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GEO-ENVIRONMENTAL ASSESSMENT (GROUND INVESTIGATION) REPORT

RAGLAN HOUSE, 1 RAGLAN ST, KENTISH TOWN, LONDON NW5 3DB

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Report Title: **Geo-environmental Assessment Ground Investigation Report for Raglan House, 1 Raglan St, Kentish Town, London NW5 3DB**

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EXECUTIVE SUMMARY

MBA Construction Management Limited commissioned Jomas Associates Ltd to undertake a Geo-environmental ground investigation at the site Raglan House, 1 Raglan St, Kentish Town, London NW5 3DB.

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) report R&D CLR11 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 was previously undertaken for the site and issued separately. A brief overview of the report is presented below. A review of earliest available historical maps dated 1873-74 shows the site as comprising terraced housing. By the map dated 1952, the site is shown to have been redeveloped into a single larger building labelled as a welfare centre. Few significant changes then occur to the site until the present day. Historically, the surrounding area has comprised mainly residential and retail buildings. Historical industrial uses include a saw mill immediately north of site; a blacking works 10m north of site; a dental products factory (and later electrical works) 30m south of site; and a piano factory 50m north of site. Published geological map data provided by Groundsure and British Geological Survey, indicates that the site is directly underlain by solid deposits of the London Clay Formation. Information obtained from the Groundsure EnviroInsight indicates that the deposits underlying the site are identified as unproductive. A review of data provided by Groundsure indicates that there are no source protection zones within 500m of the site. The nearest groundwater and potable water abstraction is located 186m south-west of site. The nearest surface water abstraction is location 921m south west of the site. According to the information provided by Groundsure, there are no surface water features or Ordnance Survey water networks reported within 250m of the site.

Site History and Ground Investigation	
Intrusive Investigation	The ground investigation was undertaken on 11th February 2021, and consisted of the following: • 6 No. hand held window sampling boreholes, drilled up to 2.50m below ground level (bgl), with associated in situ testing and sampling; • Laboratory analysis for chemical purposes,
Ground Conditions	The results of the ground investigation revealed a ground profile comprising Made Ground over deposits of gravelly clay and clay of the London Clay Formation. During the ground investigation, no groundwater strikes were reported.
Environmental Considerations	It is understood that existing building will be renovated to form 6No. residential dwellings. The existing rear structures and conservatory will be demolished to form private gardens. Following generic risk assessments, elevated concentrations of lead, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(ah)anthracene were reported in the soils in excess of generic assessment criteria for the protection of human health with respect to end users with the proposed residential with plant uptake development. No asbestos fibres were detected in the samples analysed in the laboratory. Upgraded potable pipework may be required due to elevated hydrocarbon fractions C10-C16 and C16-C40. The water supply pipe requirements should be discussed at an early stage with the relevant Utility provider. Based on the results of chemical testing, the required concrete class for the made ground is DS-1 assuming an Aggressive Chemical Environment for Concrete classification of AC-accordance with the procedures outlined in BRE Special Digest 1. A design sulphate class of DS-2 is recommended for London Clay Formation. The ground investigation has confirmed that site is directly underlain by solid deposits of the London Clay Formation, identified as unproductive. There are no source protection zones within 500m of the site. The nearest potable abstraction is located 186m south west of the site assumed to be abstracting from the chalk. No evidence of potentially mobile contamination was encountered and therefore the sensitivity to controlled waters remains low. The site is currently entirely covered by hardstanding and the proposal indicates that the much 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 any areas of soft landscaping, including the proposed private gardens, it will be necessary to replace the soils with minimum 450mm of imported clean soil, placed on a geotextile membrane. A remedial strategy is recommended for the proposed development. 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 MBA Construction Management Limited ("The Client") has commissioned Jomas Associates Ltd, to assess the risk of contamination posed by the ground conditions at a site referred to as Raglan House, 1 Raglan St, Kentish Town, London NW5 3DB, 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, September 2019), 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 Raglan House, 1 Raglan Street, Kentish Town, London, NW5 3DB	Jomas	P2385J1779, Final V1.2	17th September 2019

1.1.4 The intrusive investigation was undertaken in accordance with Jomas' proposal dated 8th February 2021.

1.2 Proposed Development

1.2.1 It is understood that existing building will be renovated to form 6No. residential dwellings. The existing rear structures and conservatory will be demolished to form private gardens.

