PRELIMINARY GEO-ENVIRONMENTAL ASSESSMENT

FOR

18 – 28 HATTON WALL, LONDON
EC1N 8JN

Specialists in the investigation & reclamation of brownfield sites

Report Title	**: Preliminary Geo-environmental Assessment for 18 – 28 Hatton Wall, London**
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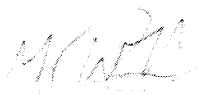

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EXECUTIVE SUMMARY

Diamond Pool Ltd commissioned Jomas Associates Ltd ('JAL') to undertake a preliminary geo-environmental assessment at the site 18 – 28 Hatton Wall, London. The principle objectives of the study were as follows:

- 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 the Environment Agency (EA) report R&D CLR11 and Planning Policy Statement 23 (PPS 23);
- To obtain documentary or other information to assess whether the land appears to be contaminated land, under the definition set out in Part IIA of the Environmental Protection Act 1990; and,
- 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 in accordance with PPS 23 (ODPM, 2004).

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.

Phase I – Desk Study	
Site History	The earliest map obtained as part of the desk study indicates that the site initially comprised buildings identified as 'warehouses' (map dated 1874). The map dated 1897 shows the layout of buildings within the site to have altered slightly, with the buildings no longer identified as warehouses. The map dated 1951 identifies the building within the site as a Tobacco Factory (on later editions the building is simply identified as a Factory). No further changes occur to the site until the map dated 2011, when the site is no longer identified as a factory, although the building footprint does not appear to change. Historically, the surrounding area has been developed for a combination of residential and industrial uses, with numerous industrial developments in close proximity to the site. A brewery and factory are noted (on maps of differing dates) to have been present immediately to the north of the site, while a gold refinery is shown to have been present approximately 150m south of the site.
Proposed Site Use	Demolition of Nos. 20 – 24 Hatton Wall and construction of a 6 storey building (with basement) for light industrial use. Also, refurbishment and extension of Nos. 26 – 28 Hatton Wall to provide mixed use development.
Site Setting	Published geological map data provided by Groundsure and British Geological Survey, indicates that the site is directly underlain by superficial deposits of the Hackney Gravel Formation. These superficial deposits are underlain by solid deposits of the London Clay Formation. No artificial deposits are reported within 500m of the site. No landslips or faults are reported within 500m of the site. A review of data held on the EA website (www.environment-agency.gov.uk) indicates that the site is not within 500m of a Source Protection Zone. The solid deposits underlying the site are designated as **Unproductive,** with the

	Superficial deposits above identified as a **Secondary A Aquifer.** No detailed river records are reported within 500m of the site. The site is not within 250m of an Environment Agency indicative Zone 2 or 3 floodplain. The Groundsure report indicates that 'no radon protective measures are necessary' at the site.
Potential Sources	• Potential for contaminated Made Ground from previous developments – on/off site (S1) • Potential for contaminated groundwater within Hackney Gravels – on site (S2) • Current and former industrial land use – on/off site (S3) • Below ground oil tank on site (precise age/condition unknown) – on site (S4)
Potential Receptors	Construction and maintenance workers, neighbouring and future site users, Controlled waters (any groundwater contained within the underlying Hackney Gravels), buried foundations and services.
Preliminary Risk Assessment	The site was considered to present a moderate risk to identified sensitive receptors

Phase II – Intrusive Investigation	
Intrusive Investigation	A geo-environmental ground investigation was undertaken on 20 April 2011. The site investigation consisted of the following elements: • 7 No. window sampling boreholes, drilled up to 3.1m below ground level (bgl) (i.e., refusal), with associated in situ testing and sampling, • Installation of 3 No. gas and groundwater monitoring standpipes, with response zone constructed in made ground deposits. • Laboratory analysis for a variety of chemical species was undertaken as recommended by the desk study; and, • 4 No. return gas and groundwater monitoring visits. All work was undertaken in accordance with BS5930 incorporating Amendment 1, BS10175:2001 and BS1377:1990
Ground Conditions	The site investigation shows the site to be directly underlain by deposits of Made Ground (generally proven to depths of up to 2.5 – 2.9 bgl). The boreholes frequently encountered obstructions at depth within the Made Ground, considered to be concrete. Below the Made Ground the site was found to be underlain by a dense to very dense sandy Gravel (Hackney Gravel Formation). During the ground investigation, all holes were found to be dry.
Environmental Considerations	Following the completion of the site investigation works, risk assessments were undertaken to assess the potential risks to current site users in accordance with Part IIA of the Environmental Protection Act 1990, best practice and the principles outlined in Contaminated Land Report 11 (CLR 11) document. The land quality risk assessment involved the comparison of land quality data with risk based generic screening values in line with the current and proposed land use (in this instance residential without homegrown produce was adopted). Following generic risk assessments, elevated concentrations of a number of Polyaromatic Hydrocarbon (PAH) compounds were noted. The elevated concentrations of PAH compounds were reported mainly within two made ground samples taken from WS2 and WS3 at 0.3m and 0.25m respectively. These two samples of made ground also revealed concentrations of Semi-volatile Organic Compounds (SVOCs), above the laboratory detection limit (up to a maximum of 15.72mg/kg). The borehole logs describe this made ground horizon as comprising a grey to black sandy gravel. PAH exceedances were also reported in made ground samples taken from WS4 and WS8. The results of Total Petroleum Hydrocarbon analysis did not indicate significant concentrations of short chain hydrocarbons, and as a result the source is considered unlikely to be a recent fuel / hydrocarbon spillage. The horizons of Made Ground within the site are frequently noted to contain ash, coal and slag, which may have resulted in the elevated PAH compounds reported in the laboratory. As the site is to be covered in its entirety with buildings and hardstanding, it is expected that the proposed development will act as a barrier mitigating risks to humans using the site post development. Leachate tests should be undertaken to establish the level of risk posed to groundwater. Further deeper boreholes and groundwater monitoring may be required depending upon the results of the leachate analysis. Based on the results of soil sulphate and pH analysis, the required concrete class for the site is DS-3 assuming an Aggressive Chemical Environment for Concrete classification of AC-3 in accordance with the procedures outlined in BRE Special

	Digest 1. Based on the GSVs calculated from the worst case methane and carbon dioxide concentrations, the site can be generally classed as Characteristic Situation 1 (GSV <0.07), where no special protection measures are required in accordance with CIRIA C665. Further gas monitoring is recommended to determine whether a hydrocarbon resistant membrane is required for the proposed development. This monitoring should include the assessment of VOCs. Based on the findings of the intrusive investigation and laboratory testing, possible pollutant linkages may be present at the site, and additional testing is recommended to establish the significance of these linkages. The presence of contamination hotspots between sampling positions cannot be discounted, and further investigation may be required following the demolition of the buildings on site. The above conclusions are made subject to approval by the statutory regulatory bodies.

