whitby wood

Nestles Avenue

Geotechnical Design Report

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PREFACE

The following Desk Study document has been prepared by our partner organisation, A-Squared, for the use of DNA Capital Partners.

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Rev	Date	Purpose/Status `
P1	25/11/2021	Stage 4 Issue

A-squared Studio

233-236 Nestles Avenue

Geotechnical Design Report

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Appendices

1. Introduction

A-squared Studio Engineers Ltd (A-squared) has been appointed by Whitby Wood Ltd to support the geotechnical and substructure engineering scope relating to the proposed development at 233 – 236 Nestles Avenue, Hayes, London.

The Geotechnical Design Report (GDR) presented herein comprises an interpretation of the factual ground investigation works undertaken at the site, providing recommendations for the key geotechnical, ground engineering, construction considerations and a geo-environmental (land contamination) risk assessment associated with the proposed development.

1.1. Report Aims and Objectives

This GDR has been prepared in accordance with the general requirements of BS EN 1997 and provides the following:

- Technical assessment and interpretation of ground investigation data carried out for geotechnical design parameters.
- Outline assessment of deep foundations (ULS and SLS performance, and groundwater considerations including uplift and heave mitigation).
- General buildability and earthworks considerations.
- Geo-environmental assessment based on the ground investigation results, proposed development plans and *Geotechnical and Geo-environmental Desk Study Report* (ref: 1412-A2S-XX-XX-RP-Y-0001-01), dated September 2020.

The geo-environmental assessments comprise Generic Quantitative Risk Assessment (GQRA) and have been undertaken in general accordance with *Land Contamination Risk Management* (LCRM) guidance, published by the Environmental Agency on the UK Government website. The GQRA and geo-environmental recommendations are provided in the context of *National Planning Policy Framework* (NPPF) requirements and *The Building Regulations 2010, Approved Document C - Site preparation and resistance to contaminants and moisture (2004 Edition incorporating 2010 and 2013 amendments).*

The ground investigation has been undertaken in general accordance with BS10175:2011 Investigation of Potentially Contaminated Sites – Code of Practice.

The aim of this report is to present geotechnical recommendations and parameters based on the ground investigation results and to identify any unacceptable risks (ref. *LCRM*) due to land contamination which require further action.

1.2. Information Sources

The principal sources of information provided by the project team, which have informed the assessment presented herein, include the following:

- A-squared *Geotechnical and Geo-environmental Desk Study Report* (ref: 1412-A2S-XX-XX-RP-Y-0001-01), dated September 2020.
- GEA *Ground Investigation Report* (J19090), dated June 2019.
- RSP *Factual Ground Investigation Report* (JER9132), dated November 2021.
- Proposed scheme drawings produced by ColladoCollins Partners LL (20026).

It is noted that A-squared's *Geotechnical and Geo-environmental Desk Study Report* should be read in conjunction with this report as the content is not repeated herein.

2. The Site and Proposed Development

2.1. Development Location & Current Site Use

The proposed development site, herein referred to as 'the site', is located at numbers 3 & 233-236 Nestles Avenue, Hayes, UB3 4SH, within the London Borough of Hillingdon, as shown in Figure 2-1. The site is located approximately at the British National Grid coordinates of 509760E, 179310N. The site is located immediately to the south of Hayes and Harlington Station and is bounded by the station car park to the north. The site is bounded by Viveash Close to the east, Nestles Avenue to the south and an alleyway to the west, which separates the site from further industrial units.

The site, measuring approximately 100m x 150m in plan, covers an area of 1.56ha and is generally level at an elevation of +30 mOD. The road on Nestles Avenue is at a slightly raised elevation than the buildings, with a general slope downwards of the hardstanding from the road level to the buildings. The car park to the north of the site is approximately 1m higher and is supported by a brick retaining wall.

Figure 2-1 Location of proposed 233 – 236 Nestles Avenue Development (Site boundary in red)

The site is currently in use and comprises several industrial buildings, with site footprint mostly covered by the existing buildings and hardstanding. The existing buildings generally range in height from one to two storeys. The nature of the construction of the existing buildings is not entirely known, however they are anticipated to be founded on shallow foundations based on the trial pit investigations conducted on the site.

The building (No. 3) on the western portion of the site is occupied by the London Motor Museum (Figure 2-2) and the space is used to exhibit automobiles. The building to the east of the museum, fronting onto Nestles Avenue, is Building No. 233-236 Claremont House (Figure 2-3). No. 236 Claremont House is believed to have comprised a motor repair workshop and storage and is now vacant. The buildings to the north and east of the site are also vacant, but were previously occupied by multiple businesses, generally within the vehicle servicing and maintenance trades with associated workshops and office spaces. An electricity substation is present adjacent to the northeast corner of the site.

Image Source: Google maps (dated May 2019)

Figure 2-2 No.3 Nestles Avenue

Image Source: Google maps (dated May 2019)

Figure 2-3 N0.233-236 Claremont House

2.2. Summary of Site History

A review of the historical maps show that the site had been undeveloped from 1864-1920 but was instead used as a National Filling Factory (NFF) to fill munitions during WW1. From 1895-1897, the existing Nestles Avenue was constructed but not labelled. Within the period of 1914-1920 the site had a small footpath crossing the southeast corner. From 1932 - 1935, the site was partially occupied by a sports ground in the south-eastern portion and part of a building in the north-eastern corner while the northwest was wooded land. Also, the surrounding area has generally been significantly developed with residential buildings and Nestles Avenue is shown immediately to the south of the site. In 1938, a large rectangular building had been constructed in the western part in a similar position to the existing museum and the sports park is no longer shown. From 1946 the site was developed to comprise four large buildings and has remained relatively unchanged to date.

2.3. Proposed Scheme

The proposed development for 233-236 Nestles Avenue will comprise the construction of four new residential buildings between 10 and 11 storeys tall, with one to two storey connecting podium structures between each pair of buildings to house car parking and plant. There are no basements proposed for any of the buildings. However, there is a proposed car parking stacking facility in the north of the site beneath Buildings A & B, which will be located within a trench approximately 1.5m deep. There are limited areas of soft landscaping proposed around the buildings.

The proposed buildings will be constructed following the demolition of the existing buildings on site and general site clearance works. This may require the removal of any existing below ground structures, including bunkers, foundations, and existing infrastructure. Piled foundations, 600 mm in diameter to a maximum depth of between 25-30mbgl has been proposed to support the buildings.

The architectural drawing scheme is presented in Figures 2-4, 2-5 , and 2-6.

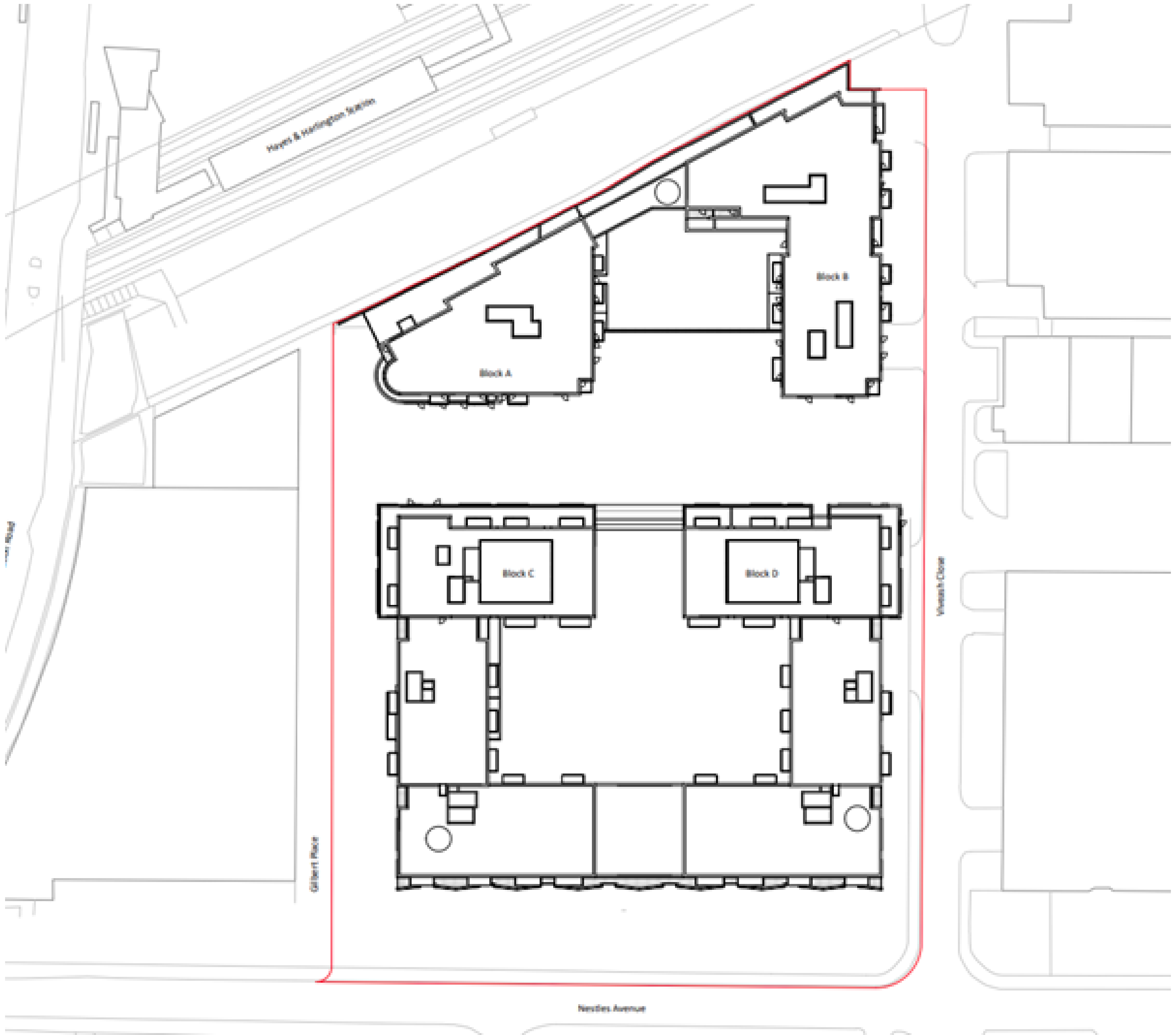


Figure 2-4 Proposed plan layout

Figure 2-5 **Proposed buildings A & B** north elevation

Figure 2-6 **Proposed buildings C & D** west elevation

2.4. Potential Land Contamination

The Preliminary Risk Assessment (PRA) presented in the *Geotechnical and Geo-environmental Desk Study Report is* summarised in Table 2.1. The Desk Study provides a baseline summary of site understanding prior to the ground investigation and GQRA presented herein. The risk assessments included in this GDR advance site geo-environmental understanding from that presented in the *Geotechnical and Geo-environmental Desk Study Report.*

Table 2.1 only includes receptors relevant to the proposed development given the context of this GDR i.e. risks to current site users are not considered.

Table 2.1 PRA summary

Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway	Risk Level Classification
On Site Made Ground Historic National Filling Factory Recent historic and current car workshops/garages Electricity Substation **Off-site** National Filling Factory Various historic and contemporary trade directories and factories Railway **Potential contaminants of concern** Heavy metals and metalloids, asbestos, hydrocarbons (PAHs and TPH), Volatile and Semi-Volatile Organic Compounds (VOCs and SVOCs), BTEX, MTBE, cyanide, PCBs, acids/alkalis, inorganics, radioactive material, explosives (TNT) acidity, elevated sulphate, vapours and ground gases (methane, carbon dioxide and hydrocarbons).	Direct human contact	Future site users (residential site users & visitors)	Yes	Moderate within any soft landscaping areas. Very Low in other areas.
	Inhalation (soil)		Yes	Moderate within any soft landscaping areas. Very Low in other areas.
	Ingestion		Yes	Moderate within any soft landscaping areas. Very Low in other areas.
	Leaching and migration via groundwater and surface water		Yes	Low
	Ground gas and vapour migration via permeable soils		Yes	Low to Moderate within any ground-floor enclosed spaces
	Direct contact with aggressive ground conditions	Building materials (services and buried concrete)	Yes	Low
	Migration of contaminants: non-aqueous phase		Yes	Low
	Migration of contaminants: aqueous phase		Yes	Low
	Migration of contaminants off-site: non-aqueous phase	Adjacent Properties	Yes	Low
	Migration of contaminants off site: aqueous phase		Yes	Low
	Ground gas and vapour migration via permeable soils		Yes	Low
	Migration of contaminants from site: non-aqueous phase	Principal Aquifer groundwater	Yes	Low
	Migration of contaminants from site: aqueous phase		Yes	Low
	Migration of contaminants from off-site onto the site: aqueous phase		Yes	Low
	Migration of contaminants via aquifer: non-aqueous phase	Surface water	Yes	Very Low
	Migration of contaminants via aquifer: aqueous phase		Yes	Very Low

3. Geological Setting

3.1. Regional Geological Overview

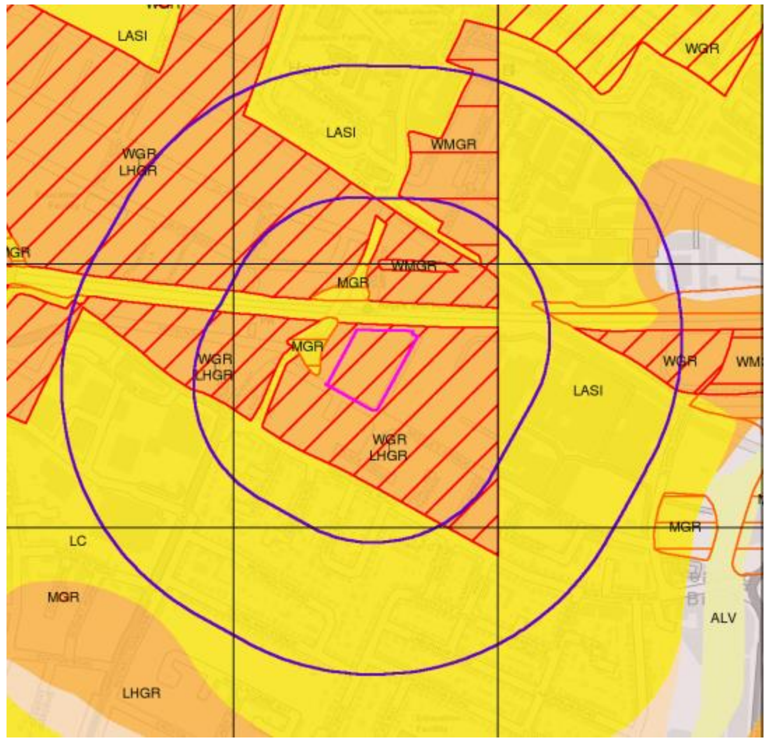
The development site is located on the edge of the London Basin, which refers to an approximately triangular synclinal structure in which the sedimentary units underlying London and much of southeast England were deposited. The London Basin is comprised of the following formations, in order of decreasing depth:

- A deep (~200m thick) layer of Chalk, deposited throughout the Upper Cretaceous period, forms the base of the basin and is the principal aquifer of the region.
- The Thanet Beds, which comprise fine, silty glauconitic sands originating in shallow seas.
- The Lambeth Group, a depositionally and geographically complex unit which comprises layers of sands and gravels, shelly and mottled clays, minor limestones and lignites, and occasional sandstone and conglomerate.
- The London Clay Formation, a fine-grained silty clay, which is the dominant Thames Group deposit.
- River Terrace Gravels, comprising the Lynch Hill Gravel Member and Langley Silt Member, deposited by the River Thames and its tributaries on top of the London Clay.

3.2. Site Geology and Anticipated Ground Conditions

Figure 3-1 shows the location of the development within the context of a regional geological map. The geological map indicates the site to be underlain by worked Made Ground, although the source of this is not clear from historic map and may be associated with the former brickfields to the north of the site, prior to 1914, or the National Filling Factory munitions factory which occupied the site during the First World War. The areas of worked Made Ground tie in with the gaps in the Langley Silt, therefore it is possible that the superficial deposits have been removed.

Based on the geological map, the site is anticipated to comprise Made Ground, underlain by the Lynch Hill Gravel Member which is further underlain by the London Clay Formation, Lambeth Group, Thanet Sands and Chalk.



Artificial Ground and Landslip

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	WGR	Worked Ground (Undivided)	Unknown/Unclassified Entry	Holocene - Holocene
	MGR	Made Ground (Undivided)	Unknown/Unclassified Entry	Holocene - Holocene
	WMGR	Infilled Ground	Unknown/Unclassified Entry	Holocene - Holocene
	LSGR	Landscaped Ground (Undivided)	Unknown/Unclassified Entry	Holocene - Holocene
	WGR	Worked Ground (Undivided)	Void	Holocene - Holocene
	WMGR	Infilled Ground	Artificial Deposit	Holocene - Holocene
	MGR	Made Ground (Undivided)	Artificial Deposit	Holocene - Holocene

Superficial Geology

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	ALV	Alluvium	Silt	Flandrian - Pleistocene
	LASI	Langley Silt Member	Silt	Devensian - Ipswichian
	LHGR	Lynch Hill Gravel Member	Sand and Gravel	Wolstonian - Chokierian
	LHGR	Lynch Hill Gravel Member	Gravel	Wolstonian - Chokierian
	TPGR	Taplow Gravel Formation	Sand and Gravel	Wolstonian - Chokierian
	BHT	Boyn Hill Gravel Member	Sand and Gravel	Wolstonian - Wolstonian

Bedrock and Faults

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	LC	London Clay Formation	Clay	Eocene - Eocene
	LC	London Clay Formation	Clay, Silt and Sand	Eocene - Eocene

Approximate site location shown in magenta

Figure 3-1 1:10,000 Geological map

4. Ground Investigation

A site-specific ground investigation was undertaken in 2019 by Geotechnical & Environmental Associates Ltd (GEA) and another one was undertaken in July to November 2021 by RPS. Details of the ground investigation findings are presented in the GEA *Ground Investigation Report* and RPS *Factual Ground Investigation Report* (as referenced in Section 1), which is included in Appendix B and Appendix C, respectively.

4.1. GEA Ground Investigation

The principal technical objectives of the work carried out were as follows:

- Assess the risk of encountering unexploded ordnance (UXO) beneath the site.
- Determine the ground conditions and their engineering properties.
- Provide advice with respect to the design of suitable foundations.
- Provide an indication of the degree of soil contamination present.
- Assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

The general scope of the investigation is summarised as follows:

- Detailed Unexploded Ordnance (UXO) risk assessment in accordance with CIRIA C681.
- 6 boreholes advanced to a depth of 30.00 m using a cable percussion rig.
- 14 boreholes advanced to a maximum depth of 2.45 m by means of an open drive percussive sampling (Terrier) rig.
- In situ standard penetration tests (SPTs) carried out at regular intervals within the boreholes to provide quantitative data on the strength of the soils.
- Installation of six gas and groundwater monitoring standpipes to a depth of 6.00 m and a single return monitoring visit.
- Sampling and testing of selected soil samples for contamination and geotechnical purposes.

The exploratory hole plans of the investigation are presented in Figure 4-1.

A series of in-situ and laboratory geo-environmental and geotechnical tests were performed as part of the investigative efforts, including the following:

In-Situ Testing:

- Standard penetration tests (SPT).

Geotechnical Laboratory Testing:

- Moisture content tests.
- Atterberg Limit tests.
- Particle size distribution tests.
- BRE SD1 Suite D tests.
- Unconsolidated Undrained triaxial compression tests.

