the lower ground floor. A further unloading pressure of 115kPa (5.7m overburden), representing the excavation of the pool area, was also modelled at formation level in the northern section of the property.

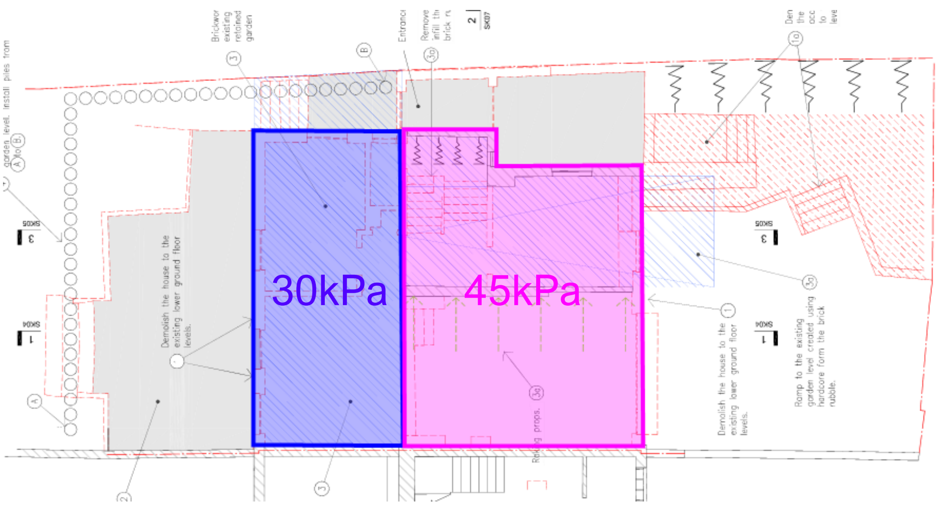


Figure 4.1 Modelled demolition area in Pdisp

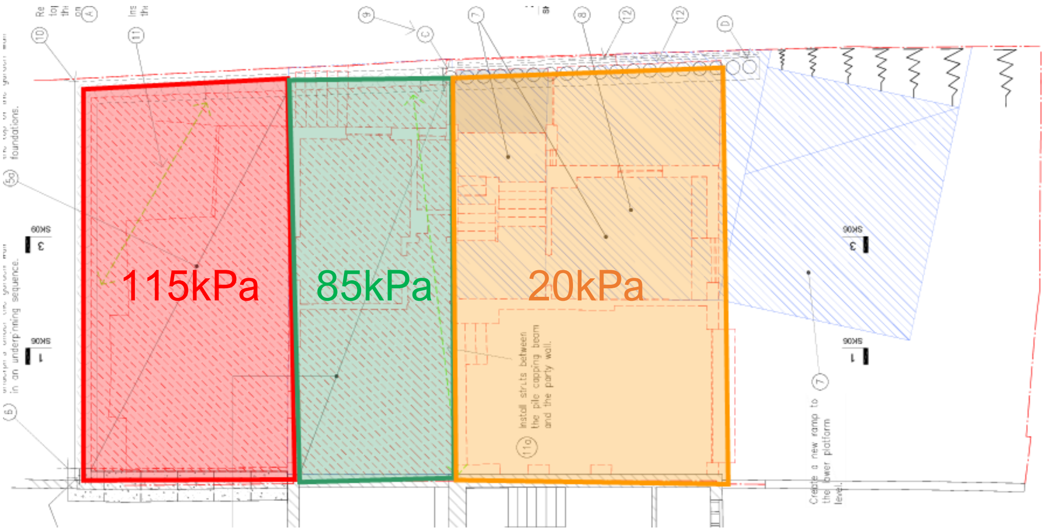


Figure 4.2 Modelled excavation area in Pdisp

The proposed residential structure will have two to four storeys. Based on an assumed surcharge of ~10kPa per storey, four uniformly distributed loading zones have been modelled at basement formation level, as shown in Figure 4.3.

