



Your Environment

PHASE 2: SITE INVESTIGATION REPORT 2 CROFT COTTAGES, PIER ROAD, LITTLEHAMPTON, BN17 5LS

For Bishop & Cammell Properties Ltd

Your Environment
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Contents

1.0	Introduction	1
2.0	Proposed Development	1
3.0	Physical Setting	1
4.0	Preliminary Conceptual Site Model and Risk Assessment	5
5.0	Fieldworks	7
6.0	Geology & Ground Conditions	7
7.0	Groundwater Conditions	7
8.0	Visual and Olfactory Observations	8
9.0	Contamination	8
10.0	Site Investigation Findings	12
11.0	Updated Conceptual Site Model and Risk Assessment	13
12.0	Recommendations	15
13.0	Limitations	17

Appendices

Appendix A: Proposed redevelopment plans

Appendix B: Site investigation plan

Appendix C: Trial pit logs

Appendix D: Site investigation photographs

Appendix E: Soil contamination laboratory results

1.0 Introduction

YourEnvironment (YE) was instructed by Bishop & Cammell Properties Ltd (Quote No: Q4641, Dated: February 11th 2021) to conduct a Site Investigation (SI) at 2 Croft Cottages, Pier Road, Littlehampton, BN17 5LS.

The SI undertaken is as a result of recommendations made by YE in our previously issued Phase 1: Desktop Study & Risk Assessment Report for the site (Report Reference: YEX1708, Issued: January 2021), to which this report should be read in conjunction with. As such this report seeks to address the potential pollutant linkages identified within the Preliminary Conceptual Site Model contained within our Phase 1: Desktop Study report.

The purpose of this report is to support the planning application Ref: LU/159/19/PL submitted to Arun District Council. Specifically, the report aims to satisfy condition 9 as set out by the local authority.

We are content that as a result of the actual site investigation works and subsequent soil testing undertaken, as outlined within this report, we have characterised the ground conditions and consequently the potential for contamination to exist on site. These works and ensuing assessment have been detailed in this report.

The information contained in this report is intended for the use of the named client (or their approved contractors). Should any part of this report be relied on by a third party, that party does so wholly at its own risk and YE disclaims any liability to such parties. Should the purposes for which the report is used, or the proposed use of the site change, this report may no longer be valid and further use of, or reliance upon the report in those circumstances shall be at the client's sole and own risk. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. YE should in all such altered circumstances be commissioned to review and update this report accordingly.

2.0 Proposed Development

We understand current plans for the development of the site include:

- New maisonette over parking area, extend crossover & alterations to rear fenestration.

The proposed redevelopment plans for the site, at the time of issuing this report can be reviewed within Appendix A.

3.0 Physical Setting

3.1 Site Information

Current Site Use

The site currently comprises a semi detached property with associated parking and soft landscaped area.

Access

The site is directly accessible from Pier Road.

Topography

The site is flat.

Buildings and Structures

2 Croft cottages, a semi-detached property part of a block of two houses.

Hard Surfaced Areas

The majority of the site is underneath the footprint of the property. The remaining area is mainly grass with some paving slabs.

Landscaped and Vegetated Areas

Hedge at eastern boundary

3.2 Geology

The relevant British Geological Survey (BGS) online mapping information indicates that the superficial ground deposits underlying the study site are comprised of Raised Beach Deposits (gravel). The bedrock geology is composed of the Nodular, Seaford, Newhaven, Culver and Portsdown Chalk Formations.

3.3 Hydrogeology

The Environment Agency designate aquifers in accordance with the Water Framework Directive. These designations reflect not only the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetlands ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey.

As a consequence of the superficial geology on site, Raised Beach deposits are designated as a Secondary (A) Aquifer.

As a result of the bedrock geology on site, the underlying chalk formations are designated as a Principal Aquifer.

3.4 Hydrology

Groundwater Abstraction Licences

There is one groundwater abstraction licence within 1000m. 953m west there is an historical record for General washing/process washing from the River Arun Estuary.

Surface Water Abstraction Licences

There are no licensed surface water abstractions within 1000m.

Potable Water Abstraction Licences

There are no potable abstraction licences within 1000m.

Groundwater Vulnerability and Soil Leaching Potential

The groundwater vulnerability in the vicinity of the site is classified as high due to the superficial aquifer and bedrock aquifers underlying the site.