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 Diamond Pool Ltd ("The Client") has commissioned Jomas Associates Ltd ('JAL'), to assess the risk of contamination posed by the ground conditions at a site referred to as 18 – 28 Hatton Wall, London, prior to redevelopment of the site for combined residential and commercial use. It is understood that no soft landscaping is proposed as part of the development.

1.1.2 To this end a desk based review (Phase I), followed by a basic intrusive investigation (Phase IIa) of the site, have been undertaken in accordance with JAL's proposal dated 13 April 2011.

1.2 Objectives

1.2.1 The objectives of JAL's investigation were as follows:

- To present a description of the present site status, based upon the published geology, hydrogeology and hydrology of the site and surrounding area;
- To review readily available historical information (i.e., Ordnance Survey maps and database search information) for the site and surrounding areas, with respect to potentially contaminative land uses;
- To provide an assessment of the environmental sensitivity at the site and the surrounding area, in relation to any suspected or known contamination which may significantly affect the site and the proposed development;
- To conduct a preliminary intrusive investigation, to determine the nature and extent of contaminants potentially present at the site; and
- 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 and PPS23.

1.3 Scope of Works

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

- A walkover survey of the site;
- A desk study, which included the review of a database search report (Groundsure EnviroInsight and GeoInsight, attached in Appendix 2) and historical Ordnance Survey maps;
- Phase II basic intrusive ground investigation to determine shallow ground conditions, and potential for contamination at the site; and,
- The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.4 Limitations

1.4.1 Jomas Associates Ltd ('JAL') has prepared this report for the sole use of Diamond Pool Ltd, 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 JAL. 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.

1.4.2 The records search was limited to information available from public sources; this information is changing continually and frequently incomplete. Unless JAL has actual knowledge to the contrary, information obtained from public sources or provided to JAL by site personnel and other information sources, have been assumed to be correct. JAL 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.

1.4.3 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.

1.4.4 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 as Figure 1.

Table 2.1: Site Information

Name of Site	18 – 28 Hatton Wall
Address of Site	18 – 28 Hatton Wall, London
Approximate size of site	0.13 Ha
Approx. National Grid Ref.	531249,181988
Site Ownership	Diamond Pool Ltd - Landlord
Site Occupation	Commercial properties including offices and jewellery workshops
Local Authority	London Borough of Camden
Proposed Site Use	Demolition of numbers 20 – 24 and redevelopment to provide light industrial building, plus refurbishment and extension of numbers 26 – 28 to provide mixed use development.

2.2 Walkover Survey

2.2.1 A site walkover survey was conducted by JAL on the Friday 15 April 2011.

2.2.2 The site was accessed via off Hatton Wall, London. The study area is approximately rectangular in shape, covering an area of approximately 0.13ha.

2.2.3 The site is occupied by multi-tenanted offices on five levels (including a basement), with an associated yard on the eastern part. A jewellery shop is present on the south-western part of the site.

2.2.4 The site is bordered by Hatton Wall and further commercial units to the south, offices to the north, and further commercial premises to the east and west.

2.2.5 Hatton Wall appears to slope in an easterly direction.

2.2.6 Photos taken during the site walkover are provided in Appendix 1.

2.3 Historical Mapping Information

2.3.1 The historical development of the site and its surrounding areas was evaluated following the review of a number of Ordinance Survey historic maps, procured from GroundSure, and provided in Appendix 3 of this report.

2.3.2 A summary produced from the review of the historical map is given in Table 2.2 below. Distances are taken from the site boundary.

Table 2.2: Historical Development

Dates and Scale of Map	Relevant Historical Information (on and off-site)
1874 1:10,560	The site is occupied by several buildings identified as warehouses. The surrounding area is occupied by a combination of residential and industrial land uses. A large Brewery is shown approximately 50m west of the site, with a sawmill shown approximately 50m south of the site. A printing works is shown approximately 200m north east of the site.
1897 1:2,500	The layout of the buildings on site has altered slightly, with several smaller buildings no longer shown, and the buildings remaining within the site area are no longer identified as warehouses. A building immediately north of the site is now identified as a Brewery. The sawmill is no longer shown. A timber yard and a railway goods depot are identified approximately 100m north east and 250m east of the site respectively.
1916 1:2,500	No significant changes noted to the site area. A Gold Refinery is now shown approximately 150m south of the site.
1951 1:2,500	The building within the site is now identified as a Tobacco Factory (although the former building footprint does not appear to have been altered). Ruins are shown in the general areas to the south and east of the site (possibly indicative of World War 2 bomb damage within the area). The site of the Brewery to the west of the site is now occupied by several small buildings identified as the Redman Buildings. The building immediately north of the site (previously identified as a Brewery) is now identified as a Factory. The timber Yard previously shown approximately 100m north east of the site is now identified as a Works. A large electrical substation is shown approximately 120m north of the site.
1954 1:2,500	No significant changes are noted on the site. The Factory immediately to the north is now identified as a Tobacco Factory.
1963 1:2,500	The Tobacco Factory within the site is now identified as a Factory. No other significant changes noted.
1967 1:2,500	No significant changes are noted on the site. The Tobacco Factory to the north of the site is now identified as a Factory.
1982 1:2,500	No significant changes are noted on the site. A Garage is now shown approximately 50m east of the site. The Factory immediately to the north of the site is no longer separately identified.
1994 1:2,500	No significant changes occur to the site. The Garage to the east of the site is no longer identified.
2011 1:2,500	The building within the site is no longer identified as a Factory, although the building footprint does not appear to have altered.

2.4 Previous Site Investigations

2.4.1 No previous site investigation reports were made available to JAL at the time of writing this report.

2.5 Local Authority Information

2.5.1 Correspondence received from Ms Anona Arthur - Environmental Health Officer, London Borough of Camden, on 15 April 2011, revealed that the Local Authority (LA) had records of the site being subjected to the following industrial activity:

- 1870's – 1920's: Unknown Industry
- 1890's: Brewery
- 1950's – 1970's: Tobacco Factory
- 1960's – 1980's: Factory

2.5.2 Ms Arthur further provided:

"Please note we do not have any previous site investigations, however from our records two trial pits and a borehole were investigated (3 sample locations) which was not considered sufficient based on the size of site".

2.6 Other Information

2.6.1 Information obtained from the client suggested the presence of a below ground oil tank within the site area. The tank is understood to be connected with an adjoining building (not part of the site). No further information relating to the use or condition of this tank was provided.

2.6.2 An initial geophysical survey of the site did not reveal the location of the tank.

2.6.3 All correspondence is provided in Appendix 5.

2.7 Proposed Development

2.7.1 The proposed development comprises the demolition of numbers 20 – 24 Hatton Wall and construction of a six storey building with basement to provide light industrial/office use. Numbers 26 – 28 Hatton Wall are to be refurbished and extended to provide a mixed use (commercial and residential) development. No soft landscaping is proposed.

2.7.2 For the purposes of the contamination risk assessment, the proposed development is classified as 'Residential without homegrown produce', as this is considered to be the most sensitive of the land use proposed for the site.

