Winter House, Highgate
Basement Impact Assessment Rev A

Prepared for
Plum Projects Ltd

March 2019

Winter House, Highgate

Basement Impact Assessment

Contents

NON-TECHNICAL SUMMARY

Plum Projects Ltd, the owner of the site, are proposing to extend the Grade II* listed Winter House by replacing a previous single storey extension to the rear of the property with a new extension at ground floor level. This extension will partially cut into the hillside requiring a retaining structure.

The proposals also include the conversion of an infilled cutting on the site into a two storey habitable basement space which will be connected to the original house and extension via a single storey underground tunnel.

As the cutting is existing, this Basement Impact Assessment by Alan Baxter Ltd considers the construction of the new underground tunnel link. The walls of this structure will be formed of a contiguous piled wall and reinforced concrete roof and basement slab. Stiff temporary propping of this wall will be required during construction. The extension that cuts into the sloped garden will be installed using cantilevered contiguous piles. These are also considered in the assessment.

Screening and scoping studies were undertaken in accordance with Camden Planning Guidance - Basements along with a site specific soil investigation. This, combined with drawings in the appendix, has been used to demonstrate that slope stability, hydrology and hydrogeology on the site will not be adversely affected by the proposed works.

There are four adjacent structures within the vicinity of the works that have been considered. These are the Highgate Cemetry building, the Highgate cemetery toilet block, Winter House and 79 Swain's Lane.

Using guidance on the design of embedded retaining walls (Ciria 760), the anticipated ground movements have been established. This, alongside a paper by Ball and Langdon in 2014, has been used to understand the anticipated impact of the basement construction and we have concluded that with stiff regular propping and controls in place to regularly monitor agreed movement trigger limits that no structural damage more than Burland Category 1 will occur to any of these structures as required by Camden's Planning Guidance for Basements and in section A5 of the Camden Local Plan. 2017.

Winter House, Highgate

Basement Impact Assessment

1.0 INTRODUCTION

Plum Projects Ltd, the owner of the site, are proposing to extend the Grade II* listed Winter House by converting an existing infilled cutting on the site into a habitable basement space. A new underground tunnel will also be constructed to connect the existing house to the new space created by excavating the existing infilled cutting.

This Basement Impact Assessment (BIA) sets out the existing site arrangement and history, the proposed structural concept design, an overall construction sequence and considers the impact the construction of the tunnel has on the building on the site and adjacent neighbouring properties. It also explores the surface and ground water flows on and near the site as well as slope stability.

This BIA has been based on the following information:

- Historical maps and in house desk study
- Geological survey maps and BGS borehole records
- Proposed layout drawings by SHH Architects
- Site visits
- A site investigation carried out by Ground Engineering during January 2014 and was updated in July 2018 with water monitoring results (Appendix J)

In preparing the BIA reference has been made to the following London Borough of Camden documents:

- Camden Local Development Framework (LDF) Policy DP27
- Camden Planning Guidance – Basements (March 2018)
- Camden Local Plan 2017 – Section A5
- Camden Geological, Hydrogeological and Hydrological Study – Guidance for Subterranean Development prepared by ARUP

The BIA has been prepared by the following persons, holding the stated qualifications:

Alan Baxter & Associates	Megan Morrison MEng Rory Dack MEng Adam Sewell MEng MIStructE CEng
Ground Engineering Ltd	S. J. Fleming MSc MCSM CGeol FGS C. M. J. Ebeling MSc (eng.) CGeol FGS MAEG

1.1 Site

The site of Winter House is in Camden and located directly adjacent to Highgate Cemetery in the garden of the former Cemetery Superintendent's House. The Superintendents House is now a neighbouring property on the southern edge of the site and is known as 79 Swains Lane. The site is bounded on the other sides by the Cemetery entrance to the north, Swains Lane to the east and the Cemetery to the west.

The site is formed of two buildings; Winter House and a post original extension to the rear which forms an L shaped property on plan.

There is an infilled cutting to the north of the site.

A single storey timber structure is located north of the cutting.

There is a small domed greenhouse (this has recently been removed).

The site slopes down from the west to the east towards Swains Lane.

The site is set approximately 2.5m above the level of the adjacent road. The level difference is accommodated by what appears to be masonry, gravity retaining wall, which is assumed to pre-date the construction of the house.

1.2 Site History

The site is located in the London Borough of Camden in the Highgate and Haringey Conservation Area.

The existing cutting towards the north of the site was constructed at the same time as the cemetery to provide a link between the cemetery entrance to the north of the site and the cemetery to the east of Swains Lane. The cutting is enclosed by a tunnel as it passes beneath Swains Lane. The cutting has since been infilled where it passes through the site. It is not known when this was done.

Winter House was constructed in the 1960's by the Architect John Winter.

A single storey extension was added to the rear of the property. The date of the construction of the single storey extension is unknown.

Refer to drawing 1173/10/01 for a site plan and photos of the site in Appendix A.

1.3 Site Geology

Site investigations were undertaken in January 2014 and consisted of 10 trial pits and two boreholes. Further ground water monitoring was also undertaken in 2018. Please refer to drawing 1173/10/10 to 1173/12/12 in Appendix D for a summary of the site investigation results.

