Soil Consultants
Ground Investigation
Geotechnical Analysis
Contamination Assessment

SITE INVESTIGATION REPORT

PROPOSED REDEVELOPMENT:

GARAGES TO THE SOUTH OF 27A WEST END LANE, LONDON, NW6 4QL

Client:	**STREETPLOT LTD.** **Unit 1.25 East London Works,** **75 Whitechapel Road,** **London E1 1DU**
Consulting Engineers:	**PRINGUER-JAMES CONSULTING ENGINEERS LTD.** **10 Beulah Road,** **Wimbledon,** **London SW19 3SB**
Report ref:	**10120/MR/CB**
Date:	**24th October 2017 [Rev 1]**

SITE INVESTIGATION REPORT

PROPOSED REDEVELOPMENT:
GARAGES TO THE SOUTH OF 27A WEST END LANE, LONDON, NW6 4QL

DOCUMENT ISSUE STATUS:

Issue	Date	Description	Author	Checked/approved
Rev 0	**24/08/2017**	**First issue**	**Matthew Rust** BSc [Hons] FGS	**Charles Bull** BSc [Hons] MSc FGS CGeol
Rev 1	**24/10/2017**	**Updated to include additional monitoring**	**Matthew Rust** BSc [Hons] FGS	**Charles Bull** BSc [Hons] MSc FGS CGeol

TABLE OF CONTENTS

APPENDIX A

Fieldwork, in-situ testing and monitoring

- Foreword
- Borehole record
- Standard Penetration Test results
- SPT hammer calibration certificates
- Trial pit records
- Ground-water and gas monitoring results

Laboratory testing

- Index property testing
- Plasticity charts
- Unconsolidated undrained triaxial test results [QUT]
- Soluble Sulphate/pH results [QTS Environmental]

Contamination testing [QTS Environmental]

- Contamination Foreword
- General soil suite
- WAC test results
- General water suite

Ground profiles

- Plot of SPT 'N' value and undrained cohesion versus depth

Plans & drawings

- Proposed development plan
- Site Plan
- Site Location Map

APPENDIX B

- GroundSure historical maps [Ref SCL-4072312]
- GroundSure EnviroInsight Report [Ref SCL-4072310]
- GroundSure GeoInsight Report [Ref SCL- 4072311]

1.0 INTRODUCTION

Consideration is being given to the construction of a new 3-storey residential building on land currently occupied by a car park and associated garages; no basement is currently proposed. In connection with the proposed works, Soil Consultants Ltd [SCL] were commissioned by the Client, StreetPlot Ltd, to carry out a ground investigation to include the following elements:

- Phase 1 Land Quality Assessment [Desk Study] including Preliminary Risk Assessment
- Phase 2 intrusive investigation
- Provision of advice on foundations and ground floor slabs
- Contamination risk assessment and revised conceptual model

This report includes the findings and conclusions of the Phase 1 research and the Preliminary Risk Assessment. It then describes the investigation undertaken, gives a summary of the ground conditions encountered and discusses various foundation options. An environmental appraisal is then provided, including a site specific contamination risk assessment and revised conceptual model.

2.0 SITE DESCRIPTION

The site is located on the north-western side of West End Lane in the London Borough of Camden with its centre at approximate NGR 525485E 183845N and with overall dimensions of approximately 25m x 25m. The site is currently occupied by a vacant car park on the north-western side of the site, with a row of eight lock-up garages along the south-eastern boundary. The car park is an open area of concrete hardstanding with properties along Mutrix Road to the south-west, Sycamore Court to the north-west and Sycamore Court car park to the north-east. The site has a slight fall from north-east [36.75mOD] to south-west [35.8mOD]. The site boundary is marked on three sides by a brick wall, up to 2.0m high in places, with wooden hoarding marking the north-east boundary of the site.

The site is surrounded by residential buildings with a significant number of trees, some of which have been identified as beech and sycamore along with various shrubs and bushes. The beech tree attained a height of approximately 10m and is located approximately 3m from the western boundary [northern end] along with a sycamore tree being located approximately 5m from the north western corner and attained a height of approximately 15m. An arboricultural survey was not available at the time of compiling this report and a specialist should be consulted regarding the adjacent tree species and heights.

The current site features are shown on the Site Plan which is included in Appendix A.

3.0 PHASE 1 LAND QUALITY ASSESSMENT [DESK STUDY]

This assessment is generally based upon current UK guidance, primarily the combined DEFRA/EA publication CLR 11 [Model Procedures for the Management of Land Contamination, 2004]. The scope of the assessment is as follows:

- A review of historical and current land–use and potential contaminated land risks
- Development of an outline conceptual model, identifying potential sources, pathways and receptors, and a Preliminary Risk Assessment
- Development of a strategy for Phase 2 intrusive investigation

3.1 Review of historical mapping

The following summary of the history of the site and surrounding area has been compiled from a series of historical maps obtained from the Groundsure database; these are included in Appendix B.

