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GEO-ENVIRONMENTAL ASSESSMENT (GROUND INVESTIGATION) REPORT

222 ARCHWAY ROAD,
HIGHGATE,
LONDON,
N6 5AX



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Report Title: Geo-environmental Assessment Ground Investigation Report for 222 Archway Road, Highgate, London, N6 5AX (Application 2)

Report Status: Final

Job No: P3562J2287/HAH

Date: 05/07/2023

QUALITY CONTROL - REVISIONS

Version	Date	Issued By	Comment

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EXECUTIVE SUMMARY

Papa Architects ('The client') commissioned Jomas Associates Ltd to undertake a Geo-environmental ground investigation at the site 222 Archway Road, Highgate, London, N6 5AX.

The principle objectives of the study were as follows:

- To determine the nature and where possible, the extent of contaminants potentially present at the site;
- To establish the presence of significant pollutant linkages, in accordance with the procedures set out within the Environment Agency (EA) land contamination risk management (LCRM) guidance and relevant guidance within the National Planning Policy Framework (NPPF);
- To assess whether the site is safe and suitable for the purpose for which it is intended, or can be made so by remedial action.

It should be noted that the table below is an executive summary of the findings of this report and is for briefing purposes only. Reference should be made to the main report for detailed information and analysis.

Site History and Ground Investigation	
Desk Study Overview	A Desk Study report has been produced for the site and issued separately. A brief overview of the desk study findings is presented below. Reference should be made to the full report for detailed information. A review of the earliest available historical maps (1864) indicates that the site was undeveloped and devoid of any features at that time. By the map dated 1894, the site was shown to be occupied by a residential-style terraced building in the west, with an external area presumed to be an associated garden in the east. The site appears to remain unchanged through to the most recent map (2021), and is presently used at ground and lower ground floor level as offices. From the earliest map (1854), the site vicinity is primarily undeveloped with ponds, a brick field and clay pits noted within 200m of the site. By 1870, a branch of the Great Northern Railway is present roughly 120m north-east of the site. The site vicinity is noted to have undergone dense residential-style development by 1894. A few industrial buildings are noted in the site vicinity through to the 1960s, following which no significant changes are noted through to the most recent map (2021). Information provided by the British Geological Survey indicates that the site is directly underlain by solid deposits of the Claygate Member. There are no artificial deposits within the site area. The solid deposits directly underlying the site are identified as a Secondary A Aquifer. A review of the Enviro+Geoinsight Report indicates that there are no source protection zones within 500m of the site. There are no groundwater, surface water or potable water abstractions reported within 2km of the site. There are no surface water features reported within 250m of the site.

Site History and Ground Investigation	
	There are no Environment Agency Zone 2 or Zone 3 floodplains reported within 50m of the site. The conceptual site model is reproduced in Table 2.2 overleaf. It was recommended that an intrusive investigation be undertaken to assess the extent of Made Ground soils present at the site, and to conduct chemical testing to assess the suitability of the soils in the proposed soft landscaped area for residential end-use.
Intrusive Investigation	The ground investigation was undertaken on 13th June 2023, and consisted of the following: • 4No. hand-held window sampling boreholes, drilled up to 3.5m below ground level (bgl), with associated sampling. • Laboratory analysis for chemical.
Ground Conditions	The results of the ground investigation revealed a ground profile comprising Made Ground over solid deposits of the Claygate Member (London Clay Formation). Groundwater was not encountered in any of the exploratory holes.
Environmental Considerations	Following generic risk assessments, elevated concentrations of arsenic and lead were reported in soils in excess of generic assessment criteria for the protection of human health within a “residential with home grown produce” end-use scenario. No asbestos fibres were detected, however a bulk sample of suspected asbestos containing material was encountered in WS4a and confirmed to contain chrysotile and amosite asbestos. Any visual asbestos materials may be removed by hand, with extensive dust control measures required during the soil screening operations for the protection of site workers and nearby residents. It should be noted that asbestos fibres will not be visible to the naked eye. The site proposal indicates that a large proportion of the site will remain covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping it will be necessary to replace the soils with minimum 600mm of imported clean topsoil, placed on a membrane. The site is directly underlain by solid deposits of the Claygate Member, identified as a Secondary A Aquifer. There are no source protection zones within 500m of the site, and no groundwater, surface water or potable water abstractions within 2km of the site. As a result, the sensitivity of controlled waters is considered low. No significantly elevated concentrations of potentially mobile contaminants have been reported within soil samples analysed. No potentially significant sources of ground gas were identified within the desk study, and no potential sources were identified during the ground investigation. On this basis, no formal ground gas protection measures are considered necessary. As with any ground investigation, the presence of further hotspots between sampling points cannot be ruled out. Should any contamination be encountered, a suitably qualified environmental consultant should be informed immediately, so that adequate measures may be recommended.