Based on the geological map of the area (refer to Appendix B) and the site investigations, the ground conditions appear to generally comprise of a layer of made ground approximately 0.4m deep overlying London Clay. The depth of the made ground locally increases where foundations have been constructed for the house and the wall bounding Swains Lane. The existing cutting was infilled with made ground and there is

also likely to be made ground around the existing culvert passing through the site. The depth of the clay layer exceeds 25m as the boreholes terminated at 25m below ground level (61.57m AOD). Well records indicate that the London Clay is about 65m deep in this area.

The geological map indicates that the Claygate Member which overlies the London Clay stratum is located 500m North West of the site.

1.4 Conceptual Ground Model

To assist the screening stage a conceptual ground model has been produced to show how the site works, which encompasses hydrological, hydrogeological and the geological information of the site. The conceptual ground model is based on the following information:

- Information obtained during the screening stage of the BIA
- The site investigation undertaken in March 2014
- Readily available published data
- Site survey information
- Application of hydrogeological principles

This is as follows.

Site location	Winter House, Swains Lane, Highgate, London
Local geology	The geology of the locality comprises made ground over London Clay. Groundwater may be encountered 'perched' within any made ground which covers the practically impervious London Clay. Based on the geological map, beneath the thick London Clay is the Lambeth Group, Thanet Sand formation and Chalk which together make up the lower Aquifer.
Local ground levels	The site slopes from west to east, towards Swains Lane. Swains lane falls north to south.
Local surface water or below ground water features	There are no local surface or below ground water features close to site.
Local groundwater level	The London Clay is sufficiently thick that it isolates the strata of the Lower Aquifer from the made ground above the Clay.
Local surface finishes	The total site surface area (including all buildings) is approximately 450m^2. Buildings and hard landscaping (consisting of 1m wide paved paths) make up approximately 150m^2 of the total site area. The surrounding area to the house is predominantly soft landscaping. The garden is covered in grass and small overgrown shrubs. There is a small paved pathway leading up from the road to the house which continues

	northwards through the centre of the garden.
Current local surface water pathway	A proportion of local rainfall will be retained in the near surface soil (made ground and topsoil) with a proportion evaporating into the atmosphere or being taken up by plant and tree root systems. Some may percolate down to the top of the Clay. Due to the cohesive nature of the Clay, during sustained periods of rainfall, water will enter the secondary groundwater system above the Clay and flow across the top of the Clay. The top of the London Clay layer slopes generally slopes from north to south. For information on the existing surface water flows across the site, refer to Appendix E.

Using the above conceptual ground model, the potential issues identified during the screening stage are discussed further.

The site is located approximately 150m north and uphill from the source of a tributary of the River Fleet based on figure 11 in the CGHHS.

The site is not located within the Hampstead Heath pond catchment zone shown on figure 14 of the CGHHS. The nearest Hampstead Heath pond within the Hampstead Heath Pond Chain is located approximately 700m to the west of the site.

The site is not within a flood risk zone. The site is in flood zone 1 and has a very low risk of flooding. The adjacent street, Swains Lane, did not flood in 1975 or 2002.

As part of the proposals for the new tunnel, no additional impermeable landscaping will be installed over the tunnel. The existing cutting is being excavated and a new roof installed over. This will add approximately 43m^2 of impermeable roofing over the cutting. Refer to page 3 of 3 in Appendix F.

1.5 Form and condition of the existing structures

The building on the site is a residential property constructed as a family home by the Architect John Winter in the 1960's and is now Grade II* listed. The property is positioned on the southern edge of the site, set back approximately 3m from the road to the east with gardens surrounding the building on three sides.

The building is three storeys high and comprises a welded steel frame with concrete floor slabs and a lightweight roof. The foundations comprise shallow mass concrete pad footings. The building is clad in Corten steel and is supported by a steel frame.

Generally, the building appears to be in reasonable condition for its type and age. There are no visible signs of any adverse settlements or ground movements and the steel frame generally appears to be in reasonable condition. There are some local areas of corrosion evident to the Corten cladding.

A single storey extension was constructed at the rear of the property about ten years ago to provide a ground floor living area for John Winter in his later years. This is understood to also be of steel framed construction.

A small single storey timber structure to the north of the site is in poor condition. A number of the timbers have rotted away. The structure is proposed to be removed.

A small area of the original cutting, immediately adjacent to the cemetery entrance has not been infilled. This, along with site investigations, suggests that the cutting is formed of a masonry wall approximately 630mm thick which continues to a depth of approximately 5m below ground level where it is founded on stiff clay. The cutting has been infilled with made ground comprising of brick, crushed concrete, clay etc.

Highgate cemetery and toilet block are located approximately 10m and 0.8m respectively from the tunnel.

The toilet block is a small single storey brick built structure with a flat roof. It was constructed at the end of the 19th Century. It is founded on corbelled masonry footings on concrete strip footings founded on the clay at a depth of 0.82m below ground level.