3 ENVIRONMENTAL SETTING

3.1.1 The following section summarises the principal environmental resources (geological, hydrogeological and hydrological) of the site and its surroundings. The data discussed herein is generally based on the information given within the Groundsure Reports (in Appendix 2).

3.2 Solid and Drift Geology

3.2.1 Published geological map data provided by Groundsure and British Geological Survey, indicates that the site is directly underlain by superficial deposits comprising the Hackney Gravel Formation, with deposits of Alluvium reported approximately 115m north of the site. These superficial deposits are underlain by solid geology of the London Clay Formation.

3.2.2 No artificial deposits are reported within 500m of the site.

3.2.3 No landslips or faults are reported within 500m of the site.

3.3 Hydrogeology

3.3.1 General information about the hydrogeology of the site was obtained from the Environment Agency (EA) website in May 2011.

Groundwater Vulnerability

3.3.2 The EA operates a classification system to categorise the importance of groundwater resources (aquifers) and their sensitivity to contamination. Aquifers were formerly classified as major, minor and non-aquifers, based on the amenity value of the resource. A major aquifer is a significant resource capable of producing large quantities of water suitable for potable supply. Minor aquifers produce water in varying quantities or qualities, and if utilised are of local importance. Non aquifers are low permeability strata, which contain no significant exploitable groundwater and have very limited capacity to transmit contaminants.

3.3.3 Since 1 April 2010, the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. The deposits (Hackney Gravel Formation) directly underlying the site are classed as a Secondary A Aquifer (these are permeable layers capable of supporting water supplies at a local rather than strategic level, and in some cases forming an important source of base flow to rivers. Generally these are formations previously identified as Minor Aquifers).

3.3.4 The solid deposits underlying these superficial deposits (London Clay) have been identified as Unproductive (These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow, previously identified as Non Aquifers).

Source Protection Zones (SPZ)

3.3.5 In terms of aquifer protection, the EA generally adopts a three-fold classification of SPZs for public water supply abstraction wells.

- Zone I - or 'Inner Protection Zone' is located immediately adjacent to the groundwater source and is based on a 50-day travel time. It is designed to

protect against the effects of human activity and biological/chemical contaminants that may have an immediate effect on the source.

- Zone II - or 'Outer Protection Zone' is defined by a 400-day travel time to the source. The travel time is designed to provide delay and attenuation of slowly degrading pollutants.
- Zone III - or 'Total Catchment' is the total area needed to support removal of water from the borehole, and to support any discharge from the borehole.

3.3.6 A review of data provided by Groundsure indicates that the site is not situated within 500m of a Source Protection Zone.

3.3.7 No surface water abstraction licenses are recorded within 1km of the site.

3.3.8 4 No. Groundwater abstraction licenses are recorded within 500m of the site, with the nearest recorded approximately 410m east of the site. The abstraction water is recorded as being the Thames Groundwater. This abstraction is also reported as being a potable water abstraction (the nearest such abstraction to the site).

3.4 Hydrology

3.4.1 According to the information provided by Groundsure, there are no Detailed River Entries within 500m of the site

3.4.2 The site is not within 250m of an Environment Agency indicative Zone 2 or Zone 3 floodplain.

3.5 Sensitive Land Uses

3.5.1 There are no environmentally sensitive sites recorded within 500m of the site.

3.6 Industrial and Statutory Consents

3.6.1 The Groundsure EnviroInsight Report also provides information on various statutory and industrial consents on and in the vicinity of the site. The following section summarises the information collected from the available sources.

Table 3.1: Industrial and Statutory Consents

Type of Consent/Authorisation	On site	Off-site (within 500m of site, unless stated otherwise)	Potential to Impact on Site from a land contamination perspective
Industrial Sites holding licences and/or authorisations.	None	8 No. within 500m of the site (although registered for the same process to the same body). The nearest is recorded 425m south east of the site and relates to combustion processes.	X
Records of Part A or Part B activities/authorisations	None	4 No. within 500m of the site. The nearest is reported 4m west of the site and relates to a dry cleaners. A metal processing/scrap metal furnace is reported 44m east of the site.	✓
Records of List 1 Dangerous Substances Inventory	None	1 No. 228m west of the site relating to Cadmium and Mercury	X
Discharge Consents.	None	None reported within 500m of the site	X
Control of Major Accident Hazards (COMAH) and Notification of Installations Handling Hazardous Substances (NIHHS) Sites.	None	None reported within 500m of the site	X
Category 3 or 4 Radioactive substances Authorisations	None	5 No. recorded within 500m of the site. Nearest reported 98m north east of the site	✓
Pollution Incidents.	None	None reported within 500m of the site	X
Contaminated Land Register Entries and Notices.	None	None reported within 500m of the site	X
Registered Landfill Sites.	None	Nearest historical landfill site recorded 482m north of the site, recorded as accepting inert waste	X
Waste Treatment and/or Transfer Sites.	None	None reported within 500m of the site.	X
Current Industrial Site Data.	4 (jewellery, fashion accessories, watches and clocks)	92 No. reported within 100m of the site (although some may represent multiple reports of the same use). The majority concern jewellery and fashion accessories, although a stone quarrying/finishing works is recorded 91m south east of the site.	✓
Petrol and Fuel Sites.	None	1 No. recorded 333m east of the site identified as Obsolete.	X
Underground High Pressure Oil and Gas Pipelines.	None	None reported within 500m of the site	X

3.7 Geological Hazards

3.7.1 The following are brief findings extracted from the GroundSure GeoInsight Report, that relate to factors that may have a potential impact upon the engineering of the proposed development.

Table 3.2 – Geological Hazards

Potential Hazard	GroundSure Hazard Rating
Shrink swell	Moderate
Landslides	Very Low
Ground dissolution soluble rocks	Negligible
Compressible deposits	Negligible
Collapsible Rock	Negligible
Running sand	Very Low
Coal mining	None within 1Km
Shallow mine workings	Low
Brine affected areas	None reported within 1Km

3.7.2 The Groundsure GeoInsight report also provides the following additional information:

- 8 No. historical surface ground working features are reported within 250m of the site, with the nearest recorded approximately 186m north east of the site. All are recorded as Tunnels.
- No current ground working within 1km (as derived from the BGS BRITPITS database).

3.8 Radon

As shown in the GroundSure GeoInsight Report, according to the Health Protection Agency, less than 1% of homes in the site area are above the Action level for Radon. Consequently, no radon protective measures are necessary in the construction of new dwellings or extensions as described in publication BR211 (BRE, 2007).

4 QUALITATIVE RISK ASSESSMENT

4.1 Legislative Framework

4.1.1 A qualitative risk assessment has been prepared for the site, based on the information collated. This highlights the potential sources, pathways and receptors. Intrusive investigations will be required to confirm the actual site conditions and risks.

4.1.2 Under Part IIA of the Environmental Protection Act 1990, the statutory definition of contaminated land is:

"land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that:

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or
(b) pollution of controlled waters is being, or is likely to be, caused."