1 INTRODUCTION

1.1 Terms of Reference

- 1.1.1 Papa Architects ("The Client") has commissioned Jomas Associates Ltd, to assess the risk of contamination posed by the ground conditions at a site referred to as 222 Archway Road, Highgate, London, N6 5AX, prior to the redevelopment of the site.
- 1.1.2 To this end a Desk Study has been produced for the site and issued separately (Jomas, July 2021), followed by an intrusive investigation (detailed in this report).
- 1.1.3 A full list of previous reports undertaken for the site by Jomas are detailed in Table 1.1:

Table 1.1: Previous Reports - Jomas

Title	Author	Reference	Date
Geo-environmental Desk Study/Preliminary Risk Assessment for as 222 Archway Road, Highgate, London, N6 5AX	Jomas Associates	P3562J2287	July 2021

- 1.1.4 The intrusive investigation was undertaken in accordance with Jomas proposal dated 17th January 2023.

1.2 Proposed Development

- 1.2.1 The proposed development is to convert the existing ground floor and lower ground floor from offices to residential use. The proposed development contains a private garden at lower ground floor level.
- 1.2.2 For the purposes of the contamination risk assessment, the proposed development is classified as 'residential with plant uptake'.

1.3 Objectives

- 1.3.1 The objectives of Jomas' investigation were as follows:
- To conduct an intrusive investigation, to determine the nature and extent of contaminants potentially present at the site;
 - To establish the presence of significant pollutant linkages, in accordance with the procedures set out within Part IIA of the Environmental Protection Act 1990, associated statutory guidance and current best practice including the EA land contamination risk management (LCRM) guidance.

1.4 Scope of Works

- 1.4.1 The following tasks were undertaken to achieve the objectives listed above:

- Intrusive ground investigation to determine shallow ground conditions, and potential for contamination at the site;
- Undertaking of laboratory chemical testing upon samples obtained;
- The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.5 Limitations

- 1.5.1 Jomas Associates Ltd has prepared this report for the sole use of Papa Architects, in accordance with the generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon by any other party without the explicit written agreement of Jomas Associates Limited. No other third party warranty, expressed or implied, is made as to the professional advice included in this report. This report must be used in its entirety.
- 1.5.2 The records search was limited to information available from public sources; this information is changing continually and frequently incomplete. Unless Jomas Associates Limited has actual knowledge to the contrary, information obtained from public sources or provided to Jomas Associates Limited by site personnel and other information sources, have been assumed to be correct. Jomas Associates Limited does not assume any liability for the misinterpretation of information or for items not visible, accessible or present on the subject property at the time of this study.
- 1.5.3 Whilst every effort has been made to ensure the accuracy of the data supplied, and any analysis derived from it, there may be conditions at the site that have not been disclosed by the investigation, and could not therefore be taken into account. As with any site, there may be differences in soil conditions between exploratory hole positions. Furthermore, it should be noted that groundwater conditions may vary due to seasonal and other effects and may at times be significantly different from those measured by the investigation. No liability can be accepted for any such variations in these conditions.
- 1.5.4 Any reports provided to Jomas Associates Limited have been reviewed in good faith. Jomas Associates Limited cannot be held liable for any errors or omissions in these reports, or for any incorrect interpretation contained within them.
- 1.5.5 This investigation and report has been carried out in accordance with the relevant standards and guidance in place at the time of the works. Future changes to these may require a re-assessment of the recommendations made within this report.
- 1.5.6 ***This report is not an engineering design and the figures and calculations contained in the report should be used by the Structural Engineer, taking note that variations may apply, depending on variations in design loading, in techniques used, and in site conditions. Our recommendations should therefore not supersede the Engineer's design.***

2 SITE SETTING

2.1 Site Information

2.1.1 The site location plan is appended to this report in Appendix 1.

Table 2.1: Site Information

Name of Site	-
Address of Site	222 Archway Road, Highgate, London, N6 5AX
Approx. National Grid Ref.	528897 187786
Site Area (Approx)	0.02ha
Site Occupation	Offices on ground floor and lower ground floor with residential use on floors above.
Local Authority	London Borough of Haringey
Proposed Site Use	Convert the existing ground floor and lower ground floor from offices to residential use.