Geo-environmental Laboratory Testing (Soil):

Determinant	No. of Laboratory Tests	Sample Matrix
Heavy metals suite also including hexavalent chromium	13	Soil
Total Organic Carbon (TOC)	13	Soil
Total Petroleum Hydrocarbon - Criteria Working Group methodology (TPHCWG) including BTEX	13	Soil
Total Petroleum Hydrocarbon (broken down into aliphatic and aromatic compounds)	1	Soil
Speciated Polycyclic Aromatic Hydrocarbons (PAHs) (EPA16 reported)	13	Soil
Asbestos	14	Soil
pH	13	Soil
Sulphate (Water Soluble)	13	Soil
Sulphide	13	Soil
Cyanide (total)	13	Soil
Phenol (total)	13	Soil
Chloride	13	Soil
Polychlorinated Biphenyl (PCBs)	6	Soil
Volatile Organic Compounds (VOCs)	13	Soil

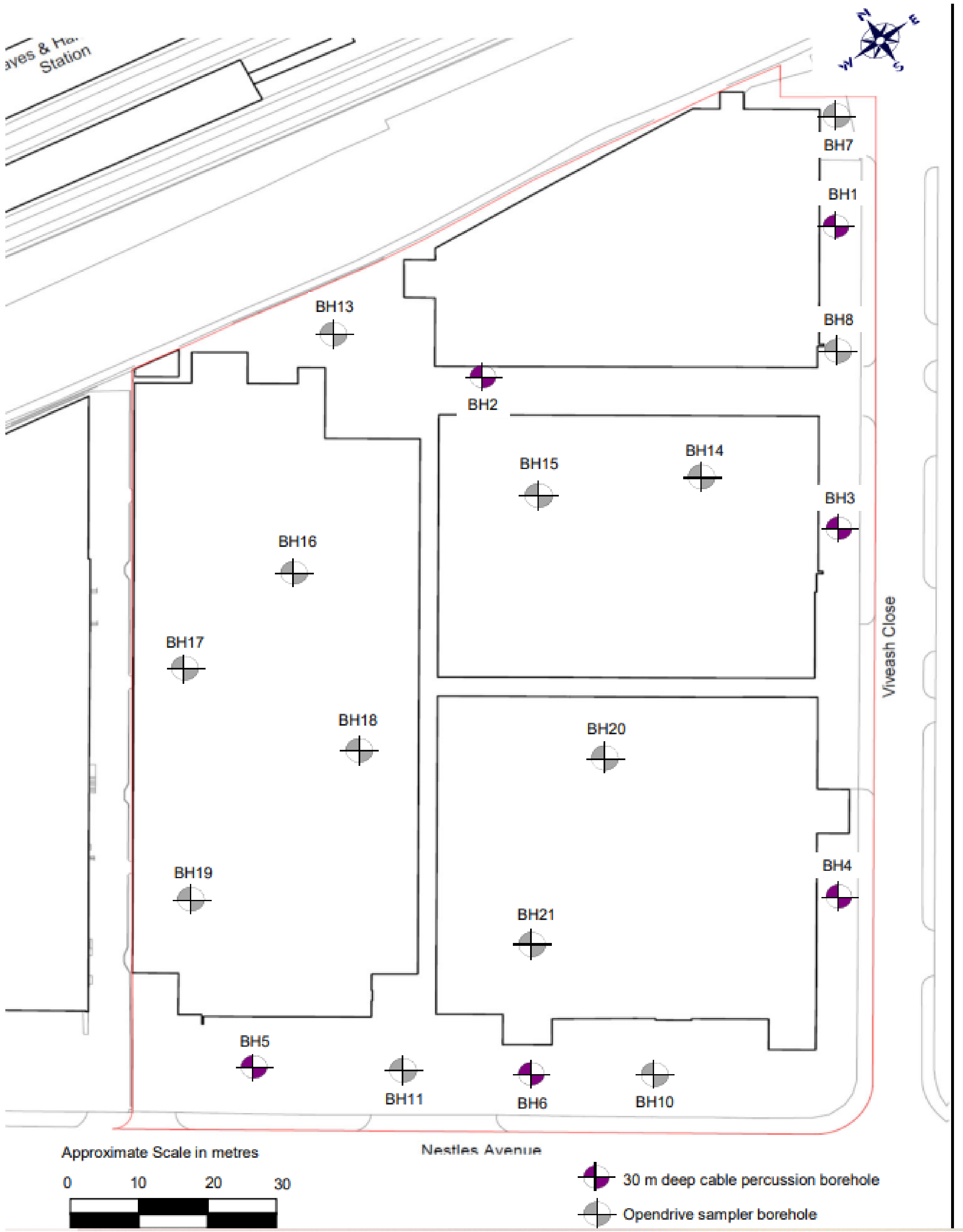


Figure 4-1 GEA Exploratory hole location plan

4.2. RPS Ground Investigation

The principal technical objectives of the work carried out were as follows:

- Verify the findings of the previous investigation undertaken by GEA.
- Provide assessments of the ground conditions for preliminary and detailed substructure design of the proposed developments.
- Determine the chemical conditions of the soil with respect to below-ground concrete.
- Determine the depth of any groundwater and the pore water pressure profile.
- Assess the current geo-environmental conditions of the site.

The general scope of the investigation is summarised as follows:

- 1 cable percussive boreholes to a depth of 30.00 metres below ground level (m bgl) (BH101).
- 5 window samples boreholes to depths of between 1.00 m and 1.50 m bgl (WS102 to WS106).
- Installation of a gas and groundwater monitoring well standpipe within the cable percussive borehole.
- Installation of gas and groundwater monitoring well standpipes to various depths within three of the window sample boreholes.
- Excavation of 5 hand dug foundation inspection pits to a maximum depth of 1.20 m bgl.
- On site screening analysis of soil samples for ionisable Volatile Organic Compounds (iVOCs) using a Photo-ionisation Detector (PID.
- Sampling and testing testing of selected soil and groundwater samples for contamination and geotechnical purposes.
- 6no. groundwater and ground gas monitoring readings from monitoring wells.

The exploratory hole plans of the investigation are presented in Figure 4-2.

A series of in-situ and laboratory geo-environmental and geotechnical tests were performed as part of the investigative efforts, including the following:

In-Situ Testing:

- Standard penetration tests (SPT)
- In-situ soil sample head-space testing for volatile organic compounds (VOCs) using a photoionisation detector (PID).

Geotechnical Laboratory Testing:

- Moisture content tests.
- Atterberg Limit tests.
- Particle size distribution tests.
- BRE SD1 Suite D tests.
- Unconsolidated Undrained Triaxial Compression tests.
- Sedimentation tests.

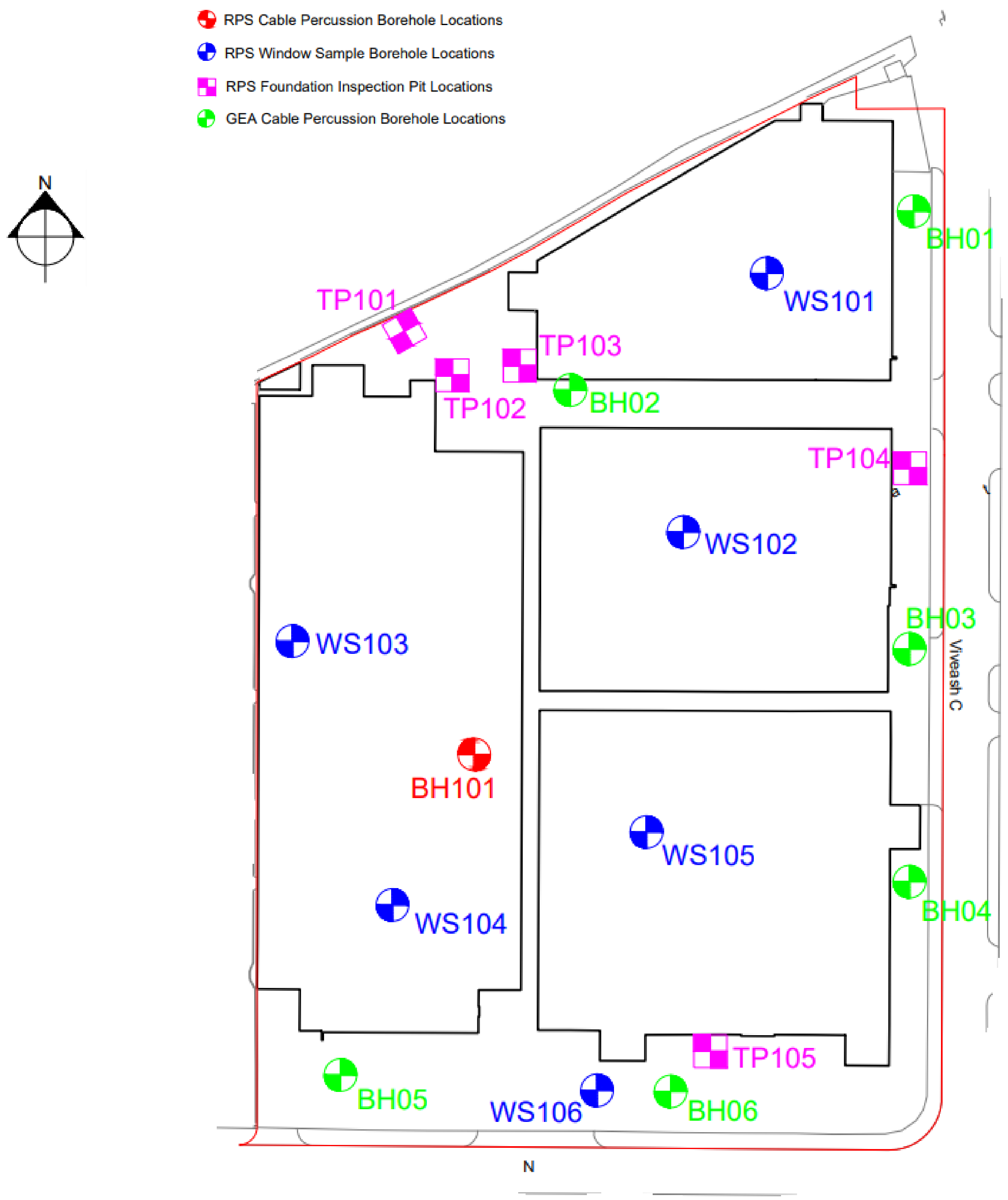
Geo-environmental Laboratory Testing (Soil):

Determinant	No. of Laboratory Tests	Sample Matrix
Heavy metals suite also including hexavalent chromium	7	Soil
Cyanide (free & total)	7	Soil
pH	7	Soil
Total Petroleum Hydrocarbon - Criteria Working Group methodology (TPHCWG) including BTEX	7	Soil
Speciated Polycyclic Aromatic Hydrocarbons (PAHs) (EPA16 reported)	7	Soil
Asbestos	7	Soil
Ammoniacal nitrogen	7	Soil
Nitrate	7	Soil

Determinant	No. of Laboratory Tests	Sample Matrix
Nitrite	7	Soil
Chlorate	7	Soil
Sulphur	7	Soil
Total sulphate	7	Soil
Water soluble sulphate	7	Soil
Volatile Organic Compounds (VOCs)	5	Soil
Polychlorinated biphenyl (PCBs) suite (WHO12).	5	Soil
Total Organic Carbon (TOC)	9	Soil
Fraction Organic Carbon (FOC)	9	Soil
Explosives suite	4	Soil
Heavy metals suite also including hexavalent chromium	7	Leachate
Speciated Polycyclic Aromatic Hydrocarbons (PAHs) (EPA16 reported)	7	Leachate

Geo-environmental Laboratory Testing (Groundwater):

Determinant	No. of Laboratory Tests	Sample Matrix
Heavy metals suite also including hexavalent chromium	6	Water
Total Petroleum Hydrocarbon - Criteria Working Group methodology (TPHCWG) including BTEX	6	Water
Speciated Polycyclic Aromatic Hydrocarbons (PAHs) (EPA16 reported)	6	Water
Volatile Organic Compounds	5	Water
PCB Suite	1	Water
Sulphate	6	Water
Cyanides	6	Water
Phenolics	6	Water



4.3. Figure 4-2 RPS Exploratory hole location planMonitoring Well Installations

Combined ground gas / soil vapour and groundwater monitoring wells were installed during both phases of investigation. The RPS wells were constructed using 50 mm internal diameter HDPE standpipe and a bung with gas valve was placed at each well head. The GEA report does not state the diameter of standpipe used or the response zone construction details. Summary detail of the well installations is presented in Table 3.1.

Table 3.1 Summary Monitoring Well Construction Details

Investigation	Location Ref.	Base of Borehole (m bgl)	Standpipe Internal Diameter (m bgl)	Top of Response Zone (m bgl)	Base of Response Zone (m bgl)	Screened Stratum
GEA 2019	BH01	30	Unknown	Unknown	6.0	Unknown
	BH02	30	Unknown	Unknown	6.0	Unknown
	BH03	30	Unknown	Unknown	6.0	Unknown
	BH04	30	Unknown	Unknown	6.0	Unknown
	BH05	30	Unknown	Unknown	5.7	Unknown
	BH06	30	Unknown	Unknown	5.8	Unknown
RPS 2021	BH101	30	50 mm	1.0	6.0	Lynch Hill Gravel Member
	WS102	1.0	50 mm	0.5	1.0	Lynch Hill Gravel Member
	WS103	1.3	50 mm	1.0	1.3	Lynch Hill Gravel Member
	WS106	1.5	50 mm	1.0	1.5	Made Ground and Lynch Hill Gravel Member

4.4. Return Monitoring Visits

6 no. return monitoring visits were undertaken as part of the RPS investigation. The return visits included ground gas monitoring at each RPS installed well location and monitoring wells from the previous GEA investigation which could be identified and were serviceable. A calibrated Gas Data GFM436 hand-held gas analyser and a calibrated MiniRae Lite ATEX PID were used. The data collected included ground gas concentrations and ground gas flow rates.

Each return visit also included groundwater level gauging at each of the installed monitoring wells using an oil-water interface probe. 1 no. round of groundwater sampling and water quality monitoring was undertaken using low-flow methods and a multiparameter water meter.

No monitoring occurred as part of the GEA 2019 investigation.

Ground Conditions

4.5. Ground Model

A summary of the ground conditions encountered during the intrusive investigation is presented in Table 0.1 below.

Table 0.1 Summary of the encountered geological profile

Unit	Maximum Level (mOD) [1]	Minimum Level (mOD)[1]	Minimum Depth (mbgl)[1]	Maximum Depth (mbgl)[1]	Thickness (m) [average]	Description
Made Ground	32.15	31.51	GL	GL	0.30 – 1.70 [0.92]	Concrete/ asphalt overlaying Made Ground aggregates comprising of brown clayey sand with variable amounts of gravel, cobbles, brick, concrete, ash, tile and pipe fragments.
Lynch hill Gravel	31.3	29,95	0.3	1.7	3.55-5.40 [4.46]	Dense and very dense yellow-brown and brown sandy gravel and gravelly sand.
London Clay[2]	26.76	25.76	4.75	5.80	Not proven	Firm brown mottled orange-brown slightly sandy slightly silty clay, stiff becoming very stiff high becoming very high and locally extremely high strength fissured brownish grey silty clay occasional pale grey veins, shell fragments, selenite crystals and sandy layers

1. Depth to the top of strata; mOD: metres above Ordnance Datum; mbgl: metres below ground level.
2. Claystone encountered at a depth of 15.5 mbgl (Borehole 3) and 14 mbgl (Borehole 4)

Water strikes were recorded in BH1, 2 and 3 (GEA) during the intrusive in the northern section of the site, at a depth of 4.50 m from within the Lynch Hill Gravel, which was noted as rising to a depth of 4.00 m.

4.5.1. Made Ground

The Made Ground is a heterogeneous mixture of natural soils and anthropogenic materials. Made Ground was encountered in the boreholes, window sample holes, and trial pits to depths of up to 1.7mbgl.

The Made Ground varies across the site but is generally comprised of subgrade type material described as either brown, dark brown, and yellowish clayey, sandy and gravelly mixture. This material contained varying amounts of oyster shells, brick, concrete, ash, slag, coal, flint, tile, and pipe fragments.

- The surface level was recorded as CONCRETE between 100 mm to 400 mm thick, although the concrete was not encountered everywhere. Reinforced concrete encountered at WS102 and TP102 of 150 mm and 250 mm thick respectively.
- 50 mm thick TARMACADAM encountered at WS106 at level surface.
- 100 mm thick Brick Paving underlying concrete at TP105.
- Yellow brown sandy gravelly, CLAY with low cobble content of brick/high cobble content of angular concrete, occasional black ash pockets (2cm x 2cm). Gravel is angular to subangular/subrounded fine to coarse of flint, brick, concrete, coal, tile and oyster shells. Sand is fine to coarse.
- Soft dark brown slightly gravelly clayey, soft brown slightly gravelly clayey SILT with frequent ash pockets (5cm x 3cm). Gravel is angular to subangular fine to medium of brick, concrete, chalk and slag.
- Dark brown clayey, brown clayey fine to coarse SAND with occasional ash, gravel, brick and concrete fragments.
- Brown slightly silty sandy grey angular coarse GRAVEL with high to medium cobble content of brick and concrete. Gravel is angular to subangular fine to coarse of concrete, brick, clinker, flint, coal fragments and oyster shells. Sand is fine to coarse.

A total of 2no. (RPS = 1no. thus, GEA = 1no. thus) in-situ SPT tests were carried out in the Made Ground layer. The SPT N_{60} blow count ranged from 39 to 59 blows/300 mm, with an average of 49.

It is noted that the Made Ground is an uncontrolled fill and is inherently variable in terms of its consistency, characteristics, and engineering properties. This stratum is not recommended to be relied upon to support any engineered structures.

Due to the variability with regards to source and deposition, the assessment of its engineering performance must be undertaken with appropriate caution. The limited thickness of the layer means that it will likely be excavated during the construction of the proposed ground floor slabs.

4.5.2. Lynch Hill Gravel

The Lynch Hill Gravels were encountered in the majority of locations, except in WS101, TP101, TP102, and TP103 (RPS) where the test depth terminated at the Made ground layer. This stratum generally comprised dense and very dense yellowish brown and brown sandy gravel and gravelly sand.

The encountered materials were described as follows:

- Dense to very dense orange yellowish sandy, orange brown slightly silty sandy, dense yellow brown sandy, brownish orange clayey sandy fine to coarse angular/subangular to subrounded/rounded flint GRAVEL. Sand is fine to medium.
- Dense to very dense yellowish brown, medium dense brown, dense brown clayey fine to coarse SAND with fine to coarse sub-angular to sub-rounded gravel, and pockets of orange-brown sandy clay.
- Soft orange brown slightly gravelly sandy SILT. Gravel is subangular to subrounded fine to medium of flint.
- Firm yellowish brown silty slightly sandy, greyish brown gravelly sandy silty CLAY with fine to coarse sub-angular to sub-rounded gravel.

A total of 55no. (RPS = 9no. thus, GEA = 46no. thus) in-situ SPT tests were carried out in the Lynch Hill Gravel layer. The SPT N_{60} blow count ranged from 18 to 98 blows/300 mm, with an average of 57.

