



Your Environment

PHASE 2: SITE INVESTIGATION REPORT FOR 37 CREEK ROAD, HAYLING ISLAND, PO11 9QZ.

For Chris Flint Associates.

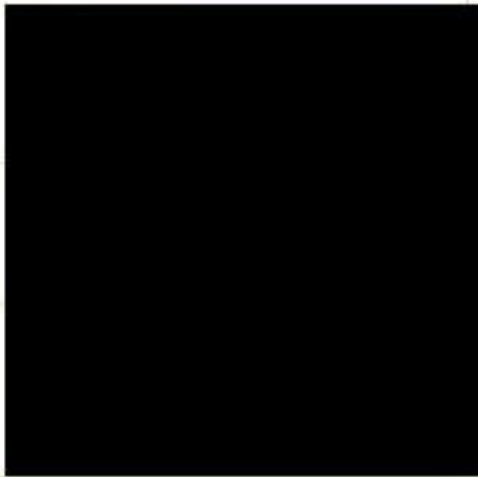
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1.0 Introduction

Your Environment (YE) were instructed by Chris Flint Associates (Quote No: Q7882, Dated: November 18th 2019) to conduct a Site Investigation (SI) at the site known as 37 Creek Road, Hayling Island, PO11 9QZ.

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: YE7136, Issued: June 2019), 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 and to accompany other documentation for the purpose of obtaining planning permission for the proposed construction through the local planning authority, namely Havant Borough Council, under reference APP/19/00211.

We are content that as a result of the site investigation works and soil testing undertaken, YE have characterised the ground conditions and the potential for contamination to exist on site.

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:

- Conversion to form 1 bedroom flat with associated parking.

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

Access

The site is accessible from Creek Road.

Topography

Both on and off site the ground is relatively flat, with a slight drop immediately to the south of the site.

Vegetation

The site is completely unvegetated.

Buildings and Structures / Floor Covering

There is one (1no.) structure on site, which is a brick-built former takeaway food store, with a concrete base and pitched, tiled roofing. The site is connected to the hair and beauty salon immediately north.

Surface Permeability / Ground Covering

It is estimated that 100% of the site is impermeable tarmac and concrete.

Drainage Features

One manhole cover was noted on site and guttering was noted along the roof of the building on site.

Other Services

The site has access to all services.

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 River Terrace Deposits (sand, silt and clay). The bedrock geology is composed of the Wittering Formation (sand, silt and clay).

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 the stratum is classified as being a Secondary (A) Aquifer. These are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as Minor Aquifers.

As a result of the bedrock geology on site, the aquifer is also designated as being Secondary (A).

3.4 Hydrology

Groundwater and Surface Water Abstraction Licences

There is one (1no.) active surface water abstraction licence within 2000m, which is 1862m northwest for a spray irrigation-storage.

Potable Water Abstraction Licences

There are no active potable abstraction licences within 2000m.

Groundwater Vulnerability and Soil Leaching Potential

The on site soil vulnerability category is listed as being 'HU', this is defined as soil information for urban areas and restored mineral workings. These soils are therefore assumed to be highly permeable in the absence of site-specific information.

Surface Water Features

There is one record within 250m of the study site which is 153m south.

Source Protection Zones

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

Detailed River Network

There are two (2no.) records within 250m of the study site, which are 153m south for an inland river not influenced by normal tidal action. The remaining results are over 165m from the study site.

3.5 Contaminant Sources

On Site Sources

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

- Possible Made Ground, from 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-Insight and Geo-Insight:

- Garages.

The following contaminants are potentially associated with these sources:

- Heavy Metals;
- TPH;
- PAH; and
- Ground gas - methane and carbon dioxide, from decomposition of organic carbon in Made Ground/infilled material associated historical development.

Off Site Sources

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

- Garage (10m southwest); and
- Electric substation (90m south).

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

- MOT garage approximately 40m southwest; and
- Previous underground storage tanks approximately 20m south.

The following off site sources have been identified from the Geo-Insight and Enviro-Insight:

- Garages (6m south);
- Vehicle repair & testing site (26m southwest); and
- Electricity substations (77-80m & 85m south).

The following contaminants are potentially associated with these sources.

- Heavy Metals;

- PAH;
- TPH;
- PCBs;
- VOCs;
- SVOCs; and
- Ground gas - methane and carbon dioxide, from decomposition of organic carbon in Made Ground/infilled material associated historical development.

