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Clive Road, Canton
Proposed Residential Development
Supplementary Geo-Environmental & Geotechnical Report

Report Reference: ESP.8711.4040 Rev3

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Clive Road, Canton
Proposed Residential Development
Supplementary Geo-Environmental & Geotechnical Report

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Report Reference: **ESP.8711.4040 Rev2**

Revision	Status	Date	Written by	Checked by	Approved by
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Contents

Executive Summary

The Client is considering the redevelopment of the subject site. ESP have undertaken a supplementary geo-environmental assessment, comprising review of previous investigation work, a supplementary intrusive investigation, laboratory testing and assessment of data.

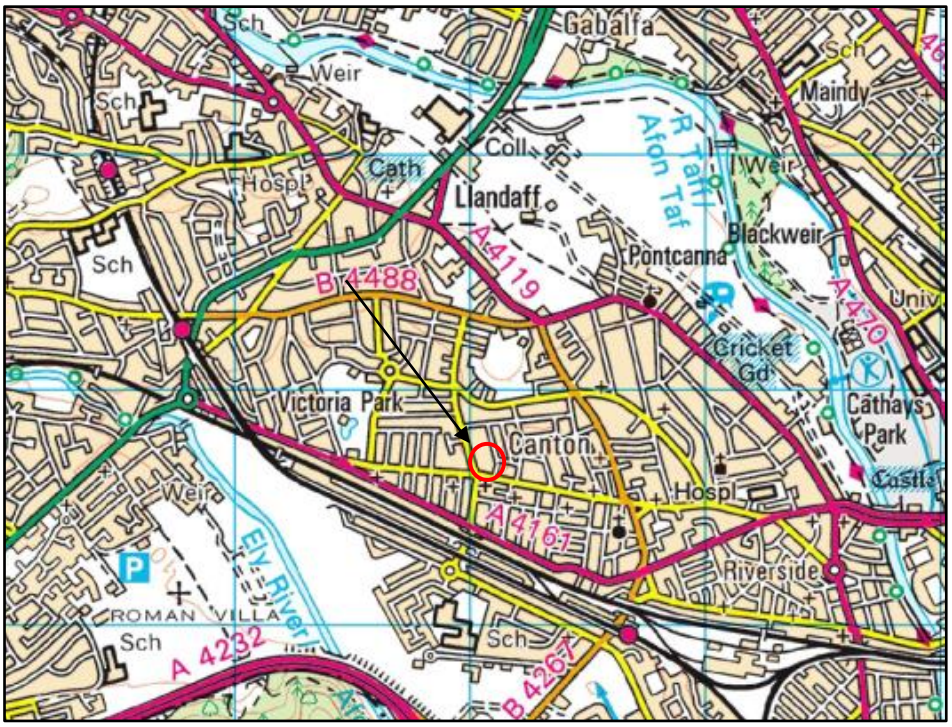
	Potential Hazard	Anticipated Risk	Discussion
Site Setting	*Current Site Status.*	-	*The site is currently vacant with previous commercial buildings having been demolished.*
	Identified Ground Conditions.	-	*The investigation has indicated cover of Made Ground overlying Glaciofluvial Sheet Deposits.*
	Groundwater Conditions.	-	*No groundwater identified during the investigation. We anticipate groundwater is within the superficial strata.*
	Historical Land Use.	-	*The site exists in a historically residential area.*
Geo-environmental	*Potential Contamination Sources*	*Low*	*No significant contamination sources identified.*
	Chronic Risks to Human Health	*Moderate*	*Occasional exceedances observed, some remedial measures required.*
	Risks to Controlled Waters	*Low*	*Site lies on a Secondary A Aquifer. No contamination identified during the investigation – low level of risk to control waters identified.*
	Hazardous Ground Gas	*Moderate*	*Gas monitoring to be undertaken and contemporary radon report obtained. .*
	Other Hazards	*High*	*Asbestos containing materials identified on site in the form of chrysotile cement sheet.*
Geotechnical	*Foundations*	*Moderate*	*Traditional foundations likely to be suitable subject to placement in coarse Glaciofluvial Deposits. May require deepening where weaker fine (clay) deposits are identified. Impact of existing drainage routes to be considered.*
	Floor Slabs	*Moderate*	*Floor slabs to be suspended and will need to take into account ground gas protection measures.*
Others	*UXO*	*Low*	*Preliminary assessment advises no further measures are considered necessary.*
	Flooding	*Low*	*A portion of the site is indicated to be at risk from flooding from reservoirs (very low). Flooding requirements to be confirmed with local authority.*
	Services	*Moderate*	*A number of services are present within or immediately adjacent to the site boundary and will require consideration as part of final design.*
	Recommendations	*Yes*	*See Section 8.0.*

Note: The above is intended to provide a brief summary of the conclusions of the assessment. It does not provide a definitive assessment and must not be referenced as a separate document. Refer to the main body of the report for details.

1 Introduction

1.1 Background

Oakleigh Developments (hereafter known as the Client) are proposing to redevelop the subject site for residential purposes. The Earth Science Partnership Ltd (ESP), Consulting Engineers, Geologists and Environmental Scientists, were instructed by Varco Consultants Ltd., acting on behalf of the Client, to undertake a supplementary geo-environmental investigation and assessment to further identify and evaluate potential ground hazards which could impact on the proposed development. The site location is shown on Insert 1.



Insert 1 - Site Location Plan from Ordnance Survey 1:25,000 scale map.
Reproduced with permission (OS License No.: AL100015788).

1.2 Objective and Scope of Works

The objective of the investigation was to obtain information on the character and properties of the ground beneath the site, potential risks posed by contamination and ground gas, and to allow an assessment of these ground conditions with particular reference to the potential impact on the proposed development.

We have been provided with planning drawings for the site, with the outline scheme design, presented as Insert 2. We understand that the development is to comprise a traditional residential development with external areas of hardstanding and landscaping.

Insert 2: Proposed Layout (Provided by Client)

ESP have previously undertaken an Exploratory Investigation which has been reported separately as the following:

- ESP 6503b.2908 July 2017 – Exploratory Geoenvironmental Investigation.