A total of 2no. (RPS = 1no. thus, GEA = 1no. thus) Moisture content and Atterberg limits tests were undertaken for clay material in the Lynch Hill Gravel strata. The results indicate that the moisture content ranges between 11.3% and 21% with an average of 16.15%. The liquid limit and plasticity index ranges between 30% to 45% and 11% to 27%, respectively, indicating a low to intermediate plasticity clay.

A total of 16no. (RPS = 4no. thus, GEA = 12no. thus) particle size distribution (PSD) tests were performed on samples from this stratum. The results show 30% to 92.3% gravel, 7.3% to 68% sand and 0.4% to 14.7% fines (<0.063 mm) contents, with coefficient of uniformity ranging from 2 to 206.

The response to loading of the Kempton Park Gravels is assumed to be drained, where excess pore pressures will not develop as a result of changes in total stress. This is based on high content of coarse sands and gravels relative to fines and typical visual description of these deposits.

The Lynch Hill Gravels been deposited recently in geological terms. The deposit has not been subjected to significant mechanical loading due to overburden nor subsequent erosion and unloading. The deposit is expected to be normally consolidated to lightly overconsolidated.

The Lynch Hill Gravels comprise a competent engineering material which will provide a medium to high bearing resistance for shallow geotechnical elements in addition to reasonable shaft resistance for bearing piles.

4.5.3. London Clay

The London Clay comprised an initial weathered layer of firm brown mottled orange-brown slightly sandy slightly silty clay, which extended to depths of between 5.2m and 6.2m. Beneath this the stratum comprised stiff becoming very stiff fissured brownish grey silty clay occasional pale grey veins, shell fragments, selenite crystals and sandy layers, which extended to the full depth of investigation of 30.0m.

Claystones were encountered at depths of 15.4m in Borehole No 3 and 14.0m in Borehole No 4 (GEA). In the RPS investigation claystones were encountered at depths of 21.1m, 23.7m, and 27.6m.

The encountered materials were described as follows;

- Firm to very stiff brown, fissured blueish grey slightly sandy becoming sandy silty CLAY with shell fragments, pale grey veins, selenite crystals.

A total of 59no. (RPS = 9no. thus, GEA = 50no. thus) in-situ SPT tests were carried out in the London Clay layer. The SPT N60 blow count ranged from 14 to 61 blows/300 mm, with an average of 35.

A total of 72no. (RPS = 16no. thus, GEA = 56no. thus) moisture content tests were undertaken on samples taken from the London Clay. The results indicate the moisture content ranges between 16% and 28% with an average of 24.84%. A total of 16no. (RPS = 7Nno. Thus, GEA = 9no. thus) Atterberg limits tests were undertaken. The liquid limit and plasticity index ranges between 61% to 77% and 37% to 52%, respectively, indicating a high to very high plasticity clay.

Two particle size distribution (PSD) test were performed on samples from this stratum (RPS, BH101). The results show between 0.5% to 5.4% gravel, 0.9% to 2% sand, 42.8% to 46.7% silt, and 45.9% to 55.8% clay contents.

54 (RPS = 8no. thus, GEA = 46no. thus) undrained triaxial compression tests were conducted on undisturbed London Clay samples. These gave undrained shear strengths ranging from 90 kPa to 352 kPa. The average dry and bulk density of the samples were approximately 1.61 Mg/m^3 and 2.02 Mg/m^3. The bulk and dry density appear to be relatively consistent over the depth of the stratum.

The London Clay is well known to be heavily overconsolidated as a result of erosion of approximately 200m of material following deposition. A coefficient of horizontal earth pressure at rest, K_0, of 1.0 to 1.5 is considered suitable for routine design work, based on past experience and extensive published data. The design of any substructure elements may consider the impact/effect of any given stress paths and installation effects, as appropriate (it is noted that the in-situ *undisturbed* K_0 may be greater than the range given – however it is common to account for disturbance, installation effects and reduction in in-situ pressure at rest conditions as part of retaining wall design, for example).

The London Clay Formation is a competent stratum and is often used to found permanent structural foundations including shallow footings, rafts, piled rafts and pile foundations in London.

The formation is considered to provide good conditions for construction, not requiring the use of dewatering systems to enable dry excavation due to its low permeability, and not requiring the use of wet construction methods when carrying out bored piling. Notwithstanding, upper layers of cohesionless superficial deposits will generally require temporary casing.

4.6. Characteristic Geotechnical Parameters

The purpose of this section of the GDR is to describe the salient physical properties of the main geological units that were encountered during the ground investigation works. The information reviewed in this chapter includes stratigraphy, in conjunction with basic physical characteristics (particle grading, density, moisture content and consistency), as evaluated from laboratory testing.

Additionally, this section aims to provide an understanding of the basic characteristics of the various soils deposited at the development site, from which a more detailed understanding of their engineering behaviour and associated risks can be derived.

The geotechnical design of the proposed development will be performed in accordance with the requirements of BS EN 1997 Eurocode 7: Part 1 Geotechnical Design. The selection of geotechnical properties for design should thus represent *characteristic* values, which is defined as that which *represents a cautious estimate of the value affecting the occurrence of the limit state* (BS EN 1997-1 §2.4.5.2(2)P). This definition of the *characteristic* value differs from that for other Eurocodes, which define the characteristic value as being based on a statistical estimate of the 95% probability of occurrence.

The use of limit states thus invokes subtleties into design that must be appreciated by the Geotechnical Designer, not least that a particular soil property (e.g. unit weight), may have multiple *characteristic* values, depending on the structure type and limit state under consideration. For example, when assessing the ultimate bearing capacity of a pad footing, the characteristic value (cautious estimate) of the unit weight of soil above the founding level may represent a *lower bound* of the measured values. However, in the evaluation of structural forces within an embedded retaining wall an *upper bound* of the measured values may represent a cautious estimate for that particular limit state.

The characteristic values presented herein represent those that are assessed to be most relevant to the types of routine calculations that may be performed, e.g. cautious (lower bound) estimates for strength and stiffness, as they are likely to relate to the design of piled foundations and embedded retaining structures. Notwithstanding this, the Designer may need to evaluate alternative *characteristic* values from the presented to facilitate design in accordance with the Eurocodes.

The characteristic geotechnical parameters determined for the main geological units are shown in Table 0.2.

Table 0.2 Characteristic geotechnical parameters adopted for design

Stratum	Top of strata (mbgl)	$\gamma_{b,k}$ (kN/m^3)[2]	$\varphi'_{cv,k}$ (°)	c'_k (kPa)	$c_{u,k}$ (kPa)	E' (MPa) [10]	E_u (MPa) [10]	ν	K_0[12]
Made Ground[3]	0.00	18	30	0	-	10.0	-	ν′ = 0.2	0.5
Lynch Hill Gravels[4]	1.00	19	38[5]	0	-	52[13]	-	ν′ = 0.2	0.38
London Clay	5.00	20	23[5]	5[6]	80 + 5.2z[1] [6]	V: 32 + 2.08z[1] [9] H: 84 + 4.16z[1] [9]	V: 40 + 2.6z[1] [7] H: 80 + 5.2z[1] [8]	ν′ = 0.2 ν_u = 0.5[11]	1.2

$\gamma_{b,k}$: bulk unit weight $\varphi'_{cv,k}$: effective critical state angle of shearing resistance c'_k: effective cohesion $c_{u,k}$: undrained shear strength E': drained Young's Modulus
E_u: undrained Young's Modulus ν: Poisson's Ratio K_0: in-situ lateral earth pressure coefficient V: Vertical H: Horizontal

1. z refers to the depth in metres below the top of the Stanmore Gravels.
2. Bulk unit weights are based on material descriptions and bulk density testing.
3. Moderately conservative geotechnical parameters representative of the variable nature of the Made Ground have been provided based on the material description.
4. The Lynch Gravels have been conservatively assumed to be a predominantly non-cohesive material based on the test data and material description.
5. The effective critical state angle of shearing resistance for the Lynch Hill Gravel & London Clay strata has been calculated from the plasticity index using Equation 7 from BS 8002:2015 Code of practice for earth retaining structures.
6. Undrained shear strength, $c_{u,k}$, of the London Clay strata has been estimated from SPT N_{60} values and unconsolidated undrained (UU) triaxial tests. SPT N_{60} and c_u have been correlated using the ratio $c_u/N_{60} = f_1 = 5.0$, per CIRIA C143. The SPT N_{60} plot and the c_u plot with the adopted design line are presented in Figure 0-1 and Figure 0-2, respectively.
7. Undrained vertical stiffness of the London Clay strata has been estimated using the relationship $E_u/c_u = 500$.
8. Undrained horizontal stiffness of the London Clay strata has been estimated using the relationship $E_u/c_u = 1000$.
9. Drained vertical and horizontal stiffnesses of the London Clay strata have been estimated using the relationship $E_u/E' = 0.8$.
10. Where no horizontal stiffness of a material is provided, the soil is assumed to be isotropic.
11. ν_u is the undrained Poisson's Ratio (no volume change undrained condition).
12. K_o calculated from $1 - \sin\varphi'$ for normally consolidated and lightly overconsolidated materials.
13. The stiffness of the Kempton Park Gravels has been determined using the correlation E' = 1-2N_{60} MPa from CIRIA C143, using a characteristic N_{60} value of 26 and taking E' as 2N_{60}.

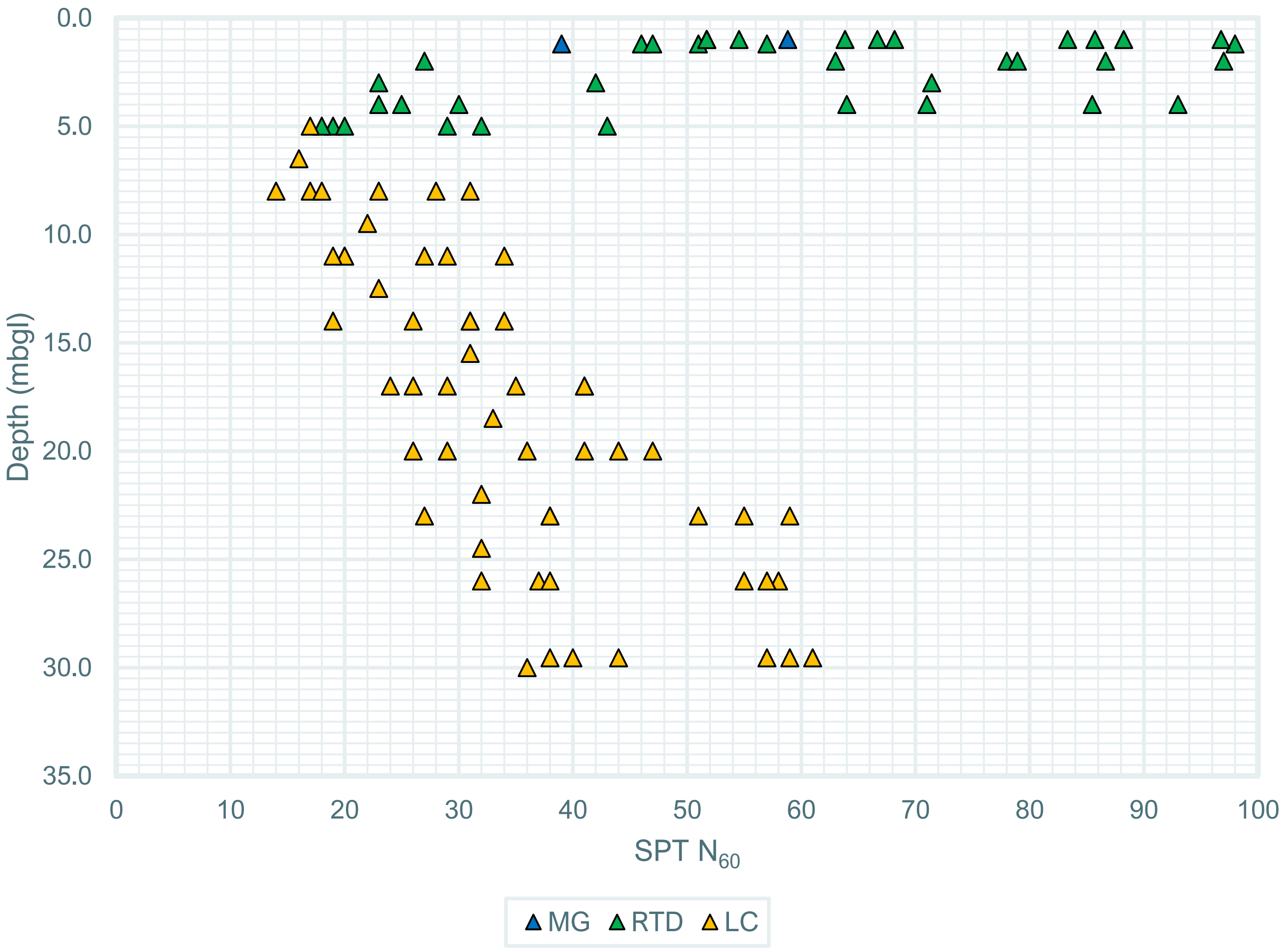
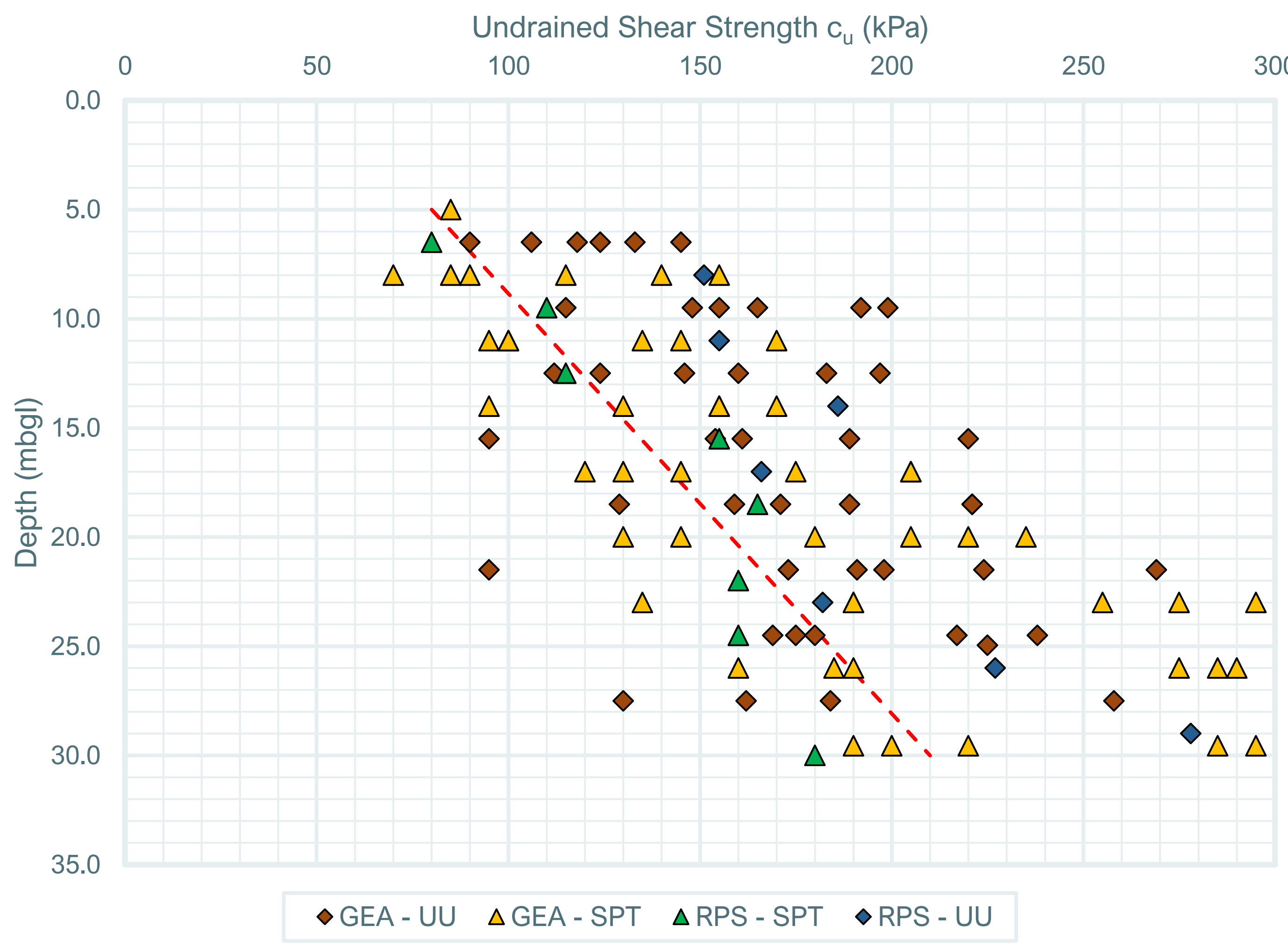


Figure 0-1 SPT N_{60} results



Design line shown in red.

Figure 0-2 Undrained shear strength, Cu (kPa)

4.7. Groundwater

Groundwater monitoring was carried out on six occasions between 21st September and 5th November 2021. A total of 9 groundwater standpipes were installed on the site; GEA - Boreholes 1, 2, 3, 4, 5, and 6 (GEA) to a depth of 6.00 mbgl and RPS – BH101, WS102, WS103 and WS106 at varying depths. Groundwater was encountered within the Lynch Hill Gravel layer, perched on the London Clay. A summary of the groundwater monitoring results is presented below in Table 0.3 and Figure 0-3.

The water table is likely to vary seasonally over the design life of the proposed development, as a result of human induced phenomena and hydrological/hydrogeological features in proximity of the site.

It is recommended that design water table at of 2.5m below existing ground level is adopted in the short-term and long term for substructure design.

