



ROBERTS ENVIRONMENTAL LIMITED



Phase II Geo-Environmental Site Investigation and Risk Assessment

Polygon Street, Manchester

November 2014

Polygon Street Limited

Reference: 140716.R.002

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Manchester**

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EXECUTIVE SUMMARY

SCOPE			
Purpose of the Report	This report has been prepared to provide geotechnical information to inform foundation design for the proposed redevelopment of the site. In addition, it provides an assessment on the concentrations of contamination present within the substrata of the subject site and can be used to dismiss associated conditions of planning.		
Future Site End-use	The proposed redevelopment of the site is for a five storey structure, comprising retail units and car parking on the ground floor with residential apartments and maisonettes on the upper floors. The development comprises 100% hardcover across the extent of the site.		
SITE INFORMATION			
Grid Reference	385280, 397030	Site Area (approx.)	0.12 hectares (0.29 acres)
Current Site Status	Currently the site is recorded as undeveloped following the demolition of the former structures. Surfacing at the site comprises a mix of demolition rubble sand and gravel, with a small stockpile of similar, site generated material on the centre of the site.		
	Based on our site investigation, no visual evidence of significant ground contamination comprising fuel or oil type materials were noted. Some isolated deposits of ash were encountered, however these deposits were not pervasive across the site. Made ground was recorded to depths of greater than 4.50m with evidence of former cellar walls encountered, given the findings of the intrusive works it is anticipated that the former cellar features have been backfilled with the demolition rubble associated with the former structures on this site.		
	The site is not considered to be at risk from ground gas; no sources were identified from the phase 1 report, other than the potential for there to be ground gas producing materials within the made ground, and from the findings of these investigation works the made ground has comprised inert building rubble of sandy gravel with bricks and sandstone and as such is not considered to be a source of ground gas.		
History	Information provided within a Phase 1 Geo-Environmental Site Assessment Report, completed by Resource and Environmental Consultants Ltd (REC), in December 2013 for this site, indicate that the site has been in continuous occupation since the earliest available Ordnance Survey historical maps were published. Initially the site was occupied by terraced housing, subsequently replaced by a textile mill and two banks. Anecdotal evidence suggests that prior to demolition pre 2013, the site was utilised for the manufacture and sale a clothing.		
Geology	From a review of British Geological Survey data the subject site is situated on an area underlain by Devensian Till (clay) overlying Chester Pebble Beds Formation.		
	The site investigation has encountered evidence to indicate that an infilled basement was present below the former structure comprising former deep footings and cellar walls, with the made ground recorded to depths of 2.80m and greater than 4.50m bcgl's. The material within the basements comprises sandy gravel of building rubble containing bricks, sandstone blocks and sections of concrete floor slab with fragments of metal and plastic pipe. The larger sandstone blocks and pieces of concrete will need to be taken in to account during future ground works. Some localised pockets of ash were noted, however, these were not persistent across the site.		
	The natural deposits, comprising sand and gravel were recorded in TP01, TP03 and TP04, from depths of between 2.80m and 3.90m bcgl's, down to depths of 400m and 4.10m bcgl's. Within TP03 the sand/gravel was recovered in small tabular		

	pieces, anticipated to be representative of completely weathered bedrock.
Hydrogeology	The geological drift deposits underlying the site are classified as non-productive and bedrock is classified as a Principal Aquifer. According to the Phase 1 Geo-Environmental Site Assessment Report by REC, there are not deemed to be any potable water abstractions or surface water features within an influencing distance of the site. The site is not located in, or within 500m of an area designated as a Groundwater Source Protection Zone.
Hydrology	Corn Brook is located 226m to the south of the site and has achieved a GQA grade C.

RISK ASSESSMENT

Hazard Identification	Source	Based upon a <i>commercial</i> end use, no elevated concentrations of contamination have been identified as a result of the human health risk assessment, however asbestos fibres have been recorded in the made ground.
	Pathway	Currently there is nothing to restrict the following pathways; direct contact, ingestion, and inhalation via outdoor soils or translocated soil and dust indoors. Inhalation, migration of ground gases through granular and fractured soils into confined spaces. Following development of the site, incorporating 100% hard cover, all of the available pathways listed above, other than the migration of ground gas will be removed.
	Receptor	Currently the site is vacant and surrounded by secure fencing, therefore there are no current site users. The key receptors that have been identified are the future construction workers, future site users and structures. Following completion of the development site users will comprise workers and customers within the retail units on the ground floor, along with those utilising the car park. The upper floors within the proposed development will include residential maisonettes.
- The subject site currently comprises a vacant plot of land, following the demolition of the former structures. - Historically the site has been developed with terraced residential housing a textile mill/works and two banks. - The bedrock deposits are named as the Chester Pebble Beds Formation and are classified as a Principal Aquifer.		
Conclusions	- Chemical analysis of the samples retrieved from site for contamination purposes has not recorded any elevated concentrations of contamination. However, some asbestos fibres were detected within the made ground. Based upon the end use incorporating 100% hardcover no future protection measures will be necessary on this site. - No significant sources of ground gas have been identified within a plausible migration distance of this site and it is not considered to be at risk from ground gas. As such a programme of gas monitoring has not been deemed necessary or carried out.	
Foundation Design	When considering the depth of fill encountered, associated with the infilled basements, conventional foundations will not be suitable for the proposed development. Due to the envisaged loadings it is anticipated that a piled foundation solution will need to be utilised.	

**Risk Assessment
Conclusions**

The results of the geo-environmental site investigation and risk assessment indicate that with the site in its current condition a significant source - pathway – receptor pollutant linkage may be present. The risk is associated with the asbestos fibres, although any potential receptors are considered to be limited since the site is securely fenced and there are no day to day current users.

Following development of the site, incorporating 100% hardcover, the pollutant linkage will be broken, with the source (asbestos fibres) and receptors (end users) being separated by the hard cover. Therefore, it is concluded that the environmental risk arising from the ground conditions at the subject site will be Low.

Recommendation

The following points are recommended;

Based upon the proposed development plans there is no requirement for any additional mitigation measures with respect to the concentrations of contamination or asbestos fibres encountered on this site.

As a minimum, future ground and construction works should ensure they have appropriate 'barrier type' personal protective equipment (PPE), which reduce any potential risks to an acceptable level.

There may potentially be a risk to construction workers and an asbestos management plan may need to be included in the onsite health and safety file to be provided to future site workers.

Should there be a change in the proposed development layout or end use then an updated risk assessment will need to be undertaken.