2.2 Desk Study Overview

- 2.2.1 A Desk Study report has been produced for the site and issued separately. A brief overview of the desk study findings is presented below. Reference should be made to the full report for detailed information.
- 2.2.2 A review of the earliest available historical maps (1864) indicates that the site was undeveloped and devoid of any features at that time. By the map dated 1894, the site was shown to be occupied by a residential-style terraced building in the west, with an external area presumed to be an associated garden in the east. The site appears to remain unchanged through to the most recent map (2021), and is presently used at ground and lower ground floor level as offices.
- 2.2.3 From the earliest map (1854), the site vicinity is primarily undeveloped with ponds, a brick field and clay pits noted within 200m of the site. By 1870, a branch of the Great Northern Railway is present roughly 120m north-east of the site. The site vicinity is noted to have undergone dense residential-style development by 1894. A few industrial buildings are noted in the site vicinity through to the 1960s, following which no significant changes are noted through to the most recent map (2021).
- 2.2.4 Information provided by the British Geological Survey indicates that the site is directly underlain by solid deposits of the Claygate Member.
- 2.2.5 There are no artificial deposits within the site area.
- 2.2.6 The solid deposits directly underlying the site are identified as a Secondary A Aquifer.
- 2.2.7 A review of the Enviro+Geosight Report indicates that there are no source protection zones within 500m of the site.

-
- 2.2.8 There are no groundwater, surface water or potable water abstractions reported within 2km of the site.
- 2.2.9 There are no surface water features reported within 250m of the site.
- 2.2.10 There are no Environment Agency Zone 2 or Zone 3 floodplains reported within 50m of the site.
- 2.2.11 The conceptual site model is reproduced in Table 2.2 overleaf.
- 2.2.12 It was recommended that an intrusive investigation be undertaken to assess the extent of Made Ground soils present at the site, and to conduct chemical testing to assess the suitability of the soils in the proposed soft landscaped area for residential end-use.

Table 2.2: Preliminary Risk Assessment for the Site

Sources	Pathways (P)	Receptors	Consequence of Impact	Probability of Impact	Risk Estimation	Hazard Assessment
- Potential for contaminated ground associated with industrial use – off site (S1) - Published goods, 14m north-west - Garage, 96m north-west (1962 – 1996) - Laundry and associated tank, ~120m north - Potential ground gas generation from infilled land – off site (S2) - Pond, ~50m north - Brick field, 70m south-east (1879) - Unspecified pit, 133m north-west (1879)	- Ingestion and dermal contact with contaminated soil (P1) - Inhalation or contact with potentially contaminated dust and vapours (P2) - Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	- Construction workers (R1) - Maintenance workers (R2) - Neighbouring site users (R3) - Future site users (R4) - Building foundations and on site buried services (water mains, electricity and sewer) (R5)	Medium	Low	Moderate	GI – Ground Investigation
			Severe for Asbestos	Low	Moderate	
	Accumulation and migration of soil gases (P5)		Severe	Unlikely	Moderate/low	
	- Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) - Horizontal and vertical migration of contaminants within groundwater (P4)	- Neighbouring site users (R3) - Building foundations and on site buried services (water mains, electricity and sewer) (R5) - Controlled waters (R6) - Secondary A aquifer, on site	Medium	Unlikely	Low	

3 GROUND INVESTIGATION

3.1 Rationale for Ground Investigation

3.1.1 The site investigation has been undertaken generally in accordance with Land Contamination Risk Management (LCRM) guidance, BS10175, NHBC Standards Chapter 4.1, and other associated Statutory Guidance. If required, further targeted investigations and remedial option appraisal would be dependent on the findings of this site investigation.

3.1.2 The soil sampling rationale for the site investigation was developed with reference to EA guidance 'Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination' (Technical Report P5-066/TR).

3.1.3 The sampling proposal was designed in order to gather data representative of the site conditions.

3.2 Scope of Ground Investigation

3.2.1 The ground investigation was undertaken on 13th June 2023.

3.2.2 The work was undertaken in accordance with BS5930 'Code of Practice for Site Investigation' and BS10175 'Investigation of Potentially Contaminated Sites'. All works were completed without incident.

3.2.3 The investigation focused on collecting data on the following:

- Quality of Made Ground/ natural ground within the site boundaries;

3.2.4 A summary of the fieldwork carried out at the site, with justifications for exploratory hole positions, are offered in Table 3.1 below.

Table 3.1: Scope of Intrusive Investigation

Investigation Type	Number of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved (mbgl)	Justification
Hand-Held Window Sample Boreholes	4	WS1 – WS4	Up to 3.5mbgl	Obtain shallow samples for contamination testing.

3.2.5 Exploratory hole positions were located approximately with reference to known features on site, as shown in the exploratory hole location plan presented in Appendix 1, Figure 2. The exploratory hole records are included in Appendix 2.

3.2.6 The exploratory holes were backfilled with the arisings (in the reverse order in which they were drilled) and the ground surface was reinstated so that no depression was left.