The contract was awarded on the basis of a competitive tender quotation. The terms of reference for the assessment are as laid down in the Earth Science Partnership proposal (ref: db/ESP.8711.lt1).

This supplementary assessment focuses on the following items only, which were communicated in provision of our scoping/project costing:

- Assessment of ground conditions beneath former building footprint (see blue boundary on Insert 2).
- Further contamination assessment below former footprint and reassessment of whole site in line with current guidelines.
- Dependant on the above, provision of remedial advice.
- Review of previous foundation and floor slab recommendations.

1.3 Report Format

This report includes an assessment of the potential geo-environmental hazards that may be present within the subject site or surrounding area in Section 2.0. An assessment of the potential for hazardous substances (contamination) or conditions to exist on, at or near the site at levels or in a situation likely to warrant mitigation or consideration appropriate to the proposed end use has been undertaken and is discussed in Section 3.0.

1.4 Limitations of Report

This report represents the findings of the brief relating to the proposed end use as detailed in Section 1.1 above. The brief did not require an assessment of the implications for any other end use or structures, nor is the report a comprehensive site characterisation and should not be construed as such. It should be appreciated that no intrusive investigation has been undertaken to date. Should an alternative end use or structure be considered, the findings of the assessment should be re-examined relating to the new proposals.

Where preventative, ameliorative or remediation works are required, professional judgement will be used to make recommendations that satisfy the site-specific requirements in accordance with good practice guidance.

Consultation with regulatory authorities will be required with respect to proposed works as there may be overriding regional or policy requirements which demand additional work to be undertaken. It should be noted that both regulations and their interpretation by statutory authorities are continually changing.

This report represents the findings and opinions of experienced geo-environmental and geotechnical specialists. Earth Science Partnership does not provide legal advice and the advice of lawyers may also be required.

2 Desk Study and Field Reconnaissance Visit

2.1 Site Location and Description

The site is located at the former 12 Clive Road, on the eastern side of Clive Road, approximately 50m from the junction with Cowbridge Road East, in the western area of Canton, Cardiff. The National Grid Reference of the centre of the site is (ST) 316004 176716 and the postcode is CF5 1JH.

Buildings and external areas that previously occupied the site, have been removed since our prior phase of works, with the site now vacant.

Services plans (see Appendix G) and visual observations have identified the presence of the following service on or adjacent to the site:

- Gas mains and BT cabling adjacent to (externally) the boundary.
- Water and sewerage adjacent to (externally) the west boundary in Clive Road.
- Sewerage/drainage within the site boundary trending north east – south west. Plans indicate this drainage connects neighbouring properties.

Insert 3 below, shows the general appearance of the site as viewed from the east boundary. The location of manholes (circled red) and asbestos containing materials (ACMs - see Section 4.0) are indicated. It should be noted, further manholes are present out of view.

Insert 3: View of current site conditions (ESP 2023)

2.2 Site History

The site history has been assessed from a review of available historical Ordnance Survey County Series and National Grid maps. Extracts from the historical maps are presented in Appendix F and the salient features since the First Edition of the County Series maps are summarised in Table 1 below.

Table 1: Review of Historical Maps

Date	On-Site	In Vicinity of Site
1880-1882	Site lies in residential area of Canton. Site encompasses several buildings comprising a main residential structure with two small buildings, front and rear gardens. Side access alley is present. A number of trees indicated in rear garden.	Site lies on Clive Road, Canton, junction with Romily Road lies approximately 300m to the north. Junction with Ely Road 50m to the south. Great Western Railway line (South Wales Division) indicated 300m to the south west. River Ely lies 800m to the south west. Cardiff Water Works and associated reservoir indicated 600m to the north. Ely Paper Mills indicated 900m to the east. Cornmill indicated 580m to the south east. Nursery and associated planting indicated 200m to the west. Cattle market and slaughterhouse indicated 300m to the east. Malthouse indicated 150m to the east. Wells indicated 60m to the north and 125m to the south. Pump indicated 50m to east.
1899 - 1901	No significant changes indicated.	Extension of residential developments evident, particularly to the north east of the site. Southern railway line now indicated as Penarth Harbour & Dock Railway. Electricity works indicated 1km to south east. Sanitorium indicated 700m to south west. Canton Brick Works indicated 700m to west. Amenity spaces such as Victoria Park 500m to the north west and Sir David's Field 400m to the north indicated. Ely Road now widened and renamed Cowbridge Road.
1915	No significant changes indicated.	Further residential developments indicated to the north and west. No further significant changes indicated.
1920-1922	No significant changes indicated.	No significant changes indicated.
1938-1940	No significant changes indicated.	Significant residential development >750m to the north west – Llandaff and Fairwater.
1947	No significant changes indicated.	Ely River to south west diverted and straightened, embankments indicated on either side of new river path.
1952-1954	No significant changes indicated.	Garage indicated 120m to south east. Electricity substation indicated 170m to the south. Soft Drinks Factory indicated 200m to the south.
1963-1965	Building is indicated as No 12.	Factories indicated along Sanitorium Road 450m to south west. The Lansdowne Hospital indicated 650m to south west on previous site of Sanitorium.
1973	No significant changes indicated.	Works indicated 750m to south west.
1984-1988	Building extended to span front of the site (indicated in 1985).	A4232 indicated >1km to south west (construction completed 1978).
1988-2014	No significant changes indicated.	No significant changes indicated.
Present Day	Buildings previously present on site are no longer indicated having been demolished.	No significant changes indicated.

2.3 Geology

The published 1:10,560 scale geological map for the area of the site (Sheet ST17NE) indicates the site to be underlain by Fluvioglacial Terrace Deposits (undifferentiated) overlying bedrock of the Mercia Mudstone Group.

The sheet indicates the superficial strata to comprise orange-brown sand, in part clayey, pebble cobble gravel with silt and fine sand, overlying the gravels.

The published 1:50,000 scale geological map for the area of the site (Sheet 263, available on the website of the British Geological Survey, 2024) indicates a similar succession.

Reference to the up-to-date mapping available on the website of the British Geological Survey (BGS, 2024) also indicates a similar succession but the superficial deposits have been renamed Glaciofluvial Sheet Deposits.