Conventional foundations are not considered appropriate for this site and alternative will need to be considered. Foundation design recommendations are presented within the appropriate section of this report.

1. Instructions

Instructions were received from Polygon Street Ltd, on 14th July 2014 to undertake a Phase II Geo-Environmental Site Investigation and Risk Assessment of the site known as Polygon Street in Manchester, M12 6AP.

It is our understanding that a Phase II Geo-Environmental Assessment is required as part of a condition of planning for the development of a five storey building, which will incorporate car parking and retail units on the ground floor and residential apartments and maisonettes on the upper levels. The proposed structure incorporates the entire area of the site and there are no proposed areas of soft landscaping on the ground floor. The site investigation has been progressed to confirm existing contamination, and geotechnical parameters of the site.

The ground investigation was undertaken in accordance with the Code of Practice for Site Investigation British Standard (BS) 5930 (1999), Code of Practice for the Investigation of Potentially Contaminated Sites BS10175:2011 and the DEFRA/Environment Agency Report CLR11 "Model Procedures for the Management of Land Contamination".

The chemical screening undertaken has comprised a standard generic contamination suite (based on the current CLEA SGV listed analytes with historical additions), speciated PAH's, and asbestos fibres. The results of the analysis for the generic suite and the PAH's has been subjected to statistical analysis utilising the contaminated land statistical analysis sheets developed by CL:AIRE.

Report Reliance

This report has been prepared in accordance with the scope of the Roberts Environmental Ltd appointment with the client and is subject to the terms of that appointment. It is addressed to and for the sole use and reliance of Polygon Street Ltd. We accept no liability for any use of this report other than by our client. No person other than Polygon Street Ltd may copy, use or rely on the contents of this report.

2. Location

The subject site is located adjacent and to the north of Polygon Street, in the Ardwick area of Manchester, 1.8km to the south east of the centre of Manchester. Site Location and Layout Plans are presented below.

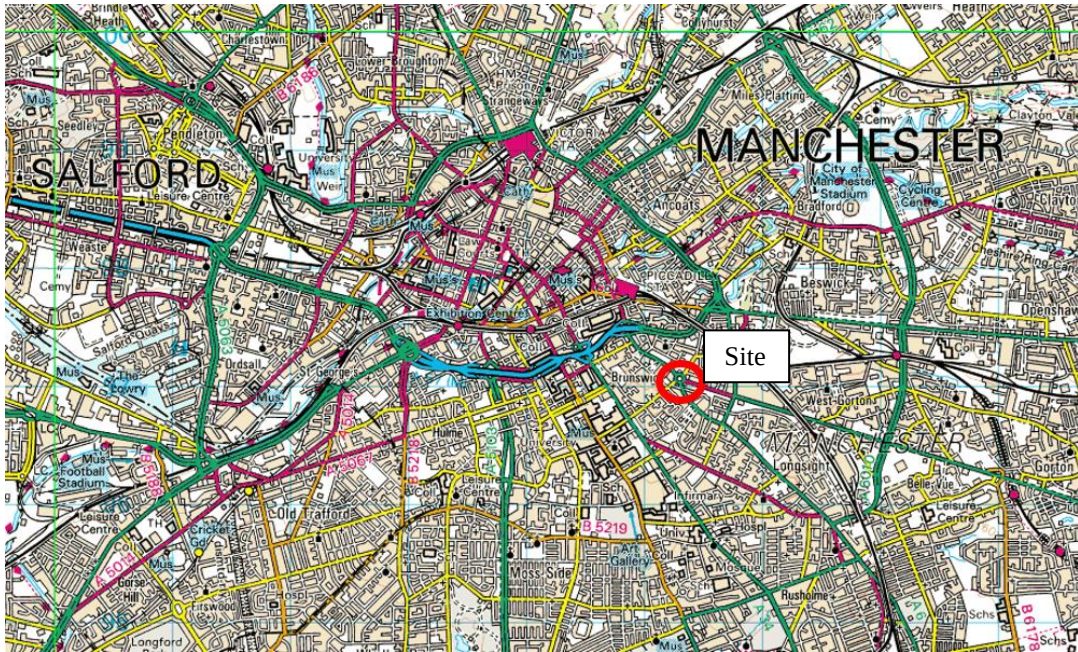


Figure 1: Site Location Plan (boundaries shown are indicative only)

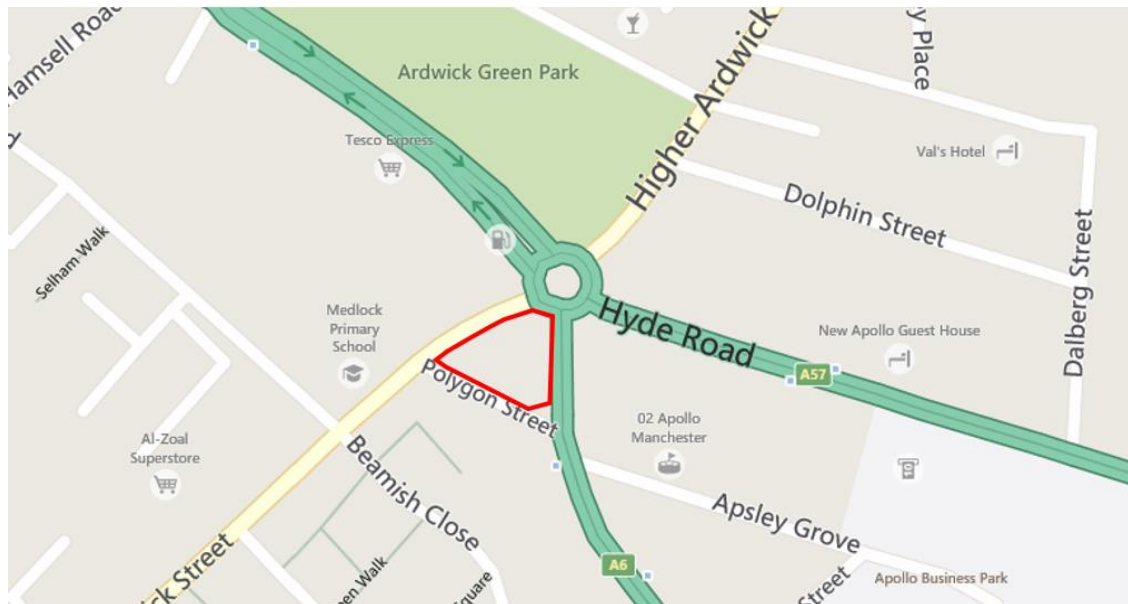


Figure 2: Site Layout Plan (boundaries shown are indicative only)

3. Phase 1 Summary

Site Details and Location

In an initial Phase 1 Geo-Environmental Site Assessment Report has been completed by Resource and Environmental Consultants Ltd (REC) for the site named as Polygon Street, Manchester (ref. 45358p1r0) and was completed in December 2013. The subject site is centred approximately at National Grid Reference: 385280, 397030. Site information gathered during the preliminary report is summarised in the table below.

