7.0 GROUND CONDITIONS AND CONTAMINATION

INTRODUCTION

7.1 This Chapter addresses the potential impacts of the proposed development relating to ground conditions and contamination.

7.2 This Chapter presents the methodology for the assessment of the ground conditions (geology and soils) and hydrogeological features of the site. The Chapter considers the baseline ground conditions, including existing land contamination, and provides an assessment of potential impacts and effects of the proposed development. Mitigation measures that can be implemented during the design, construction or operational phases are presented and discussed.

7.3 The Chapter has been informed by the following reports prepared by Enzygo Environmental Ltd.:

- Geo-Environmental Report, October 2021 (Appendix 7.1);
- Basement Impact Assessment Scoping, Screening and Assessment (Appendix 7.2); and
- Ground Investigation, Screening and SuDS Assessment Report (Appendix 7.3).

LEGISLATION AND PLANNING POLICY CONTEXT

7.4 The following section sets out the legislation and policy that is relevant to this Chapter.

National

National Planning Policy Framework (NPPF), 2021

7.5 Paragraphs 174, 183, 184 and 185 of the National Planning Policy Framework (NPPF)[1], Department for Communities and Local Government[2], July 2021 states the following:

"170. Planning policies and decisions should contribute to and enhance the natural and local environment by:

a) protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan);

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans.

183. Planning policies and decisions should ensure that:

a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);

b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and

c) adequate site investigation information, prepared by a competent person, is available to inform these assessments.

184. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

185. Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development."

Environmental Protection Act 1990 IIa2

7.6 Part IIa of the Environmental Protection Act (EPA) 1990 (inserted by Section 57 of the Environment Act 1995) provides a regime for the control of specific threats to health or the environment from existing land contamination regarding current land use.

7.7 In accordance with the Act, the statutory guidance document, and The Contaminated Land (England) Regulations 2000, the definition of contaminated land is intended to embody the concept of risk assessment. Within the meaning of the Act, land is only "contaminated land" where it appears to the regulatory authority, by reason of substances within, on, or under the land that:

- Significant harm is being caused, or there is significant possibility of harm being caused; or;
- Significant pollution of Controlled Waters is being, or is likely to be, caused.
- The guidance defines 'risk' as the combination of:
- The probability, or frequency, of occurrence of a defined hazard (for example, exposure of a person to a substance with the potential to cause harm); and,
- The magnitude (including seriousness) of the consequences.

7.8 Part IIa of the EPA was introduced specifically to address the historical legacy of land contamination. It applies where there is unacceptable risk, based on current site use and is not intended to be applied when assessing risks in relation to a future use of the

land that would require a specific grant of planning permission. This is primarily a task for the planning system, which aims to control development and land use in the future.

ASSESSMENT METHODOLOGY

7.9 This section outlines the methodology for baseline data gathering, the assessment of effects and guidance that has been referred to.

Method of Baseline Data Gathering

7.10 The sources listed have been reviewed and used to identify the baseline conditions:

- Geo-Environmental Report by Enzygo, May 2021 (Ref CRM.1027.087.GE.R.001)
    - This report covers a desk study and ground investigation comprising 18no. window sample boreholes drilled to a maximum depth of 4.45m. Subsequent monitoring of groundwater and land gas was undertaken.
- Geo-Environmental Report by Enzygo, October 2021 (Ref CRM.1027.087.GE.R.003)
    - This report expands on the earlier April 2021 works to drill 6no. deep boreholes (two to 25m depth and four to 10m), primarily to inform foundation design. In addition, 6no. soakaway tests were undertaken on 26th and 27th October 2021.
- Basement Impact Assessment Scoping, Screening and Assessment by Enzygo, February 2022 (Ref CRM.1027.GE.BIA.R001)
    - This report covers the baseline ground conditions of the site and assesses the scheme's risks posed to Structural stability of the building and neighbouring property, land stability, groundwater impacts and groundwater flooding; and surface Water risks.
- Ground Investigation, Screening and SUDS Assessment Report by Enzygo, February 2022 (Ref CRM.1027.GE.BIA.R002).
    - This report covers the ground investigation and preliminary SUDS assessment in relation to the proposed basement.