The cemetery building (the gatehouse to the western cemetery) was constructed as part of the Western Cemetery and was completed in 1838. It is Grade II listed. It is a load bearing masonry structure with a large Tudor archway in the centre of the building providing access to the Western Cemetery and two chapels flanking each side of the entrance. Investigations and access to the building have not been possible however, its distance from the proposed excavation and the fact that a deep cutting passes between the proposed tunnel and the cemetery building means ground movements to the cemetery building associated with excavations for the new tunnel will be negligible.

No. 79 Swains Lane is located 2.3m to the south of the tunnel. It was formerly the Superintendents House on the boundary of the Western cemetery and was built between 1869 and 1894. The land around the Superintendents house encompassed the current site of Winter House but it is now a neighbouring property on the southern edge of the site known as 79 Swains Lane. The structure is formed of load bearing masonry walls supported on concrete strip footings approximately 1.1m below ground level. A single storey extension exists in the rear garden of No.79 Swains Lane and is founded on the strip footings at the same depth as the main house. The structure is not listed

Winter House is located within the site and is approximately 0.8m from the proposed tunnel.

There are generally three small trees located on the site. Two of these trees are being removed as part of the proposals.

An existing sewer enters the site from the North West and exits the site to the east where it connects into the main sewer below Swains Lane. Drainage from the property connects to the sewer where it passes through the site via a manhole. Refer to the site plan in Appendix D. The Architect has proposed to retain the existing sewer, with the tunnel proposals.

For further information on the site, refer to the site plan and sections through the site in Appendix D.

1.6 The Proposals

The proposed scheme involves the following:

- Excavation of the fill to the existing cutting and conversion of the cutting into an enclosed two storey below ground space.
- Construction of a new single storey tunnel to link the existing house with the cutting.
- Replacement of the single storey extension to the rear of the existing house.

As the tunnel is curved on plan and to mitigate noise generated by the works, the tunnel will be formed of two contiguous piled walls for the sides of the tunnel with a reinforced concrete base slab and roof slab fixed into these walls.

The contiguous piled wall will need to be propped in the temporary case until the tunnel base slab and roof slab are formed. An assumed sequence of construction of the tunnel is shown in Appendix H.

This report relates to the proposed construction of a new tunnel to link Winter House to an existing cutting. The approach to the design of the new tunnel includes consideration of the following key items:

- Ground conditions
- Groundwater regime
- Surface flow and flooding
- Slope and ground stability
- The structure of the existing adjacent buildings
- The effects on surrounding and adjoining properties
- An appropriate design and construction methodology

2.0 SCREENING

The purpose of the screening stage of the BIA is to identify any matters of concern which should be investigated further through the BIA process. The screening process has been undertaken as outlined in the Camden Planning Guidance – Basement and the Camden geological, hydrogeological and hydrological study prepared by ARUP.

The screening flow charts given in CPG - Basements have been used and are provided in Appendix C along with figures from Camdens Hydrological Study. The screening tables cover the three main issues addressed in this report:

- Hydrology (Surface flow and flooding)
- Hydrogeology (subterranean groundwater flow, and
- Slope and ground stability

Several items in the screening checklists were identified as being relevant to this proposal and therefore a BIA is necessary. Those that have been identified as being relevant are discussed in the following Scoping Stage.

The screening has confirmed that 5 screening questions need to be reviewed in more detail as part of the scoping stage. These are:

Hydrology (surface water flow and flooding)

3	Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	Yes, the area of hardstanding surfaces will be slightly increased by the new covering over the existing cutting.	Y

Hydrogeology (groundwater flow)

None of the screening questions as part of the Hydrogeology require further input and so, no further assessment is considered necessary. There will be no impact to the hydrogeology.

Slope and ground stability

1	Does the existing site include slopes, natural or manmade greater than 7o (approx. 1 in 7)?	Yes. Locally to the south west of the site the ground slopes from west to east varying from 7 to 8 degrees. Figure 16 of Arup's Hydrogeological report – Slope angle map shows the site has some areas greater than 7 degrees and some greater than 10 degrees.	Y
4	Is the site within a wider hillside setting in which the general slope is greater than 7o (approx. 1 in 7)?	Yes. Figure 16 of Arup's report – Slope angle map, shows the site is located on a band of slope that is greater than 7 degrees indicating that the site is located on a hill.	Y
5	Is the London Clay the lowest strata at the site?	Yes, the London Clay is the lowest strata on the site. Refer to Figure 3 of the Arup Hydrogeological report – Camden Geology Map.	Y
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes, a small tree will be removed in the location of the new tunnel. This tree is not within any tree protection zones.	Y

3.0 SCOPING (STAGE 2)

The purpose with the scoping stage of the assessment process is to define further the potential impacts identified in the screening stage in section 2.0, as a device to define

what further investigations are needed in order to assess the impacts. This stage has been undertaken as set out in the following documentation:

- Camden Planning Guidance – Basements March 2018
- Camden Geological, hydrogeological and hydrological study prepared by ARUP

3.1 Hydrology (surface water flow and flooding)

3	Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	Yes, the area of hardstanding surfaces will be slightly increased by the new covering over the existing cutting.	Y

The amount of hardstanding surfaces will be slightly increased as the 5m of fill within the existing cutting will be removed and a new roof covering installed over the existing cutting. This will reduce the volume of rainfall seeping into the ground below and subsequently into underground aquifers. This is a small area and will have a negligible effect on the volume of surface water infiltrating into the groundwater below as the underlying stratum is relatively impermeable and the ground water will flow downhill from north to south.

