

Science Block, Highgate School

Structural and Civil Engineer's Basement Impact Assessment Report



Contents		Page	Executive Summary
	Executive Summary	2	This report confirms, in accordance with Haringey Council’s Development Management DPD, that the proposed subterranean extension will not cause harm to the built or natural environment and local amenity, including to the local water environment, ground conditions and biodiversity.
1	Scope	3	
2	The Site	4	This Basement Impact Assessment Report (BIA) has been produced to supplement the planning application for the proposed development of the Science Block at Highgate School, located in the London Borough of Haringey.
3	Ground Conditions	5	
4	Site Hydrology & Hydrogeology	6	The following report assesses the impact of the proposed basement in accordance with Haringey London Borough Council’s (HLBC) ‘Draft Basement Development Guidance Note’.
5	Proposed Structure New Superstructure New Substructure Construction Sequence	6	
6	Design Drawings	7	Price & Myers LLP are experienced in designing basements and have extensive knowledge of different types of basement construction and design, and ground conditions within London and Haringey.
			A geotechnical site investigation was carried out by Lister's Geotechnical in November 2018 and is included in Appendix D.

Appendices:

Appendix A	Proposed Basement Construction Sequence Sketch
Appendix B	Price & Myers Flood Risk Asssessment
Appendix C	Blue Sky Thinking Construction Review Report
Appendix D	Lister's Geotechnical Site Investigation Report

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Job Number: 26574

Date	Version	Notes/Amendments/Issue Purpose
March 2019	1	Planning
April 2019	2	Updated

Note:
This report has been prepared for Highgate School and their advisors, using the information available to us at the time. It should not be relied upon by anyone else or used for any other purpose. This report is confidential to our Client; it should only be shown to others with their permission. We retain copyright of this report which should only be reproduced with our permission.

1 Scope

The following Tables 1, 2 and 3 form the screening stage of the BIA to see the effect of the basement on the surrounding area and to establish the outline of the works within this report. These tables have been prepared based on the Desk Study and Ground Investigation by Lister’s Geotechnical.

Table 1 - Subterranean (ground water) screening chart

Impact Question	Answer (Yes/No)	Justification
Q 1a: Is the site located directly above an aquifer?	Yes	The London Clay formation is designated as a Secondary ‘A’ Aquifer by the Environment Agency. The London Clay formation at this site is understood to be around 50m depth based on British Geological Survey information. Subsoils encountered in the site investigation are made ground upon the Bagshot Formation underlain by the Claygate Member and London Clay.
Q 1b: Will the proposed basement extend beneath the water table surface?	No	The basement excavation is proposed to extend to approximately 3 to 4m below existing ground level. Investigations encountered ground water at approximately 8m below existing ground level.
Q 2: Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No	
Q 3: Is the site within the catchment of the pond Chains on Hampstead Heath?	No	
Q 4: Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No	The existing and proposed schemes share approximately the same footprint.
Q 5: As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No	The site drainage is to be designed to maintain the existing situation.
Q6: 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 ponds chains on Hampstead Heath) or spring line.	No	

Table 2 - Slope stability screening chart

Impact Question	Answer (Yes/No)	Justification
Q 1: Does the existing site include slopes, natural or manmade, greater than 7°? (approximately 1 in 8)	No	The site is flat
Q 2: Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7°? (approximately 1 in 8)	No	
Q 3: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°? (approximately 1 in 8)	No	
Q 4: Is the site within a wider hillside setting in which the general slope is greater than 7°? (approximately 1 in 8)	Yes	The site is located in the area at the top of Highgate hill. The landscape to the east of the site (20m away), on the other side of Southwood lane, slopes down towards the Finsbury park area.
Q 5: Is the London Clay the shallowest strata at the site?	No	The Bagshot Formation and Claygate Member are underlain by London Clay.
Q 6: Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree zones where trees are to be retained?	No	
Q 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	Yes	The Claygate Member has moderate risk of shrink-swell/volume change potential. The London Clay formation is a recognised shrinkable soil. The Bagshot Formation is not a shrink/swell hazard.
Q 8: Is the site within 100m of a watercourse or a potential spring line?	No	
Q 9: Is the site within an area of previously worked ground?	No	
Q 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Yes	The London Clay formation is designated as a Secondary ‘A’ Aquifer by the Environment Agency. No dewatering is anticipated. The basement excavation is proposed to extend to approximately 3 to 4m below existing ground level. Investigations encountered ground water at approximately 8m below existing ground level.

Q 11: Is the site within 50m of the Hampstead Heath ponds?	No	Refer to site location Plan. The site is approximately 600m north of the Hampstead Heath Ponds
Q 12: Is the site within 5m of a highway or pedestrian right of way?	Yes	The Site is bounded by a public road (Southwood Lane) to the East.
Q 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes	The existing structure has a lower ground floor. The proposed basement is to be situated under the proposed annex building and is not located under the existing building. The basement will increase relative foundation depths compared to the adjacent structures, which are included within the scope of the project.
Q 14: Is the site over (or within the exclusion zone of) any tunnels e.g. railway lines?	No	The site is not above any tunnels.

Table 3 - Surface flow and flooding screening chart

Impact Question	Answer (Yes/No)	Justification
Q 1: Is the site within the catchment of the ponds on Hampstead Heath	No	The Site lies to the North East of the Hampstead Heath Ponds catchment.
Q 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	Where possible the existing drainage will be used.
Q 3: Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No	The proposed development will occupy approximately similar areas to that of the existing.
Q 4: Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses?	No	There will be no surface expression of the basement development, so the surface water flow regime will be unchanged.
Q 5: Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No	There will be no surface expression of the basement development, so the surface water flow regime will be unchanged.
Q 6: Is the site in an area known to be at risk from Surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No	The site has a low flooding risk from surface water, sewers, reservoirs, groundwater and fluvial/tidal watercourses.

2 The Site

The site is located within Highgate Schools' campus between North Road and Southwood Lane; refer to Figure 1. To the north of the Science Building is the Garner Quad and to the south is the Science Quad. The existing structures are late Victorian / early Edwardian Steel frames, with load bearing masonry and early age filler joist concrete floors. In 2005 Price & Myers were involved in the design of the third floor/roof extension to the Chemistry (phase 2) and Biology blocks (phase 1), which form part of the current Science Building.

The proposed project involves the refurbishment of the Science block, along with a new extension of the Biology block with a 4-storey steel frame extension, with basement. The report will focus on the new 4 storey annex and subterranean basement development.

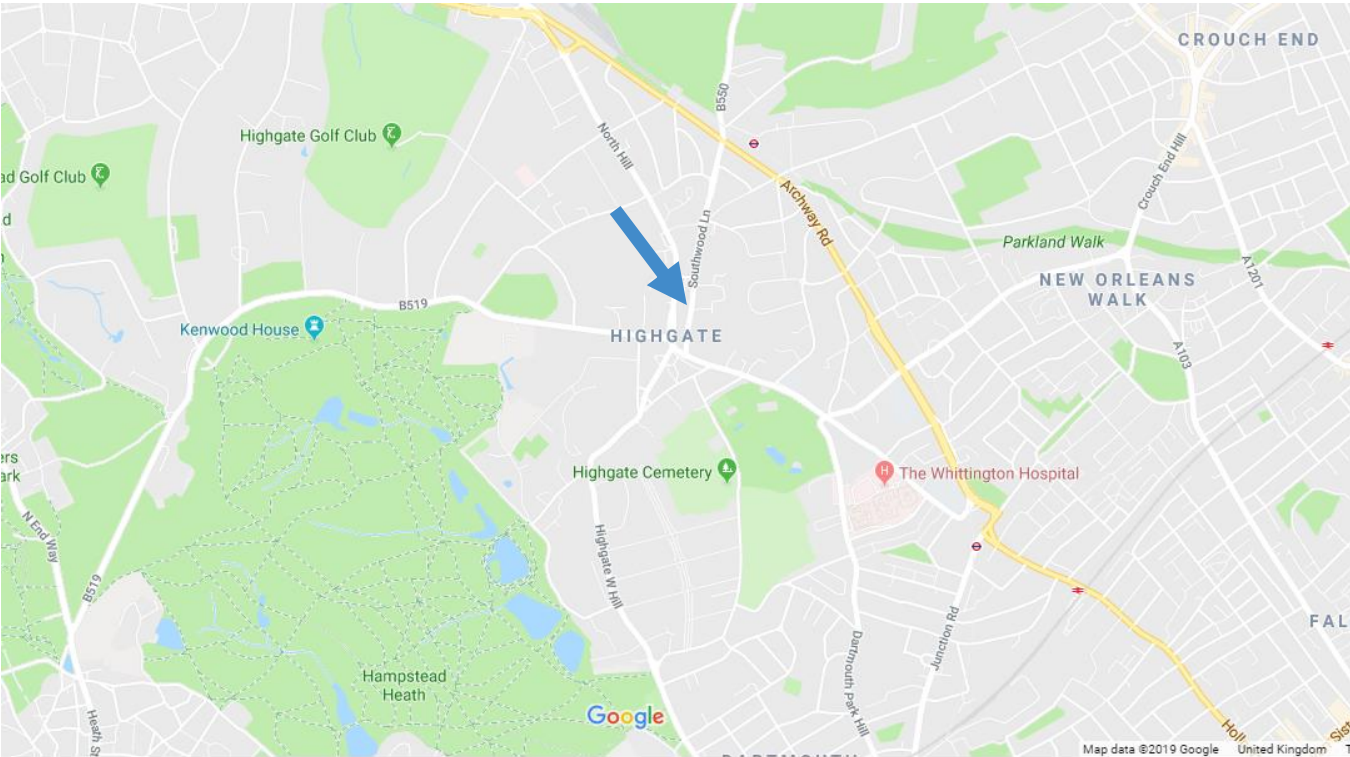


Figure 1 - Site location - Google Maps extract 2019

Hampstead Heath lies to the south west of the site. The site is not located with the Highgate Chain Catchment boundaries of the ponds. Refer to Figure 2.

The proposed 4 storey annex is located discretely within the Science Quad. The proposed footprint of the basement is approximately 3m x 15m in plan. Refer to Figure 3.



Figure 2 - Highgate Chain Catchment Boundaries (Contains Ordnance Survey data, Crown copyright and database right 2013)

3 Ground Conditions

A detailed geotechnical site investigation has been carried out for this planning application by Listers Geotechnical Consultants Ltd (Listers), Reference 08.07.019 dated November 2018. This report is included in Appendix D. The aim of this investigation was to determine the ground conditions and hydrogeology, to assess the extent of any contamination and to provide information for the design and construction of the proposed works.

The physical geotechnical investigation consisted of two cable percussion boreholes to 15m BGL, two continuous tube sample boreholes, one super heavy dynamic probe, 4No hand dug foundation inspection pits and two dynamic cone penetrometer tests.

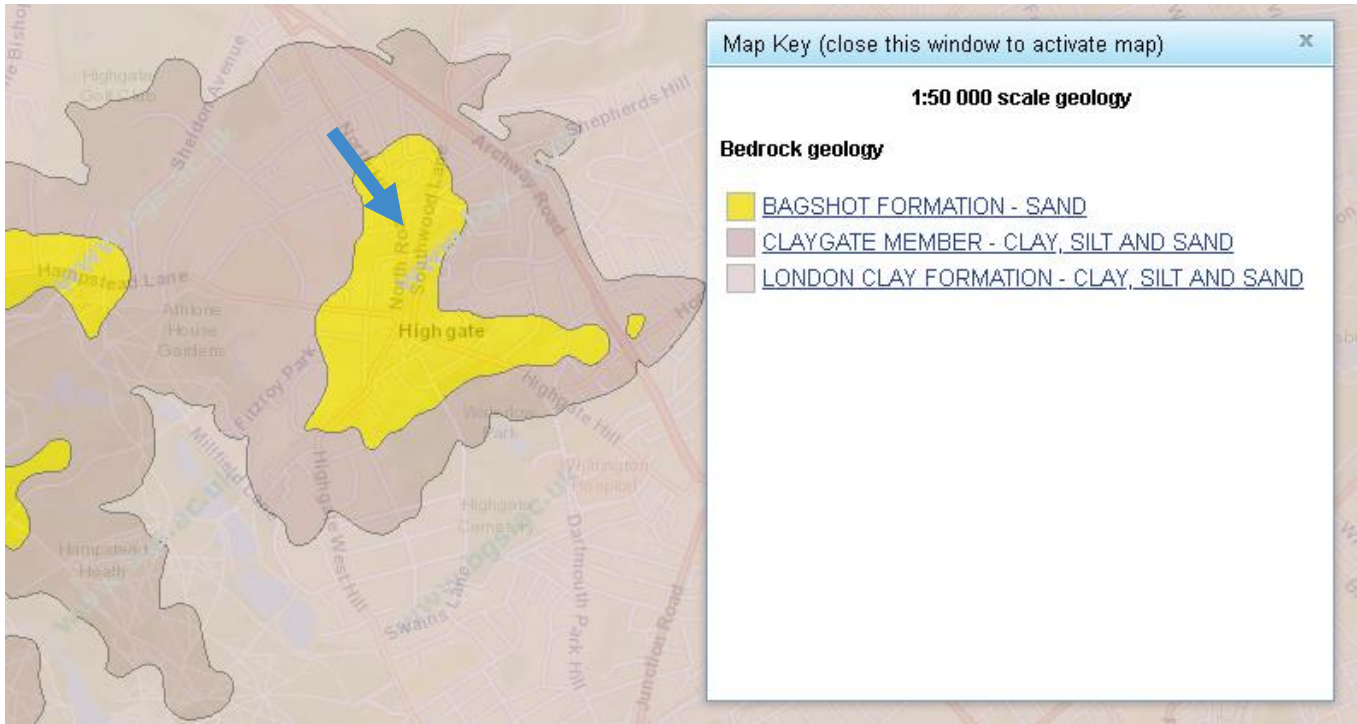


Figure 4 - Extract of geological map showing Highgate. Contains British Geological Survey materials © NERC [2019]

As shown on figure 4 the site is underlain by a layer of Bagshot Formation sand, over the Claygate Member over London Clay.

Ground conditions were found to be broadly in line with those indicated by the Geological Survey maps. Below the (0.4m) fill, Bagshot formation (CLAY/SAND) was found to 11.5m bgl over the Claygate member proven to 15m.

Groundwater was encountered at 9 to 12.5m BGL during drilling. Subsequent monitoring of the standpipes three weeks after installation found the groundwater to be 8.6m BGL.



Figure 3 - Location of proposed development - Google Maps extract 2019

4 Site Hydrology & Hydrogeology

The site falls with Environment Agency Flood Zone 1 “areas with little or no potential risk of flooding” from watercourses.

The site is located within a Critical Drainage Area (CDA) (Group 4_062); however, the site is at low risk of flooding from all sources, including surface water, groundwater, public sewers or reservoirs.

Therefore, the proposed development has an acceptable flood risk within the terms and requirements of the NPPF.

A detailed flood risk assessment is included in Appendix B.

5 Proposed Structure

New Superstructure

A new four storey annex with basement is proposed to abut the Biology block. There are a number of structural options for this frame. A steel frame is the most suitable option, given the wide range of Contractors able to carry out the work and the speed at which it could be erected. A traditional timber frame, a glue laminated timber frame or an insitu reinforced concrete frame, have also been considered. The lift shaft (4 storeys + basement) will be constructed with a steel frame, to provide stability to the proposed steel framed annex.

New Substructure

For the small subterranean extension, a contiguous piled wall with a reinforced concrete lining wall in combination with reinforced concrete underpins to the existing building foundations is proposed. This option provides the safest means of excavating the proposed basement, it also minimises the risk of damage to the existing building.

The basement grade to be provided is a ‘Grade 3 basement’ as defined in BS8102:2009 ‘Code of Practice for Protection of Below Ground Structures’

The load bearing columns and walls of the superstructure are to be located along the façade of the new extension and will utilise the piled retaining wall as its foundation.

The contiguous piled wall will be installed prior to any underpinning works being carried out to the existing structure. The piled wall will be designed to cantilever, to negate temporary works requirements to prop the wall and any complicated sequences of works which can lead to extended programmes and difficult site logistics.

The site investigation suggests that a ground bearing basement slab will be suitable at the proposed formation level. The slab will be designed for a heave loading of 30kN/m2 as highlighted in the ground investigation report. This uplift will be resisted by the piled wall construction.

The basement will be designed assuming a raised water table, 1m BGL, to allow for the unlikely event of a burst water main. The basement walls will be designed for hydrostatic pressure, and the basement structure as a whole will be designed to resist buoyancy. This will be justified by a combination of the dead load of the existing and proposed building and the tensile capacity of the continuous flight augured RC piles.

The new subterranean development is to be a rigid reinforced concrete U-shape structure, utilising reinforced concrete underpins to lower the founding level of the existing structure. This underpinning will be installed in a non-sequential order. During the installation of the underpins, they shall be sequentially

propped off the contiguous piled wall retaining the Science Quad, until the basement slab is cast and the cantilever is activated. The reinforced concrete lining wall will be designed to be laterally propped at the top by the capping beam and bottom by the basement slab in the permanent case.

The foul water from the proposed basement sink, toilet and four showers will require pumping due to the proposed levels relative to the sewer. Pumping minimises the potential flood risk from a surcharged sewer. The sump will be formed with an insitu RC box and a GRP pumping chamber installed within it. The sump will be sized for 24hr storage. The proposed drainage layout is included within Appendix B

The concrete structure will be designed to BS EN 1992. The concrete will be specified as waterproof concrete with a pore blocker admixture as the first line of defence (type B) to achieve a Grade 3 ‘habitable’ basement in accordance with BS8102. An internal drained cavity system will be installed to provide the second line of defence (type C).

Construction Sequence

All of the works, particularly the sub-structure are to be carried out in a manner, which minimises noise and vibration that may affect the neighbouring properties. The Structural Engineer will make regular site visits during the construction, to monitor that the works are being executed generally in accordance with the contract documents and good engineering practice. Outline construction sequence and temporary works assumed in the design as described below will be superseded by the Contractor’s proposals. The Contractor will be required to submit full proposals, method statements and calculations to the Structural Engineer for review prior to the start of any works on site. The Contractor will be responsible for the design, erection and maintenance of all temporary works in accordance with all relevant British Standards or Eurocodes. The Contractor is to provide adequate temporary works and supervision to ensure that the stability of the existing structure, excavations and surrounding structures are maintained at all times.

Refer to Appendix A for Price & Myers Proposed Basement Construction Sequence Sketch

Phase 1 - Piling

- i. Install piling mat
- ii. Install CFA RC piles
- iii. Cast capping beam

Phase 2 – Reduce dig

- i. Reduce level in proposed basement to bottom of existing foundation

Phase 3 – Underpin and prop

- i. Install RC underpin in non-sequential order.
- ii. Install propping against piled wall.
- iii. Dry Pack installed to joint between existing foundation and top of underpin – Allow 48hours curing before proceeding with adjacent pins

Phase 4 – Cast slab and wall

- i. Cast basement slab.
- ii. Allow enough time for slab to gain enough strength.
- iii. De-prop underpins.
- iv. Cast lining wall.

Blue Sky Thinking were commissioned to carry out a detailed Construction Review Report, which is included in Appendix C. This describes and sets out the site logistics, construction operations and the anticipated sequence of construction. The report also presents an anticipated Construction programme.

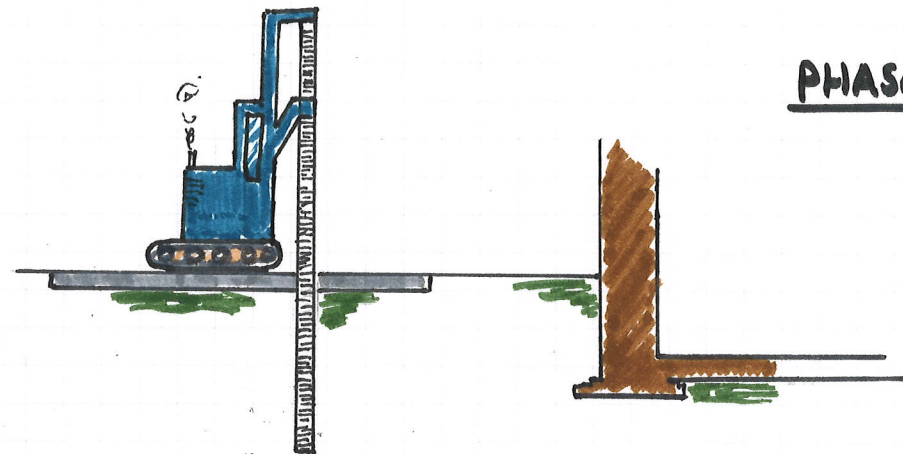
6 Design Drawings

- 26574-10_1 Basement Floor Plan
- 26574-20_1Ground Floor Plan
- 26574-30_1 Mezzanine Plan
- 26574-40_1 First Floor Plan
- 26574-50_1 Second Floor Plan
- 26574-60_1 Third Floor Plan
- 26574-70_1 Roof Plan
- 26574-100_1 Section A-A

Appendix A

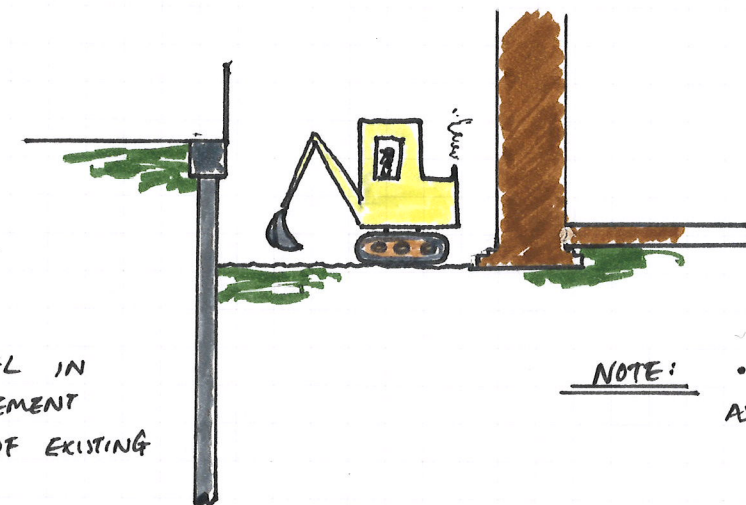
Proposed Basement Construction Sequence Sketch

SUGGESTED SEQUENCE FOR PROPOSED BASEMENT.



PHASE 1 - PILING

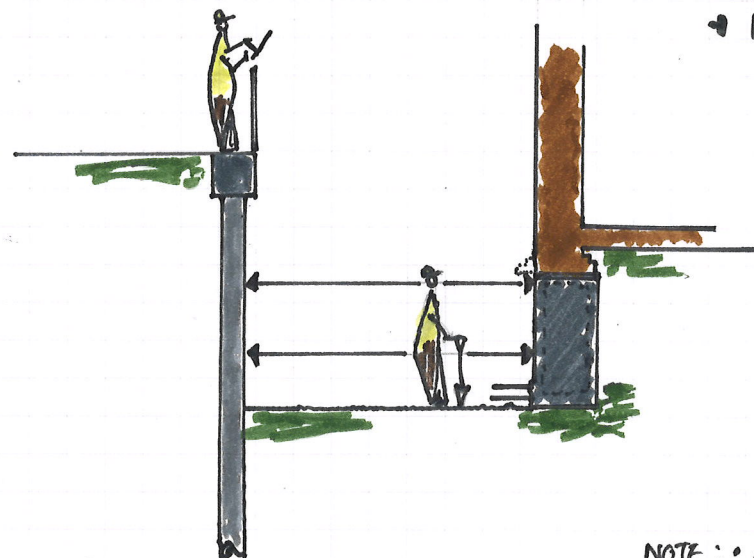
1. INSTALL PILING MAT
2. INSTALL CFA RC PILES
3. CAST CAPPING BEAM



PHASE 2 - REDUCE DIG

1. REDUCE LEVEL IN PROPOSED BASEMENT TO BOTTOM OF EXISTING FOUNDATION

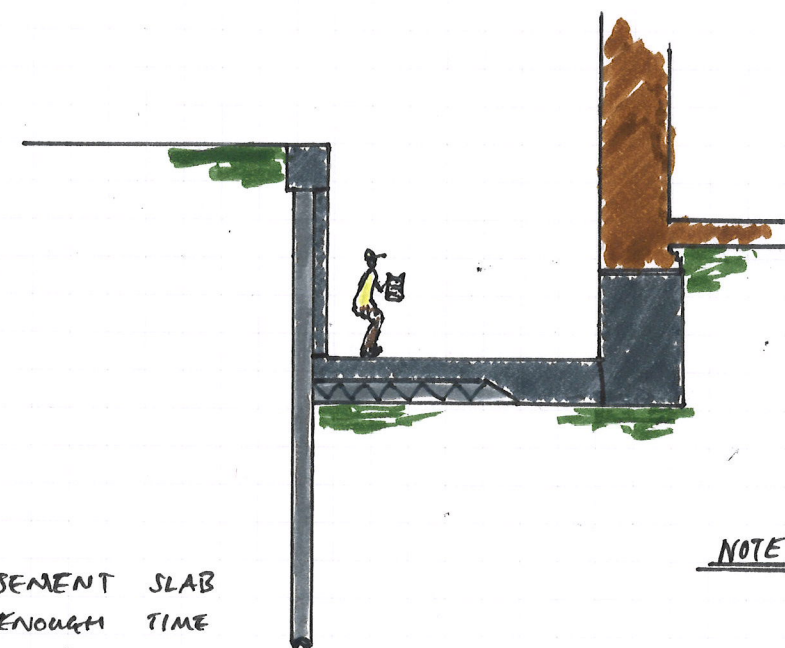
NOTE: • PILES DESIGNED AS PERMANENT CANTILEVER.