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 report R&D CLR 11.

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 Supplied Documentation

1.5.1 Jomas Associates have not been supplied with any previously produced reports at the time of writing this report.

1.6 Limitations

1.6.1 Jomas Associates Ltd has prepared this report for the sole use of MBA Construction Management Limited, 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.

1.6.2 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.

1.6.3 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.

1.6.4 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.

1.6.5 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.

1.6.6 ***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	Raglan House
Address of Site	1 Raglan Street, Kentish Town, London, NW5 3DB
Approx. National Grid Ref.	528921, 184852
Site Area (Approx)	0.039ha
Site Ownership	MBA Construction Management Limited
Site Occupation	Disused (formerly a day-care centre)
Local Authority	London Borough of Camden
Proposed Site Use	Demolition of the existing conservatory, redevelop the existing building into 6No residential dwellings with private gardens.

2.2 Desk Study Overview

2.2.1 A Desk Study report has been produced for the site and issued separately (Jomas, September 2019). 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 earliest available historical maps dated 1873-74 shows the site as comprising terraced housing. By the map dated 1952, the site is shown to have been redeveloped into a single larger building labelled as a welfare centre. Few significant changes then occur to the site until the present day.

2.2.3 Historically, the surrounding area has comprised mainly residential and retail buildings. Historical industrial uses include a saw mill immediately north of site; a blacking works 10m north of site; a dental products factory (and later electrical works) 30m south of site; and a piano factory 50m north of site.

2.2.4 Information provided by the British Geological Survey indicates that the site is directly underlain by solid deposits of the London Clay Formation, identified as an unproductive stratum.

2.2.5 There are no artificial or superficial deposits within the site area.

2.2.6 Borehole records from approximately 160m south of the site indicated the London Clay Formation to extend down to approximately 39mgbl; overlying deposits of Lambeth Group and Upper Chalk.

2.2.7 The nearest groundwater and potable water abstraction is located 186m south-west of site (most likely abstracting from a chalk aquifer).

2.2.8 The nearest surface water abstraction is location 921m south west of the site.

2.2.9 There are no source protection zones within 500m of the site.

2.2.10 There are no surface water features or Ordnance Survey water networks reported within 250m 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 assess the potential risks to the identified receptors from contaminants in soil.

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 Made Ground associated with previous development operations – on site (S1)
• Potential for contaminated ground associated with previous land uses off-site (S2):
  ○ Saw Mill (1m N)
  ○ Blacking works (10m N)
  ○ Dental products factory and electrical works (30m S)
  ○ Piano factory (50m N)
• Potential asbestos containing materials within existing buildings – on site (S3)
• Potential asbestos impacted soils from demolition of previous buildings – on site (S4)
	• 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 for Asbestos	
	• Accumulation and migration of soil gases (P5)		Severe	Unlikely	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)	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 Contaminated Land Report 11, 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 11th February 2021.

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;
- Presence of groundwater beneath the site (if any), perched or otherwise;

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 (m BGL)	Justification
Window Sample Boreholes (Hand held)	6	WS1 – 6	Up to 2.50m bgl	Obtain shallow samples for contamination testing. Non-targeted, across both proposed building and gardens.

3.2.5 In all cases, all holes were logged in accordance with BS5930:2015.

3.2.6 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. The exploratory hole records are included in Appendix 2.

3.2.7 Sampling positions were agreed with the client during a site visit. The client then arranged for concrete to be cored out to allow Jomas' sampling.

3.2.8 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.

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^{o}C) and preserved in accordance with laboratory guidance.