Summary of the site information as recorded during the Phase 1 Report

Current Site Status	The subject site is currently vacant of development following the demolition of the former structures and removal of any ground floor slabs. Site surfacing comprises site generated, crushed granular material. A small stockpile is situated in the centre of the subject site with a similar composition to that of the surface material. The site is generally triangular in shape, bounded by a number of roadways, which includes Stockport Road (east), Polygon Street (south) and Brunswick Street (west). A waste skip is situated along the northern boundary filled with timber pallets and chip board. Several timber pallets were also noted stacked adjacent to the skip. Adjacent land uses comprise mixed residential and commercial operations such as a theatre and a fuel retail station.
History	The available Ordnance Survey historical mapping indicates that the site has been utilised for terraced residential housing, subsequently replaced by a Textile Mill / works and two banks until their demolition in pre 2013.
Geology	From a review of the British Geological Survey information, the area where the subject site is positioned is recorded as Devensian Till (clay) which is in turn underlain by the Chester Pebble Beds Formation. The site is not at risk from coal mining or from Radon gas.
Hydrogeology	The Chester Pebble Beds Formation is classified as a Principal Aquifer. No Source Protection Zones are recorded within 500m of the site, however, two groundwater abstractions are recorded within 1km of the site, neither of these are for potable purposes and so are not considered to be particularly sensitive.
Hydrology	Corn Brook is located 226m to the south of the subject site.
Regulatory Enquiries	No landfills are, or have been identified within the vicinity of the site and the potential for the deposition of made ground is considered to be the only potential source of hazardous ground gas. Given the type and nature of the historical development the likelihood of the site being affected by the presence of any gross on-site contamination is considered to be low. The site is not considered to be at significant risk from flooding from rivers or sea and is positioned within Flood Zone 1.
Proposed Use	The redevelopment of the site comprises the construction of mixed commercial and residential end use, comprising 39 residential dwellings and four retail outlets.

4. Preliminary (Phase 1) Conceptual Model

A preliminary conceptual model has been developed based on the information described.

Ground Conditions / Contamination Sources

The Phase I Desk Study Report, produced by REC, has identified that the likelihood of the site being affected by the presence of any on-site contamination to be low. However, it has identified the following potential on-site sources;

- Made ground material: Made ground materials generated during demolition of the historical buildings has the potential to contain toxic heavy metals, sulphates, asbestos, ground gases, PAH and petroleum range hydrocarbons from the deposition of ash or lead pipework.

With potential off-site sources as follows;

- A Petrol Filling Station (PFS) has been identified approximately 20m to the north and historically Textile Mills and engineering works have been located within influencing distance of the site and are a potential source of hydrocarbon impact (however, given the likely hydraulic gradient (eastward) the PFS is not considered likely to affect the subject site and the risk is therefore low).

Pathways

Currently the site is surrounded by secure fencing, there is no access to the public and there are no current site users.

The proposed development will comprise the entire site being encapsulated by hard standing with the ground floor being utilised for car parking and a retail/commercial end use. The nature of the development will remove any direct contact pathways.

Receptors

The key receptors at the site have been identified as being the future proposed redevelopment works and will include construction workers, future site users and the proposed structure.

Potentially Significant Pollution Linkages

The principal receptor to potential ground contamination at the site is its future redevelopment for mixed retail and residential use. During and following the future redevelopment, ground workers could be exposed to ground contaminants via direct contact, ingestion and/or inhalation pathways, depending on the location and nature of contaminants. However, the site is to be completely covered by the proposed development and will comprise 100% hardstanding. Therefore, a number of the potential pollutant pathways will be removed, including direct contact and ingestion and future pathways will be limited to inhalation pathways, associated with any volatile products that might be present.

In addition, should there be any significant quantities of deleterious material in the made ground, there is the potential for the production of ground gas which has the potential to ingress into future buildings on the site through service ducts and discontinuities in floor slabs.

5. Site Investigation

Objectives and Constraints

The objective of this investigation is to identify and characterise the ground conditions, the hazard sources, pathways and receptors, to reduce uncertainties and to provide an overview of site conditions. In addition, geotechnical information will be provided to inform foundation design.

Specific objectives include:

- characterisation of made ground in soils across the site including determination of the depth within any infilled basements;
- to determine the depth to the natural strata across the site;
- to determine the potential presence and depth at which groundwater is present;
- to undertake a range of chemical analysis on soil samples, to include determinands associated with the sites historical use to determine the sources of contamination (if present);
- to undertake a preliminary assessment on made ground to determine if it is likely to represent a potential source of made ground and if necessary carryout a programme of gas monitoring for the potential presence of harmful ground gases;
- To provide information on the load bearing characteristics of the natural strata deriving if possible an assessment of the suitability of appropriate founding techniques.

Constraints to the investigation include:

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected area of the site. However, due to the size of this site and the general uniformity of the findings within each of the trial pits, it is considered unlikely there will be any extreme deviations from the recorded ground conditions below the remainder of the site. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions these cannot be determined with complete certainty.

Design of Investigation

The site investigation was undertaken in general accordance and with reference to the following documents;

- Specification for Ground Investigation, Site Investigation Steering Group, Thomas Telford, 1994.
- British Standard BS 10175:2011 Investigation of potentially contaminated sites – code of practice.
- Eurocode 7; BSEN 14688 and 14689 2010.
- British Standard BS 5930:1999 + A2 2010 Code of Practice for Site Investigations.
- Environment Agency (2000) Secondary model procedures for the development of appropriate soil sampling strategies for land contamination. Technical Report P5-066/TR.
- With reference to 'The Model Procedures for the Management of Land Contamination, CLR 11'.

The works comprised a series of trial pits supervised and logged by a representative from Roberts Environmental Ltd. The investigation was designed to provide a preliminary assessment of the ground conditions at the subject site. Prior to the progression of the site investigation holes all areas were checked for services.