2.4 Hydrogeology

Reference to the aquifer maps published on the environmental data report indicates that the superficial deposits beneath the site (Glaciofluvial Sheet Deposits) are classed as Secondary A Aquifer, whilst the bedrock (Mercia Mudstone Group) is classed as Secondary B.

Secondary A Aquifers generally correspond with the previously classified minor aquifers and comprise permeable layers capable of supporting water at a local, rather than strategic, scale and in some cases form an important base flow to rivers. Secondary A Aquifers are sensitive to pollution.

Secondary B Aquifers generally correspond with the previously classified water bearing parts of non-aquifers and comprise strata of generally lower permeability, but which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. In some circumstances, Secondary B Aquifers can be sensitive to pollution.

3 Preliminary Geo-Environmental Risk Assessment

3.1 Phase One Conceptual Site Model

Following completion of our exploratory investigation we provided a summary of plausible pollutant linkages. Pertinent elements and those discussed further in this report are re-presented in Table 2 overleaf.

3.2 Preliminary Risk Evaluation & Plausible Pollutant Linkages

The land use history of the site and surrounding area, as established from the desk study and walkover, has identified a number of potential contamination linkages due to ground conditions or former operations either on, adjacent to, or in the vicinity of the site. Note that these potential linkages will need to be later assessed and re-established using actual site data obtained from an exploratory investigation.

3.2.1 Introduction to Risk Evaluation Methodology

The general methodology set out in CIRIA C552 *Contaminated Land Risk Assessment – A Guide to Good Practice* (Rudland et al, 2001), has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

Whilst at a later stage, this methodology may be informed by quantitative data (such as laboratory test results) the assessment is a qualitative method of interpreting findings to date and evaluating risk. The methodology requires the classification of:

- The magnitude of the potential consequence (severity) of risk occurring (Table A1 in Appendix A):
- The magnitude of the probability (likelihood) of risk occurring (Table A2 in Appendix A).

The classifications defined above are then compared to indicate the risk presented by each pollutant linkage, allowing evaluation of a risk category (Tables A3 and A4 in Appendix A). These tables have been revised slightly by ESP from those presented in CIRIA C552, to allow for the circumstances where no plausible linkage has been identified and, therefore, no risk would exist.

The methodology described above has been used to establish Plausible Pollutant Linkages (PPL) based on the Conceptual Site Model generated for the site and proposed development, and to evaluate the risks posed by those linkages, using information known about the site.

3.2.2 Tabulated Plausible Pollutant Linkages

Table 2: Plausible Pollutant Linkages (PPL) From ESP Report 6503b.2908 – July 2017

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Unlikely	Low Risk	General low levels of contamination encountered, and no obvious evidence of asbestos recorded.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Unlikely	Very Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Principal Aquifer	Unlikely	Low Risk	
Asbestos in shallow soils	Ingestion of fibres	Demolition/ Construction Workers	Medium – potential for chronic levels	Unlikely	Low Risk	
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Unlikely	Very Low Risk	
Ground gas generated in soils	Asphyxiation/ poisoning, injury by explosion	Site Users / Visitors (residents)	Severe	Unlikely	Moderate/Low Risk	Further assessment required as part of this current phase of works.
	Damage through explosion	Buildings	Severe	Unlikely	Moderate/Low Risk	
	Asphyxiation/ poisoning, injury by explosion	Construction/ Maintenance Workers	Severe	Unlikely	Moderate/Low Risk	
Radon Gas	Migrating into Buildings	Site Users (residents)	Medium – potential for chronic levels	Unlikely	Low Risk	Low risk based on previous assessment and confirmed with an up to date Radon report (see Appendix J).

Notes:
1. Plausible pollutant linkages taken from ESP Report 6503b.2908 – July 2017

4 Supplementary Exploratory Investigation

4.1 Investigation Points

4.1.1 Introduction

The intrusive investigation was undertaken between the 12th and 13th December 2023 in accordance with BS5930:2015 and BS10175:2017. It comprised supplementary trial pits and windowless samples boreholes.

4.1.2 Investigation Strategy

The works were implemented in order to confirm ground conditions previously identified at the site and also undertake supplementary investigations in areas previously occupied by the former building(s).

4.1.3 Trial Pits

Four supplementary trial pits (TP101 to TP104) were excavated across the site on the 12th of December 2023 using a wheeled, backacting excavator. The trial pits were excavated to a maximum depth of 3.0m. The trial pit records are presented as Appendix C.

Disturbed samples were collected from the trial pits for laboratory testing. On completion, the trial pits were backfilled with arisings in layers compacted with the excavator bucket. The arisings were left slightly proud of the adjacent surface to allow for future settlement.

4.1.4 Windowless Sampling

5no. windowless sample drillholes (WS01 to WS05) were constructed on the 13th of December 2023 to depths between 2.2m and 3.0m. The borehole records are presented as Appendix D, and their positions are shown on Figure 1.

A hydraulically powered rig was used to drive plastic lined sampling tubes into the ground, with the soil recovered within the tubes, which are then split to allow sampling and logging. Disturbed samples were obtained throughout the boreholes for identification and laboratory testing purposes, as shown on the borehole records. The windowless sampling provided generally good recovery to the depth of refusal. At the commencement of borehole and a service inspection pit excavated by hand to a depth of 1.2m.

Whilst no geotechnical assessment was required, Standard Penetration Tests (SPT) were carried out using a split spoon in the boreholes in accordance with BS EN ISO 22476-3 (2005) and BS5930 (2015) as is good practise during investigation.

As required in BS5930:2015, the SPT N-values shown on the borehole records are the direct, uncorrected results obtained in the field. Depending on the nature of the test undertaken and the soils subjected to testing, field SPT N-values may require correction before using in design. In accordance with BS EN ISO 22476-3 (2005), SPT N-values in sandy soils need to be corrected for a number of aspects such as overburden pressure, rod length and rod energy ratio in sands.

4.2 Sampling Strategy

A non-targeted, random sampling strategy was used to obtain representative information on soil contamination across the site as a whole. Environmental samples (denoted as ES on the exploratory holes records) were collected for possible geo-environmental laboratory testing and generally comprised a plastic tub, an amber glass jar and an amber glass vial. The sample containers provided clean by the testing laboratory appropriate for the proposed testing to be scheduled. Immediately after collection the samples were placed in sealed cool boxes with ice packs where they remained during storage and transport to the laboratory.