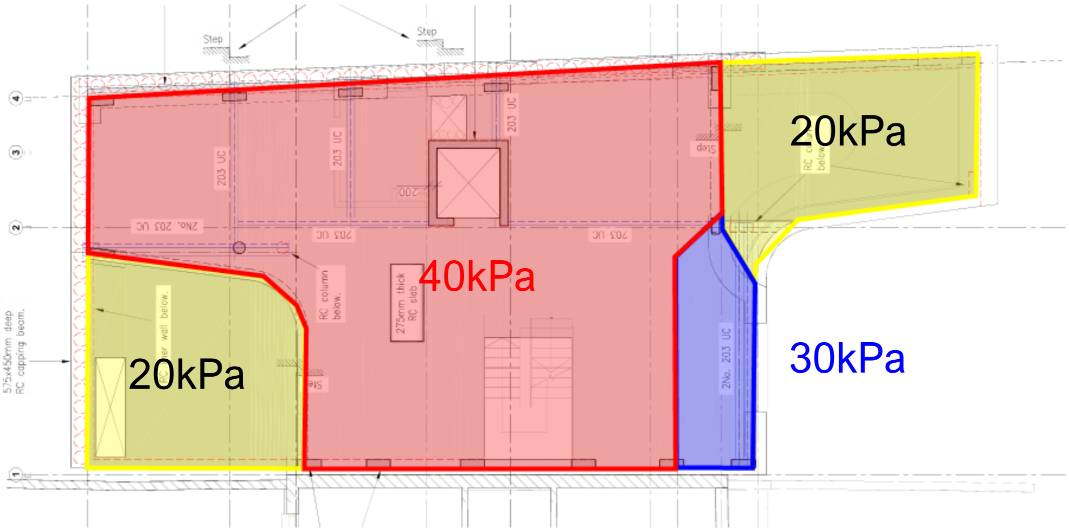


Figure 4.3 Proposed building loading areas

The Group B assessments adopt the normalised ground displacement curves reported in CIRIA C760. In addition to the effects arising from the excavation, the ground movement effects associated with the installation of the contiguous wall and underpinning have been considered. The following CIRIA C760 normalised ground movement curves were adopted to assess ground movements due to retention system installation and excavation works:

- *Underpin installation*: Installation of planar diaphragm wall in stiff clay.
- *Contiguous wall*: Installation of contiguous bored pile wall in stiff clay.
- *Excavation to formation*: Excavation in front of a high stiffness wall in stiff clay.

The empirical data set for diaphragm wall installation is not strictly compatible with the construction technologies adopted in underpinning works. However, it is assessed that the ground movement mechanisms are reasonably well-matched and, in lieu of better empirical relationships, the diaphragm wall curves are considered to provide a satisfactory and conservative approximation.

As part of the underpin installation process, the load redistribution from the existing shallow foundations supporting the Party Wall to the new underpins on the west boundary has been modelled as a pressure acting at the base of the new underpins, assumed to be

1m wide. The weight of the adjacent structure acting on the underpins has been modelled as 114kPa, equivalent to the tributary area of the Party Wall supporting a 30kPa surcharge (approximately 10kPa per storey for 18B Frognal Gardens). This represents the redistribution of the stress bulb induced by the building loading on the Party Wall / underpins to lower strata.

In the B2 assessment, the CIRIA ground movements are combined with the long-term settlements induced by the proposed building loading (evaluated in Pdisp).

The two sets of analyses enabled the production of an envelope of damage classification results, with the worst-case results presented herein. A representative geometry has been adopted for defining the excavation/installation geometry implemented in the 3D modelling efforts.

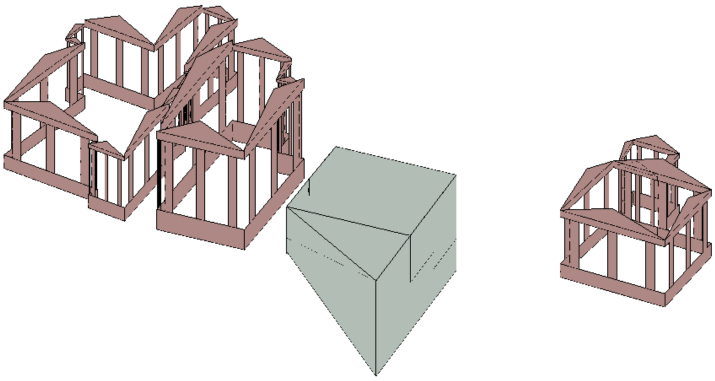


Figure 4.4 Indicative plot of the three-dimensional analytical model using the Oasys Xdisp software suite