Assessment Approach

Sensitivity

7.11 Environmental receptors can show different sensitivities in relation to their environment. Environmental impacts can operate over a range of different geographical areas and inherently the geographical scale must be considered in the magnitude/scale of the impact, as well as the receptor.

7.12 This assessment within this Chapter determines and quantifies sensitivity with words of estimated probability, from very high to high, medium, and low as detailed in Table 7.1.

Table 7.1 Methodology for Assessing Receptor Sensitivity

Sensitivity	Criteria	Example Criteria
Very High	Attribute has a high quality and/or rarity on a regional or national scale	Sites of Special Scientific Interest (SSSIs) with geological/geomorphological qualifying interest. Groundwater aquifers currently used, or likely to be suitable for use as, public potable supplies (e.g. Principal Aquifers, Source Protection Zone for a potable groundwater supplies). Groundwater that is providing baseflow to 'very good' WFD status quality surface waters. Soils with a very high likelihood of readily transmitting contaminants to nearby sensitive receptors or over a large distance (e.g. granular deposits in saturated zone or in continuity with river systems etc.). H1 soils as defined by the Environment Agency groundwater vulnerability classification system. Agricultural land use / soil quality (based on ALC Grades 1, 2 and 3a) (the 'best and most versatile'). Human population (e.g. local residents and site construction workers etc.). Mineral Resource with planning permission for extraction.
High	Attribute has a high quality and/or rarity on local scale	Regionally Important Geological Sites (RIGS). Groundwater aquifers currently used for, or likely to be suitable for, providing non-potable supplies or limited domestic supplies (e.g. Secondary Aquifers for domestic supplies or industrial abstractions). Groundwater that is providing baseflow to 'good' WFD quality status surface waters. Soil sensitivity to pollution: soils with a moderately high potential to transmit contaminants to other receptors or over a significant distance (e.g. mixed cohesive and granular deposits of alluvium). H2/H3 soils as defined by the Environment Agency groundwater vulnerability classification system. Agricultural land use / soil quality of ALC Grade 3b (moderate). Resource identified in Mineral Safeguarding Area.
Medium	Attribute has a medium quality and / or rarity on local scale	Groundwater that is unlikely to be suitable for providing abstractions (e.g. aquifers in areas of saline intrusion). Soils with an intermediate potential to transmit contaminants (e.g. Glacial Clays with occasional sand bands). Soils of intermediate (I1 or I2) leaching potential as defined by the Environment Agency groundwater vulnerability classification system. Agricultural land use / soil quality of ALC Grade 4 (poor). Underlying mineral resource is not currently viable. (in respect to quality of quantity).

Low	Attribute has a low quality and/or rarity on local scale.	Non-sensitive water resources (non-classified, static groundwater). Soils with a low potential to transmit contaminants (e.g. competent clay). Soils of low (L) leaching potential as defined by the Environment Agency groundwater vulnerability classification system. Agricultural land use/soil quality of ALC Grade 5 (very poor) or less. No Mineral resource.

Effect Magnitude

7.13 The magnitude of potential impacts during both construction and operation of the proposed development has been assessed using the criteria presented in Table 7.2. The magnitude (scale of change) is determined by considering the degree of deviation from the baseline conditions and whether this is likely to result in any exceedances of statutory objectives or changes in suitable uses of the receptor.

7.14 In determining the scale of impacts, some consideration must be made regarding the likelihood of impact occurring. When assessing impacts relating to contamination and soil or groundwater quality, it is possible to envisage a sliding scale of impacts. For instance, it is possible that minor fuel leaks during construction work may result in a localised area of soil contamination; however, it is also possible, though significantly less likely, that a major fuel leak could occur during construction and this could affect a much larger area of soil. In assessing the magnitude of impacts we have assumed a plausible and conservative scenario. It is not considered suitable to undertake the assessment using the worst possible scenario for all impacts as these are unlikely to occur in normal circumstances.