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 (YE7136), 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 without 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 inorganics such as TPH, PAH, phenols, VOC and SVOCs.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Low Likelihood	Moderate/Low  	A moderate to low risk is assessed due to the garages on and off site. Direct contact is not likely between future residential occupiers/visitors and contaminants in the shallow soil as the proposed development does not contain any soft landscaping areas. There is possibly an appreciable risk from vapour intrusion.
		Construction Workers	Medium	Likely	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	Medium	Low Likelihood	Low/Moderate  	A low to moderate risk is assessed due to the potentially contaminative sources on and off site. The site is recorded as having a Secondary (A) Aquifer within the superficial deposits and a Secondary (A) Aquifer within the bedrock underlying the site. The nearest surface water abstraction licence is 1862m northwest for spray irrigation point. There are no portable or ground water abstraction licences within 2000m. In addition, the nearest surface water feature is water network is 153m south and the site is not within a source protection zone.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Likely	Moderate 	Hydrocarbons, especially aromatics are known to permeate plastic pipes. 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.
	Uptake	Plant and Wildlife	Mild	Low Likelihood	Low 	A low risk is assessed as there are no indicated areas of soft landscaping on the proposed site plans.
On Site: Asbestos at/near ground surface in	Inhalation of fibres in airborne dust	Future end users and site visitors	High	Low Likelihood	Low 	Likelihood is considered to be low as although the site walkover did not identify any potential asbestos containing materials (ACMs), the commercial history of the site creates potential for asbestos contamination.

Made soils.	Ground		Construction Workers	High	Low Likelihood	Low ●	Despite the lack of identified ACMs during the walkover, 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: Ground 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.	High	Low Likelihood	Moderate/Low ● ●	A moderate to low risk is given due to historical study showing presence of garages on and off site, possible risk for hydrocarbon volatilisation. Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation.
Off Historical uses and activities, Made Ground/infilled material possibly containing elevated metals, other inorganics, TPH, PAH, PCBs, phenols, VOC and SVOCs.	Site: land and	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Mild	Low Likelihood	Low /Moderate ● ●	Given the variable permeability of the underlying geology and hydrogeology, there would be a moderate risk for the leaching of contaminants onsite. However, the walkover survey shows that the site estimated coverage is 100% impermeable tarmac and concrete which creates an extra capping layer resulting in a low to moderate risk.
		Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Low Likelihood	Low /Moderate ● ●	A low to moderate level of risk is assessed due to the potentially contaminative land uses/activities onsite and proximal to the site that could pose a potential risk to the site.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off site Made Ground historical land uses/activities.		Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	High	Low Likelihood	Low /Moderate ● ●	The potentially contaminative land uses/activities proximal to the site create a potential for ground gas generation. Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation.

Table 1: Preliminary Conceptual Site Model and Risk Assessment

5.0 Fieldworks

5.1 Site Investigation

The following SI works were completed on December 15th 2017 under the supervision of a Geo-Environmental Engineer from YE. In summary, the investigation included:

- A two-man team ascertained the routes of any below ground services in close proximity to the proposed exploratory hole positions, using a CAT) and lifting up any man hole covers. Following the CAT scan, hand dug starter pits were completed to a depth of 1.20 metres below ground level (mbgl).
- Two (2no.) windowless sampler boreholes (WS01 and WS02) were advanced, by means of an Archway rig, to a maximum depth of 5.00mbgl. The locations of exploratory positions were selected relative to the historic land use and current proposed redevelopment plans for the site whilst providing a broad coverage of the site as feasibly as possible.
- The windowless sampler boreholes 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 depth every 1.00mbgl or when the underlying stratum changed. Samples were 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 forwarded to our designated laboratory for analysis.
- Both boreholes were installed with a standpipe comprising of 50mm pipework to a maximum depth of 5.00mbgl to enable future gas and groundwater monitoring to be undertaken. This was completed with a lockable cover, flush with the ground, to protect the installation.
- Upon completion, all exploratory holes were back filled, compacted, and made good to existing levels and finishes, with any surplus spoil bagged up and removed from site.

The positions of exploratory holes in relation to the existing site layout can be reviewed within [Appendix B](#). Exploratory windowless sampler logs located in [Appendix C](#).