PHASE 3 - UNDERPIN + PROP + REDUCE DIG

1. INSTALL RC UNDERPINS IN NON SEQUENTIAL ORDER / INSTALL PROPPING AGAINST PILED WALL

NOTE: • MIN 48HRS CONCRETE CURING BEFORE PROCEEDING TO ADJACENT PIN
• INSTALL HYDROPHYLIC STRIPS
• INSTALL DRY PACK BETWEEN EXISTING FOUNDATION AND TOP OF PIN.



PHASE 4 - CAST SLAB WALL

1. CAST BASEMENT SLAB
2. ALLOW ENOUGH TIME FOR SLAB TO GAIN SUFFICIENT STRENGTH
3. DEPROP UNDERPINS
4. CAST LINING WALL.

NOTE: • ALL CAST IN WATER PROOF CONCRETE.

Appendix B

Price & Myers Floor Risk Assessment

Highgate School Science Building, North Road

Flood Risk Assessment and Surface Water Drainage Strategy Report

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Job Number: **26574**

Date	Version	Notes/Amendments/Issue Purpose
March 2019	01	Issued for BIA

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Appendix H1

Appendix A Ground Investigations Report Extracts

Appendix B Thames Water Asset Location Map

Appendix C Preliminary Below Ground Drainage Drawing

1 Introduction

This Flood Risk Assessment (FRA) and surface water drainage strategy report has been produced to accompany the Basement Impact Assessment (BIA) for Highgate School, North Road, Highgate, London, N6 4AY.

This report has been carried out in accordance with the National Planning Policy Framework (NPPF) and the accompanying Planning Practice Guidance (PPG) "Flood Risk and Coastal Change". This report also incorporates advice and guidance from the Environment Agency, the London Borough of Haringey Strategic Flood Risk Assessment (SFRA, 2014), the London Borough of Haringey Surface Water Management Plan (SWMP, 2011), CIRIA documents and Haringey SUDS Design Requirements for Lead Local Flood Authority (LLFA) Technical Assessment 1.0 (2016). We acknowledge the SUDS Flow and Volumes – LLFA Technical Assessment Proforma form, however, this has not been completed as it is proposed to retain the existing drainage strategy.

2 Flood Risk Assessment

2.1 Flood Risk from Watercourses and Tidal Flooding

The EA's indicative floodplain map shows that the site is located in Flood Zone 1 and is not at risk of fluvial and/or tidal flooding. Developments in this flood zone do not have any restrictions, provided they do not increase the risk of flooding elsewhere.

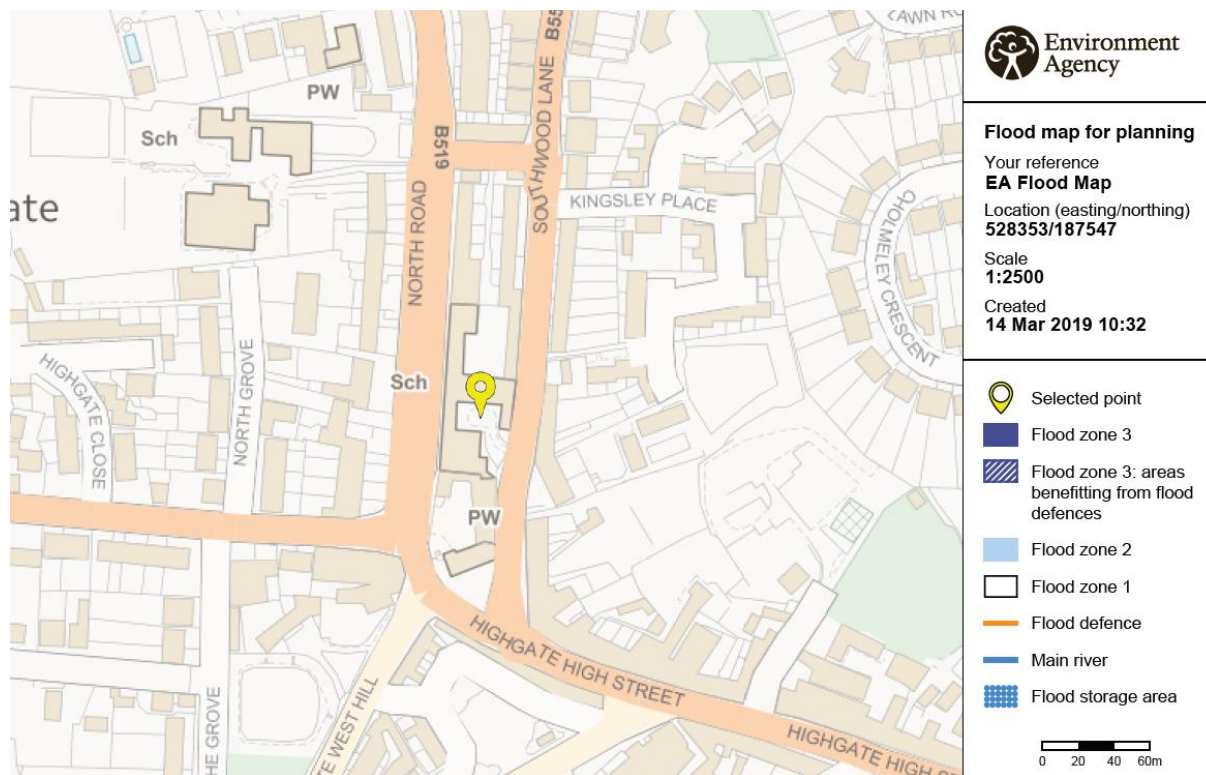


Figure 2.1: Extract from EA Flood Map for Planning (Map data © 2019 OS 100022861)

2.2 Flood risk from Groundwater

Groundwater flooding occurs when water originating from sub-surface permeable strata emerges from the ground, typically after prolonged rainfall.

The “Increased Potential for Elevated Groundwater” map in Haringey Council's SWMP indicates that the proposed site is in an area with no recorded historic groundwater flooding and is not susceptible to elevated groundwater levels. An extract from the map is included in Figure 2.2 below.

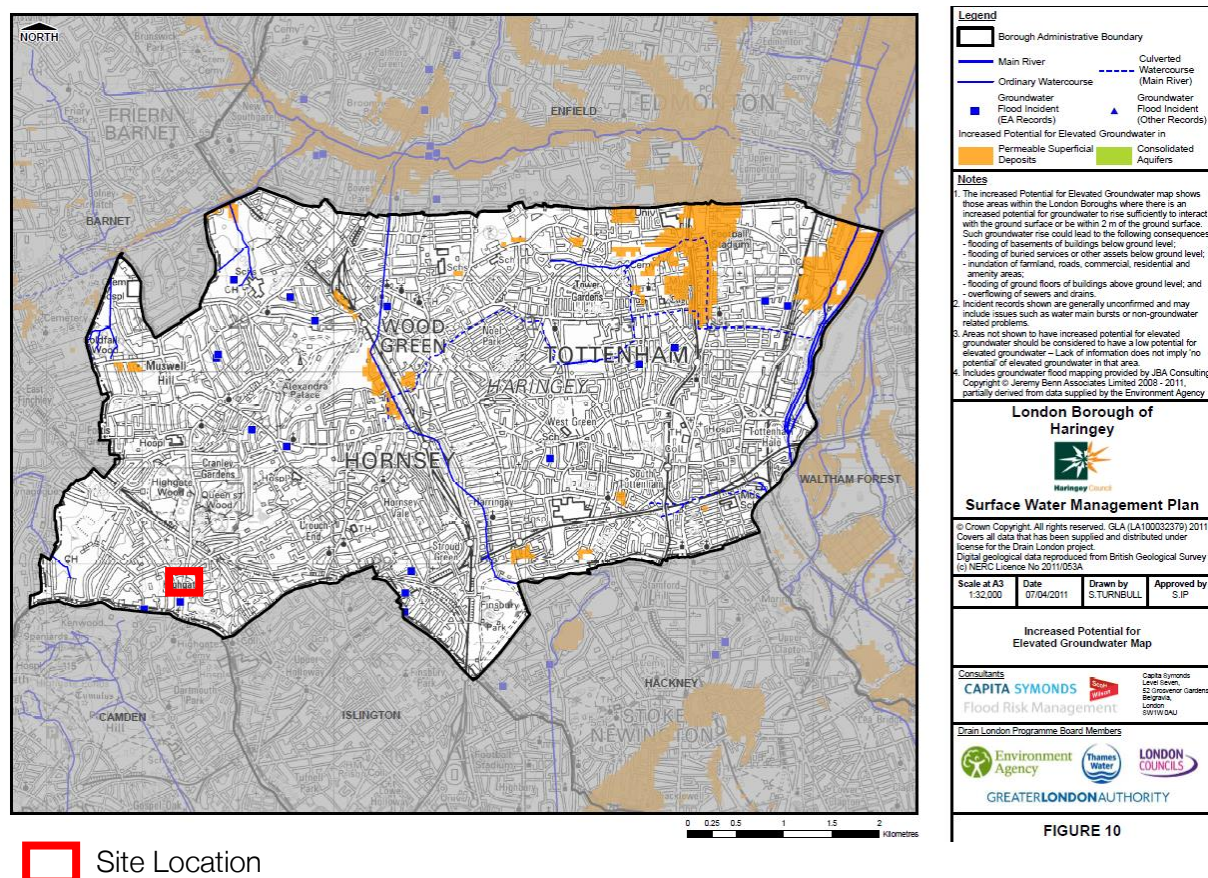


Figure 2.2: Increased Potential for Elevated Groundwater Map (Extract from SWMP)

The British Geological Survey (BGS) map for this area shows that the site is underlain by Bagshot Formation – Sand, as shown in Figure 2.3 below.

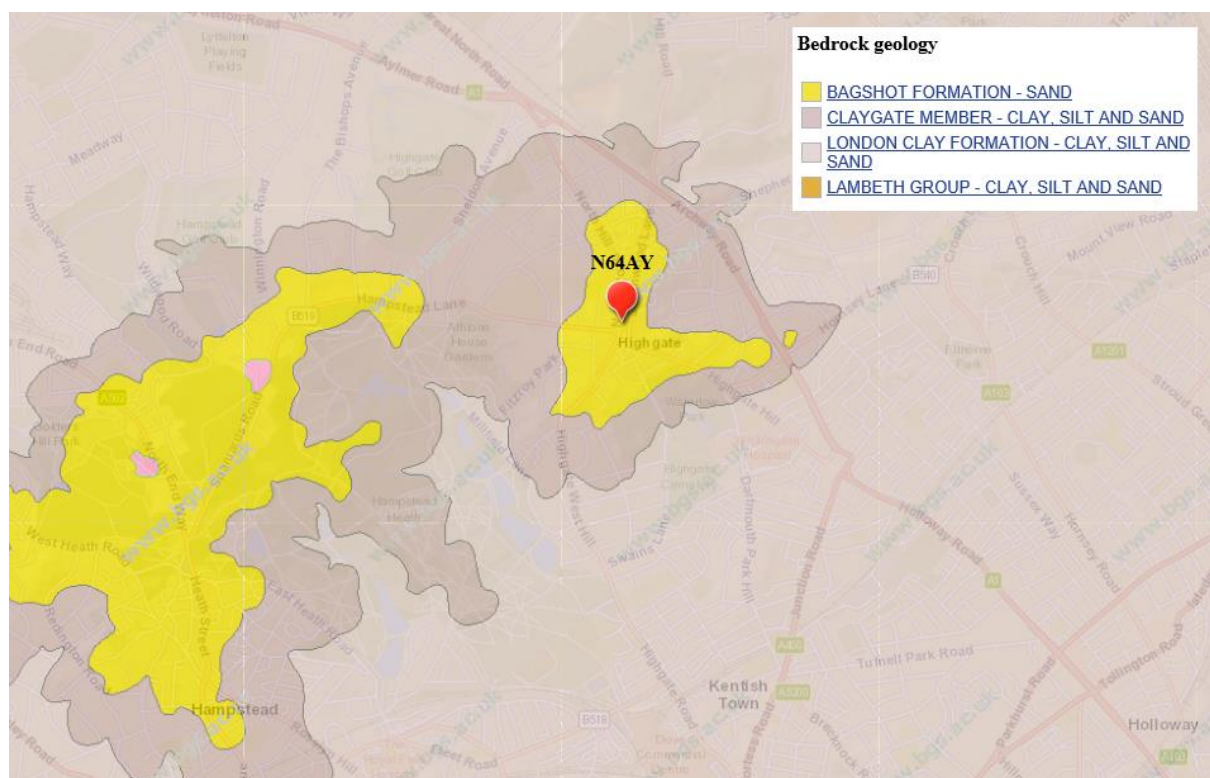


Figure 2.3: Local Geology (Map data British Geological Survey © NERC 2019)

The North London SFRA concludes that "*groundwater flooding was found to be a relatively low risk. However the local geology does increase the risk of groundwater flooding and these risk zones were highlighted*" for Haringey.

Listers Geo have carried out a geotechnical site investigation and prepared an accompanying report (reference no: 18.07.019) The investigation revealed that a layer of engineered fill and Made Ground is above Bagshot Formation, extending to depths of 11.50m bgl, over the Claygate Member to a full depth of 15.1m.

Groundwater was encountered during intrusive works between 8.0m and 12.5m bgl and Claygate Member between 2.5m and 11.5m proven a maximum depth of 15.1m bgl. Although groundwater was found to be deep and is likely to be below the base of the basement excavation, the proposed basements will be designed to be fully waterproof for the lifetime of the development, further reducing the residual risk of groundwater flooding.

The EA have defined Source Protection Zones (SPZ) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. The closer the activity, the greater the risk. The EA maps confirm that the site is not located within any groundwater SPZ, as shown in the Figure 2.4. Therefore, it can be concluded that the groundwater flood risk to the site is low.

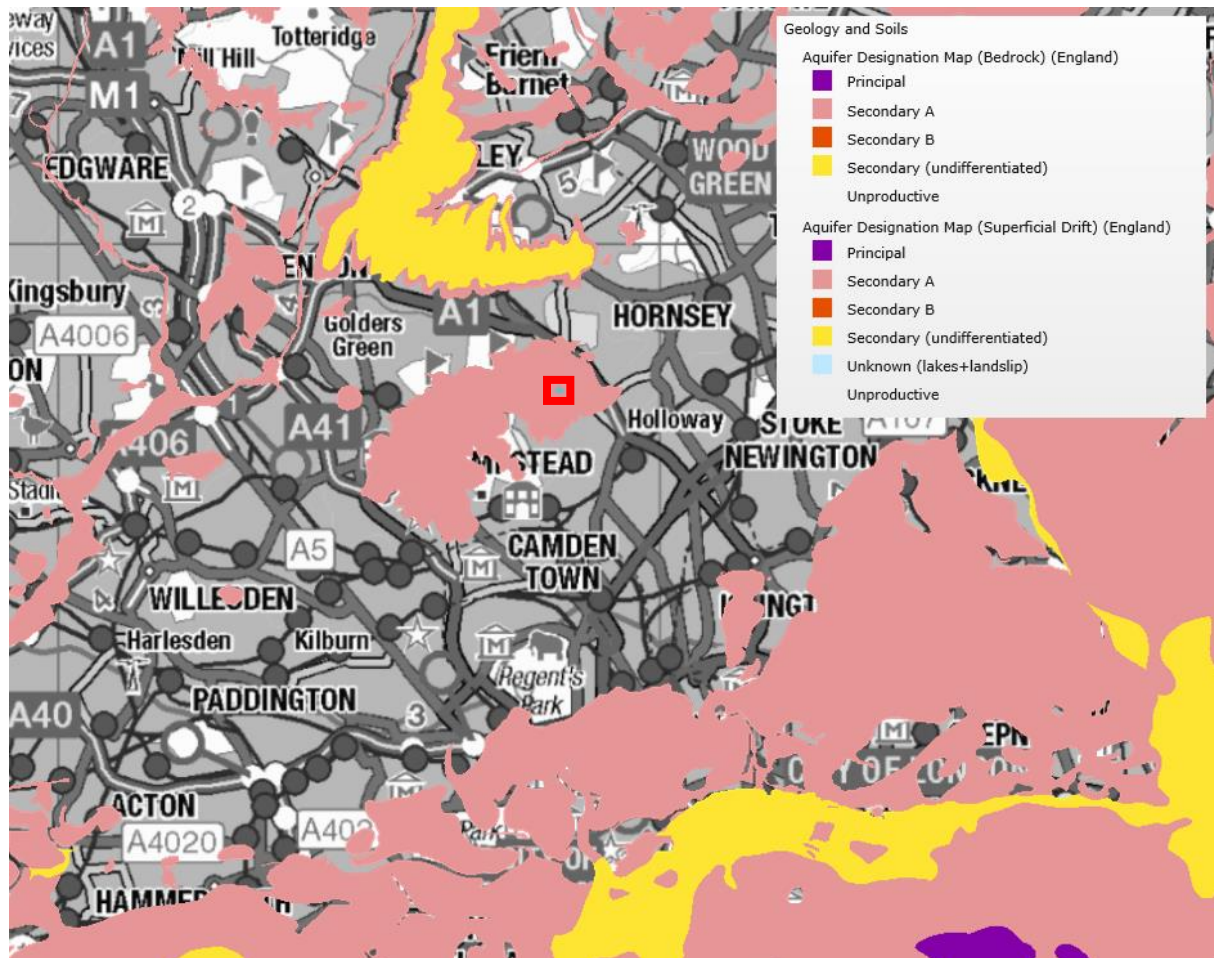


 Site Location

Figure 2.4: Source Protection Zones (Map data © 2019 OS 100022861)

The underlying Bagshot Formation is classified as a Secondary A aquifer, corresponding with the information shown in Figure 2.5 below. The Claygate Member is classified as Unproductive Strata. According to the site investigation, no significantly elevated concentrations of contaminants were detected in soils at this site, it is considered unlikely that significant contamination will migrate from soils into the groundwater of the Secondary A aquifer.

Subsequent migration of contamination to surface water is also considered unlikely, particularly given their proximity from the site.



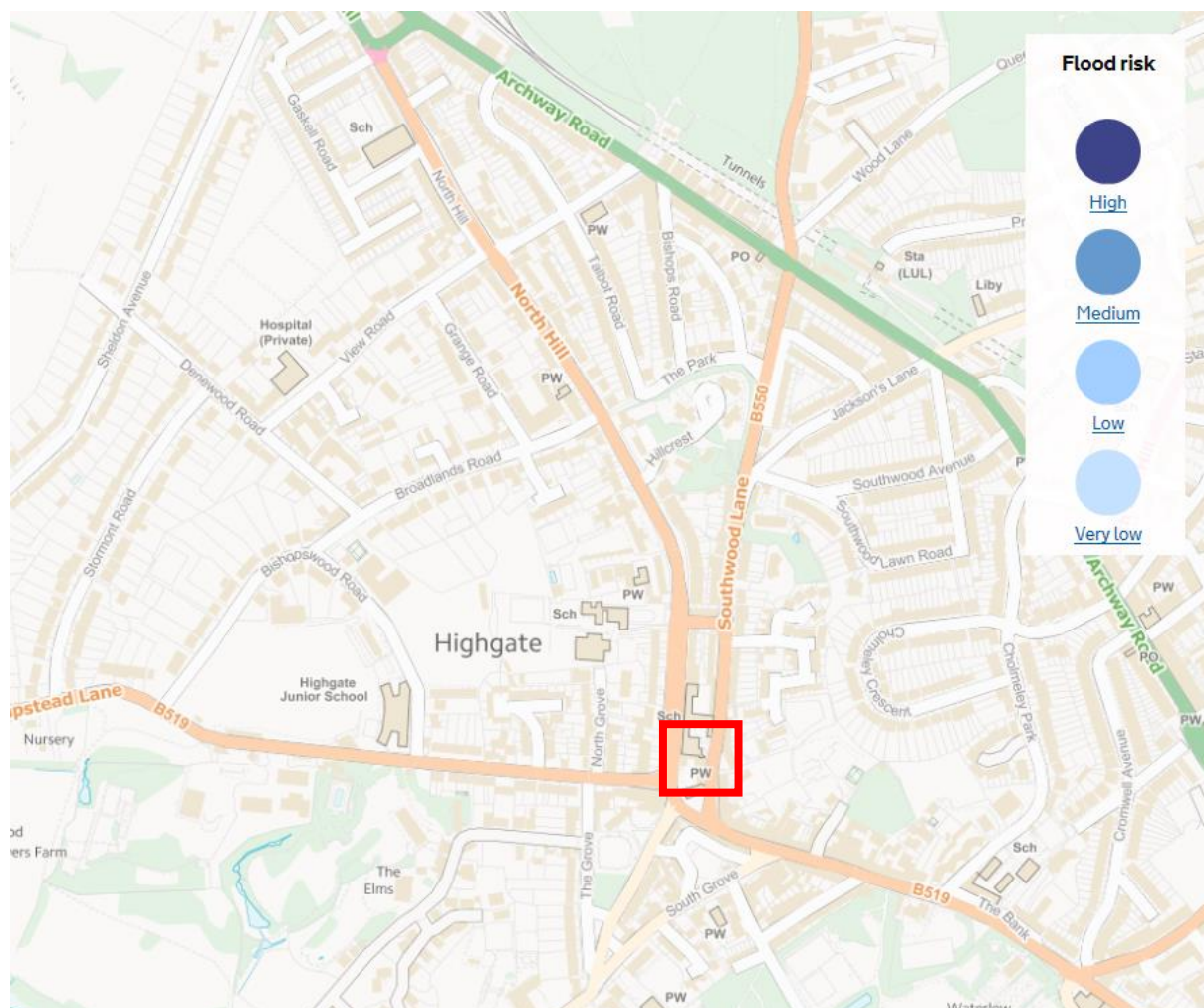
 Site Location

Figure 2.5: Aquifer Designation Map (Map data © 2019 OS 100022861)

2.3 Flood Risk from Surface Water and Overland Flows

Surface water flooding occurs when intense rainfall is unable to soak into the ground or enter a drainage system due to blockages or the capacity of the system being exceeded. Overland flows can also be generated by burst water mains, failed dams and any failure in a system storing or transferring water.

The EA's indicative Surface Water Flooding Map, Figure 2.6, shows that the site is at very low risk of surface water flooding.



Site Location

Figure 2.6 Environment Agency Surface Water Flood Risk Map (Map data © 2019 OS 100022861)

The site is located in a Critical Drainage Area (CDA) Group4_062, however the site is at low risk of surface water flooding. The surface water flood risk identified in this CDA refers to Milton Park and Causton Road, which are located 500m + away from the site location.

Therefore, the flood risk from surface water and overland flows is considered low.