Table 0.3 Groundwater monitoring results

Location	Well base (mbgl)	Groundwater Reading - mbgl					
		21/09/21	07/10/21	14/10/21	21/10/21	26/10/21	05/11/21
BH01	6.00	3.57	3.41	3.44	3.37	3.36	3.21
BH02	6.00	3.09	2.95	3.10	3.06	2.99	3.17
BH03	6.00	3.31	3.06	3.09	3.13	3.09	3.16
BH05	5.70	3.39	3.28	3.35	3.39	-	-
BH06	5.80	-	-	3.15	3.10	2.72	3.11
BH101	6.00	3.23	3.14	3.28	3.09	5.25	3.31
WS102	1.00	Dry	Dry	Dry	Dry	Dry	Dry
WS103	1.30	Dry	Dry	Dry	Dry	Dry	Dry
WS106	1.50	Dry	Dry	Dry	Dry	Dry	Dry

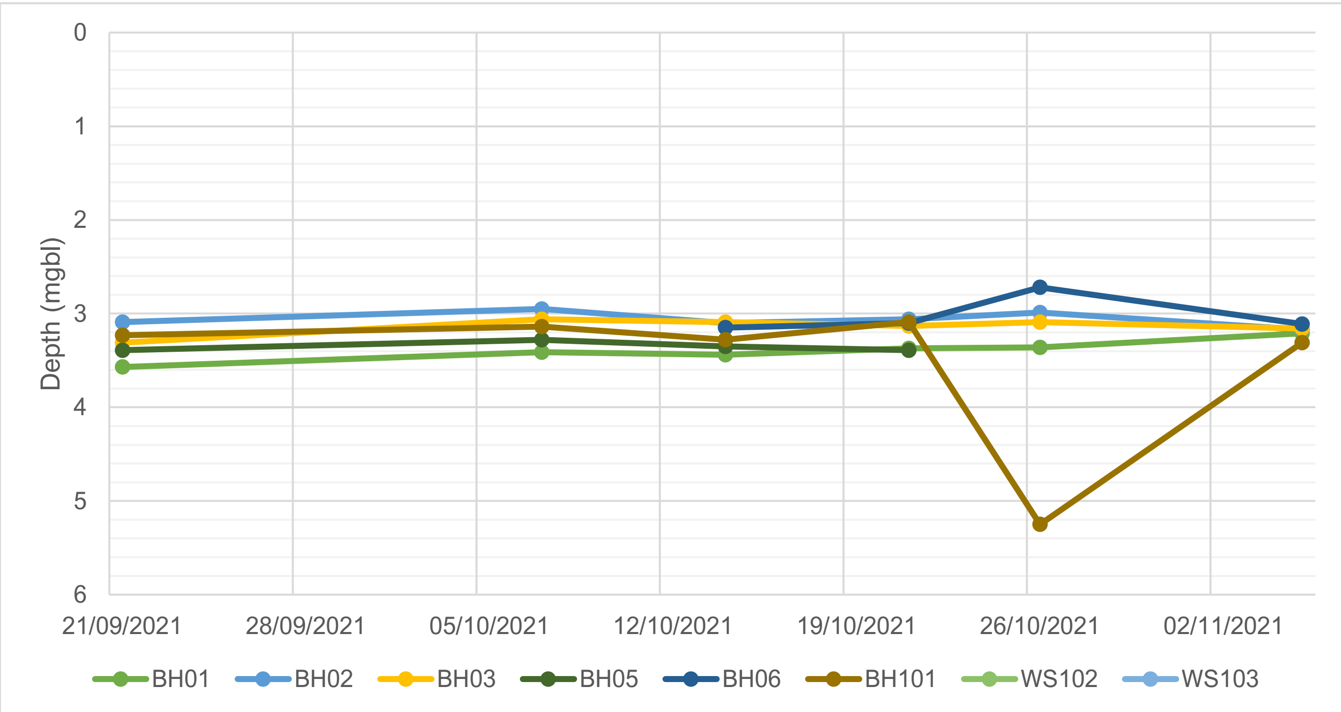


Figure 0-3 Groundwater monitoring elevations

The groundwater dip data is diagrammatically presented in Figure 5-5 as elevations in m aOD.

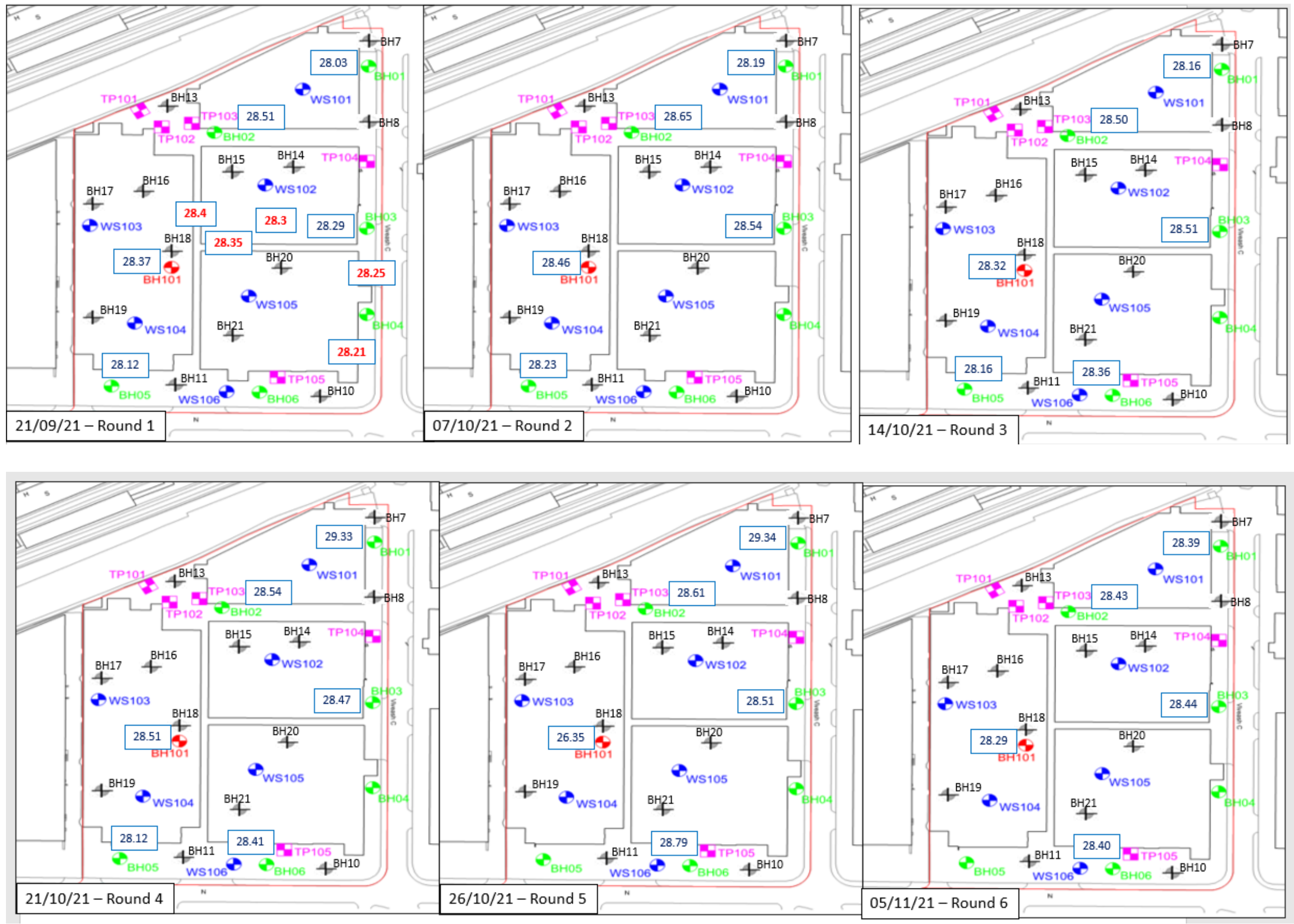


Figure 5-5 Groundwater Elevations Data

The calculated groundwater elevations do not indicate a consistent groundwater flow direction across all monitoring rounds.

4.8. Ground Gas and Soil Vapour

The ground gas and soil vapour monitoring results are summarised in Table 5.5.

Table 5.5 Summary Ground Gas / Soil Vapour Monitoring Results

Exploratory Hole Reference	Monitoring Round Date	Minimum O_2 (%)	Maximum CO_2 (%l)	Maximum CH_4 (%)	Maximum H_2S (ppm)	Maximum CO (ppm)	Flow Rate (l/H)	Maximum PID (ppm)	Barometric Pressure (mb)
BH01	21/09/21	20.5	0.1	<0.1	<1	<1	<0.1	<0.1	1028
	07/10/21	18.3	1.6	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	16.6	2.2	<0.1	<1	<1	<0.1	<0.1	1020
	21/10/21	17.8	1.6	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	19.6	0.5	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	19.2	0.4	<0.1	<1	<1	<0.1	<0.1	1024
BH02	21/09/21	15.2	2.0	<0.1	<1	<1	<0.1	<0.1	1028

Exploratory Hole Reference	Monitoring Round Date	Minimum O_2 (%)	Maximum CO_2 (%l)	Maximum CH_4 (%)	Maximum H_2S (ppm)	Maximum CO (ppm)	Flow Rate (l/H)	Maximum PID (ppm)	Barometric Pressure (mb)
	07/10/21	19.3	0.7	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	20.3	4.0	<0.1	<1	<1	<0.1	<0.1	1020
	21/10/21	14.6	2.0	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	20.2	0.2	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	19.6	0.5	<0.1	<1	<1	<0.1	<0.1	1024
BH03	21/09/21	19.9	0.7	<0.1	<1	<1	<0.1	<0.1	1028
	07/10/21	18.7	0.7	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	14.8	2.0	<0.1	<1	<1	<0.1	<0.1	1020
	21/10/21	18.0	1.0	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	20.2	0.2	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	20.1	0.1	<0.1	<1	<1	<0.1	<0.1	1024
BH05	21/09/21	20.5	0.8	<0.1	<1	<1	<0.1	<0.1	1028
	07/10/21	19.4	1.0	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	19.9	0.8	<0.1	<1	<1	<0.1	<0.1	1020
	21/10/21	19.8	0.4	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	Unable to locate							1015
	05/11/21	Unable to locate							1024
BH06	21/09/21	Unable to locate							1028
	07/10/21	Damaged well lid							1022
	14/10/21	17.4	2.0	<0.1	<1	<1	<0.1	<0.1	1020
	21/10/21	10.6	5.6	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	19.5	0.4	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	19.8	0.2	<0.1	<1	<1	<0.1	<0.1	1024
BH101	21/09/21	8.6	6.2	<0.1	<1	<1	<0.1	0.4	1028
	07/10/21	8.8	6.3	<0.1	<1	<1	<0.1	0.8	1022
	14/10/21	9.0	5.5	<0.1	<1	<1	<0.1	3.2	1020

Exploratory Hole Reference	Monitoring Round Date	Minimum O_2 (%)	Maximum CO_2 (%l)	Maximum CH_4 (%)	Maximum H_2S (ppm)	Maximum CO (ppm)	Flow Rate (l/H)	Maximum PID (ppm)	Barometric Pressure (mb)
	21/10/21	13.1	3.7	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	9.3	5.4	<0.1	<1	<1	<0.1	0.5	1015
	05/11/21	15.7	2.9	<0.1	<1	<1	<0.1	<0.1	1024
WS102	21/09/21	11.3	5.3	<0.1	<1	<1	<0.1	<0.1	1028
	07/10/21	13.6	4.1	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	13.9	4.0	<0.1	<1	<1	<0.1	1.1	1020
	21/10/21	17.7	4.9	<0.1	<1	<1	<0.1	<0.1	1009
	26/10/21	13.6	4.0	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	14.8	3.4	<0.1	<1	<1	<0.1	<0.1	1024
WS103	21/09/21	10.3	6.1	<0.1	<1	<1	<0.1	<0.1	1028
	07/10/21	12.9	4.4	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	Unable to access							1020
	21/10/21	16.0	2.8	<0.1	<1	<1	0.1	<0.1	1009
	26/10/21	13.6	4.2	<0.1	<1	<1	<0.1	0.1	1015
	05/11/21	15.7	2.9	<0.1	<1	<1	<0.1	<0.1	1024
WS106	21/09/21	15.0	4.2	<0.1	<1	<1	0.7	<0.1	1028
	07/10/21	16.5	3.3	<0.1	<1	<1	<0.1	<0.1	1022
	14/10/21	15.9	3.2	<0.1	<1	<1	<0.1	0.6	1020
	21/10/21	12.3	5.3	<0.1	<1	<1	1.0	<0.1	1009
	26/10/21	16.5	3.3	<0.1	<1	<1	<0.1	<0.1	1015
	05/11/21	18.3	1.8	<0.1	<1	<1	<0.1	<0.1	1024

4.9. Visual and Olfactory Evidence of Contamination

Evidence of contamination was generally not encountered. Identifications are included in the respective factual reports.

5. Geotechnical Engineering Design

The design of temporary and permanent structures shall conform with BS EN 1997 Eurocode 7: Part 1 - Geotechnical Design (EC7). EC7 adopts a limit state approach to design, whereupon the safety of the structure is assessed under Ultimate Limit States (ULS) and performance under Serviceability Limit States (SLS). Any element of geotechnical design should also consider relevant guidance and industry best practice to supplement compliance with codes.

ULS conditions shall be evaluated such that the Design Resistance, R_d, of the structure/element is equal to or greater than the Design Effect of Actions, E_d.

The Design Resistance is determined in accordance with the requirements of the particular limit state under consideration as defined in EC7. The Design Resistance is evaluated from the Characteristic Resistance of the design element, which has been reduced as specified by the code to allow for uncertainty in the estimation of soil properties and the means and methods of evaluating the ultimate strength.

With regards to geotechnical design of the proposed development, the following ultimate limit states should be verified:

Verification of Strength

- Geotechnical (GEO): GEO assesses the ultimate geotechnical capacity of a design element as it interfaces with and relies upon the ground to maintain stability, for example, the geotechnical capacity of piles subject to axial loading.
- Structural (STR): STR assesses the integrity of structural elements to withstand the internal stresses generated from the application of external loads. With regards to typical geotechnical design works, an example may be reinforcing requirements for an embedded wall.

Verification of Stability

- Uplift (UPL): UPL relates to the assessment of the loss of static equilibrium due to buoyancy effects.
- Hydraulic (HYD): HYD relates to the loss of stability resulting from internal seepage forces such as at the toe of a retaining wall partially embedded in a saturated, permeable stratum.
- Equilibrium (EQU): EQU relates to the global stability of the structure and its equilibrium.
- Other soil-structure interaction and stability mechanisms applicable to the particular structure or engineering challenge under consideration.

Verification of Serviceability

Design of geotechnical and structural elements for the verification of serviceability should conform to the requirements of the British National Annex to Eurocode 7, adopting load and material factors equal to 1.0. Performance criteria shall be compared with relevant allowable limits for the superstructure. Adopting Design Approach 1, and the material factors and load multipliers for Combinations 1 and 2.

5.1. Geotechnical Category

EC7 defines three Geotechnical Categories that relate to the risk associated with a structure (or portion of that structure). Figure 5-1 provides a summary description of the three Geotechnical Categories.

Table 5.1 provides a summary of geotechnical design elements that are anticipated to require consideration as part of the final scheme and their associated Geotechnical Category.

It is assessed that most geotechnical design elements will fall within Geotechnical Category 2 and will thus be suitable for design via routine methods, with appropriate consideration of the site-specific constraints.

GC	Includes ...	Design requirements	Design procedure
1	Small and relatively simple structures ... with negligible risk	Negligible risk of instability or ground movements; ground conditions are 'straightforward'; no excavation below water table (or such excavation is 'straightforward')	Routine design and construction (i.e. execution) methods
No examples given in EN 1997-1			
2	Conventional types of structure and foundation with no exceptional risk or difficult soil or loading conditions	Quantitative geotechnical data and analysis to ensure fundamental requirements are satisfied	Routine field and lab testing Routine design and execution
Examples: spread, raft, and pile foundations; walls and other structures retaining or supporting soil or water; excavations; bridge piers and abutments; embankments and earthworks; ground anchors and other tie-back systems; tunnels in hard, non-fractured rock, not subject to special water-tightness or other requirements			
3	Structures or parts of structures not covered above	Include alternative provisions and rules to those in Eurocode 7	

Reproduced from Bond and Harris, 2008

Figure 5-1 Geotechnical categories

Table 5.1 Geotechnical categories of geotechnical design elements.

Geotechnical Design Element	Geotechnical Category
RC retaining wall design in the Lynch Hill Gravel	2
Pile design in the Lynch Hill Gravel and London Clay	2

5.2. Codes of Practice for Geotechnical Design

In addition to the Principles and Recommendations described in EC7, the following codes of practice provide non-conflicting (with EC7) guidance regarding the routine design of geotechnical elements (as deemed relevant for the proposed development):

- BS 6031:2015 – Code of practice for earthworks.
- BS 8002:2015 – Code of practice for earth retaining structures.
- BS 8004:2015 – Code of practice for foundations.

5.3. Temporary Works Design

The design of temporary works shall comply with:

- BS EN 1997: Part 1 – Geotechnical Design.
- PAS8811 (2017): Temporary Works.
- PAS8812 (2017): Temporary Works. Application of European Standards in Design.

5.4. Design Life

A 50-year design life has been assumed.

5.5. Review of Key Constraints

The proposed scheme comprises the demolition of the existing buildings on site and general site clearance works. This will require the removal of any existing below ground structures, including bunkers, foundations, and existing infrastructure. Trial pits investigation show that the existing buildings are founded on shallow concrete footings. Also the brick retaining wall north of the site is about 2.3 m high from its foundation to the top of the wall.

The new superstructures will be supported by piled foundations of 600 mm diameter to a maximum depth of 25-30mbgl.

The primary substructure engineering constraints and risks that have been reviewed as part of this assessment are as follows:

1. Interaction of the proposed structures (comprising both temporary and permanent works considerations) across adjacent foundations.
2. Damage to adjacent third-party assets including buildings, utilities, hard standing etc. (via retaining wall deflections and unload / reload mechanisms).
3. Groundwater considerations during construction where seasonal variations in groundwater may occur. Appropriate means of temporary earth retention and ground water cut-off (where required) taking these aspects into account.
4. Construction programme and assessment of time-dependent movements within cohesive strata (i.e. applicability of undrained/drained assumptions in design).
5. Elevated concentration of sulphide around the area of BH20 (GEA) could potentially affect plant growth on the site. Therefore, it is suggested to excavate out the existing made ground and import clean material for areas of soft landscaping around the area.
6. The proximity of the car parking stacker facility to the northern site boundary, which includes an existing brick concrete retaining wall, beyond which is the Hayes and Harlington Station and associated infrastructure, will pose constraints on the type of construction methodologies for the excavation and piling works.

The following sections provide an overview of potential soil retention and foundation options for the development taking into account the current proposals, site constraints and geological conditions.

5.6. Excavation Works and Retention

5.6.1. Excavated Material

Based on the proposed scheme information provided, excavation works for general site regrading and construction of the buildings ground floor will be within soils comprising Made Ground and Lynch Hill Gravel. Excavation depths are anticipated up to a maximum of approximately 2.5 m and localised instabilities are particularly likely where groundwater is encountered.

Six groundwater monitoring visits have been completed on site and the results shows that shallow perched groundwater is anticipated to be present in the Lynch Hill Gravels at approximately 3.0 mbgl which is seasonal. The Lynch Hill Gravels ground conditions are generally high permeability strata and therefore the groundwater migration through the ground is anticipated to be relatively fast. Significant inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from perched water tables within the made ground. Such inflows should be suitably controlled by sump pumping.

5.6.2. Earth Retention

5.6.2.1. Excavation and General Earthworks Considerations

It is anticipated that the proposed excavation may be carried out using standard means and methods for the general site regrading and construction of the trench located beneath buildings A and B.

Temporary batter slopes may be assumed to be constructed at a slope of approximately $1_V{:}2_H$ within the Made Ground and up to $1_V{:}1.5_H$ within the Lynch Hill Gravel beds. Temporary sheet piles or trench sheets may be considered as an alternative means of localised excavation to form the retaining wall through the centre of the site.

5.6.2.2. Retaining Wall Design Earth Pressures

Active and passive earth pressures acting on normal to the face of a vertical retaining wall may be calculated using the equations below from BS EN 1997-1:2004 Annex C. The effects of porewater pressure are added to the earth pressures evaluated from the equations:

Active Limit State $\sigma'_a(z) = K_a \sigma'_v - 2c'\sqrt{K_a}$

Passive Limit State $\sigma'_p(z) = K_p \sigma'_v + 2c'\sqrt{K_p}$

The effective vertical stress σ'_v acting at a depth z below the ground surface shall include the effects of soil weight and, where appropriate, surcharge loading. Recommended values of active and passive earth pressure coefficients are summarised in Table 5.2 below. Because of the use of partial factors under EC7, earth pressure coefficients are not constant for each limit state.