5.2 Ground Gas and Groundwater Monitoring

Three (3no.) rounds of ground gas and groundwater monitoring have been carried out, dated 5th, 19th March and 2nd April 2020 using the standpipe installations of exploratory hole locations of WS01 & WS02.

5.2.1 Ground Gas

Ground gas monitoring was carried out in accordance with the guidelines presented in CIRIA C665 '*Assessing risk posed by hazard ground gases to buildings*' using a GA5000 and involved the following steps:

Flow was monitored for a period of two minutes where possible; maximum flow was recorded. Ground gases, including concentrations of methane, carbon dioxide, hydrogen sulphide and carbon monoxide were monitored for up to five minutes. During monitoring, ground gas readings were logged every thirty seconds.

5.2.2 Groundwater

A groundwater sample was recovered, where possible, from each of the installations.

Groundwater monitoring was completed in accordance with BS6068:2009 Water Quality Sampling: Guidance on Sampling of Groundwater.

A two phase dip meter was used to determine the presence of Light Non Aqueous Phase Liquids (LNAPL) and Dense Non Aqueous Phase Liquids (DNAPL). Each well was purged before a sample was taken and retained in a 1 litre coloured glass bottle (Winchester).

The samples were then placed in a cool box prior to transit to the laboratory.

The monitoring results are presented in [Appendix F](#).

6.0 Geology & Ground Conditions

The following ground conditions were encountered during the SI;

Made Ground - Encountered in both of the exploratory positions to a maximum depth of 1.20mbgl in WS02 and although varied, generally comprised a greyish brown sandy clayey GRAVEL. Sand is fine to coarse. Gravel is angular to sub angular of fine to coarse chalk, flint, brick and mixed lithology.

River Terrace Deposits - Natural soils were encountered at a subsurface depth of 0.90mbgl to the maximum excavated depth of 5.00mbgl. The stratum generally comprised of a soft becoming firm, light brown sandy, gravelly CLAY. Sand is fine to coarse. Gravel is angular to sub-angular, fine to medium of chalk, flint and mixed lithology.

7.0 Groundwater Conditions

Groundwater was not encountered during the site works completed. However, it was encountered within three of the monitoring rounds within both WS01 and WS02. The following table presents the levels recorded in each installation and round of monitoring.

Exploratory Hole	MON1 Standing Level (mbgl)	MON2 Standing Level (mbgl)	MON3 Standing Level (mbgl)
WS1	2.50	2.30	2.60
WS2	1.65	1.23	1.55

Table 2: Groundwater level recorded in installs

It should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought.

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 eight (8no.) 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 without 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. Other potential contaminants of concern are only shown where there is at least one result exceeding the limit of detection. All the soil contamination laboratory analytical results are presented within **Appendix D**.

Metalloids

Determinant	Min	Max	GAC	Number of exceedances
Arsenic	4.9	10.0	40*	0
Cadmium	<0.2	<0.2	85*	0
Chromium (III)	54	134	910*	0
Chromium (VI)	<1	<1	6*	0
Copper	5.2	12.8	7100*	0
Lead	8	23	310*	0
Mercury	<0.5	<0.5	56 ^a	0
Nickel	8.9	24	180 ^{ab}	0
Selenium	0.6	2.2	430*	0
Zinc	30	63	40000*	0
Total Phenols	<0.5	<0.5	550*	0
Total Cyanide	<1	<1	550*	0

Table 3: Metalloids Soil Exceedances

*LQM/CIEH GAC for Residential without 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 no exceedances for metalloids screened.

Organics

Determinant	Min	Max	GAC	Number of exceedances
Naphthalene	<0.02	0.07	2.3*	0
Acenaphthylene	<0.02	<0.02	2900*	0
Acenaphthene	<0.02	<0.02	3000*	0
Fluorene	<0.02	0.02	2800*	0
Phenanthrene	<0.02	0.31	1300*	0
Anthracene	<0.02	0.08	31000*	0
Fluoranthene	<0.02	0.99	1500*	0
Pyrene	<0.02	0.84	3700*	0
Benzo(a)anthracene	0.02	0.54	11*	0
Chrysene	<0.03	0.67	30*	0

Benzo(b)fluoranthene	<0.02	0.79	3.9*	0
Benzo(k)fluoranthene	<0.03	0.26	110*	0
Benzo(a)pyrene	<0.02	0.67	3.2*	0
Indeno(1,2,3-cd)pyrene	<0.02	0.53	45*	0
Dibenz(a,h)anthracene	<0.02	0.10	0.31*	0
Benzo(ghi)perylene	<0.02	0.43	360*	0

Table 4: PAH Soil Exceedances

There are no exceedances noted from the screening undertaken on PAH congeners.