Excavations

The site works involved the excavation of four trial pits (TP's 01 – 04) using a JCB 3CX, backhoe excavator. The site works were completed over a single day on the 18 July 2014.

A site plan showing the trial pit locations can be seen in **Appendix I**.

Sampling

Sampling at the site was undertaken to investigate the ground conditions present.

Environmental soil samples representative of the underlying conditions were collected and submitted for a suite of determinands based on the Department for Environment Food and Rural Affairs (DEFRA) Contaminated Land Report 8 (Tables 2.1 and 2.2) to an appointed UKAS accredited laboratory.

All the holes were logged and sampled by a Roberts Environmental Ltd representative.

Quality Control

The samples were despatched under a chain of custody procedure to Chemtech Environmental of Consett, Co. Durham, who are United Kingdom Accreditation Service (UKAS) accredited laboratories (MCERT certified), for subsequent chemical analysis. Where appropriate samples were stored within cool boxes containing ice packs prior to screening.

Health and Safety

All work carried out on site was in accordance with Roberts Environmental Ltd Health & Safety Policy. In addition, a site specific risk assessment was produced prior to the works beginning on site.

6. Physical Ground conditions

General

Surfacing across the site comprises demolition rubble of sand and gravel with bricks and concrete fragments. The underlying made ground comprises similar demolition materials of building rubble containing sand, gravel, bricks, sandstone blocks, sections of concrete floor slab with fragments of metal and plastic pipe. The larger sandstone blocks and pieces of concrete will need to be taken into account during future groundworks. In addition some layers of recompacted clay and pockets of ash were noted, however, the ash was not persistent across the site. There was no evidence of any putrescible material or material likely to produce ground gas. The made ground was recorded to depths of between 2.80m and greater than 4.50m bcgl's.

The natural deposits, comprising sand and gravel were recorded in TP01, TP03 and TP04, from depths of between 2.80m and 3.90m bcgl's, down to depths of 4.00m and 4.10m bcgl's. Within TP03 the sand/gravel was recovered in small tabular pieces, anticipated to be representative of completely weathered bedrock.

Groundwater

No water ingresses were recorded within any of the investigation positions, and they remained dry on completion.

Based upon the observations made during these investigation works, a shallow continuous water surface (water table) is not anticipated to be present below the site.

Despite the lack of any groundwater being recorded, it would be considered prudent to allow for the introduction of temporary groundwater control measures, i.e. pumping equipment, during any future ground works, in order to take care of any surface water ingresses or undiscovered pockets of trapped surface drainage within the made ground or natural strata, particularly during the wetter periods of the year.

Underground Structures and Obstructions

Evidence of relic wall features were encountered in TP01 and TP02, anticipated to be part of the former basement construction. In addition, several large sandstone blocks and sections of concrete floor slab were encountered, up to 0.90m long. These features will need to be taken into account during any future groundworks.

Olfactory and Visible Evidence of Contamination

Some small localised deposits of ash were noted within the trial pits. However, there was no visual or olfactory evidence of gross fuel or oil type contamination noted during the ground investigation works.

No materials of a putrescible nature were encountered within the made ground suggesting that there are no significant sources of ground gas present within the made ground.

7. Geotechnical Assessment

Ground Conditions

Section 6 provides a review of the recorded ground conditions encountered during the site investigation.

The ground investigation works were limited to trial pits and as such it was not possible to undertake Insitu Standard Penetration Tests (SPT's). In addition, given the granular nature of the natural deposits it was not appropriate to undertake insitu hand shear vane tests, which are performed on cohesive deposits.

Due to the inherent variability of the made ground the materials are not considered suitable as bearing strata and as such no insitu geotechnical tests were undertaken on these deposits.

Determination of pH and SO₄

Sulphate is not considered hazardous to human health, but is potentially deleterious to the cement content in buried concrete structures.

Representative samples of the made ground recovered during the investigation, were tested in order to determine their acidic (pH) and soluble sulphate (SO₄) levels. The results are shown in the table below and are also contained within the Chemtech Environmental Limited Analytical Report, a copy of which can be seen in **Appendix III**.

BH No.	Depth (m)	Strata Type	pH	SO ₄ (mg/l)	Design SO ₄ Class	ACEC Class
TP01	0.40-0.50	MG	8.0	1639	DS-3	AC-3
TP02	0.80-1.00	MG	7.1	55	DS-1	AC-1
TP03	0.20-0.40	MG	8.0	813	DS-2	AC-2
TP04	0.40-0.60	MG	7.9	871	DS-2	AC-2

ACEC = Aggressive Chemical Environment for Concrete site classification

From these results it can be seen that the pH values for the samples of soil tested range from 7.1 up to 8.0, and the amount of soluble sulphate present falls within and outwith the negligible range (<500mg/l).

Therefore, in accordance with BRE Special Digest 1: 2005 (3rd Edition), the site can be given a concrete design class of DS-3 and ACEC class of AC-3 for all foundations and buried concrete.

Foundation Options

When considering the foundation options available for the proposed five storey development, conventional foundations will not be suitable on this site. Therefore, an alternative will need to be considered and it is anticipated that piles will provide a suitable solution. Due to the numerous types of pile foundations available and the various methods of installation the information from these ground investigation works will need to be passed onto specialised piling contractors so that they can design and price a suitable scheme, particularly as a detailed piling design lies outwith the scope of these comments.

A future piling contractor is likely to require additional information on the underlying bedrock and as such a series of boreholes progressed into the bedrock may be required. During future groundworks the presence of the large obstructions within the made ground, comprising sandstone blocks and sections of concrete slab, will need to be taken into account.

Made ground is in excess of 600mm and a suspended reinforced ground slab or precast concrete floor should therefore be used. However, if the made ground was removed from beneath the footprint of the building and a blanket of compacted inert granular fill was placed in accordance with an engineering specification, ground bearing slabs may be possible, if applicable.

Lateral trench support should also be considered for excavations, in order to prevent trench wall collapse or over excavation, as well as to provide a safe working environment especially below a depth of 1.20m for drainage runs and the like. In addition, it is recommended that excavations remain open for as short a period as possible, since most of these materials will be susceptible to deterioration, if left open to the natural elements for any significant periods of time. Reference to CIRIA 97 'Trenching Practice' would be beneficial to establish a suitable means of support or battering of excavation sides during construction.

For deeper excavations, drainage, service runs or the like that may pass close to or beneath any existing or proposed new foundations, these should be undertaken with care and completed prior to the preparation of any new foundations, so as not to allow any loose or granular material to move or 'flow', thus causing settlement to occur to any new or adjacent old foundation based at a higher level.