4.2. Impact Assessment

4.2.1. General

The potential impact / damage induced on primary façade / wall elements of the buildings around the proposed scheme (including retained party walls forming part of the proposed development) have been evaluated on the basis of the calculated ground movement fields. The masonry walls of concern are shown in Figure 4.5, including the wall nomenclature / reference system adopted. The arrangement is based on the currently available survey information and presents an array of masonry façades running both perpendicular and parallel to the proposed lower ground floor (covering the key deformation mechanisms). In total, 31 façades of the neighbouring buildings were considered for the current study and these are grouped in the following manner:

- 18B.01 – 18B.07: 18B Frognal Gardens
- 20FG.01 – 20FG.16: 20 Frognal Gardens
- 17HW.A01 – 17HW.A04: 17 Holly Walk house
- 17HW.B01 – 17HW.B04: 17 Holly Walk shed

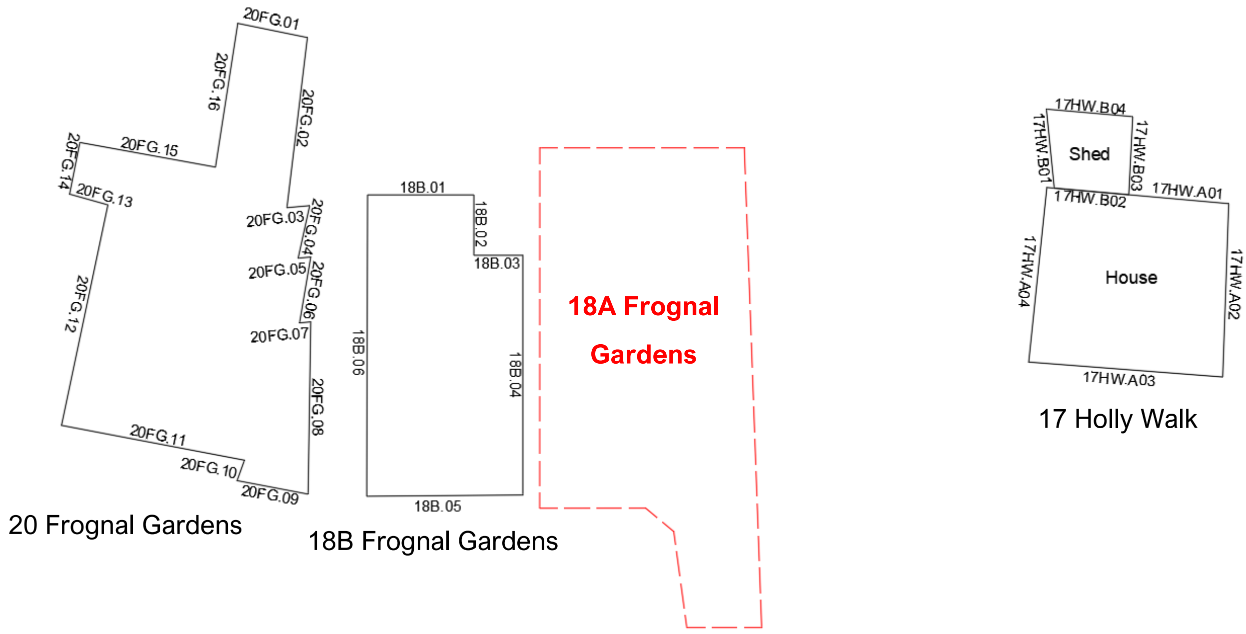


Figure 4.5 Simplfied scheme and nomenclature for each building façade/masonry wall element

Each wall has been assumed to behave as an equivalent beam subject to a bending and extension/compression deformation mechanism, based on the evaluated greenfield ground movement, as outlined previously.

Tensile strains induced within the building masonry walls have been evaluated based on the deflection ratios Δ/L and horizontal extension mechanisms estimated from the analyses. The assessment considers the well-established Burland (1997) damage classification method, as presented and summarised in Figure 4.6 and Figure 4.7. This method involves a relatively simple but robust means of assessment, which is widely adopted and is considered to comprise an industry standard / best practice basis for impact assessments of this typology.

Potential damage categories are directly related to the tensile strains induced by the proposed construction stages, arising from a combination of direct tension and bending induced tension mechanisms. The evaluated damage categories correspond to an unlikely to be exceeded scenario (on the basis of the data sets adopted and greenfield assumptions).