The retaining wall must deflect sufficiently to mobilise the limiting active and passive earth pressures. It is reasonable to assume such conditions will exist at the ultimate limit state. However, earth pressures under serviceability conditions may represent intermediate conditions between the at-rest condition (K_0) and ultimate limit state. The below values assume the retaining wall will be backfilled with site won arisings, assumed engineered structural backfill properties have also been provided for guidance.

Table 5.2 Recommended ULS and SLS earth pressure coefficients for retaining wall design

Stratum	ϕ'_k (°)	c'_k (kPa)	δ/ϕ'_k	K_0	EC7 DA1 Combination 1 & SLS[1,3]		EC7 DA1 Combination 2[1,3]	
					K_a	K_p	K_a	K_p
Lynch Hill Gravels	38	0	0.67	0.38	0.23	4.20	0.29	3.39
Engineered Structural Backfill (6N/6P)[2]	36	0	0.67	0.41	0.25	16.41	0.32	8.09

1. Presented values do not take into consideration any compaction pressures.
2. Engineered backfill properties should be reviewed against project specific earthworks specification, properties / assumptions may vary to those presented above.
3. Based on EC7 Annex C.

5.6.2.3. Ultimate Limit State

The retaining walls should be designed for geotechnical (GEO) and structural (STR) limit states using the Design Approach 1 Combination 1 & 2 partial factors.

Evaluation of the GEO and STR limit states shall consider the effect of over excavation on global stability and structural forces. The overdig allowance should be taken as the lesser of 10% of the retained height, or 0.5m. The design over-excavation depth may be reduced to 0.1m if appropriate construction controls are incorporated into the work method statements for the excavation works.

The groundwater level data obtained from the groundwater monitoring visits should be adopted for the design of the retaining walls.

It is recommended that a minimum surcharge of 10kPa is applied to the retained ground surface for both ULS and SLS analyses. A higher surcharge may be warranted if the retained ground in proximity of the wall:

- Will be used to provide storage/laydown of provide staging areas for heavy plant.
- If there will be a low level of control over the placement of materials.
- Specific surcharging requirements are required such as plant or column loadings from car park.

5.6.2.4. Serviceability Limit State

Deflection limits should be set by the engineer, however, are not anticipated to be critical for a cast in-situ reinforced concrete retaining wall.

5.6.2.5. Other Considerations

- The active horizontal earth pressure coefficients shown in Table 5.2 are dependent on the stiffness of the retention system and the earth pressure coefficient adopted for structural design purposes should take cognisance of the compaction effort and relative stiffness of the wall. The deformation of the system allows the mobilisation of the active earth pressures. High stiffness retention systems do not allow as much mobilisation of active earth pressure as softer systems, leading to horizontal earth pressures between K_0 (no mobilisation or stress relief) and K_a (full mobilisation) and higher design bending moments and shear forces. However softer systems will allow more horizontal ground movements as they deform, leading to lower design bending moments and shear forces.
- The design guidance provided above is based on the groundwater levels from the monitoring results from the ground investigation.

5.7. Pile Foundations

Pile foundations will be used for the proposed development. Pile construction methods that would suit the site include mini piling for small diameters and contiguous flight auger (CFA) piling.

5.7.1. Ultimate Limit State

The geotechnical capacity of a single pile has been evaluated by the Method of Calculation, as defined in EC7. The design geotechnical pile resistance, R_d, may be assessed as the sum of the characteristic shaft ($R_{s,k}$) and base ($R_{b,k}$) resistance reduced by appropriate partial factors (γ), as shown in the equation below:

$$R_d = R_{s,d} + R_{b,k} = \frac{R_{s,k}}{\gamma_s \gamma_{Rd}} + \frac{R_{b,k}}{\gamma_s \gamma_{Rd}}$$

The evaluation of unit shaft resistance, f_s, and unit base resistance, f_b, is based on the following equations:

Cohesive Soils (α-method)	$f_s = \alpha\, c_u$ $f_b = N_c\, c_u$
Cohesionless soils (β-method)	$f_s = K_S \tan\delta$ $f_b = \sigma'_v\, N_q$

α: refers to the soil adhesion factor.

K_s: earth pressure coefficient for pile interface friction, δ: angle of interface friction.

N_c & N_q, refer to bearing coefficients.

Equivalent safe working loads piles in general accordance with EC7 and BS 8004:2015 have been provided as part of this GDR. The methodology adopted to determine the safe working loads is presented in Appendix A.

Table 5.3 summarises the recommended pile design parameters to evaluate unit shaft and base resistance of the anticipated materials.

Table 5.3 Recommended pile design parameters

Stratum	Method	α	K_s	δ/φ'	N_c	N_q
Made Ground	Not used					
Lynch Hill	β-method	-	0.7	1.0	-	40
London Clay	α-method	0.5	-	-	9.0	-

Table 5.4 below provides an overview of compressive and tensile equivalent safe working loads for piles at varying lengths, calculated in accordance with EC7 and non-conflicting guidance.

Table 5.4 Pile equivalent safe working loads (kN) in axial compression

	Length (m)	15	20	25	30
Pile Diameter (mm)	450	425	645	905	-
	600	595	895	1245	1650
	750	775	1160	1605	2115
	900	970	1440	1985	2605

1. Pile capacities calculated using EC7 NA Design Approach 1 Combination 2 partial factors assuming a 70%/30% DL/LL split.
2. Serviceability limit state design partial factors in accordance with BS 8004:2015.
3. Length taken from the top of the pile at ground level.
4. Diameters are tool diameters.
5. Lateral pile loading has not been considered in the provided capacities.
6. Long-term water table adopted.
7. GEO evaluation only. STR verification to be completed in accordance with BS EN 1992.

5.7.2. Serviceability Limit State

The performance of individual piles under working load tests should be defined as part of the piling works specification. The settlement of individual piles under working loads are typically limited to 0.5% to 1.0% of the pile diameter. Group effects between any potential closely spaced pile foundations would result in greater settlements.

5.8. Concrete Aggressivity

20no. samples were taken from the Made Ground, Lynch Hill Gravel, and London Clay layers for chemical testing. The characteristic sulphate values and resulting design sulphate and aggressive chemical environment for concrete classes are presented in Table 5.5.

Table 5.5 Concrete aggressivity assessment

Stratum	No. of samples	Maximum Water-Soluble Sulphate (mg/l)	pH range	Total Potential Sulphate (%)	Design Sulphate (DS) Class	Aggressive Chemical Environment for Concrete (ACEC) Class
Made Ground	3	150	6.9-8.2	0.20	DS-1	AC-1
Lynch Hill Gravel	8	160	7.9-9.2	0.36	DS-2	AC-2
London Clay	9	340	7.5-8.9	0.45	DS-2	AC-2

Based on the above, the Design Sulphate Class is DS-2 and the corresponding ACEC Class is AC-2 for mobile groundwater.

5.9. Future Considerations

Further ground engineering considerations are summarised below:

- **Below ground obstructions**. No significant obstructions were noted in the ground investigation; however, the project team should consider the presence of potential below ground obstructions across the site including the former bunker/basement and existing foundations (natural and anthropogenic).
- **Groundwater ingress:** Whilst significant dewatering is not anticipated to be required for the proposed development works, it is suggested that appropriate provisions for nominal dewatering via sump pumps are made with regards to construction means and methods, temporary works and groundwater control.
- **Site logistics and construction means and methods**. Specialist contractor advice should be sought in relation to site access, logistics and any plant limitations and constraints.
- **Surrounding buildings and third-party assets**: The proximity of the car parking stacker facility to the northern site boundary, which includes an existing brick concrete retaining wall, beyond which is the Hayes and Harlington Station and associated infrastructure, will pose constraints on the type of construction methodologies for the excavation and piling works. The NR tracks are considered to be a sufficient distance from the site, and therefore a GMA is not anticipated to be required, particularly given no basements are proposed.

6. Quantitative Risk Assessment (Geo-environmental)

The following section provides a detailed assessment of the available information including data gathered from both phases of ground investigation. This section comprises GQRA. The CSM and geo-environmental risk assessments have been undertaken to advance geo-environmental site understanding from PRA stage. The assessments in this section have been undertaken to assess potential land contamination issues with respect to the specific proposed development.

It is considered that risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase risk assessments and method statements (RAMS). The associated construction phase risks from potential contamination are not considered further in this document but should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and Construction Phase Plan (CPP).

6.1. Human Health Risk Assessment (Dermal Contact, Ingestion and Inhalation of Soil)

The soil sample laboratory analytical results have been compared to generic assessment criteria (GAC) considered appropriate for the assessing the risks to the specific proposed development. The selected human health GAC include the LQM/CIEH 'Suitable 4 Use Levels' (S4ULs). The S4ULs are based on Health Criteria Values that represent minimal or tolerable levels of risks to health as described in the Environment Agency's SR2 guidance.

For each chemical substance, S4ULs include individual GAC for six generic land uses (residential with home grown produce, residential without home grown produce, allotments, commercial and two Public Open Space land uses) and a range of Soil Organic Matter (SOM) contents. All toxicological and physical-chemical parameters used in the derivation of the S4ULs are presented and discussed in the source publication.

In some instances, selected human health GAC used in this Report have been applied from the DEFRA Category 4 Screening Levels (C4SLs), CL:AIRE GAC and the Environment Agency (EA) Soil Guideline Values. The source reference used for the human health GAC for each chemical determined is presented in the screening tables included in Appendix E. When available for a chemical compound, C4SLs have been used preferentially.

The generic land use scenario used for selecting GAC is 'residential without home grown produce'. This scenario has been selected as the exposure assumptions best represent the proposed site end-use.

GAC have been derived for SOM values of 1%, 2.5% and 6%. GAC derived assuming 1.0 % SOM have been used in this assessment on a conservative basis.

There is no published human health GAC with respect to asbestos or asbestos containing materials (ACMs) in soil. Industry best practice document '*Asbestos in soil and Made Ground: a guide to understanding and managing risks', CIRIA C733, 2014*, identifies that soils containing asbestos concentrations of 0.001 % w/w may be able to liberate airborne fibre concentrations that exceed the contemporary occupational exposure limit for nuisance dust. However, as detailed in other research, including publications such as the *CAR-SOIL Industry Guidance (2016)*, in circumstances where very low concentrations of asbestos are identified in soils, the associated risks are considered low. In this study A-squared adopt an asbestos human health GAC of <0.001 % w/w i.e. mitigation or further assessment is required if asbestos in soil is detected at or above <0.001 % w/w.

Screening tables comparing the soil laboratory results to the selected human health GAC are provided in Appendix E. All soil samples which underwent laboratory analysis for geo-environmental purposes were collected from Made Ground or the underlying natural strata. Where laboratory method detection limits are greater than the human health GAC (if any) this is not recorded as an exceedance. Please be aware that since no VOC or SVOC species were detected above laboratory method detection limits these compounds are not included in Appendix E (the exception is PAHs which are included).

Based on the screening of the soil sample laboratory analytical results the following exceedances of the selected human health GAC have been identified:

- <0.001 % w/w chrysotile asbestos has been detected in Made Ground at WS104 (0.30 m). The GAC is 'no asbestos present'.
- Chrysotile asbestos has been detected in a fragment of cement visually identified in Made Ground at BH08. The GAC is 'no asbestos present'.
- 2.0 mg/kg beryllium has been detected in Made Ground at WS106 (0.20 m bgl). The GAC is 1.7 mg/kg.
- Lead has been detected as follows – 1,900 mg/kg (BH18 at 0.4 m bgl), 350 mg/kg (BH17 at 0.3 m bgl), 320 mg/kg (BH11 at 0.5 m bgl) and 380 mg/kg (BH14 at 0.3 m bgl). The GAC is 310 mg/kg.
- Dibenzo(a,h)anthracene has been detected in Made Ground as follows – 0.37 mg/kg (BH21 at 0.40 m bgl) and 0.53 mg/kg (BH08 at 0.6 m bgl). The GAC is 0.31 mg/kg.
- 2,200 mg/kg TPH (C21-C35) has been detected in Made Ground at BH20 (0.20 m bgl). The GAC is 1,900 mg/kg.

The identified exceedances appear to be associated with the quality of on-site Made Ground and represent unacceptable risk to proposed on-site human health in areas of proposed soft-landscaping / garden. Where there is building footprint or hardstanding at the ground surface then the route for exposure is not present and there is no unacceptable risk to on-site human health.

Where soft-landscaping / garden is proposed there is a requirement for remediation to appropriately mitigate the risks. Possible remediation includes construction of an appropriate clean capping layer. However, the specific details of the required remediation should be considered and specified in a Remediation Strategy.

None of the GAC exceedances are for volatile contaminants. Therefore, the results indicate no unacceptable risk to human health due to vapour phase inhalation. However, vapour phase risks are discussed further in Section 7.2.3.

The proposed site layout includes limited areas of soft-landscaping where airborne dust / soil could be liberated so it is considered that there is no unacceptable risk to off-site human health due to inhalation of windblown dust / soil. No contamination with the potential to migrate off-site at shallow depth within the unsaturated zone has been identified, so there is also no unacceptable risk to off-site human health via direct contact / ingestion / inhalation of contaminated soil particles.

6.2. Human Health and Building and Structures Risk Assessment (Ground Gas / Soil Vapour)

6.2.1. Ground Gas

Where present, Made Ground is a potential source of ground gas and subject to assessment in this section. The natural deposits beneath the site are not considered a potential source of ground gas, as per the PRA, and are not assessed further.

The construction of the monitoring wells installed at the site mean that a ground gas assessment for on-site Made Ground using the available monitoring data is not generally appropriate. Therefore, rather than using ground gas monitoring data, the assessment of ground gas risk at the site lends itself to a methodology using Total Organic Carbon (TOC) data, as described in *BS8485:2015+A1:2019 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings* and *CL:AIRE, A Pragmatic Approach to Ground Gas Risk Assessment, RB17, 2012.*

21 no. samples of Made Ground have undergone laboratory TOC analysis and the results are summarised in Appendix E. The TOC results range from 0.7 % to 5.03 %.

TOC results are affected by the presence of hydrocarbon compounds. Hydrocarbon compounds elevate TOC results such that the ground gas generation potential of Made Ground can be exaggerated by the assessment methodology implemented herein. Concentrations of hydrocarbon compounds have been detected in some of the Made Ground samples. The presence of coal, clinker and ash can also elevate TOC results, but these materials are not readily degradable forms of organic carbon which would generate ground gas. In this instance, all TOC results have been taken forward for assessment, but the potential effects of the identified hydrocarbons, clinker and ash should be recognised and the assessment therefore can be considered to reflect a worse-case condition.

The average TOC result for on-site Made Ground has been calculated as 2.02 %. The detected TOC concentrations are consistent with the field descriptions provided on the exploratory hole logs which typically do not identify potential degradable constituents within Made Ground. The site history as described in the available Phase I Desk Study indicates that Made Ground at the site has been in place for over 20 years, so if the characteristic TOC content is equal or less than 3 % then Characteristic Situation 2 applies. Therefore, in accordance with *CL:AIRE, RB17, 2012, Table 1,* the Made Ground at the site has been classified as Characteristic Situation 2 (ref. *BS8485*) i.e. low hazard potential.

A summary of *CL:AIRE, RB17, 2012, Table 1* is provided as Table 7.1.

Only 4 no. of the TOC results exceed 3.0 %, as follows – BH101 at 0.8 m bgl (3.1 % TOC), TP103 at 0.5 m bgl (5.03 % TOC), BH16 at 0.3 m bgl (3.2 % TOC) and TP105 at 0.5 m bgl (3.16 % TOC). Ash was identified in Made Ground at BH01. Clinker was identified in Made Ground at BH16. Coal was identified in Made Ground at TP103. These inclusions will be elevating the TOC results without a corresponding increase in ground gas generation potential so a Characteristic Situation 2 assessment is still appropriate. The TOC concentration detected in Made Ground at TP105 is equal to 3 % when considering the data accuracy required for the assessment (i.e. zero decimal places). Therefore, the concentration also indicates that a Characteristic Situation 2 assessment is still appropriate.

Since Characteristic Situation 2 has been assess, mitigation may be required to be incorporated into the proposed development. It is recommended that a ground gas protection specification is included in a Remediation Strategy. The ground gas protection specification should enable onward detailed design, installation and verification of protection measures to be undertaken in accordance with *BS8485*. The Remediation Strategy should include an assessment of building type (ref. *BS8485*) to enable appropriate protection measures to be specified based on the correct number of gas protection score points for Characteristic Situation 2.

Table 7.1 Ref. *CL:AIRE, RB17, 2012, Table 1*

Characteristic situation (BS 8485 and CIRIA C665)	Thickness of Made Ground (m)	Maximum total organic carbon content of Made Ground - TOC (%) see note 1, 2 and 3		Comments
		Made Ground	Made Ground in place for > 20 years	
CS1	Maximum 5m Average < 3m	≤1.0	≤1.0	Limiting values based on reported soil organic matter (SOM) content of natural soils up to about 1%
CS2	Maximum 5m Average < 3m	≤1.5	≤3	Limiting values based on gas generation modelling assuming slow degradation Equilibrium methane concentration in building above <0.01%
CS3	Maximum 5m Average < 3m	≤4	≤6	Limiting values based on gas generation modelling assuming slow degradation Equilibrium methane concentration in building above <0.01%
This method can only be used to define characteristic situations up to 3.	Gas monitoring required where TOC is greater than 4% (or 6% in old Made Ground). Gas monitoring results will show whether the high TOC is available and conditions are suitable to generate ground gas.			

The assessment of Characteristic Situation 2 (CS2) is in relation to on-site human health and buildings and structures. The Made Ground at the site does not represent an unacceptable risk to off-site human health or buildings and structures as there should be notable dilution and attenuation if any ground gas migrates off-site.

There is a possibility that off-site sources of ground gas impact the site. The monitoring wells installed at the site are suitable for intercepting ground gas if it is migrating onto site from an off-site source. The ground gas monitoring data collected during the recent investigation has been assessed for this purpose. The ground gas assessment for potential off-site sources has been undertaken in general accordance with guidance contained within *CIRIA 665, 'Assessing risks posed by hazardous ground gases to buildings'* and *BS8485:2015+A1:2019 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*. The method requires use of both gas concentrations and ground gas well flow rates to calculate a gas screening value (GSV). The GSV is calculated as follows:

$$GSV = \frac{Analyte\ Concentration\ (\%)\ \times Flow\ rate\ (L/hr)}{100}$$

The calculation is carried out for methane (CH_4) and carbon dioxide (CO_2).

6 no. rounds of ground gas monitoring has been undertaken. The results of the ground gas monitoring are presented in the Factual Report.

BS8485 utilises the GSV and categorises the ground gas risk into 6 no. different hazard potentials, referred to as Characteristic Situations (CS1 – CS6). These are summarised in Figure 7.1.

CS	Hazard potential	Site characteristic GSV [A)] L/h	Additional factors
CS1	Very low	<0.07	Typically <1% methane concentration and <5% carbon dioxide concentration (otherwise consider an increase to CS2)
CS2	Low	0.07 to <0.7	Typical measured flow rate <70 L/h (otherwise consider an increase to CS3)
CS3	Moderate	0.7 to <3.5	–
CS4	Moderate to high	3.5 to <15	–
CS5	High	15 to <70	–
CS6	Very high	>70	–

[A)] The figures used in this column are empirical.

NOTE The CS is equivalent to the characteristic GSV in CIRIA C665 [6].