8. Chemical Ground Conditions

Assessment Criteria

The laboratory test results for the four soil samples screened are in **Appendix III**. The total analysis carried is as follows:

Soils

- 4 no. Generic Soils Suite - based on the current CLEA SGV listed analytes with historical additions, comprising disturbed natural strata mixed with anthropogenic debris, of an unknown source (suite comprises; Arsenic, Cadmium, Chromium (III & VI), Copper, Lead, Mercury, Nickel, Selenium, Zinc, pH, Soluble Sulphate, free Cyanide, and Total Organic Carbon (TOC)).
- 4 no. Speciated Polycyclic Aromatic Hydrocarbons (PAH's) – based on the current USEPA 16 PAH's & Benzo(j)fluoranthene.
- 4 no. Asbestos fibre screens.

The screening results will be compared to guideline values based upon the following hierarchy;

- CLEA SGV Values (Version 1.06)
- LQM CIEH Generic Assessment Criteria Values, 2nd Edition (2009).
- CLEA SGV values (Version 1.0 beta)
- Atkins ATRISK SOIL SSV Values (2011)

The proposed development is to comprise a five storey structure comprising retail units and car parking on the ground floor with residential apartments and maisonettes on the upper floors. The development is to comprise 100% hardcover across the extent of the site. Therefore, with respect to the proposed end use it is felt that a *Commercial* end use category can be adopted for this site. Since there is adequate separation between any future residents and potentially contaminated materials.

The results of the soil screening have been used to carry out a Level 1: Quantitative Human Health Risk Assessment for the ground contamination present against standards based upon a *Commercial* end use of the property. These results can also be used for a preliminary assessment for off-site disposal classification.

Soils

Made ground was encountered during the site investigation and as a result samples were analysed for a standard suite of contaminants. In addition, a visual assessment for the presence of hydrocarbon impacted soils or landfill type material was also undertaken. The results of laboratory analysis are discussed below.

The soil screening results have been subjected to statistical analysis utilising the contaminated land statistical analysis sheets developed by CL:AIRE, and a copy of the calculation sheet and the statistical methodology can be found within **Appendix IV**. A summary of the results of the Level 1 risk assessment from the results of the soil concentrations can be seen below.

Analyte	No. of Samples Screened	Target Conc. (C_c) mg/kg	Max. Conc. (C_M) recorded mg/kg	Statistical Upper Bound Value ($UCL_{0.95}$) mg/kg	Has $UCL_{0.95}$ exceeded C_c	No. of Samples > C_c	Is C_M an outlier (statistical 'hot spot')
Arsenic	4	640 ⁽¹⁾	14	14.48	NO	0	~
Cadmium	4	230 ⁽¹⁾	1	0.70	NO	0	~
Chromium III	4	30400 ⁽³⁾	86.00	86.74	NO	0	~
Chromium VI	4	35 ⁽³⁾	<1	0.5	NO	0	~
Copper	4	71700 ⁽³⁾	95	86.48	NO	0	~
Lead	4	6490 ⁽²⁾	699	659.24	NO	0	~
Mercury	4	3600 ⁽¹⁾	14	12.93	NO	0	~
Nickel	4	1800 ⁽¹⁾	50	44.93	NO	0	YES
Selenium	4	13000 ⁽¹⁾	1.10	1.08	NO	0	~
Zinc	4	665000 ⁽³⁾	271	322.42	NO	0	~
Cyanide	4	34 ⁽²⁾	<2	1	NO	0	~

⁽¹⁾ = CLEA SGV Values (Commercial – Version 1.06), ⁽²⁾ = ATRISK^{SOIL} SSV (2011) Commercial, ⁽³⁾ = LQM CIEH Generic Assessment Criteria Values, 2nd Edition (2009) for Commercial site setting.

The results of the generic screening have identified the following:

- None of the C_M values for any of the analytes exceed the chosen C_c values for this site.
- None of the statistical upper confidence limit values ($UCL_{0.95}$) for any of the analytes exceed the chosen critical concentration values (C_c) for this site.
- When taking into account the normal/non-normal distribution of the results the maximum concentration (C_M) for, Nickel, is a statistical outlier, however, its maximum value does not exceed the chosen critical concentration value (C_c) for this site. Subsequently, it is not considered to represent a risk to future end users.
- Therefore there will NOT be a requirement for removal, treatment, protection measures and/or further risk assessment (DQRA), of these materials, in order to protect sensitive receptors in the future i.e. human health.

Organic Contaminants – Speciated PAH's

Analyte	No. of Samples Screened	Target Conc. (C_c) mg/kg	Max. Conc. (C_M) recorded	Statistical Upper Bound Value (UCL_{0.95}) mg/kg	Has UCL_{0.95} exceeded C_c	No. of Samples > C_c	Is C_M an outlier (statistical hot spot)
PAH's							
Acenaphthene	4	98000	1.61	1.42	NO	0	NO
Acenaphthylene	4	97000	0.19	0.17	NO	0	NO
Anthracene	4	540000	3.54	3.16	NO	0	NO
Benzo(a)anthracene	4	95	5.82	5.49	NO	0	NO
Benzo(a)pyrene	4	14	6.07	5.79	NO	3	NO
Benzo(b)fluoranthene	4	100	6.45	6.15	NO	0	NO
Benzo(ghi)perylene	4	660	3.97	3.76	NO	0	NO
Benzo(k)fluoranthene	4	140	2.78	2.63	NO	0	NO
Chrysene	4	140	6.73	6.29	NO	0	NO
Dibenz(ah)anthracene	4	13	0.73	0.70	NO	0	NO
Fluoranthene	4	23000	15.98	14.60	NO	0	NO
Fluorene	4	69000	1.29	1.13	NO	0	NO
Indeno(123cd)pyrene	4	61	3.94	3.78	NO	0	NO
Naphthalene	4	480	1.98	1.72	NO	0	NO
Phenanthrene	4	22000	15.59	13.93	NO	0	NO
Pyrene	4	54000	15.26	13.91	NO	0	NO

⁽¹⁾ LQM CIEH Generic Assessment Criteria Values, 2nd Edition (2009) for Commercial (2.5% SOM from site data).