3.3 Sampling Rationale

- 3.3.1 Our soil sampling rationale for the site investigation was developed with reference to EA guidance 'Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination' (Technical Report P5-066/TR).
- 3.3.2 The exploratory holes were positioned by applying a combined non-targeted sampling strategy, as well as sample locations positioned with reference to sources identified from the desk study.
- 3.3.3 Soil samples were taken from across the site at various depths as shown in the exploratory hole logs.
- 3.3.4 Jomas Associates Limited's engineers normally collect samples at appropriate depths based on field observations such as:
- appearance, colour and odour of the strata and other materials, and changes in these;
 - the presence or otherwise of sub-surface features such as pipework, tanks, foundations and walls; and,
 - areas of obvious damage, e.g. to the building fabric.
- 3.3.5 A number of the samples were taken from the top 0-1m to aid in the assessment of the pollutant linkages identified at the site. In addition, some deeper samples were taken to aid in the interpretation of fate and transport of any contamination identified.
- 3.3.6 Samples were stored in cool boxes (<4°C) and preserved in accordance with laboratory guidance.

3.4 Sampling Limitations

- 3.4.1 WS4 was moved from where initially positioned due to potential asbestos containing material (ACM) being encountered in the shallow sub-surface. A new location was undertaken approximately 0.5m away. A bulk sample of the suspected ACM was obtained and identified.
- 3.4.2 All boreholes were terminated at a depth of 3.5mbgl due to the limits of using handheld windowless sampling.

3.5 Laboratory Analysis

- 3.5.1 A programme of chemical laboratory testing, scheduled by Jomas Associates Limited, was carried out on selected samples of Made Ground and natural strata.

Chemical Testing

- 3.5.2 Soil samples were submitted to Terra Tek Site Investigation and Laboratory Services (a UKAS and MCerts accredited laboratory), for analysis.
- 3.5.3 The samples were analysed for a wide range of contaminants as shown in Table 3.2 below:

Table 3.2: Chemical Tests Scheduled

Test Suite	No. of tests	
	Made Ground	Natural
Basic Suite 3	3	-
Total Organic Carbon	2	-
Asbestos Screen & ID	4	-
Bulk Asbestos ID	1	
Hydrocarbon Suite	1	-
S5 Suite	1	-

- 3.5.4 The determinands contained in the basic suite are as detailed in Table 3.3 overleaf:

Table 3.3: Basic Suite of Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	0.5	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Cadmium	0.1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Chromium	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Chromium (Hexavalent)	4	N	APHA/AWWA, 19th edition: Method 3500Cr-D
Lead	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Mercury	0.1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Nickel	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Selenium	0.5	Y (ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Copper	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Zinc	0.5	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Boron (Water Soluble)	0.2	Y (ISO 17025)	MAFF Book 427: The Analysis of Agricultural Materials: Method 8
pH Value	0.1 units	Y (MCERTS/ISO 17025)	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.
Sulphate (Water Soluble)	0.01g/l	Y (MCERTS/ISO 17025)	In-house documented method
Total Cyanide	1	N	Colorimetry
Speciated/Total PAH	0.05/0.10	Y (MCERTS/ISO 17025)	GACHAMJA A.M. Chromatography and Analysis: 1992 9-11 (modified)
Phenols	0.7	N	Skalar Analysis of Soil
Total Petroleum Hydrocarbons (banded)	1	N	TNRCC Method 1005: 2001 (modified)

3.5.5 To support the selection of appropriate tier 1 screening values, 2No. samples were also analysed for total organic carbon.

Laboratory test results are summarised in Section 6, with raw laboratory data included in Appendix 3.

4 GROUND CONDITIONS

4.1 Soil

- 4.1.1 Ground conditions were logged in accordance with the requirements of BS5930:2015. Detailed exploratory hole logs are provided in Appendix 2. The ground conditions encountered are summarised in Table 4.1 below, based on the strata observed during the investigation.

Table 4.1: Ground Conditions Encountered

Stratum and Description	Encountered from (mbgl)	Base of strata (mbgl)	Thickness range (m)
Brown sandy gravelly clay. Sand is fine to coarse. Gravel consists of subangular to subrounded flint and brick. Occasional rootlets. MADE GROUND.	GL	1.00	1.00
Orange brown mottled grey CLAY. (CLAYGATE MEMBER/LONDON CLAY FORMATION)	1.00	>3.50	>2.50

4.2 Hydrogeology

- 4.2.1 Groundwater was not encountered in any of the exploratory holes.

4.3 Physical and Olfactory Evidence of Contamination

- 4.3.1 Other than the suspected asbestos found within the original position of WS4, visual or olfactory evidence of contamination was not observed during the course of the investigation.

5 RISK ASSESSMENT – ANALYTICAL FRAMEWORK

5.1 Context and Objectives

- 5.1.1 This section seeks to evaluate the level of risk pertaining to human health and the environment which may result from both the existing use and proposed future use of the site. It makes use of the site investigation findings, as described in the previous sections, to evaluate further the potential pollutant linkages identified in the desk study. A combination of qualitative and quantitative techniques is used, as described below.
- 5.1.2 The purpose of generic quantitative risk assessment is to compare concentrations of contaminants found on site against screening level generic assessment criteria (GAC) to establish whether there are actual or potential unacceptable risks. It also determines whether further detailed assessment is required. The approaches detailed all broadly fit within a tiered assessment structure in line with the framework set out in the Department of Environment, Food and Rural Affairs (DEFRA), EA and Institute for Environment and Health Publication, Guidelines for Environmental Risk Assessment and Management.
- 5.1.3 It should be noted that the statistical tests carried out in this report in accordance with CL:AIRE and CIEH (2008) recommendations, are for guidance purposes only and the conclusions of this report should be approved by the local authority prior to any redevelopment works being undertaken.