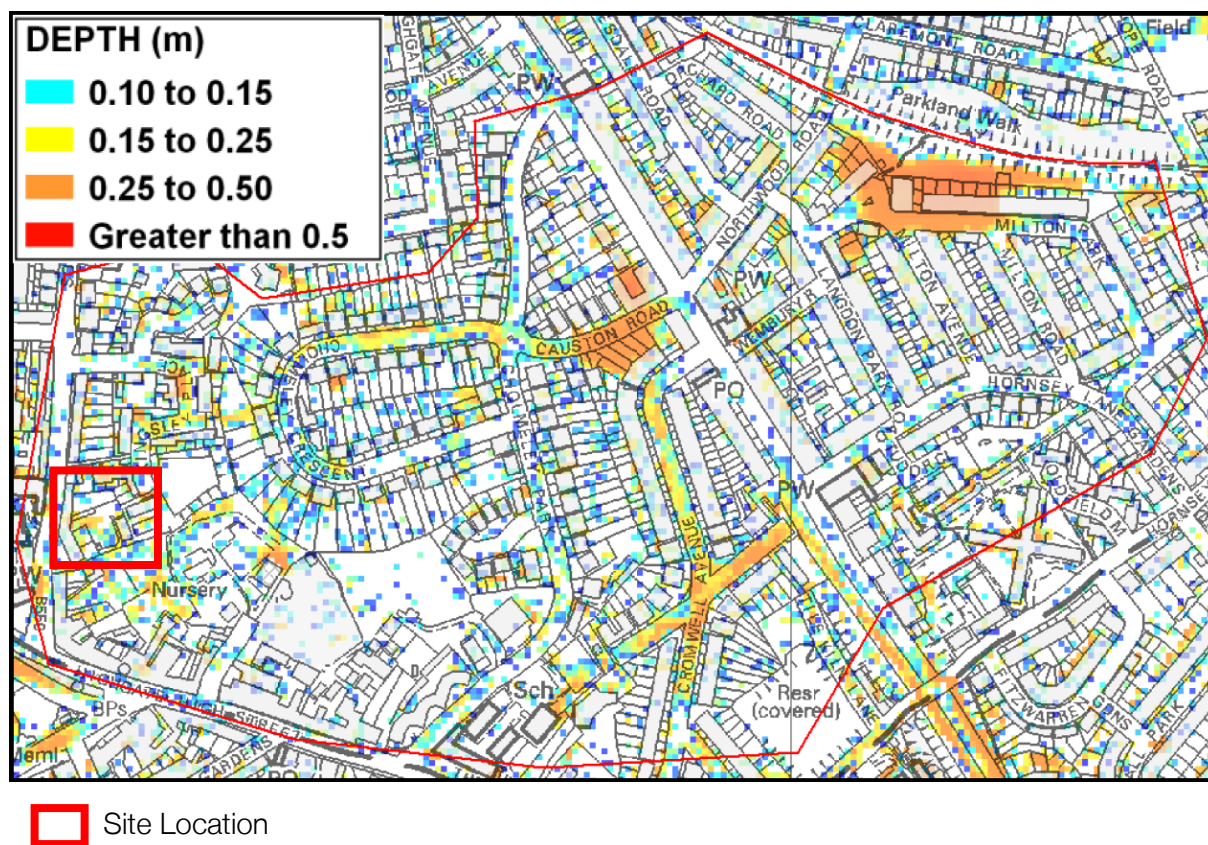
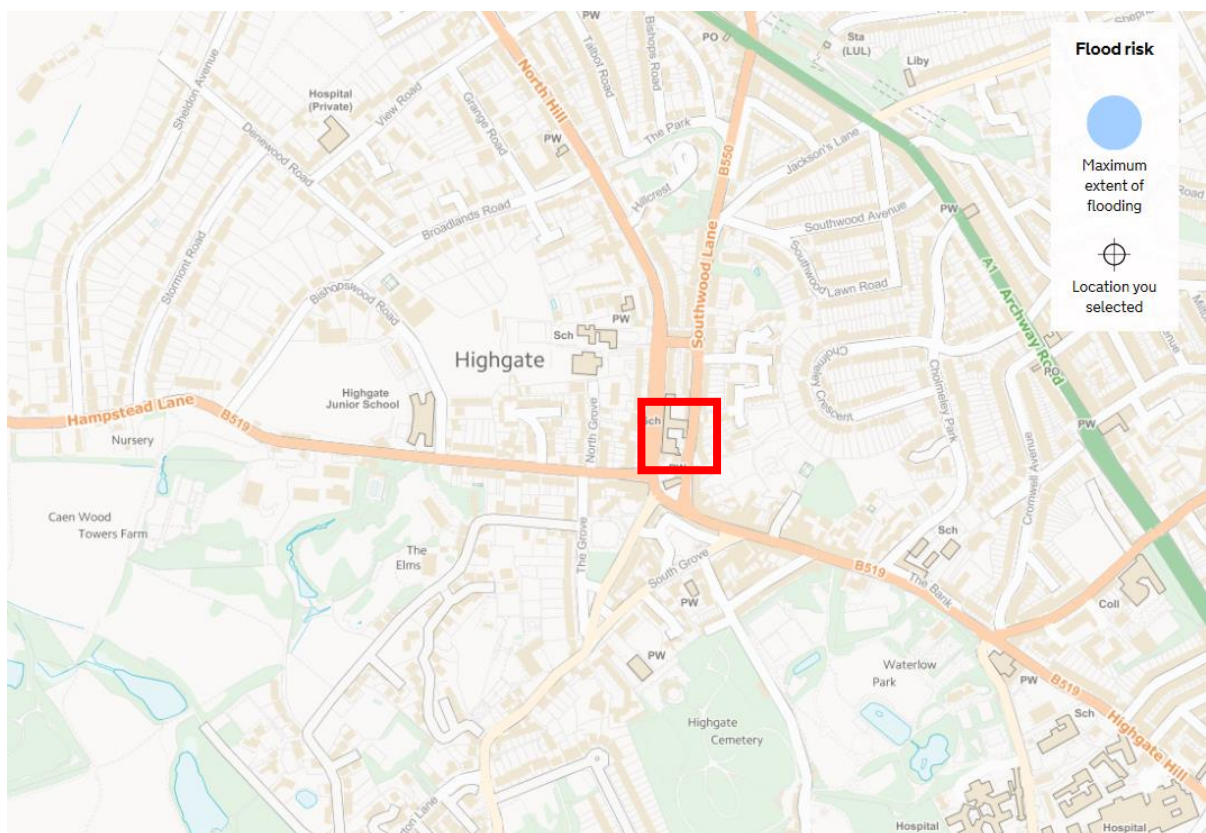


Figure 2.7 Critical Drainage Areas (Extract from SWMP)

2.4 Flood Risk from Reservoirs

The EA provides information on flood risk from reservoirs. The figure below shows that the site is not at risk of reservoir flooding.



 Site Location

Figure 2.8 Environment Agency Risk of Reservoir Flooding Map (Map data © 2019 OS 100022861)

3 Drainage strategy

3.1 Existing Drainage

The Thames Water sewer records indicate that there is a 229mm diameter foul water public sewer and a 229mm diameter surface water public sewer located in Southwood Lane. The existing private foul and surface water drainage network is separate.

Highgate School's foul drainage connects via manhole 3506, it is assumed that there is another direct connection to the foul water public sewer downstream of manhole 3505. It is also assumed there is a direct connection to the surface water public sewer downstream of manhole 3504. Refer to Appendix B for information.

3.2 Existing Surface Water Run-off

The total site area is approximately 1350m² or 0.0135 ha, of which 1298m² is currently impermeable

The existing run-off rate for the 1 in 100-year storm event was calculated using the modified rational method as shown below:

$$Q_x = 2.78 \times i \times A$$

Where 'x' is the return period in years, 'A' is the catchment area in ha and 'i' is the rainfall intensity in mm/hr as estimated from Micro Drainage software.

$$Q_{100} = 2.78 \times 127.795 \times 0.01298 = 4.611 \text{ l/sec}$$

3.3 Proposed Surface Water Run-off

The proposed development will increase the impermeable areas by a small margin (4m²) to 1302 m². The run-off rate from the proposed development was also calculated using the modified rational method.

$$Q_{100} = 2.78 \times 127.795 \times 0.01302 = 4.626 \text{ l/sec}$$

3.4 Development Proposal

The developed design includes two extensions and refurbishment of the existing facilities. The Garner Quad extension is an extension of the upper levels only, increasing the size of the 1st floor and 2nd floor science laboratories. The Science Quad extension will accommodate a lift and stairs. At basement level, an additional sink, toilet and four showers are proposed.

Foul water appliances in the basement will require pumping due to the proposed levels relative to the sewer, pumping minimises the potential flood risk from a surcharged sewer.

The increase in hardstanding areas is negligible and the number of pupils and staff post-development will remain as existing. Therefore, it is proposed to reuse the existing drainage connections where feasible, including the existing connections to the Thames Water public sewers.

4 Conclusions

- This Flood Risk Assessment and surface water strategy report has been produced to accompany the Basement Impact Assessment for Highgate School, North Road, Highgate, London, N6 4AY.
- The site falls within Flood Zone 1 “areas with little or no potential risk of flooding” from watercourses.
- The site is located within a CDA (Group 4_062); however, the site is at low risk of flooding from all sources, including surface water, groundwater, public sewers or reservoirs.
- Therefore, the proposed development has an acceptable flood risk within the terms and requirements of the NPPF.

Appendix H1

Ground Investigations Report Extracts

GROUND CONDITIONS

The intrusive investigation revealed that the general succession of strata was represented by a layer of engineered fill and Made Ground above Bagshot Formation overlying the Claygate Member to the full depth of the investigation at 15.1m depth in the site in the west of the school, and directly overlying Claygate Member in the east of the Dyne House Parade Ground.

The Ground Model for the site is as follows. Detailed logs are included in Appendix B and full geotechnical testing results are included in Appendix C.

ENGINEERED FILL

Engineered fill was encountered at sixteen of the eighteen exploratory hole locations from ground level down to depths of between 0.1m and 0.4m, with an average thickness of 0.2m.

It was represented by concrete paving or asphalt-concrete hardstanding over a sandy, gravelly or cobbly sub-base.

MADE GROUND

Made Ground was encountered at thirteen of the eighteen exploratory hole locations from between ground level and 0.4m bgl down to depths of between 0.4m and the base of TP D in the Parade Ground at 3.4m bgl. In the western site, the Made Ground was generally deepest in the foundation inspection pits, particularly those around the Science Block.

The Made Ground soils comprised a variable mix of soft to firm, brown sandy and gravelly clays, and loose to dense sandy gravels. Gravel was fine to coarse, angular to subrounded brick, concrete, flint, clinker, clay pipe fragments, and glass.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	8 to 27	No evidence of desiccation
Liquid Limit (%)	28 to 37	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 19	
Plasticity Index (%)	9 to 19	
Modified Plasticity Index (%)	7 to 19	Non-shrinkable and shrinkable soils of LOW Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	2 to 21	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	38 to 78	Represents fines (silt/clay) fraction

TOPSOIL

Topsoil was encountered at TP4 from ground level down to 0.15m and was represented in general by dark grey brown, very sandy, slightly silty clay.

BAGSHOT FORMATION

Bagshot Formation was encountered at five of the eighteen exploratory hole locations from between 0.1m and 1.2m bgl depth down to depths of between the base of the TP B at 2.15m and 11.5m bgl, with an average thickness of 10.7m (where full thickness encountered).

It was represented by soft to stiff, yellow brown and orange brown, silty and sandy clays, and medium dense to very dense, yellow brown and orange brown, clayey sands.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	7 to 48	No evidence of desiccation
Liquid Limit (%)	33 to 49	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 22	
Plasticity Index (%)	12 to 30	
Modified Plasticity Index (%)	12 to 30	Shrinkable soil of LOW to MEDIUM Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	0 to 7	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	39 to 80	Represents fines (silt/clay) fraction

Full laboratory sieve analyses identified gravel contents of up to 0.5%, sand content of between 54% and 73% and fines (silt/clay) between 27% and 45%.

The following shear strength tests were undertaken under laboratory conditions:

Test method	Range (kPa)
Hand Vane	2 to 50
Triaxial	20

The following table provides details of the 'N' values derived from standard penetration testing (SPT) and the number of blows taken to retrieve a U100 sample from the boreholes. Strength tests (including conversion of SPT N-values, using the Stroud method and a factor, f_1 , of 5.5, indicates low to very high undrained shear strength, generally increasing with depth.

Parameter	Range	Comments
SPT 'N' Value	4 to 73	Increasing with depth
U100 blows	15 to 42	
SHDP blows (N ₁₀₀)	1 to 33	max. test depth 10m bgl

The results of the SHDP testing indicated that the penetrative resistance of the stratum varied with depth, with the softer sections correlating with the clay bands.

CLAYGATE MEMBER

Claygate Member was encountered at four of the eighteen exploratory hole locations from 11m and 11.5m bgl down to the base of the boreholes at 15.1m depth, in the western site, and from 2.5m and 2.6m to the base of the trial pits at 2.6m and 2.9m respectively in the Parade Ground in the east of the school. It was represented by stiff, green grey, sandy clay and medium dense, grey, clayey sand.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	24 to 44	No evidence of desiccation
Liquid Limit (%)	35 to 40	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 20	
Plasticity Index (%)	15 to 23	
Modified Plasticity Index (%)	15 to 23	Shrinkable soil of LOW to MEDIUM Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	0 to 1	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	39 to 63	Represents fines (silt/clay) fraction

The 'N' values derived from standard penetration testing (SPT) ranged from 16 to 23, increasing with depth. Conversion of these SPT N-values, using the Stroud method and a factor, f_1 , of 5.5, indicates a high undrained shear strength, increasing with depth.

CALIFORNIA BEARING RATIO (CBR) TESTS

In-situ testing was undertaken using a TRL DCP probe at two locations across the site to obtain equivalent CBR with depth profiles to a maximum of 1m depth.

Results are summarised in the following table and provided in full in Appendix B. Test locations are shown on the Exploratory Hole Location Plans in Appendix A.

The results of the testing ranged as follows:

Likely Stratum	Depth (m)	CBR (%)
Made Ground	0.1 to 0.9	8.2 to >40%
Bagshot Formation	0.4 to 0.9	2.6 to 10.6

SULPHATE AND PH TESTS

Water-soluble sulphate and pH testing were carried out on 21 soil samples recovered from the exploratory holes across the site. These recorded values as shown in the table below:

Stratum	Samples	Range	
		Water-soluble Sulphate (g/l)	pH
Made Ground	12	0.02 to 0.86	6.3 to 12.3
Bagshot Formation	8	0.06 to 0.21	6.3 to 8.1
Claygate Member	1	0.23	7.2

GROUNDWATER

Groundwater was encountered at various depths during the intrusive works, as summarised below.

Borehole	Type	Depth (m bgl)	Resting level (m bgl)	Source Stratum
BH1	Strike	9.0	8.0	Bagshot Formation
BH2	Strike	12.5	10.5	Claygate Member
TPC	Seepage	2.8	-	Claygate Member

Long term monitoring carried out as part of the project has revealed standing groundwater levels within the natural deposits of between 8.60m and 8.61m bgl (118.04m and 118.03m above Ordnance Datum; m AOD) in BH1 in the Garner Quad in the north of the site. It is not possible to infer hydraulic gradient or groundwater flow direction due to limited spatial data.

OBSERVED SOIL CONTAMINATION

Evidence of contamination during the intrusive works was observed as ash in the Made Ground at BH2 and clinker in Made Ground at TP5.

INFILTRATION TESTING

Infiltration testing was carried out at four locations within the Parade Ground at Dyne House in the east of the school campus, in accordance with BRE Digest 365, 'Soakaway Design'.

Infiltration at TP A and TP B was negligible over the timescale available and as such it was not possible to calculate infiltration rates for these locations. TP C collapsed in during testing and as such the infiltration rate

has been extrapolated to provide an indicative value. It should be noted that this procedure is not in accordance with BRE 365 and caution should be exercised when using extrapolated values for design purposes.

Results are summarised in the following table and presented in full in Appendix B.

Location	Test depth (m bgl)	Test strata	Soil Infiltration Rate (m/s)		
			Test 1	Test 2	Test 3
TP A	1.9 to 2.8	Made Ground Claygate Member	Negligible*	-	-
TP B	1.1 to 2.2	Bagshot Formation	Negligible*	-	-
TP C	2.1 to 2.9	Made Ground Claygate Member	2.0×10^{-6} #	-	-
TP D	2.3 to 3.4	Made Ground	1.5×10^{-4}	1.1×10^{-4}	9.3×10^{-5}

* = Rate not determinable due to insufficient infiltration during test timescale.

= Rate extrapolated. Use with caution.

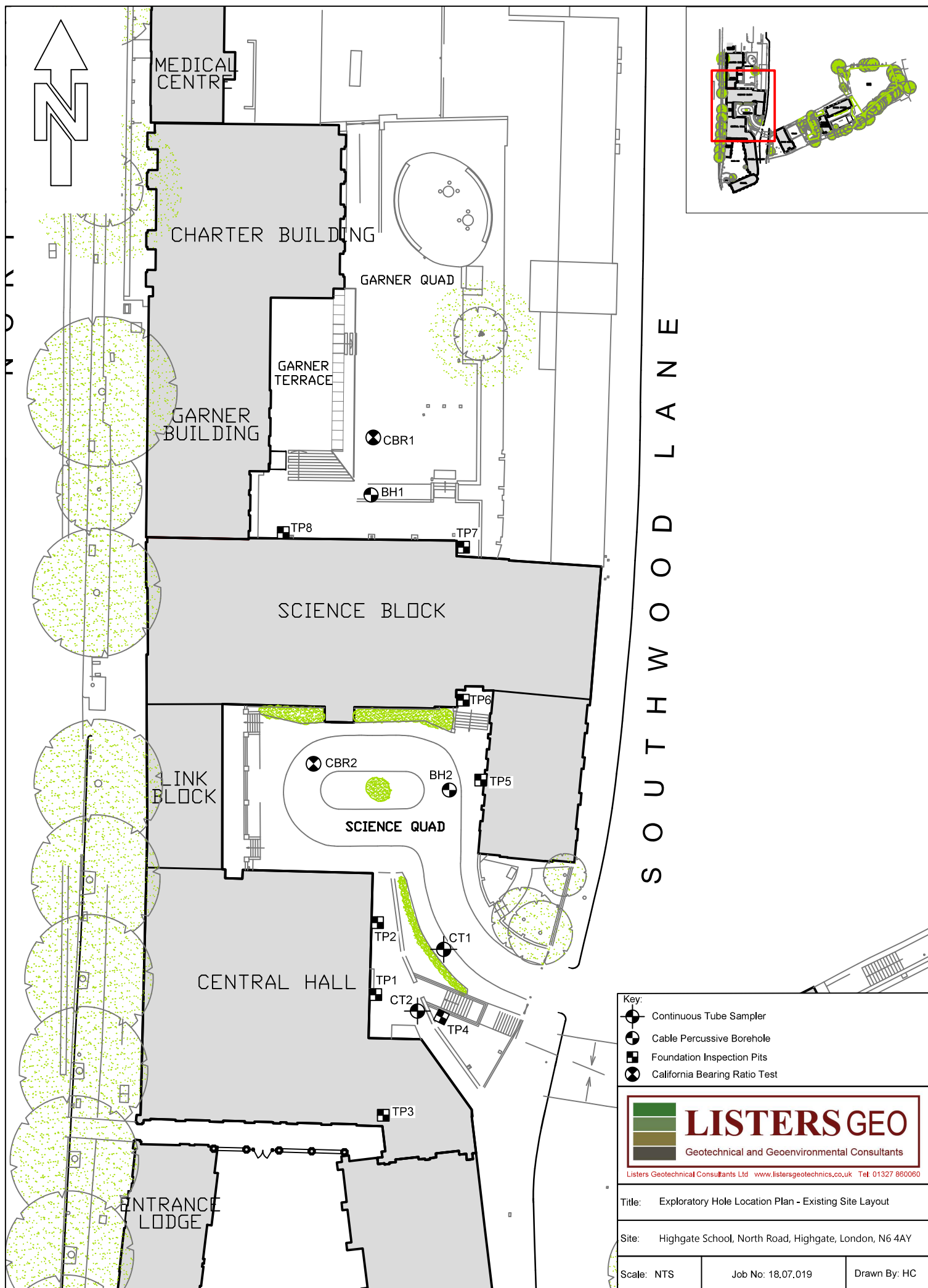
EXISTING FOUNDATIONS

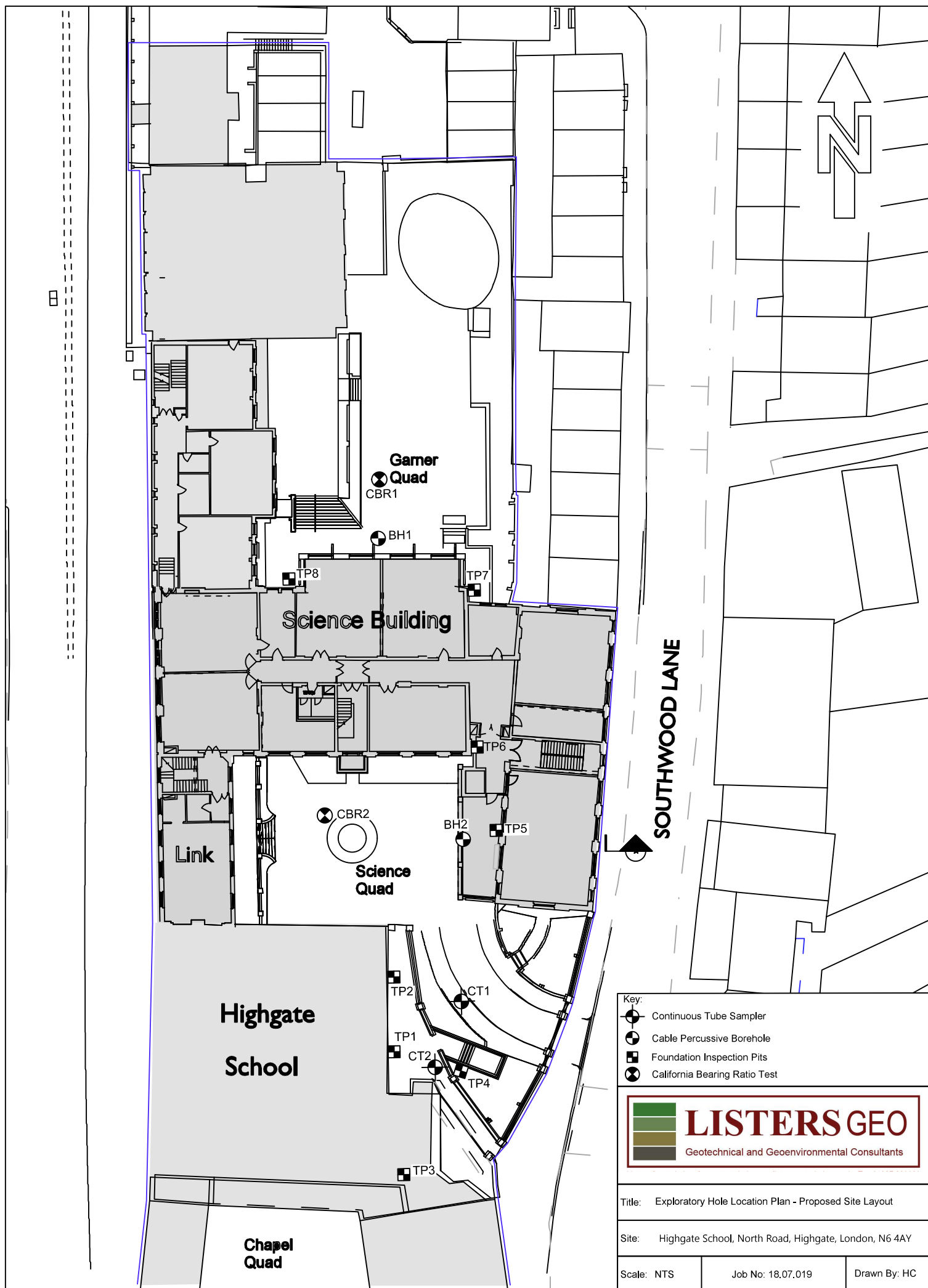
Existing foundations of the were revealed in hand-excavated trial pits, TP1 to TP8, in locations selected by the client's structural engineer. The findings are summarised in the following table.

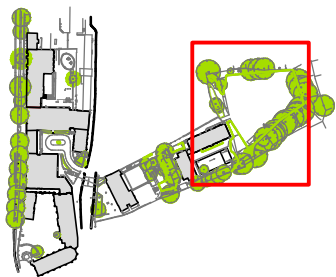
Trial Pit	Foundation Depth (m bgl)	Description	Maximum Projection (mm)	Founding Stratum
TP1	0.75	Brick and concrete	400	Bagshot Formation
TP2*	>0.59*	Brick and concrete*	>410*	Unknown*
TP3	0.40	Concrete	150	Bagshot Formation
TP4	0.40	Concrete	700	Bagshot Formation
TP5*	>1.50*	Brick*	>0*	Unknown*
TP6	1.15	Brick	100	Bagshot Formation
TP7*	>1.24*	Brick*	>240*	Unknown*
TP8*	>0.70*	Brick*	>50*	Unknown*

* Pit terminated before reaching foundation base.

Diagrammatical profiles of the existing foundations are provided in Appendix B.







Key:

■ Trial Pits



Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Exploratory Hole Location Plan - Existing Site Layout

Site: Highgate School, North Road, Highgate, London, N6 4AY

Scale: NTS

Job No: 18.07.019a

Drawn By: HC

Appendix H2

Thames Water Asset Location Map

Asset Location Search Sewer Map - ALS/ALS Standard/2015 2989764



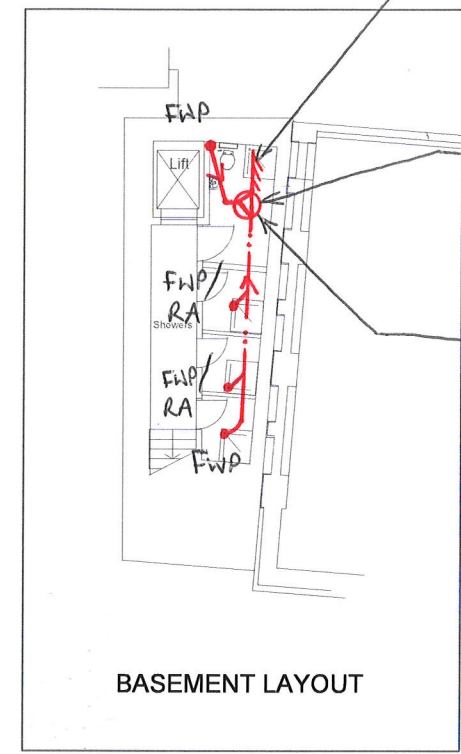
The width of the displayed area is 500 m and the centre of the map is located at OS coordinates 528436,187538
The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

Based on the Ordnance Survey Map with the Sanction of the controller of H.M. Stationery Office, License no. 100019345 Crown Copyright Reserved.

Appendix H3

Preliminary Below Ground Drainage Drawing

CAVITY DRAINAGE & PUMP
SPECIFICATION/SIZE BY
SPECIALIST.