Figure 6.1 CS vs. GSV (ref. *BS8485*)

GSV have been calculated to define the gas regime at the site as per *BS8485*. The measured worst-case parameters across all wells have been adopted for the calculation on a conservative basis. The GSV for carbon dioxide and methane have been calculated using the maximum concentrations of carbon dioxide (6.3%) and methane (<0.1%) detected during the return monitoring visits. The maximum detected steady gas flow rate (1.0 l/hr) has also been used in the calculation. Where parameter values are not recorded above the equipment detection limit then the limit of detection has been assumed for the calculation. The calculated GSV for CO_2 and CH_4 are:

- Carbon dioxide: 0.063 l/hr
- Methane: 0.0001 l/hr

On the basis of the calculated GSV for off-site potential sources of contamination could be classified as characteristic situation 1 (CS1) – 'very low risk'. However, due to the maximum concentration of carbon dioxide exceeding 5% consideration of an upgrade to Characteristic Situation 2 (CS2) is required. In the absence of notably elevated gas flow rates, the slightly elevated CO_2 concentrations without corresponding CH_4 concentrations can be attributed to natural microbial respiration and do not represent an elevated risk to buildings / structures or human health. Therefore, it has been assessed that CS1 is appropriate and no upgrade to CS2 is required.

In summary, quantitative ground gas risk assessment has been undertaken for CO_2 and CH_4 and CS2 has been identified due to on-site Made Ground. Very low risk has been identified due to off-site potential sources of ground gas. As discussed earlier, due to the CS2 classification it is recommended that an appropriate ground gas protection specification is included in a Remediation Strategy.

On the return monitoring visits hydrogen sulphide (H_2S) and carbon monoxide (CO) were not detected above equipment detection limits in each of the wells (<1ppm). Figure 7.2 has been taken from *CIRIA C665* and includes Occupational Exposure Limits (OELs) for long-term and short-term exposure by humans. The monitoring data for H_2S and CO indicates no exceedances of the OELs and therefore it is considered that there is no unacceptable risk with respect to hydrogen sulphide and carbon monoxide and the proposed development. No mitigation for H_2S and CO is required.

Properties	Methane	Carbon dioxide	Carbon monoxide	Hydrogen sulphide	Hydrogen
Chemical symbol	CH_4	CO_2	CO	H_2S	H_2
Density (g/l)	0.71	1.98	1.25	1.53	0.09
Melting point (°C)	−184	−78.5 (subliming point)	−205	−85	−259
Boiling point (°C)	−164		−191	−61	−252.87
Colour	Colourless	Colourless	Colourless	Colourless	Colourless
Odour	Odourless	Odourless (acid taste)	Odourless	Rotten eggs Sense of smell disabled at high (toxic) concentrations	Odourless
Flammability	Explosive in air at 515 % Range decreases if CO_2 present. >25 % CO_2 will render non-flammable	Non-combustible	Explosive in air at concentrations of 12.5–74.2 %	Flammable at concentrations of 4.5–45.5 % in air	Explosive in air at 4–74 %
Solubility in water (at 25°C)	25 mg/l	1450 mg/l pH dependent	21.4 mg/l	4100 mg/l	1.62 mg/l* at 21°C
Formation	Anaerobic degradation of organic material	Oxidation and combustion of organic materials, respiration	Incomplete combustion of organic material. Indicator of underground fires	Anaerobic decomposition of organic matter containing sulphur	Anaerobic degradation of organic material
Reactiveness	Fairly inert except with chlorine or bromine in direct sunlight	–	Low	Moderate – atmospheric half life of 1–30 hours	
Toxicity effects on humans	**Low** But at high concentrations (>33 %) can result in asphyxiation due to displacement of oxygen	**High** Headaches and shortness of breath at 3 % Loss of consciousness at 10 – 11 % Fatality at 22 %. OELs 1.5 % (short-term) and 0.5 % (long-term)	**High** OELs 200 ppm (short-term) and 30 ppm (long-term) EAL 350 µg/m³ (long-term) 10 000 µg/m³ (short-term)	**High** Asphyxiant at 400 – 500 ppm OELs 10 ppm (short-term) and 5 ppm (long-term) EAL 140 µg/m³ (long-term) 150 µg/m³ (short-term)	**Low** But at high concentrations (>30 %) can result in asphyxiation due to displacement of oxygen
Toxicity effects on vegetation	Displacement of oxygen	Cause toxic reactions in root systems. Displacement of oxygen			

Figure 6.2 Physical and chemical properties of common hazardous soil gases (ref. *CIRIA C665*)

6.2.2. Soil Vapour

Table 5.5 summarises the soil vapour concentrations detected in monitoring wells during return monitoring rounds. VOC head-space results detected for soil samples are shown on the exploratory hole logs. The readings are all low and do not represent an unacceptable risk to human health or buildings and structures. It is also noted that no volatile contaminants have been detected above laboratory method detection limits in the groundwater samples collected from the site. Furthermore, and as per Section 7.1, none of the soil sample laboratory results indicate exceedances of the human health GAC for volatile contaminants.

6.3. Buildings and Structures Risk Assessment

No gross contamination which might represent an unacceptable risk to the structural integrity of the proposed development and off-site buildings via direct contact has been encountered.

A sulphate class assessment is provided in the geotechnical sections of this GDR.

6.4. Controlled Waters Risk Assessment

Groundwater laboratory analytical results have been compared to generic assessment criteria (GAC) considered appropriate for the assessing controlled waters risks. Controlled waters GAC have been selected to assess risks to drinking water quality, and these GAC are based on Drinking Water Standards (DWS) published by the UK and EU, as well as Guidance Values (GVs) published by the World Health Organisation (WHO). The DWS and GVs are used as values indicative of low risk to drinking water quality and have been selected given the aquifer status of the superficial deposits beneath the site. Controlled waters GAC based on freshwater Environmental Quality Standards (EQS) have also been adopted for the site given the presence of surface waters in the vicinity of the site. The EQS values are based on the UK and EU versions of these criteria, and operational targets published by the Environment Agency (EA). The EQS operational targets are used as values indicative of low risk to the aquatic environment.

The EQS, operational targets, DWS and GVs utilised as controlled waters GAC in this assessment are generally considered to be highly conservative for the manner used in this report, but technically robust for a GQRA type assessment.

The groundwater laboratory analytical results are presented in a screening table comparing the detected chemical concentrations to the selected controlled waters GAC in Appendix E. Where, in a few instances, laboratory method detection limits are greater than the controlled waters GAC this is not recorded as an exceedance. Please be aware that since no VOC or SVOC species were detected above laboratory method detection limits these compounds are not included in Appendix E (the exception is PAHs which are included).

No chemical concentrations in groundwater have been detected exceeding the selected controlled waters GAC. This is consistent with the chemical concentrations detected in soil at the site, which are generally low in a controlled waters context. Where any elevated TPH concentrations are present in soils it is the more complex aromatic or aliphatic compounds which have been detected at the greatest concentrations (i.e. C21-C35) and these compounds typically have very aqueous solubility and mobility. It is considered that there is no unacceptable risk to controlled waters.

6.4.1. Piling Risk

Piling is not anticipated to penetrate the base of the London Clay Formation beneath the site so there is not potential for preferential pathways to be created between shallow soils and the deeper aquifers at the base of the London Clay Formation. Piling should not increase the potential for shallow soil contamination to impact the superficial aquifer beneath the site.

6.5. Human Health Risk Assessment (Drinking Water Supply Pipes)

The soil sample geo-environmental laboratory results have been compared to assessment criteria presented in *UKWIR "Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites (Ref 10/WM/03/21)"*. Only relevant assessment criteria for the available chemical results and potential contaminants of concern identified in the Phase I report have been used. The results are summarised in Table 7.2.

Table 7.2 Water Supply Pipes Assessment Summary

Determinand	Polyethylene (PE) Pipe Assessment Criteria (mg / kg)	Polyvinylchloride (PVC) Pipe Assessment Criteria (mg / kg)	Maximum Concentration Detected in Soil (mg / kg)
VOCs	0.5	0.125	Below method detection limits
VOCs, BTEX and MTBE	0.1	0.03	Below method detection limits
SVOCs and C5-10 aliphatic / aromatic hydrocarbons	2	1.4	Below method detection limits
C11-20 aliphatic / aromatic hydrocarbons	10	Pass	823 (BH20 at 0.2 m bgl)

Determinand	Polyethylene (PE) Pipe Assessment Criteria (mg / kg)	Polyvinylchloride (PVC) Pipe Assessment Criteria (mg / kg)	Maximum Concentration Detected in Soil (mg / kg)
C21-40 aliphatic / aromatic hydrocarbons	500	Pass	2,200 (BH20 at 0.2 m bgl)

No exceedances of the PVC assessment criteria for water supply pipes have been identified. Exceedances of the assessment criteria for PE water supply pipes have been identified in Made Ground. Therefore, it is considered that the results generally indicate a low risk to the human health, although PE specification pipe may not be suitable where water supply pipes are laid in Made Ground.

It should be noted that the final pipe specification to be installed at the site should be agreed with the utility provider. Additional Made Ground sampling may enable an assessment that PE specification pipe is in fact suitable for installation based on the specific pipe runs.

Risks to off-site water supply pipes are assessed as low (i.e. no unacceptable risk).

7. Updated Conceptual Site Model (CSM) and Risk Assessment

The results of the GQRA presented in Section 7 are summarised in Table 8.1. Table 8.1 presents an update of Table 2.1 based on the results of the ground investigation and GQRA presented herein. No ground conditions were encountered which required an update to the PRA prior to undertaking the quantitative risk assessments. The risk assessment matrix used in preparing Table 8.1 is provided as Appendix D.

It is considered that risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase risk assessments and method statements (RAMS). The associated construction phase risks from potential contamination are not considered further in this document but should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and Construction Phase Plan (CPP). Construction phase risks are not considered further in this GDR.

Table 8.1 Updated Risk Assessment Summary

Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway	Risk Level Classification
On-site	Direct contact with soil	Proposed site end users	Yes (see Section 7.1 - unacceptable risk is only potentially present in areas of proposed soft-landscaping and garden) (Remediation Strategy required)	Low to moderate †
	Inhalation of windblown soil			Low to moderate †
	Ingestion of soil			Low to moderate †
	Impact to water supply pipes followed by ingestion of contaminated water supply		Yes (see Section 7.5 – there are possible restrictions on new water supply pipe construction which can be safely installed)	Low to moderate †
	Ground gas / soil vapour generation and inhalation		Yes (see Section 7.2 – CS2 protection recommended so a ground gas protection specification should be prepared) (Remediation Strategy required)	Low to moderate †
	Inhalation of windblown soil from the site	Off-site human health receptors	Yes (the proposed site layout includes limited areas of soft-landscaping so airborne dust / soil is unlikely to be liberated)	Very low
	Off-site migration and direct contact with impacted soil		Yes (no contamination with the potential to migrate off-site and impact off-site shallow soils (as well as water supply pipes installed within them) has been identified)	Low
	Off-site migration and ingestion of impacted soil			Low
	Impact to water supply pipes followed by ingestion of contaminated water supply			Low
	Ground gas / soil vapour generation, off-site migration and inhalation		Yes (see Section 7.2 – no unacceptable risk to off-site human health identified)	Low
	Direct contact	On-site below ground structures (proposed)	Yes (see geotechnical sections for the sulphate design class to be implemented so that the risk is 'low')	Low
	Migration followed by ignition of ground gas / soil vapour		Yes (see Section 7.2 – CS2 protection recommended so a ground gas protection specification should be prepared) (Remediation Strategy required)	Low to moderate †
	Off-site migration followed by direct contact	Off-site below ground structures	Yes (no gross contamination identified with the potential to migrate off-site and damage structures)	Very low
	Off-site migration followed by migration followed by ignition of ground gas / soil vapour		Yes (see Section 7.2 – no unacceptable risk to off-site buildings and structures identified)	Low

Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway	Risk Level Classification
	Leaching and migration to groundwater via the unsaturated zone; Perched water percolation or lateral migration; Migration via advection and diffusion in the saturated zone; Vertical and lateral migration of free-phase product in the unsaturated and saturated zones; and Preferential pathways created by piling.	Controlled waters (groundwater and surface waters)	See Section 7.4 – no unacceptable risk identified following GQRA	Low
Off-site	On-site migration followed by direct contact or ingestion of soil	Proposed site end users	Yes (See Section 7.1 – the shallow soil contamination identified at the site has been assessed as derived from on-site rather than off-site)	Low
	Inhalation of windblown soil from off-site		Yes (no notable source of off-site windblown soil / dust has been identified)	Very low
	On-site migration followed by impact to water supply pipes and ingestion of the water supply		Yes (See Section 7.5 – the shallow soil contamination identified at the site has been assessed as derived from on-site rather than off-site)	Low
	Ground gas / soil vapour generation, on-site migration and inhalation		Yes (see Section 7.2 – no unacceptable risk identified following GQRA)	Low
	On-site migration followed by direct contact	On-site below ground structures (proposed)	Yes (no gross contamination with the potential to damage proposed structures has been identified)	Very low
	On-site migration followed by ignition of ground gas / soil vapour		Yes (see Section 7.2 – no unacceptable risk identified following GQRA)	Low

† - unacceptable risk (ref. *LCRM*)

Following GQRA, it is considered that in accordance with *LCRM* guidance there is unacceptable risk to proposed on-site human health in soft-landscaping and garden areas and a suitable Remediation Strategy is required to mitigate the risk. Appropriate ground gas protection measures are also required for the proposed buildings in accordance with CS2 level protection, so a ground gas protection specification should be included in the Remediation Strategy. Appropriate new water supply pipe construction is also required in consultation with the utility provider.

If the sulphate design class is implemented as specified in the geotechnical sections then it is considered that there are no unacceptable risks to proposed on-site building structures.

The risks to maintenance workers during the operational phase of the proposed development can be managed by preparing a site operational Health & Safety File. This GDR, along with the Phase I Desk Study, should be made available to those preparing the Health & Safety File.

Once detailed design has been completed, the client should inform A-squared of the termination depths for the proposed piles so that the controlled waters risk classification (in respect to preferential pathways created by piling) indicated in this GDR can be confirmed.

8. Preliminary Waste Assessment

The results of the geo-environmental soil analysis have been considered in view of waste status in accordance with *Technical Guidance WM3 - Waste Classification: Guidance on the classification and assessment of waste (1st Edition v1.1)*. All soil samples have been collected from Made Ground and natural strata and are indicative of Non-hazardous waste if soils are excavated and sent for off-site disposal. An exception is Made Ground sampled at BH20 at 0.2 m bgl where potentially Hazardous concentrations of TPH have been identified. However, a final detailed waste assessment should be undertaken for the specific excavation and disposal activities to be undertaken once the specific details are known.

9. Conclusions

A-squared Studio Engineers Ltd (A-squared) has been appointed by Whitby Wood Ltd to support the geotechnical and substructure engineering scope relating to the proposed development at 233 – 236 Nestles Avenue, Hayes, London.

The proposed development for 233-236 Nestles Avenue will comprise the construction of four new residential buildings between 10 and 11 storeys tall, with one to two storey connecting podium structures between each pair of buildings to house car parking and plant. There are no basements proposed for any of the buildings. However, there is a proposed car parking stacking facility in the north of the site beneath Buildings A & B, which will be located within a trench approximately 1.5m deep. There are limited areas of soft landscaping proposed around the buildings.

This GDR comprises an interpretation of the findings from the recent ground investigation undertaken at the site and provides an assessment of key geotechnical considerations associated with the proposed development. The aim of this report is to provide recommendations on primary geotechnical aspects relating to the scheme and to evaluate representative parameters, which will inform the design and performance assessment calculations/analyses to be carried out as part of design development.

The ground conditions at the site location comprise Made Ground overlying Lynch Hill Gravel, and London Clay. Groundwater was encountered during post-fieldwork monitoring visits at between 2.7 to 3mbgl. Design water tables in the short- and long-term conditions should be considered at 2.5m below ground level, considering the potential variation of the superficial aquifer and any accidental rise in groundwater over the life of the development (for example, due to a burst water main).

Concrete aggressivity was determined based on laboratory testing, and concrete within the Made Ground, Lynch Hill Gravels and London Clay layer should conform to DS-2 and AC-2 assuming a 50-year design life subject to considerations in Section 5.8.

Potential considerations for earthworks and retaining wall design, and deep foundation options suitable for the development have been discussed in the context of the currently proposed scheme. Equivalent safe working loads for pile foundations have been calculated following Eurocode 7 approaches. Recommendations for the management of tree removal and planting have been provided for guidance. Further recommendations are presented in Section 5.

Following GQRA, it is considered that in accordance with *LCRM* guidance there is unacceptable risk to proposed on-site human health in soft-landscaping and garden areas and a suitable Remediation Strategy is required to mitigate the risk. Appropriate ground gas protection measures are also required for the proposed buildings in accordance with CS2 level protection, so a ground gas protection specification should be included in the Remediation Strategy. Appropriate new water supply pipe construction is also required in consultation with the utility provider.

If the sulphate design class is implemented as specified in the geotechnical sections then it is considered that there are no unacceptable risks to proposed on-site building structures.

The risks to maintenance workers during the operational phase of the proposed development can be managed by preparing a site operational Health & Safety File. This GDR, along with the Phase I Desk Study, should be made available to those preparing the Health & Safety File.

Once detailed design has been completed, the client should inform A-squared of the termination depths for the proposed piles so that the controlled waters risk classification (in respect to preferential pathways created by piling) indicated in this GDR can be confirmed.

Appendix A: Pile Safe Working Load Calculation Summary

Safe working load (SWL) capacities should be used with SLS loading, and contain the following relevant pile and concrete resistance checks:

- BS EN 1997-1 ULS GEO Design Approach 1 Combination 1 Pile Resistance.
- BS EN 1997-1 ULS GEO Design Approach 1 Combination 2 Pile Resistance.
- BS 8004:2015+A1:2020 SLS Ultimate Shaft Friction Settlement Check.
- BS EN 1992-1-1 ULS STR Pile Resistance.

A full summary of the partial factors implemented in each of the checks is shown in the table below. The partial factors presented are in accordance with BS EN 1997-1 (with the UK National Annex) Design Approach 1 (DA1) for contiguous flight auger (CFA) or bored piles.

DA1 design combinations are as follows:

- Combination 1 (C1): A1 + M1 + R1.
- Combination 2 (C2): A2 + M1 + R4.

Table A.1 Summary of design guidance and partial factors considered in the pile safe working loads

Check	Design Guidance	Action Factors (A)	Material Factors (M)	Resistance Factors (R)
ULS GEO Design Approach 1 Combination 1 Pile Resistance	BS EN 1997-1 BS 8004:2015 + A1:2020	γ_G = 1.35, γ_Q = 1.50	-	γ_s = 1.00, γ_b = 1.00, γ_{Rd} = 1.40
ULS GEO Design Approach 1 Combination 2 Pile Resistance	BS EN 1997-1 BS 8004:2015 + A1:2020	γ_G = 1.00, γ_Q = 1.30	-	γ_s = 1.60, γ_b = 2.00, γ_{Rd} = 1.40
SLS Ultimate Shaft Friction Settlement Check	BS 8004:2015 + A1:2020	γ_G = 1.00, γ_Q = 1.00	-	$\gamma_{s,SLS}$ = 1.20
ULS STR Pile Resistance	BS EN 1992-1-1	γ_G = 1.35, γ_Q = 1.50	α_{cc} = 0.85, γ_c = 1.5, k_f = 1.1	-

A1 and A2 are partial factor sets applied to the permanent (γ_G) and variable loading (γ_Q) applied to the pile and are independent of additional pile testing. Where action partial factors are applied, these have been converted into a lump factor based on an indicative dead/live load split of the building. Where loading has been provided, the load split is determined from this. Where no loading is provided, indicative splits of 60%/40% or 70%/30% (depending on the nature of the scheme) are adopted.