No further assessment is considered necessary. There will be no impact to the hydrology.

3.2 Slope and ground stability

1	Does the existing site include slopes, natural or manmade greater than 7^{o} (approx. 1 in 7)?	Yes. Locally to the south west of the site the ground slopes from west to east varying from 7 to 8 degrees. Figure 16 of Arup's Hydrogeological report – Slope angle map shows the site has some areas greater than 7 degrees and some greater than 10 degrees.	Y

The site slopes at an angle of approximately 7-8 degrees to the west of the site. This drops to less than 1 degree to the east of the site, giving an average angle of slope across the site of approximately 4 degrees. So generally the site is less than 7 degrees in slope angle. The proposed tunnel is generally located below the area of 1 degree slope so the tunnel will not affect slope stability after it is constructed.

No further assessment is considered necessary.

4	Is the site within a wider hillside setting in which the general slope is greater than 7^{o} (approx. 1 in 7)?	Yes. Figure 16 of Arup's report – Slope angle map, shows the site is located on a band of slope that is greater than 7 degrees indicating that the site is located on a hill.	Y

The site is within a wider hillside setting with the west part of the site sloping at 7-8 degrees. An area of flat garden is to be formed within this area and so the slope will be locally cut into in this area. The slope stability of the London Clay around the garden will be dealt with by a cantilevered contiguous piled retaining wall. This can be designed to maintain slope stability. This is a local excavation and will have no impact on the wider hillside setting or slopes.

No further assessment is considered necessary. There will be no impacts to slope stability.

5	Is the London Clay the lowest strata at the site?	Yes, the London Clay is the lowest strata on the site. Refer to Figure 3 of the Arup Hydrogeological report – Camden Geology Map.	Y

Site investigation proposed to determine properties of London Clay on site which is discussed in section 5.0.

6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes, two small trees will be felled.	Y

Two small trees on the site will be felled as part of the proposals.

One of the trees will be felled to allow the new tunnel to be constructed . The tree is located on a 1 degree slope of the site, so it is not contributing significantly to slope stability.

The other tree is being felled to allow the construction of the new garden which will cut into the section of the garden which slopes at 7-8 degrees. Whilst it is unlikely that this small tree is providing much stability to the slope, on the assumption that is marginally contributing to slope stability, the slope will be stabilised in this location by a new contiguous piled retaining wall and will no longer rely on the tree for any slope stability.

The proposed tunnel will be deeper than the existing foundations of the house. Therefore the depths of the foundations surrounding the site will be investigated and the strata confirmed through a site investigation.

3.3 Conclusions

The scoping has identified a few matters that need to be investigated further. A site investigation must therefore be undertaken and include the following in order to gain enough information to address the potential issues identified in the scoping stage.

- Boreholes to determine the ground conditions on the site and the contours of the London Clay stratum
- Standpipe to monitor groundwater levels in the borehole over an extended period
- Trial pits adjacent to the existing boundary wall, existing walls of the cutting and the foundations of the existing house to determine the type, size and condition of the foundations to these adjacent structures.

4.0 SITE INVESTIGATIONS AND STUDY (STAGE 3)

From the scoping stage of the BIA, a site investigation has been designed and implemented by Ground Engineering Limited. A copy of their report can be found in Appendix J, which includes a desk study, factual and interpretative reports.

The ground conditions on the site comprise made ground over London Clay. The top of the London Clay is located approximately 0.4m below the ground level of the site. Based on the boreholes and trial pits undertaken on the site, the top of the London Clay broadly follows the topography of the site which falls from the west, towards Swains lane. The trial pits to the boundary wall confirmed that the London Clay along this wall dips down and is located approximately 1.7m below the ground level. This was to allow a deep enough depth to found the boundary wall when it was constructed in order to accommodate the change in level of the rear garden and Swains lane.

No groundwater was encountered in the shallow trial pits. 7.00m and 10.00m deep standpipes were installed within BH1 and BH2 respectively. Water was recorded at depths between 5.20m and 5.12m below ground level (81.25mOD and 81.33mOD, BH1 – borehole within the cutting), and between 5.35m and 4.59m below ground level (82.25mOD and 83.01mOD, BH2), during the three monitoring 2014 visits. During the 2018 monitoring, water levels were recorded in BH1 at 5.13m and at 1.34m/1.63m in BH2. Both appear to represent water 'perched' within the made ground upon the underlying practically impervious London Clay.

The site investigation indicated that the made ground contained Benzo[a]pyrene and lead with a moderate risk to Construction workers and the end user. For private residential and garden areas, Ground Engineering Ltd recommend that the made ground be completely removed and replaced with an equivalent thickness of inert topsoil or removed to a minimum depth of 0.6m below finished ground level.

5.0 IMPACT ASSESSMENT (STAGE 4)

The impact assessment stage of the BIA describes the impacts of the proposed tunnel on the environment and how this will be mitigated in the design and construction. For the factual and interpretative site investigation reports refer to Appendix J.