- None of the **C_M** values for any of the analytes exceed the chosen **C_c** values for this site.
- None of the statistical upper confidence limit values (**UCL_{0.95}**) for any of the analytes exceed the critical concentration values (**C_c**) chosen for this site.
- When taking into account the normal/non-normal distribution of the results, none of the **C_M** values for any of the analytes represent statistical outliers - 'hot spots', and the **UCL_{0.95}** values can be considered as representative for the site.
- Therefore there will NOT be a requirement for removal, treatment, protection measures and/or further risk assessment (DQRA), of these materials, in order to protect sensitive receptors in the future i.e. human health.

No visual or olfactory evidence of hydrocarbon contamination was recorded during the site investigation.

Asbestos Screening

The four soil samples have also been screened for asbestos fibres. The results are also presented on the Chemtech Laboratory Results Sheets 52127 which are included in **Appendix III**, and have been summarised on the following page;

Asbestos Screening Matrix	Sample ID and Depth (m)			
	TP01 0.40-0.50	TP02 0.80-1.00	TP03 0.20-0.40	TP04 0.40-0.60
Asbestos fibres detected	Chrysotile	NAD	Amosite	Chrysotile & Amosite

NAD = No Asbestos Detected

Asbestos fibres identified as Amosite and Chrysotile have been detected in three out of four of the samples.

Amosite or brown asbestos was used mostly in the manufacture of thermal insulation products and was also used in the production of acoustic and anti-condensation material.

Chrysotile was commonly used in cemented asbestos products and is generally regarded as a lower risk, when in its cemented form, and compared to other asbestos fibres. Cemented asbestos materials can often be readily identified on site, and provided adequate PPE is utilised, can be separated from other soil materials, 'bagged' and removed from site to an appropriate waste site for safe disposal.

At this stage the proposed development is anticipated to comprise 100% hard cover, and as such the presence of asbestos fibres in the made ground are not considered to represent a significant risk to the future end users. The hardcover will act as a physical barrier between the source and the receptors therefore breaking the pollutant linkage. However, there may potentially be a risk to construction workers and an asbestos management plan may need to be included in the onsite health and safety file to be provided to future site workers.

9. Environmental Risk Assessment

In order to assess the risks associated with the presence of ground contamination, the linkages between the sources and potential receptors need to be established and evaluated. This is in accordance with Part 2A of the Environmental Protection Act (EPA) 1990, which provides a statutory definition of Contaminated Land and as revised under The Contaminated Land (England) (Amendment) Regulations 2012. To fall within this definition it is necessary that, as a result of the condition of the land, substances may be present on or under the land such that:

- Significant harm is being caused or there is a significant possibility of such harm being caused; or
- Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused;

Risk from contamination is assessed by consideration of possible linkages between contaminant sources and potential receptors which could be harmed or polluted, and the potential pathways between them. A contaminant linkage must exist in relation to particular land before the land can be considered potentially to be contaminated land under Part2A, including evidence of the actual presence of contaminants.

Environmental risk assessment is a systematic, staged process, which generally comprises the following stages:

1. Formulation of a conceptual model;
2. Hazard identification;
3. Hazard assessment;
4. Risk estimation; and
5. Risk evaluation.

Refined Conceptual Model

The preliminary conceptual model has been further developed during the investigation, primarily by the identification and partial quantification of contamination sources within the site and the assessment of potential exposure patterns of current and future site users.

Physical Conditions

Layer 1 comprises made ground to a maximum depths of between 2.80m and greater than 4.50m bcgl's, with the deeper made ground associated with the infilled basement features. The made ground generally consisted of demolition rubble of sand and gravel with unreactive anthropogenic debris including bricks, sandstone blocks, pieces of concrete floor slab with fragments of metal and plastic pipe, some occasional localised fragments of ash were also noted.

Underlying the made ground natural deposits, comprising sand and gravel, were encountered, from depths of between 2.80m and 3.90m bcgl's, down to depths of 4.00m and 4.10m bcgl's. Within TP03 the sand/gravel was recovered in small tabular pieces, anticipated to be representative of completely weathered bedrock.

No visual or olfactory evidence of gross contamination was recorded within the natural strata.

Groundwater

No water ingresses from the made ground or natural strata were recorded within any of the investigation positions.

Receptors

The key receptors that have been identified for this site are the construction workers during the development, and the future site users, who will be the workers and customers at the retail units on the ground floor, and to a lesser extent the residents on the upper floors of the development, and the structure.

Hazard Identification

The main objective of hazard identification is the refinement of the linkages within the conceptual model of the site. This, primarily, comprises the identification of potential contaminant sources and clarification of the properties of the potential pathways.

Specific Soil Contamination

When considering the Human Health risk assessment and the laboratory screening for metals, inorganic and organic compounds within the made ground deposits, there have been no recorded concentrations that exceed the chosen threshold criteria for this site. Therefore, there is not considered to be a risk to human health for the future end users with respect to these contaminants.

A number of the samples were found to contain asbestos fibres, identified as chrysotile and amosite. At this stage the proposed development is to comprise 100% hardcover, which will act as a physical barrier between the source (asbestos) and the receptors (end users), therefore breaking pollutant linkage. Therefore, there is not considered to be a significant risk to the future end users.

However, there may potentially be a risk to construction workers and an asbestos management plan may need to be included in the onsite health and safety file to be provided to future site workers.

Groundwater

No groundwater was encountered during the site investigation works. Due to the lack of any sensitive receptors within a plausible migration distance of the site, Controlled Waters are not considered to be at a significant risk from this site and as such groundwater or leachate screening was not deemed necessary.

Soil Gas

According to the findings of the Phase 1 report, the only potential source of ground gas for this site relates to the possibility of it being produced from within any made ground deposits present on this site, no other sources of have been identified within a plausible migration distance. From these ground investigation works a significant thickness of made ground has been recorded on this site. However, the made ground does not contain materials that are likely to produce ground gas, generally comprising inert demolition rubble. As such, it has not been considered necessary to undertake a ground gas risk assessment.

Uncertainties

Contaminated soils and groundwater may exist at locations and depths not tested. However, as far as practicable within the scope of the investigation, the results obtained are likely to be reasonably representative of overall conditions.

Assessment of Risk Estimation to Receptors

Current Site Users / Construction Workers (Human Health)

The site is currently vacant and there are no current users. However, workers who excavate into the ground may be exposed more directly to the soils containing contamination. Workers must undertake a risk assessment before carrying out such excavations and would normally be expected to adopt precautionary measures such as the use of protective clothing to minimise contact and avoid soil ingestion. An asbestos management plan may be required for the construction workers on this site otherwise, the general level of contamination encountered is unlikely to present a significant risk of harm to workers taking such precautions.