M1 is a material partial factor set, applied to the soils (1.00 for both combinations).

R1 and R4 are partial factors applied to the base and shaft resistance of the pile. An additional Model Factor (γ_{Rd}) is applied to the reduced base and shaft resistances in both combinations. In general, partial factors included in SWL capacities do not consider the presence of working load or preliminary pile testing. If working load or preliminary pile testing is proposed, the SWL values can be amended accordingly.

The settlement of the pile foundation is verified within the SWL calculations by ensuring that the characteristic compressive force applied to the pile is less than the characteristic value of the pile's ultimate shaft friction. Including a serviceability shaft friction partial factor $\gamma_{s,SLS}$ is one method of further controlling the settlement of an individual pile, and the SWL calculations apply a factor of $\gamma_{s,SLS}$ = 1.20 to limit the settlement of the pile to less than 1% of the pile diameter.

The concrete axial capacity of the pile has been calculated in accordance with BS EN 1992-1-1 adopting a standard pile concrete cylinder strength of f_{ck} = 28MPa and reduced diameter d_{nom} (in accordance with BS EN 1992-1-1, 2.3.4.2(2)). An additional safety factor multiplier of k_f = 1.1 is also applied in addition to the concrete material partial factor of γ_c = 1.5. α_{cc} is taken as 0.85. Structural resistance from steel reinforcement is not considered.

Appendix B: GEA Factual Report

GROUND INVESTIGATION REPORT

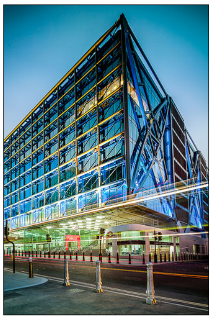
233-236 Nestles Avenue
Hayes & Harlington
London
UB3 4SH

Client: Buccleuch Property

J19090

June 2019



Document Control

Project title	233-236 Nestles Avenue, Hayes & Harlington, London UB3 4SH	**Project ref**	J19090
Report prepared by	Alex Taylor BSc MSc FGS Senior Geotechnical Engineer		
Report checked and approved for issue by	Steve Branch BSc MSc CGeol FGS FRGS Managing Director		

Issue No	Status	Amendment Details	Date	Approved for Issue
1	Final		13 June 2019	

This report has been issued by the GEA office indicated below. Any enquiries regarding the report should be directed to the project engineer at the office indicated below or to Steve Branch in our main Herts office.

✓	**Hertfordshire**	tel 01727 824666
	Nottinghamshire	tel 01509 674888
	Manchester	tel 0161 209 3032

Geotechnical & Environmental Associates Limited (GEA) disclaims any responsibility to the Client and others in respect of any matters outside the scope of this work. This report has been prepared with reasonable skill, care and diligence within the terms of the contract with the Client and taking account of the manpower, resources, investigation and testing devoted to it in agreement with the Client. This report is confidential to the Client and GEA accepts no responsibility of whatsoever nature to third parties to whom this report or any part thereof is made known, unless formally agreed beforehand. Any such party relies upon the report at their own risk. This report may provide advice based on an interpretation of legislation, guidance notes and codes of practice. GEA does not however provide legal advice and if specific legal advice is required a lawyer should be consulted.

This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

CONTENTS

EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Gardiner and Theobald on behalf of Buccleuch Property. The proposed development comprises demolition of the existing buildings and subsequent construction of four new apartment buildings varying in height from four storeys to eleven storeys. The purpose of the investigation has been to determine the ground conditions, to provide an indication of the presence of contamination and to provide information to assist with the design of suitable foundations.

SITE HISTORY

The earliest map studied, dated 1864, shows the site to have formed part of a large field at that time. A footpath crossed the southeastern corner of the site by 1914, at which time the area to the north of the site had been significantly developed. The Preliminary UXO Risk Assessment indicates that the site lay within the bounds of a National Filling Factory (NFF), which were created during WW1 in order to supply munitions for the military. By 1934, the site formed part of a sports ground. The 1938 map shows a building to have been constructed on the western portion of the site in a similar position to the existing museum. Post-War aerial photography, dated 1946, shows this building to have been cleared. By 1965, the existing site layout had been established, with the building housing the museum constructed in the west and the building in the east of the site labelled as an employment exchange. The on-site building to the south of the employment exchange was labelled as government offices by 1972. The site has essentially remained largely unchanged since that time.

GROUND CONDITIONS

Below a nominal to moderate thickness of made ground, Lynch Hill Gravel is present over London Clay, which was proved to the maximum depth of investigation of 30.00 m. Beneath the concrete surfacing the made ground generally comprised brown clayey sand with variable amounts of gravel, brick, concrete, ash, tile and pipe fragments, and extended to depths of between 0.3 m and 1.70 m. The Lynch Hill Gravel generally comprised dense and very dense yellowish brown and brown sandy gravel and gravelly sand to depths of between 4.75 m and 5.80 m. The density of the gravel generally decreased below a depth of 4.00 m and this decrease is most likely to be attributable to the presence of groundwater. The London Clay comprised an initial weathered layer of firm brown mottled orange-brown slightly sandy slightly silty clay, which extended to depths of between 5.20 m and 6.20 m. This was underlain by stiff becoming very stiff high becoming very high and locally extremely high strength fissured brownish grey silty clay, which extended to the full depth of investigation of 30.00 m. Claystones were encountered at depths of 15.40 m in Borehole No 3 and 14.00 m in Borehole No 4. Groundwater was encountered in Borehole Nos 1, 2 and 3, in the northern section of the site, at a depth of 4.50 m from within the Lynch Hill Gravel, which was noted as rising to a depth of 4.00 m. Groundwater was not encountered elsewhere. The chemical analyses have indicated four samples of the made ground to contain elevated concentrations of lead, while a single sample was found to contain an elevated concentration of TPH. Furthermore a single sample was found to contain an elevated concentration of sulphide. Asbestos was not detected in any of the 13 samples of made ground screened, but a single fragment of suspected asbestos containing cement board was tested and was found to contain chrysotile asbestos.

RECOMMENDATIONS

For the lower rise buildings the use of spread foundations bearing within the Lynch Hill Gravel may be appropriate and moderate width strip or pad foundations bearing on the dense gravel of the Lynch Hill Gravel may be designed to apply a net allowable bearing pressure of 300 kN/m^2. However, for the taller buildings it is likely that the loads will necessitate the use of piled foundations. In view of the ground conditions encountered beneath the site the most suitable method for the installation of piles is likely to be through continuous flight auger (CFA) methods.

A thickness of imported soil will be required in areas of proposed soft landscaping to protect end users and to ensure successful plant growth. Where the fragment of asbestos was encountered it would be prudent to inspect the soils once hardstanding has been removed to determine whether the fragment was an isolated occurrence. The soil in the area of the elevated TPH concentration should be removed from site and replaced with a suitable clean fill material.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

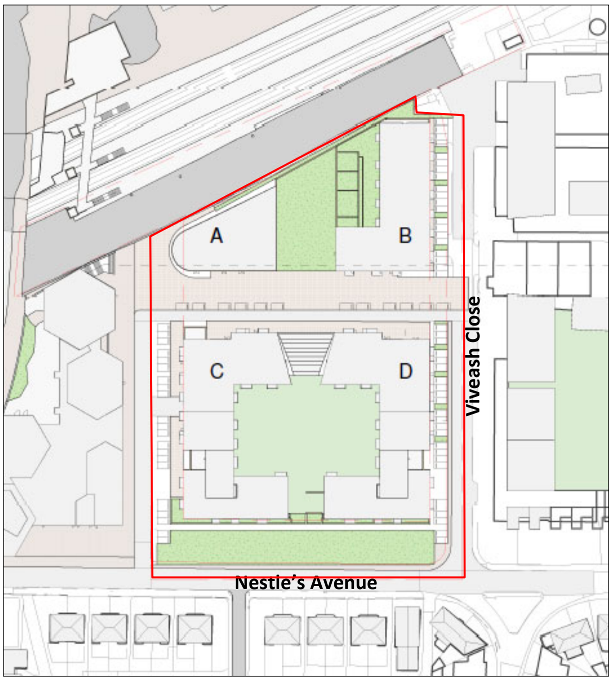
1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Gardiner & Theobald on the behalf of Buccleuch Property, to carry out a ground investigation at Nos 233–236 Nestles Avenue, Hayes & Harlington, London UB3 4SH.

The site has previously been the subject of a desk study report prepared by GEA (report reference J18167, dated 12th February 2018) and a summary of the findings of the report has been included for completeness.

1.1 Proposed Development

It is understood that it is proposed to demolish the existing buildings and subsequently construct four new apartment blocks, rising to between four storeys and eleven storeys, with commercial units at ground floor level. There are no basements included within the proposals. The buildings will be surrounded by areas of soft landscaping that will comprise managed communal space.



Proposed site plan (from drawing TFP-03-site arrangement-03-100, dated 18/01/16, provided by the consulting engineers)

This report is specific to the proposed development and the advice herein should be reviewed if the development proposals are amended.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- to assess the risk of encountering unexploded ordnance (UXO) beneath the site;
- the determine the ground conditions and their engineering properties;
- to provide advice with respect to the design of suitable foundations;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

A desk study has previously been completed for the site by GEA, and in the light of this desk study an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- six boreholes advanced to a depth of 30.00 m using a cable percussion rig;
- a series of 14 boreholes advanced to a maximum depth of 2.45 m by means of an opendrive percussive sampling (Terrier) rig;
- standard penetration tests (SPTs) carried out at regular intervals within the boreholes to provide quantitative data on the strength of the soils;
- the installation of six gas and groundwater monitoring standpipes to a depth of 6.00 m and a single return monitoring visit;
- testing of selected soil samples for contamination and geotechnical purposes; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The report includes a contaminated land assessment which has been undertaken in accordance with the methodology presented in Contaminated Land Report (CLR) 11[1] and involves identifying, making decisions on, and taking appropriate action to deal with, land contamination in a way that is consistent with government policies and legislation within the United Kingdom. The risk assessment is thus divided into three stages comprising Preliminary Risk Assessment, Generic Quantitative Risk Assessment, and Site-Specific Risk Assessment.

The exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

1 *Model Procedures for the Management of Land Contamination* issued jointly by the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) Sept 2004

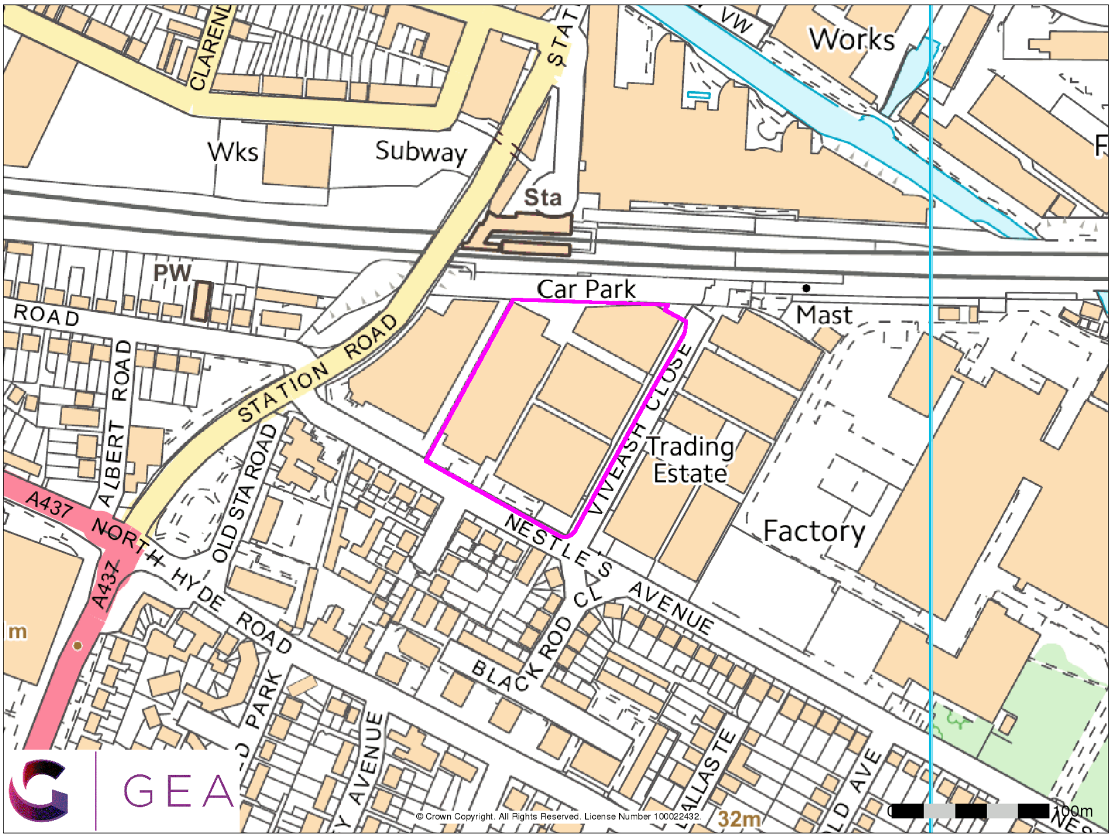
1.4 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or ground water samples tested. No liability can be accepted for conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from third parties are given in good faith on the assumption that the information is accurate; no independent validation of third party information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located in the London Borough of Hillingdon, less than 20 m south of Hayes and Hillingdon railway station and approximately 3 km northwest of Heathrow Airport. The site is bounded by a car park for Hayes & Harlington railway station to the north, by Viveash Close to the east, Nestles Avenue to the south and an alleyway to the west separating the site from an Access Self Storage building next to Station Road further to the west. An electricity substation is present adjacent to the northeastern corner of the site. The site may be additionally located by National Grid Reference 509757 179312 and is shown on the map extract below.



The site is irregular in shape, measuring approximately 165 m northeast to southwest by 105 m northwest to southeast in maximum dimensions, and is within a generally mixed industrial and residential setting. It is occupied by four large industrial style buildings, three of which in the eastern portion of the site are roughly square in shape and occupied by numerous workshops, whilst the fourth in the west forms a more rectangular shaped building occupied by the London Motor Museum.

A walkover of the site was carried out by a geotechnical engineer from GEA on 11th January 2017, although full access to all the buildings was not provided. A second walkover was carried out by an engineer from GEA on 29th April 2019, during the ground investigation.

The museum is a two-storey flat roofed building fronting onto Nestles Avenue to the south, with single storey extensions to the east and west. It was empty at the time of the investigation with no visible signs of contamination being noted. A car park is located at the front of the building and is in relatively good condition, with minor cracks, scars and service covers in the concrete surfacing. The majority of the site is roughly level although Nestles Avenue to the south is at a slightly higher elevation than the buildings fronting the road, with the hardstanding in this portion of the site sloping down slightly towards the buildings. The car park to the north of the site is approximately 1 m higher than the site; a brick retaining wall supports the northern elevation of the site.

No 233 to 236 Claremont House is a two-storey flat roof brick building located to the east of the museum and occupies the southernmost portion of the site. A tall single storey extension with an industrial style roof adjoins the building to the east, which is separated from the museum by an alleyway. At the time of the investigation the buildings were being used as storage areas and no potential sources of contamination were identified.

Panoramic view of the southern elevation of the site along Nestles Avenue, including the London Motor Museum occupying the western portion of the site. To the east of this is the extension to No 233 Claremont House and then the main building, which occupies the southern portion of the site. There is soft landscaping and hardstanding to the front of both buildings.

Access to No 236 Claremont House could not be provided but the consulting engineers have indicated this portion of the site to have been occupied by a motor repair workshop and storage, although it is currently vacant.

The eastern elevation of Claremont House extends along Viveash Close, beyond which are the two remaining buildings on the site that front onto Viveash Close to the west. These buildings in the north and east of the site are occupied by multiple businesses, all of which are involved with vehicle servicing, remodelling and maintenance and mostly form workshops with associated office space. The consulting engineers have indicated that No 2A Viveash Close was recently used as a design workshop and storage. The building was found to be vacant but the flooring in the workshop area of the building was clearly largely covered by a film of oil, although the floor slab was noted as being in a good condition with very few cracks. Access to the ground floor of No 1 Viveash Close was not available at the time of the walkover or the ground investigation but is understood to have been vacant. The first floor was in use as office space by a firm of solicitors. An alleyway separates the two buildings, through which is an area of open space in the northern portion of the site. This is currently used to store vehicles and provides access to the garages occupying the northern portions of the buildings. During the walkover general waste was noted in the area.

Hoarding surrounds an area of hardstanding in the northeastern corner of the site, immediately adjacent to No 1 Viveash Close. The area generally comprised hardstanding with miscellaneous items presumably left by the previous occupiers of the building, including office furniture and tyres. Beyond this, the site is bordered by the railway car park to the north and the electricity substation to the northeast.

Panoramic view of the eastern elevation of the site along Viveash Close, including No 236 Claremont House on the corner.

Asbestos cement warning labels are present along the buildings in the alleyway between the two buildings fronting Viveash Close. It is likely that other asbestos containing materials are present throughout the structures and an asbestos survey will be required for the site.

Looking roughly west at the alleyway between the two buildings fronting Viveash Close, which are occupied by numerous garage businesses and workshops

Looking roughly northwest at the electricity substation outside the northeastern corner of the site, beyond which is the car park bordering the site to the north

The site is mostly covered by the footprints of the buildings and the hardstanding, the majority of which is formed of tarmac or concrete in a relatively poor condition with cracks and staining. The hardstanding to the front of No 236 Claremont House comprises chippings in a rubber mesh and could be forming a root protection zone. A small area covered by grass is present to the front of the museum and No 233 Claremont House. There are no other notable areas of soft landscaping present on the site. There are however large mature trees along Nestles Avenue to the south of the site.

2.2 Site History

The site history has been researched by reference to historical Ordnance Survey (OS) maps obtained from the Envirocheck database.

The earliest map studied, dated 1864, shows the site to have formed part of a large field. The existing railway line to the north had been established but not named and Hayes station was located approximately 35 m to the north of the site, on the other side of the tracks. The Grand Junction Canal is shown in its existing position running roughly northwest to southeast. A small extension of the canal ran under a bridge into the area to the north of the site. Brickfields occupied the surrounding area from approximately 100 m to the northwest and from 200 m to the northeast of the site and included associated infrastructure such as wells and clay mills to the northeast. The existing Nestles Avenue had been constructed but not labelled.

By 1895, the site was bounded to the south by a road extending south of the railway bridge and remained part of a field. A large rectangular carriage shed had been constructed on the other side of the railway line but before the extension of the canal, approximately 65 m to the north of the site. The brickfields and mills to the northeast and northwest are no longer labelled.

A footpath crossed the southeastern corner of the site by 1914, at which time the area to the north of the site had been significantly developed. The existing rows of properties along Station Road and the newly constructed Clayton Road and Blythe Road had been established from around 110 m north of the site, most likely housing the workers of the surrounding newly established works and factories. These included an engineering works, a marble, granite and slate works and a printing works from 310 m to the northwest of the site, on the other side of the canal. The extension of the canal had been demolished and the map indicates the ground to have been mounded, potentially formed of made ground or infilling material.