5.2 Analytical Framework – Soils

- 5.2.1 There is no single methodology that covers all the various aspects of the assessment of potentially contaminated land and groundwater. Therefore, the analytical framework adopted for this investigation is made up of a number of procedures, which are outlined below. All of these are based on a Risk Assessment methodology centred on the identification and analysis of Source – Pathway – Receptor linkages.
- 5.2.2 The CLEA model provides a methodology for quantitative assessment of the long term risks posed to human health by exposure to contaminated soils. Toxicological data have been used to calculate Soil Guideline Values (SGV) for individual contaminants, based on the proposed site use; these represent minimal risk concentrations and may be used as screening values.
- 5.2.3 In the absence of any published SGVs for certain substances, or where the assumptions made in generating the SGVs do not apply to the site, Jomas Associates Limited have obtained Tier 1 screening values for initial assessment of the soil, based on available current UK guidance including the LQM/CIEH S4ULs and DEFRA C4SL. Site-specific assessments are undertaken wherever possible and/or applicable. All assessments are carried out in accordance with the CLEA protocol.

- 5.2.4 CLEA requires a statistical treatment of the test results to take into account the normal variations in concentration of potential contaminants in the soil and allow comparisons to be made with published guidance.
- 5.2.5 The assessment criteria used for the screening of determinands within soils are identified within Table 5.1.

Table 5.1: Selected Assessment Criteria – Contaminants in Soils

Substance Group	Determinand(s)	Assessment Criteria Selected
<i><u>Organic Substances</u></i>		
Non-halogenated Hydrocarbons	Total Petroleum Hydrocarbons (TPHCWG banded)	S4UL
	Total Phenols	S4UL
Polycyclic Aromatic Hydrocarbons (PAH-16)	Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenzo(a,h)anthracene, Benzo(ghi)perylene	S4UL
Volatile Organic Compounds (VOCs/SVOCs).	Toluene, Ethylbenzene, Benzene, Xylenes	S4UL
<i><u>Inorganic Substances</u></i>		
Heavy Metals and Metalloids	Arsenic, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium, Copper, Zinc	S4UL
	Copper, Zinc, Nickel	BS: 3882 (2015).
Cyanides	Free Cyanide	CLEA v1.06
Sulphates	Water Soluble Sulphate	BRE Special Digest 1:2005

5.3 BRE

- 5.3.1 The BRE Special Digest 1:2005, 'Concrete in Aggressive Ground' is used with soluble sulphate and pH results to assess the aggressive chemical environment of future underground concrete structures at the site.

5.4 Site Specific Criteria

- 5.4.1 The criteria adopted in the selection of correct screening criteria from published reports as previously described, are provided within Table 5.2.

Table 5.2: Site Specific Data

Input Details	Value
Land Use	Residential with plant uptake
Soil Organic Matter	1%

- 5.4.2 It is understood that the site is to be converted to provide residential units with private gardens. As a result, the site has been assessed with regards to a “residential with plant uptake” end use scenario.
- 5.4.3 GAC have been selected with consideration to the Soil Organic Matter (SOM) content of the soil. From the soils analytical results, the average value for Total Organic Carbon for the Made Ground is 12.1%, which gives an equivalent SOM of 20.7%.
- 5.4.4 Published GAC have been selected as those derived assuming a SOM of 1% as this provides the most conservative assessment.

6 GENERIC QUANTITATIVE RISK ASSESSMENT – SOIL DATA

6.1 Screening of Soil Chemical Analysis Results – Human Health Risk Assessment

6.1.1 To focus on the contaminants of potential concern (COPC), the results have been compared with the respective SGV/GAC. Those contaminants which exceed the SGV/GAC are considered to be the COPC. Those which do not exceed the respective SGV/GAC are not considered to be COPC and as such do not require further assessment in relation to the proposed development of the site.

6.1.2 Laboratory analysis for soils are summarised in Table 6.1 to Table 6.4. Raw laboratory data is included in Appendix 3.