4.3 Evidence of Site Hazards Found During Site Works

No direct visual/olfactory evidence of extraordinary contamination was identified in the exploratory holes. However, Made Ground was present across the site and identified in thicknesses up to between 0.5m and 1.0m.

The potential for asbestos containing materials (reinforced concrete sheeting) has been identified in the south east portion (see Insert 3).

4.4 Geo-environmental Laboratory Testing

The geo-environmental analyses were carried out by a UKAS accredited testing laboratory with detection limits being generally compatible with the relevant guideline values adopted in the assessment. To allow an assessment of the potential chronic risks posed to human health, supplementary samples of near surface soils have been analysed. The general suite of geo-environmental laboratory testing undertaken comprised:

- Arsenic, barium, beryllium, boron, cadmium, total chromium, chromium VI, copper, lead, mercury, nickel, selenium, vanadium, zinc;
- US EPA 16 polyaromatic hydrocarbon (PAH) compounds;
- Total monohydric phenols;
- Total cyanide,
- Asbestos qualitative screen (presence or absence);
- Soil organic content, pH value.

The geo-environmental soil test results are presented in Appendix E.

5 Development of the Revised Conceptual Model

5.1 Conceptual Ground Model - Geology

The exploratory holes have identified the site to be generally underlain by Made Ground overlying possible Marine Beach Deposits and The Oxwich Head Limestone Formation. These strata are discussed in more detail in the following sections.

Made Ground (General): encountered to depths between 0.5m and 1.0m over both phases of works as a black to brown, sandy, gravelly clay with frequent man-made fragments noted.

Glaciofluvial Sheet Deposits: encountered in all exploratory holes to a maximum depth of 2.9m as an orange-brown sandy clay becoming a slightly clayey cobbly sand and gravel. Occasional organic material has been noted.

Previous assessment at the site has indicated particle size analyses within the coarse-grained glacial soils to comprise between 6 and 58% gravel, predominantly coarse, between 6 and 21% sand and between 9 to 36% cobbles. Based on our observations on site, these proportions would appear representative of the in-situ soils

Mercia Mudstone Bedrock: Not encountered in the investigation. Bedrock is anticipated to be present at depths of around 10m, comprising medium strength red brown mudstone.

5.2 Chronic Risks to Human Health – Generic Assessment of Risks

5.2.1 Assessment Methodology

The long-term risks to health have been assessed using methodologies and frameworks determined by the Environment Agency within documents SR2, SR3, SR4 and the CLEA Technical Review published to support the Contaminated Land Exposure Assessment Model (CLEA). Where applicable, reference has been made to the supporting toxicological reports (TOX Series) and the Soil Guideline Value reports (SGV Series). It is assumed that the reader is familiar with the above documents, and it is not intended to repeat these described methodologies in detail, for further information, please refer directly to the specific documents.

In order to provide an initial 'screen' to identify elevated levels of contaminants, a Generic Quantitative Risk Assessment (GQRA) has been undertaken using the most appropriate Generic Assessment Criteria (GAC) determined by assessment of exposure frequency/duration relevant to the critical receptor.

5.2.2 Assessment Criteria

In 2013, CL: AIRE published the Category 4 Screening Levels (C4SL – CL:AIRE, 2013) for use in Part 2A determinations. The C4SL are designed to be more pragmatic, but still strongly precautionary, assessment criteria compared to the previous assessment criteria (SGV – see below) used to assess chronic human health risks. The C4SL have been calculated for a limited number of contaminants at this stage, and range of land uses including residential, commercial and public open space, but are based on a 'low level' of risk rather than the 'minimal level' of risk adopted by the Environment Agency in preparing their Soil Guideline Values (SGV). The C4SL have also only been published for a limited number of contaminants commonly identified in

contaminated land risk assessments at present (arsenic, cadmium, chromium VI, lead, benzene, benzo[a]pyrene). However, the C4SL have been published for a range of land uses, including residential, commercial, allotments and two types of public open space.

The C4SL are designed for use in deciding whether land is suitable for use and definitely not contaminated, and DEFRA and the Welsh Government have recommended that they be used in assessing human health risks during the planning regime (i.e., as part of standard development investigations). The Welsh Local Government Association and Natural Resources Wales (WLGA/NRW) have confirmed that, '*where the site conditions are applicable to the land use scenarios adopted in their calculation, the C4SL levels can be used as screening tools*' for development site risk assessments (WLGA/NRW, 2017). The C4SL have also been accepted by the NHBC for use as generic screening levels on residential developments in England and Wales (NHBC, 2014). Given this, where available and applicable, the C4SL have been adopted as the Generic Assessment Criteria in this assessment.

Where no C4SL is currently available, the Suitable For Use Levels (S4ULs) published in January 2015 by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM) (Nathanail et al, 2015) have been adopted. These assessment criteria adopt updated toxicological data and exposure models, and the same 'minimal level' of risk as the SGV (i.e., unlike the C4SL). The S4ULs have been published for a large number of contaminants typically found on brownfield sites in the UK, and for the same range of land uses as the C4SL, i.e., including public open space scenarios.

Where no C4SL or S4UL is available, the Soil Guideline Values (SGV) published by the Environment Agency have been adopted as the Generic Assessment Criteria (GAC) – note several SGV have been withdrawn since originally published. However, the SGV are only available for a limited number of contaminants for three proposed land uses (residential, commercial and allotments – and not public open space).

For more exotic, predominantly organic, compounds no SGV, S4UL or C4SL assessment criteria have been published. In this instance, GAC published by CL: AIRE and the Environmental Industries Commission (CL:AIRE/EIC, 2010) have been adopted. These GAC have also been developed using the CLEA UK software based on a 'minimal level' of risk and for the same land use scenarios as the SGVs (i.e., not public open space).

Details of the Generic Assessment Criteria (GAC) adopted for each contaminant are presented on the assessment tables in the following section.

The proposed development comprises conventional residential properties with private gardens. Therefore, the GAC appropriate for the residential land use with plant uptake have been adopted in this assessment.