Historical development of site and surrounding area		
Map date	**The site**	**Significant development / features in surrounding area**
1865 - 1874	The site is undeveloped and located within agricultural land	The immediate area N and W is undeveloped A tree shown to the south-east Residential properties are located to the south and east Queen's Road, aligned NE-SW, is located immediately SE of site Development along Edgware Road, which is around 175m SW [at closest point] Kilburn Station shown to be 175m S, with railway running ENE-WSW St Paul's Church situated 200m W and St Mary's Church 250m NE Schools and public house shown 220m W Armory and rifle range located 350m W Ponds 80m W and 120m NW

Historical development of site and surrounding area		
Map date	**The site**	**Significant development / features in surrounding area**
1894 - 1951	Two dwellings have been constructed on the site	By 1894 significant residential development has occurred around the site Mutrix Road [west] and Birchington Road [north] have been constructed A priory and two chapels shown 175m to 200m to NE Public Houses located 120m SE, 200m W and 220m SW Queen's Road now known as West End Lane By 1915 Picture Theatre and Sorting Office located around 175m S By 1935 Ladder Works [40m SE], Priory Works [120m S] and Albert Works [100m SW] are all shown, but usage is unknown Edgware Road is now shown as [Kilburn] High Road and Maida Vale
1953 - 1973	No significant changes	Residential properties on south side of West End Lane have been replaced by Holmesdale House, Wharfedale House and Birchington Court, part of Kilburn Vale Estate Ladder Works also replaced as part of redevelopment Albert Works no longer shown Picture Cinema is now the Shannon Club Banba Dance Club shown 120m SE Electricity sub-station present 90m NE
1974 - present	Houses have been replaced by 8no garages	Area to north and west has been redeveloped. Sycamore Court located immediately NW Birchington Road no longer present to north, but still present SW of Mutrix Road Redevelopment bounded by West End Lane to south and east, Quex Road to north and Mutrix Road to west. Access into redevelopment is via Bransdale Close, a new turning off West End Lane, to north-east of site Quex Road Open Space and Adventure playground shown 100m N Kilburn Market shown 200m WSW

3.2 Groundsure database information

The Groundsure report includes information from a database of local activities encompassing a range of subjects related to land use, pollution, and geological/hydrological conditions. A summary of contaminative uses and other environmental issues covered within the site and its immediate surroundings [generally within 250m] is presented below. The full Groundsure report is included as Appendix B and this should be read and understood fully in conjunction with this summary.

Historical Industrial Sites

- Potentially contaminative uses: 18no within 250m; nearest being a smithy 155m W; remainder are railway sidings/station [with duplicates].
- Historical tank database: 3no unspecified tanks within 250m; closest is 22m SW.
- Historical energy features database: 28no within 250m [including duplicates]; closest is 87m NE electricity substation [some duplicates are present in the report].
- Historical garage and motor vehicle repair database: 8no entries within 250m [including duplicates]; closest is garages located 202m N.
- Potentially infilled land: 1no cutting recorded 250m S.

Environmental Permits, Incidents and Registers

- Records of Part A[2] and Part B Activities: 4no within 500m [all dry cleaning, including duplicates]; nearest is 257m S.
- 3no records on the National Incidents Recording System [NIRS] List 2; closest located 202m SW - contaminated water with firefighting run-off.

Landfill and other Waste Sites

- Records of Environment Agency licenced waste sites within 1500m: 1no located 1084m NE – Canfield Place, London NW6, not specified.

Current Land Use

- Potentially contaminative uses: 22no within 250m; the nearest being 108m SE - vehicle repair/testing/servicing.
- Petrol and Fuel Sites: 1no within 500m; obsolete garage located 476m W.
- National Grid High Voltage Underground Electricity Cables; 1no located 171m SW - 400kV A/C underground cable.

Geology

- Artificial/ Made Ground: None recorded.
- Bedrock/Solid Geology: London Clay formation [mixed flow, very low to moderate permeability], no faults recorded within 500m.
- Radon: the property is not in a Radon Affected Area [<1% of properties are above action level] - no protective measures required.
- There are no historical surface ground working features shown by the GroundSure database within 250m of the study site boundary. However, reference to the BGS 6" geological mapping indicates that the site is within an area of pits, 2-3m deep, excavated within the London Clay_[original geological mapping dated 1889; last revised 1980].
- Historical Underground Workings: 12no within 1000m of the site; the nearest being 938m E; these are all recorded as tunnels and air shafts.
- Mining, Extraction & Natural Cavities: 7no recorded within 1000m of site boundary; all labelled as air shafts.
- Natural Ground Subsidence: moderate risk for shrink-swell clays; all other categories negligible to very low.
- Borehole Records Map: 15no within 250m of site, of which 1no is located directly on the site [Kilburn Vale Estate BH7].
- Estimated Background Soil Chemistry: no data.