RIISING MAIN TO
HIGH-LEVEL BY
M&E ENGINEER

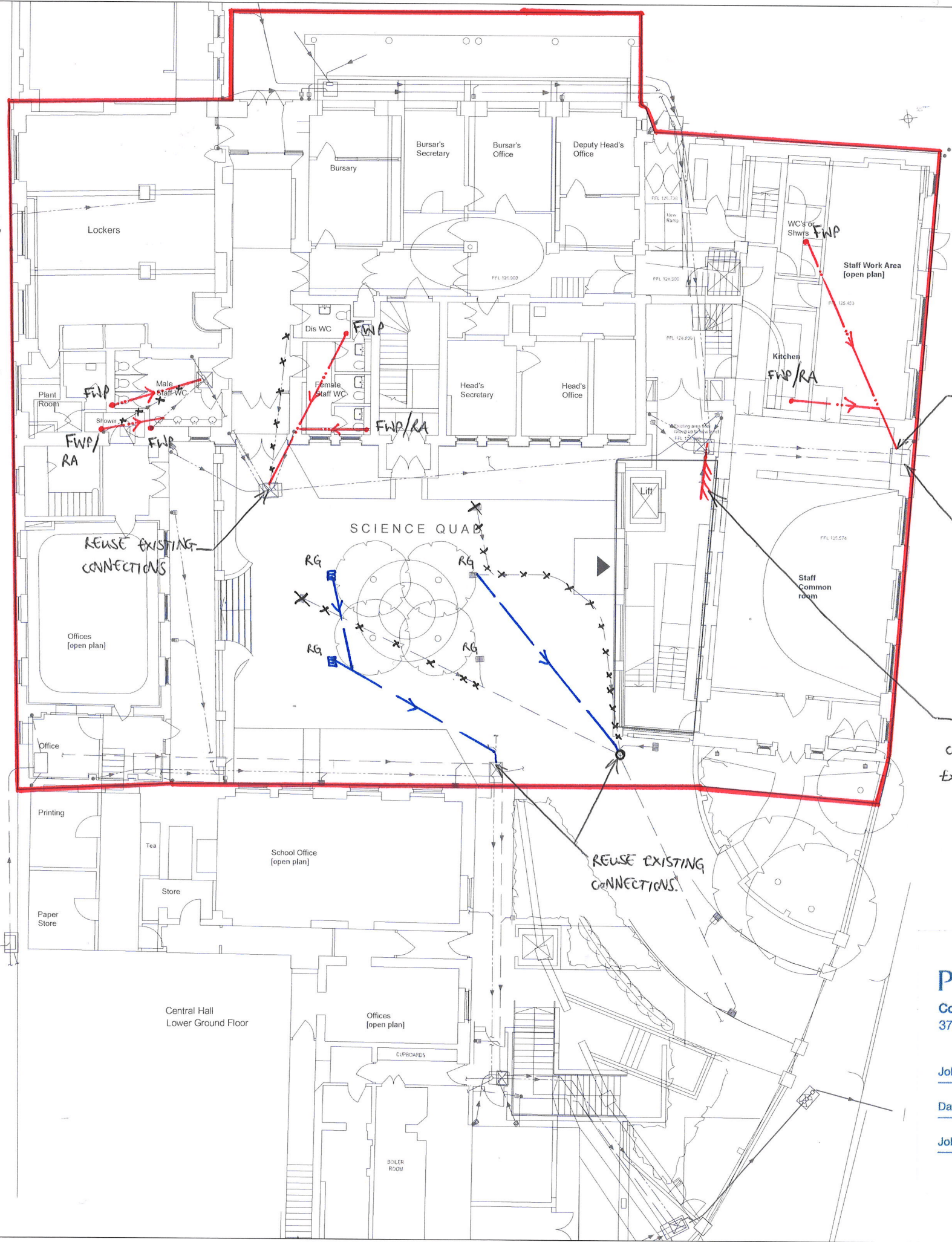
VENT & DUCT WORK
TO HIGH-LEVEL BY
M&E ENGINEER

RC BOX WITH
WORKING SPACE FOR
FOUL WATER PUMP
& CAVITY DRAIN
PUMP (SEPERATE
PUMPS REQUIRED).

NORTH ROAD

- KEY:
- SITE BOUNDARY
 - NEW FOUL WATER DRAIN
 - NEW SURFACE WATER DRAIN
 - ||||| RISING MAIN
 - x x x x DEMOLISH/ABANDON
 - FWP/RA FOUL WASTE PIPE/ ABOVE GROUND ROADABLE ACCESS
 - RG ROAD GULLY
 - ⊙ FOUL WATER PUMPING STATION.

CONDITION OF ALL EXISTING DRAINAGE TO BE
CONFIRMED. REMEDIAL WORKS OR REPLACEMENT
AS REQUIRED.



TH WOOD LANE

MANHOLE REBENCHED
TO SUIT ADDITIONAL
CONNECTIONS.

MANHOLE
INVERT LEVEL
TO BE
CONFIRMED.

RIISING MAIN
CONNECTION TO
EXISTING MANHOLE

REUSE EXISTING
CONNECTIONS.

- Notes :
1. This drawing is to be read in conjunction with all relevant Architect's, Engineer's and specialists' drawings and specifications.
 2. Do not scale from this drawing in either paper or digital form. Use written dimensions only. To check that this drawing has been printed to the intended scale this bar should be 50mm long @ A1 or 25mm long @ A3.
 3. Health & Safety :
All specific drawing notes are to be read in conjunction with the project "Information Pack" and "Site Rules".

SCALE 1:100 AT A1
1:200 AT A3.

1	20.03.19	AH	SRe	Issued for Information
Ver	Date	Drawn	Eng	Amendment

HIGHGATE SCHOOL,
NORTH ROAD

PRICE & MYERS

Consulting Engineers
37 Alfred Place London WC1E 7DP 020 7631 5128

Job No 26574 Page SK-CIV-01 Ver 1

Date 18/03/19 Eng SRe Chd

Job HIGHGATE SCHOOL - PRELIMINARY BELOW
GROUND DRAINAGE LAYOUT

PRICE & MYERS * * *
Consulting Engineers
37 Alfred Place London WC1E 7DP
T 020 7631 5128 F 020 7462 1390
E mail@pricemyers.com www.pricemyers.com

Appendix C

Blue Sky Thinking Construction Review Report

Highgate School

INITIAL CONSTRUCTION REVIEW FOR SCIENCE BUILDING PROJECT

Rev A August 2018



CONTENTS

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1.0 Executive Summary

Blue Sky Building was appointed to carry out a review of the construction programme and logistics for the Extension and Refurbishment of the Science Block, on behalf of Highgate School.

This report considers the programme and logistics impact of the project. Once finalised these proposals will form the basis of a Construction Management Plan to be prepared by Blue Sky Building for inclusion in the Planning Application Submission.

The Science Block project involves the refurbishment of the existing laboratories and associated spaces, including the Link Building to the West side of the Science Quad, together with two extensions. An extension of the first and second floors into the Garner Quad to the North side of the block will allow better special use for laboratories. An extension of basement, ground, 1st and 2nd floors into the Science Quad to the south side improves entrance and circulation space, including a new lift shaft.

Improvements have been made to some elevations in recent years but not all, and the works include window replacements where required and external cleaning. Internally the majority of mechanical and electrical services will be replaced, along with building finishes.

The block will be vacated for the duration of the works to temporary classrooms in a separate location. This report does not include the temporary space.

Programme Summary

Our Outline Construction Programme (section 4.2) forecast dates are based on what we would consider a realistic delivery programme against which Highgate School might consider to add contingency in overall development planning terms, and set shorter targets when procuring the works.

As requested we have considered potential improvements by working through the critical activities and targeting earlier or shortened periods and these are shown in section 2.2 and in a Target construction programme in section 4.2. That programme shows a potential shortening of the programme of 8 weeks.

Our programme is around a month longer than the programme issued by Highgate School. Whilst it remains possible that works could be condensed to meet the one year target for decant it would be a risky strategy to follow without allowing for a contingency for not being able to move back in.

A key point will be discovery and evaluation of unknowns as they arise. Refurbishment and structural adaption of buildings carries risks of additional or prolonged works due to unexpected finds. Building structures and services should be thoroughly explored and surveyed to the fullest possible extent that can be accommodated in the live environment before conclusion of designs.

Programme Periods

Our programme periods are based on the intricate nature of the works and the limited space for materials movements and plant. There will be works that can be approached with more vigour during periods of school closure and the final programme should take benefit of those occasions as far as possible. Care should be taken however to rely too heavily on holidays, as long delays can accrue if time slots are missed.

General Deliveries

Construction access to the Science Quad from Southwood Lane is reasonable for the scale of works involved, although reversing of vehicles in or out of the gate is inevitable. Temporary removal of one of the gate piers would be useful and we understand there is precedence for this.

Access via the rear gate to Garners Quad is to be avoided, except for occasional plant deliveries. We propose that a first floor level gantry is proposed in the CMP, serving the Southwood Lane elevation. Adoption of it might be subject to Contractor's choice in the future, but showing it in the CMP could at least provide an option. The old doors onto Southwood Lane could also be used for kerbside deliveries, subject to Haringey's views on use of the pavement.

Cranage & Plant Selection

Construction of the new extensions will call for careful management and plant selection. We have offered suggestions of cranes and plant in the programme commentary but it will be essential that contractors are fully aware of the constraints at tender stage and are able to ensure that final designs are matched to methodology.

2.1 Risks & Mitigation

KEY RISKS / ISSUES	MITIGATION
Substructure	
Front extension foundation design (piles) and rig access to the site	Piling specialist input at an early stage to ensure the design is matched to a rig size and methodology that works with the limited access
Excavation plant and accessibility for excavation of rear extension	Consider methodology with design. Could be manually excavated, or min excavator from rear gate or through the existing building.
Below ground services diversions delay substructure construction	Early identification of works required with intrusive surveys undertaken as necessary.
Superstructure	
Structural interventions to the existing building (stairs, riser and plant support) could extend the programme or overload the structure	Early consideration of composite dead loadings and live construction loading & timescale.
Steel frame to Garner Quad extension currently programmed without craneage. Supply chain appreciation needed or risk of extended programme	Ensure clarity of site constraints in tender documents. Spider crane from rear gate could be substituted for our proposed method
Temporary works loadings may not work for existing structure.	Establish loading constraints with Engineer prior to tender returns. Ensure tenderers have a workable solution in their returns.
General	
Full consideration of on-site, school and public health and safety at all stages of planning and execution.	Detailed risk analysis of site operations.
A strategy to minimise disruption to the school, local environment and adjoining properties/owners.	Positive approach to neighbours – newsletters/site talks.
A methodology to secure the highest quality.	Samples/mock-ups prepared in advance and signed off.
Full consideration of both site and public health and safety at all stages of planning and execution	Detailed risk analysis of site operations
A realistic preconstruction period which provides the best input to the Client and Design Team	Ensure strategic programme and procurement route allows sufficient time to coordinate all aspects of the project
Provide above industry average facilities for the workforce	Make the site attractive to the workforce. Attract best tradesmen
Safe segregation of M&E services between site and occupied school areas	Early surveys and identification of services. Safe system of work throughout stripping out and construction phases.

KEY RISKS / ISSUES	MITIGATION
Logistics / LBH & Neighbours	
Demolition impact for noise and general disruption.	Ensure environmental monitoring is in place and a robust demolition plan is agreed with LBH and neighbours.
Delayed availability of Temporary Accommodation delays vacant possession of main works	Early alignment of VP schedule for main works with the procurement and erection of temporary classrooms. Contingency plan for late vacation.
Hours of Work conflict between LBH, neighbours and school.	Beware conflicting desires for noisy work times. Ensure pre-agreement before finalising programme.
Scaffold access over Alms house not agreed	Consider alternative access strategies and potential reduction in scope of work as a contingency plan.
Welfare location unavailable	Make a contingency plan for the project that meets programme strategy and dates
Oversailing agreements restrict mobile crane operations	Review crane positions and make early approaches to neighbours if required
School Access impacted by construction	Early agreement of delivery strategy with school and regular review with contractors
Continuity of Building Services to school and neighbouring property.	Ensure before services are terminated that all systems I are truly separated and will continue to function.
School decant programme clashes with contractors initial set up in the Science Quad	Agree vehicle slots for school use separately to contractor. Agree phased parameters of closing in hoardings with due attention to CDM requirements.

2.2 Target Programme Considerations

As requested by Highgate School we have reviewed our initial findings in order to explore potential programme savings to ensure completion of works in time for the start of Autumn term 2020.

Critical Activities

Whilst our programme is outline, limited by the current level of design the critical path can be identified as being:

- Site set up
- Preparation (stripping out and opening up unknowns)
- Structural interventions including forming risers and service routes
- Installing new services
- Commissioning and setting to work

The creation of new space in terms of the front and rear extensions is believed to be more predictable and therefore less critical, provided it is managed properly.

Potential Programme Savings

In the following table we have Identified potential improvements to critical activities to target earlier completion and to ensure term start date is met. These are categorised as:

- Discovery – de-risking of the programme by carrying out extensive and intrusive surveys of services and structure ahead of the main works
- Early Works – Things that could be brought forward along with opening up works to ensure that the start of main works is meaningful
- Main works programme periods – shortening of durations, either due to improved knowledge or as targets to achieve, plus potential contingency planning

Target Programme

We have factored the results of the table into a Target Programme which is included in section 4.2 with our first drafted programme.

This indicates a theoretical saving of 8 weeks, by using Easter and half term holidays to “get ahead” with opening up and establishing site, and shortening main works targets accordingly.

Those early works might equally be achieved in part by using evenings and week-ends, combined with the school’s regular maintenance contractors.

CRITICAL PROGRAMME ISSUE		MITIGATION			
ACTIVITY	CURRENT DURATION	SCHOOL ACTIVITY	DISCOVERY	EARLY WORKS or ENABLING PACKAGE	MAIN WORKS PROGRAMME
School Decant Space Needs to work with term and holiday periods. Risk of clash with contractor’s set up with vehicles wanting to use the same space.	6 weeks	Clear non-essential material early to shorten period Plan to use different routes when contractor starts, so contractor has the Science Quad while Removal Company has North Road and Garner Quad perhaps.			
Establish Site	2 weeks			Start works in Easter break, half term or weekends: ➤ Remove Gates & Alter Front Gate Piers ➤ Clear external furniture ➤ Probe hoarding locations and erect some posts ➤ Set up Office/ Welfare space	

ACTIVITY	CURRENT DURATION	SCHOOL ACTIVITY	DISCOVERY	EARLY WORKS or ENABLING PACCKAGE	MAIN WORKS PROGRAMME
Make Safe Services Risky item, until services are traced and identified	2 weeks		Establish early surveys and recording of all services routes out of hours. Open up ceilings and ducts and ensure there is knowledge of what feeds which area.	Use Easter Break, half term or weekends for: ➤ Intrusive surveys ➤ Identify, record and label services ➤ Remove redundant services where possible ➤ Make good fire protection to allow school use to continue	
Protect Live Services This programme item assumes that there will be live services remaining in place through the building site in order to feed live areas of school. Ideally they would be terminated or diverted, but where that is not practicable they work be securely encased and remain in position (subject to a risk assessment).	2 weeks		Early services surveys should identify which pipes and cables might need to continue to supply live areas. Subsequently a plan to divert or encase would be drawn up.	Use Easter Break, half term or weekends to: ➤ Identify services as above ➤ Install diversions if time permits ➤ Install physical enclosures and signage if time permits ➤ Complete a design of what needs to be implemented early in the main works programme	Benefits from clearer understanding of requirements at commencement of the works.
Soft strip internally	4 weeks	Early disposal of non-essential equipment and fixtures. Ensure identification and clearance of hazardous waste and chemicals from stores (Discovery of un-labelled bottles once the contractor has started cause disproportionate delays!) Identify any rooms or spaces that could be emptied and stripped a term or half a term early	Early intrusive inspections to fully understand the scope of work including asbestos removal Use empty rooms to explore and improve knowledge of the structure and services	Use Easter Break, half term or weekends to: ➤ Remove fixtures and fittings from redundant labs or rooms.	Benefits from any volume that is removed early and remaining scope is clarified from the learning accrued
Crash deck/ Break Out Floors (New Stair) Early structural interventions will be the key to opening up the building and progressing	2 weeks + 4 weeks				Shorten the period by targeting quicker start and shorter duration based on better knowledge Use the knowledge derived from

through to new structural works uninterrupted.					early opening up to progress the design of new structural elements and take surveys.
New Riser(s) As above, preparing for new services distribution is as important as building the new space (Programme not fully quantified at this stage given that more detailed design is needed to fully understand scope and difficulty)	8 weeks		Use early investigations of structure and services to better understand what's needed in the final design.		Design structural solutions that have flexibility of components, and allow details to be finalised as work progresses.
Services distribution and services second fix (Programme not fully quantified at this stage given that more detailed design is needed to fully understand scope and difficulty)	12 weeks + 12 weeks		Use early investigations of structure and services to better understand what's needed in the final design.		The earlier that services can be sized and their routes identified, the earlier components can be ordered and deliveries committed.
Services commissioning & setting to work The current, outline programme identifies commissioning as the main critical activity to completing the programme but as more detail is added the critical path will encompass all of the fitting out activities to varying degrees. (Programme not fully quantified at this stage given that more detailed design is needed to fully understand scope and difficulty)	12 weeks + 4 weeks	Consider contingency options that might be available should the programme overrun Autumn term start and what the impact might be: ➤ Can school continue to use temporary space for a half or full term? Consider the minimum time needed for decant ➤ Factor in the implications of temporary space – hire cost? Availability for next project? ➤ Would partial occupation be workable at all (if plant and commissioning can be configured to achieve it)	Use early investigations of structure and services to better understand what's needed in the final design.		Set early targets in tender and contract programme as far as possible and monitor progress tightly. Include the need for a commissioning strategy and programme to be prepared early in the construction process Request progress reporting with forward predictions of key milestones of watertight, power on, heat on and commissioning such that contingency plans can be kept under review.

3.0 Programme Assumptions

- Temporary Accommodation set up and ready to meet decant dates
- Beneficial use of permanent lift when hoist is removed.
- Progressive installation of rain water pipes and hoppers.
- New external cladding will comprise stick system curtain wall/ rendered panellised system. Inner skin assumed as Metsec or similar SFS system to allow early progress of fit out with outer skin progressing to non-critical programme.
- Logistics proposals acceptable to LBH for deliveries and crantage.
- Cladding and fit out materials selection can be procured in the time allowed.
- Fire strategy will be achievable to accommodate live school areas.
- Programme allows for removal of normal levels of asbestos expected for buildings of this age and type. Full R&D surveys to establish content and allow formal notices to be served before site start.
- No allowance for removal of contaminated spoil.
- All necessary permissions in respect to party wall agreements will be obtained to allow the programme to proceed as drafted.
- Programme is based on a working week Mon – Fri 08.00 to 18.00, Saturday 08.00 to 13.00.
- Planning & reserved matters can be dealt with within the proposed programme parameters.
- Noisy structural alteration works are allowed to be carried out in line with normal local authority timescales, i.e. minimum of four hours per day.
- Vacant possession of the site means “all of the site” and no access or constraints will need to be considered other than those which are directly associated with the works. This also means that all loose FFE will have been removed.
- Occasional access is available from the Caste Yard gate for plant delivery.
- We have assumed that the extent of service terminations/ isolations/reconnections required within the existing spaces, are restricted to those services affected by the proposed works. We have made no allowances for either the upgrading, uprating or making good which would be associated with such works.
- No allowance in the programme for any “down-time” associated with environmental matters.
- Crane licenses if necessary for the over-sailing of buildings or highways will be granted.
- Procurement route has not been assessed. Start on site dates are as advised by Highgate School.
- Full rights of access assumed from Southwood Lane and Castle Yard (occasional).
- Refurbished building to be served from existing utility supplies or, at worst new connections to mains in the immediate vicinity. No allowance for external diversions.
- Existing sewer and drain connections assumed to be adequate for the new project.
- Highway, footway and Science Quad are capable of taking the temporary vehicle and crane loading.
- All statutory service providers to deliver services to allow the programme to proceed as drafted.
- Piling (front extension) to be undertaken from ground level using a rig that can access the Quad.
- Frame is steel construction with metal deck/ concrete floors
- Roof structure to be metal deck plus traditional roof finishes.
- Stairs to be lightweight steel treads (Stairmaster or similar) with pumped concrete.
- No extensive tank construction or rainwater attenuation measures allowed for.
- No allowance for discovery and removal of munitions.
- No allowance for archaeological investigation.
- Fixed lab furniture included in contractors scope. Loose furniture and FF&E to be by school separately.

4.0 Science Block

4.1 Programme Commentary

4.1.1 Site Context

The Science Building is the central part of the Highgate School “island site”, bounded by North Road and Southwood Lane. Two enclosed quads border the building, Science Quad to the south and Garner to the north side.

The Science Building is central to school activity and, apart from housing classrooms and management offices, is a major thoroughfare for school activity. The proposal is to vacate the live classrooms and functions to temporary accommodation for the duration of the works. An access route is to be kept open for staff and pupils through the ground floor of the building, segregated into a protected route.

Vehicle access is possible into the Science Quad. Vehicle size is limited but it appears suitable for the scale of the envisaged works. One or both of the existing brick gate posts should be temporarily removed for easier access for lorries. Occasional access could be made to the Garner Quad from the rear gate from Castle Yard. The school have expressed a wish that the gate should only be used when essential, and not for general material deliveries.

The Southwood Lane elevation offers potential additional access. That elevation is to receive new windows and cleaning, for which a full scaffold will be needed. We propose that the scaffold incorporates a loading gantry at 1st floor level where vehicles can be offloaded from kerbside. We will propose that in the CMP for Planning although Haringey may want to impose time restrictions on its use. There are also two doorways onto the Southwood Lane pavement (currently sealed and unused). One or both of these could be opened up for smaller, hand carried or trolleyed goods

Adjoining Alms Houses form the boundary of Garner Quad. Works to the north elevation of the Science Building will necessitate a scaffold bridging the neighbour’s property for which oversailing agreement will be required.

The west elevation (North Road) is largely unaffected by the works and offers no usable access. Scaffolding is not needed there.

4.1.2 Logistics and Transport

Given the context of the site and the nature of the proposed works, deliveries to site and methods of materials handling will require detailed planning and consultation with the local authority and TfL, particularly for larger vehicles. Access to the science quad is limited to small vehicles only, and the design of the buildings should progress with due consideration of the limits on space, such that many components can be delivered in small, manageable loads.

Plant and craneage is also a consideration for the piling, basement and superstructure elements, where the design must be matched to methodology and plant sizing.

4.1.3 Site Establishment & Commencement

Project Commencement is targeted to make use of the summer school holidays to prepare the site for the works.

Completion of the temporary classrooms needs to be assured in advance of the break so as not to delay decant and site preparation operations. We assume that the moving of school equipment is outside the construction contract and to be managed by school staff and removal contractors. Vehicles will need to access the Science Quad for loading away of goods and waste, and the period should be carefully programmed to ensure that both removers and incoming contractors have time and space to complete their works.

Incoming contractors will need to ensure that critical works to segregate the construction site from the continued use of school are fully completed in time for the new term. This will include hoardings, services isolations and separation, and the construction of the protected access route. They will also need to establish site welfare and office accommodation, ensure temporary services are in place for the site, and that life safety systems and wayfinding are all in place for the return of the school.

As contractors take possession of the building, the external space or sections of “emptied” area it will be important to record responsibilities and control of individual areas. The Principal Contractors duties under CDM are more onerous than those on maintenance and removal companies and they must be in a position to enforce site rules on their staff and any others entering site space.

We understand that an asbestos register exists and that relatively small levels of asbestos are present in the building. If not completed beforehand a full Refurbishment and Demolition survey should be carried out as soon as the building is vacant, with licenced contractors being appointed for removal, and formal notices submitted in due time to meet the start on site dates.

At commencement the buildings need to be made safe and secure to a standard that meets CDM regulations. Remaining live services in the buildings would be made safe and temporary power and water installations installed. It appears that main incoming gas and electric supplies will remain live within the “site” area. Whilst these are away from the larger structural interventions the live routes must be thoroughly traced and physical protection added if they remain in working areas.

Redundant services must be traced, isolated and identified as safe before temporary works or stripping out get underway. Fire and smoke detection should be adapted for site conditions, and to maintain live school areas.

Hoardings and gates will be erected to the Garner and Science Quads. The protected route through the building should be designed to meet the appropriate fire standards and needs to be fully constructed before the school term starts. Each end of the tunnel should be protected by a scaffold crash deck which would best be constructed in advance of the main scaffolding.

A number of options exist for site accommodation and should be decided upon before tender. Possible locations include:

- Use space inside the buildings being refurbished. Perhaps in the link building. This has the benefit of being cheap and quick to set up but hampers fit out progress and requires one or more moves.
- Cabins in the Science Quad would be possible to meet some of the space requirement but probably not all. The space may be better left for logistics and material storage use which would be more beneficial.
- Space is believed to be available in the Tabernacle building on the opposite side of Southwood Lane. If used then it might be combined with a small cabin in the quad to ensure that site supervision is maintained in the immediate site area.

4.1.4 Early Works and Stripping Out

Hoardings outside the school property would be pre-agreed with the London Borough of Haringey and neighbours and subject to licence application in advance.

Traditional scaffolding will be required to all elevations of the Science Building and Link, except to North Road (no works there) or to the west elevation of Biology (where the front extension is to be built. Scaffolds should not be an urgent item to erect as the early priority will be on segregation and readiness for term start. External scaffold erection should be programmed to follow the initial site set up, in parallel to stripping out starting.

Scaffolds are to serve façade treatments and to provide access and environmental protection for demolition. They should be fully sheeted with Monarflex or similar sheeting which assists with preventing dust and noise escape whilst presenting a more acceptable view of the site to school and neighbours.

A small platform goods hoist will be required and should be erected in the Science Quad together with a Haki stair for operatives' access. We propose that a loading gantry be included in the scaffold to Southwood Lane, with a lifting beam to facilitate direct offloading of lorries, to reduce the extensive use of the quad.

Once the site is established and services isolations in place, the soft-strip can commence. Materials will be moved in bins to skips or lorries located in the Science Quad, or Southwood Lane.

Materials arising from upper floors would be placed into bins at source and then taken down to the quad, utilising the goods hoist, and loaded into a compactor truck or skips.

Once soft-strip is far enough advanced the hard demolition would commence as described in the following sections. Access should be sufficient to allow the use of Brokk robot machines with shear and grapple attachment or alternatively simple manual techniques. Materials would be moved to skips in the Science Quad using bins or loaded to lorries in Southwood Lane.



BROKK ROBOT

4.1.5 Garner Quad Extension

The constraints dictating the choice of plant and methodology are the enclosed site and limited access. Our methodology is based on the smallest plant, or manual alternatives. Once the building is stripped out a route through from the Science Quad to the rear could be made available, reducing the need for plant to access from the rear gate.

The proposed strip foundation for the new extension could be small enough to be excavated entirely by hand. Alternatively the mini excavator shown here retracts to under 1m wide and weighs around 1.5 tonne. It could be delivered through the building with only minor temporary works to accommodate it.