5.2.3 Generic Quantitative Risk Assessment (2017 and 2024)

At this stage, all samples have been considered across the site as one averaging area. If any exceedances are identified, a statistical analysis based on particular averaging areas may be undertaken to further assess the risks. The risks from asbestos are considered further in Section 5.3.4. The results of the Generic Quantitative Risk Assessment for the proposed development are presented in Table 3. below. It should be appreciated that if the development were to change, the following assessment should be reviewed and, if necessary, updated.

Table 3: Generic Assessment of Human Health Risks (2017 & 2024)

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	6.5 - 38 mg/kg	37mg/kg	C4SL[2]	1 of 11 (2024)
Beryllium	0.7 – 1.2 mg/kg	1.7mg/kg	S4UL[4]	None of 11
Boron	< 0.2 – 1.4 mg/kg	290mg/kg	S4UL[4]	None of 11
Cadmium	0.3 – 4.3 mg/kg	26mg/kg	C4SL[2]	None of 11
Chromium (total)[7]	18 - 100 mg/kg	910mg/kg	S4UL[4]	None of 11
Chromium (hexavalent)	< 1 mg/kg	21mg/kg	C4SL[2]	None of 11
Copper	12 - 310 mg/kg	2,400mg/kg	S4UL[4]	None of 11
Lead	120 - 2800 mg/kg	200mg/kg	C4SL[2]	3 of 11 (2017 & 2024)
Mercury[8]	0.06 - 0.75 mg/kg	40mg/kg	S4UL[4]	None of 11
Nickel	13 - 120 mg/kg	130mg/kg	S4UL[4]	None of 11
Selenium	< 0.5 - 1 mg/kg	250mg/kg	S4UL[4]	None of 11
Vanadium	17 - 43 mg/kg	410mg/kg	S4UL[4]	None of 11
Zinc	53 - 1300 mg/kg	3,700mg/kg	S4UL[4]	None of 11
Polyaromatic Hydrocarbons (PAH)				
Acenaphthene	< 0.03 mg/kg	210mg/kg	S4UL[4,9]	None of 11
Acenaphthylene	< 0.03 mg/kg	170mg/kg	S4UL[4,9]	None of 11
Anthracene	< 0.03 mg/kg	2,400mg/kg	S4UL[4,9]	None of 11
Benzo(a)anthracene	< 0.03 - 0.17 mg/kg	7.2mg/kg	S4UL[4,9]	None of 11
Benzo(a)pyrene	< 0.03 - 0.14 mg/kg	5mg/kg	C4SL[2,9]	None of 11
Benzo(b)fluoranthene	< 0.03 - 0.25 mg/kg	2.6mg/kg	S4UL[4,9]	None of 11
Benzo(ghi)perylene	< 0.03 - 0.09 mg/kg	320mg/kg	S4UL[4,9]	None of 11
Benzo(k)fluoranthene	< 0.03 - 0.08 mg/kg	77mg/kg	S4UL[4,9]	None of 11
Chrysene	< 0.03 - 0.22 mg/kg	15mg/kg	S4UL[4,9]	None of 11
Dibenzo(a,h)anthracene	< 0.03 - 0.04 mg/kg	0.24mg/kg	S4UL[4,9]	None of 11
Fluoranthene	0.05 - 0.46 mg/kg	280mg/kg	S4UL4,9	None of 11
Fluorene	< 0.03 mg/kg	170mg/kg	S4UL4,9	None of 11
Indeno(123-cd)pyrene	< 0.03 - 0.09 mg/kg	27mg/kg	S4UL4,9	None of 11
Naphthalene	< 0.03 mg/kg	2.3mg/kg	S4UL[4,9]	None of 11
Phenanthrene	< 0.03 - 0.2 mg/kg	95mg/kg	S4UL[4,9]	None of 11
Pyrene	0.04 - 0.41 mg/kg	620mg/kg	S4UL[4,9]	None of 11
Other Organic Compounds				
Phenol	<0.3-1.4mg/kg	280mg/kg	S4UL[4,9]	None of 11

Notes:

1. Assessment for residential land use with home-grown produce uptake (apart from barium – see Note 6 below).
2. C4SL: Category 4 Screening Level, published by CL:AIRE.
3. SGV: Soil Guideline Value published by Environment Agency.
4. S4ULs Suitable 4 Use Levels. Copyright Land Quality Management Limited, reproduced with permission; Publication No. S4UL3156. All Rights Reserved.
5. CL:AIRE/EIC GAC published by CL:AIRE and Environment Industries Commission.
6. GAC for barium for residential use without plant uptake. No GAC published for plant uptake risk drivers.
7. In the absence of Chromium VI, all chromium present likely to be Chromium III. GAC for Chromium III adopted.
8. GAC for inorganic mercury adopted.
9. GAC for organic compounds based on 1% soil organic content.
10. GAC for xylene based on p-xylene (lowest S4UL).

The majority of determinands are below their respective guideline values, however the following exceedances were noted, both in the sample taken from WS05 – 0.3-0.45m):

- Arsenic - within 1no. of 11no. samples, concentrations of between 6.5mg/kg to 38mg/kg with an mean value of 15mg/kg against a guideline value of 37mg/kg. Recorded in WS05, 0.3-0.45m.

- Lead - within 3no. of 11no. samples, concentrations of between 120mg/kg to 2800mg/kg with an mean value of 444mg/kg against a guideline value of 200mg/kg. Recorded in WS05, 0.3-0.45m and in 2no. samples from 2017 investigation.

Whilst they do not exceed guideline values, the higher concentrations of other determinands were also record in sample WS05, 0.3-0.45m.

5.2.4 Asbestos

Of the 11no. samples tested between the two phases of work undertaken in 2017 and 2023, no evidence of asbestos was identified in laboratory samples

It should be noted that a sheet of potentially asbestos containing materials was encountered in the south east corner of the site. A sample of this material was collected and tested at the laboratory. The testing has identified the material as chrysotile asbestos cement.

5.3 Ground Gas

5.3.1 Degradation of Organic Materials

Due to the previous development history of the site, Made Ground encountered across the site and organic material identified in Glacial soils, recommendations for ground gas monitoring have been made to the Client under separate cover and have recently been instructed.