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	< 4	1100*	0
Aliphatic >C16 - C35	< 4	122	65000*	0
Aromatic >C5 - C7	< 0.01	< 0.01	730*	0
Aromatic >C7 - C8	< 0.01	0.02	860*	0
Aromatic >C8 - C10	< 0.01	< 0.01	47*	0
Aromatic >C10 - C12	< 1	< 1	250*	0
Aromatic >C12 - C16	< 1	< 1	1800*	0
Aromatic >C16 - C21	< 1	3	1900*	0
Aromatic >C21 - C35	< 1	5	1900*	0

Table 5: TPH CWG Aliphatic/Aromatic Soil Exceedances

* LQM/CIEH GAC Residential without 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.

Determinant	Min	Max	GAC	Number of exceedances
Benzene	<1	<1	380*	0
Toluene	<1	1	880000*	0
Ethylbenzene	<1	<1	83000*	0
p & m-xylene	<2	<2	79000*	0
o-xylene	<2	<2	79000*	0
MTBE	<2	<2	49000*	0

Table 6: BTEX and MTBE Soil Exceedances

There were no exceedances for BTEX/MTBE congeners.

Others

The asbestos screening returned a negative result for the presence of fibrous material from all samples analysed.

The soil contamination laboratory certificates can be reviewed within [Appendix D](#).

9.4 Groundwater Testing

Samples obtained from the rounds of monitoring undertaken were analysed by DETS Ltd in their UKAS and MCERTS accredited laboratory testing facility in accordance with laboratory protocol.

The testing completed comprised of a suite of testing similar to that undertaken for soils such as heavy metals, pH, speciated Total Petroleum Hydrocarbons (Aromatic/ Aliphatic Split) and speciated Polycyclic Aromatic Hydrocarbons (PAH - including the more carcinogenic forms naphthalene and benzo(a)pyrene), total cyanide, total phenols, BTEX, MTBE, and pH.

The results of this laboratory testing have been compared to the UK Drinking Water Standards (DWS) for inorganic and contaminants, where available which is considered to be overly protective given the low risk which has been attributed to the groundwater as a potable resource.

9.5 Groundwater Results

The results of the groundwater testing are shown in the following tables below where they are compared to the available Drinking Water Standards. Results are given in µg/l unless stated otherwise.

Metals and Metalloids

Determinant	Max	GAC	Number of exceedances
Arsenic	<5	10	0
Beryllium	<3		0
Boron	197	1000	0
Cadmium	<0.4	5.0	0
Chromium	7	50	0
Copper	<5	2000	0
Lead	<5	10	0
Mercury	<0.05	10	0
Nickel	6	20	0
Selenium	8	10	0
Vanadium	<5		0
Total Phenols	<10		0
Total Cyanide	<5	50	0

Table 7: Metalloids Groundwater Exceedances

Organics

Determinant	Min	Max	GAC	Number of exceedances
Polycyclic Aromatic Hydrocarbons	<0.01	<0.01	0.10*	0

Table 8: PAH Groundwater Exceedances

Determinant	Max	GAC	Number of individual exceedances
Total TPH >C5 - C35	<10	10+	0

Table 9: TPH Groundwater Exceedances

Determinant	Max	GAC	Number of exceedances
Benzene	<1		0
Toluene	<5		0
Ethylbenzene	<5		0
p & m-xylene	<10		0
o-xylene	<5		0
MTBE	<10		0

Table 10: BTEX and MTBE Groundwater Exceedances

* Based on the sum of 4 named PAH congeners (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene).

+ Based on individual TPH fractions.

In summary, the groundwater monitoring results show:

- There were no exceedances from any of the water samples analysed; and
- All results in respect for BTEX and MTBE indicate none are above the LoD.

The groundwater contamination laboratory certificates can be reviewed within [Appendix E](#).

9.5 Gas Monitoring Results

Gas monitoring was carried out on three separate occasions using a Gas monitor (GA5000). Readings were taken from the installed window sampler boreholes of WS01 WS02.