Surface Water Features

The River Arun is located 91m southwest.

Source Protection Zones

The study site is not located within any Source Protection Zone.

Detailed River Network

There is one record 91m south west referring to a tidal river or stream named River Arun.

3.5 Contaminant Sources

On Site Sources

The following possible on site sources have been identified from the historical study:

- Historical saw mill
- Made ground associated with historical development

The following on site sources have been identified from the site walkover:

- None identified

The following possible on site sources have been identified from the Enviro + Geo Insight data:

- Saw mill

The following contaminants are potentially associated with all the on site sources listed above:

- Heavy Metals
- TPH
- PAH
- PACM
- Ground Gas

Off Site Sources

The following off site sources have been identified from the historical study:

- Saw Mill - adjacent
- Various wharfs - 15m west, 30m west, 40m north west, 50m south, 150m north west, 170m north west and 200m north west
- Tank - 50m north
- Gas Works - 115m south
- Works - 125m south
- Smithy - 150m north west
- Engineering works - 175m north east
- Garage - 175m north west
- Builders Yard - 250m north east

There are further entries present but these are considered far enough from the site to pose no risk.

The following off site sources have been identified from the site walkover:

- Builders Merchant and Yard - adjacent east and south

The following possible off site sources have been identified from the Enviro + Geo Insight data:

- Gas works - 87m to 120m south
- Gasometer - 100 to 145m south
- Tanks - 44m north, 94m north and 152m south, 238m north

The following contaminants are potentially associated with all the off site sources listed above:

- Heavy Metals
- PAH
- TPH
- VOCs
- SVOCs
- BTEX
- MTBE
- Ground gas - from decomposition of organic carbon in infilled material, leading to generation of methane and carbon dioxide

4.0 Preliminary Conceptual Site Model and Risk Assessment

This presented Conceptual Site Model has been re-issued from the previous Phase 1: Desktop study (YEX1708), to provide information regarding the possible **sources** of contamination on site, the **pathway** in which the contamination can migrate and a vulnerable **receptor** to the contamination, all of which need to be present for there to be a risk. Given the continued end use of the site the generic land use of ‘residential with homegrown produce’ has been applied. Consequently, the following Source - Pathway - Receptor relationships have been identified.

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site possibly containing elevated metals, other organics such as TPH, PAH, phenols.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Low Likelihood	Moderate/Low ●●	A moderate/low risk rating has been assessed due to the history of potentially contaminative land uses on site although the contamination potential is not considered to be high. Contact is likely between future residential occupiers/visitors and contaminants in the shallow soil in garden areas of the site, soil/dust tracked back into the house, from ingestion of homegrown produce and from vapour intrusion.
		Construction Workers	Medium	Low Likelihood	Moderate/Low ●●	Construction workers are likely to come into direct contact with soils during groundworks. Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Mild	Low Likelihood	Low ●	A low risk rating has been assessed due to the presence of potentially contaminative sources on site and the presence of a Secondary (Undifferentiated) Aquifer within the superficial deposits and a Principal Aquifer within the bedrock underlying the site.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Low Likelihood	Moderate/Low ●●	Hydrocarbons, especially aromatics are known to permeate plastic pipes. Provision of water supply pipes and connectors formed from proprietary “barrier pipe” materials (eg polyethylene-aluminum-polyethylene) may be required by the water supply company.
	Uptake	Plant and Wildlife	Mild	Low Likelihood	Low ●	Contact is possible between wildlife and potentially contaminated soils in proposed garden areas of the development.
On Site: Asbestos at/near ground surface in	Inhalation of fibres in airborne dust	Future end users and site visitors	Medium	Low Likelihood	Moderate/Low ●●	A moderate/low risk rating has been assessed due to the commercial history of the site creates potential for asbestos contact may be possible in areas of proposed soft landscaping.