5.1 Updated Ground Model

The ground model from the scoping stage has been updated to reflect the findings from the site investigation and shall be used to inform the design of the tunnel, its construction and assess its effects on the potential issues highlighted in the scoping stage.

Site location	Winter House, Swains Lane, Highgate, London
Local geology	The geology of the locality comprises approximately 0.4m of made ground over Clay. The Clay is locally deeper where it has been cut into to allow construction of the strip footing for the boundary wall (1.6m), the pad footings of the existing house (1.2m) and the existing cutting and culvert that runs through the site. The thickness of the London Clay stratum exceeds 25m in thickness.
Local ground levels	The site is within a wider hill setting. The site slopes at an angle of approximately 7-8 degrees to the west of the site. This drops to less than 1 degree to the east of the site, giving an average angle of slope across the site of approximately 4 degrees.
Local surface water or below ground water features	There are no local surface or below ground water features close to site.
Local groundwater level	The London Clay is sufficiently thick that it isolates the strata of the Lower Aquifer from the made ground layer. No groundwater was encountered in the shallow trial pits. 7.00m and 10.00m deep standpipes were installed within two boreholes. During 2014 water monitoring, water was recorded at depths between 5.20m and 5.12m below ground level (81.25mOD and 81.33mOD, BH1 – borehole within the cutting), and between 5.35m and 4.59m below ground level (82.25mOD and 83.01mOD, BH2). During the 2018 monitoring, water levels were recorded in BH1 at 5.13m and at 1.34m/1.63m in BH2. Both appear to represent water 'perched' within the made ground upon the underlying practically impervious London Clay.
Local surface finishes	The surrounding area to the house is predominantly soft landscaping. The garden is covered in grass and small overgrown shrubs. There is a small paved pathway leading up from the road to the house which continues northwards through the centre of the garden.
Current local surface water	A proportion of local rainfall will be retained in the near surface soil (made ground and topsoil) with a proportion evaporating into the atmosphere or

pathway	being taken up by plant and tree root systems. Some may percolate down to the top of the Clay. Due to the cohesive nature of the Clay, during sustained periods of rainfall, water will enter the secondary groundwater system above the Clay and flow across the top of the Clay. The top of the London Clay layer slopes generally slopes from north to south. Winter House, situated on the east of the site has pad foundations that bear onto the London Clay stratum. The top of the London Clay stratum was confirmed during the site investigation in 9 locations across the site. Spaces between the pad foundations of Winter House allow surface water which has infiltrated into the topsoil overlying the clay to flow across the footprint of the House to Swains Lane as shown in Appendix E. Water passes through weepholes in the boundary wall where it enters Swains Lane and drains southwards along Swains Lane (downhill). The surface water flows are a combined result of the topography of the site and an existing cutting which crosses the north east corner of the site and diverts flow.

5.2 Design of tunnel

The proposed structure drawings are included in Appendix G.

The existing cutting will have the infill within it removed to allow the cutting to be converted into a two storey below ground space to the owners of Winter House. The cutting is proposed to have a glazed roof to allow in natural light. In order to link the existing house with this new space, a new one storey underground tunnel is proposed. Access to the tunnel will be via a new staircase within a new single storey extension to Winter House.

The tunnel will be formed of two contiguous piled walls for the sides of the tunnel as it comes in close proximity to the shallow foundations of the shallow pad foundations of Winter House, the neighbouring property of no. 79 Swains Lane and an existing single storey brick built structure to the rear of the grounds of Highgate cemetery (believed to be the cemetery's toilet block). The tunnel walls will be formed of bored contiguous piles installed with a Continuous Flight Auger (CFA). The piles, combined with the R.C. roof and base slabs, will provide stability to the ground surrounding the foundations of these buildings in the permanent case. The roof and base slab of the tunnel will span between the piled walls.

The top of the new tunnel will be below the top of the London Clay which is generally around 0.4m below ground level. This 0.4m depth is in in accordance with the minimum depth specified in the CPG Basements. In addition, the sides of the new tunnel will be backfilled with Clay with tapered clay backfill over the top of the tunnel to match the existing clay slope. This allows the ground around the tunnel to maintain the same properties as the existing site and allows the current surface water pathway (running from north to south) to be maintained over the tunnel. Refer to Appendix I for preliminary design calculations for the piled retaining wall.

The topography over the tunnel will be the same as existing and only 1 degree, so slope stability will be maintained as the existing.

Due to the shallow construction of the tunnel, clay heave will be negligible and so, the floor slab of the tunnel will sit directly on the clay.

The sequence of construction of the new tunnel is discussed in section 5.3.

The waterproofing strategy detailed by the architect will comprise of a waterproofing membrane around the outside of the tunnel and a drained cavity. Any small amounts of water that seep through the concrete structure will be collected and discharged into the drainage system.

The existing drainage will be retained.

5.3 Sequence of construction of the tunnel

A construction sequence of the tunnel has been carefully considered and has been developed to suit conventional techniques that reduce, as far as is practicable, the impact on ground movements to mitigate disturbance to the existing buildings on the site and neighbours properties.