Hydrogeology and Hydrology

- There are no aquifers within superficial deposits.
- Aquifer within bedrock deposits: 'Unproductive' [London Clay].
- Groundwater Abstraction: 4no within 2000m of site including duplicates; nearest being 1320m E, Thames groundwater borehole for spray irrigation.

Flooding

- No Zone 2 or 3 floodplains or flood defences within 250m of site.
- Risk of flooding from rivers and the sea is very low [less than 1 in 1000].
- Groundwater flooding – not applicable.

Designated Environmentally Sensitive Areas

- Local Nature Reserves: 3no within 2000m [including duplicates]; nearest is 1722m SE - St John's Wood Church Grounds.

Railways and Tunnels

- Railway and railway sidings have been identified 162m SE of the site boundary.
- Nearest active railway shown as Watford DC lines, located 176m SE.
- Site is within 5km of High Speed 2 rail project.

3.3 Other Reports

A database search report conducted through the London Borough of Camden formed part of our works however this 'Contaminated Land Enquiry Report' was applied for but had not been issued at the time of compiling this report.

3.4 Walk-over survey

Our site walkover survey was undertaken in conjunction with the fieldwork on 13th July 2017.

The general topography of the site is a slight fall from north-east to south-west. The garages, which form the south-eastern boundary of the site, were disused at the time of our investigation and access to the car park area and six of the eight garages was restricted by the presence of wooden hoardings and a padlocked gate to the secured area. Extensive vegetation, including trees was observed along the north-western and south-western boundaries, with some vegetation located within the boundary of the site along the south-eastern boundary, behind the garages. All other vegetation is located beyond the site boundary.

Along the north-western, south-western and south-eastern boundaries, brick walls of varying heights had been constructed and generally these appeared to be retaining the car park and garages. There is a manhole cover in the western part of the site. The site was found to be in a clean and tidy state with no waste, rubbish, tanks etc present. The surrounding areas were also noted to be in a well-maintained and tidy state. A small electricity substation was indicated 87m to the NW of the site [outlined on the historical maps 1965 to 1991] along Abbot's Place; however, no substation was present within the marked location during the walk-over survey. No significant surface staining around it to indicate significant historical oil spillages etc.

The accessible garages appeared to be in a relatively tidy state although sealed containers were present, which comprised possible concentrated hard limescale remover, tile adhesive & grout and two 5l plastic petrol cans. Faint surface staining was noted, which could be the result of oil and chemical spillages. However, due to the presence of the concrete slab, the potential for migration should be low. As the buildings and garages were constructed before 2000 the potential for asbestos materials being present, particularly in the garage roof sheets, cannot be ruled out.

3.5 Preliminary Risk Assessment and Conceptual Model

The Phase 1 study has indicated that that site has had a fairly consistent history, with the site occupied by two residential properties. By 1974 these properties had been demolished and replaced with 8no garages.

The surrounding area has been also been developed for mainly residential usage, with some small works of unknown usage within 40m to 120m.

The walk-over survey did not identify any particular current high risk features [such as fuel tanks, above or below ground], materials [such as chemical containers] or land use within the site or in its immediate vicinity. There was a sub-station present 87m to the NE of the site identified by historical mapping and, whilst no longer present, it would have been a potential risk during its lifecycle. The 6" geology map suggests that the site lies within an area of 2-3m 'pits' and therefore some infilling could be present.

A summary of the main potential contaminants is as follows:

- Asbestos
- Metals and semi-metals
- Migrating ground gases/vapours
- Sub-station PCB's

The history of land usage [both within the site and its vicinity] indicate a **low to moderate** risk potential of contaminative sources which could affect the site.

The Preliminary Risk Assessment [PRA] and Conceptual Model based upon the information reviewed and a walk-over survey is as follows:

Source/ hazard	Pathway	Receptor	Potential sources identified	Assessed Risk level
Contaminated soil: on-site sources	Ingestion/ contact	End user and construction workers	• Made ground of unknown source • Potential for ACM from pre-2000 construction • Nearest electricity substation located 87m NE	**Low to moderate**
	Migration of contaminated ground water and/or surface run-off through contaminated fill into aquifer	Aquifer and surface water	Non aquifer present (London Clay)	
Contaminated soil: off-site sources	Dissolution into shallow groundwater and subsequent lateral migration to the site	End user and construction workers	• General unidentified 'works', ladder-works, vehicle repair garage, sub-station and smithy within 200m of the site • Electricity sub-stations	**Low to moderate**

Source/ hazard	Pathway	Receptor	Potential sources identified	Assessed Risk level
Ground gas: on-site and off-site sources	Migration	End-user and buildings	- Possible made ground on site a potential gas source - BGS 6" geological mapping indicates that the site is within an area of pits, 2-3m deep, excavated within the London Clay - No Radon protective measures required	**Low to Moderate**

3.6 Design of intrusive investigation

The PRA has identified potential contaminative sources which could affect various receptors. In designing the Phase 2 intrusive investigation, the various elements in the PRA need to be taken into account. Key elements of the intrusive investigation are as follows:

Type and extent of investigation: identification of the soil sequence in particular the type and thickness of any made ground. A combination of a cable percussive borehole and trial pits should allow determination of the full thickness of the made ground, the nature of the underlying natural soils and groundwater levels. Borehole installations pipe to groundwater/gas monitoring and sampling.