Table 7.2 Methodology for Assessing Magnitude of Impact

Impact Magnitude	Example Criteria
Substantial negative	Change in soil quality or ground gas regime for a large area (>20ha) of land, sufficient to alter land use (e.g., remediation of 20ha of industrial land sufficient to enable mixed residential / commercial use) Permanent loss of any area of agricultural land (ALC Grades 1, 2 and 3a) Change in groundwater conditions sufficient to change aquifer use (e.g., contamination that prevents abstraction for potable supplies, or remediation of impacted aquifer sufficient to enable potable abstractions) Generation of large volumes of non-inert waste materials for disposal off-site to landfill. Sterilisation of Mineral Resource.

Moderate negative	Change in soil quality or ground gas regime for a moderate area of land (<20ha) to a degree sufficient to alter land use in localised portions of the site or to a degree requiring a change in management / mitigation measures for site use.
Slight negative	Measurable but relatively small-scale change in an area of contaminated land or ground gas regime, but insufficient to alter end land use. Change in groundwater conditions that are insufficient to change status or potential use of the water body. Permanent loss of any area of agricultural land (ALC Grades 3b, 4 or 5). Sterilisation of non-viable mineral resource.
Negligible	No measurable contamination mobilised. No measurable change in area of agricultural land. No discernible change to groundwater regime. No change to mineral resource.
Table Notes: (1) We assume that as a minimum waste will be managed in accordance with legislation and thus not fly tipped. We also assume that appropriate PPE is used when handling waste therefore no health risks. (2) An impact magnitude can be either positive or negative, except for negligible. (3) If the assessor is certain that a receptor or attribute of a feature will suffer no impact whatsoever then the term 'No Impact' can be used in the place of 'Negligible Impact'. However, it is not usually possible to determine 'No Impact' in many cases with 100% certainty so the term 'Negligible' should be used in these cases.	

7.15 The EIA Regulations require a description of the likely effects of the proposed development and whether they are significant or not. Therefore, environmental effects are described as:

- Adverse or beneficial;
- Direct or indirect;
- Temporary or permanent;
- Short, medium or long term;
- Reversible or irreversible;
- Cumulative.

7.16 It should be noted that this Chapter makes distinction between an 'impact' and an 'effect' and, to help the reader understand the matrix approach, different terminology is used. Impact magnitudes are termed 'substantial', 'moderate', 'minor' and 'negligible' or 'no impact', whereas effects are termed 'major', 'intermediate', 'slight' and 'neutral'. Furthermore, distinction is made with valency terminology whereby impact magnitude is either 'negative' or 'positive', and significance of effect is 'adverse' or 'beneficial'.

7.17 The EIA Regulations require consideration of a variety of types of effect, namely direct/indirect, secondary, cumulative, positive/negative, short/medium/long-term, and permanent/temporary. In this ES, effects are considered in terms of how they arise, their valency (i.e. whether they are positive or negative) and duration. Each will have a source originating from the development, a pathway and a receptor.

7.18 Most predicted effects will be adverse/negative or beneficial/positive, direct, indirect, secondary or cumulative, temporary or permanent, short, medium or long term. Table 7.3 provides definitions of typical terminologies used in describing the nature of effects. In some cases, it is appropriate to identify that the interpretation of a change is a matter of opinion, and such effects will be described as 'subjective'.

7.19 The temporal scope of environmental effects is stated where known. Effects are typically described as:

- Temporary – these are likely to be related to a particular activity and cease when the activity finishes. The terms 'short-term' and 'long-term' may also be used to provide a further indication of how long the effect will be experienced; and
- Permanent – this typically means an unrecoverable change.

Table 7.3 Terminology Definitions for Typical Effects

Nature of Effect	Description
Direct	Effects arising on-site
Indirect	Effects arising off-site due to the proposed development.
Temporary	Effects which cause a change to the baseline for a limited period of time.
Permanent	Effects causing an irreversible change to the baseline.
Short-term	These temporal scales are defined within each topic assessment at levels appropriate to the receptor being assessed.
Medium-term	
Long-term	
Cumulative	Effects which arise from multiple types of effect on a particular receptor. These may overlap spatially or temporally.

Effect Significance

7.20 Table 7.4 shows how the interaction of magnitude and sensitivity results is used to determine the significance of an environmental effect. If the impact is negative (i.e. undesirable) then the resulting effect is adverse. If the impact is positive (i.e. desirable) then the resulting effect is beneficial.