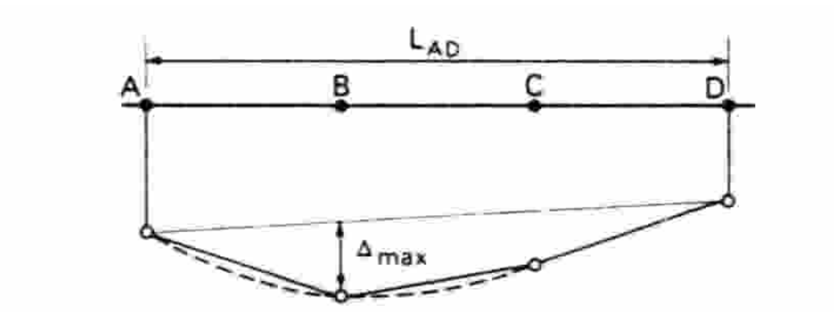


Figure 4.6 Definition of relative deflection Δ and deflection ratio Δ/L

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	

After Burland et al. 1977, Boscardin and Cording 1989, and Burland 2001.

Figure 4.7 Building damage classification – relationship between category of damage and limiting strain ε_{lim}

4.2.2. Results

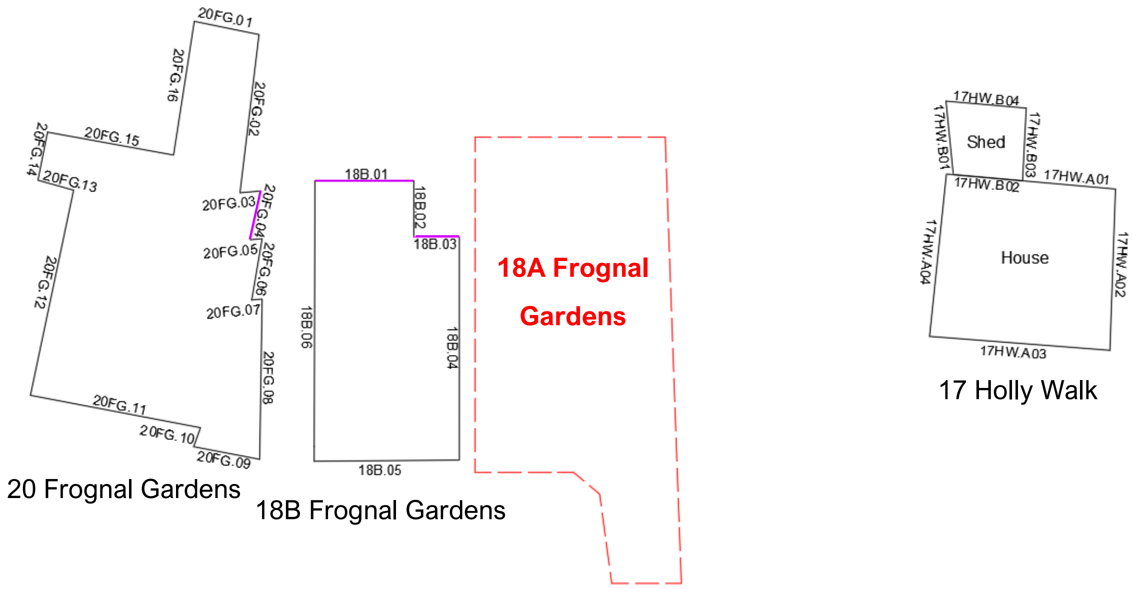
The results of the assessment are presented in Table 4.1. Note that the results presented in this table represent the worst-case output arising from all analysis runs. Damage category results are presented in Figure 4.8 for the affected façades. Figure 4.9 and Figure 4.10 depict the vertical and horizontal displacements, respectively, induced by the contiguous wall and underpin installation and excavation calculated as per CIRIA C760 datasets (assessment B1).

Table 4.1 Evaluated damage categories extracted from Xdisp

Façade Reference	Analysis Scenario				
	A1	A2	A3	B1	B2
18B.01	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight
18B.02	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible

18B.03	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight	Category 1 – Very Slight	Category 0 – Negligible
18B.04	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
18B.05	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
18B.06	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
18B.07	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.01	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.02	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.03	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.04	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight
20FG.05	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.06	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.07	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.08	Category 0 – Negligible	Category 0 - Negligible	Category 0 - Negligible	Category 0 - Negligible	Category 0 - Negligible
20FG.09	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.10	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.11	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.12	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.13	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.14	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
20FG.15	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible

20FG.16	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.A01	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.A02	Category 0 – Negligible	Category 0 - Negligible	Category 0 - Negligible	Category 0 - Negligible	Category 0 - Negligible
17HW.A03	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.A04	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.B01	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.B02	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.B03	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible
17HW.B04	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible



Purple – Category 1 (Very Slight)

Figure 4.8 Damage category results after analyses A3 and B2

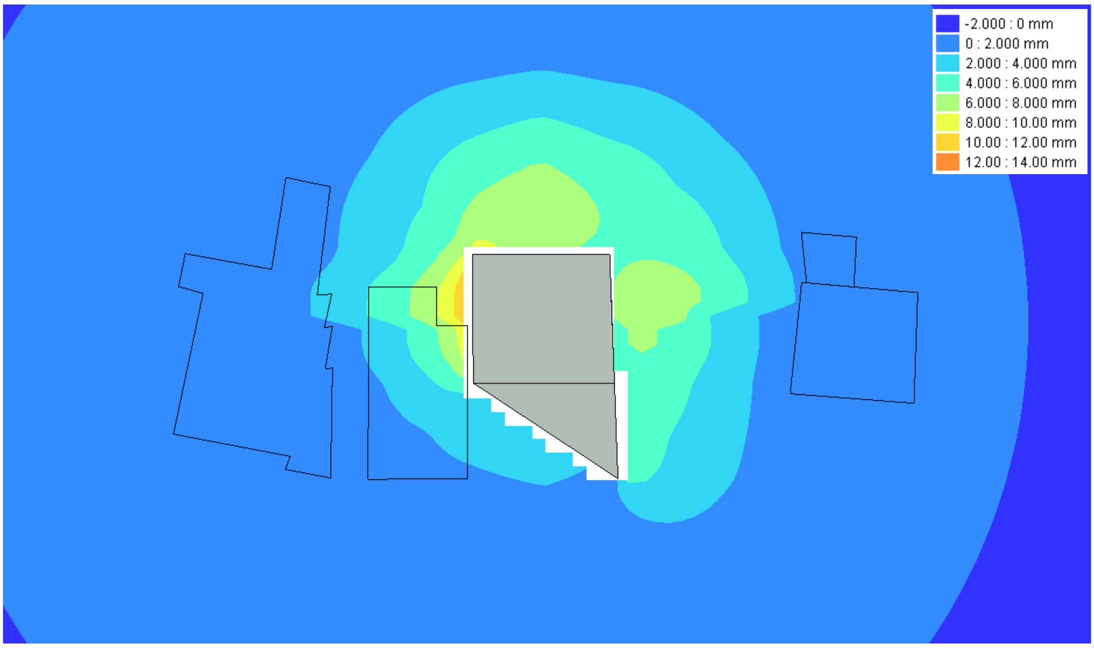


Figure 4.9 Resultant Xdisp vertical displacement contours for scenario B1 – units in mm – contiguous wall and underpin installation and excavation (CIRIA C760)