3.3.7 No groundwater strikes were noted during the drilling of the boreholes.

3.4 Sampling Limitations

3.4.1 WS5 was terminated due to a suspected active gas pipe being uncovered.

3.4.2 The remaining boreholes were completed to depths of between 2.0m and 2.5m bgl.

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 i2 Analytical (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

	No. of tests	
Test Suite	**Made Ground**	**Natural**
Basic Suite 3	3	0
Total Organic Carbon	3	0
Basic Suite 5	2	0
Hydrocarbon suite	2	0
Asbestos Screen	5	0

3.5.4 The determinands contained in the Basic Suite 3 are as detailed in Table 3.3 below. Basic Suite 5 contains the same determinands but without the hydrocarbon compounds to avoid overlapping with the extended hydrocarbon testing.

3.5.5 The Hydrocarbon Suite includes TPHCWG, PAH, phenols, VOCs BTEX & MTBE.

Table 3.3: Basic Suite 3: Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	1	Y (MCERTS)	ICPMS
Cadmium	0.2	Y (MCERTS)	ICPMS
Chromium	1	Y (MCERTS)	ICPMS
Chromium (Hexavalent)	4	Y (MCERTS)	Colorimetry
Lead	1	Y (MCERTS)	ICPMS
Mercury	0.3	Y (MCERTS)	ICPMS
Nickel	1	Y (MCERTS)	ICPMS
Selenium	1	Y (MCERTS)	ICPMS
Copper	1	Y (MCERTS)	ICPMS
Zinc	1	Y (MCERTS)	ICPMS
Boron (Water Soluble)	0.2	Y (MCERTS)	ICPMS
pH Value	0.1 units	Y (MCERTS)	Electrometric
Sulphate (Water Soluble)	0.0125g/l	Y (MCERTS)	Ion Chromatography
Total Cyanide	1	Y (MCERTS)	Colorimetry
Speciated/Total PAH	0.05/0.80	Y (MCERTS)	GCFID
Phenols	1	Y (MCERTS)	HPLC
Total Petroleum Hydrocarbons (banded)	-	N Y (MCERTS)	Gas Chromatography

3.5.6 To support the selection of appropriate tier 1 screening values, 3No. samples were also analysed for total organic carbon.

3.5.7 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 (m bgl)	Base of strata (m bgl)	Thickness range (m)
Asphalt/concrete. (MADE GROUND)	0.0	0.22-0.30	0.22-0.30
Polystyrene. (MADE GROUND) WS3 ONLY	0.24	0.29	0.05
Brown sandy gravelly clay/clayey gravel. Gravel consists of fine to medium angular to rounded flint, concrete, brick and occasional ash, asphalt and porcelain. (MADE GROUND)	0.22-0.30	0.50-1.50	0.27-1.20
Soft to stiff consistency* brown slightly gravelly CLAY. Gravel consists of fine to medium angular to rounded flint and selenite crystals. (LONDON CLAY FORMATION).	1.00-1.50	>2.50 (Base not proven)	>1.47 (Thickness not proven)

4.1.2 Given the likely ground strata profile identified in the Desk Study and the BGS descriptions of the materials given in Section 3 of the Desk Study it is considered that the encountered natural strata represents the London Clay Formation.

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 Dark brown mottled black material was encountered within the 'made ground' strata at location, WS1 only. This stratum was also noted to contain ash and asphalt.

4.3.2 Ash was also reported within the Made Ground of WS2 from 0.3-1.0m bgl.

No other visual or olfactory evidence of contamination was 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
Organic Substances		
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
Inorganic Substances		
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 Tables 5.2.

Table 5.2: Site Specific Data

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

5.4.2 As the published reports only offer the option of selecting an SOM value of 1%, 2.5% or 6%, an SOM value of 1% has been used for the generation of generic assessment criteria, as 0.6% was the mean TOC value obtained from laboratory analysis.

5.4.3 It is understood that the site is to be converted to provide residential dwellings with private gardens. As a result, the site has been assessed as residential with plant uptake.

6 GENERIC QUANTITATIVE RISK ASSESSMENT

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 Tables 6.1 to 6.4. Raw laboratory data is included in Appendix 3.