Table 7.4 Methodology for assessing significance of impact

		Magnitude of Impact			
		Substantial magnitude	Moderate magnitude	Slight magnitude	Negligible magnitude
Sensitivity of Receptor	Very High	Major	Major	Intermediate	Neutral
	High	Major	Intermediate	Minor	Neutral
	Medium	Major	Intermediate	Minor	Neutral
	Low	Major	Minor	Neutral	Neutral

7.21 The residual risk after consideration of the mitigation or remediation associated with identified significant effects is reassessed using the same methodology as given in the assessment tables above.

7.22 Impacts of intermediate or higher significance are deemed to be potentially significant and require, where practicable, mitigation methods to be adopted.

7.23 For the operational phase assessment, an assumption of the potential impacts associated with the operational land uses are be made and the above assessment methodology undertaken regarding the potential future impacts. These assumptions are checked and revised as detailed design progresses for the scheme.

7.24 The methodology for the assessment of the level of confidence is attributed as high or low in accordance with the assessment criteria detailed in the Environmental Impact Assessment Approach in Chapter 1.

Contaminated Land Risk and Assessment Methodology

7.25 Potential contamination impacts and associated risks to human health are assessed using a methodology based upon the CIRIA C552 Contaminated Land Risk Assessment – A Guide to Good Practice document. This method is specifically tailored to assess the impacts and risks that may arise from exposure to ground contamination and ground gases.

7.26 The CIRIA C552 method (Rudland, 2001)[4] uses a broadly similar approach to that detailed above detailed above and makes use of the matrix presented in Table 7.5 to evaluate the significance of any identified risks. The main differences in the two approaches are that the CIRIA C552 method integrates the sensitivity of the receptor into the assessment of the magnitude (defined as consequence in C552) of harm and then compares this against the likelihood of the harm occurring. Impacts of moderate or higher are deemed to be potentially significant and require, where practicable, mitigation methods to be adopted.

Table 7.5 CIRIA 552 Methodology Risk Assessment Categories

		Potential Severity			
		Severe	Medium	Mild	Minor
Probability of Risk	High Likelihood	Very high	High	Moderate	Moderate
	Likely	High	Moderate	Moderate	Low
	Low Likelihood	Moderate	Moderate	Low	Very low
	Unlikely	Low	Low	Very low	Very low

7.27 In addition to, and in conjunction with, the use of above risk matrix where laboratory data is available consideration is given to the application of relevant standards that can be used to determine the potential significance of a contaminant source. Most notably current criteria used to evaluate the potential for risk to human health from contaminants in soils include the following:

- Category 4 Screening Levels (C4SLs). (CL:AIRE 2014)[5]
- Suitable for Use Levels (S4ULs) (LQM 2015)[6]

7.28 The C4SLs and S4UL are considered to be the most appropriate current criteria for evaluating potential health risk from contaminants in soil and these have been used to verify whether the chemical data collected by third party consultants is suggestive of potentially harmful levels of contaminants in soil.

7.29 No groundwater sampling has been undertaken within the application site to date; it has therefore not been possible to screen water samples to compare against relative water quality standards. The soil sampling from the site investigation (Appendix 7.1) is a good indicator of likely contamination levels in the Made Ground in application site and a useful indicator of potential for harm to health.

BASELINE CONDITIONS

Existing Baseline

7.30 This assessment has been undertaken using several sources previously listed in section 7.11.

7.31 An initial desk study was completed by Chelmer Consultancy Services, included within the appendix of the October 2021 Enzygo Geoenvironmental Ltd Report (Appendix 7.1). This Report gave an overview of the history of the site and surrounding area, the environmental setting, and potential sources of contamination.

7.32 Two site investigations have been undertaken on this site by Enzygo Geoenvironmental Ltd, comprising of 18 No. window sample boreholes to a max depth of 4.45m bgl and 6 No. deeper boreholes, 4 No. to 10m bgl and 2 No. to 25m bgl and 6no. soakaway tests. Geo-environmental and geotechnical soil testing has taken place. 6 No. monitoring visits were completed across a 2-month period, all 7 boreholes were reported to be dry so no groundwater samples were obtained. The gas monitoring was undertaken at the same time and no elevated concentrations of ground gas was recorded. The investigations have been compiled into a factual Geo-environmental report by Enzygo Geoenvironmental Ltd (Appendix 7.1).