4.1.3 The Statutory Guidance provided in the DEFRA Circular 01/2006 lists the following categories of significant harm:

- death, disease, serious injury, genetic mutation, birth defects or the impairment of reproduction functions in human beings;
- irreversible adverse change, or threat to endangered species, affecting an ecosystem in a protected area (i.e. site of special scientific interest);
- death, serious disease or serious physical damage to pets, livestock, game animals or fish;
- a substantial loss in yield or value of crops, timber or produce; and
- structural failure, substantial damage or substantial interference with right of occupation to any building.

4.1.4 Contaminated land will only be identified when a 'pollutant linkage' has been established.

4.1.5 A 'pollutant linkage' is defined in Part IIA as:

"A linkage between a contaminant Source and a Receptor by means of a Pathway".

4.1.6 Therefore, this report presents an assessment of the potential pollutant linkages that may be associated with the site, in order to determine whether additional investigations are required to assess their significance.

4.1.7 In accordance with Planning Policy Statement 23 (HMSO, 2004), where development is proposed, the developer is responsible for ensuring that the development is safe and suitable for use for the purpose for which it is intended, or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

- whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model;
- whether the development proposed will create new linkages, e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors; and

- what action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable development and future occupancy of the site and neighbouring land.

4.1.8 A potential developer will need to satisfy the LA that unacceptable risk from contamination will be successfully addressed through remediation without undue environmental impact during and following the development.

4.2 Conceptual Site Model

4.2.1 On the basis of the information summarised above, a conceptual site model (CSM) has been developed for the site. The CSM is used to guide the investigation activities at the site and identifies potential contamination sources, receptors (both on and off-site) and exposure pathways that may be present. The identification of such potential "pollutant linkages" is a key aspect of the evaluation of potentially contaminated land.

4.2.2 The site investigation is then undertaken in order to prove or disprove the presence of these potential source-pathway-receptor linkages. Under current legislation an environmental risk is only deemed to exist if there are proven linkages between all three elements (source, pathway and receptor).

4.2.3 This part of the report lists the potential sources, pathways and receptors at the site, and assesses based on current and future land use, whether pollution linkages are possible.

4.2.4 Potential pollutant linkages identified at the site are detailed below:

Table 4.1: Potential Sources, Pathways and Receptors

Source(s)	Pathway(s)	Receptor(s)
• Potential for contamination within Made Ground from previous developments – on/off site (S1) • Potential for contamination in Groundwater within Hackney gravels – on site (S2) • Current and former industrial land use – on/off site (S3) • Below ground oil tank – on site (S4)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • 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. (P4) • Horizontal and vertical migration of contaminants within groundwater (P5) • Accumulation and migration of soil gases (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Controlled waters (any groundwater present within the underlying Hackney Gravels) (R5) • Building foundations and on site buried services (water mains, electricity and sewer) (R6)

4.3 Qualitative Risk Estimation

4.3.1 Based on information previously presented in this report, a qualitative risk estimation was undertaken.

4.3.2 For each potential pollutant linkage identified in the conceptual model, the potential risk can be evaluated, based on the following principle:

Overall contamination risk = Probability of event occurring x Consequence of event occurring

4.3.3 In accordance with CIRIA C552, the consequence of a risk occurring has been classified into the following categories:

- Severe
- Medium
- Mild
- Minor

4.3.4 The probability of a risk occurring has been classified into the following categories:

- High Likelihood
- Likely
- Low Likelihood
- Unlikely

4.3.5 This relationship can be represented graphically as a matrix (Table 4.2).

Table 4.2: Overall Contamination Risk Matrix

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate risk	Low risk
	Low Likelihood	Moderate risk	Moderate risk	Low risk	Very low risk
	Unlikely	Low risk	Low risk	Very low risk	Very low risk

4.3.6 The risk assessment process is based on guidance provided in CIRIA C552 (2001) *Contaminated Land Risk Assessment – A Guide to Good Practice*. Further information including definitions of descriptive terms used in the risk assessment process is included in Appendix 4.

4.3.7 The degree of risk is based on a combination of the potential sources and the sensitivity of the environment. The risk classifications can be cross checked with reference to Table A4.4 in Appendix 4.

4.3.8 Hazard assessment was also carried out, the outcome of which could be:

- Urgent Action (UA) required to break existing source-pathway-receptor link.
- Ground Investigation (GI) required to gather more information
- No action required (NA)

4.3.9 The preliminary risk assessment for the site is presented in Table 4.3 below.

Table 4.3: Preliminary Risk Assessment for the Site

Sources	Pathways (P)	Receptors	Consequence	Probability of pollutant linkage	Risk Estimation	Hazard Assessment
• Potential for contamination within Made Ground from previous developments – on/off site (S1) • Potential for contamination in Groundwater within Hackney gravels – on site (S2) • Current and former industrial land use – on/off site (S3) • Below ground oil tank – on site (S4)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4)	Medium	Likely	Moderate	Ground investigation (GI) – Total concentrations of relevant contaminants in soil. Soil Gas Monitoring in accordance with CIRIA C665 dependent upon the conditions encountered on site, specifically the thickness of any Made Ground encountered on site.
	• 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 (P5) • Accumulation and migration of soil gases (P5)	• Neighbouring site users (R3) • Controlled waters (any groundwater present within the underlying Hackney Gravels) (R5) • Building foundations and on site buried services (water mains, electricity and sewer) (R6)	Medium	Likely	Moderate	

4.3.10 It should be noted that the identification of potential pollutant linkages does not necessarily signify that the site is unsuitable for its current or proposed land use. It does however act as a way of focussing data collection at the site in accordance with regulatory guidance in CLR 11.

4.4 Outcome of Risk Assessment

4.4.1 The risk estimation matrix indicates a moderate risk as defined above. An intrusive ground investigation is recommended.

4.5 List of Key Contaminants

4.5.1 The possible contamination implications for both on-site and off-site sources have been assessed based on the information presented in the report. This has been achieved using guidance publications by the Environment Agency, together with other sources.

4.5.2 Based on recommendations within the guidance publications, an initial soil and water chemical testing suite would need to consider a basic range of contaminants as follows:

- *Metals*: cadmium, chromium, copper, lead, mercury, nickel, zinc;
- *Semi-metals and non-metals*: arsenic, boron, sulphur;
- *Inorganic chemicals*: cyanide, nitrate, sulphate and sulphide;
- *Organic chemicals*: aromatic hydrocarbons, aliphatic hydrocarbons, petroleum hydrocarbons, phenol, polyaromatic hydrocarbons; volatile organic carbons, semi-volatile organic carbons
- *Others*: pH.

4.5.3 Soil gas monitoring should be conducted in accordance with CIRIA C665. An initial four monitoring visits over a period of 1-2months is recommended.

5 GROUND INVESTIGATION

5.1 Rationale for Ground Investigation

5.1.1 The site investigation has been undertaken 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.

5.1.2 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).

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

5.2 Scope of Ground Investigation

5.2.1 The ground investigation was undertaken on 20 April 2011.

5.2.2 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.