6.1.3 Further analysis for soils are summarized in Tables 6.5 to 6.9.

Table 6.1: Soil Laboratory Analysis Results – Metals, Metalloids, Phenol, Cyanide

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Arsenic	mg/kg	5	S4UL	37	12	25	0
Cadmium	mg/kg	5	S4UL	11	<0.2	<0.2	0
Chromium	mg/kg	5	S4UL	910	23	29	0
Lead	mg/kg	5	C4SL	200	110	510	3No; WS1 @ 0.35m WS2 @ 0.50m WS5 @0.25m
Mercury	mg/kg	5	S4UL	40	1.3	6.9	0
Nickel	mg/kg	5	S4UL	180	14	30	0
Copper	mg/kg	5	S4UL	2400	29	130	0
Zinc	mg/kg	5	S4UL	3700	51	290	0
Total Cyanide [A]	mg/kg	5	CLEA v 1.06	33	<1	<1	0
Selenium	mg/kg	5	S4UL	250	<1.0	<1.0	0
Boron Water Soluble	mg/kg	5	S4UL	290	0.8	3.6	0
Phenols	mg/kg	5	S4UL	120	<1.0	<1.0	0

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

Table 6.2: Soil Laboratory Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Naphthalene	mg/kg	5	S4UL	2.3	<0.05	0.31	0

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Acenaphthylene	mg/kg	5	S4UL	170	<0.05	0.46	0
Acenaphthene	mg/kg	5	S4UL	210	<0.05	0.86	0
Fluorene	mg/kg	5	S4UL	170	<0.05	0.58	0
Phenanthrene	mg/kg	5	S4UL	95	<0.05	9.4	0
Anthracene	mg/kg	5	S4UL	2400	<0.05	1.6	0
Fluoranthene	mg/kg	5	S4UL	280	<0.05	15	0
Pyrene	mg/kg	5	S4UL	620	<0.05	13	0
Benzo(a)anthracene	mg/kg	5	S4UL	7.2	<0.05	7.8	WS5 @ 0.25m
Chrysene	mg/kg	5	S4UL	15	<0.05	6.8	0
Benzo(b)fluoranthene	mg/kg	5	S4UL	2.6	<0.05	10	WS5 @ 0.25m
Benzo(k)fluoranthene	mg/kg	5	S4UL	77	<0.05	2.8	0
Benzo(a)pyrene	mg/kg	5	S4UL	2.2	<0.05	7.9	WS5 @0.25m
Indeno(123-cd)pyrene	mg/kg	5	S4UL	27	<0.05	3.7	0
Dibenzo(ah)anthracene	mg/kg	5	S4UL	0.24	<0.05	1.1	WS5 @0.25m
Benzo(ghi)perylene	mg/kg	5	S4UL	320	<0.05	4.2	0
Total PAH	mg/kg	5	-	-	<0.65	86.1	-

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

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
$>C_{10}$-C_{12}	mg/kg	3	S4UL	74	<2	<2	0
$>C_{12}$-C_{16}	mg/kg	3	S4UL	140	<4	8.4	0
$>C_{16}$-C_{21}	mg/kg	3	S4UL	260	<1	31	0
$>C_{21}$-C_{35}	mg/kg	3	S4UL	1100	<10	110	0
Total TPH	mg/kg	3	-	-	<17	<151.4	-

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		Min	Max	No. Exceeding
$>C_5$-C_6 Aliphatic	mg/kg	2	S4UL	42	<0.001	<0.001	0
$>C_6$-C_8 Aliphatic	mg/kg	2	S4UL	100	<0.001	<0.001	0
$>C_8$-C_{10} Aliphatic	mg/kg	2	S4UL	27	<0.001	<0.001	0