Future Site Users (Human Health)

The site will be developed to form a five storey structure, comprising retail units and car parking on the ground floor with residential apartments and maisonettes on the upper floors. The development comprises 100% hardcover across the extent of the site.

Where areas of hardstanding are present, including building footprints, there is not considered to be a risk to the end users from any of the recorded concentrations of contamination or from the asbestos fibres identified within the made ground. The hardstanding will provide a physical barrier that will separate the source from the receptors, thus removing the pathway.

However, there may potentially be a risk to construction workers and an asbestos management plan may need to be included in the onsite health and safety file to be provided to future site workers.

Property (Plants)

During the ground investigation works, no managed vegetation was noted on site, with some indiscriminate areas of scrub vegetation identified. There was no evidence to suggest significant phytotoxic contamination being present on site.

Ground Waters

No significant sources of groundwater contamination have been identified and Controlled Waters are not considered to be at significant risk from this site

Surface Water

No significant surface watercourses have been identified within close proximity of the subject site, the nearest being Corn Brook 226m to the south of the site. In addition, no potentially leachable contamination has been identified.

Adjacent Property

No significant recorded concentrations of soil contamination have been identified at the site as confirmed by the visual and olfactory evidence, field works and laboratory analysis results. Therefore, there is unlikely to have been significant impact on the adjacent properties.

Risk Evaluation

Following the implementation of the Phase 2 site investigation, the pollutant linkages identified during the Phase 1 Desk Study have been re-evaluated and re-classified in relation to the additional information obtained. The risk of significant harm or of pollution of controlled waters given the current site uses has been assessed qualitatively as **low**, **medium** or **high**. The results of the reassessment are summarised on the following pages.

Assessment of Potential Pollutant Linkages

Receptor	Potential sources	Pathways	Risk	Justification
Human Health				
Construction and maintenance workers / Users of the site	Organic, metal contamination and asbestos.	Direct contact, ingestion, and inhalation via outdoor soils or translocated soil and dust indoors.	Low to Medium	Concentrations of contaminants within the made ground are not considered to represent a significant risk. However, asbestos fibres were identified within the made ground. Construction and maintenance work should be subject to risk assessment. Workers should use appropriate procedures to manage risk from exposure to materials on site and exposure durations will be short.
	Ground gas and vapours	Inhalation, Migration through granular and fractured soils into confined spaces.	Low	No potential sources of ground gas have been identified.
Future site users	Organic, metal contamination and asbestos in soils.	Direct contact, ingestion, and inhalation of outdoor soils or translocated soil and dust indoors.	Low	No elevated concentrations have been recorded relating to the contamination screening based upon a <i>commercial</i> end use. However, asbestos fibres were identified within the made ground. The site is to comprise 100% hard cover with retail units and car parking on the ground floor. As such no future risk to human health is deemed to be present.
	Ground gas and vapour	Inhalation, migration through granular and fractured soils into confined spaces.	Low	No potential sources of ground gas have been identified.
Property				
Site structures and services	Acidic and sulphate content of soil and presence of contaminates within site soils	Direct contact between soil and structures or services.	Low	No significant concentrations of organic contamination have been recorded which may have potential to degrade or penetrate some building materials or pipework. A concrete design class of DS-3 and ACEC class of AC-3 should be adopted for all foundations and buried concrete.

Receptor	Potential sources	Pathways	Risk	Justification
	Ground gas and vapour	Migration through granular and fractured soils into confined spaces.	Low	No potential sources of ground gas have been identified.
Plants /Landscaping	Metals and organic contamination in soils	Root contact and uptake	Low	Existing vegetation appeared unaffected. No significant concentrations of phytotoxic contamination were recorded in the samples that have been screened.
Adjacent Property				
Adjacent properties	Metals and organic contamination in soils	Soil leaching and migration and translocation as dust of soil contamination.	Low	Adjacent land uses are unlikely to be exposed to contaminants in sufficient quantity to be of significance.
Groundwater's				
Principal Aquifer	Metals and organic contamination in soils	Soil leaching and migration of potential soil contamination.	Low	No groundwater was encountered during the ground investigation works. Any deeper groundwater below the site is not considered to be a significant risk from the subject site or the development.
Surface Waters				
None identified within a plausible migration distance.	Leachable metals and organic contamination	Soil leaching and migration into drains and sewers which discharge into the ditch.	Low	Concentrations of contaminants are not considered likely to pose a significant threat to surface water bodies.

10. Conclusions

The subject site has historically been utilised for residential terraced housing subsequently redeveloped by a textile mill and two banks. Anecdotal evidence suggests that prior to demolition (pre 2013), the site was utilised for the manufacture and sale of clothing. Surrounding land uses identified include residential, academic and commercial operations including infrastructure of roadways and footpaths associated with the urban setting. A petrol filling station was noted to the north of the site.

The proposed development will comprise the construction of a five storey structure comprising retail units and car parking on the ground floor and residential maisonettes on the upper floors. The development is to comprise 100% hardcover. Based upon this, it has been considered appropriate to adopt a *Commercial* end classification for the site.

The geological sequence encountered during the investigation comprised made ground recorded to depths of between 2.80m and greater than 4.50m bcgl's, which is associated with the infilling of former basement features. The made ground comprised a mix of sand and gravel of building rubble containing bricks, sandstone blocks, sections of concrete floor slab with fragments of metal and plastic pipe.

The natural deposits, comprising sand and gravel were recorded in TP01, TP03 and TP04, from depths of between 2.80m and 3.90m bcgl's, down to depths of 4.00m and 4.10m bcgl's. Within TP03 the sand/gravel was recovered in small tabular pieces, considered to be representative of completely weathered bedrock.

Chemical analysis of the samples retrieved from the site have not identified any concentrations of contamination that are considered to represent a significant risk to the end users on this site, based upon a *Commercial* end use. However, asbestos fibres have been detected within the made ground, but since the proposed development is to incorporate 100% hardcover, there is not considered to be future ongoing risk to the end users on this site. However, future ground workers should undertake a risk assessment prior to commencement of any works.

Controlled Waters are not deemed to be at a significant risk from the materials on site. As such, a detailed Controlled Waters risk assessment has not been undertaken.

No sources of ground gas have been identified within a plausible migration distance of the site. Despite a significant depth of made ground being encountered on the site, it generally

comprises inert demolition rubble and as such is not considered to be a significant source of ground gas. Therefore, no ground gas monitoring has been undertaken.