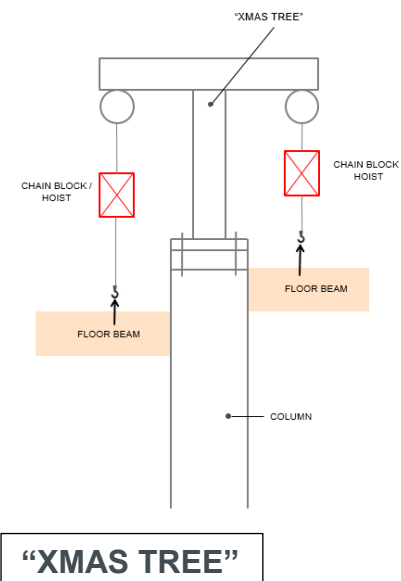
MINI-EXCAVATOR

The foundation and any associated local drain diversions can be constructed while stripping out continues inside and in advance of scaffold erection.

Once the inside is stripped and the foundation in place internal propping and external scaffold can be erected. We envisage that the external scaffold can be adapted to serve as access as well as support for temporary needles, as shown on our sequence diagram overleaf. The contractor should consider bringing in new permanent steel for the wall support *before* the propping is erected – to ensure it can be manoeuvred into place.

Once supported the old façade wall can be demolished in to the building and debris removed in bins to the front quad. New supporting steel is then lifted by block and tackle using the scaffold and temporary works for support.

Other methods of manual erection could be employed including the “Xmas Tree” system where the new permanent columns are adapted to lift the beams into place:



With the new steel placed, packed and load transferred the external scaffold is adapted to be used to pull the new extension steelwork into place. Alternatively the scaffold could be removed and a small spider crane brought in from the rear gate, although that seems an unnecessary expense for the small amount of steel to be erected. The steel itself would be delivered via the front and trolleyed through the ground floor.

Internal propping can be dismantled when no longer needed. Metal deck floors would be constructed top down, dismantling the scaffold as they complete. A new external scaffold would be erected for access to build the façade.

We assume that the façade will be small components erected manually. Ideally the inner skin would be a Metsec or similar Structural Framing System, incorporating the glazing or with temporary weatherproofing such that the fit out can proceed while the external cladding finishes continue.

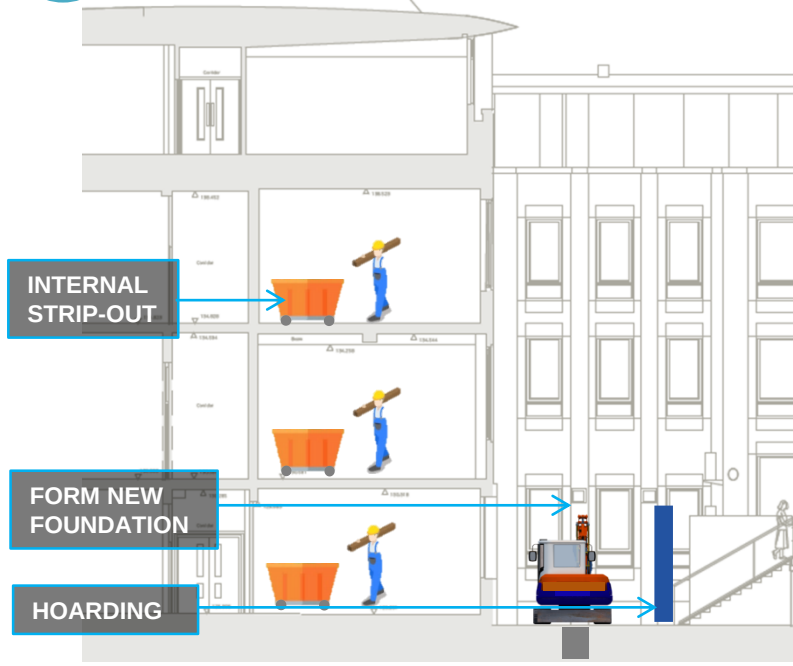
Finally the scaffold is removed and the external works completed by hand or using small machines.

SPIDER CRANE ALTERNATIVE FOR EXTENSION STEEL

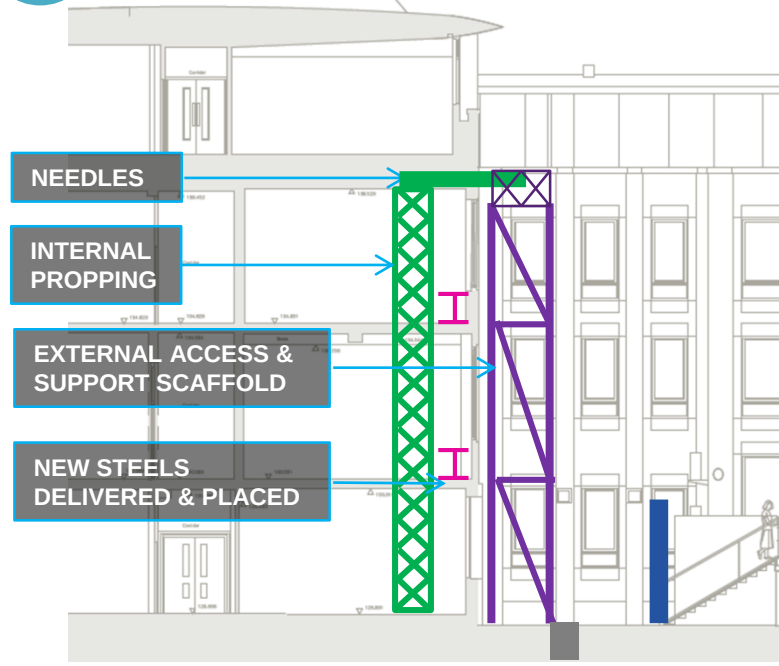


Please refer to drawing BSB-HS-002 – Rear Extension Sequence.

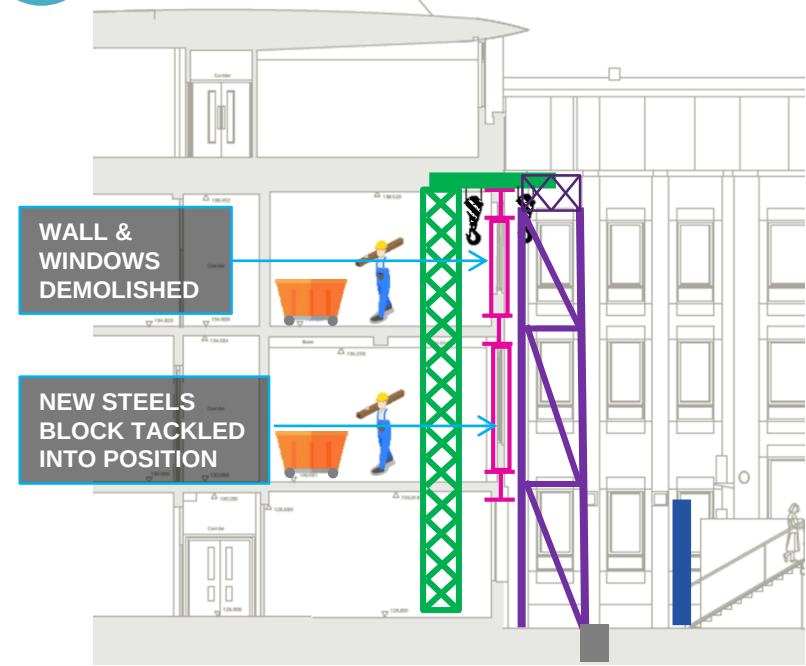
1 Prepare



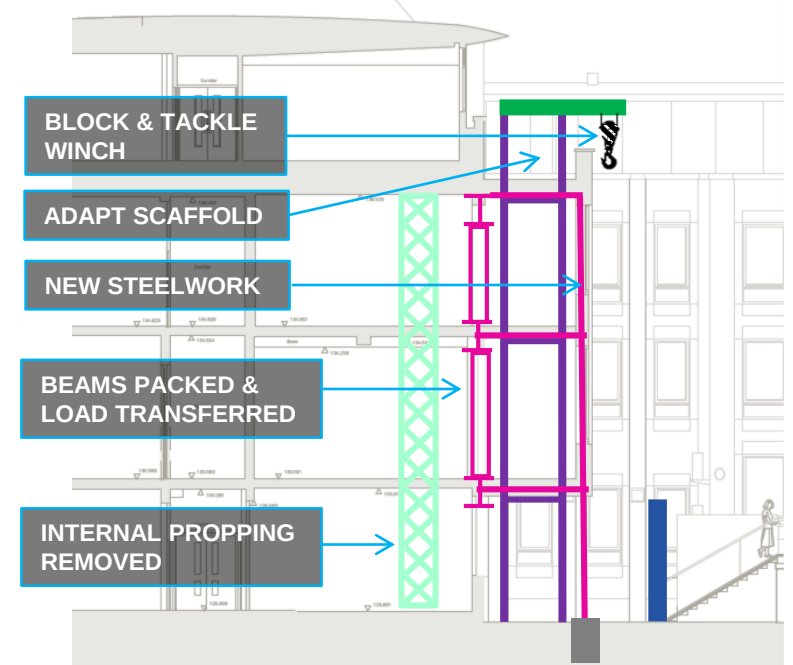
2 Prop



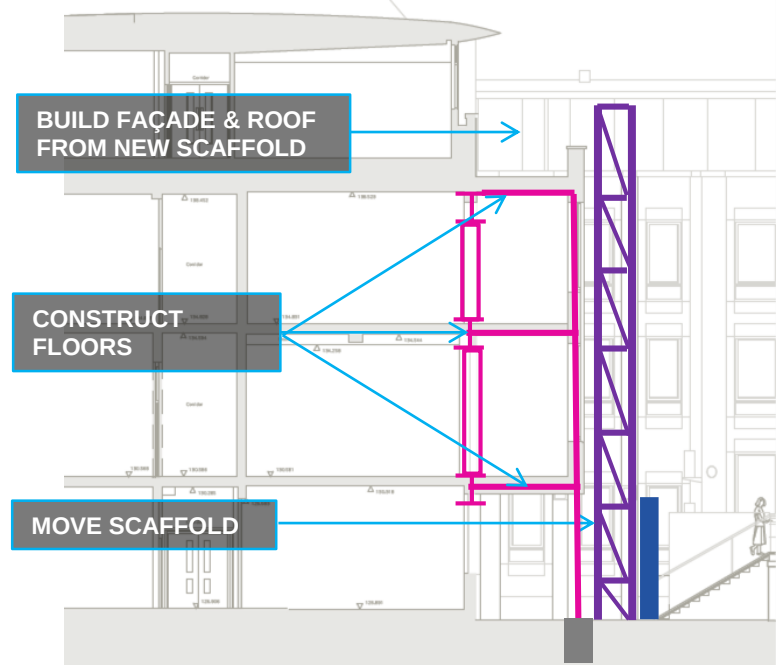
3 Demolish Façade / Install Steel



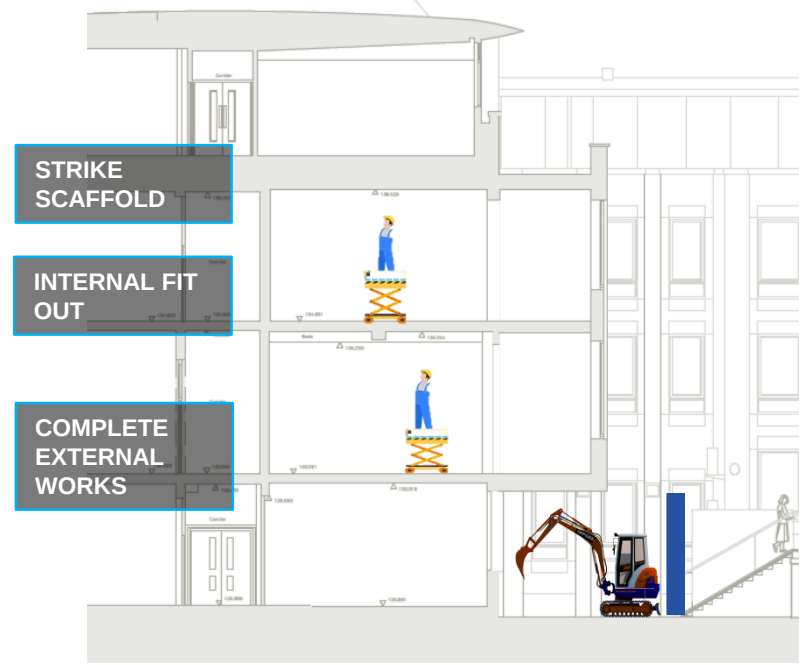
4 New Extension Structure



5 Envelope



6 Fit Out



PROJECT: Highgate School | Science Project
CLIENT: Highgate School Estate
TITLE: Rear Extension Sequence

DRAWING NO.: BSB-HS-002
REVISION NO. & DATE: Rev 0 – 11/07/2018
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4.1.6 Science Quad Extension

The Science Quad extension will be the most critical piece of the construction, as it is the largest element of work and has an effect on overall watertightness and fit out.

Internal strip out should be focused on clearing the areas of the new stair, old stair to be removed and corner wall. An external demolition scaffold should be erected in that corner in parallel to internal strip out. All of the demolition should be undertaken early in the programme to clear the way for new construction.

Underpinning the existing wall will be a slow, manual process and should be commenced as soon as possible. Works to the south end are sufficiently removed from the demolition area to get underway early. Underpinning can't be completed until the demolition completes and the corner scaffold is removed.

Piling would be undertaken from ground level using a small rig that can be driven through the entrance gate, similar to the rig in the photograph here. We estimate that 4-5 piles per day would be achievable. Arisings would be stock piled for removal by skip or lorry. Concrete deliveries would be by ready mix truck to the quad and placed directly.



**CF3 RIG,
2.2M WIDE, 11 TONNES**

Machine selection for basement excavation should be the biggest machine that can be got in. Excavation to underside of raft will proceed when piling and underpinning are clear, with temporary propping as required.



**KOMATSU EXCAVATOR,
2.4M WIDE, 8 TONNES**

We have allowed only a short period for below slab services before the raft is constructed. Large scale diversions of drainage have been suggested as possible and more time should be allowed if this transpires as necessary.

Stair trimming steel and new landings should proceed while the basement is built as the stair is most accessible before the new extension is built. The stairs should be as light as possible since the roof level is remaining in place and lifting will therefore be difficult. We envisage stair sections being delivered via the quad, lifted over the basement and pulled up through the new well from the top level. Alternative access could be possible through the first floor from the loading gantry, in which case the programme criticality between stairs and extension is reduced.

Stairs could otherwise be in-situ concrete. Slow to form but the site doesn't suit the lifting of heavy pre-cast flights.

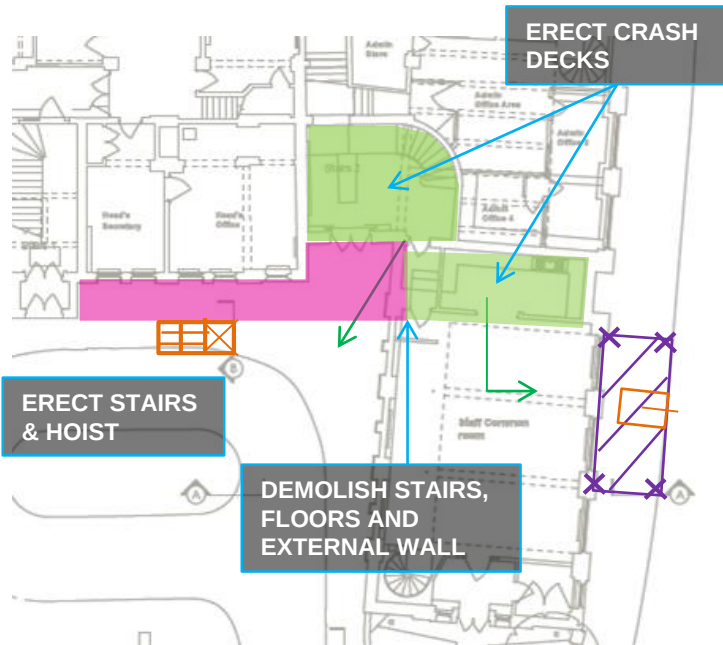
The new steelwork frame should be possible by small mobile crane operating in the front quad. Steel member should be manageable with the emphasis on crane manoeuvrability rather than capacity.

Steel for both extensions should be designed to allow small deliveries on rigid vehicles that can access the quad.

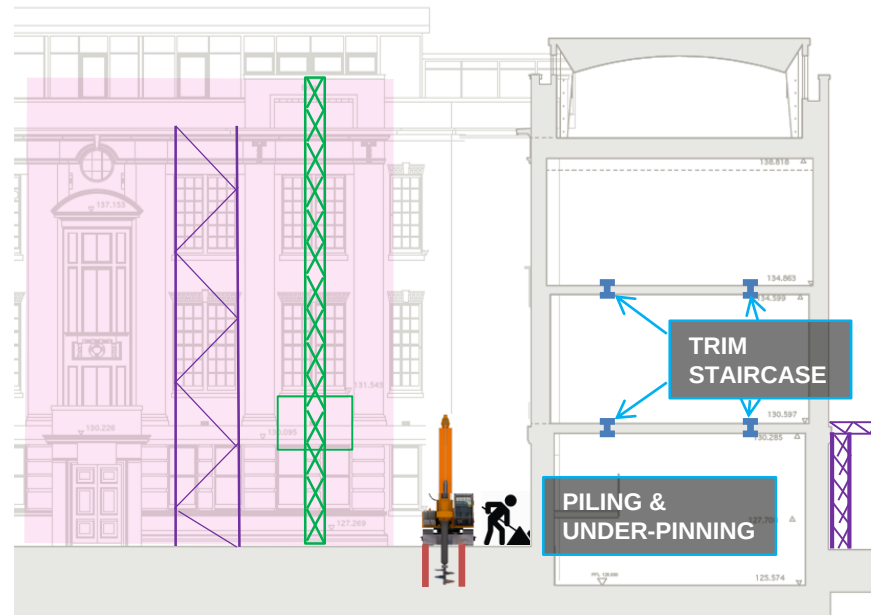
Metal deck should be placed by the mobile crane and concrete floors pumped from the quad. Then an external scaffold will provide access for erection of cladding.

Please refer to drawing BSB-HS-003 – Front Extension Sequence.

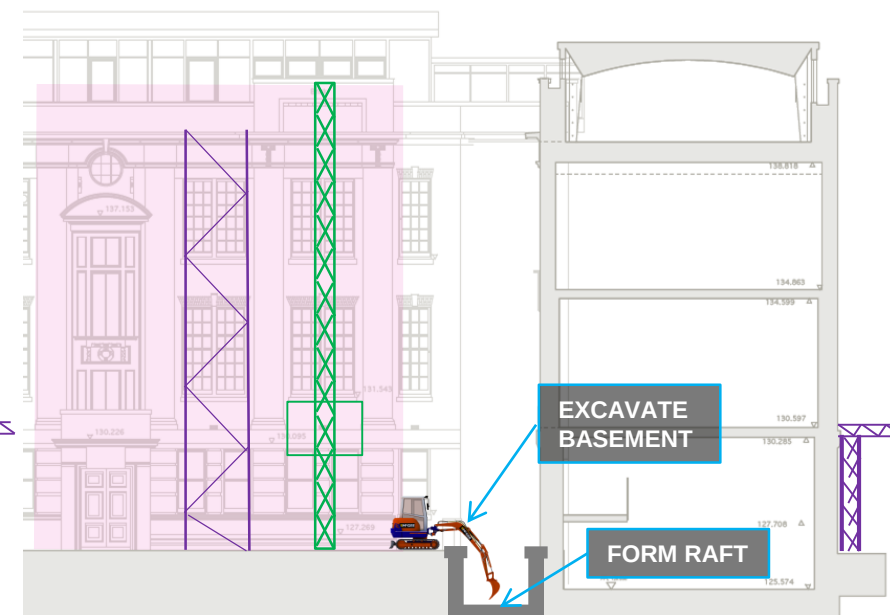
1 Demolition



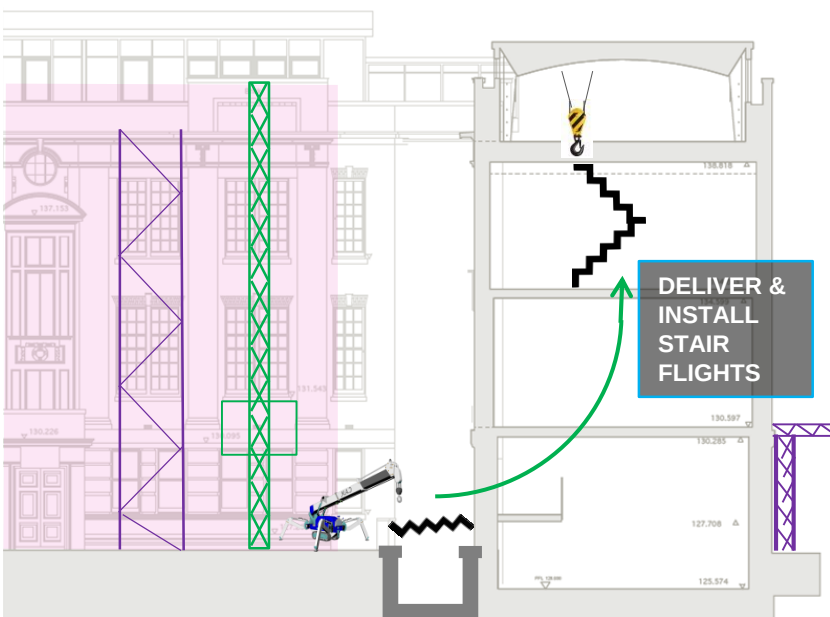
2 Foundations



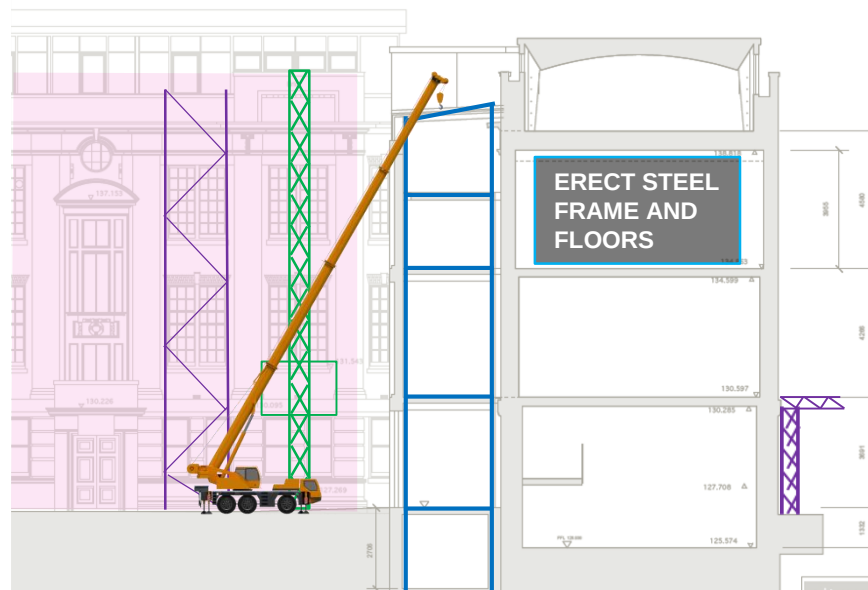
3 Basement



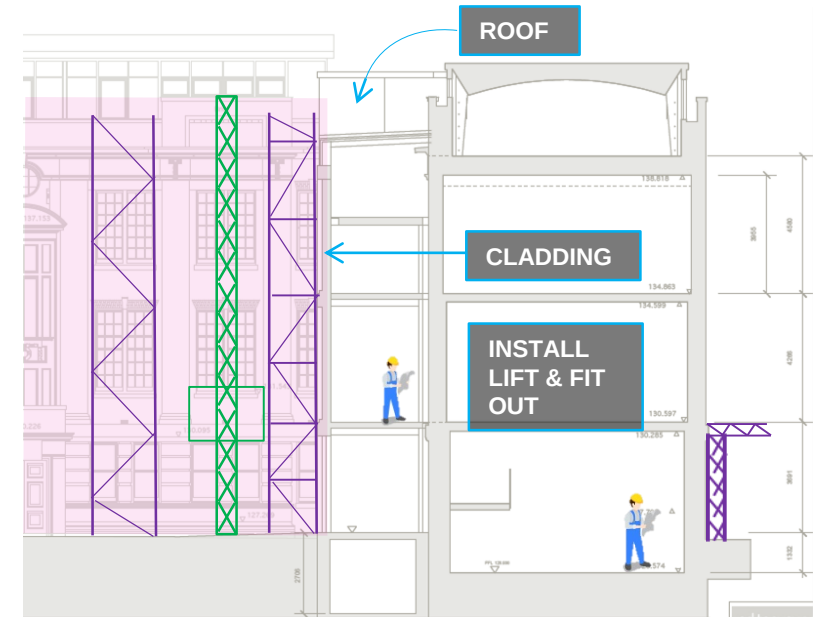
4 New Stairs



5 Frame



6 Envelope & Fit Out



NOT TO SCALE



PROJECT: Highgate School | Science Project
CLIENT: Highgate School Estate
TITLE: Front Extension Sequence

DRAWING NO.: BSB-HS-003
REVISION NO. & DATE: Rev 0 – 11/07/2018

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4.1.7 Existing Building Fabric and Envelope

We have programmed new facades on the basis of the inner skin being SFS that can be erected quickly from the new floors. Existing façade refurbishment is planned to ensure that any window replacements are similarly early such that the whole building achieves watertight in due time for the fit out. Window openings would either be fixed to the SFS or temporarily weathered to allow fitting out to start as soon as possible.

Brickwork would then follow from the external scaffold, using pre-mixed mortar delivered in tubs daily. If the inner skin was traditional blockwork there would be a programme increase, albeit not major, given the scale of work involved to achieve watertight in due time to allow services and fit out to proceed.

4.1.8 M&E Services

We understand that no significant new utility connections are required and that the new facilities are served from the existing incomers.