Table 6.1: Soil Laboratory Test Results - Metals, Metalloids, Phenol, Cyanide

Determinand	Unit	No. samples tested	Screening Criteria	Min	Max	No. Exceeding
Arsenic	mg/kg	4	S4UL	37	27.4	46.5 2No. (WS3@0.60mbgl, WS4@0.30mbgl)
Boron Water Soluble	mg/kg	4	S4UL	290	1.1	3.4
Cadmium	mg/kg	4	S4UL	11	1.11	4.14
Chromium	mg/kg	4	S4UL	910	32	47
Chromium (hexavalent)	mg/kg	4	S4UL	6	<0.3	<0.3
Copper	mg/kg	4	S4UL	2400	113	162
Lead	mg/kg	4	C4SL	200	384	3400 4No. (WS1@0.30mbgl, WS2@0.60mbgl, WS3@0.60mbgl, WS4@0.30mbgl)
Mercury	mg/kg	4	S4UL	40	0.39	1.86
Nickel	mg/kg	4	S4UL	180	43	58
Selenium	mg/kg	4	S4UL	250	0.61	1.40
Zinc	mg/kg	4	S4UL	3700	287	1240
Total Cyanide ^A	mg/kg	4	CLEA v 1.06	33	0.32	0.75
Phenols	mg/kg	4	S4UL	120	<0.7	0.8

Notes: ^A Generic assessment criteria derived for free inorganic cyanide.

Table 6.2: Soil Laboratory Test Results - Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Acenaphthene	mg/kg	4	S4UL	210	<0.05	<0.05	0
Acenaphthylene	mg/kg	4	S4UL	170	<0.10	<0.10	0
Anthracene	mg/kg	4	S4UL	2400	<0.10	0.48	0
Benzo(a)anthracene	mg/kg	4	S4UL	7.2	<0.05	1.04	0
Benzo(a)pyrene	mg/kg	4	S4UL	2.2	<0.05	0.65	0
Benzo(b)fluoranthene	mg/kg	4	S4UL	2.6	<0.10	1.30	0
Benzo(ghi)perylene	mg/kg	4	S4UL	320	<0.05	0.51	0
Benzo(k)fluoranthene	mg/kg	4	S4UL	77	<0.10	0.63	0
Chrysene	mg/kg	4	S4UL	15	<0.10	1.14	0
Dibenzo(ah)anthracene	mg/kg	4	S4UL	0.24	<0.10	<0.10	0
Fluoranthene	mg/kg	4	S4UL	280	<0.10	2.39	0
Fluorene	mg/kg	4	S4UL	170	<0.05	<0.05	0
Indeno(123-cd)pyrene	mg/kg	4	S4UL	27	<0.10	0.43	0
Naphthalene	mg/kg	4	S4UL	2.3	<0.05	0.44	0
Phenanthrene	mg/kg	4	S4UL	95	<0.10	0.91	0
Pyrene	mg/kg	4	S4UL	620	<0.10	2.18	0
Total PAH	mg/kg	4	-	-	<1.3	10.1	-

Table 6.3: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPH)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
C ₈ -C ₁₀	mg/kg	3	S4UL	27	<1	1	0
>C ₁₀ -C ₁₂	mg/kg	3	S4UL	74	<1	<1	0
>C ₁₂ -C ₁₆	mg/kg	3	S4UL	140	4	10	0
>C ₁₆ -C ₂₁	mg/kg	3	S4UL	260	1	14	0
>C ₂₁ -C ₃₅	mg/kg	3	S4UL	1100	26	110	0
Total TPH	mg/kg	3	-	-	35	132	-

Note: *The lower value of guidelines for Aromatic/Aliphatics has been selected

Table 6.4: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPHCWG)

TPH Band	Unit	No. Samples Tested	Screening Criteria	Result	No. Exceeding
>C ₅ -C ₆ Aliphatic	mg/kg	1	S4UL 42	<0.01	0
>C ₆ -C ₈ Aliphatic	mg/kg	1	S4UL 100	<0.01	0
>C ₈ -C ₁₀ Aliphatic	mg/kg	1	S4UL 27	<1.0	0
>C ₁₀ -C ₁₂ Aliphatic	mg/kg	1	S4UL 130	1	0
>C ₁₂ -C ₁₆ Aliphatic	mg/kg	1	S4UL 1100	33	0
>C ₁₆ -C ₃₅ Aliphatic	mg/kg	1	S4UL 65000	119	0
>C ₃₅ -C ₄₀ Aliphatic	mg/kg	1	S4UL 65000	<1.0	0
>C ₅ -C ₇ Aromatic	mg/kg	1	S4UL 70	<0.01	0
>C ₇ -C ₈ Aromatic	mg/kg	1	S4UL 130	<0.01	0
>C ₈ -C ₁₀ Aromatic	mg/kg	1	S4UL 34	<0.01	0
>C ₁₀ -C ₁₂ Aromatic	mg/kg	1	S4UL 74	<1.0	0
>C ₁₂ -C ₁₆ Aromatic	mg/kg	1	S4UL 140	<1.0	0
>C ₁₆ -C ₂₁ Aromatic	mg/kg	1	S4UL 260	2	0
>C ₂₁ -C ₃₅ Aromatic	mg/kg	1	S4UL 1100	24	0
>C ₃₅ -C ₄₀ Aromatic	mg/kg	1	S4UL 1100	<1.0	0
Total TPH (Ali/Aro)	mg/kg	1	S4UL -	179	-