Soil and groundwater sampling: sampling of the made ground and natural soils and ground water if present.

Contamination testing: testing of both made ground and natural soil samples to be carried out. The PRA has identified certain off-site risks and 'unknown' made ground on-site. The contamination testing of soils and groundwater to include petroleum hydrocarbons, metals, phenols and poly-aromatic hydrocarbons to reflect the potential identified risks.

Gas monitoring: precautionary gas monitoring should be carried out for CH_4, CO_2, CO and H_2S. Initially, at least two monitoring visits should be allowed for, with subsequent monitoring if required depending on initial results.

Asbestos: careful visual inspection of soils for suspected Asbestos Containing Materials should be carried out as a matter of course. Screening of all contamination soil samples for asbestos.

4.0 EXPLORATORY WORK AND LABORATORY TESTING

The site investigation was carried out in July 2017. At this time four of the garages were inaccessible. The investigation comprised the following elements.

4.1 Cable percussion borehole

One cable percussion borehole was carried out to a depth of 15m in the centre of the concrete-surfaced car parking area. A 50mm diameter monitoring standpipe was installed to 5.0m depth, with a response zone between 1.0m and 5.0m depth.

Sampling and in-situ testing were carried out at appropriate intervals over the full depth of the borehole. The hammer Energy Ratio [E_r] for the equipment used was 70% and the relevant test certificate is included in Appendix A.

The ground level at the borehole has been extrapolated from the spot levels on the Engineer's drawing.

4.2 Trial pits

Two trial pits [TP1 and TP2] were excavated using hand tools against the existing boundary wall of the property, on the north-western side of the site, in order to establish details of the existing foundations. A further four trial pits [TP3 to TP6] were excavated within garages, using hand tools and also concrete coring equipment, to enable near surface sampling for contamination testing.

4.3 Ground-water and gas monitoring

Water and gas monitoring was carried out on three occasions, following completion of the site works, on 18th July, 27th July and 10th August 2017. Further water and gas monitoring was undertaken on 16th October and 23rd October 2017.

4.4 Geotechnical and chemical laboratory testing

The following geotechnical laboratory testing was completed:

- Index properties tests [Atterberg Limits]
- Unconsolidated, undrained triaxial tests
- Soluble sulphate/sulphur/pH analyses [QTS Environmental Ltd]

4.5 Chemical and contamination testing

Selected soil samples were delivered to a specialist laboratory [QTS Environmental Ltd] and the following testing was carried out:

- General soil suite - 8no samples
- Asbestos screening - 8no samples
- Waste Acceptance Criteria [WAC] - 1no sample
- General water suite - 1no sample

The engineering logs of the exploratory holes and the laboratory testing results are included in the Appendix.

5.0 GROUND CONDITIONS

Published BGS information indicates that the site is underlain by the London Clay with no superficial deposits present. Made ground of varying thickness has been recorded overlying the London Clay in nearby boreholes. The six inch geological mapping for this part of London indicates that the site is within an area of pits, 2-3m deep, excavated within the London Clay [original geological mapping dated 1889; last revised 1980].

This sequence was confirmed by our investigation, which indicated made ground with a maximum thickness of 2.2m encountered in the borehole. The base of the made ground was not encountered in any of the trial pits, which reached depths of between 0.70m and 1.60m. London Clay was encountered to the base of the borehole at 15.0m depth

Detailed descriptions are presented on the exploratory hole records, which are included in Appendix A.

5.1 Made ground

The existing concrete slab varied in thickness between 150mm to 600mm and was noted to be reinforced within the garages. The underlying made ground extended to a maximum depth of 2.20m in the borehole, although the base of this stratum was not found in the trial pits, which extended to a maximum depth of 1.60m. The made ground was heterogenous but generally comprised dark brown to grey silty sandy gravelly clay to clayey sandy gravel with variable amounts of flint, brick, concrete, ash, clinker, slate, chalk and glass. Live and decaying roots were observed to depth of between 0.60m and 1.30m in TP1 to TP4 inclusive with some evidence of partial desiccation in TP1 and TP2. It is likely that this made ground is a result of the historical excavations which are identified on the 6” geological map.