Made soils.	Ground	Construction Workers	Severe	Low likelihood	Moderate	During groundworks, safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from residual asbestos in soils.
On Site: Ground Gases (CH ₄ , CO ₂) from Made on site Ground.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Mild	Low likelihood	Low	A low risk rating has been assessed due to the limited thickness and lack of organic and/or degradable content assumed to be present in the made ground. Such made ground is generally classified as very low risk in terms of potential for gas generation.
Off Site: Historical land uses activities, Made Ground/infilled material possibly containing elevated metals, other inorganics, TPH, PAH, phenols, BTX, MTBE, VOC and SVOCs.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Medium	Likely	Moderate	Given the variable permeability of the underlying geology and hydrogeology, there is a moderate risk for the leaching and migration of contaminants. This combined with the presence of gasworks and tanks in the surrounding area upgradient of the site with a high contamination potential create a risk for contamination on site.
	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Low likelihood	Moderate/Low	A very low level of risk rating has been assessed as the potentially contaminative land uses/activities in proximity to the site have been subject to redevelopment and are now predominantly hard surfaced.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off site historical landfilling activities.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Mild	Low likelihood	Low	A low risk rating has been assessed as no land filling activities have been identified in the area surrounding the site.

Table 1: Preliminary Conceptual Site Model and Risk Assessment

5.0 Fieldworks

5.1 Site Investigation

All SI works were completed on March 19th 2021 under the supervision of a Geo-Environmental Engineer from YE. In summary the investigation included:

- Three (3no.) hand excavated trial pits (TP01-TP04) were completed to a maximum depth of 1.00mbgl, by a YE Geo-Environmental Engineer.
- The trial pits were logged with any groundwater conditions noted and representative soil samples removed in accordance with current guidelines.
- Soil samples were removed from shallow sub surface locations, with further samples taken at depths of 0.15mbgl, 0.30mbgl, 0.50mbgl 0.70mbgl and 1.0mbgl. Samples were subsequently placed in suitable containers including 1kg tubs and 250ml glass jars and placed in cool boxes with cool packs prior to storage within our *in-house* laboratory fridges and then subsequent forwarding to our designated laboratory for analysis.
- The trial pits were backfilled immediately after excavation.

The positions of exploratory holes in relation to the existing site layout can be reviewed within Appendix B, with exploratory trial pit logs located in Appendix C and photographs taken during the SI in Appendix D.

6.0 Geology & Ground Conditions

The following ground conditions were encountered during the SI;

Topsoil - Encountered in TP01 and TP02 to a maximum depth of 0.30mbgl and consisted a brown clayey slightly gravelly SAND.

Made Ground - Encountered in all of the exploratory positions to a maximum depth of 1.1mbgl in TP03, in the form of a soft light brown - grey slightly gravelly slightly sandy CLAY. Gravel is fine to medium, rounded to subrounded of flint and rare brick. (MADE GROUND

Raised Beach Deposits (gravel) - Natural soils were encountered at a subsurface depth of 0.80mbgl within TP01 only. The stratum comprised of a Reddish brown slightly clayey very gravelly fine to medium SAND. Gravel is fine to medium, subangular to subrounded of flint.

7.0 Groundwater Conditions

Groundwater was not encountered in any of the trial pits during investigative works undertaken.

However, it should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought. However, as a consequence of the anticipated depth to standing water level such seasonal variations are unlikely to have an effect on site development.

8.0 Visual and Olfactory Observations

With the exception of general anthropogenic material identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered as part of the investigative works undertaken.

9.0 Contamination

9.1 Soil Testing

A total of six (6no.) samples have been analysed by Chemtech Environmental Ltd in their UKAS and MCERTS accredited laboratory-testing facility in accordance with laboratory protocol.

The testing completed comprised of a focused suite of heavy metals, speciated Total Petroleum Hydrocarbons (TPH CWG Aromatic/aliphatic split) and speciated Polycyclic Aromatic Hydrocarbons (PAH) including the more carcinogenic benzo(a)pyrene (BaP) and naphthalene, asbestos, soil organic matter (SOM) content, pesticides, MTBE & BTEX, cyanide, pH and sulphates.

The results of this laboratory testing have been compared to the Soil Guideline Values (SGVs) as well as the CIEH 'LQM' guideline values for inorganic and organic contaminants in soils. The proposed development of the site is intended to comprise of residential and therefore screening has been made against a land use of 'residential with homegrown produce'.

9.2 Selection of Screening Criteria

The on site receptors for the study site are considered to be:

- Construction workers (during redevelopment of the site only);
- Future maintenance workers (following redevelopment);
- Future end users and site visitors (following redevelopment); and
- Trespassers (during redevelopment).