6.2 Assessment of Soil Analytical Data with Respect to Controlled Waters

6.2.1 At the Preliminary Risk Assessment (Desk Study) stage, risks to controlled waters were considered low.

6.2.2 The following controlled waters receptors were identified:

- Secondary A Aquifer within the Claygate Member

6.2.3 With reference to Section 4.3, no visual or olfactory evidence of potentially mobile contamination was encountered, and therefore a pollutant linkage to controlled waters is not considered to exist.

6.2.4 Generally low levels of polyaromatic hydrocarbons (PAHs) have been found in the Made Ground soils. The only PAHs with stated “moderate” or “high” mobility rankings in groundwater (as per CL:AIRE, 2017) are naphthalene, acenaphthylene, and acenaphthene. Of these compounds, only naphthalene has a statutory water quality standard. As naphthalene has only been detected in low concentration, and no visual/olfactory evidence of potentially mobile contamination has been encountered, the concentrations of PAHs detected in soils are not considered to pose a risk to controlled waters.

6.3 Vapour Risk Assessment from a Soil Source

6.3.1 As outlined in **Error! Reference source not found.** and Table 6.3, no organic contaminants have been found in excess of their generic screening criteria for the protection of human health within a 'residential with homegrown produce' end-use scenario. The generic screening criteria considers all possible pathways between the source and the receptor. On the basis that the generic assessment criteria for organic contaminants have not been exceeded, a significant vapour risk is not considered to exist.

6.4 Asbestos in Soil

6.4.1 5No samples of the Made Ground were screened in the laboratory for the presence of asbestos. The results of the analysis is summarised below in Table 6.5

Table 6.5: Asbestos Analysis – Summary

Sample	Screening result.	Quantification result (%)	Comments
WS1 – 0.3mbgl	None Detected	N/A	N/A
WS2 – 0.6mbgl	None Detected	N/A	N/A
WS3 – 0.6mbgl	None Detected	N/A	N/A
WS4 – 0.3mbgl	None Detected	N/A	N/A
WS4A – 0.1mbgl (bulk sample)	Detected	N/A	Chrysotile (White Asbestos) Amosite (Brown Asbestos)

6.4.2 Asbestos was identified within the bulk sample of suspected ACM, but no loose fibres were detected in soil. It should be assumed that asbestos may be present elsewhere on site.

6.5 Summary of Human Health Generic Quantitative Risk Assessment

6.5.1 In summary, concentrations of arsenic and lead in excess of the GAC have been recorded in samples of Made Ground.

6.6 Screening of Soil Chemical Analysis Results – Potential Risks to Plant Growth

6.6.1 Zinc, copper and nickel are phytotoxins and could therefore inhibit plant growth in soft landscaped areas. Concentrations measured in soil for these determinands have been compared with the pH dependent values given in BS: 3882 (2015).

6.6.2 Adopting a pH value of greater than 7, as indicated by the results of the laboratory analysis, the following is noted;

Table 6.6: Soil Laboratory Analysis Results – Phytotoxic Determinands

Determinand	Threshold level (mg/kg)	Min (mg/kg)	Max (mg/kg)	No. Exceeding
Nickel	110	43	58	0
Copper	200	113	162	0
Zinc	300	287	1240	3No. (WS2@0.60mbgl, WS3@0.60mbgl, WS4@0.30mbgl)

6.7 Screening for Water Pipes

6.7.1 The results of the analysis have been assessed for potential impact upon water supply pipes. Table 6.7 below summarises the findings of the assessment.

Table 6.7: Screening Guide for Water Pipes

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Total VOCs	1	0.5	-	<0.0029	0
BTEX	1	0.1	-	<0.030	0
MTBE	1	0.1	-	<0.005	0
EC ₅ -EC ₁₀	3	1	<1	≥1, <1.05*	0
EC ₁₀ -EC ₁₆	3	10	≥4 <5	34	1No (WS2@0.60mbgl)
EC ₁₆ -EC ₄₀	3	500	27	145	0
Naphthalene	4	5	<0.05	0.44	0
Phenols	4	2	<0.7	0.8	0

*Laboratory detection limit, assumed to exceed where detected concentration exceeds assessment criteria

6.7.2 The above suggests that upgraded pipe work may be required in the vicinity of WS2. Alternatively, it may be possible to utilise other protection methods including (but not limited to):

- diversion of the pipe,
- localised remediation
- embedding the pipe in a sufficient thickness of clean granular material

6.7.3 The water supply pipe requirements for this site should be discussed at an early stage with the relevant utility provider.