7.33 The Basement Impact Assessment by Enzygo Geoenvironmental Ltd (Appendix 7.3) indicated that groundwater was recorded within the on site borehole between 3.2m and 3.8mbgl likely associated with the interface between the Kempton Park Gravel and The underlying London Clay.

Current Site Description

7.34 The site is currently occupied by residential apartment blocks with communal grassed areas and occasional trees across the central and western areas of the site. Internal roadways, parking areas and garages were present between the apartment blocks.

7.35 Within the southern area of the site an amenity hall and clinic are present with associated parking. The eastern area of the site is open land vegetated with grass and including footpaths. An electricity substation is present on the western boundary. This appears to be of modern construction with no evidence of leakage.

7.36 The southern boundary of the site is marked by Ashburnham Road with further residential developments beyond. To the east of the site lays Wiggins Lane and Ham Street with residential developments beyond. In the west is St Richard's C of E Primary School and associated playing fields. The northern boundary of the site is bordered by Woodville Road with residential development beyond.

7.37 The site is approximately 30% (1.42Ha) soft landscaping including public open green space with some trees and a playground. The remaining 70% (3.18Ha) includes the current residential footprint, access roads, car parking and Ham Hall and Youth Centre. The elevation across the centre of the site is consistently 8mAOD, the south-western corner of the site increases to 9mAOD and the north-eastern corner of the site increases to 10mAOD.

Geology

7.38 During the two ground investigations undertaken in May 2021 and August 2021, (reported in Appendix 7.1)., Made Ground was reported in all window sample and borehole locations. The thickness of the Made Ground varied from 0.40m bgl in WS8 and

WS9 to 1.20m bgl in WS17. The characteristics of the Made Ground varied slightly at each location but can be summarised as follows:

- Brown and grey clayey fine sand and flint gravel with fragments of brick concrete and ash.
- This material is consistent with typical Made Ground comprising natural soils with anthropogenic inclusions associated with demolition of historic buildings.

7.39 Superficial strata of the Kempton Park Gravels was encountered directly underlying the Made Ground at all locations. This was defined by two units, a thin layer of firm clay between 0.00-0.90m thick, followed by a sandy flint gravel layer between 3.80-5.30m thick. The characteristics of the Kempton Park Gravels encountered were fairly consistent across the site and can be summarised as follows:

- Firm and stiff brown clay and gravelly clay (not present in locations WS5 and WS15).
- Loose becoming medium dense and dense with depth brown sand and flint gravel encountered at depths of between 0.4m and 1.5m bgl.

7.40 Bedrock geology of the London Clay Formation was recorded only in the deeper boreholes from between 5.20m bgl (BH2) to 5.80m bgl (BH5). The London Clay was proved to be greater than 20m in thickness. The characteristics of this formation can be summarised as:

- Stiff grey brown silty clay with occasional claystone gravel.

7.41 The London Clay is underlain by the Lambeth Group, Thanet Sands and White Chalk at depth.

Mining

7.42 According to the environmental database report (Landmark 2017), no historical or current coal mining extraction has been identified within 1000m of the site. No other mining activity has been identified within 1000m of the site.

Landfilling

7.43 There are no active landfills within 250m of the site. The environmental database report (Landmark 2017), suggest previous history of a landfill on site but has no further data or information regarding this. History of another landfill is apparent over 650m from the site. Whilst two instances of potentially infilled land are apparent with unknown filled ground mapped in 1992, one is 92m due south and one is 330m due northwest.

Radon

7.44 The environmental database report (Landmark 2017), indicates that the site lies within an area where less than 1% of properties are above the action level and that no protection measures are likely to be required in the construction of new properties.

Ground Gas

7.45 Detailed in the Enzygo Geoevironmental Report, October 2021, monitoring of Ground Gas was undertaken within 7 No. window sample boreholes across 6 separate visits. Throughout this period, no significant ground gas levels had been measured. Up to 1.20m of Made Ground has been identified in the Enzygo investigation, October 2021 which has the potential to generate ground gas along with naturally occurring organic rich deposits.