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_{10}-C_{12} Aliphatic	mg/kg	2	S4UL	130	<1.0	<1.0	0
>C_{12}-C_{16} Aliphatic	mg/kg	2	S4UL	1100	<2.0	7.5	0
>C_{16}-C_{35} Aliphatic	mg/kg	2	S4UL	65000	<16.0	636	0
>C_5-C_7 Aromatic	mg/kg	2	S4UL	70	<0.001	<0.001	0
>C_7-C_8 Aromatic	mg/kg	2	S4UL	130	<0.001	<0.001	0
>C_8-C_{10} Aromatic	mg/kg	2	S4UL	34	<0.001	<0.001	0
>C_{10}-C_{12} Aromatic	mg/kg	2	S4UL	74	<1.0	<1.0	0
>C_{12}-C_{16} Aromatic	mg/kg	2	S4UL	140	<2.0	<2.0	0
>C_{16}-C_{21} Aromatic	mg/kg	2	S4UL	260	<10	30	0
>C_{21}-C_{35} Aromatic	mg/kg	2	S4UL	1100	<10	160	0
Total TPH (Ali/Aro)	mg/kg	2	S4UL	-	<20	840	-

6.2 Volatile Organic Compounds

6.2.1 In addition to the suites outlined previously, 2No samples were tested for the presence of volatile organic compounds including BTEX compounds (benzene, toluene, ethylbenzene, xylene).

6.2.2 No VOCs were reported above the laboratory detection limit within any tested sample.

6.3 Vapour Risk Assessment from a Soil Source

6.3.1 As outlined in Table 6.2, a number of polyaromatic hydrocarbons have been found in excess of their generic screening criteria for the protection of human health within a 'residential with plant uptake' end-use scenario. The generic screening criteria considers all possible pathways between the source and the receptor. In order to assess potential risks from inhalation of vapour, each organic compound that has been found in excess of its GAC will be assessed in terms of the contribution to total exposure from vapour inhalation inside a structure as reported within the LQM/CIEH S4UL document. Where a significant proportion of the total exposure is reported from vapour inhalation, there could be a potential risk from vapour inhalation.

Table 6.5: Soil Laboratory Analysis Results – Contribution to Total Exposure from Vapour Inhalation (Indoor)

Compound	Contribution of Vapour Inhalation to Total Exposure (%)	Screening Criteria (mg/kg)	Maximum recorded value (mg/kg)	Potential Vapour Risk?
Benzo(a)anthracene	0.1	7.2	7.8	X

Compound	Contribution of Vapour Inhalation to Total Exposure (%)	Screening Criteria (mg/kg)	Maximum recorded value (mg/kg)	Potential Vapour Risk?
Benzo(b)fluoranthene	<0.1	2.6	10	X
Benzo(a)pyrene	0.0	2.2	7.9	X
Dibenzo(ah)anthracene	<0.1	0.24	1.1	X

6.3.2 As shown in the table above, all of the PAHs detected in soils in excess of generic assessment criteria have a negligible contribution to total exposure via inhalation pathway (less or equal to 0.1%).

6.3.3 Therefore, it is considered that there is not a significant risk to end users of the proposed development associated with vapour risk inhalation from soils.

6.4 Asbestos in Soil

6.4.1 5No samples of the Made Ground were screened in the laboratory for the presence of asbestos.

6.4.2 No asbestos fibres were reported in samples analysed in the laboratory.

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

6.5.1 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).

6.5.2 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 (mgkg)	Max (mg/kg)	No. Exceeding
Zinc	300	51	290	0
Copper	200	29	130	0
Nickel	110	14	30	0

6.6 Screening for Water Pipes

6.6.1 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	2	0.5	<0.056*	<0.056*	0
BTEX	2	0.1	<0.005*	<0.005*	0
MTBE	2	0.1	<0.001*	<0.001*	0
EC5-EC10	2	1	<0.006*	<0.1*	0
EC10-EC16	2	10	<6*	<11.5	WS1 @ 0.35m WS5 @ 0.25m
EC16-EC40	2	500	<11.0*	826	WS1 @ 0.35m
Naphthalene	2	5	<0.05*	0.31	0
Phenols	2	2	<1*	<1*	0

*Laboratory detection limit

6.6.3 The above suggests that upgraded pipe work may be required.

6.6.4 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

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

6.7 Waste Disposal

6.7.1 The classification of materials for waste disposal purposes was outside the scope of this report. Should quantities of material require off-site disposal, Waste Acceptance Criteria testing will be required.