Key issues for the M&E sequence are to have the risers and main plant in place as soon as possible and to work away from those through the floors. With the extensions predominantly watertight (roof finishes and SFS skin in place) services distribution up the risers would take place.

Lift installation appears straightforward and we have sequenced installation to start early (subject to design and fabrication). Beneficial use of lifts should be allowed once ready to allow earliest removal of the external hoist and infill of the final windows.

4.1.9 Fit Out Works

Internal fit out is assumed to be standard school finishes incorporating hard wearing materials and detailing with the minimum of frills. That is to say, hard ceilings and exposed service spines rather than suspended ceilings for example.

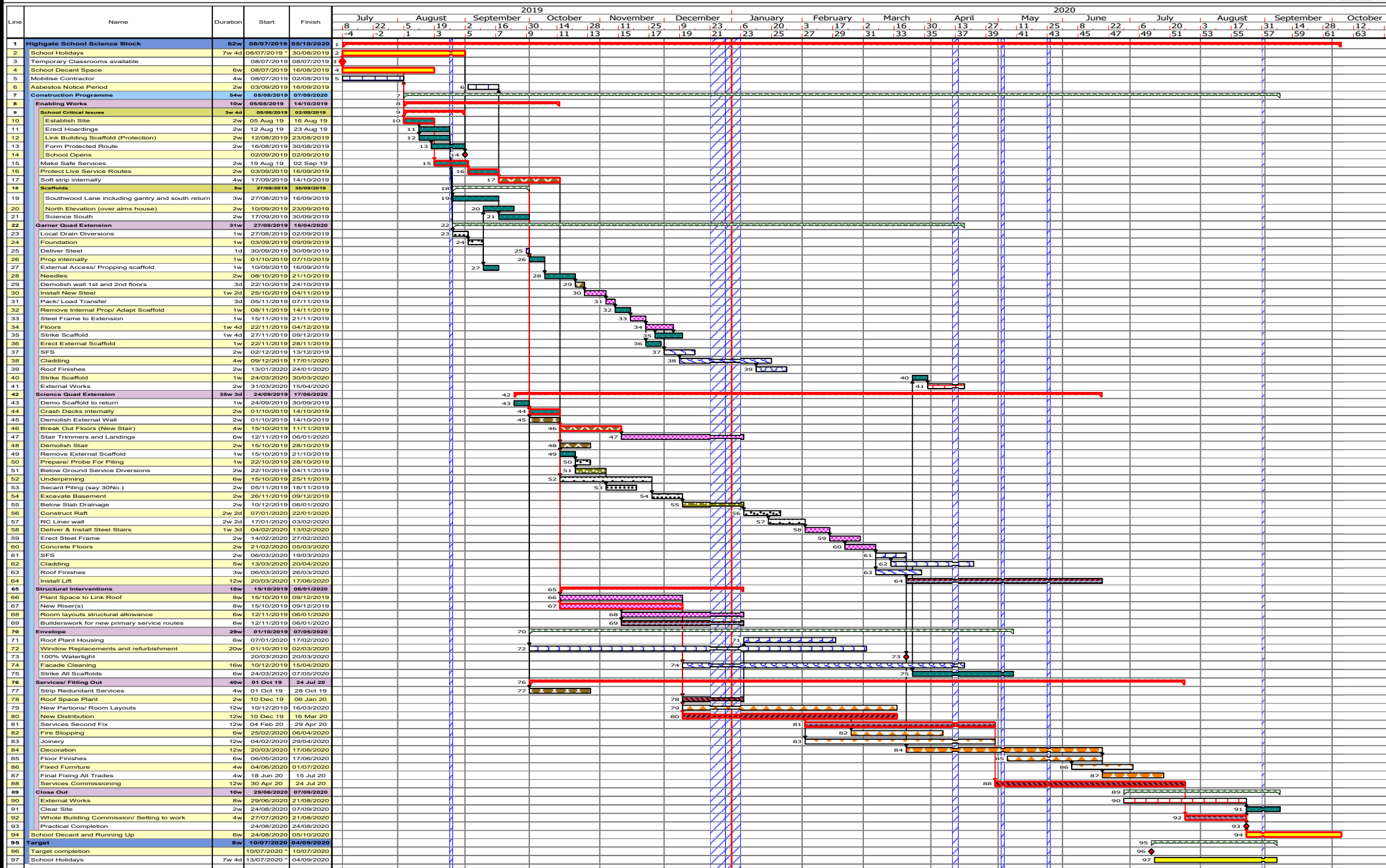
4.1.9 Finals & Handover

We have allowed for a 12 week commissioning period for individual services followed by 4 weeks of whole building testing beyond physical completion of the works to prove and complete the building. This should mean there are minimal if any defects.

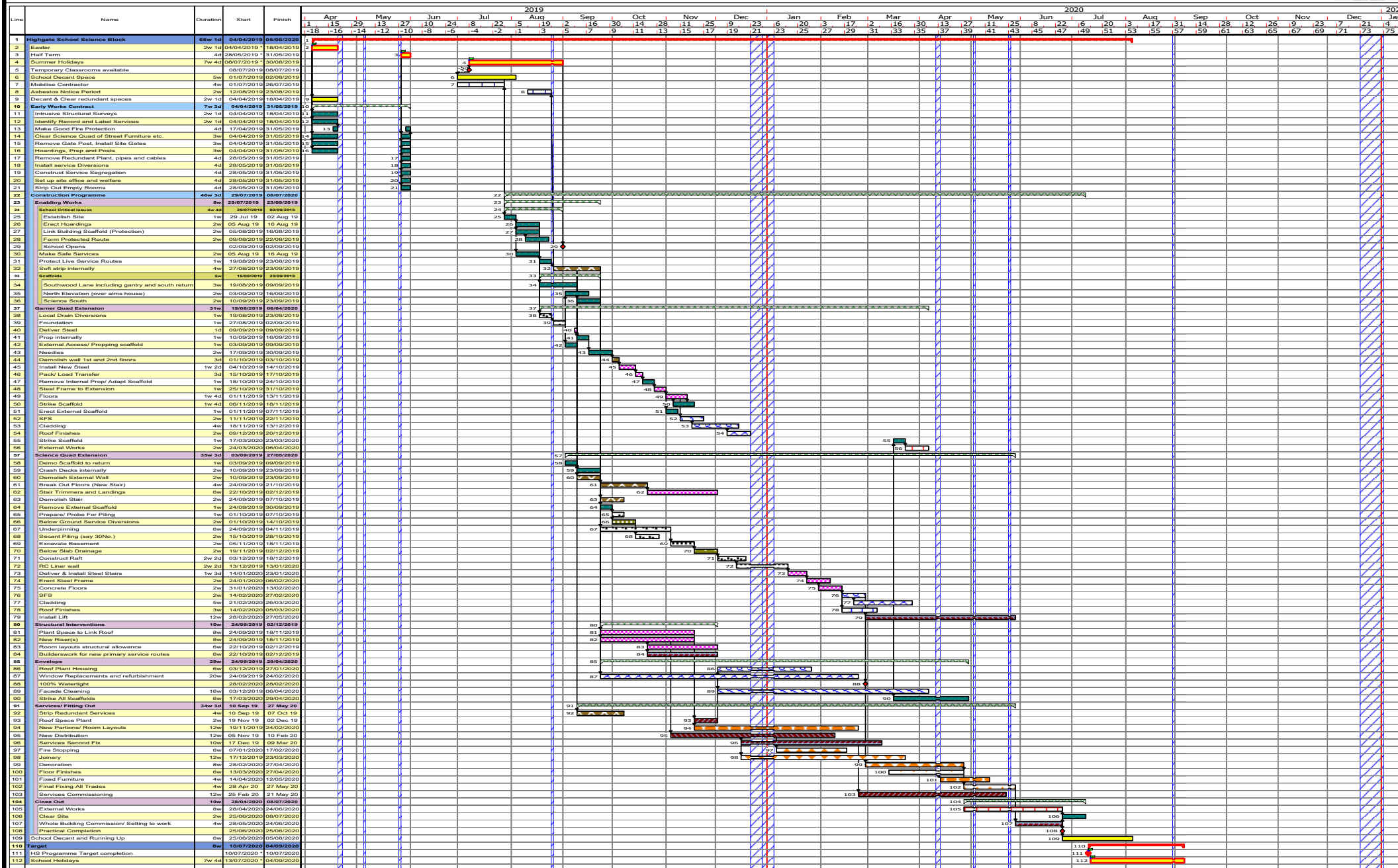
4.2 Programme

Please refer overleaf to the Outline Construction Programme and Target Construction Programme

Highgate School Science Block: Outline Construction Programme

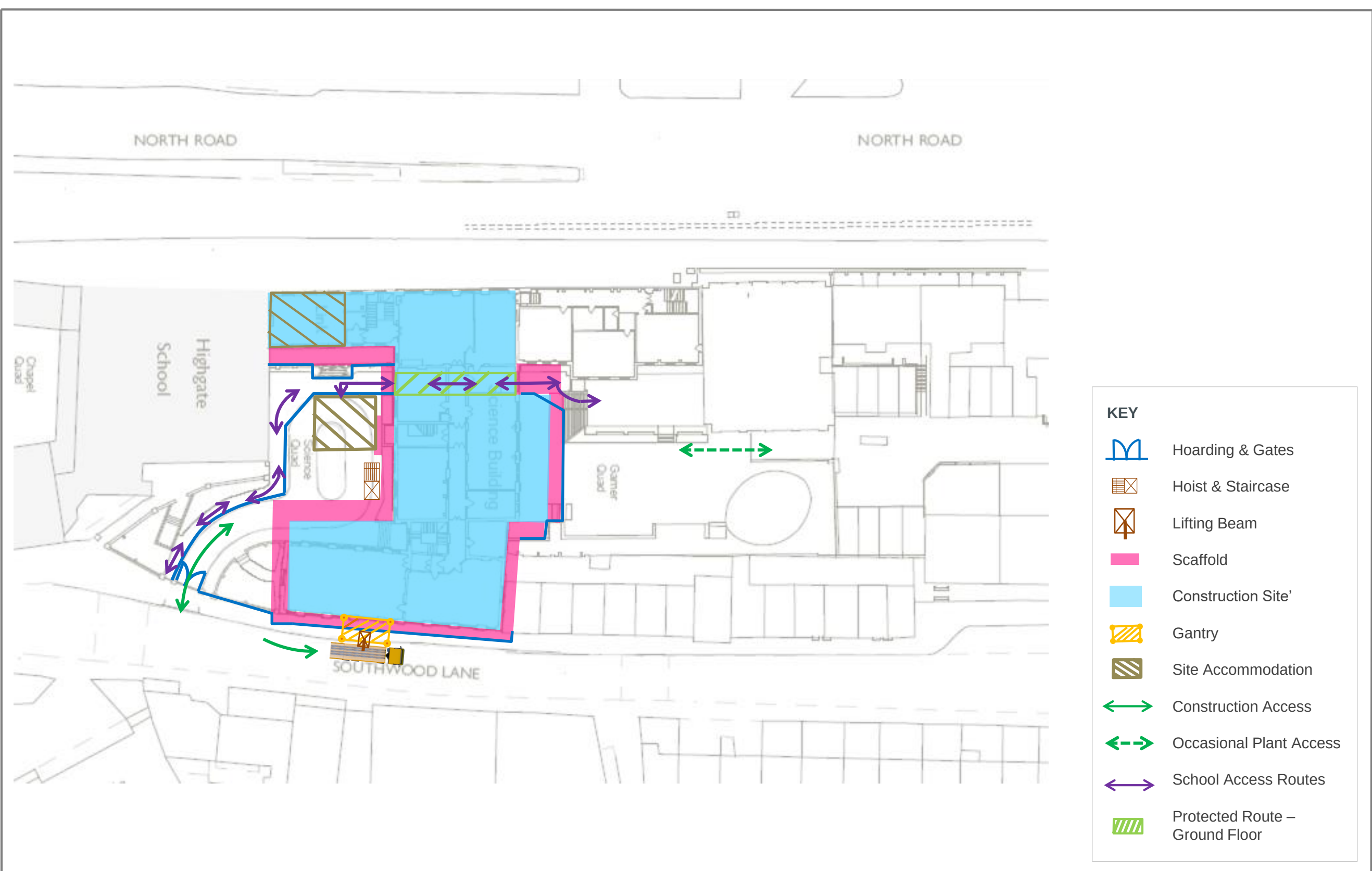


Highgate School Science Block: Target Construction Programme



4.3 Site Logistics Drawing

Please refer overleaf.



KEY

-  Hoarding & Gates
-  Hoist & Staircase
-  Lifting Beam
-  Scaffold
-  Construction Site
-  Gantry
-  Site Accommodation
-  Construction Access
-  Occasional Plant Access
-  School Access Routes
-  Protected Route – Ground Floor

 PROJECT: Highgate School Science Project CLIENT: Highgate School Estate TITLE: Logistics Plan		DRAWING NO.: REVISION NO. & DATE:	BSB-HS-001 Rev 0 – 10/07/2018 Copyright © 2018 Blue Sky Building
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Appendix D

Lister's Geotechnical Site Investigation Report

FINAL

Highgate School

Phase 1 and 2 Ground Investigation

**North Road
Highgate
London
N6 4AY**

**Report No: 18.07.019
November 2018**

DOCUMENT RECORD

Report Title Phase 1 and 2 Ground Investigation Report

Project Address Highgate School, North Road, Highgate, London, N6 4AY

Project Number 18.07.019

Client Highgate School

Prepared By


Signed.....

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Checked By


Signed.....

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BSc (Hons), MSc (Dipl), FGS, CGeol

For and on behalf of ListersGeo, trading name of Listers Geotechnical Consultants Ltd

Issue No	Date	Status
1	13 th November 2018	Draft
2	28 th November 2018	Final

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EXECUTIVE SUMMARY

Project Reference	18.07.019
Site Location	Highgate School, North Road, Highgate, London, N6 4AY
OS Grid Reference	528350, 187560
Development Proposals	Extension to the science block in the west of the school; including construction of a basement, a pillar-supported first and second floor extension, and a lift shaft.
Current Site Usage	The site is currently a secondary school.
Existing Buildings	The school currently comprises predominantly four-storey buildings surrounding two outdoor courtyards; the Garner and Science Quads.
Topography	The general area slopes gently downwards in all directions whilst the site itself is generally flat lying.
Vegetation	Beds of mature shrubs and bushes were present adjacent to the road access to the Science Quad.
Published Geology	The site is shown to be directly underlain by bedrock of the Bagshot Formation over Claygate Member.
Site History	The site has been a secondary school since earliest available historical mapping.
Unexploded Ordnance	Preliminary Risk Assessment indicated the school campus to be at low risk from unexploded ordnance.
Hydrology	The nearest surface water is a cluster of ponds approximately 350m south-east, and an unnamed stream approximately 530m west of the site.
Hydrogeology	The underlying Bagshot Formation is classified as a Secondary A Aquifer and the Claygate member is classified as Unproductive Strata. No groundwater Source Protection Zones or abstractions are located within 1km of the site.
Ground Conditions Encountered	Engineered fill and Made Ground were encountered down to between 0.4m and the base of TP D at 3.4m bgl, overlying Bagshot Formation to between the base of TP B at 2.15m and 11.5m bgl and Claygate Member from between 2.5m and 11.5m proven to a maximum of 15.1m bgl.
Groundwater Encountered	Groundwater was encountered during intrusive works between 8.0m and 12.5m bgl, and during subsequent groundwater monitoring at 8.6m bgl.
Risks to Human Health	No significant risk of significant harm to human health identified.
Risks to Controlled Waters	No significant risk of significant harm to Controlled Waters identified.
Remediation Required	None required.
Geotechnical Hazards	There is low to medium risk from shrink-swell clays.
Foundations	Shallow foundations may be suitable in the three-storey extension into the Garner Quad. Piled foundations are recommended for use in the five-storey extension into the Science Quad.
Floor Slabs	Suspended floor slabs are recommended due to the volume change potential of the Bagshot Formation.
Soil Gases	Radon protection measures may be required due to the inclusion of a basement in the proposed design.
Waste Soil Classification	Site soils have generally been classified as 'non-hazardous' for waste purposes however are locally classified as 'hazardous' due to a high pH. Further classification is required prior to off-site disposal.
Chemical Attack on Buried Concrete	A Design Sulphate class of DS-2 and Aggressive Chemical Environment for Concrete class of AC-2s are considered appropriate.

Roads & Hard Standing Design	A CBR of 4% is recommended for pavement on Made Ground and a CBR of 2% where pavement is founded on Bagshot Formation. Pavement thickness should be a minimum of 450mm due to geological frost susceptibility.
Infiltration Measures	At Dyne House Parade Ground in the east of the school, permeability ranges from negligible to poor (9.3×10^{-5} m/s).
Recommendations	Existing foundations within influence of the basement excavation may require supporting by underpinning. Long-term groundwater monitoring is recommended. A detailed ground movement analysis may be required. Where Made Ground deeper than 0.6m bgl is encountered beneath the area of proposed pavement soil reinforcement may be necessary. Should a soakaway drainage solution be pursued at the site, supplementary infiltration tests in machine-excavated trial pits should be undertaken at proposed soakaway locations in order to inform their design.

This executive summary should be read in conjunction with the main report.

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- HazWasteOnline Report

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- Envirocheck Datasheet
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- Site Sensitivity, Borehole and Estimated Soil Chemistry Maps
- Historical Ordnance Survey and National Grid Maps

INTRODUCTION

A Phase 1 and Phase 2 Ground Investigation has been undertaken for proposed extensions to Highgate School, North Road, Highgate, London, N6 4AY. A Site Location Plan is provided in Appendix A. The Ordnance Survey National Grid reference for the approximate centre of the site is 528350, 187560.

Instructions to undertake the investigation in the west of the site (Science Block and Island) were received from the client in their email dated 23rd July 2018. Additional instruction to undertake supplementary work in the east of the site (Dyne House Parade Ground) was received 15th August 2018.

This report describes the desk study and intrusive site investigation activities carried out by ListersGeo in order to provide an evaluation of the ground conditions and the extent of any soil contamination present on the site. The report presents initial human health and groundwater risk assessments based on both the findings of the desk study information and subsequent contamination laboratory testing. The report also discusses the geotechnical implications with regard to the proposed development based on the findings of the fieldwork and subsequent laboratory testing.

It is understood that the eastern part of the school, known as Dyne House, has been subject to a previous site investigation by Geotechnical & Geoenvironmental Associates Ltd but this has not been reviewed as part of this investigation. Information contained therein has not be considered within this report to aid recommendations and as such this current report should be considered separate to the previous report.

This report has been prepared for the sole use of the client and their professional advisors. This report shall not be relied upon by third parties without the express written authority of ListersGeo. If an unauthorised third party comes into possession of this report, they must not rely on it and the authors owe them no duty of care and skill.

SCOPE OF THE INVESTIGATION

The scope of the investigation, as initially requested by Price & Myers, the client's structural engineers, was to undertake a desk study and walkover survey and provide an assessment of the geotechnical engineering properties of the ground and the extent of any soil contamination on the site with respect to the proposed extension to the science block in the west of the site.

The investigation includes a contaminated land risk assessment based on the EA's Contaminated Land Exposure Assessment (CLEA) and Remedial Targets Methodology (RTM) guidelines as well as providing geotechnical design parameters including those for pavement design.

The scope was subsequently broadened to include additional intrusive investigation to the south of the science block, and preliminary assessment of the feasibility of adopting a soakaway drainage solution at the Parade Ground adjacent to Dyne House in the east of the site. Proposals for these areas were not disclosed and as such information on these areas is reported factually only.

PROPOSALS

It is proposed to extend the science block in the west of the school; including construction of a basement, a pillar-supported first and second floor extension, and a lift shaft. A proposed site layout plan is provided in Appendix A along with more detailed development proposal drawings provided by the client.

If the proposed end use or site layout should alter significantly following issue of this report, then the contents will require re-evaluation.

SITE INFORMATION AND WALKOVER SURVEY

A walkover survey of the site and its immediate surrounds was undertaken on the 13th August 2018. A selection of site photographs is presented in Appendix A along with a plan showing the existing site layout.

The site is situated within Highgate School which lies in a predominantly residential area. The school campus consists of a hollow-wedge-shaped parcel of land bisected by Southwood Lane with access to the west of the campus afforded from the south-west via North Road, west via Southwood Lane, and north via Castle Yard (road), and access to the east of the campus from the east via Southwood Lane and north via Kingsley Place (road). A pedestrian subway under Southwood Lane connects the two halves of the campus.

The section of the school campus to the west of Southwood Lane is roughly rectangular in shape, trends north south, measures approximately 160m by 35m, and covers approximately 0.57 ha in area. The section of campus to the east of Southwood Lane, referred to as Dyne House, is also roughly rectangular in shape, trends north-east south-west, measures approximately 165m by 50m, and covers 0.67 ha in area.

This walkover survey was undertaken prior to instruction on the east of the campus and as such refers only to the site proposed for the extension works, comprising the external areas known as the Science Quad and the Garner Quad in the northern portion of the western part of the school campus, hereafter referred to as “the site”.

The general topography of the area slopes gently downwards in all directions from the site, whilst the site itself is generally flat lying.

The site is bordered by residential properties in all directions with the shops and restaurants of Highgate High Street to the south-east. Additionally, pubs which may contain cellars are located across the road to the west, south-west, and south-east, and properties on Southwood Road are likely to also have basements.

The site itself, as defined above, comprised two external areas of the school campus: the Science Quad in the south and the Garner Quad in the north, separated by a school building.

The Science Quad comprised an oval planted roundabout almost fully enclosed by school buildings, with a road leading to a vehicle entrance in the south-east, on to Southwood Lane. A planted border was present on the northern wall and there were steps to a raised area forming the entrance to the eastern building. Large planted areas were present either side of the road leading to the school exit containing mature shrubs and bushes as well as a pedestrian access to the subway under Southwood Lane on the southern side.

The Garner Quad comprised a paved, recreational area with a raised area of seating along its eastern length and stairs up to a mezzanine roof terrace along the western boundary. An exit on to Castle Yard (road) was located on the northern boundary.

No obvious evidence of potential spills or blocked drains was apparent, and all hardstanding was observed to be in good condition.

PREVIOUS WORK

It is understood that the eastern part of the school was the subject of a site investigation by Geotechnical & Geoenvironmental Associates Ltd (reference J15093) but this has not been reviewed as part of this investigation. Information contained therein has not be considered within this report to aid recommendations and as such this current report should be considered separate to the previous report.

DESK STUDY AND BACKGROUND INFORMATION

A desk study review of the site and its history has been undertaken to determine the former land usage and the potential for any historically derived sources of chemical contamination, as well as provide information to aid assessment.

The information provided in the desk study is obtained from independent third-party sources but no guarantee can be given for the accuracy or completeness of the third-party data used. It should be appreciated that such data is not exhaustive and is constantly being updated and reviewed in light of new information and procedures. Therefore, improved practices, technology, and new information may affect the conclusions and hence this report should be referred back to ListersGeo for reassessment if new data comes to light, or changes in legislation/best practise is identified prior to development. Similarly, should the development commence after expiry of one year from publication of this report, then it is recommended that this report is referred back to ListersGeo for reassessment.

The desk study comprises a review of the following consultations and information sources:

- Environment Agency (EA)
- Natural England
- National Geoscience Information Service
- Public Health England
- Centre for Ecology & Hydrology
- British Geological Survey (BGS)
- Contemporary Trade Directories
- Historical Ordnance Survey maps
- Aerial Imagery
- Unexploded Ordnance (UXO) maps

Information from the above referenced sources has been utilised to develop a conceptual model of the site for use in the geotechnical appraisal and source-pathway-receptor risk assessment.

A copy of the desk study information obtained from Landmark is presented in Appendix H of this report.

GEOLOGY

Published Geology

Reference to the British Geological Survey 1:50,000 scale map, sheet 256 for North London, dated 2006, and other published geological information on the area indicates that the site is directly underlain by Bedrock

geology, the Bagshot Formation over the Claygate Member of the London Clay Formation both of Paleogene age. The Claygate Member is mapped to be present at surface in the east of the school campus.

Bagshot Formation

The Bagshot Formation is generally represented by light yellow brown, light grey, and orange, fine to coarse-grained laminated sands occurring up to approximately 20m in thickness in this area. Beneath the site itself the formation is expected to be thinner than this, further decreasing in thickness towards the east, and be potentially absent in the east of the school campus.

Claygate Member

The Claygate Member is generally represented by dark grey, sandy clays occurring up to approximately 20m in thickness in this area. Beneath the site itself the formation is expected to underlie the Bagshot Formation but be present from surface in the east of the school campus.

Historical Boreholes

The British Geological Survey holds records of exploratory holes historically put down during previous investigations. Unfortunately, no records are held for boreholes within a suitable distance to be potentially representative of the site itself.

HISTORY OF THE SITE

The history of the site has been established by reviewing available historical Ordnance Survey maps and aerial imagery of the area. This has identified the following:

Time Period	Historical Usage of the Site	Historical usage of the Surrounding Area
1850	The site was occupied by numerous buildings lining the streets to the east and west with an access road from Southwood Lane through the centre.	The roads bounding the site (North Road, Southwood Lane, and Highgate High Street) are shown in their current position. Limited other detail is depicted.
1864	The south-east of the site is labelled 'British School' from the 1864 map, and is presumed to have made up part of the present-day school, which is understood have been founded in 1565.	The roads are lined by a mixture of small terraced buildings (including Almshouses), shops, pubs and occasional larger residential properties with fields beyond to the east and west and further development to the south. The Dyne House plot is labelled as 'Cholmeley's School'. A waterworks ('covered') is shown approximately 140m south-west of the site. A small clay pit was mapped approximately 340m north-east of the site and another labelled 'old' was 440m to the north-east. The labels are not shown from 1873 onwards. Brickfields are shown approximately 600m east and 630m north of the site.