5.2 London Clay

The London Clay was encountered only in the borehole. It comprised brown and orange brown fissured silty clay becoming dark grey at around 10.30mbgl. The clay contained occasional partings of silt, rare manganese staining and occasional selenite crystals above 10.30mbgl. Below this, rare partings of silt were noted along with rare shell fragments. Laboratory triaxial testing and SPTs indicate the London Clay to be of medium becoming high strength with depth - the measured strength profile in included in Appendix A. The plasticity index testing has shown the London Clay to be of Very High plasticity [BS5930] and High Volume Change Potential [NHBC Standards]. No rootlets were observed within the London Clay at the borehole position.

5.3 Ground-water

Ground-water was not encountered in any of the exploratory holes during the investigation. Subsequent monitoring of the standpipes recorded water levels at 2.55m, rising to 0.58m on 10th August. We attribute this to gradual inflow of water from the made ground.

Ground-water levels can of course vary seasonally and with prevailing weather conditions. We recommend that continued monitoring is undertaken prior to design and construction to ascertain water levels in relation to the development/construction works.

5.4 Environmental observations

Potential asbestos containing materials [ACMs] were observed in TP4, together with and clinker throughout the made ground.

During the monitoring visit undertaken on 16th October 2017 a slight hydrocarbon odour was noted from the borehole. Consequently, a water sample was taken from the borehole and sent to QTS Environmental for testing.

6.0 GEOTECHNICAL ASSESSMENT

The proposed works at this site include the following elements:

- demolition of the existing walls and garages
- construction of a new 3-storey residential building

No details of the anticipated column loads were available at the time of compiling this report.

Our investigation has revealed that beneath a significant thickness of made ground [up to 2.20m in the borehole] the London Clay is present to at least 15.0m depth. Spread foundations placed within the London Clay could probably be used for supporting the structural loads, although they will need to be relatively deep and significant support and water control will be required. Piled foundations will present an alternative.

6.1 Spread foundations

Spread foundations must bypass any made ground and be placed within the natural London Clay. On the basis of the borehole, foundation depths of at least 2.20m would be required to bypass any made ground and ensure that the natural soils are exposed, although it must be noted that deeper pockets of fill could be present. It may be also necessary to deepen foundations to take account of existing and future tree growth in accordance with NHBC Standards; this is discussed further below.

The founding stratum will comprise medium becoming high strength clay. As required by EC7, the design engineer must ensure that the correct comparisons are made between Design Actions and Design Resistances after the application of appropriate partial factors and using the final base geometry. For ULS design, both drained and undrained bearing resistances should be determined to calculate the degree of utilisation of the foundation [limit state GEO]. SLS checks should be carried out using appropriate methods in accordance with current practice. For preliminary assessment of the feasibility and sizing of foundations, we envisage that an allowable bearing resistance of $125kN/m^2$ would be appropriate for the London Clay at 2.2m and below; this would be applicable to moderate sized strip or pad foundations, say up to 2.5m width.

Within the zones of influence of existing vegetation, precautions will need to be taken with respect to root action. All foundations will need to be designed fully accordance with NHBC Standards [Chapter 4.2, Building near trees'] and deepened as necessary. Based upon our investigation, **medium** and **high** volume change potential classifications should be adopted for the made ground and London Clay respectively to determine the safe foundation depths. For any trees that are not to be removed, mature tree heights should be assumed when determining the foundation depths. Of particular, but not exclusive, concern should be the Beech and Sycamore trees located around the site and it is possible that the new structure may be affected by these trees.

The foundation excavations will encounter variable made ground which is both cohesive and granular and provision for temporary lateral support will need to be made. On the basis of the borehole monitoring, ground-water inflows should be expected within the excavations. Close trench sheeting, sealed into the London Clay will probably be required to control ground-water inflows. It would be a useful exercise for the groundworks contractor to carry out machine excavated trial pits in advance to determine the likely rate of inflow and the confirm the most appropriate control techniques. As discussed in Section 5.3, continued monitoring of the borehole installation would be advisable.

The excavations will need to be carefully inspected by an experienced foundation engineer to ensure that a competent bearing stratum is exposed. Local deepening should be carried out if obviously desiccated/root-infested clays or soft clay are encountered.

6.2 Piled Foundations

The presence of relatively thick made ground, coupled with shallow ground water may result in some difficulties in forming traditional foundations and therefore piled foundations may be considered as an alternative.

For the ground conditions encountered, either CFA or conventional rotary augered piles could be considered, with the latter type requiring temporary casing sealed into the London Clay. The following table of coefficients may be used for the preliminary determination of the pile resistance.