The findings of this ground gas assessment will be reported separately once complete, however, review of the first three visits, indicates no methane and carbon dioxide up to 1%. Whilst formal recommendations will be provided on completion of gas monitoring, based on the ground conditions encountered and presence of evidence of ground gas, some ground gas protection measures are likely to be required.

5.3.2 Radon

During the 2017 investigation, available information suggested a low risk from radon, however, since this time the radon classification of the UK has been updated.

A contemporary radon report has been obtained which confirms the low risk (see Appendix K).

5.4 Sulphate Attack

The assessment of the concrete protection against sulphate attack has been undertaken in accordance with BRE SD1 (2005).

5.4.1 Classification of Site

Due to the presence of up to 1m of Made Ground comprising on the site, we consider that it should be considered as ‘brownfield’ in terms of concrete classification. For the purpose of this assessment the Made Ground and Glacial Deposits have been assessed together.

5.4.2 Groundwater Setting

No groundwater was encountered in the exploratory holes to a depth of 3m. However, no long term monitoring (in excess of 24 hours) of groundwater levels has been undertaken at present and is underway as part of extended monitoring. Therefore, in accordance with the BRE guidelines, we recommend that groundwater be considered as 'mobile' in terms of foundation concrete assessment.

5.4.3 Sulphate Levels

Laboratory test results indicate pH to be between 7.5 – 9.2, the levels of water soluble sulphate (as SO4) to be between 12 and 33mg/l. As levels of water soluble sulphate are less than 3,000mg/l, there is no need to consider the levels of magnesium present in the soils. Levels of acid soluble sulphate varied between 0.01 and 0.07% and total sulphur between 0.01 and 0.03%.

From these results, the calculated levels of total potential sulphate are between 0.03 and 0.09%, and oxidisable sulphides are between 0.01 and 0.03%. As the levels of oxidisable sulphide are well below 0.3%, pyrite is unlikely to be present.

5.4.4 Foundation Concrete Design

Using the above results, we consider that the following characteristic values are applicable for the shallow soils at the site (all as SO4):

Water soluble sulphate:	33mg/l;
Total potential sulphate:	0.09%
pH value:	7.5

6 Phase Two Geo-Environmental Risk Assessment

6.1 Discussion on Occurrence of Contamination and Distribution

Made Ground has been identified across the site and has been recorded to depths of between 0.5m and 1m. As standoffs were implemented around drainage runs, Made Ground has not been confirmed in these areas and may be deeper.

The majority of determinands are below their respective guideline values, however the following exceedances were noted:

- Arsenic - within 1no. of 11no. samples, concentrations of between 6.5mg/kg to 38mg/kg with an mean value of 15mg/kg against a guideline value of 37mg/kg.
- Lead - within 3no. of 11no. samples, concentrations of between 120mg/kg to 2800mg/kg with an mean value of 444mg/kg against a guideline value of 200mg/kg.

Whilst they do not exceed guideline values, the higher concentrations of other determinands were also record in the same sample where arsenic and lead are recorded in 2024 (WS05, 0.3-0.45m).

No asbestos has been encountered in samples tested, however, a sheet of potentially asbestos containing materials was encountered in the south east corner of the site. A sample of this material was collected and tested at the laboratory. The testing has identified the material as chrysotile asbestos cement.

6.2 Revised Risk Evaluation & Relevant Pollutant Linkages

As discussed in detail within Section 3.2, the methodology set out in CIRIA C552 (2001) has been used to assess whether or not risks are acceptable, and to determine the need for collating further information or remedial action.

The risks evaluated following previous assessment at the site have been updated and revised in Table 3 following information learned from the exploratory works and results of laboratory testing.

Table 3: Updated Risk Evaluation & Plausible Pollutant Linkages (PPL)

Source	Pathway	Receptor	Classification of Consequence	Classification of Probability	Risk Category	Further Investigation or Remedial Action to be Taken
Potential contaminants in shallow soils	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users (residents)	Medium – potential for chronic levels.	Unlikely[1]	Moderate/Low Risk	Elevated levels of arsenic and lead encountered in one location. Further consideration required (see Section 7.1.2).
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Unlikely[1]	Low Risk	Likely to be manged by PPE and good site practise.
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Principal Aquifer	Unlikely[1]	Low Risk	Likely low risk based on site setting and findings.
Asbestos in shallow soils	Ingestion of fibres	Demolition/ Construction Workers	Medium – potential for chronic levels	Unlikely[2]	Moderate/Low Risk	No asbestos recorded in soils but asbestos containing materials confirmed on site.
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Unlikely[3]	Low Risk	Generally low levels encountered.
Ground gas generated in soils	Asphyxiation/ poisoning, injury by explosion	Site Users / Visitors (residents)	Severe	Unlikely[4]	Moderate/Low Risk	Ground gas monitoring has been recommended and is being undertaken under separate cover.
	Damage through explosion	Buildings	Severe	Unlikely[4]	Moderate/Low Risk	
	Asphyxiation/ poisoning, injury by explosion	Construction/ Maintenance Workers	Severe	Unlikely[4]	Moderate/Low Risk	
Radon Gas	Migrating into Buildings	Site Users (residents)	Medium – potential for chronic levels	Unlikely[5]	Low Risk	Low risk advised on contemporary Radon report.

Notes:

1. Made Ground encountered across the site.
2. Asbestos not recorded in samples tested, however ACMs noted on site.
3. Require reviewing by foundation designer.
4. Ground gas monitoring recommended and underway.
5. Contemporary radon report should be obtained.

7 Remedial Strategy for Contamination Risks

The following recommendations are based on interpretations and information obtained from investigation and assessment to date. If at any stage of the construction works, contamination or a potential for such contamination is identified that is different to that presented within this report, all of the following should be reviewed, and the advice of a geo-environmental specialist sought immediately.

7.1 Risks to Health

7.1.1 Asbestos

No asbestos has been encountered in soil samples tested over two phases of work, however, a sheet of potentially asbestos containing materials was encountered in the south east corner of the site. A sample of this material was collected and tested at the laboratory. The testing has identified the material as chrysotile asbestos cement.

The asbestos containing material will need to be appropriately disposed of in line with regulatory requirements. A watching brief should be undertaken during development for any other potentially asbestos containing materials which should also be disposed of in an appropriate manner.