Owing to the depth of fill encountered, associated with the infilled basements, conventional foundations will not be suitable for the proposed development. Therefore, it is envisaged a piled foundation solution will need to be utilised.

Due to the numerous types of piled foundations available and the various methods of installation the ground investigation information will need to be passed onto specialised piling contractors so that they can design and price a suitable scheme, particularly as a detailed piling design lies outwith the scope of this report. However, a piling contractor may require additional information relating to the deeper ground conditions below the site and boreholes to a greater depth may be required.

When considering the risk to building materials, it is recommended that a concrete design class of DS-3 and ACEC class of AC-3 for all foundations and buried concrete.

The results of the geo-environmental site investigation and risk assessment indicate that with the site in its current condition a significant source - pathway – receptor pollutant linkage may be present. The risk is associated with the asbestos fibres, although any potential receptors are considered to be limited since the site is securely fenced and there are no day to day current users.

Following development of the site, incorporating 100% hardcover the pollutant linkage will be broken, with the source (asbestos fibres) and receptors (end users) being separated by the hardcover. Therefore, it is concluded that the environmental risk arising from the ground conditions at the subject site will be **Low**.

Disposal of Soils

Any materials removed from site should be undertaken in accordance with the Duty of Care Regulations 1991. There will also be a requirement to classify the waste in accordance with the European Waste Catalogue. The laboratory screening results provided with this report can also be used for a preliminary assessment for off-site disposal classification. However, there may be a requirement for Waste Acceptance Criteria (WAC) testing, it is recommended that discussion with landfill operators takes place at an early stage. The presence of ACM's within the general matrix of the made ground may result in elevated costs of disposal to landfill.

11. Recommendations

The following points are recommended;

- Based upon the proposed development plans there is no requirement for any additional mitigation measures with respect to the concentrations of contamination or asbestos fibres encountered on this site.
- There may potentially be a risk to construction workers and an asbestos management plan may need to be included in the onsite health and safety file to be provided to future site workers.
- Future ground and construction works should ensure they have appropriate 'barrier type' personal protective equipment (PPE), which reduce any potential risks to an acceptable level.
- Should there be a change in the proposed development layout or end use then an updated risk assessment will need to be undertaken.

Definitions and Reservations used in this report are presented in **Appendix V**.

APPENDIX I

TRIAL PIT LOCATION PLAN AND PROPOSED GROUND FLOOR LAYOUT PLAN

APPENDIX II

TRIAL PIT LOGS

APPENDIX III

RESULTS OF LABORATORY ANALYSIS

For the avoidance of doubt, Roberts Environmental has prepared the following alphabetical list of definitions and reservations to aid the client in understanding the content of our advice and or written reports(s):

Accuracy	Level of agreement between true value and observed value.
ACM's	Asbestos Containing Materials
Conceptual Exposure model	Textual and or schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the base of the information from the preliminary investigation and refined during subsequent phases of investigation and which is an essential part of the risk assessment process. Note 1: The conceptual exposure model is initially derived from the information obtained by the preliminary investigation. This conceptual model is used to focus subsequent investigations, where these are considered to be necessary, in order to meet the objectives of the investigations and the risk assessment. The results of the field investigation can provide additional data that can be used to further refine the conceptual model.
Contamination	Presence of a substance which is in, on or under land, and which has <u>the potential</u> to cause significant harm or to cause significant pollution of controlled water. Note 1: There is no assumption in this definition that harm results from the presence of the contamination. Note 2: Naturally enhanced concentrations of harmful substances can fall within this definition of contamination. Note 3: Contamination may relate to soils, groundwater or ground gas.
Controlled water	Inland freshwater (any lake, pond or watercourse above the freshwater limit), water contained in underground strata and any coastal water between the limit of highest tide or the freshwater line to the three mile limit of territorial waters. Note 1: See Section 104 of The Water Resources Act 1991.
Enquiries	Any enquiries undertaken by Roberts Environmental of local authorities and statutory undertakers are made verbally in respect of environmental issues. Local searches are not undertaken and no responsibility is accepted for any inaccurate information provided.
Harm	It is further assumed unless otherwise stated that all necessary licences, permits etc either run with the property or are transferable to a new occupier as appropriate. Adverse effect on the health of living organisms, or other interference with ecological systems of which they form part, and, in the case humans, including property.
Hazard	Inherently dangerous quality of a substance, procedure or event.
Pathway	Mechanism or route by which a contaminant comes into contact with, or otherwise affects, a receptor.
Precision	Level of agreement within a series of measurements of a parameter.
Receptor	Persons, living organisms, ecological systems, controlled water, atmosphere, structures and utilities that could be adversely affected by the contaminant(s).
Risk	Probability of the occurrence, magnitude and consequences of an unwanted adverse effect on a receptor.
Risk assessment	Process of establishing, to the extent possible, the existence, nature and significance of risk.
Sampling	Methods and techniques used to obtain a representative sample of the material under investigation.
Soil	Upper layer of the earth's crust composed of mineral parts, organic substance, water, air and living matter.

Note 1: In accordance with BS 10175:2001 the term soil has the meaning ascribed to it through general use in civil engineering and includes topsoil and subsoil; deposits such as clays, silt, sand, gravel, cobbles, boulders and organic deposits such as peat; and material of natural or human origin (e.g. fills and deposited wastes). The term embraces all components of soil, including mineral matter, organic matter, soil gas and moisture, and living organisms.

Source Location from which contamination is, or was, derived.

Note 1: This could be the location of the highest soil or groundwater concentration of the contaminant(s).

Uncertainty Parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurement.

Risk Classification

In line with current UK guidance, the Environmental Assessment has been undertaken using a risk based approach, with the potential environmental risk assessed qualitatively using the 'source-pathway-receptor' scenario. In consideration of the information gathered an overall risk rating has been provided for the site based on the following definitions:

Low Risk

The site is considered suitable for present use and environmental setting. It is unlikely that any issues will arise as a liability/cost for the freehold owner of the site.

Medium Risk

The site may not be suitable for present use and environmental setting. Contaminants are probably or certainly present and are likely to have an unacceptable impact on the identified receptors. It is possible that the issue(s) could arise as a liability/cost for the freehold owner of the site. Further work is usually required to clarify the risk.

High Risk

The site is not suitable for present use and environmental setting. Contaminants are probably or certainly present and are very likely to have an unacceptable impact on the identified receptors. It is likely that the issue(s) will arise as a liability/cost for the freehold owner of the site. Further work is urgently needed.