5.2.3 The investigation focused on collecting data on the following:

- Quality of Made Ground/ natural ground within the site boundaries;
- Permeability of underlying soils; and,
- Presence of groundwater beneath the site (if any), perched or otherwise.

5.2.4 A summary of the fieldwork carried out at the site, with justifications for exploratory hole positions, are offered in Table 5.1 below.

Table 5.1 –Scope of Intrusive Investigation

Investigation Type	Number of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved (m BGL)	Justification
Window Sampling Boreholes	7 of 8 proposed	WS1 – WS8	Up to 3.1m bgl	General site coverage
Monitoring Wells	3	WS2, WS4, WS6	Up to 2.7m bgl	To facilitate return gas and groundwater monitoirng

5.2.5 The exploratory holes were completed to allow soil samples to be taken in the areas of interest identified in Table 5.1 above, and to provide general site coverage. In all cases, all holes were logged by a suitably qualified engineer in accordance with BS5930:1999, incorporating Amendment 1.

5.2.6 Exploratory hole positions were measured in using tape and reel, as shown in Figure 2. The exploratory borehole records are included in Appendix 6.

5.2.7 Where no monitoring wells were installed, the boreholes 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. The surrounding areas were left clean and clear of any debris.

5.3 Sampling Rationale

5.3.1 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).

5.3.2 The exploratory holes were positioned by applying a non-targeted sampling strategy.

5.3.3 Soil samples were taken from across the site at various depths as shown in the borehole and trial pit logs.

5.3.4 JAL'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.

5.3.5 No such observations were made during the ground investigation.

5.3.6 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.

5.3.7 Samples were stored in cool boxes (<4°C) and preserved in accordance with laboratory guidance.

5.3.8 Bulk samples and, where possible, undisturbed liner samples were collected for geotechnical analysis.

5.4 Standard Penetration Tests (SPTs)

5.4.1 In-situ standard/cone penetration tests were undertaken in the boreholes in accordance with BS EN ISO 22476-2 'Methods of Test on Soils for Engineering Purposes (Part 9)'; to determine the relative density of the underlying , and therefore give an indication of soil 'strength'.

5.4.2 The results are presented on the individual exploratory hole records in Appendix 6.

5.5 Gas and Groundwater Monitoring

5.5.1 To comply with guidance within CIRIA C665, 4 Nr weekly return gas and groundwater monitoring visits have been undertaken from 21 April to 16 May 2011. Results are presented in Appendix 7.

5.5.2 Groundwater strikes noted during drilling, are recorded within the exploratory hole records in Appendix 6.

5.6 Laboratory Analysis

5.6.1 A programme of chemical laboratory testing, scheduled by JAL, was carried out on selected samples of Made Ground and natural strata.

Chemical Testing

5.6.2 Ten soil samples were submitted to The Environmental Laboratory Ltd, East Sussex (a UKAS and MCerts accredited laboratory), for analysis.

5.6.3 The samples were analysed for a wide range of contaminants as shown in Table 5.2 below:

Table 5.2: Chemical Tests Scheduled

Test Suite	No. of tests	
	Made Ground	Natural
Basic Suite 2	7	3
Total Organic Carbon	3	2
Water Soluble Sulphate	7	3
Volatile Organic Compounds	5	-
Semi-volatile Organic Compounds	5	-
Asbestos screen	5	-

5.6.4 The determinands contained in the basic suite are as detailed in Table 5.3 below:

Table 5.3: Basic Suite of Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	5	Y (MCERTS)	ICPMS
Cadmium	0.5	Y	ICPMS
Chromium	1	Y (MCERTS)	ICPMS
Chromium (Hexavalent)	2	N	Colorimetry
Lead	1	Y (MCERTS)	ICPMS
Mercury	0.5	Y	ICPMS
Nickel	1	Y (MCERTS)	ICPMS
Selenium	1	PENDING	ICPMS
Copper	1	Y (MCERTS)	ICPMS
Zinc	1	Y (MCERTS)	ICPMS
Boron (Water Soluble)	0.5	PENDING	ICPMS
pH Value	0.1 units	Y (MCERTS)	Electrometric
Sulphate (Water Soluble)	0.01ug/l	Y	Ion Chromatography
Total Cyanide	1	Y (MCERTS)	Colorimetry
Speciated PAH	0.5	Y (MCERTS)	GCFID
Phenols	1	Y (MCERTS)	HPLC
Total Petroleum Hydrocarbons (banded)	5	Y (MCERTS)	Gas Chromatography

5.6.5 To support the derivation of appropriate tier 1 screening values, 5 No. samples were also analysed for total organic carbon.

5.6.6 Laboratory test results are summarised in Section 8, with raw laboratory data included in Appendix 8.

6 GROUND CONDITIONS

6.1 Soil

6.1.1 Ground conditions were logged in accordance with the requirements of BS5930:1999, incorporating Amendment 1. Detailed borehole logs are provided in Appendix 6. The ground conditions encountered are summarised in Table 6.1 below, based on the strata observed during the investigation.

Table 6.1 : Ground Conditions Encountered

Stratum and Description	Encountered from (m bgl)	Base of strata (m bgl)	Thickness range (m)
Tarmac (where encountered)	0.0	0.05 – 0.13	0.05 - 0.13
Concrete (where encountered)	0.0	0.05 – 0.43	0.05 – 0.43
MADE GROUND Grey brown gravelly sand. Gravel is of brick, concrete and flint (where encountered)	0.15 – 0.43	0.3 – 0.6	0.14 – 0.45
MADE GROUND Granite Cobbles (considered to represent original road – where encountered)	0.06 – 0.3	0.27 – 0.54	0.2 – 0.23
MADE GROUND Grey brown black sandy gravel. Gravel is of concrete, flint, coal, clinker, metal , bone, shell and slate	0.05 – 0.62	1.2 – 2.5	0.58 – 2.45
MADE GROUND Black sandy gravel of clinker, ash, coal, pot and slag (where encountered)	1.2	2.45	1.25
MADE GROUND Relic Topsoil comprising re-worked grey brown sandy, gravelly clay. Gravel is of flint with occasional shell fragments (where encountered).	0.45 – 0.8	1.40 – 3.10	0.6 – 2.65
Dense to very dense, brown sandy GRAVEL. Gravel is of flint (WS2, WS6 and WS8 only)	3.1	>4.0	>0.9

6.2 Hydrogeology

6.2.1 During the ground investigation, groundwater was not observed within the boreholes.

6.3 Physical and Olfactory Evidence of Contamination

6.3.1 No visual or olfactory evidence of soil contamination was reported during the site works.

7 RISK ASSESSMENT – ANALYTICAL FRAMEWORK

7.1 Context and Objectives

7.1.1 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.

7.1.2 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.

7.1.3 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.

7.2 Analytical Framework – Soils

7.2.1 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.

7.2.2 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.

7.2.3 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, JAL have derived Tier 1 screening values for initial assessment of the soil, based on available current UK guidance including the LQM/CIEH generic assessment criteria. Site-specific assessments are undertaken wherever possible and/or applicable. All assessments are carried out in accordance with the CLEA protocol.