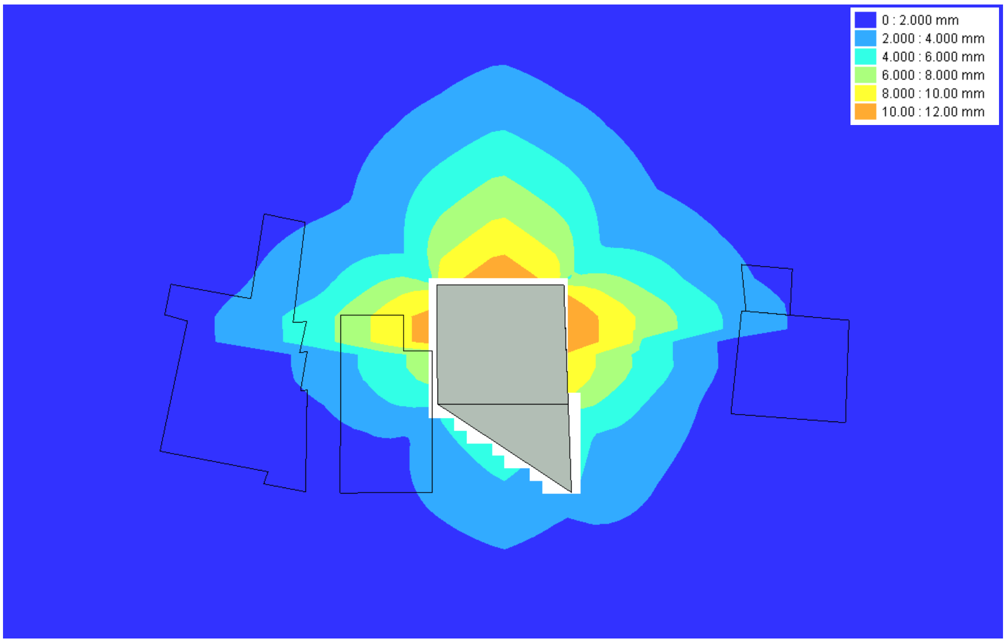


Figure 4.10 Resultant Xdisp horizontal displacement contours for scenario B1 – units in mm – contiguous wall and underpin installation and excavation (CIRIA C760)

4.2.3. Basement Excavation Criteria

The results of this analysis show that all buildings fall within the acceptable damage classification if the ground movements caused by the site development are limited to the values presented in Table 4.2. The ground movements below present the maximum movements directly adjacent to the contiguous piled wall. Specific wall/façade deflection limits and trigger levels may be developed as part of the proposed monitoring regime, on the basis of the ground movement field presented herein.

Table 4.2 **Limiting ground movement values at various construction stages**

Stage	Maximum Cumulative Ground Movement (mm)	
	Vertical	Horizontal
Contiguous Wall Installation	4	4
Underpin Installation	9	3
Excavation	12	12
Long-Term Condition	21	12

5. Conclusions & Closing Remarks

The interaction between the proposed 18A Frognal Gardens development and the neighbouring properties within the zone of influence of the scheme has been reviewed as part of the GMA study presented herein.

The proposed development construction operations comprise three stages: demolition of the existing property, installation of the contiguous wall and underpinning, and bulk excavation. The impact of the construction stages have been reviewed on the basis of two alternative methods, i.e. evaluating the effects of unloading/overburden removal using Pdisp and simulating the excavation induced ground movements using empirical CIRIA curves in Xdisp. In the latter case, a propped retaining wall solution (during the temporary works stage) has been considered, utilising the CIRIA C760 ground movement curves for high stiffness walls in stiff clay.

These two different scenarios have been considered in order to bind the potential ground movements arising from excavation operations (i.e. maximum potential heave and settlement respectively). This strategy ensures a robust evaluation of potential impact in light of the bespoke, intricate and workmanship-dependent construction methodology. Both short-term (undrained) and long-term (drained) conditions have been assessed by adopting the relevant soil stiffness parameters for each case.

In order to best limit ground movements in proximity to movement sensitive neighbouring buildings, due consideration may be given to suitable means and methods of construction. For example, reducing the extent of temporary excavations during earth removal operations in close proximity to buildings considered to be at most risk of damage.

The results from the GMA analyses are presented in Table 4.1 (denoting the evaluated damage categorisation in accordance with the Burland criteria described herein). It is observed that the maximum damage classification for the neighbouring properties is Category 1 – Very Slight. Specific wall / façade deflection limits / trigger levels may be developed as part of the proposed monitoring regime (based on the findings presented herein).

It is noted that the predicted ground movements, the associated wall tensile strains, and the level of damage categorisation are considered to be moderately conservative in view of the relatively cautious data selection and greenfield nature of the assessment undertaken.

It is also noted that the GMA will be supplemented by a project-specific monitoring regime and Action Plan, which will delineate lines of responsibility, trigger levels in accordance with those presented in this GMA and appropriate mitigation measures. The assessment presented herein is dependent and reliant on the works being undertaken by an experienced contractor, high quality workmanship, and appropriate supervision of construction means and methods by experienced personnel.

In particular, the ultimate and serviceability limit state performance of the proposed underpins supporting the building loading in the temporary and long-term conditions should be assessed and monitored by an experienced engineer.

It is recommended that this report is reviewed and understood in full by the project team and major stakeholders. Where significant changes are made to items such as construction sequencing, temporary propping arrangements and scheme design the engineer should thoroughly review the discrepancy and evaluate any potential impacts on ground movement and building damage. If necessary, the building damage categories should be re-evaluated.

It is critical that the permanent and temporary works designs are carried out in a coordinated manner between performance specified elements and substructure contractors, with the aim to ensure that such design elements are in alignment with the assumptions/findings of the GMA and overall design intent.

A-squared Studio

A-squared Studio Engineers Limited
One Westminster Bridge Rd
London, SE1 7XW

020 7620 2868
contact@a2-studio.com
www.a2-studio.com