The contractor is to adopt Considerate Contractors Standards and should comply with the requirements set out in the Camden Council Planning Guidance Basements and A5 in the Camden Local Plan 2017. He will be required to mitigate noise and dust throughout the construction works. This will be achieved through the use of screens, hoarding and appropriate construction techniques.
The bored contiguous piled wall will need to be propped in the temporary case until the top slab of the new tunnel is completed. The top slab of the new tunnel will replace the propping action provided by the temporary props. The new piled walls have been set back from neighbouring buildings and the house on the site to provide the necessary working room to allow them to be installed.

A sequence of construction for the tunnel is summarised below and illustrated in Appendix H.

5.4 Programme

Based on basement developments of a similar scale and considering the site constraints and construction access, the construction of the tunnel is expected to last around 6 months.

5.5 Construction Management Plan

The Contractor will be required to submit his own Construction Management Plan and Site Waste Management Plan prior to work commencing on site. The contents of this plan must be in accordance with The London Borough of Camden's guidance and be agreed by them.

The contractor will be required to demonstrate due diligence and commitment toward minimising environmental disturbance to local residents and will be required to complete the work in accordance with the Considerate Constructors Scheme standards.

Noise, dust and vibration will be controlled by employing best practicable means as prescribed in legislation such as; The Control of Pollution Act, 1972; The Health & Safety at Work Act, 1974; The Enviornmental Protection Act, 1990; Construction Design and

Management Regulations, 1994 and The Clean Air Act, 1993. Noise, vibration and dust monitoring to be implemented.

The contractor will need to produce a Traffic Management Plan. This should carefully consider vehicle movements and their impact on other road users, pedestrians, residents and the environment. Mitigation measures should be implemented where necessary.

The work is to be carried out in one phase.

The contractor will erect site hoarding to define the boundaries of the site

Working hours to be restricted as required by the London Borough of Camden

Vehicles should be washed and cleaned before leaving site and vehicles should not be left idling. For further information on access for vehicles, refer to the Construction Management Plan (produced by others).

Measures should be adopted to prevent site runoff of water or mud

Water to be used as a dust suppressant

Skips should be covered

All temporary works are to be designed by a qualified Temporary Works Coordinator

Movements of surrounding buildings should be monitored throughout construction, the results reviewed and action taken to mitigate excessive movements.

The size of plant and construction methods used should take into account the size of the existing access road (Swains lane) and the tunnel beneath it. Piling will be achieved via a mini demountable piling rig.

5.6 Ground Movements and Structural Damage

A ground movement assessment in accordance with CIRIA C760 has been carried out and the impact of ground movements on nearby structures assessed in accordance with the Burland Categories of damage.

Refer to Appendix I for details of the assessment

Whilst Burland states that the design and construction of basements should maintain a level of risk to buildings no higher than Burland Category 2, Camden's Council's Local Plan (2017) states that that the risk of damage to neighbouring properties should be no higher Burland Category 1 "very slight". The assessment shows that Winter House and 79 Swains Lane are Burland Category 1 and Highgate cemetery building is Burland Category 0.

The toilet block is a small single story structure and only slightly falls into Burland Category 2 based on Ciria C760 alone.

The Burland scale is based on recorded movements of buildings on past projects and used to assess buildings responses to different basement techniques at different depths and proximities to buildings. It is widely accepted that Ciria 760 is a conservative method of analysis. Ball and Langdon have published a paper in relation to the actual movements that have been observed in basement construction where stiff support is maintained to the excavation. This shows that lower strains occur than would be predicted by Ciria C760 alone. Applying the same approach to this assessment would

lead to ground movements associated with the toilet block also falling into Burland Category 1 “very slight” damage.

The structural proposals have been designed to provide stiff restraint to the contiguous piled tunnel walls in the permanent case and during construction where the tunnel passes in close proximity to the three existing structures mentioned above. During the construction phase, temporary stability of the contiguous piled retaining walls will be provided by lateral propping to allow the excavations to extend to the tunnel formation level.

In the permanent case the in-situ reinforced concrete tunnel floor and roof slabs will provide the propping action to the contiguous piled retaining walls.

During construction the Contractor will be required to undertake monitoring of the groundwater levels and ground conditions encountered to ensure that the assumptions and findings from the BIA remain valid.

5.7 Impact of tunnel on groundwater, surface water and soil

The measured ground water levels during the monitoring period in January and February 2014 and 2018 show that the perched water table is located in the made ground above the clay, at 5.2m in the cutting (where clay was excavated to form the cutting) and between 1.34 (86.26 AOD) and 1.63m (86.31 AOD) across the site generally.

Winter House, situated on the east of the site has pad foundations that bear onto the London Clay stratum. The top of the London Clay stratum was confirmed during the site investigation in 9 locations across the site. Spaces between the pad foundations of Winter House allow surface water which has infiltrated into the topsoil overlying the clay to flow across the footprint of the House as shown in Appendix E.

The surface water flows are a combined result of the topography of the site and an existing cutting which crosses the north east corner of the site and diverts flow.