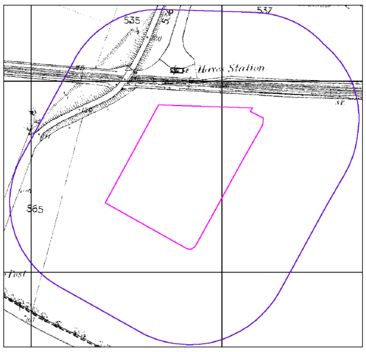
The Preliminary UXO Risk Assessment indicates that the site lay within the bounds of a National Filling Factory (NFF), which were created during WW1 in order to supply munitions for the military. The research suggests that the NFF at Hayes assembled numerous munitions including projectiles, fusing, exploders and detonators. It is not however clear from the evidence available the site's position within the NFF and the potential for the site to be contaminated with items of unexploded ordnance.

By 1934, the site formed part of a sports ground with the southern portion comprising open space and the northern portion covered by trees. A gated structure encroached onto the northeastern corner of the site and a rectangular building was present to the northwest. Further development had occurred in the surrounding area, including the construction of a canal engineering works around 130 m to the northwest of the site, on the other side of the railway. The carriage shed to the north had been demolished, leaving behind railway lines, and more branches had been added in the area previously occupied by mounds further to the north.

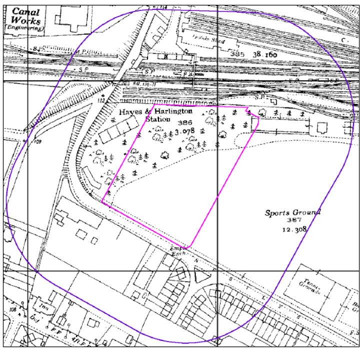
The larger scale mapping, dated 1938, shows a building to have been constructed on the western portion of the site in a similar position to the existing museum. Large industrial style buildings had also been constructed in the area to the east of the site, covering a section of the sports ground.

Post-War aerial photography, dated 1946, shows the western portion of the site to have been cleared, presumably where the building had been damaged by bombing. The UXO report has not found any evidence to indicate any bombing incidents occurred directly on site, however there are records of bomb strikes to the northeast and northwest of the site. It is possible that the strikes to the northwest affected the site. The aerial photography shows that the existing rectangular shaped industrial buildings were constructed over the remainder of the site.

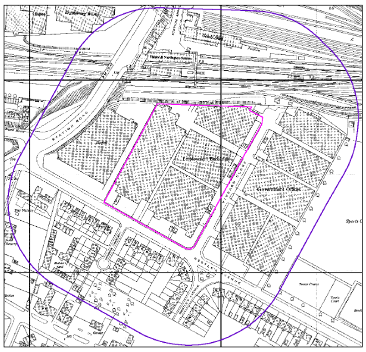
By 1965, the existing site layout had been established. The building housing the existing museum had been constructed in the west in the previously cleared area, fronting onto Nestles Avenue to the south. The building in the east of the site was labelled as an employment exchange. A depot had been constructed to the west and similar large industrial style buildings to the east, one of which was labelled as government offices. These developments had reduced the size of the sports ground. A garage was located 110 m to the south and a builders yard was within a residential area approximately 85 m to the southwest.



1864 historic map



1934 historic map



1965 historic map

The government offices to the east had been relocated into the building to the south of the employment exchange on the site by 1972. Tanks had been constructed around 60 m to the northeast of the site and a metal works had been constructed 80 m to the north, on the other side of the railway lines. An electricity transfer station had been constructed around 560 m to the southeast of the site by 1974 and it is likely that the electricity substation to the northeast of the site had been constructed around this time. The industrial buildings to the east of the employment exchange had been replaced by a collection of smaller units labelled 'Squirrels Trading Estate' by 1992.

The most recent map, dated 2017, shows the Network Rail car park to the north of the site. The tanks to the northeast and northwest are not labelled, but the mapping after 1972 is only at the larger scale and so it is possible that they were present after this time but not mapped in detail.

2.3 Other Information

The Envirocheck report has indicated that there is a historic landfill site 298 m to the east that accepted inert, commercial and household waste, although the last input date is listed as 1936. The age of the last input for this landfill is such that it is unlikely to affect the site and the next nearest historic landfill to the site is 770 m to the east. A licensed waste management facility and a registered waste transfer site are both located 516 m to the northeast of the site. Areas of infilled land (non-water) are listed from 120 m to the northwest, most likely associated with the brickfields in the historic mapping. Areas of infilled land over water are listed from 107 m to the north of the site and are likely to be associated with the infilling of the extension to the Grand Canal, which was present in historic mapping until 1914. These features are at such a distance that they are unlikely to have affected the site.

There are several pollution incidents to controlled waters within 200 m of the site. A single incident 145 m to the northeast in 1990 was classified as a Category 2 – significant incident, although it is unlikely to have affected the site due to the distance and date of the event. The remaining incidents are all greater than 100 m from the site and classified as Category 3 – minor incidents. A prosecution relating to controlled waters was issued in 1999 for the pollution of the Grand Union Canal with heavy fuel oil and diesel 352 m to the southeast of the site. This is unlikely to have migrated and affected the site as the canal is expected to be lined and therefore not in hydraulic connectivity with the surrounding ground.

Several BGS Recorded Mineral Sites are within 400 m of the site, located 124 m to the east, 283 m to the northwest, 309 m and 320 m to the northeast, all of which are listed as opencast operations at Botwell Brickfield. These sites correspond to the previously identified brick fields in the area surrounding the site in historic mapping and are all listed as having ceased activity.

Five Contemporary Trade Directory (CTD) entries are listed for the site, as detailed below;

CTD Entry name	Type of service	Location on site	Status
Sterling Performance Cars Limited	Car dealers	2a Viveash Close (NE)	Active
Lords Commercial Services	Garage	2 Viveash Close (NE)	Inactive
Cabmates	Car engine tuning and diagnostic services	233-236 Nestles Avenue	Active
Wrench Limited	Window tinting	1a Viveash Close	Active
T K O London	Car customisation and conversion specialists	1a Viveash Close	Inactive

The last two entries are also listed as Points of Interest for Commercial Services for vehicle repair, testing and services. A third Point of Interest for Commercial Services is positioned on site, named ‘Vanmatic Limited’, which is also listed for vehicle repair, testing and services.

The nearest fuel station entry is located 107 m to the southwest of the site, named South Hayes Express ESSO garage and is recorded as open. Hayes & Harlington railway station is located 46 m north of the site.

2.4 Detailed UXO Risk Assessment

A Preliminary UXO Risk Assessment was completed by 1st Line Defence (report ref EP5858-00, dated 11 January 2018) as part of the previously completed desk study report. The report concluded that further research in the form of a Detailed UXO Risk Assessment was required in order to determine the risk of encountering UXO beneath the site.

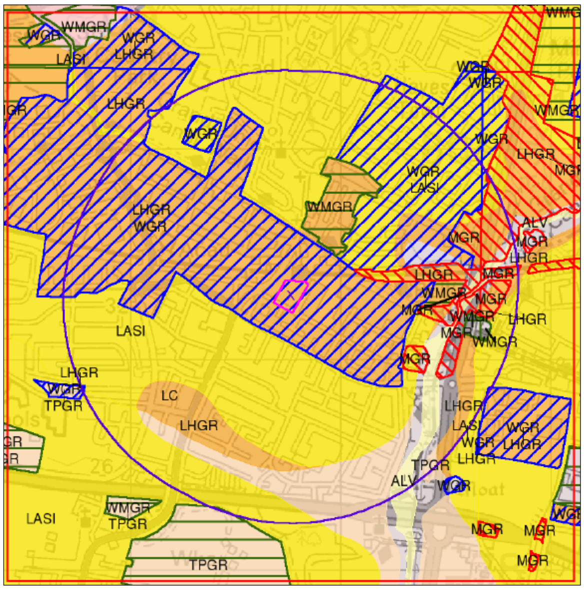
As a result, a detailed UXO Risk Assessment was commissioned by GEA and was completed by 1st Line Defence (report ref DA8572-00, dated 17th April 2019). A copy of the report has been included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA, which state that the likelihood of encountering and detonating UXO below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

The report indicated that, during World War I, the site was located within the former bounds of a National Filling Factory (NFF), an explosive ordnance production facility. There is therefore the potential for contamination of the site with items of WWI explosive ordnance. During World War II, the site was located within the Urban District of Hayes and Harlington, which sustained a low to moderate density bombing campaign. Whilst no strikes are recorded for the site, records indicate bomb strikes to the north and northwest of the site, with photographic records indicating potential bomb damage to a building in the west of the site. The site is thought to have sustained a relatively good level of access during the war and post war aerial imagery suggests that the buildings on and around the site escaped serious bomb damage.

The site was cleared and redeveloped in the inter-war period with development continuing until after WWII. This redevelopment is expected to have included significant intrusive works into the ground and as a result and WW1 ordnance would probably have been found as part of the previous redevelopment. As a result, the risk of encountering UXO at the site is considered to be low. It is recommended that site-specific UXO awareness briefings are provided for all personnel conducting intrusive works, but on-site supervision of work will not be required.

2.5 Geology

The British Geological Survey (BGS) map of the area (Sheet 269), as reproduced by Envirocheck and shown on the extract below, indicates the site to be underlain by the Lynch Hill Gravel Member over the London Clay Formation. The Lynch Hill Gravel typically comprises sand and gravel, locally with lenses of clay, silt or peat. The London Clay Formation typically comprises homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine-grained sand.



Geology 1:50,000 Maps Legends

Artificial Ground and Landslip

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	WMGR	Infilled Ground	Artificial Deposit	Cenozoic - Cenozoic
	WGR	Worked Ground (Undivided)	Void	Holocene - Holocene
	MGR	Made Ground (Undivided)	Artificial Deposit	Holocene - Holocene

Superficial Geology

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	ALV	Alluvium	Clay, Silt, Sand and Gravel	Flandrian - Flandrian
	LASI	Langley Silt Member	Clay and Silt	Devensian - Devensian
	LHGR	Lynch Hill Gravel Member	Sand and Gravel	Wolstonian - Wolstonian
	TPGR	Taplow Gravel Formation	Sand and Gravel	Wolstonian - Wolstonian
	BHT	Boyn Hill Gravel Member	Sand and Gravel	Wolstonian - Hoxnian

Bedrock and Faults

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	LC	London Clay Formation	Clay, Silt and Sand	Eocene - Eocene
	LC	London Clay Formation	Clay and Silt	Eocene - Eocene

The site is also within an area of worked ground. It is possible that the worked ground is associated with the brickfields that were present in the surrounding area until around 1914. It is however unclear as to why the site has been included as being underlain by worked ground, as the historic maps after 1864 do not indicate the site to have been occupied by any activity that would result in worked ground.

The BGS do not hold archive records of boreholes drilled in proximity to the site. The nearest records are for a borehole advanced approximately 170 m to the east of the site, also within the area of worked ground, which is noted to have been re-drilled in 2004. The records indicate London Clay to be present from the surface and to extend to a depth of 58 m; the Lynch Hill Gravel was not encountered. Beneath this, soils of the Woolwich and Reading Beds, more recently classified as the Lambeth Group, were encountered to a depth of 77 m, over Thanet Sand to 78 m and then Upper Chalk to the full depth of investigation at 165 m.

A ground investigation has previously been carried out by GEA at a site located approximately 60 m to the east-southeast of the site. The investigation encountered a moderate thickness of made ground over Lynch Hill Gravel which was underlain by the London Clay. The made ground extended to a depth of 0.80 m. Very dense and dense sand and gravel of the Lynch Hill Gravel was then encountered and extended to a depth of 6.50 m, with a reduction in the density attributable to groundwater. The underlying London Clay comprised an initial weathered layer of firm brown and yellowish brown clay with rare fine gravel, which extended to a depth of 6.80 m, and was underlain by very stiff fissured brownish grey clay with mica and occasional partings of light brownish grey silt and fine sand, to the base of the borehole at 30.00 m. Claystones were encountered at depths of 15.70 m and 25.80 m.

2.6 Hydrology and Hydrogeology

The Environment Agency classifies the Lynch Hill Gravel beneath the site as a Principal Aquifer, referring to rock layers or drift deposits that have high intergranular and / or fracture permeability and therefore usually provide a high level of water storage, supporting water supply and / or river base flow on a strategic scale. Principal Aquifers were formerly classified as major aquifers. The London Clay Formation is classified as Unproductive Strata under the same scheme, which refers to rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Envirocheck records the nearest surface water feature to be 134 m to the northeast, the Grand Union Canal, although this is likely to be lined and therefore not in hydraulic connectivity with the surrounding soil. The nearest natural surface water feature is the River Crane approximately 750 m to the southeast of the site. Groundwater flow is therefore likely to be in a roughly south-easterly or easterly direction towards the river.

The majority of the site is covered by the existing buildings and hardstanding and therefore infiltration of rainwater into the ground beneath the site will be limited to the areas of soft landscaping. The majority of surface runoff is likely to drain into combined sewers in the main road.

There is the potential for groundwater flooding to occur at the surface in the north of the site and it is therefore recommended that a flood risk assessment be carried out by a specialist.

The aforementioned BGS archive record indicates a resting groundwater level of 8.59 m below ground level within the London Clay, which is likely to represent a seepage within a silty or sandy zone, although the details are limited.
As part of the GEA investigation referred to in the previous section, groundwater was monitored at depths of between 2.71 m and 2.87 m within a single borehole. In addition, during three ground gas monitoring visits, no elevated concentrations of ground gas were detected.

2.7 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.7.1 Source

On site sources

The desk study findings indicate the site to have a potentially contaminative history as it has mostly been occupied by industrial buildings of unknown use from 1938. There are five contemporary trade directory entries for the site, three of which are currently active, and numerous vehicle servicing and maintenance workshops are known to be present in the northeast of the site. A vehicle museum recently occupied the building in the west of the site.

The existing use of the site by vehicle servicing garages with associated car parking areas indicates a number of potential sources of contamination. The walkover survey also identified drums of fuel or engine oil, asbestos containing materials and general waste. Hydrocarbon contamination is the most likely to be encountered due to localised spillages of fuel. The Department of the Environment (DoE) Industry Profile[2] indicates the following contaminants associated with vehicle workshops:

- metals and their compounds, including lead, copper and other metals from parts of the engine;
- acids/ alkalis;
- asbestos;
- organic compounds including non-halogenated solvents and halogenated solvents, polyaromatic hydrocarbons (PAHs) and other hydrocarbons, ethylene glycol and polymerised glycols and ethers from brake fluids, anti-freeze, cleaners and de-greasers etc.; and
- volatile organic compounds (VOCs) from paints.

If re-fuelling of vehicles occurs within the garages on site, reference to the relevant DoE Industry Profile[3] indicates that Methyl tert-butyl ether (MTBE), benzene, toluene, ethylbenzene and xylene (BTEX), total petroleum hydrocarbons (TPH) and naphthalene (a PAH) contamination may also be encountered, in addition to the above contaminants.

It is also possible that the buildings on site have been occupied by works and factories in the past. Contamination typically associated with factories and works includes heavy metals from paint, hydrocarbons from machine tools, solvents from paint and degreasers, asbestos used in fire protection, acids and alkalis and PAH from the incomplete combustion of waste wood.
The site is over an area of worked ground and therefore there is the potential for a source of soil gas production to be present beneath the site. This is not considered to be significant unless significant quantities of putrescible or organic material are encountered beneath the site during intrusive investigations.

2 Department of the Environment Industry Profile (1996) *Road vehicle fuelling, service and repair garages*- transport and haulage centres. HMSO

3 Department of the Environment Industry Profile (1996) *Road vehicle fuelling, service and repair - garages and filling stations* HMSO

The UXO Risk Assessment has indicated that an explosive ordnance production facility may have been present on site during World War I. The following contaminants are associated with explosives, propellants and pyrotechnics works, depending on the type of activities occurring within the factory[4];

- explosive materials;
- acidic effluent and explosive residues;
- mineral acids;
- non-chlorinated organic solvents / compounds and chlorinated organic cleaning solvents;
- general inorganic salts and inorganic compounds;
- calcium as lime;
- metals and metal salts, non-metals e.g. sulphur;
- asbestos and fuel oil; and
- PCBs (if electricity substations or transformers were present on the site).

Off-site sources
The site is located in an area with an industrial history. The historic map dated 1972 indicates tanks to have been constructed along the railway line approximately 80 m to the north of the site and alongside the buildings to the east, approximately 60 m to the northeast of the site; the contents and capacity of the tanks is unknown.

A metal works had been constructed beyond the railway line and goods shed by 1972, although it is not known whether this comprised an electroplating or other metal finishing works, iron and steel works, lead works or non-ferrous metal works. Along with the aforementioned contaminants, the following contaminants are associated with metal works with reference to the relevant Department of the Environment (DoE) Industry Profiles[5, 6, 7 & 8];

- mineral acids;
- oil;
- electroplating metals including copper, cadmium, chromium, lead, nickel, mercury, silver, tin and zinc;
- other metals and metalloids – beryllium, aluminium, magnesium, iron, manganese, molybdenum, vanadium;
- inorganic compounds including borates, nitrates, phosphates, fluoride, ammoniacal liquor and thiocyanate.

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4 Department of the Environment Industry Profile (1995) *Chemical works: explosives, propellants and pyrotechnics manufacturing works*. HMSO

5 Department of the Environment Industry Profile (1995) *Metal manufacturing, refining and finishing works: electroplating and other metal finishing works*. HMSO

6 Department of the Environment Industry Profile (1995) *Metal manufacturing, refining and finishing works: iron and steel works*. HMSO

7 Department of the Environment Industry Profile (1995) *Metal manufacturing, refining and finishing works: lead works*. HMSO

8 Department of the Environment Industry Profile (1995) *Non-ferrous metal works (excluding lead works)*. HMSO

The desk study has identified a historic landfill 298 m to the north of the site and areas of infilled land within 150 m of the site, most likely associated with the former brick fields surrounding the site from 1864 until around 1935. Given the distance of the infilled land and date of the infilling of the historic landfill, these are unlikely to have impacted the site or result in the on-going production of significant quantities of landfill gas. However, whilst these are not considered to represent significant sources of gas, the migration of landfill or soil gas onto the site is still possible.

2.7.2 Receptor

The proposed redevelopment of the building for residential purposes will result in the end users representing relatively high sensitivity receptors. As the site is expected to be underlain by a Principal Aquifer, groundwater is also considered to represent a highly sensitive receptor. Adjacent sites are also therefore sensitive receptors.

Concrete and buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into contact with any contaminants present in the soils during construction works. Both are considered to be sensitive receptors.

2.7.3 Pathway

Within the site, end users will be isolated from direct contact with any contaminants that may be present within the made ground by the presence of the new building and the extent of the hardstanding, which will effectively form a barrier. However, in areas of soft landscaping, a pathway would exist whereby end users could come into contact with potentially contaminated soils through direct contact. As the areas of soft landscaping are to comprise managed areas, as opposed to communal or private gardens with the potential for produce to be grown, this is not considered to be significant.

A pathway is currently in existence in areas of soft landscaping and through cracks or gaps in the hardstanding.

As the site is expected to be underlain by the Lynch Hill Gravel, these granular soils would allow the migration of potentially contaminated groundwater or soil gas through the shallow soils to surrounding sites and vice versa.

Buried services and concrete may be exposed to any contaminants present within the soil through direct contact and site workers will come into contact with the soils during construction works.

There is thus considered to be a moderate potential for a contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.