6.8 Concrete in the Ground

6.8.1 Sulphate attack on building foundations occurs where sulphate solutions react with the various products of hydration in Ordinary Portland Cement (OPC) or converted High-Alumina Cement (HAC). The reaction is expansive, and therefore disruptive, not only due to the formation of minute cracks, but also due to loss of cohesion in the matrix.

6.8.2 In accordance with BRE Special Digest 1, the characteristic values of sulphate used to determine the concrete classification are determined using the methodology summarised in the table below.

Table 6.8: Concrete in the Ground Characteristic Value Determination

No. Samples in the dataset	Method for determining the sulphate characteristic value
1 - 4	Highest value
5-9	Mean of the top 2no. highest results
10 or greater	Mean of the top 20% highest results

6.8.3 Table 6.9 summarises the analysis of the aggressive nature of the Made Ground encountered within the ground investigation.

Table 6.9: Concrete in the Ground Class

Stratum	No. Samples	pH range	Characteristic WS Sulphate (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	5	8.1-9.6	345	DS-1	AC-1

6.8.4 It should be noted that the BGS description of the London Clay Formation notes that it includes “disseminated pyrite”. It is therefore common practice to ensure that buried concrete formed in London Clay Formation has a Design Sulphate Class of at least DS-2.

6.8.5 The concrete structures, including foundations, will need to be designed in accordance with BS EN 1992-1-1:2004+A1:2014.

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 existing building will be renovated to form 6No. residential dwellings. The existing rear structures and conservatory will be demolished to form private gardens.

- Following generic risk assessments, elevated concentrations of lead, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(ah)anthracene were reported in the soils in excess of generic assessment criteria for the protection of human health with respect to end users with the proposed residential with plant uptake development.

- No asbestos fibres were detected in the samples analysed in the laboratory.

- Upgraded potable pipework may be required due to elevated hydrocarbon fractions C_{10}-C_{16} and C_{16}-C_{40}. The water supply pipe requirements should be discussed at an early stage with the relevant Utility provider.

- Based on the results of chemical testing, the required concrete class for the made ground is DS-1 assuming an Aggressive Chemical Environment for Concrete classification of AC- accordance with the procedures outlined in BRE Special Digest 1. A design sulphate class of DS-2 is recommended for London Clay Formation.

- The ground investigation has confirmed that site is directly underlain by solid deposits of the London Clay Formation, identified as unproductive. There are no source protection zones within 500m of the site. The nearest potable abstraction is located 186m south west of the site assumed to be abstracting from the chalk. No evidence of potentially mobile contamination was encountered and therefore the sensitivity to controlled waters remains low.

- The site is currently entirely covered by hardstanding and the proposal indicates that the much 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 any areas of soft landscaping, including the proposed private gardens, it will be necessary to replace the soils with minimum 450mm of imported clean soil, placed on a geotextile membrane.

- A remedial strategy is recommended for the proposed development.

- 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.

Table 7.1: Plausible Pollutants Linkages Summary (Pre Remediation)

Potential Source (from desk study)	Pathway	Receptor	Relevant Pollutant Linkage?	Comment

• Potential for Made Ground associated with previous development operations – on site (S1)
• Potential for contaminated ground associated with previous land uses off-site (S2):
  ○ Saw Mill (1m N)
  ○ Blacking works (10m N)
  ○ Dental products factory and electrical works (30m S)
  ○ Piano factory (50m N)
• Potential asbestos containing materials within existing buildings – on site (S3)
• Potential asbestos impacted soils from demolition of previous buildings – on site (S4)
	• 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)
			Y	see Section 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.
				
				Contact should be made with relevant utility providers to confirm if upgraded materials are required
				
				The concrete classification to protect buried concrete is discussed in Section 6.8.

	• 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)	**X**	Contact should be made with relevant utility providers to confirm if upgraded materials are required. The concrete classification to protect buried concrete is discussed in Section 6.8.

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APPENDICES

APPENDIX 1 – FIGURES

APPENDIX 2 – EXPLORATORY HOLE RECORDS

APPENDIX 3 – CHEMICAL LABORATORY TEST RESULTS

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