Shaft adhesion

Stratum	Depth (see note e)	Undrained cohesion (from strength profile)	Ultimate unit shaft adhesion 'q_s'
All soils above London Clay	Above say 2.2m depth	N/A	Ignore
London Clay	2.2m to 15m depth	Increases linearly from 60kN/m^2 at a rate of 7kN/m^2/m	Increases linearly from 30kN/m^2 at a rate of 3.5kN/m^2/m (incorporates α = 0.50)

Notes:
a) Unit shaft adhesion 'q_s' = α x c_u (where α = 0.50 and c_u is the undrained cohesion from the design line)
b) The α value of 0.5 is based upon 102mm diameter triaxial tests and this should not be varied
c) The average shaft adhesion over the pile length should be limited to 110kN/m^2
d) The maximum value for unit shaft adhesion should be limited to 140kN/m^2
e) Depth relates to current ground level at the borehole location – approx +36.15mOD

End bearing

Stratum	Depth (see note c)	Undrained cohesion (from strength profile)	Ultimate unit base resistance 'q_b'
London Clay	Below 10m depth	Increases linearly from 115kN/m^2 at a rate of 7kN/m^2/m	Increases linearly from 1035kN/m^2 at a rate of 60kN/m^2/m (incorporates Nc = 9)

Notes:
a) Unit base resistance 'q_b' = Nc x c_u (where Nc = 9 and c_u is the equivalent undrained cohesion from the design line)
b) Depth relates to current ground level at the borehole location – approx +36.15mOD

Under EC7 (BS EN 1997-1:2004 and UK National Annex) the limit states GEO and STR must be verified using Design Approach 1, which checks reliability with two different combinations of partial factors. The following partial factors are applicable to bored and CFA piles, to be used in conjunction with a Model Factor of 1.4:

Parameter			Combination 1			Combination 2			
			A1	M1	R1	A2	M1	R4	R4+
Permanent actions (G)	Unfavourable	γ_G	1.35			1.0			
	Favourable	$\gamma_{G, fav}$	1.0			1.0			
Variable actions (Q)	Unfavourable	γ_Q	1.5			1.3			
	Favourable	$\gamma_{Q, fav}$	0			0			
Material properties (X)		γ_M		1.0			1.0		
Base resistance (R_b)		γ_b			1.0			2.0	1.7
Shaft resistance (R_s)		γ_s			1.0			1.6	1.4

Parameter		Combination 1			Combination 2			
		A1	M1	R1	A2	M1	R4	R4+
Total resistance (R_t)	γ_t			1.0			2.0	1.7
Tensile resistance ($R_{s,t}$)	$\gamma_{s,t}$			1.0			2.0	1.7

For guidance purposes, indicative pile resistances for CFA/bored piles are as follows, calculated using the above preliminary parameters and partial factors where relevant:

Pile diameter (mm)	Pile toe depth (m bgl)	Compressive Resistance (kN) Combination 1	Combination 2
300	12	190	110
	15	340	205
450	12	330	190
	15	565	335
600	12	500	285
	15	820	480

Notes:
a) Concrete stress should be considered in the final design
b) Pile depth measured from existing ground level at the borehole location – approx 36.15mOD
c) Pile capacities are given as a guide and are not constituted as design recommendations

The design engineer must ensure that the correct comparisons are made between the properly factored Design Actions and Design Resistances. The above pile resistances have incorporated the required partial factors for ULS design but do not incorporate explicit checks on serviceability.

It is noted that groundwater was observed within the standpipe installation within BH1 and that there could be perched groundwater within the made ground. Some modification of the pile parameters or downgrading of the pile capacities may be warranted to mitigate the possible risk of clay softening, although this should be minimal with well-installed CFA piles. If deeper piles are needed required further investigation may be required.

A piling specialist must be consulted at an early stage to confirm the most appropriate pile type and to ultimately provide the final pile design. Due consideration should be given to potential desiccation effects and the designer should use the NHBC guidelines to determine potential depths of desiccation. If pile testing is undertaken it will be possible to apply lower partial factors, resulting in increased pile resistances.

6.3 Ground floor slab

Our investigation encountered a significant thickness of non-engineered made ground and we recommend that fully suspended floor slabs are specified, supported by the main foundations. The slabs should incorporate a suitable void, based on 'High' volume change potential soils to accommodate potential swelling/shrinkage of the underlying clay soils, in accordance with NHBC requirements.

6.4 Foundation concrete

The concentrations of water soluble sulphates [2:1 water/soil extract and groundwater], measured in selected soil samples, and the groundwater sample, varied from 176 mg/l to 3290 mg/l, with near neutral to slightly alkaline pH values [7.6 to 9.3]. The results fall into Site Design Class DS-3 of Table C2 given in BRE Special Digest 1 [2005]. We assess the site as having 'mobile' ground water and this would result in an ACEC Class of AC-3.

Consideration should also be given to the potential oxidation of pyritic soils. Following the procedure recommended in the BRE digest, the amount of oxidisable sulphides is seen to be >0.3% in a number of the samples, suggesting that pyrite is probably present. The characteristic value of Total Potential Sulphate is 3.0%, which equates to Class DS-4 with a resultant classification of ACEC AC-4. If it is deemed unlikely that the foundations will be exposed to disturbed ground which might be vulnerable to oxidation, this more onerous classification may not be required; this must be determined by the designer who should provide the final classification.