Risks to construction workers during the redevelopment process will be mitigated by adhering to appropriate health and safety legislation, and the wearing of appropriate personal protective equipment (PPE). During redevelopment, the site will be securely fenced to prevent trespassers from accessing the site, and good site management practices will be implemented to mitigate exposure to off-site receptors.

The potential pathways for contaminants within the soil to human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

The potential pathways for contaminants within the soil to off-site human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;

- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside if contamination within soil is able to migrate across the site boundary within.

In the first instance, the results of this laboratory testing have been compared to generic assessment criteria (GAC) for the residential with homegrown produce land use scenario. These incorporate the following pathways:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Contaminants have been screened against revised LQM/CIEH S4UL criteria¹ where available. These GAC have been designed for use under planning, using Health Criteria Values based on minimal risk, and updated exposure parameters. The S4UL are intended to replace the previous LQM/CIEH GAC. The S4UL are based on the assumption of a sandy loam soil the 1.0% soil organic matter (SOM) criteria have been used, where available and appropriate, in the first instance. All soil samples were analysed for %SOM, the range was from 0.1-3.3%, and so this conservative approach is considered appropriate for initial screening.

Where no S4UL are available, the EIC/ AGS/ CL:AIRE/ GAC² have been used. The toxicological criteria within these are also based on minimal risk. It is recognised that these criteria have not recently been updated, and in particular, do not incorporate the slightly higher inhalation rates that have been used within the S4UL. However, given that they incorporate additional pathways, they are considered suitable for an initial screen. The EIC/ AGS/ CL:AIRE/ GAC are also based on a sandy loam soil and the 1% SOM criteria have been used in the first instance.

There is neither an S4UL nor a EIC/ AGS/ CL:AIRE/ GAC available for lead. In the absence of a GAC based on minimal risk, the C4SL for lead has been used. It is recognised that this is based on a “low level of toxicological concern” rather than on a minimal risk level. However, it is considered appropriate for use under planning, especially for a site where there will effectively be no pathways for inorganic metals following redevelopment.

All the GAC are based on a sandy loam soil. This is considered appropriate for use for initial screening. Although it is apparent from the laboratory soil descriptions, that the Made Ground, by its very nature is heterogeneous, and often has a significant sand/gravel component, especially at shallow depths, it is noted that many of the soil descriptions have a significant clay component at increasing depth.

All of the GAC assume unsaturated soils. However, the use of the GAC are considered to be conservative, because they assume a certain air-filled porosity and water-filled porosity.

The GAC also assume that no free phase product is present, and are not intended for use in this instance. No free product was observed within soils during the site investigation.

¹ Nathanail et al. (2015) The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, 2015. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3495

² CL:AIRE (2010) The EIC/AGS/CL:AIRE Generic Assessment Criteria for Human Health Risk Assessment

9.3 Soil Testing Results & Screening

All metals, PAHs, and TPH CWG analytes are presented in the following tables with units in mg/kg unless otherwise stated. Other potential contaminants of concern are only shown where there is at least one result exceeding the limit of detection. All of the soil contamination laboratory analytical results are presented within Appendix E.

Metalloids

Determinant	Min	Max	GAC	Number of exceedances
Arsenic	11	70	37*	3
Cadmium	0.3	2.7	11*	0
Chromium (III)	95	132	910*	0
Chromium (VI)	<1	<1	6*	0
Copper	48	2003	2400*	0
Lead	311	7988	200*	6
Mercury	<0.5	<0.5	40**	0
Nickel	21	103	180**	0
Selenium	0.7	2.2	250*	0
Zinc	164	755	3700*	0
Total Phenols	<0.5	1.0	420*	0
Total Cyanide	<1.0	1.0	140*	0

Table 2: Metalloids Soil Exceedances

*LQM/CIEH GAC for Residential with homegrown produce land use scenario based on a sandy loam soil and 1% SOM.

- a) Based on the inorganic mercury GAC as the conceptual site model does not suggest that other forms of mercury are likely to be present on site.
- b) LQM issued an update to the nickel S4ULs in August 2015 and this has been taken into account.

- There are nine (9no.) exceedances for metals/metalloid, three of which were for arsenic (GAC of 37mg/kg), located in TP01 at 0.8-1.0mbgl (47mg/kg) and TP03 at 0.2-0.5mbgl (70mg/kg) and 0.9-1.1mbgl (68mg/kg). All samples returned exceedances for lead (GAC of 200mg/kg) with results ranging from 311-7988mg/kg.