The proposal is, as far as practicable, to maintain the status quo of the ground water and surface water flows on the site. This will be achieved by setting the new tunnel roof slab at the top of the clay layer. Generally a minimum of 0.5m depth of topsoil over the top of the new tunnel will be reinstated to allow infiltrated surface water to flow as it does currently and be absorbed by vegetation. The tunnel will not be located below the measured ground water level.

To create access into the tunnel from the ground floor level, the tunnel will locally extend into the topsoil layer. In this area the retaining walls will divert a small amount of water around the tunnel. Elsewhere, the tunnel walls and shoring will be cut off at the top of the clay layer to facilitate the flows described above.

The strategy for the ground water flows described above are summarised in Appendix F.

5.8 Comparison of existing and proposed site

In accordance with the Camden Policy Guidance, the table below summarises the existing situation and the effect on this of the proposals.

Attribute	Existing situation	Proposed
Groundwater levels	Perched groundwater was found approx. 1.35 and 5.2m below the ground level	This will be unchanged in the proposed scheme
Structural integrity of surrounding structures	No survey has been undertaken internally of neighbouring properties. However, external cracking was not evident to no. 79 or the toilet block when viewed from the back garden of Winter House	Whilst Burland states that the design and construction of basements should maintain a level of risk to buildings no higher than Burland Category 2, Camden's Council's Local Plan (2017) states that that the risk of damage to neighbouring properties should be no higher than Burland Category 1 "very slight". The assessment shows that Winter House and 79 Swains Lane are Burland Category 1 and Highgate cemetery building is Burland Category 0. The toilet block is a small single story structure and only slightly falls into Burland Category 2 based on an assessment using Ciria C760 methodology. The Burland scale is based on recorded movements of buildings on past projects and used to assess buildings responses to different basement techniques at different depths and proximities to buildings. It is widely accepted that Ciria 760 is a conservative method of analysis. Ball and Langdon have published a paper in relation to the actual movements that have been observed in basement construction where stiff support is maintained to the excavation. This shows that lower strains occur than would be predicted by Ciria C760 alone. Applying the same approach to this assessment would lead to ground movements associated with the toilet block also falling into Burland Category 1 "very slight" damage.
Contamination	No abnormal levels of contamination were encountered as part of the investigation.	The ground is removed as part of the proposed scheme. No special conditions would be required during the development of the site by workers who may come into contact with the soil during groundworks. It is expected that

		the arisings of natural soils from the excavations across this site would fall into the inert category under the European Waste Catalogue description 'Soil and Stones'.
Surface water run offs	Surface water that falls on the site will infiltrate into soft landscaping and flow through the secondary aquifer following the topography of the site in the north east direction	Unchanged, the surface water flows follow the existing patterns on the site

5.9 Impact of the proposal development on existing trees

There are three trees on the existing site as shown on the site plan in Appendix D. Two small trees on the site will be felled as part of the proposals.

One of the trees will be felled to allow the new tunnel to be constructed . The tree is located on a 1 degree slope of the site, so it is not contributing significantly to slope stability.

For more information refer to Arboriculturalist's report in Appendix K.

5.10 Conclusions

A basement impact assessment, as required for planning by the London Borough of Camden has been undertaken by Alan Baxter Ltd and Ground Engineering Limited for the proposed tunnel through the rear garden of Winter House to connect Winter House to an existing cutting within the garden of Winter House.

Site investigations were undertaken in 2014 prior to the scheme being fully developed. Issues requiring further consideration were highlighted in the screening stage and further study of the site investigation results were undertaken by a chartered Geologist from Ground Engineering Ltd in July 2018.

The engineering rationale and construction issues associated with the proposed construction of the new tunnel have been explored and summarised in this report. A structural scheme design has been prepared, which aims, as far is practicable, to maintain the status quo for the existing local groundwater regime, slope stability, surface water regime and adjacent structures. The buildability of the proposed scheme has also been explored and the principles for the sequence of construction defined.

- The BIA has concluded there is a low risk of groundwater flooding since the proposed scheme has negligible impact on the existing groundwater flows.
- The BIA has concluded there are no impacts on the wider hydrogeological environment.

- The BIA has concluded there is a very low risk of surface water flooding and there are no wider impacts on the hydrological environment.
- The BIA has concluded there will not be a risk or stability impacts to the development or adjacent sites due to the slope of the site and site geology.

Appendix A Site location, historical development, site investigations, topography and photos

Appendix B – Geology map

Appendix C – Screening flowcharts

Hydrology (Surface water flow and flooding) screening

Screening Question No.	Screening Question	BIA response	Carried forward to Scoping (Y or N)
1	Is the site within the catchment of the pond chains on Hampstead Heath?	No, the site is well removed from these ponds, and outside the catchment area shown on Figure 14 of Arup's Hydrogeological study – Hampstead Heath Surface Water Catchments and Drainage.	N
2	As part of the proposed site drainage, will surface water flows (e.g. volume of rainwater and peak run-off be materially changed from the existing route?	No, the existing water flows from run-offs and rainfall will be materially unchanged following the construction of the tunnel.	N
3	Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	Yes, the area of hardstanding surfaces will be slightly increased by the new covering over the existing cutting.	Y
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 water courses?	There will be no changes in the profile of the inflows of surface water being received by the adjacent properties or downstream watercourses.	N
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?	There will be no change in the quality of the surface water being received by the adjacent properties or downstream watercourses as the use of land remains unchanged.	N
6	Is the site in an area known to be at risk from surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding for example because the proposed basement is below static water level of a nearby surface water feature?	Figure 15 of Arup's Hydrogeological study – Hydrology and Hydrological Study Floor Map shows that no flooding has occurred to Swains lane.	N