The following sections presume that any arising risks from asbestos materials at the site are mitigated.

7.1.2 Site End Users

Summary of Findings

A proposed residential end use has been utilised for the assessment and assume the external areas of the development will include landscaping. This has been confirmed by the Client who has provided an outline development plan which includes landscaping proposals (see Appendix J).

Made Ground has been encountered across the site and elected levels of arsenic and lead recorded in up to 3no. locations between 2017 and 20224. Whilst the mean values are below their respective guideline values, there is the potential for an increased risk to end users in this part of the site. Further consideration will be required in this area of the site.

It should be noted that during 2017 the levels of lead were not considered to pose a risk, however, guideline values have been revised in recent years and two results from 2017 from locations TP1 and TP2 (see Appendix B) do now not meet guideline criteria.

The outline development plan indicates that this area will be hard standing or bin storage. Options could comprise further detailed contamination testing in proposed external areas to further reduce the risk or due to the relatively small size of the site, once the building and parking areas are constructed, then the incorporation of an imported, clean, cover system may prove to be a cost effective solution to mitigate risk.

Outline Remedial Strategy

The remedial strategy should comprise imported clean fill, or a clean soil cover system (600mm), with a geotextile separator membrane required. Site levels would need to be accommodate the cover system.

Imported fill materials or soils would require assessment and verification prior to import to ensure that they are suitable for use, and this would be applicable (but not limited to) the following materials:

- Sand.
- Aggregates.
- Imported recycled hardcore.
- Stone chippings/decorative gravel.
- Top soil.
- Sub soil.

Some of the above, if sourced from natural, certified sources, such as quarries, may not need testing prior to import and further advice on this can be given once finalised.

Other Considerations

The remedial strategy/implementation will require consideration of the following items as/when required:

- Acceptance of remedial strategy by Planning Authority.
- Notifying the Planning Authority remedial works are taking place (in line with planning conditions).
- Testing of imported materials prior to transport to site.
- Viewing of placement, and post placement testing.
- Production of final validation report for submission to Planning Authority.

7.1.3 New Service Connections

The current water industry guidance for the suitability of pipe materials on potentially contaminated sites (Blackmore et al, 2010) has onerous requirements and it is likely/possible, based on this guidance, that the levels of contaminants on site may prevent the use of plastic pipework. We recommend that enquiries are made to the local water authority to confirm their requirements for underground service materials for this development.

7.1.4 Risk to Construction and Maintenance Workers

Short term (acute) risks to construction and maintenance workers are generally poorly understood within the industry, certainly when compared to the volume of research undertaken on long term risks. However, we anticipate that the levels of contamination at the site are not likely to pose a severe acute risk to construction workers or future maintenance workers. Ground workers would need to undertake their own assessment of the risks to their workers.

Notwithstanding the above, we recommend that construction workers adopt careful handling of the potential contaminants and good standards of personal hygiene should be adopted to reduce the risk of possible ingestion and skin contact should any hotspots be encountered. The contractor should comply with the appropriate current Health and Safety at work legislation.

7.1.5 General Public/Neighbouring Properties

We do not anticipate any significant risks to the general public from the development of the site. However, careful dust control measures should be adopted during construction to minimise the risk (and nuisance) to the general public and neighbouring residents.

7.2 Controlled Waters

No specific assessment of the risks to controlled waters has been undertaken to date. However, the following points are considered salient.

- No significant past contaminative use has been identified at the site.
- The levels of most soil contaminants are below the GAC adopted.
- The proposed development comprises a conventional residential dwelling which will include areas of car parking which are anticipated to be hard surfaced.
- Soakaways are being considered for the development.
- The site is underlain by fine and coarse grained glacial soils.
- The bedrock beneath the site is classified as a Secondary B aquifer. The glacial soils are defined as a Secondary A. Groundwater is anticipated within the superficial soils from depths of approximately 5m.
- The River Ely lies some 900m to the east at its closest point,

Given the above and site setting, we consider that the overall risk to controlled waters from the development of the site is likely to be low and no further assessment is warranted.

7.3 Ground Gas

The findings of this ground gas assessment will be reported separately once complete, however, review of the first three visits, indicates no methane and carbon dioxide up to 1%.

Whilst formal recommendations will be provided on completion of gas monitoring, based on the ground conditions encountered and presence of evidence of ground gas, some ground gas protection measures are likely to be required. Based on UK guidance, the protection measures are likely to include the use of gas resistant membrane and floor slab options.

7.4 Re-Use of Materials/Disposal of Excess Arisings

7.4.1 General Comments on Re-use/Disposal

All soils or other materials excavated from any site are generally classified as waste under the Waste Framework Directive (European Union, 2008) and their re-use is controlled by this legislation.

If the soils are to be re-used on site (e.g., within the red-line planning boundary), provided that they are 'uncontaminated' or other naturally occurring deposits and they are certain to be used for the purposes of construction in their natural state on the site from which they are excavated, they may be excluded from waste regulation (Duckworth, 2011). A Materials Management Plan (MMP) may be required – further guidance can be provided by this office once proposals have been finalised. However, if they are man-made or contaminated materials, their use on the site may be limited.

If the soils are to be removed from site, they are automatically classified as waste, and they may only be:

- Disposed at a licensed landfill;
- Disposed at a licensed, permitted soil treatment centre; or
- Removed to a Receiver Site for beneficial re-use.

In Scenarios 1 and 2, the materials must be transferred by a licensed waste carrier and the waste producer (the developer) must ensure that the destination landfill or treatment centre is a legitimate operation (e.g., by requesting a copy of the Environmental Permit before releasing the soils). Prior to removal from site, the excavated arisings would need to be classified as either 'hazardous' or 'non-hazardous' waste based on the hazard that they pose– a WM3 assessment (note that this is a different assessment to the risk assessments reported on in earlier sections of this report). This can commonly be undertaken on the results of soils testing undertaken during the investigation, although further sampling and testing may be required. Only once the soils have been classified under the WM3 assessment, would Waste Acceptability Criteria (WAC) testing then be required to determine the type of landfill in which the arisings could be disposed in Scenario 1. Further testing and assessment may also be required by the soil treatment centre in Scenario 2.