Time Period	Historical Usage of the Site	Historical usage of the Surrounding Area
1870 to 1879		The 'Great Northern Railway' is shown approximately 560m north of the site from the 1870 map. A large brick field is shown approximately 760m east of the site.
1895 to 1896	The site is no longer labelled 'British School'.	The Dyne House plot is now labelled as 'Cholmeley House'. The present-day school chapel is shown along with one of the existing buildings immediately south of the site, labelled 'Sir Roger Cholmeley's School (Boys)'. A tramline is shown to run eastward along Highgate High Street from 95m south of the site. The waterworks is now labelled as 'Reservoir'. A horticultural nursery is located approximately 200m west of the site. Both of the clay pits appear to have been infilled as are the brickfields, which have been replaced with housing.
1915 to 1920	A number of buildings in the south of the site have been replaced with a larger building joined to the school to the south, no longer labelled 'Sir Roger Cholmeley's School (Boys)'. The remaining buildings have also changed configuration slightly.	Substantial residential development has occurred north and west of the site, extending towards the site from the railway as well as more limited development from approximately 350m north-west of the site.
1935 to 1951	The Science Quad and the surrounding buildings are showing in their current configuration.	Residential development is shown to have further encroached on the site from 160m east with substantial development from approximately 430m south.
1952 to 1976	The school is labelled as 'Highgate School'.	The tramline is no longer shown.
1978	A garage is labelled in the north of the site, believed to refer to row of domestic garages.	Minor residential infilling has occurred east and west of the site. The Parade Ground to the rear of the Dyne House plot, approximately 90m east of the site, is shown as lowered ground. The buildings to the west of the Parade Ground are shown in their current configuration, with Dyne House itself being shown as it is currently from 1968 mapping.
1991 to 2013	The buildings immediately adjacent to the school in the north of the site have been replaced by part of the current school building and a large external area, shown to contain a small rectangular structure in its centre on the 1991 map.	Aerial photography shows the petrol filling station immediately opposite North Road to the north-west of the site to have been present since at least 1999.

Time Period	Historical Usage of the Site	Historical usage of the Surrounding Area
2018	The small buildings in the north-west corner of the site are shown to be included within the school buildings.	

UNEXPLODED ORDNANCE AND BOMB SITES

The Zetica bomb risk map shows that the site is located in an area where there is a moderate risk of unexploded ordnance. As such, a Preliminary Unexploded Ordnance (UXO) Risk Assessment, has been undertaken for both the western and eastern areas of the school campus by MACC International Ltd. The report, ref. JM/5320/04, identifies that these sites are within a low risk area of encountering UXO and a copy of the report is provided in Appendix G.

HYDROLOGY

The nearest surface water is a cluster of ponds in Waterlow Park, from approximately 350m south-east of the site. An unnamed stream also issues approximately 530m west of the site before flowing underground southward to join with the Highgate Ponds approximately 900m south-west of the site.

The EA's Catchment Data Explorer indicates that the site lies within the Operational Catchment for 'Lee Lower Rivers and Lakes', and that within this catchment the stretch of river closest to the site, the Moselle Brook, 2.8km north-east of the site, has an overall water body classification of 'Moderate' as recorded in 2016.

The Envirocheck data indicates that the site lies outside of any flood impact zones. However, this information does not constitute a site-specific Flood Risk Assessment (FRA) as the results of a site-specific FRA may differ to the information provided in the baseline desk study. It is therefore recommended that further enquiries are made to determine if a site-specific FRA is required to support the planning application/development at the site.

There are no potentially-active or historical surface water abstraction licenses located within 1000m of the site.

HYDROGEOLOGY

Information obtained from the EA indicates that the Bagshot Formation is classified as a Secondary A Aquifer and the Claygate Member is classified as Unproductive Strata.

The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are divided into two different types of aquifer designation:

- **Superficial (Drift)** - permeable unconsolidated (loose) deposits e.g. sands and gravels.
- **Bedrock** - solid permeable formations e.g. sandstone, chalk and limestone.

For each type there are classifications of Principal, Secondary A and Secondary B Aquifers and Unproductive Strata, each with a decreasing rank of importance.

The EA's Catchment Data Explorer indicated that the site lies on the southern limit of the catchment indicating that groundwater is likely to flow north-west towards the Moselle Brook, located approximately 2.8km from the site.

There are no potentially-active or historical groundwater abstraction licenses located within 1000m of the site.

According to information provided by the EA the site lies outside of any Source Protection Zones (SPZ) for potable water supply.

WASTE TREATMENT AND LANDFILL SITES

There are no current or historical landfill disposal sites, waste transfer sites, waste treatment sites, or waste management facilities within 1000m of the site area.

ENVIRONMENTAL PERMITS, INCIDENTS AND REGISTERS

There have been no recorded pollution incidents to controlled waters, land, or air within 500m of the site.

There are no potentially-active discharge consents to surface water or groundwater located within 1000m of the site.

There are two Local Authority Pollution Prevention and Control licenses within 500m of the site. These relate to a petrol filling station located 20m north-west of the site and a dry cleaners 280m to the south-east. A further three licenses are present within 2000m of the site.

INDUSTRIAL USAGE SITES

There are seventeen past or present trade directory entries that have been identified up to 250m from the site. These include vehicle maintenance garages, dry cleaners, other cleaning services, a hospitals, and various manufacturers.

The nearest active fuel filling station is identified as the Gulf service station at John Nichols Cars on North Road opposite the site.

Historical Site Usage

The site has been used at least in part as a school since the earliest historical map, dated 1864. The northern part of the site was occupied by smaller buildings, presumed to have been residential houses or shops, and gradually joining the school buildings with the last having joined in recent years.

WORKED OUT GROUND/MADE GROUND

Worked out ground is recorded 340m and 440m north-west and 480m south of the site and from 600m east and 630m north of the site. Evidence of infilling and redevelopment in these areas is shown on the historical maps.

RADON GAS

Desk study information indicates that the site lies within an area where less than 1% of homes exceed the action level of 200 Bq/m³ for radon gas. Should the public occupancy of the building be less than 2,000 hours per year however, then the action level is increased to 400 Bq/m³, double that of domestic usage. In accordance with BR 211, 'Radon: guidance on protective measures for new dwellings', radon protection measures are not necessary in the construction of new buildings or extensions without underground rooms on this site.

Radon levels may however be higher in the proposed basement and in accordance with BRE Quick Guide 7 (2015), mitigation measures should be included in the basement design of residential properties. However, as this is not a residential dwelling, and provided the public occupancy of the building is less than 2,000 hours per year, the need for protection measures may be reduced or removed dependent upon discussion with the Local Authority and the final design of the proposed buildings.

POTENTIAL GEOTECHNICAL HAZARDS

Geological

The risk of naturally occurring geotechnical hazards at the site is recorded in the Envirocheck report to be as follows:

Ground Stability Hazard	Hazard Potential Rating	
	Bagshot Formation	Claygate Member
Shrinking and swelling clays	No Hazard	Moderate
Landslides	Very Low	Low
Running sand	Low	Very Low
Collapsible deposits	Very Low	Very Low
Compressible deposits	No Hazard	No Hazard
Ground dissolution from soluble rocks	No Hazard	No Hazard

Mining

The desk study information identified that the site does not lie within an area likely to be affected by coal or non-coal mining.

BACKGROUND SOIL CHEMISTRY

Information from the BGS provides urban soil chemistry averages for the area within 1000m of the site, as follows:

Contaminant	Urban Soil Averages (mg/kg)
Arsenic	17
Cadmium	0.9
Chromium	79
Lead	280
Nickel	28

These concentrations are all well below the generic assessment criteria (GAC) for the site usage. The adopted screening standards are discussed further in the Contamination Risk Assessment section of this report.

POTENTIALLY SENSITIVE LAND USES

The site is not located within 500m of any environmentally sensitive land uses.

CONCEPTUAL SITE MODEL

A qualitative risk assessment has been carried out using the source-pathway-receptor principle to create a Conceptual Site Model (CSM). It is understood that it is proposed to extend the science block in two directions, as shown in Appendix A.

Potential sources of contamination and potential receptors have been assessed using the Contaminated Land Exposure Assessment (CLEA) Guidelines. This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

POTENTIAL SOURCES OF CONTAMINATION

The results of the desk study and walkover indicate that the following potential sources of contamination are present at or in close proximity to the site:

Soil/Groundwater

- Made Ground is likely to be present at the site associated with historical development.
- Current off-site petrol filling station, located approximately 20m north-west opposite the site, since c.1990s
- Current off-site horticultural nursery, located approximately 200m west of the site, since c. 1890s

Ground Gas/Soil Vapour

- Current off-site petrol filling station, located approximately 20m north-west opposite the site, since c.1990s
- Naturally-occurring radon.

POTENTIAL RECEPTORS

The following receptors have been identified at or in close proximity to the site:

Human Health

- End users of the site - the future staff and pupils of the school
- Surrounding residents
- Surrounding workers
- Construction workers

Controlled Waters

- Groundwater of the underlying Secondary A Aquifer, the Bagshot Formation
- Surface water of the unnamed stream, approximately 530m west of the site

Infrastructure

- Buried substructures and foundations
- Water supply pipes

POTENTIAL PATHWAYS

It is considered that the following potential pathways exist between these potential sources and the receptors identified above.

Human Health

- Direct soil ingestion in areas of exposed soil
- Inhalation of indoor and outdoor vapours and dust
- Dermal contact with contaminated soil
- Inhalation of soil gases or vapours migrating through permeable strata into the buildings

Controlled Waters

- Migration of contaminants through the unsaturated zone
- Migration of contaminants through the groundwater
- Movement of contaminants through drains or services runs

Infrastructure

- Direct contact with leachable or corrosive contaminants within the soil
- Direct contact with leachable or corrosive contaminants within the groundwater

PRELIMINARY ENVIRONMENTAL RISK ASSESSMENT

Based on the desk study research, the following potentially-complete pollutant linkages have been assessed:

Source	Pathway	Receptor	Complete Linkage Potential
Potentially impacted soils and groundwater <i>- including Made Ground, hydrocarbons, PAH, and pesticides</i>	Ingestion - in areas of exposed soil	End users of the site - the future staff and pupils	Unlikely due to prevalence of hardstanding.
		Surrounding residents and workers	
		Construction workers	Possible
	Inhalation - indoor and outdoor dusts and vapours	End users of the site - the future staff and pupils	Possible
		Surrounding residents and workers	

		Construction workers	
	Dermal contact - with areas of exposed soil and wind-blown dusts	End users of the site - the future staff and pupils	Unlikely due to prevalence of hardstanding.
		Surrounding residents and workers	
		Construction workers	Possible
	Direct contact - corrosive contaminants with infrastructure	Buried substructures	Possible
		Water supply pipes	
	Migration of contaminants through the unsaturated zone, groundwater, or service runs	Groundwater – underlying Secondary A Aquifer	Unlikely, based on limited contamination anticipated and distance to known potable abstraction points and surface water.
		Surface water – unnamed stream 530m west	

The geoenvironmental investigation and risk assessment detailed in the remainder of this report has been conducted to validate this CSM and preliminary risk assessment.

GEOTECHNICAL CONCEPTUAL SITE MODEL

Depending on the building loads and published geology, it is possible that piled foundations will be required. Shrink-swell soils, with the potential to result in subsidence and soil heave, may be present associated with the Claygate Member.

As depth to groundwater is unknown, it is not known whether groundwater will flood excavations and/or affect stability during groundworks.

It is likely that the coarse-grained Bagshot Formation may be amenable to conventional Sustainable Drainage Systems (SuDS), however it is unlikely that the finer-grained Claygate Member will be as suitable.

The intrusive investigation has been implemented to address these main issues and establish any potential problems for foundations and the general development of the site.

EXPLORATION AND TESTING

A total of fourteen exploratory holes were formed at the site between the 13th and 17th August 2018. These included two cable percussion boreholes, two continuous tube sample boreholes (one with Super Heavy Dynamic Probe (SHDP) follow-on), one SHDP hole, eight hand-dug foundation inspection pits, and two Dynamic Cone Penetrometer (DCP) tests.

An additional four machine-excavated trial pits were excavated in the Parade Ground in the east of the school campus on 24th August 2018 for infiltration testing purposes.

The positions of all exploratory holes undertaken at the site as part of this investigation can be seen on the Exploratory Hole Location Plans in Appendix A. The logs and foundation profiles are provided in Appendix B and the results of the geotechnical laboratory testing are provided in Appendix C.

Gas and groundwater monitoring was undertaken on two occasions over the first few weeks following the fieldwork.

SAMPLING STRATEGY

The investigation was undertaken in accordance with the scope of works agreed with the client, who selected the positions of the exploratory holes.

Foundation inspection pit, TP3, was located inside the building whilst all other exploratory positions were external.

METHODOLOGY

Science Block Extensions

Prior to commencement of boring, the proposed locations were scanned using a Cable Avoidance Tool in order to minimise the dangers from/to buried services. At the borehole and probe locations, a service avoidance pit was dug, using insulated hand tools, to a depth of around 1.2m bgl.

At positions located on existing hardstanding/floor slab, the surfacing was broken-out using a handheld electric breaker.

Continuous tube sample boreholes CT1 and CT2, located in the south of the Science Quad, were put down using an Archway Competitor Dart rig to a maximum depth of 10m bgl. Boreholes were advanced using a plastic lined steel tube sampling system, driven into the ground by a top drive percussive hammer. A near continuous core sample, decreasing from 87mm to 37mm with depth, was recovered for future examination and sub-sampling. Prior to sampling, an SHDP test was performed adjacent to the positions of CT1 to give an indication of the relative penetration resistance of the soils encountered. Standard Penetration Tests (SPTs) were taken at 1.0m intervals in CT2 to 6.5m, whereupon drilling refused on hard strata, and SHDP follow-on was undertaken to 10m bgl.

Cable percussion boreholes, BH1 and BH2, were drilled utilising a standard cable percussion rig, at a diameter of 150mm, down to a maximum depth of 15.1m below ground level. Metal casing was extended to a maximum depth of 14.0m, to avoid the collapse of the loose deposits within the upper part of the boreholes and seal out groundwater inflows. Disturbed samples were collected at regular intervals throughout the borehole for future laboratory inspection and testing. Standard Penetration Tests (SPTs) and undisturbed tube samples (U100s) were taken at 1.0m intervals down to 10m depth and at 1.5m intervals thereafter.

On completion of the boring, boreholes BH1 and BH2 were installed as groundwater monitoring wells with 50mm diameter slotted uPVC standpipe from 7.0m to 11.0m bgl and 3.0m to 8.0m bgl respectively. The slotted section of the standpipe was surrounded with pea gravel and sealed with expansive bentonite clay. The standpipe was finished with a stopcock cover which was concreted flush with ground level.

Foundation inspection pits, TP1 to TP8, located around the perimeter of buildings within the site, were excavated by hand using insulated tools to depths of between 0.6m and 1.5m bgl to determine the design of existing foundations. On completion, all trial pits were carefully backfilled with arisings, ensuring that excavated material was replaced in the same order as it had been removed.

In-situ DCP testing was carried out in two locations within the hardstanding areas of the Science and Garner Quads to provide indicative California Bearing Ratio (CBR) values for pavement design.

Dyne House, Parade Ground

Trial pits, TPA to TPD, located in the Parade Ground in the east of the school campus, were excavated with an 8-tonne rubber-tyred backhoe excavator to depths of between 2.15m and 3.4m below ground level under the supervision of a geotechnical engineer, who made a record of the arisings. Disturbed samples were taken at selected depths down to the base of the holes for subsequent laboratory testing and inspection. On completion, infiltration testing was undertaken in accordance with BRE Digest 365 'Soakaway Design' then carefully backfilled with arisings in thin layers, ensuring that excavated material was replaced in the same order as it had been removed.

Conclusions given in this report are based on data obtained from these sources, but it should be noted that variations, which affect these conclusions, may inevitably occur between and beyond the test locations.

GROUND CONDITIONS

The intrusive investigation revealed that the general succession of strata was represented by a layer of engineered fill and Made Ground above Bagshot Formation overlying the Claygate Member to the full depth of the investigation at 15.1m depth in the site in the west of the school, and directly overlying Claygate Member in the east of the Dyne House Parade Ground.

The Ground Model for the site is as follows. Detailed logs are included in Appendix B and full geotechnical testing results are included in Appendix C.

ENGINEERED FILL

Engineered fill was encountered at sixteen of the eighteen exploratory hole locations from ground level down to depths of between 0.1m and 0.4m, with an average thickness of 0.2m.

It was represented by concrete paving or asphalt-concrete hardstanding over a sandy, gravelly or cobbly sub-base.

MADE GROUND

Made Ground was encountered at thirteen of the eighteen exploratory hole locations from between ground level and 0.4m bgl down to depths of between 0.4m and the base of TP D in the Parade Ground at 3.4m bgl. In the western site, the Made Ground was generally deepest in the foundation inspection pits, particularly those around the Science Block.

The Made Ground soils comprised a variable mix of soft to firm, brown sandy and gravelly clays, and loose to dense sandy gravels. Gravel was fine to coarse, angular to subrounded brick, concrete, flint, clinker, clay pipe fragments, and glass.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	8 to 27	No evidence of desiccation
Liquid Limit (%)	28 to 37	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 19	
Plasticity Index (%)	9 to 19	
Modified Plasticity Index (%)	7 to 19	Non-shrinkable and shrinkable soils of LOW Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	2 to 21	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	38 to 78	Represents fines (silt/clay) fraction

TOPSOIL

Topsoil was encountered at TP4 from ground level down to 0.15m and was represented in general by dark grey brown, very sandy, slightly silty clay.

BAGSHOT FORMATION

Bagshot Formation was encountered at five of the eighteen exploratory hole locations from between 0.1m and 1.2m bgl depth down to depths of between the base of the TP B at 2.15m and 11.5m bgl, with an average thickness of 10.7m (where full thickness encountered).

It was represented by soft to stiff, yellow brown and orange brown, silty and sandy clays, and medium dense to very dense, yellow brown and orange brown, clayey sands.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	7 to 48	No evidence of desiccation
Liquid Limit (%)	33 to 49	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 22	
Plasticity Index (%)	12 to 30	
Modified Plasticity Index (%)	12 to 30	Shrinkable soil of LOW to MEDIUM Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	0 to 7	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	39 to 80	Represents fines (silt/clay) fraction

Full laboratory sieve analyses identified gravel contents of up to 0.5%, sand content of between 54% and 73% and fines (silt/clay) between 27% and 45%.

The following shear strength tests were undertaken under laboratory conditions:

Test method	Range (kPa)
Hand Vane	2 to 50
Triaxial	20

The following table provides details of the 'N' values derived from standard penetration testing (SPT) and the number of blows taken to retrieve a U100 sample from the boreholes. Strength tests (including conversion of SPT N-values, using the Stroud method and a factor, f_1 , of 5.5, indicates low to very high undrained shear strength, generally increasing with depth.

Parameter	Range	Comments
SPT 'N' Value	4 to 73	Increasing with depth
U100 blows	15 to 42	
SHDP blows (N ₁₀₀)	1 to 33	max. test depth 10m bgl

The results of the SHDP testing indicated that the penetrative resistance of the stratum varied with depth, with the softer sections correlating with the clay bands.

CLAYGATE MEMBER

Claygate Member was encountered at four of the eighteen exploratory hole locations from 11m and 11.5m bgl down to the base of the boreholes at 15.1m depth, in the western site, and from 2.5m and 2.6m to the base of the trial pits at 2.6m and 2.9m respectively in the Parade Ground in the east of the school. It was represented by stiff, green grey, sandy clay and medium dense, grey, clayey sand.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	24 to 44	No evidence of desiccation
Liquid Limit (%)	35 to 40	CLAY of LOW to INTERMEDIATE plasticity (BS 5930 Casagrande)
Plastic Limit (%)	17 to 20	
Plasticity Index (%)	15 to 23	
Modified Plasticity Index (%)	15 to 23	Shrinkable soil of LOW to MEDIUM Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	0 to 1	Represents 'coarse soil' fraction (BS 1377)
Passing 63µm sieve (%)	39 to 63	Represents fines (silt/clay) fraction

The 'N' values derived from standard penetration testing (SPT) ranged from 16 to 23, increasing with depth. Conversion of these SPT N-values, using the Stroud method and a factor, f_1 , of 5.5, indicates a high undrained shear strength, increasing with depth.

CALIFORNIA BEARING RATIO (CBR) TESTS

In-situ testing was undertaken using a TRL DCP probe at two locations across the site to obtain equivalent CBR with depth profiles to a maximum of 1m depth.

Results are summarised in the following table and provided in full in Appendix B. Test locations are shown on the Exploratory Hole Location Plans in Appendix A.

The results of the testing ranged as follows:

Likely Stratum	Depth (m)	CBR (%)
Made Ground	0.1 to 0.9	8.2 to >40%
Bagshot Formation	0.4 to 0.9	2.6 to 10.6

SULPHATE AND PH TESTS

Water-soluble sulphate and pH testing were carried out on 21 soil samples recovered from the exploratory holes across the site. These recorded values as shown in the table below:

Stratum	Samples	Range	
		Water-soluble Sulphate (g/l)	pH
Made Ground	12	0.02 to 0.86	6.3 to 12.3
Bagshot Formation	8	0.06 to 0.21	6.3 to 8.1
Claygate Member	1	0.23	7.2

GROUNDWATER

Groundwater was encountered at various depths during the intrusive works, as summarised below.

Borehole	Type	Depth (m bgl)	Resting level (m bgl)	Source Stratum
BH1	Strike	9.0	8.0	Bagshot Formation
BH2	Strike	12.5	10.5	Claygate Member
TPC	Seepage	2.8	-	Claygate Member

Long term monitoring carried out as part of the project has revealed standing groundwater levels within the natural deposits of between 8.60m and 8.61m bgl (118.04m and 118.03m above Ordnance Datum; m AOD) in BH1 in the Garner Quad in the north of the site. It is not possible to infer hydraulic gradient or groundwater flow direction due to limited spatial data.

OBSERVED SOIL CONTAMINATION

Evidence of contamination during the intrusive works was observed as ash in the Made Ground at BH2 and clinker in Made Ground at TP5.

INFILTRATION TESTING

Infiltration testing was carried out at four locations within the Parade Ground at Dyne House in the east of the school campus, in accordance with BRE Digest 365, 'Soakaway Design'.

Infiltration at TP A and TP B was negligible over the timescale available and as such it was not possible to calculate infiltration rates for these locations. TP C collapsed in during testing and as such the infiltration rate

has been extrapolated to provide an indicative value. It should be noted that this procedure is not in accordance with BRE 365 and caution should be exercised when using extrapolated values for design purposes.

Results are summarised in the following table and presented in full in Appendix B.

Location	Test depth (m bgl)	Test strata	Soil Infiltration Rate (m/s)		
			Test 1	Test 2	Test 3
TP A	1.9 to 2.8	Made Ground Claygate Member	Negligible*	-	-
TP B	1.1 to 2.2	Bagshot Formation	Negligible*	-	-
TP C	2.1 to 2.9	Made Ground Claygate Member	2.0×10^{-6} #	-	-
TP D	2.3 to 3.4	Made Ground	1.5×10^{-4}	1.1×10^{-4}	9.3×10^{-5}

* = Rate not determinable due to insufficient infiltration during test timescale.

= Rate extrapolated. Use with caution.

EXISTING FOUNDATIONS

Existing foundations of the were revealed in hand-excavated trial pits, TP1 to TP8, in locations selected by the client's structural engineer. The findings are summarised in the following table.

Trial Pit	Foundation Depth (m bgl)	Description	Maximum Projection (mm)	Founding Stratum
TP1	0.75	Brick and concrete	400	Bagshot Formation
TP2*	>0.59*	Brick and concrete*	>410*	Unknown*
TP3	0.40	Concrete	150	Bagshot Formation
TP4	0.40	Concrete	700	Bagshot Formation
TP5*	>1.50*	Brick*	>0*	Unknown*
TP6	1.15	Brick	100	Bagshot Formation
TP7*	>1.24*	Brick*	>240*	Unknown*
TP8*	>0.70*	Brick*	>50*	Unknown*

* Pit terminated before reaching foundation base.

Diagrammatical profiles of the existing foundations are provided in Appendix B.

GROUND CONTAMINATION ASSESSMENT

SOIL TESTING

In total, seven soil samples collected on site during this investigation were tested for a range of contaminants; five of which were of Made Ground and two of natural soils.

The suite of testing carried out on the samples was decided upon following consultation of R&D CLR Publications, published as part of the Contaminated Land Exposure Assessment (CLEA), a joint venture between the Department for Environment, Food and Rural Affairs (DEFRA) and the EA.

The test suite included a range of:

- Inorganic substances, including metals and metalloids.
- Speciated Polyaromatic Hydrocarbons (PAH).
- Total Petroleum Hydrocarbons (TPH), with eight band split.
- Asbestos screening.

Unless explicitly stated on the laboratory report, the soil samples were tested to obtain 'Total' values within the soil.

Full chemical analytical results are included in Appendix C.

RISK ASSESSMENT GUIDELINES – HUMAN HEALTH

The human health risk assessment has been undertaken using the guidance provided in the EA's publication CLR11, '*Model Procedures for the Management of Contaminated Land*', published in September 2004.

Human health assessment criteria used are based upon the proposed final land use of the site. As the site is to continue to be used as a school, ListersGeo's in-house Generic Assessment Criteria (GAC) for a 'Secondary School' setting have been used. This enables a more accurate assessment than any of the published GAC provide for this site setting.

This set of in-house GAC have been derived using the EA's CLEA software to model a generic 'Secondary School' setting. The model uses the following parameters:

- Most sensitive receptor: Female aged between 11 to 16 years old.
- Occupancy period: 8 hours per day inside, 2 hours per day outside, 195 days per year.
- Building type: Office-style building of post-1970s construction.
- Soil type: Sandy loam
- Exposure pathways: Soil and dust ingestion, indoor and outdoor dermal contact and inhalation of indoor and outdoor dust and vapours.