7.0 ENVIRONMENTAL APPRAISAL

This appraisal is generally based on the DEFRA/EA publication CLR 11 [Model Procedures for the Management of Contaminated Land, 2004], adopting current UK practice which uses the Source-Pathway-Receptor methodology to assess contamination risks. For a site to be designated as contaminated a plausible linkage between any identified sources and receptors must be identified, ie whether significant pollution linkages [SPLs] are present. In considering the potential for contamination to cause a significant effect, the extent and nature of the potential source are assessed and pathways/receptors identified; without an SPL there is theoretically no risk to the receptors from contamination. The assessed risks to the various potential receptors are summarised in the tabulated Conceptual Site Model which forms Section 7.6 of this report.

7.1 Environmental setting and context

The site is underlain by the London Clay which has a Bedrock Aquifer Designation of '**Unproductive**'. The site does not lie within a Source Protection Zone. Environment Agency records indicate that there are no borehole or surface abstraction points reported within 500m of the site.

The site is assessed as being of **Low** Environmental Sensitivity.

7.2 Potential contamination sources [on-site and off-site]

The Phase 1 Land Quality Assessment has indicated that that site was formerly open fields, before residential construction was undertaken in the 1890s, which was present until the 1970s. Since then, the site has been used for car parking with lock-up garages present along the southern boundary. The surrounding land use has historically been residential and commercial, with works of unknown usage being shown within 100m of the site. No electricity substations have been recorded on site, historically with the nearest located 87m NE although this was not observed during the walkover survey.

The history of residential/commercial usage [both within the site and its vicinity], coupled with the presence of the works of unknown usage, indicates a **Low to Moderate** risk that potential contaminative sources could affect the site.

7.3 Contamination testing

In order to identify whether known or unknown sources within [and outside] the site have caused contamination, we have carried out testing on 8no soil samples and 1no water sample that were recovered during the investigation. The testing was for a range of contaminants considered to reflect the potential historical and current site usages.

The results have been assessed where relevant against the DEFRA Soil Guideline Values [SGV] and the LQM/CIEH Suitable 4 Use Level [S4UL] for Human Health Risk Assessment in which LQM/CIEH have derived Generic Assessment Criteria [GACs] from the current CLEA Model [2nd Edition, 2009]. There is no current recommended SGV for Lead contamination and DEFRA Category 4 Screening Levels [C4SLs] have been used to assess the Lead results, together with several other common contaminants. For Extractable/Total Petroleum Hydrocarbons, the results have been compared with the frequently used EA remedial target of 1,000mg/kg. The contamination testing was carried out specifically for the purpose of providing a general guidance evaluation for the proposed development. Reference should be made to the foreword to the appended contamination test results in order to fully understand the context in which this discussion should be viewed.

It is believed that the redevelopment will include 100% of hard cover by the new building and external area. We have therefore used, where relevant, the trigger levels for **residential development with no plant uptake** to assess the results of the contamination testing. Using these criteria the following results are of note:

- **Lead:** elevated concentrations of lead were measured in five samples of made ground, when compared to the C4SL threshold level of 310mg/kg. The desk study has indicated a no data but the typical background concentration of 820mg/kg [BGS urban soil guidance], which was exceeded by three of the samples [BH1@1.4m – 980mg/kg, TP4@0.6m – 1410mg/kg and TP1@1.4m – 5020mg/kg]. There is evidence of demolition rubble and pockets of ash within the made ground which are considered likely to be the source of the lead concentrations measured
- **Petroleum hydrocarbons:** generally low in all samples
- **Polycyclic Aromatic Hydrocarbons:** generally low in all samples
- **Asbestos:** both Chrysotile and Amosite were encountered in the sample from TP1 at 1.4m depth, as microscopic cement fragments and a bundle in the soil sample

- **Ground-water:** Following the slight hydrocarbon odour noted during monitoring, we have carried out testing on 1no ground-water sample. This did not indicate any elevated hydrocarbon levels, with all other determinands below the thresholds set out in the drinking water regulations.

The results indicate localised elevated levels of lead and sulphates. Suspected Asbestos-Containing Materials [ACM] were observed on site in TP4 and ACMs were positively identified in the sample from TP1 at 1.4m depth. We note that buildings [especially those constructed before 2000] are a potential source of ACM and any made ground, construction or demolition materials on site may also contain ACM. The implications of these results and observations are addressed in the revised site-specific Risk Assessment and Conceptual model below.

It should be noted that whilst our investigation provided relatively good coverage of the site, there may of course be pockets of undetected contamination.