Hydrogeology (Groundwater) flow screening

Screening Question No.	Screening Question	BIA response	Carried forward to Scoping (Y or N)
1a	Is the site located directly above an aquifer?	The maps in Appendix C show the site is not located above an aquifer. The location of aquifers is shown in figure 8 of Arup's Hydrogeological study. The closest aquifer is the secondary A aquifer, approximately 80m north of the site.	N
1b	Will the proposed basement extend beneath the water table surface?	No, it will not be constructed below the water table.	N
2	Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	The site is located is 150m from a tributary of the Fleet river as shown on Figure 11 of Arup's Hydrogeological study – Watercourses.	N
3	Is the site within the catchment of the pond chain on Hampstead Heath?	No, the site is well removed from these ponds, and outside the catchment area shown on Figure 14 of Arup's Hydrogeological study – Hampstead Heath Surface Water Catchments and Drainage	N
4	Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	Yes, the area of hard standing will increase as a result of the proposed development.	Y
5	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than present be discharged into the ground (e.g. via soakaways and/or SUDS)?	No, the status quo of the surface water will be maintained	N
6	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond (not just the pond chain on Hampstead Heath) or spring line?	No, the elevation of the site is approximately 87m AOD. There is a small pond located approximately 182m and 190m north east in Waterflow park but there are no ponds or spring lines hydraulically connected to the site	N

Slope and ground stability screening

Screening Question No.	Screening Question	BIA response	Carried forward to Scoping (Y or N)
1	Does the existing site include slopes, natural or manmade greater than 7^{o} (approx. 1 in 7)?	Yes. Locally to the south west of the site the ground slopes from west to east varying from 7 to 8 degrees. Figure 16 of Arup's Hydrogeological report – Slope angle map shows the site has some areas greater than 7 degrees and some greater than 10 degrees.	Y
2	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7^{o} (approx. 1 in 7)?	No, the profile of the landscaping at site will retain the same slope as the existing.	N
3	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7^{o} (approx. 1 in 7)?	No, Swains Lane has a gradient of approximately 4 degrees based on survey information. Figure 16 of Arup's Hydrogeological report and site observations have confirmed this is the case	N
4	Is the site within a wider hillside setting in which the general slope is greater than 7^{o} (approx. 1 in 7)?	Yes. Figure 16 of Arup's report – Slope angle map, shows that part of the site is located on a band of slope that is greater than 7 degrees indicating that the site is located on a hill. This was confirmed by site observations and the general slope of Swains Lane.	Y
5	Is the London Clay the lowest strata at the site?	Yes, the London Clay is the lowest strata on the site. Refer to Figure 3 of the Arup Hydrogeological report – Camden Geology Map.	Y
6	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes, two small trees will be felled.	Y
7	Is there a history of seasonal shrink-well subsidence in the local area, and/or evidence of such effects on site?	There are no signs on the site of such effects	N
8	Is the site within 100m of a watercourse or a potential spring line?	Yes the site is within 100m of a tributary of the Fleet river as shown on Figure 11 of Arup's Hydrogeological study – Watercourses.	Y

9	Is the site within an area of previously worked ground?	Historical records and Figure 3 of Arup's Hydrological report – Camden Geological report indicate the site is not on worked ground. The fill within the existing cutting is to be removed as part of the proposals.	N
10	Is the site within an aquifer? If so, will the proposed basemen extend beneath the water tale such that dewatering may occur during construction?	The maps in Appendix C show the site is not located above an aquifer. The location of aquifers is shown in figure 8 of Arup's Hydrogeological study. The closest aquifer is the "Secondary A" aquifer, approximately 80m north of the site.	N
11	Is the site within 50m from the Hampstead Heath ponds?	No, Figure 14 of Arup's Hydrogeolgical report –Hampstead Heath Surface Water Catchment and Drainage – and Figure 13 Hampstead Heath Map – show that the site is well removed from the Hampstead Heath Pond Chain.	N
12	Is the site within 5m of a highway or pedestrian right of way?	No, the proposed tunnel is not within 5m of a highway or public right of way.	N
13	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No, the nearest neighbouring property to the south of the site (79 Swains Lane) is located approximately 3m away from the proposed tunnel.	N
14	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No, based on our in-house information the site is outside of any exclusion zones. The LU Northern Line runs approximately 700m to the east.	N

Appendix D The existing site and structures

Appendix E Existing Groundwater Flows

Appendix F Proposed Groundwater Flows

Appendix G Proposed Structure Drawings

Appendix H Assumed Sequence of Construction

Appendix I Calculations

Appendix J Site Investigation Report 2015

Appendix K Arboriculturalist's Report

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