In Scenario 3, management of soils could be undertaken via an Environmental Permit or Exemption. However, these can take time and are costly to arrange. Therefore, in certain circumstances, it is permissible to use the protocols laid down in the CL: AIRE Definition of Waste, Development Industry Code of Practice (DoWCoP, Duckworth, 2011) to classify the arisings and put a management plan in place to control the use. This involves approval of the proposals by a Qualified Person and is generally more efficient (in terms of time and cost) to implement.

With regard to the soils identified on site, apart from the isolated exceedences noted, the concentrations of potential contaminants in the soil are similar for the Made Ground and near surface natural soils and would likely be considered together for excavation/disposal.

Further guidance on the legislative requirements of the re-use/disposal of materials generated by the development, including further investigation to refine soil disposal options can be provided by this office once the development proposals have been finalised.

7.4.2 Imported Materials

Any soils or materials to be imported to site (including Topsoil) should be certified clean and inert, and suitable for use. An appropriate number of samples (depending on the volume of soils imported) should be analysed for an appropriate suite of contaminants, and verification certificates should be provided. Further guidance can be provided by this office when required.

8 Geotechnical Comments

8.1 Site Preparation and Earthworks

8.1.1 Invasive Plants

No evidence of invasive plants such as Japanese Knotweed/Himalayan Balsam etc. was identified on the site during the site works.

8.1.2 Existing Foundations and Services

No evidence of old foundations and underground structures have been identified in the investigation area. If still present, the foundations of the current structure on site will require grubbing up within the zone of influence of the development as part of the site preparation works.

We understand that existing drainage is to be re-routed as part of development works and this has not been considered further, however, backfill of previous service trenches should be undertaken with clean, compacted engineering fill.

8.1.3 New Services

For new services, flexible pipework and connections should be provided as a safeguard against potential settlements. Consideration could be given to increasing the gradients on sewage connections to mitigate against possible settlements.

8.1.4 Earthworks

We have not been advised that the development requires any significant earthworks. The site is relatively flat and, therefore, no such earthworks are anticipated.

8.2 Foundation Design and Construction

We understand that the site is being considered for potential development for a three-storey structure.

Our previous report provided a preliminary foundation design which has been reviewed as part of this assessment. On the basis of the available investigation information, we consider that mass concrete spread foundations could be used at the site, placed at a minimum depth of 1.0m within the coarse Glaciofluvial Deposits.

For foundations placed in this stratum, an allowable bearing pressure of 125kPa is appropriate for initial design purposes for foundations placed in In locations where weaker, fine (clay) soils are recorded, which have also been recorded to have intermediate to high plasticity, the foundation excavations will need to be deepened into the coarse deposits.

For all spread foundation options, the formations should be cleaned, and subsequently inspected by a suitably qualified engineer prior to placing concrete. Should any soft, compressible or otherwise unsuitable materials be encountered they should be removed and replaced by lean mix concrete or suitable compacted granular material. We recommend that a blinding layer of concrete be placed on the formation after excavation and inspection in order to protect the formation against softening and disturbance.

8.3 Floor Slab Foundations

Due to the presence of over 600mm of Made Ground soils at the site, we consider that ground bearing floor slabs would not be suitable for the development, and floor slabs should be suspended. We understand that the development preference is for beam and block flooring.

It should be noted that floor slabs will also likely have to take into account gas protection measures, which if beam and block flooring is used, will need to take the form of a gas resistant membrane and vented underfloor void etc. This will be discussed further in our ground gas addendum on completion of all monitoring.

9 Recommendations

We consider that the following further investigation and assessment would be required or prudent prior to development:

Required Further Actions:

- Completion of ground gas monitoring and presentation of assessment.
- The asbestos containing material will need to be appropriately disposed of in line with regulatory requirements. A watching brief should be undertaken during development for any other potentially asbestos containing materials which should also be disposed of in an appropriate manner.
- Appropriate testing, classification and disposal of any soils to be removed as part of the development.
- Appropriate testing, classification and validation of soils to be imported to site.
- Production of validation report following implementation of remedial strategy.

Recommended Further Actions (not addressed in this report)

- Consideration of previous historic ESP report for aspects not addressed in this document.
- Obtain confirmation from Local Authority, that Flood Consequence Assessment is not required.

10 References

ALLEN D J, BREWERTON L J, COLEBY L M, GIBBS B R, LEWIS M A, MacDONALD A M, WAGSTAFF S J and WILLIAMS A T. 1997. The Physical Properties of Major Aquifers in England & Wales. BGS Technical Report WD/97/34 - EA R&D Publication 8. BGS and Environment Agency.

BRITISH GEOLOGICAL SURVEY (BGS). 2020. Website accessed January 2021.

BRITISH STANDARDS INSTITUTION (BSI). 1990. Methods of Test for Soils for Civil Engineering Purposes. BS1377, Parts 1 to 9, HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2002. Geotechnical Investigation and Testing: Identification and Classification of Soil, Part 1. Identification and Description. BS EN ISO 14688-1. HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2018. Geotechnical Investigation and Testing: Identification and Classification of Soil, Part 2. Principles for Classification. BS EN ISO 14688-2:2018. HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2004. Eurocode 7: Geotechnical Design – Part 1: General Rules. BS EN 1997-1:2004, HMSO, London. (including UK National Annex).

BRITISH STANDARDS INSTITUTION (BSI). 2007. Eurocode 7: Geotechnical Design – Part 2: Ground Investigation and Testing. BS EN 1997-2:2007, HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2011. Investigation of Potentially Contaminated Sites – Code of Practice. BS10175, HMSO, London.

BRITISH STANDARDS INSTITUTION (BSI). 2015. Code of Practice for Ground Investigation. BS5930:2015. HMSO, London.

ENVIRONMENT AGENCY (EA). 2020. Website accessed January 2021.

HEALTH & SAFETY EXECUTIVE. 1991. Protection of Workers and the General Public During the Development of Contaminated Land. HMSO, London.

STONE K, MURRAY A, COOKE S, FORAN J and GOODERHAM L. 2009. Unexploded Ordnance (UXO). A Guide for the Construction Industry. CIRIA, rpt C681.