7.4 Ground gas monitoring

Ground gas monitoring within the borehole installation was undertaken on five occasions following completion of the fieldwork [18th and 27th July, 10th August 2017, 16th and 23rd October 2017. All of the monitoring visits have indicated that concentrations of carbon dioxide were generally low, with methane very low. Carbon monoxide and hydrogen sulphide not detected but low oxygen levels were recorded on two occasions. A maximum emission rate of 9.8l/hr was recorded on 10th August 2017. A photo-ionisation detector [PID] was used on three of the visits and all of the readings were low.

On the basis of the monitoring carried out to date, the worst-case gas screening values indicates that Characteristic Situation 2 is applicable [as described in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings", 2007]; appropriate protective measures against ground gas should therefore be incorporated.

7.5 Disposal of excavated soils

One Waste Acceptance Criteria [WAC] test was undertaken on a sample of made ground and the threshold levels for 'inert' waste landfill were not exceeded. A rigorous hazard assessment of the results was not within the scope of our investigation, but our preliminary conclusion, taking into account the WAC test result and the general contamination testing, is that the made ground will probably classify as 'non-hazardous' industrial waste, with an 'inert' classification for natural soils. The made ground and natural soil should be separated prior to disposal.

Where ACMs are observed within the made ground a more onerous classification is likely and careful sorting/isolation will be required. The elevated levels of lead and sulphates could also affect the waste classification. We recommend that early consultations are be made with appropriate waste facilities or regulators to confirm the classification for off-site disposal.

7.6 Revised Risk Assessment and Conceptual Model

Taking into account the above discussion, the assessed risks to potential receptors are summarised as follows:

Source/ hazard	Pathway	Receptor	Mitigation measures/explanation	Assessed Risk level
Contaminated soil: on-site and off-site sources	Ingestion/ contact	End user and construction workers	- Contamination testing indicated elevated lead concentrations [up to 5020 mg/kg] within the made ground, greatly in excess of the BGS normal background concentrations value in urban domains [820 mg/kg] - The new construction will have hardcover over the majority of the site - Where landscaped areas or planting are proposed, a 600mm thick layer of clean, imported topsoil should be placed - Risks to construction workers will be controlled by the use of appropriate PPE - elevated sulphate & lead levels must be addressed in the site H&S plan - The presence of ACM and asbestos fibres should be specifically addressed in the H&S plan - A careful watching brief should be kept during construction and if obvious or suspected contamination is encountered this should be dealt with prescriptively	**LOW** [subject to the mitigation measures and with asbestos risks being adequately addressed in the H&S plan]
Contaminated soil: on-site sources	Migration of contaminated ground water and/or surface run-off through contaminated fill into aquifer	Aquifer and surface water	- Contamination testing indicated elevated lead and sulphate levels - However, the site is of low environmental sensitivity, underlain by 'unproductive' strata [London Clay], with no nearby surface water features or abstraction points; the main chalk aquifer is at depth and protected by a thick layer of very low permeability clay - The new construction will have hardcover over the majority of the site	**LOW**

Source/ hazard	Pathway	Receptor	Mitigation measures/explanation	Assessed Risk level
Ground gas: on-site and off-site sources	Migration, ingress and accumulation	End-user and buildings	- Generally low concentrations of hazardous ground gases were measured, but with a significant positive flow rate during one visit - Based on the gas monitoring visits, a CIRIA 665 Characteristic Situation 2 has been derived and gas protection measures will be required - Protection measures against Radon are not required based on the desk study	**LOW** [subject to incorporation of appropriate gas protection measures]

In conclusion, based upon the information reviewed and the results of the investigation, our assessment is that the risks to potential receptors following appropriate mitigation measures is **LOW.** The H&S plan should specifically address the localised presence of ACMs and also the elevated concentrations of lead.

It is self-evident that there may be zones of contamination within the site which were not encountered in our exploratory points. A careful watching brief should be kept during construction to ensure that any potentially contaminated soil encountered is disposed of in a safe and controlled manner. Site workers should observe normal hygiene precautions when handling soils and if material suspected of being contaminated is identified during construction, this should be set aside under protective cover and further tests undertaken to verify the nature and levels of contamination present. If contamination is present, a full site re-assessment may be required and a contingency should be in place in this regard.

♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦ ♦

APPENDIX A

Fieldwork, in-situ testing and monitoring

- Foreword
- Borehole record
- Standard Penetration Test results
- SPT hammer calibration certificates
- Trial pit records
- Ground-water and gas monitoring results

Laboratory testing

- Index property testing
- Plasticity charts
- Unconsolidated undrained triaxial test results [QUT]
- Soluble Sulphate/pH results [QTS Environmental]

Contamination testing [QTS Environmental]

- Contamination Foreword
- General soil suite
- WAC test results

Ground profiles

- Plot of SPT ‘N’ value and undrained cohesion versus depth

Plans & drawings

- Proposed development plan
- Site Plan