6.8 Waste Characterisation

- 6.8.1 The classification of materials for waste disposal purposes was outside the scope of this report. Should quantities of material require off-site disposal, waste classification will be required to determine whether soils may be treated as hazardous or non-hazardous.
- 6.8.2 Note that Waste Acceptance Criteria (WAC) analysis may then be required by the landfill operator to determine whether materials can be disposed of at either an inert, stable non-reactive hazardous or hazardous landfill.
- 6.8.3 Any soils containing >0.1% asbestos or visible asbestos containing materials would be considered hazardous waste.
- 6.8.4 Alternatively, if Made Ground soils are to be excavated and re-used on site, a Materials Management Plan (MMP) must be produced in accordance with CL:AIRE Definition of Waste: Development Industry Code of Practice (DoWCoP) and approved by a Qualified Person ahead of the commencement of any material movement.

7 SUMMARY OF RESULTS

7.1 Land Quality Impact Summary

7.1.1 Following the ground investigation, the following is noted:

- It is understood that the proposed development is to convert the existing ground floor and lower ground floor from offices to residential use. The proposed development contains a private garden at lower ground floor level.
- Following generic risk assessments, elevated concentrations of arsenic and lead were reported in soils in excess of generic assessment criteria for the protection of human health within a “residential with home grown produce” end-use scenario.
- No asbestos fibres were detected, however a bulk sample of suspected asbestos containing material was encountered in WS4a and confirmed to contain chrysotile and amosite asbestos. Any visual asbestos materials may be removed by hand, with extensive dust control measures required during the soil screening operations for the protection of site workers and nearby residents. It should be noted that asbestos fibres will not be visible to the naked eye.
- The site proposal indicates that a large proportion of the site will remain covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping it will be necessary to replace the soils with minimum 600mm of imported clean topsoil, placed on a membrane.
- The site is directly underlain by solid deposits of the Claygate Member, identified as a Secondary A Aquifer. There are no source protection zones within 500m of the site, and no groundwater, surface water or potable water abstractions within 2km of the site. As a result, the sensitivity of controlled waters is considered low. No significantly elevated concentrations of potentially mobile contaminants have been reported within soil samples analysed.
- No potentially significant sources of ground gas were identified within the desk study, and no potential sources were identified during the ground investigation. On this basis, no formal ground gas protection measures are considered necessary.
- As with any ground investigation, the presence of further hotspots between sampling points cannot be ruled out. Should any contamination be

encountered, a suitably qualified environmental consultant should be informed immediately, so that adequate measures may be recommended.

- 7.1.2 The above conclusions are made subject to approval by the statutory regulatory bodies.

7.2 Review of Pollutant Linkages Following Site Investigation

- 7.2.1 The site CSM has been revised and updated from that suggested in the desk study in view of the ground investigation data, including soil laboratory analysis results. Table 7.1 highlights whether pollutant linkages identified in the original CSM are still relevant following the risk assessment, or whether pollutant linkages, not previously identified, exist.

SECTION 7

SUMMARY OF RESULTS

Table 7.1: Plausible Pollutants Linkages Summary (Pre Remediation)

Potential Source (from desk study)	Pathway	Receptor	Relevant Pollutant Linkage?	Comment
- Potential for contaminated ground associated with industrial use – off site (S1) - Published goods, 14m north-west - Garage, 96m north-west (1962 – 1996) - Laundry and associated tank, ~120m north - Potential ground gas generation from infilled land – off site (S2) - Pond, ~50m north Brick field, 70m south-east (1879) - Unspecified pit, 133m north-west (1879)	- Ingestion and dermal contact with contaminated soil (P1) - Inhalation or contact with potentially contaminated dust and vapours (P2) - Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6) - Accumulation and migration of soil gases (P5) - Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) - Horizontal and vertical migration of contaminants within groundwater (P4)	- Construction workers (R1) - Maintenance workers (R2) - Neighbouring site users (R3) - Future site users (R4) - Building foundations and on site buried services (water mains, electricity and sewer) (R5) - Neighbouring site users (R3) - Building foundations and on site buried services (water mains, electricity and sewer) (R5) - Controlled waters (R6) - Secondary A aquifer, on site	✓ X X	See 7.1 above for remedial measures. The findings of this report should be included in the construction health and safety file, with adequate measures put in place for the protection of construction and maintenance workers. No significant source identified in the Desk Study, and no source identified during the GI. No formal gas protection considered necessary. No significant risk to controlled waters receptors identified. Contact should be made with relevant utility providers to confirm if upgraded materials are required.

8 REFERENCES

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APPENDICES

APPENDIX 1 – FIGURES

APPENDIX 2 – EXPLORATORY HOLE RECORDS

APPENDIX 3 – CHEMICAL LABORATORY TEST RESULTS

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