The standpipe was tested for the presence of methane, oxygen, carbon dioxide and hydrogen sulphide. The flow rates of the gas and barometric pressure were also recorded.

The ground condition was noted to be wet on the 1st round, moist on the 2nd and dry on the 3rd of monitoring and the wind conditions were noted to be varied with calm conditions on the 2nd and 3rd with moderate conditions on the 1st round. Two rounds of monitoring were completed during steady pressure conditions and the 1st within falling conditions.

Methane was recorded at a maximum peak concentration of 0.4% volume during the second of the monitoring rounds. Oxygen concentrations ranged from a minimum of 10.9% obtained during the 2nd monitoring round to a maximum of 20.9% obtained during the 1st round. The maximum peak concentration of carbon dioxide of 4.0% was obtained during the 3rd round of monitoring.

Flow rates were recorded during each round of monitoring from all installations, ranging from a minimum of -11.6l/hr during the 2nd monitoring round to a maximum of 2.9l/hr during the 3rd round round. Concentrations of hydrogen sulphide were returned as 0.0ppm from all the rounds of monitoring undertaken. Concentrations of carbon monoxide were at a peak concentration of 5ppmv, however this reduced to a steady state of 0ppmv.

Barometric pressure ranged from a low of 997mBars during the 1st monitoring round to a high of 1024mBars attained during the 2nd monitoring round.

The recorded concentrations of methane and carbon dioxide have been used to calculate a Gas Screening Value (GSV) for the gassing regime at this site. This value has been subsequently compared against CIRIA values supplied within CIRIA Document C665 *Assessing risks posed by hazardous ground gases to buildings* (2007) using Situation B for carbon dioxide and methane.

The values used represent the worst case CO₂ and CH₄ concentrations across all installations.

The observed flow rate of -11.6l/hr is believed to be a result of the shallow groundwater creating a negative pressure in the borehole; therefore, this is not deemed representative of the natural conditions and is discounted from the GSV calculation.

The maximum flow rate was 2.9l/hr taken during the 3rd monitoring round.

The GSV is calculated as:

(Worst case CO₂ and CH₄ concentration / 100) x worst case flow rate = GSV

Peak Flow Rate (l/hr)	Worst Case CO ₂	CO ₂ GSV	Worst Case CH ₄	CH ₄ GSV
2.9	4.0l/hr CO ₂	0.116l/hr CO ₂	0.4l/hr CH ₄	0.012l/hr CH ₄

Table 7: Calculated GSV's

This GSV is a conservative estimate based on the maximum concentrations and flow rate.

This approach has been taken at this stage based upon the three monitoring visits that have been undertaken.

Based on the maximum calculated GSV of 0.116l/hr, the site falls within the threshold given by CIRIA C665 for Situation B. Consequently, gas protection measures appropriate to Characteristic Situation 2 should be considered, in which the site would be characterised by BS8485:2019 for a Type A building and as 'low risk'. Gas/vapour protection measures are considered necessary to be incorporated into the proposed development and are included below:

Two levels of protection are considered necessary in accordance with BS8485:2019 to achieve 3.5 gas protection points which should be selected from:

- A structural barrier (e.g. floor slab);
- Underfloor venting, e.g. passive sub floor dispersal layer with "very good" performance as described in BS8485; and

- c) A gas, hydrocarbon and VOC resistant membrane installed in accordance with manufacturers recommendations, with all joints and penetrations sealed, and installation independently verified.

Note: All joints and penetrations must be sealed. The membrane used should be vapour resistant as well as gas resistant.

The full monitoring sheets can be viewed in [Appendix F](#).

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.

All of the selected soil samples from the SI which were submitted for the range of inorganic and organic analyses have returned concentrations below the available SGVs and LQM guidance values for each determinant which were adopted as Generic Assessment Criteria (GAC) within YE's risk assessment for the site.

However, it should be noted that a risk from ground gas has been identified, this is discussed in section 10.5.

10.2 Risks to Controlled Waters

A low risk has been assessed based on the lack of exceedances from the water samples analysed when compared to UK Drinking Water Standards (DWS).

10.3 Risks to Plants and Wildlife

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

10.4 Risks to Site Workers

Despite the absence of 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 toolbox 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.