7.2.4 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.

7.2.5 The assessment criteria used for the screening of determinands within soils are identified within Table 7.1.

Table 7.1: Selected Assessment Criteria – Contaminants in Soils

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

Site Specific Criteria

7.2.6 The criteria adopted in the selection of correct screening criteria from published reports as previously described, are provided within Tables 7.2.

Table 7.2: Site Specific Data

Input Details	Value
Land Use	Residential without homegrown produce
Soil Type	Sandy
pH	10
Soil Organic Matter	1%

7.2.7 A pH value of '10' has been used for the derivation of generic screening criteria as 9.75 was the mean pH value of samples analysed.

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 1.1% was the mean value obtained from the laboratory analysis.

BRE

7.2.8 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.

7.3 Analytical Framework – Groundwater and Leachate

7.3.1 The groundwater quality assessment is undertaken in accordance with the EA P20 Document.

7.3.2 The criteria used by JAL in the assessment of groundwater and leachate quality are shown in Table 7.3.

Table 7.3: Selected Assessment Criteria – Contaminants in Water

Substance Group	Determinand(s)	Assessment Criteria Selected
Metals	Arsenic, Copper, Cyanide, Mercury, Nickel, Lead, Zinc, Chromium	EQS/DWS
	Selenium	WHO
Poly Aromatic Hydrocarbons	Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(123-cd)pyrene, Dibenz(ah)anthracene, Benzo(ghi)perylene	LEC
Total Petroleum Hydrocarbons	Aliphatic C5-C6, Aliphatic >C6-C8, Aliphatic >C8-C10. Aliphatic >C10-C12, Aliphatic >C12-C16, Aliphatic >C16-C21, Aromatic C5-C7, Aromatic >C7-C8, Aromatic >C8-C10, Aromatic >C10-C12, Aromatic >C12-C16, Aromatic >C16-C21, Aromatic> C21-C35	Dutch Intervention Values/DWS/WHO
Oxygen Demand	Chemical Oxygen Demand and Biological Oxygen Demand	Urban Waste Water Treatment (England and Wales) Regulations

Environmental Quality Standards EQS

Environmental Quality Standards (EQS) have been released by the EA for dangerous substances, as identified by the EC Dangerous Substances Directive. EQS can vary for each substance, for the hardness of the water and can be different for fresh, estuarine or coastal waters.

Lowest Effect Concentration (LEC)
These criteria relate to the concentration of PAHs in groundwater. They are taken from the EA R&D Technical Report P45 – Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development (2001).

WHO Health
These screening criteria have been taken from the World Health Organisation Guidelines for Drinking Water Quality (1984). The health value is a guideline value representing the concentration of a contaminant that does not result in any significant risk to the receptor over a lifetime of exposure.
Further criteria have been obtained from 'Petroleum Products in Drinking-water' - Background document for development of WHO Guidelines for Drinking-water Quality (2005).

UK Drinking Water Standards (DWS)
These comprise screening criteria provided by the Drinking Water Inspectorate (DWI) in the Water Supply (Water Quality) Regulations 2006,

Dutch Intervention Values (DIV)
The Dutch Institute and Human Toxicology data are used for speciated TPH. Whilst they do not have force of law in the UK, they are recognised as a valid source of information by the EA. For example, they are recommended in the EA document 'Biological Test Methods for Assessing Contaminated Land'.

Urban Waste Water Treatment (England and Wales) Regulations - UWWT Regs
The Urban Waste Water Treatment (England and Wales) Regulations SI/1994/2841 as amended by SI/2003/1788 sets down minimum standards for the discharge of treated effluent from waste water treatment works to inland surface waters, groundwater, estuaries or coastal waters. Standards of (125mg/L) COD and (25mg/L) BOD have been set.

8 GENERIC QUANTITATIVE RISK ASSESSMENT

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

8.1.1 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.

8.1.2 Laboratory analysis for soils are summarised in Tables 8.1 to 8.3. Raw laboratory data is included in Appendix 7.

Table 8.1: Soil Laboratory Analysis Results – Metals, Metalloids, TPH

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No of Exceedences
Arsenic	mg/kg	10	35	CLEA v1.06	<5	11.0	0
Cadmium	mg/kg	10	18	CLEA v1.06	<0.5	<0.5	0
Chromium	mg/kg	10	36	CLEA v1.06	3	21	0
Lead [A]	mg/kg	10	750	CLEA v1.06	7	496	0
Mercury	mg/kg	10	238	CLEA v1.06	<0.5	3.8	0
Nickel	mg/kg	10	127	CLEA v1.06	1	22	0
Copper	mg/kg	10	7126	CLEA v1.06	2	57	0
Zinc	mg/kg	10	26727	CLEA v1.06	7	114	0
Total Cyanide [B]	mg/kg	10	531	CLEA v1.06	<1	1.7	0
Selenium	mg/kg	10	595	CLEA v1.06	<0.5	0.9	0
Water Soluble Boron	mg/kg	10	3	CLEA v1.06	<0.5	2.4	0
Phenols	mg/kg	10	310	CLEA v1.06	<1	53.4	0

Notes:

[A] SGV screening criteria for Lead using the SEGH model.

[B] Generic assessment criteria derived for free inorganic cyanide.

Table 8.2: Soil Laboratory Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeded
Naphthalene	mg/kg	10	LQM GAC	1.5	<0.5	5	0
Acenaphthylene	mg/kg	10	LQM GAC	170	<0.5	4.7	0
Acenaphthene	mg/kg	10	LQM GAC	210	<0.5	20.1	0
Fluorene	mg/kg	10	LQM GAC	160	<0.5	20.2	0
Phenanthrene	mg/kg	10	LQM GAC	92	<0.5	187.3	1 WS3 at 0.25m
Anthracene	mg/kg	10	LQM GAC	2300	<0.5	64.4	0
Fluoranthene	mg/kg	10	LQM GAC	260	<0.5	210.3	0
Pyrene	mg/kg	10	LQM GAC	560	<0.5	169.7	0
Benzo(a)anthracene	mg/kg	10	LQM GAC	3.1	<0.5	102.3	4 WS2, WS3, WS4
Chrysene	mg/kg	10	LQM GAC	6.0	<0.5	102.8	3 WS2, WS3, WS4
Benzo(b)fluoranthene	mg/kg	10	LQM GAC	5.6	<0.5	111.7	4 WS2, WS3, WS4
Benzo(k)fluoranthene	mg/kg	10	LQM GAC	8.5	<0.5	40.4	4 WS2, WS3
Benzo(a)pyrene	mg/kg	10	LQM GAC	0.83	<0.5	82.0	5 WS2, WS3, WS4, WS8
Indeno(123-cd)pyrene	mg/kg	10	LQM GAC	3.2	<0.5	50.9	4 WS2, WS3, WS4
Dibenz(ah)anthracene	mg/kg	10	LQM GAC	0.76	<0.5	14.1	4 WS2, WS3, WS4
Benzo(ghi)perylene	mg/kg	10	LQM GAC	44	<0.5	41.0	0
Total PAH	mg/kg	10	-		<0.5	1226.9	-

Table 8.3: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPH)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeded
C_8-C_{10}	mg/kg	10	19	LQM*	<5	<5	0
>C_{10}-C_{12}	mg/kg	10	69	LQM*	<5	<5	0
>C_{12}-C_{16}	mg/kg	10	140	LQM*	<5	50	0
>C_{16}-C_{21}	mg/kg	10	250	LQM*	<5	253	1 (WS3 at 0.25m
>C_{21}-C_{35}	mg/kg	10	890	LQM*	<5	802	0
Total TPH	mg/kg	10	-		<5	1050	-

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

8.1.3 In addition to the suite of contaminants outlined above, 5 No. samples of Made Ground were also analysed for a suite of Volatile Organic Compounds (VOCs). All results were reported below the detection limit of 10µg/kg.