Organics

Determinant	Min	Max	GAC	Number of exceedances
Naphthalene	0.02	0.14	2.3*	0
Acenaphthylene	0.03	0.25	170*	0
Acenaphthene	0.03	0.10	210*	0
Fluorene	0.05	0.13	170*	0
Phenanthrene	0.28	3.17	95*	0
Anthracene	0.04	0.68	2400*	0
Fluoranthene	0.55	7.69	280*	0
Pyrene	0.44	6.28	620*	0

Benzo(a)anthracene	0.19	3.75	7.2*	0
Chrysene	0.30	3.95	15*	0
Benzo(b)fluoranthene	0.32	4.39	2.6*	1
Benzo(k)fluoranthene	0.12	1.66	77*	0
Benzo(a)pyrene	0.22	3.41	2.2*	1
Indeno(1,2,3-cd)pyrene	0.16	1.86	27*	0
Dibenz(a,h)anthracene	0.04	0.55	0.24*	3
Benzo(ghi)perylene	0.18	2.24	320*	0

Table 3: PAH Soil Exceedances

- There were five (5no.) exceedances for PAH congeners, three of which were within TP03 at 0.90-1.10mbgl for benzo(b)fluoranthene (GAC of 2.60mg/kg) at 4.39mg/kg, benzo(a)pyrene (GAC of 2.20mg/kg) at 3.41mg/kg and dibenz(a,h)anthracene (GAC of 0.24mg/kg) at 0.55mg/kg. There were two more exceedances for dibenz(a,h)anthracene, within TP03 at 0.20-0.50mbgl (0.27mg/kg) and TP01 at 0.20-0.25mbgl (0.30mg/kg).

Determinant	Min	Max	GAC	Number of exceedances
Aliphatic >C5 - C6	<0.1	<0.1	42*	0
Aliphatic >C6 - C8	<0.1	<0.1	100*	0
Aliphatic >C8 - C10	<0.1	<0.1	27*	0
Aliphatic >C10 - C12	<4	<4	130*	0
Aliphatic >C12 - C16	<4	5	1100*	0
Aliphatic >C16 - C35	9	270	65000*	0
Aromatic >C5 - C7	<0.01	<0.01	70*	0
Aromatic >C7 - C8	<0.01	0.01	130*	0
Aromatic >C8 - C10	<0.01	<0.01	34*	0
Aromatic >C10 - C12	<1	<1	74*	0
Aromatic >C12 - C16	<1	<1	140*	0
Aromatic >C16 - C21	2	19	260*	0
Aromatic >C21 - C35	2	21	1100*	0

Table 4: TPH CWG Aliphatic/Aromatic Soil Exceedances

* LQM/CIEH GAC Residential with Homegrown Produce land use scenario based on a sandy loam soil and 1.0% SOM. It is noted that the LQM/CIEH S4UL guidance recommends an additive approach for the TPH fraction, so that a hazard index approach is used. Based on a preliminary conservative comparison of maximum concentrations to S4ULs, no forward modelling is necessary to prove that this would still result in no exceedances at the site.

- There are no exceedances noted from the screening undertaken on the respective TPH CWG bands.

Others

- The asbestos screening returned a negative result for the presence of fibrous material from all samples analysed.
- BTEX/MTBE screening returned a negative result for any congeners.

The soil contamination laboratory certificates can be reviewed within Appendix E.

10.0 Site Investigation Findings

10.1 Risks to Human Health

With the exception of the limited depth of Made Ground identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered during the SI works undertaken, which focussed in the proposed private garden areas and also underneath the footprint of the proposed dwellings.

Overall, there were fourteen (14no.) exceedances identified from the site investigation. The most pertinent of these was lead (GAC of 200mg/kg) with exceedances returned from each sample from all positions results ranging from 311-7988mg/kg.

Therefore, it would be reasonable to conclude that there is a possible risk to human health receptors.

10.2 Risks to Plants and Wildlife

A low risk has been attributed given the concentrations of phytotoxic contaminants below elevated concentrations often below the limit of detection returned.

10.3 Risks to Site Workers

Due to the returned elevated concentrations of determinants, precautions should be taken to minimise exposure of site workers during ground works through the implementation of site safety procedures and the use of suitable personal protective equipment (PPE). Such precautions should include, but not be limited to:

- Personal hygiene, washing and changing procedures;
- Availability of site welfare;
- Provision of PPE appropriate to the task; and
- Daily safety briefings and tool box talks.