In-house GAC have been derived for Soil Organic Matter (SOM) contents of 1%, 2.5%, and 6% in line with the published GAC currently available (Suitable For Use Values, S4UL, produced by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) in 2015). In the absence of site-specific SOM results, the in-house GAC for 1% SOM have conservatively been adopted as a preliminary screening tool.

The full settings are presented in Appendix D.

If the proposed site use should alter from the above, then the human health risk assessment will require re-evaluation for the new end-use scenario.

Data Sources

Where chemical specific data has been used in the above assessments, data has been sourced from available TOX reports, published by DEFRA, The Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) literature and toxicological and physical data obtained from EA Publication, 'Human Health Toxicological Assessment of Contaminants in Soil', August 2008.

RESULTS OF SOIL ANALYSIS

Screening for the presence of asbestos did not reveal any asbestos containing material (ACM) or fibres in the three samples of Made Ground soils analysed.

Results of the soil testing have been compared to relevant in-house GAC as discussed above.

None of the contaminants were detected at concentrations in excess of their relevant GAC for human health for a 'Secondary School' setting.

HUMAN HEALTH RISK ASSESSMENT

The following quantitative risk assessment has been carried out using the source-pathway-receptor principle. Potential sources of contamination and potential receptors identified in the Conceptual Site Model have been assessed using the Contaminated Land Exposure Assessment (CLEA) Guidelines. This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

The potential human receptors evaluated for their individual risk are:

- End users of the site - the future staff and pupils of the school
- Surrounding residents
- Surrounding workers
- Construction workers

If the proposed site use or layout should alter significantly, then the human health risk assessment will require re-evaluation.

SOIL CONTAMINATION

None of the soil contamination tests carried out as part of this investigation revealed elevated concentrations of contaminants in the soil in excess of their relevant GAC. As such there is considered to be no significant risk of significant harm to the long-term receptors.

ADDITIONAL CONSIDERATIONS

Construction Workers

For construction workers and maintenance workers that are exposed to the ground, there is a short-term exposure risk (at each site they attend, which contributes to an overall lifetime exposure risk) and the pathway of primary concern is 'direct soil ingestion'. Protective measures that are different to those taken to protect the long-term exposure group (such as end-users of the site) are therefore required.

In order to reduce the risk from contamination to as low as reasonably practicable for the construction workers, it is recommended that appropriate health and safety measures be implemented along with the use of Personal Protective Equipment (PPE). All personnel coming into contact with the soil, ground workers in particular, should be instructed to use gloves when on site to avoid dermal contact and restrict inadvertent hand-to-mouth ingestion. Washing facilities should be provided for the site staff and should be used prior to eating or smoking. Reference should be made to the HSE Document, "Protection of Workers and the General Public during Development of Contaminated Land".

Additionally, although no asbestos was identified as part of this investigation, the presence of ACM and fibres within Made Ground at any site cannot be ruled out. Groundworkers should be made aware of potential risks of asbestos during the groundworks prior to beginning work.

REGULATORY APPROVAL

The findings of this report will require approval by the Local Authority and building warranty provider prior to any development taking place.

CONTROLLED WATERS RISK ASSESSMENT

As with the Human Health Risk Assessment above, the following quantitative risk assessment has been carried out using the source-pathway-receptor principle. This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk and is in accordance with the procedures set out in the EA's Remedial Targets Methodology *Hydrogeological risk assessment for contaminated land* (2006).

The potential Controlled Waters receptors considered during this risk assessment were:

- Groundwater of the underlying Secondary A Aquifer, the Bagshot Formation
- Surface water of the unnamed stream, approximately 530m west of the site

Groundwater samples were not obtained under the scope of this investigation and consequently chemical analysis is not available. This risk assessment is therefore qualitative only and should be considered to represent a preliminary assessment.

CONTROLLED WATERS CONTAMINATION

As no significantly elevated concentrations of contaminants were detected in soils at the site it is considered unlikely that significant contamination will migrate from soils into groundwater of the Secondary A underlying the site. Subsequent migration of contamination to surface water is also considered unlikely, particularly given their proximity from the site.

Similarly, as no evidence of gross leaks or spills was observed on site, nor were any obvious sources of contamination identified in the desk study, it is considered unlikely that direct contamination to groundwater has occurred.

There is therefore considered to be no significant risk to groundwater or surface water from the site.

GEOTECHNICAL ENGINEERING CONCLUSIONS

The proposed works are understood to comprise extensions to the science block including construction of a single-level basement, a pillar-supported first and second floor extension, and a lift shaft. Plans showing the development proposals are included in Appendix A. The following geotechnical conclusions refer solely to these proposals in the west of the school campus.

The exploratory and laboratory work from this investigation has proven the general strata sequence to comprise engineered fill and Made Ground above soft to stiff, low to intermediate plasticity clays and medium dense to very dense sand of the Bagshot Formation, overlying stiff low to intermediate plasticity clays and medium dense sand of the Claygate Member, proven to 15.1m bgl.

Groundwater was encountered in both of the cable percussion boreholes, as inflows from the Bagshot Formation 9.0m bgl (BH1) and 12.5m bgl (BH2) and rising to 8.0m and 10.5m bgl respectively. Subsequent groundwater monitoring recorded standing groundwater levels of approximately 8.6m bgl (118.04m AOD) in BH1.

Laboratory testing indicates that both the Bagshot Formation and the Claygate Member are of low to medium volume change potential. No evidence of desiccated soils was identified during this investigation.

SITE EXCAVATION

Conventional hydraulic plant should be satisfactory for excavating foundation and service trenches within the Bagshot Formation. Specialist breaking plant may be required to break out existing foundations, where required.

In line with HSE guidelines, all excavations requiring personnel access should be adequately supported to avoid the risk of collapse. Consideration should also be given to the stability of open trenches where personnel are working in close proximity. During the fieldwork, excavations within the Bagshot Formation remained stable for the short time that the boreholes were open.

Groundwater is expected to be present at approximately 8-9m bgl and, as such, excavations, with the exception of the proposed basement, are likely to remain dry and dewatering is unlikely to be required.

Measures will have to be put in place to ensure that the existing buildings are not undermined or otherwise affected by the construction work, particularly with regard to excavation of the proposed basement.

FOUNDATION SOLUTIONS

Spread Foundations

The Made Ground is considered unsuitable as a bearing stratum due to its thickness, variability, and potential for unacceptable total and differential settlement under applied foundation loadings.

The proposed extension into the Garner Quad is three-storeys high and the client's structural engineer has provided a loading for this building of 90kN serviceability limit state (SLS). For this extension, the Bagshot

Formation is considered to be suitable bearing stratum for pad foundations of 1m square at not less than 1.0m bgl or 0.2m into the top of the formation, whichever is deeper. At this depth an allowable bearing pressure of 130 kPa should be achievable. Strip foundations are unlikely to be economical.

The proposed extension into the Science Quad is five-storeys high. The Allowable Bearing Pressure of the site geology is considered insufficient for extensions of this proposed size, making shallow foundations unsuitable for use in this extension. In view of the high superstructure loads anticipated, a piled foundation solution is recommended for this extension.

Piled Foundations

A piled solution would transmit the superstructural loads of the five-storey Science Block extension down through the Made Ground and shallow Bagshot Formation into the stronger Bagshot Formation and Claygate Member at depth to obtain end bearing and shaft friction support.

The in-situ and laboratory test data has been used, with recognised conversion factors where appropriate, to produce a plot of shear strength of the Bagshot Formation and Claygate Member against depth. Values taken from the Characteristic Design Line shown on this plot have been used to calculate the preliminary ultimate shaft and base resistance of a range of pile specifications combines to form an ultimate load. A factor of safety has then been applied in order to derive a working load. The shear strength plot and a preliminary pile design data sheet of the raw ultimate values are included in Appendix E.

Pile diameter (mm)	Pile toe depth (m)	Ultimate load (kN)	Working load* (kN)
300	10	314	100
	13	441	145
450	10	506	165
	13	713	235
600	10	723	240
	13	1020	335

** Based on a factor of safety of 3.0, conservatively rounded to the nearest 5 kN.*

The values provided are for illustrative purposes only and do not constitute recommendations as to the diameter or length of the piles to be constructed. The advice of a specialist piling contractor should be obtained to determine the most appropriate pile type and their exact design specifications. Values have been derived from existing ground level and are based on the strength of the Claygate Member alone, disregarding any additional support that may potentially be provided by the shallow Bagshot Formation (<1.0m bgl) and overlying Made Ground. Consideration will be required to the final site levels when designing piles as well as basement impacts including potential heave. A factor of safety of 3.0 has been used and a conservative alpha of 0.45. A lower factor of safety may be permissible following pile load testing.

GAS PROTECTION

In accordance with CL:AIRE Research Bulletin RB17 and CIRIA Report C665 it is considered that no potential sources of ground gas exist at the site and therefore long-term ground gas monitoring was not required.

Although the site lies within an area where risks from radon gas are low, one of the proposed extensions includes a basement level. Risks of radon are increased in underground rooms and radon protection measures may be required in the basement design. However, as this is not a residential dwelling, and provided the public occupancy of the building is less than 2,000 hours per year, the need for protection measures may be reduced or removed dependent upon discussion with the Local Authority and the final design of the proposed buildings.

WORKING PLATFORMS FOR TRACKED PLANT

If construction on the site requires the use of heavy tracked plant then reference will need to be made to BRE guidance document, BR 470 'Working Platforms for Tracked Plant' (2004).

Use of such plant will require construction of either a working platform or an adequate running surface if the subgrade is determined as being already adequate to support the anticipated plant loadings.

The subgrade down to 2.0m depth should be considered as essentially a fine soil. Accordingly, the following soil characteristics should be used for preliminary Working Platform design in accordance with BR 470 (BRE, 2004).

Parameter	Made Ground	Bagshot Formation
Undrained Shear Strength, c_u (kPa)	12	20
Angle of shearing resistance of coarse-grained subgrade, ϕ'_s (°)	30	N/A
Effective unit weight of subgrade material, γ'_s (kN/m ³)	18*	18

* Estimate as no site-specific data available.

It should be noted that soft spots and zones of poor subgrade may exist on any site at shallow depth that will have a significant influence on the instability of tracked plant. The location of such features will not readily be determined by a general ground investigation for foundation design and more specific investigation at shallow depth may be required before the design of a working platform can be completed.

The advice of a specialist contractor should be sought to determine the most suitable size and thickness of platform required for their specific plant. This will take into account the size of the plant and anticipated loadings imposed on the working platform.

BASEMENT AND RETAINING WALL DESIGN

It is proposed to construct a basement in the extension to the eastern wing of the science block. The following sections are based on the development proposals included in Appendix A.

Basement Excavation

The proposed finished floor level of 124.075m AOD will require an excavation around 3.1m deep. Based on the findings of the boreholes, this excavation will involve the total removal of the Made Ground and exposure of the Bagshot Formation at formation level.

It should be noted that although significant groundwater was found to be deep, groundwater levels will be critical, and it is recommended that continued monitoring is undertaken to establish potential seasonal variations that may impact the excavation. Any localised water seepages, where present, will need to be controlled by sump pumping.

Regardless of groundwater level, the excavation will require full support, or excavation in panels, to prevent risk of collapse and minimise ground movements.

Retaining Wall Design Parameters

For the design of both temporary and permanent retaining structures at the sides of the basement, groundwater should be assumed to be at approximately 8.0m bgl and the design parameter presented in the following table should be used, in accordance with BS 8002:2015.

Parameter	Made Ground	Bagshot Formation
Effective apparent cohesion, c' (kPa)	0*	0*
Effective Angle of Internal Friction, ϕ' (°)	30	25 - 35
Shear Strength, c_u (kPa)	12	20 - 40
Weight Density, γ_b (kN/m ³)	18*	18

**Estimate as no site-specific data available.*

The structural engineer should use the above parameters to derive the active and passive earth pressure coefficients, K_a and K_p . The determination of appropriate earth pressure coefficients, together with factors such as the pattern of earth pressure distribution, will depend on the type/geometry of the wall and the overall design approach.

Basement Floor Slabs

If the basement floor slab is not designed to be part of a piled raft then a ground-bearing floor slab could be adopted, supported by the Bagshot Formation, following proof-rolling and removal/replacement of any soft or loose material with well-compacted coarse-grained fill or lean-mix concrete.

Basement Heave

The basement excavation will cause unloading of the strata (max. 60 kPa for the envisaged 3.1m depth) resulting in potential long-term heave of the underlying strata. This report provides preliminary ground movement estimates only. If an assessment of construction-related ground movements is critical to design, then a separate detailed ground movement analysis should be undertaken.

The basement heave has been estimated assuming an empirical coefficient of volume increase, m_v , of 0.035 m^2/MN within the Bagshot Formation, a 14m x 3m x 3m nominal basement volume, a weight density of 18 kN/m^3 within the Made Ground and Bagshot Formation and no effect below 20m bgl. Total heave within the centre of the excavation is expected to be approximately 5 to 10 mm. This calculation does not take load imposed by the proposed structure into account.

Typically, at least 50% of the total heave may be anticipated during typical construction timescales and before any new imposed building loads are introduced. The final pile design should take into consideration the tensile forces generated due to soil heave.

Of course, variations in the depth or size of excavation and new imposed loadings will affect the above estimations and further assessment may be warranted should significant changes to the design be made.

Hydrostatic Uplift Pressures

Standing groundwater has been recorded at approximately 8.6m bgl at the site. Long-term groundwater monitoring would be necessary in order to determine seasonal variations at the site, however a water level of 8.0m bgl may be considered appropriate for preliminary design purposes.

As groundwater is likely to be consistently below the base of the excavation, no hydrostatic uplift is anticipated, however, it should be noted that build up of water pressure may still occur in the low permeability clays, and installation of permanent drainage measures such as land drains may be prudent.

Hydrostatic pressures should be reassessed once the final basement design has been established and the final design approach may need to be agreed with local Building Control.

Settlement of Adjacent Structures

When excavating a basement, loss of lateral support to the adjacent soil (along with other factors) can lead to settlement of the ground surrounding that excavation. It is vital, therefore, that temporary and permanent works are adequately designed and undertaken by a reputable contractor and that consideration is given to underpinning of adjacent structures.

SUBSURFACE CONCRETE

The concrete design mix recommendations for subsurface concrete have been assessed in accordance with the procedure in BRE Special Digest 1.

The site has no known industrial history and is shown to have been occupied, at least in part, by a school since earliest available mapping (1864). As such the site has been considered 'greenfield' for the purposes of this assessment. As groundwater was only encountered at depth, the groundwater beneath the site is considered 'static' with regard to shallow concrete foundations.

Chemical testing has recorded a characteristic soil soluble sulphate concentration of 563 mg/l, corresponding to a Design Sulphate (DS) class of DS-2, and a characteristic pH of 6.5 corresponding to an Aggressive Chemical Environment for Concrete (ACEC) class of AC-1s.

Piled foundations would extend into the potentially-pyritic Claygate Member, and underlying London Clay Formation, and it is therefore recommended that the ACEC class is increased to AC-2s at depth. This requirement could be confirmed by way of additional testing within these strata.

ACCESS ROADS AND PARKING

The structural design of a road or hardstanding is based on the strength of the subgrade, which is assessed on the CBR scale.

The Made Ground and Bagshot Formation are both considered to be frost susceptible, with reference to TRRL report LR1132 (1984), and therefore a pavement thickness of at least 450mm is required. At this depth and with reference to Transport and Road Research Laboratory Report, LR1132, and the laboratory classification tests, it is recommended that for preliminary design purposes a subgrade CBR value of 4% is adopted for formation prepared in Made Ground and a CBR of 2% in Bagshot Formation. This is based on equilibrium soil conditions, a thin pavement construction, low water table and average construction conditions. The site conditions should be reassessed at the time of construction and the CBR/pavement design updated accordingly if considered necessary.

Any areas of soft or deleterious material should be excavated and replaced with a properly compacted, coarse-grained fill.

Where Made Ground deeper than 0.6m bgl is encountered beneath the area of proposed pavement it is recommended that geogrids or similar soil reinforcement techniques be employed to provide a subgrade with a known CBR value. Reinforcement measures will also mitigate lateral and vertical displacement from traffic loadings and differential settlement over variable ground. Discussions should be held with a soil reinforcement specialist to design a subgrade to a specified CBR value.

The following should also be taken into consideration:

- Inspection of the formation and removal of any surface areas of soft, organic, or other unsuitable materials.
- 'Heavy' proof rolling of the resultant formation, to compact loose coarse materials and locate any soft spots at shallow depth beneath the formation for subsequent removal.
- Removal of intact or loose obstructions where noted at surface, or known based on the investigation, to a depth of at least 600mm beneath the formation to prevent the creation of hard spots or voiding.
- Backfilling of any excavation with well-compacted inert coarse material.
- Pavement design based upon an equilibrium CBR of less than 2%.

The site conditions should be reassessed at the time of construction and the CBR/pavement design updated accordingly if considered necessary.

UNDERGROUND SERVICES

It should be noted that the utility companies often have their own local guidelines and standards on concentrations of shallow soil contamination in the ground that may or may not be acceptable for the installation of below ground services. These standards may be different to those specified for assessing risks to human health and groundwater.

The local requirements should be obtained from the particular service supply company as soon as possible to avoid unexpected delays or additional development costs.

Approval should be sought for the type of pipes proposed before they are installed.

DYNE HOUSE PARADE GROUND

The following section applies only to the Dyne House Parade Ground in the east of the school campus and is not applicable to the extensions to the Science Block being undertaken in the west of the school campus.

INFILTRATION MEASURES

Appropriately designed sustainable drainage systems (SuDS) are more sustainable than using piped drainage to local sewer systems. However, infiltration measures close to buildings may result in undermining of foundations and softening of soils leading to instability. Attenuation measures should be located at suitable distances, minimum 5m, from foundations and infrastructure and consideration given to the effects on slopes, flooding and mobilisation of contaminants.

Results were highly variable across the Parade Ground. The best soakaway potential was recorded in TP D in the east of the Parade Ground (1.5×10^{-4} m/s decreasing to 9.3×10^{-5} m/s). The worst soakaway potential recorded was in TP A and TP B, in the west of the Parade Ground, where infiltration was negligible, and rates were too low to be determined.

Infiltration rates generally reduce as the soil become saturated and the worst-case infiltration rate for each test should be used for design. The worst-case infiltration varied from negligible infiltration to 9.3×10^{-5} m/s, indicating impermeable to poor permeability, dependant on the location of the test.

If infiltration measures are to be progressed further, it is recommended that further soakaway testing is undertaken in the proposed soakaway locations, given the extent of permeability variation encountered.

In order for conditions to be optimal for the use of soakaways, a buffer if ideally at least 1m of unsaturated soils should be present beneath the base of the soakaway.

It should be noted that the Environment Agency will not approve applications for construction of soakaways in contaminated ground. As such, it should be confirmed that significantly elevated concentrations of contaminants were not detected during the previous site investigation by Geotechnical & Geoenvironmental Associates Ltd.

DISPOSAL AND RE-USE OF SURPLUS MATERIAL

It is likely that site redevelopment will produce a considerable amount of arisings, some of which may be able to be re-used on-site and some of which will be surplus to requirement. Under current waste management legislation any arisings that are surplus to requirement is classed as waste and needs disposing to a licensed facility. Records must be kept of where the waste is taken upon leaving site and its final destination.

The classification is a two-fold process using the soil chemical testing results and the European Waste Catalogue for removal from the site, followed by testing under the Waste Acceptance Criteria (WAC) specifically for landfill disposal.

EUROPEAN WASTE CATALOGUE DETERMINATION

Soils

Any soil classified as waste requires classification of the chemical constituents prior to leaving site in accordance with the European Waste Catalogue.

Excluding asbestos, the 'Total' soil contamination test results from this investigation, excluding asbestos, have been used in conjunction with the HazWasteOnline spreadsheets and the Technical Guidance WM3 published by the EA in order to determine whether the waste soils are deemed hazardous or non-hazardous.

The site soils were generally classified as non-hazardous, however were locally classified as hazardous due to a high pH. It is therefore recommended that any waste soil is tested prior to disposal and reassessed in order to minimise the quantity requiring costly hazardous disposal.

Different categories of waste soils must not be mixed. The action of mixing hazardous waste with non-hazardous waste to dilute hazardous concentrations or to dispose of one waste as/with another is illegal.

The assessment report is provided in Appendix F.

Asbestos

No obvious visual evidence of asbestos containing material (ACM) was noted in the soils during the fieldwork nor was any identified during laboratory testing.

Technical Guidance WM3 states that 'if the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% w/w or more asbestos'. It also states that 'where the waste contains identifiable *pieces* of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1% or more'.

In soils in which asbestos pieces visible by the naked eye are encountered, this soil is considered as mixed waste and must be separated whenever possible and each separate waste stream classified accordingly.

WASTE CLASSIFICATION

At present, it must be assumed that all waste soil leaving the site is 'hazardous' due to high pH.

If it is decided that the surplus arisings will be disposed of at a landfill facility, the implementation of the Landfill Directive means that the waste soil requires additional classification under the Waste Acceptance Criteria (WAC) to determine whether it should be destined for an inert, non-hazardous, stable non-reactive hazardous, or hazardous landfill, which can also lower landfill disposal costs. WAC testing has not been carried out under the scope of this investigation.

Uncontaminated soil and stones, including naturally occurring sands and clays, may be accepted in an inert landfill without testing, provided that it is not topsoil or peat and excludes soil from contaminated sites. Inert

waste should not undergo change, will not burn, react, biodegrade or adversely affect human health or the environment. It should not contain metals or plastics.

Should any soils be encountered that differ from those encountered during this investigation, further testing and waste classification of those soils will be required.

Different categories of waste soils must not be mixed. The action of mixing hazardous waste with non-hazardous waste to dilute hazardous concentrations or to dispose of one waste type as/with another is illegal.

Should pieces of ACM be encountered they should be segregated and disposed of as hazardous waste unless gravimetric testing indicates that the concentrations of asbestos fibres in the pieces is less than 0.1%.

Analytical results relevant to the materials being disposed of should be provided to the landfill operators or waste management contractors to confirm whether it meets their license agreements and to confirm tipping costs.

Asphalt surfaces may contain coal tar if laid down prior to the 1980s when coal tar was in production. Coal tar was used as a binder and later more commonly as top dressing. In the 1980s, the transition was made to bitumen however care should be taken where roads were constructed/improved after this date, as they may have been constructed using older road planings. Further assessment will be necessary to determine whether any asphalt contains coal tar for waste classification purposes.

LANDFILL TAX ASSESSMENT

It should be noted that in May/June 2012, HMRC issued Briefs 15/12 and 18/12 clarifying how construction spoil and excess soils will be assessed for landfill tax purposes. Detailed accurate descriptions of waste are required for all wastes to support the landfill tax assessment. Uncontaminated naturally occurring soils will remain inert by default and eligible for the lower rate of landfill tax. Similarly, 'reworked soils' and demolition 'stone' comprising ONLY materials listed in the Schedule of the Landfill Tax (Qualifying Material) Order 2011 (SI 2011/1017) will also be eligible for the lower rate of landfill tax.

RE-USE OF MATERIAL ON SITE

Currently, if surplus arisings are 'fit for re-use' on the site and have not been treated, its re-use is allowed within the planning law. If it needs treating prior to re-use, exemptions can be sought from the Environment Agency to allow this activity.

A recent voluntary code of practice published by CL:AIRE, in conjunction with the EA, (the Definition of Waste: Development Industry Code of Practice, Version 2) endorses the re-use of arisings on and off the site of origin without the need for exemptions from the EA, dependent on whether it is "fit for purpose". It also supports the use of "Hub and Cluster" sites (to enable surplus soil to be used on agreed sites in the local vicinity, dependent on the soil being 'fit for purpose').

Based upon the human health and groundwater risk assessments, the soils on this site are considered to be suitable to be re-used on site for landscaping, dependent on the agreement of the Local Authority, or for earthworks purposes, subject to appropriate compaction testing results.

RECOMMENDATIONS

No significantly elevated concentrations of contaminants were recorded by this investigation and as such, there is considered to be no significant risk of significant harm from contamination to the identified human health and controlled waters receptors.

Whilst there is considered to be a low risk of contamination at this site, it is prudent to bear in mind that some areas of the site have not been investigated. Soil is a heterogeneous material and variations, which affect the conclusions, may inevitably occur between and beyond the test locations. The risk of significant variation to the Ground Model is considered to be low however should ground conditions vary noticeably from the Ground Model, then it is recommended that work is ceased until further assessment by a suitably qualified person has been carried out.

Piled foundations are considered necessary within the Science Quad and the advice of a specialist piling contractor should be obtained to determine the most appropriate pile type and exact design specifications. If an assessment of construction-related ground movements is critical to design, then a separate detailed ground movement analysis should be undertaken.

Regarding the basement, it is recommended that existing foundations within influence of the excavation be supported by underpinning. Long-term groundwater monitoring is also recommended to establish potential seasonal variation that may impact basement excavation.

The requirement and specification of radon protection measures, with respect to the proposed basement and occupation should be discussed with the Local Authority.

Where Made Ground deeper than 0.6m bgl is encountered beneath the area of proposed pavement it is recommended that advice is sought from a soil reinforcement specialist to provide a subgrade with a known CBR value.

Should off-site disposal be required then further waste classification testing is recommended in order to reduce disposal costs. WAC testing will also be required should any soils be destined for landfill.

Infiltration tests undertaken in the standpipe installations varied significantly across the Parade Ground. Should a soakaway drainage solution be pursued, then it is recommended that supplementary infiltration tests are conducted in machine-excavated trial pits at proposed soakaway locations in order to aid their design. Contamination testing should also be undertaken should this not have been undertaken in this area previously.

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