10.5 Risks to Proposed Structures

Based on the maximum calculated GSV of 0.116l/hr, the site falls within the threshold given by CIRIA C665 for Situation B. Consequently, gas protection measures appropriate to Characteristic Situation 2 should be considered, in which the site would be characterised by BS8485:2019 for a Type A building and as 'low risk'. Gas/vapour protection measures are considered necessary to be incorporated into the proposed development and are included below:

Two levels of protection are considered necessary in accordance with BS8485:2019 to achieve 3.5 gas protection points which should be selected from:

- a) A structural barrier (e.g. floor slab);
- b) Underfloor venting, e.g. passive sub floor dispersal layer with "very good" performance as described in BS8485; and
- c) A gas, hydrocarbon and VOC resistant membrane installed in accordance with manufacturers recommendations, with all joints and penetrations sealed, and installation independently verified.

Note: All joints and penetrations must be sealed. The membrane used should be vapour resistant as well as gas resistant.

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 without 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, OCPs and OPPS.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Unlikely	Low ●	A low risk has been assessed based on the lack of exceedances returned from the laboratory analysis and the lack of areas of soft landscaping in the proposed development.
		Construction Workers	Medium	Unlikely	Low ●	Construction workers are likely to come into direct contact with soils during groundworks. Despite the lack of exceedances, 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	Unlikely	Very Low ●●	A low risk is assessed given the lack of exceedances returned from the water samples analysed.
	Permeation of plastic water pipes	Construction materials, future end users and site visitors	Medium	Unlikely	Low ●	There were no exceedances for any of contaminants tested in the laboratory analysis, so the risk posed to the permeation of the pipes is low. However, 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	N/A	N/A	Negligible	. A negligible risk rating has been assessed due to the lack of significant concentrations found during laboratory testing and the lack of proposed soft landscaping.
On Site: Asbestos at/near ground surface in made ground soils.	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.
		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: Ground 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.	Severe	Low Likelihood	Moderate ●	A moderate risk is assessed based on the calculated GSV of 0.116l/hr; therefore, gas protection measures are deemed necessary for the site.
Off Site: Limited off site development.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Mild	Unlikely	Low ●	A low risk has been assessed based on the lack of exceedances from the groundwater samples analysed.
	Inhalation of vapours	Future end users and site visitors	Medium	Low Likelihood	Low ●	A low risk has been assessed based on the lack of volatile compounds detected and the results of the ground gas monitoring.
Off Site: Ground 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.	Severe	Low Likelihood	Moderate ●	A moderate risk has been assessed based on the calculated GSV of 0.116l/hr; therefore, gas protection measures are deemed necessary for the site.

Table 8: Updated Conceptual Site Model and Risk Assessment

12.0 Recommendations

The following recommendations are based on the results of chemical laboratory testing to date, and do not constitute a formal remediation strategy and/or validation report. A remediation strategy (Phase 3: Remediation Method Statement) should be agreed with the relevant local authority prior to such works commencing and/or the production of a validation report.

12.2 Ground Gas

Based on the maximum calculated GSV of 0.116l/hr, the site falls within the threshold given by CIRIA C665 for Situation B. Consequently, gas protection measures appropriate to Characteristic Situation 2 should be considered, in which the site would be characterised by BS8485:2019 for a Type A building and as 'low risk'. Gas/vapour protection measures are considered necessary to be incorporated into the proposed development and are included below:

Two levels of protection are considered necessary in accordance with BS8485:2019 to achieve 3.5 gas protection points which should be selected from:

- a) A structural barrier (e.g. floor slab);
- b) Underfloor venting, e.g. passive sub floor dispersal layer with "very good" performance as described in BS8485; and
- c) A gas, hydrocarbon and VOC resistant membrane installed in accordance with manufacturers recommendations, with all joints and penetrations sealed, and installation independently verified.

Note: All joints and penetrations must be sealed. The membrane used should be vapour resistant as well as gas resistant.

12.1 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; and
- 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 Contaminated Land Officer (CLO). However, this is considered unlikely at this particular site.

12.2 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.

12.3 Services

If new services are to 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.

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.

12.4 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.

12.5 Installed Boreholes

The boreholes which have been installed may be required to be decommissioned in accordance with the EA guidance document '*Decommissioning Redundant Boreholes and Wells*'.

This should be undertaken once appropriate consultation has been concluded within the relevant consultees.

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.

12.9 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.