All site works will be undertaken in accordance with the guidelines prepared by the Health and Safety Executive (1991) and all work will be carried out in accordance with the Principal Contractor's Health and Safety Plan.

10.4 Risks to Proposed Structures

A low risk has been attributed given the limited Made Ground on site, the low organic content in the samples tested and the concentration of hydrocarbons returned from the laboratory thus giving a low risk for potential volatilisation. Furthermore, off site there is limited historical development and a lack of nearby potentially infilled land, ground workings and/or landfills that pose a risk for ground gas generation.

11.0 Updated Conceptual Site Model and Risk Assessment

The Conceptual Site Model has been re-formulated based upon the results from the SI in accordance with BS10175:2015. It aims to provide information regarding the sources of contamination and the pathways in which contamination can migrate to a vulnerable receptor, all of which need to be present for there to be a risk. This is in relation to the proposed end use being classified as 'residential with homegrown produce'. The following linkages have been identified:

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site containing Hydrocarbons (TPH, PAH) heavy metals, phenols, BTEX, MTBE.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Likely	Moderate/	A moderate level of risk is considered due to the returned results, which identified exceedances for lead, PAHs and arsenic in the shallow Made Ground. Contact is likely between future residential occupiers/visitors and contaminants in the shallow soil in garden areas of the site, soil dust tracked back into the house, from ingestion of homegrown produce and from vapour intrusion.
		Construction Workers	Medium	Likely	Moderate	Construction workers are likely to come into direct contact with soils during groundworks. Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.
	Leaching soils and migration via groundwater or soil pore moisture	Controlled Waters	Mild	Low Likelihood	Low	A moderate risk would be assessed due to the identified exceedances. However, the risk is reduced due to the immobile nature of lead and marginal nature of the hydrocarbon exceedances. The risk is further reduced by the presence of a Secondary (Undifferentiated) Aquifer within the superficial deposits underlying the majority of the site.
	Permeation of plastic water pipes	Construction materials, future end users and site visitors	Medium	Likely	Moderate	A moderate risk is assessed due to the identified levels of PAH. Provision of water supply pipes and connectors formed from proprietary "barrier pipe" materials (eg polyethylene-aluminium-polyethylene) may be required by the water supply company.
On site: Phytotoxic Contamination.	Uptake	Plant and Wildlife	Mild	Low Likelihood	Low	A low risk is assessed given the returned laboratory results which indicates there to be no significant concentrations of phytotoxic contamination.
On Site: Asbestos at/near ground surface in	Inhalation of fibres in airborne dust	Future end users and site visitors	Medium	Unlikely	Low	Although screening has revealed no asbestos to be present within the samples analysed from exploratory holes undertaken, it cannot be guaranteed that asbestos is not present within the soils across the site.

made soils.	ground	Construction Workers	Medium	Unlikely	Low	Asbestos fibres have not been identified in the samples returned from laboratory analysis. However, Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from asbestos in soils.
On Site: Gases (CH ₄ , CO ₂) from on site Made Ground.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Mild	Low likelihood	Low	Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation. Furthermore, the limited Made Ground identified on site is not considered to pose a significant potential risk due to limited historical development and lack of infilled land/landfills within proximity to the site. The returned laboratory results show that there were only marginal exceedances of any organic contaminants within the samples taken, so the risk of any volatilisation is low.
Off Site: Limited off site development.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Medium	Likely	Moderate	Given the identified exceedances and proximal sources of contamination, it is potential that the contaminants have migrated to the site.
	Inhalation of vapours	Future end users and site visitors	Medium	Unlikely	Low	A low risk is assessed given the marginal nature of the organic exceedances.
Off Site: Gases (CH ₄ , CO ₂ , H ₂ S) from off site Made Ground.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	Mild	Low likelihood	Low	Due to lack of historical development, the current land uses/activities, Made Ground off site, potentially infilled land and landfills within the vicinity, there is a low risk from ground gas generation.

12.0 Recommendations

The following recommendations are based on the results of chemical laboratory testing to date.

The following recommendations made do not constitute a formal remediation strategy and/or validation report. A remediation strategy should be agreed with the relevant local authority prior to such works commencing and/or the production of a validation report.