8.1.4 The same five samples were also analysed for a range of Semi-volatile Organic Compounds (SVOCs). While no specific criteria exist for the majority of these potential contaminants, their presence within samples can be indicative of general anthropogenic contamination. The concentrations of the majority of SVOCs were reported below the laboratory method detection limit. However, a total of 6 No. contaminants were recorded, all within the upper layers (0.25m bgl – 0.3m bgl) of the

Made Ground horizon within window sample boreholes WS2 and WS3. Those detected include: Phenol (3.57mg/kg), 2-methyl phenol (0.54 mg/kg), 2,4-dimethyl phenol (2.1mg/kg), 2-methyl napthalene (5.73mg/kg), 1-methyl napthalene (5.45mg/kg) and dibenzofuran (15.72mg/kg).

8.2 Asbestos Screening

8.2.1 5 No. samples of made ground taken from the site were also screened in the laboratory for asbestos fibres. No asbestos fibres were reported.

8.3 Statistical Analysis

8.3.1 Where samples tested exceeded the selected screening criteria, and the minimum numbers of samples were more than six, statistical analyses of the dataset are undertaken.

8.3.2 The CL:AIRE/CIEH Guidance 'Guidance on Comparing Soil Contamination Data with a Critical Concentration' (2008) describes the new approach to statistical analysis of datasets generated through the investigation of contaminated land. This includes differing statistical methodologies for the analysis of normally and non-normally distributed data. Different approaches to datasets being analysed under Part IIA and under the planning regime are also presented.

8.3.3 Chemical data from the laboratory testing has been assessed in accordance with the CL:AIRE/CIEH Guidance under a planning scenario. The purpose of the assessment is to determine if the land is suitable for the proposed development. Under the planning scenario, the key question is 'is there sufficient evidence that the true mean concentration of the contaminant within the data set (μ) is less than the critical concentration (Cc, in this instance the derived GAC). This is assessed by calculation of the upper confidence limit (UCL). The statistical test assesses the 95th percentile of contaminant populations across a site, and compares this value against the relevant GAC. Furthermore, the test determines statistically whether contaminants exceeding the soil guideline value could be regarded as outliers. Outliers are contaminant values which indicate a localised area of contamination or error in sampling, and may not be a member of the underlying population.

8.3.4 The statistical tests were run for:

- Benzo(a)anthracene
- Chrysene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo (a) pyrene
- Indeno(123-cd)pyrene
- Dibenz(ah)anthracene

8.3.5 The results of statistical tests are presented in Appendix 9. Table 8.4 below provides the summary of statistical tests, and identifies any potential outliers.

Table: 8.4 Statistical Test Results

Determinand	95% UCL	Cc/GAC	GAC Exceeded
Benzo(a)anthracene	62.82	3.1	yes
Chrysene	62.97	6.0	yes
Benzo(b)fluoranthene	123.5	5.6	yes
Benzo(k)fluoranthene	45.81	8.5	yes
Benzo (a) pyrene	49.62	0.83	yes
Indeno(123-cd)pyrene	57.24	3.2	yes
Dibenz(ah)anthracene	15.82	0.76	yes

8.3.6 Based on the findings of the statistical tests summarised above in Table 8.4, all the contaminants identified above are considered to have the potential to pose an unacceptable risk to sensitive receptors (i.e. where UCL exceeds GAC).

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

8.4.1 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 BS3882:2007.

8.4.2 Adopting a pH value of >7, as indicated by the results of the laboratory analysis, the following is noted;

- Zinc concentrations revealed by this investigation ranged from 7mg/kg to 114mg/kg, below the threshold value of 300mg/kg.
- Copper concentrations revealed by this investigation ranged from 2mg/kg to 57mg/kg, below the threshold value of 200mg/kg.
- Nickel concentrations revealed by this investigation ranged from 1mg/kg to 22mg/kg, below the threshold value of 110mg/kg.

8.5 Waste Disposal

8.5.1 The classification of soils using the Waste Acceptance Criteria (WAC) is outside the scope of this investigation. It must however be noted that under the Landfill Regulations, WAC testing is required for waste disposal purposes prior to removal of materials from site.

8.6 Concrete in the Ground

8.6.1 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.

8.6.2 Characteristic sulphate values for soil and groundwater have been devised based upon the recommendations set out in the BRE Special Digest 1: 2005. This indicates

that in a data set where there are 10 or more results available, the mean of the highest 20% of the sulphate test results (rounded to 100 mg/l) should be taken as the characteristic value for water-soluble sulphate (mg/l SO4).

8.6.3 Consideration of pH (of soils and groundwater) is also necessary in selecting a Design Sulphate Class. The Design Sulphate Class should subsequently be selected based upon the lower pH determination resulting from these reviews.

8.6.4 Ten soil samples collected from the site were analysed for water soluble sulphate. Results ranged from 48mg/l to 2821mg/l, with associated pH concentrations ranging from 7.6 to 11.3. The mean of the top 20% of samples (rounded to the nearest 100mg/l) indicated a value of 2100mg/l. The full analytical results are presented in Appendix 8.

8.6.5 Based on the results the required concrete class for the site is DS-3 assuming an Aggressive Chemical Environment for Concrete classification of AC-3 in accordance with the procedures outlined in BRE Special Digest 1.

9 SOIL GAS RISK ASSESSMENT

9.1 Soil Gas Results

9.1.1 Following the ground investigation, a total of 4 No. return visits have been undertaken to monitor for soil gas at the site. The results are summarised in Table 9.1 below.

Table 9.1 : Summary of Gas Monitoring Data

Hole Nr.	CH4 (%)	CO2 (%)	O2(%)	H2S (ppm)	Atmospheric Pressure (mb)	Flow Rate (l/hr)	Depth to water	Depth of hole
WS2	0	0.0 – 0.2	20.1 – 21.0	0	997 – 1027	0	Dry	2.73
WS4	0	0.0 – 0.1	20.3 – 21.3	0	997 – 1027	0	Dry	1.87
WS6	0	0.8 – 1.1	19.9 – 20.9	0	997 - 1027	0	Dry	2.09

In addition to the above monitoring data, the wells were also monitored for Volatile Organic Compounds (VOC) using a photo ionisation detector. VOCs have been recorded in all three monitoring wells, with a maximum concentration of 99.8ppm recorded within borehole WS6.