12.1 Soils

Given the identified lead and hydrocarbon contamination in the proposed area of soft landscaping, we would recommend that soils are removed in the garden area of the site to a depth of 600mm, a geotextile layer is installed at a depth of 600mm across the entire proposed soft landscaping area followed by 600mm of clean imported material, comprised of 300mm of subsoil and 300mm of topsoil. The removal of this shallow subsoil from across the site would be sufficient to mitigate the risks posed by the contamination encountered during the site investigation.

As construction workers are likely to come into contact with contaminated soils during the removal of the soil and subsequent groundworks, safe working practices should be implemented and appropriate PPE should be used to mitigate the risks of contact with contaminated soils.

Alternatively, a layer of hardstanding could be installed across the garden areas. This would act as capping layer, breaking the pathway for interaction between future inhabitants and the identified contamination in the soil below.

A remedial strategy should be formulated and presented to the Local Authority Planning Authority to seek their comments and approval in advance of such works proceeding.

12.2 Watching Brief and Discovery Strategy

A watching brief should be maintained by the Main Contractor at all times during the groundworks stage. Should any unforeseen contamination, such as oils or soils/groundwater with an unusual colour or odour, be encountered during groundworks then the following procedure should be implemented:

- Work to cease in that area to prevent exposure to ground workers and potential contaminants being spread around;
- Notify a Geo-Environmental Consultant, to attend site and sample material;
- Notify the Environmental Health Department / Contaminated Land Officer(s) of the Local Planning Authority.

If the nature and extent of the contamination is unmanageable under the procedure set out above, then a suitable management, mitigation or remediation procedure will be agreed with the CLO. However, this is considered unlikely at this particular site.

12.3 Asbestos

Although screening has revealed no asbestos to be present within the samples analysed from exploratory holes undertaken, it cannot be guaranteed that asbestos is not present within the soils across the remainder of the site. Consequently, we would recommend that a watching brief be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs). If any ACMs are identified these need to be dealt with accordingly in relation to the Hazardous Waste Regulations 2005.

12.4 Services

If new services will be installed as part of the redevelopment of the site, we would recommend the local water board be contacted to determine their specification for the type of pipework which should be used on this site.

All services and in particular potable water supply pipework should comprise of material that is resistant to attack and degradation to chemical attack.

Further information can be found within the published guidance for the '*Selection of Water Supply Pipes to be used in Brownfield Sites*', issued in January 2011 by the UK Water Industry Research (UKWIR), this supersedes the Water Regulations Advisory Scheme (WRAS) Information and Guidance Note - '*Laying Pipes in Contaminated Land*' which has been withdrawn.

12.5 Surface Water

It should be noted that the Environment Agency does not recommend that soakaways be placed within Made Ground, potentially contaminative land or in ground previously identified as contaminated.

12.6 Verification Reporting

It is recommended that you confirm with the relevant environmental consultees whether they require a validation and/or closure report providing documentation/audit trail for the completion of any remediation/mitigation works completed on site.

If a verification Report is required it should include, but not be limited to, the following:

- Site visit records and photographic records from the watching brief;
- Site visit records and photos from visits completed by a Geo-Environmental Consultant;
- Duty of care records for disposal of waste material including the landfill site(s) or disposal facility where the material has been disposed and a copy of the Contractor's current waste carrier's licence (to be provided by Contractor);
- Records and test certificates relating to the management and disposal or unforeseen contaminants and/or ACMs (if any);
- Details of source and chemical test results for imported materials; and
- Confirmation of water supply pipe materials installed.

12.7 Report Submission

This report should be submitted to the Local Planning Authority at the earliest opportunity to seek their acceptance of the findings of this report.

13.0 Limitations

YE have prepared this report with all reasonable skill, care and diligence. The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources.

The opinions given in this report have been dictated by the finite data on which are they based and are relevant only to the purpose for which the report was commissioned.

Information reviewed should not be considered exhaustive and has accepted in good faith as providing true and representative data with respect to site conditions. Should additional information become available which may influence the opinion expressed in this report, YE reserves the right to review such information and, if warranted, to alter the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed.

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time and as such is not a guarantee that the study site is free of hazardous conditions.

This report has been prepared solely for the use of the named client, and may not be relied upon by other parties without written consent from YE. YE disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.