9.2 Screening of Results

9.2.1 As shown in Table 9.1, no methane has so far been encountered during monitoring at the site. Carbon dioxide levels ranged from 0.0%v/v to 1.1%v/v and oxygen levels ranging from 19.9%v/v to 21.3%v/v.

9.2.2 In the assessment of risks posed by hazardous ground gases and selection of appropriate mitigation measures, CIRIA document C665 (2007) identifies two types of development, termed Situation A and Situation B.

9.2.3 Situation A relates to all development types except low rise housing. Situation B relates to low rise housing with gardens. Situation A has been adopted as the relevant category for the proposed development due to the lack of low rise residential housing within the proposed development.

9.2.4 The soil gas assessment method is based on that proposed by Wilson & Card (1999), which was a development of a method proposed in CIRIA publication R149 (CIRIA, 1995). The method uses both gas concentrations and borehole flow rates to define a characteristic situation based on the limiting borehole gas volume flow for methane and carbon dioxide. In both these methods, the limiting borehole gas volume flow is renamed as the Gas Screening Value (GSV).

9.2.5 The Gas Screening Value (litres of gas per hour) is calculated by using the following equation

GSV = (Concentration/100) X Flow rate

Where concentration is measured in percent (%)
and flow rate is measured in litres per hour (l/hr)

9.2.6 The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

9.2.7 To accord with C665, worst case conditions are used in the calculation of GSVs for the site.

9.2.8 A worst case flow rate of 0.1l/hr (detection limit of the instrument) will be used in the calculation of GSVs for the site.

For carbon dioxide, the worst-case conditions and the corresponding GSV is presented below.

- **Conservative flow rate:** **0.1 l/hr flow use**
- **Highest CO_2 concentration:** **1.1% v/v**
- **GSV Value:** **0.0011_{C02} (l/hr)**

On the basis of the above, the following Design GSVs and corresponding gas concentrations may be adopted for the development:

- Carbon dioxide: 0.0011 l/hr, 1.1%vol

9.2.9 Based on the GSVs calculated from the worst case methane and carbon dioxide concentrations, the site can be generally classed as Characteristic Situation 1 (GSV <0.07), where no special protection measures are required in accordance with CIRIA C665.

9.2.10 The results of the monitoring indicated the presence of VOCs within the monitoring wells, with a maximum concentration of 99.8ppm recorded. Further gas monitoring is recommended to determine whether a hydrocarbon resistant membrane is required for the proposed development.

10 SUMMARY OF RESULTS

10.1 Risk Assessment - Land Quality Impact Summary

10.1.1 Following the quantitative risk assessments, the following is noted:

- The proposed land use comprises a commercial development with residential apartments on the upper floors. It is understood that no soft landscaping is proposed. A residential without homegrown produce land use has been adopted in conducting quantitative risk assessments.

- Following generic risk assessments, elevated concentrations of a number of Polyaromatic Hydrocarbon (PAH) compounds were noted. The elevated concentrations of PAH compounds were reported mainly within two made ground samples taken from WS2 and WS3 at 0.3m and 0.25m respectively. These two samples of Made Ground also revealed concentrations of Semi-volatile Organic Compounds (SVOCs), above the laboratory detection limit i.e., up to 15.72mg/kg. The borehole logs describe this Made Ground horizon as comprising a grey to black sandy gravel. PAH exceedances were also reported in made ground samples taken from WS4 and WS8. The results of Total Petroleum Hydrocarbon analysis did not indicate significant concentrations of short chain hydrocarbons, and as a result the source is considered unlikely to be a recent fuel / hydrocarbon spillage. The horizons of Made Ground within the site are frequently noted to contain ash, coal and slag, which may result in elevated PAH compounds.

- As the site is to be covered in its entirety with buildings and hardstanding, it is expected that the proposed development will act as a barrier mitigating risks to humans using the site post development. Leachate tests should be undertaken to establish the level of risk posed to groundwater. Further deeper boreholes and groundwater monitoring may be required depending upon the results of the leachate analysis.

- Based on the results of soil sulphate and pH analysis, the required concrete class for the site is DS-3 assuming an Aggressive Chemical Environment for Concrete classification of AC-3 in accordance with the procedures outlined in BRE Special Digest 1.

- Based on the GSVs calculated from the worst case methane and carbon dioxide concentrations, the site can be generally classed as Characteristic Situation 1 (GSV <0.07), where no special protection measures are required in accordance with CIRIA C665. Further gas monitoring is recommended to determine whether a hydrocarbon resistant membrane is required for the proposed development.

- Based on the findings of the intrusive investigation and laboratory testing, possible pollutant linkages may be present at the site, and additional testing is recommended to establish the significance of these linkages. The presence of contamination hotspots between sampling positions cannot be discounted, and further investigation may be required following the demolition of the buildings on site.

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

10.2 Review of Pollutant Linkages Following Site Investigation

10.2.1 The site CSM has been revised and updated from that suggested in Section 4 in lieu of the ground investigation data, including soil laboratory analysis results. Table 10.1 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 10.1: Plausible Pollutants Linkages Summary

Potential Source	Pathway	Receptor	Relevant Pollutant Linkage?	Comment
• Impacted Made Ground from previous developments – on/off site (S1) • Impacted Groundwater within Hackney Gravels – on site (S2) • Current and former industrial land use – on/off site (S3) • Below ground oil tank – on site (S4)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Leaching (P3) • Horizontal and vertical migration of contaminants within groundwater (P4) • Accumulation and migration of soil gases (P5)	• Future site users (R4)	x	Risks to humans using the site post development are expected to be mitigated through the hardstanding cover proposed across the site.
			?	Further gas monitoring is recommended to determine whether a hydrocarbon resistant membrane is required for the proposed development.
		• Construction workers (R1) • Maintenance workers (R2)	✓	Appropriate health and safety measures will be required for construction and maintenance workers who may be exposed to contamination. General guidance on these matters is provided within the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". The Contractor and Client shall satisfy the HSE and their obligations under the CDM Regulations 2007 with regard to matters concerning the health, safety and welfare of persons on the site.
		• Neighbouring site users (R3) • Secondary Aquifer within Hackney Gravels (R5)	?	Leachate tests should be undertaken to further assess potential risks to groundwater and neighbouring site users.
		• Building foundations and on site buried services (water mains, electricity and sewer) (R6)	✓	Based on the results the required concrete class for the site is DS-3 assuming an Aggressive Chemical Environment for Concrete classification of AC-3 in accordance with the procedures outlined in BRE Special Digest 1. Due to the recorded concentrations of Polyaromatic Hydrocarbons within the Made Ground, it may be necessary for buried services (in particular water pipes) to be installed within a trench of clean material. Advice should be sought from the relevant utility provider.

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