7.46 Gas monitoring was undertaken during return visits which has not recorded elevated concentrations of Methane and no flow. Based on the gas monitoring undertake the Gas Screening Value is less than 0.07l/hr and therefore falls within Characteristic Situation 1 (CS1) compared against the Gas Screening Values given in CIRIA Report 665.

Hydrogeology

7.47 During the Enzygo Geoenvironmental 2021 investigations, October 2021, groundwater was encountered as seepages at depths of between 2.2m to 4.3 bgl from within the Kempton Park Gravels. On subsequent follow up visits to monitor the boreholes, all positions were dry and no groundwater was encountered. Within the deeper boreholes groundwater was encountered during drilling between 2.5m and 5.0 mbgl however, no monitoring standpipes were installed, and the locations were backfilled with arisings.

Aquifer Classification

7.48 The Environment Agency maps show the site to be located over a Secondary A Aquifer of the superficial deposits. The bedrock of the London Clay Formation is classified as Unproductive Strata (Landmark, 2017).

7.49 Secondary A Aquifers comprise permeable layers capable of supporting water supplies at a local rather than strategic scale, may be an important source of base flow to local rivers. The soils overlying the aquifers are assumed to have a high leaching potential (U). A worst-case vulnerability classification (H) is assumed due to a lack of data available for urban areas.

Source Protection Zones

7.50 The site does not lie within a Source Protection Zone (SPZ) and there are no SPZs within 5km of the site.

Groundwater Abstractions

7.51 The environmental database report (Landmark 2017)identifies one groundwater abstraction point just under 1500m away to the northeast of the site [517840, 173860], this is for three separate companies all of which use it for Spray Irrigation for sports grounds/facilities.

Hydrology

7.52 The nearest surface water course to the site would appear to be a drain which is approximately 295 metres to the southwest at the nearest point. This is considered to be too distant to be significantly impacted by the site. The Environment Agency maps[7] show the site is not located within a flood zone. The British Geological Society data (environmental database report (Landmark 2017)) shows the site lies in an area with potential for groundwater flooding of property situated below ground level and potential for groundwater flooding to occur at surface.

Historical Land Uses

7.53 Historical mapping (environmental database report (Landmark 2017)) shows the site was initially used as farmland and later developed for residential and commercial use.

Table 7.6 Historical Land Uses

From	Description
1850 - 1868	Site appears to be occupied by open land with a pathway across the south and east parts of the site.
1868 - 1896	Site appears to be occupied by buildings in the eastern part of the site, labelled as a farm.
1896-1947	Site appears to have change of buildings in the eastern part of the site.
1947-1959	Site appears to now be a residential area with some open grass space.
1959-1969	There appears to be a ruin in the east part of the site.
1969-1983	The ruin is no longer illustrated. The site no longer has residential buildings in the east part of the site. A new development of residential housing has been constructed in the west part of the site. The west part of the site overlays part of a school adjacent to the site. Appears to be a clinic in the southern part of the site.
1983-Present	A car park shown in the south-eastern part of the site. Site appears as it does in the present day.

Identified contamination from ground investigations

7.54 The Enzygo Geoenvironmental October 2021 Phase 2 assessments reports some exceedances of the GAC values (based on a residential land use with private gardens) for some constituents. Reference values were obtained from the Contaminated Land Exposure Assessment (CLEA), Soil Guideline Values (SGV) and General Acceptance Criteria (GAC) published by LQM and derived in consultation with the Chartered Institute of Environmental Health. Exceedances of the LQM/CIEH S4ULs values are shown in Table 7.7 below.

Table 7.7 Contaminant Exceedances (Enzygo Geoenvironmental, October 2021)

Exploratory Hole	Determinant	Concentration (mg/kg)	
		GAC	Soil Sample
WS2 0.20m	Asbestos	N/A	0.006%
	Arsenic	37	40
WS6 0.04m	Asbestos	N/A	<0.001%*
WS8 0.40m	Asbestos	N/A	3.127%
	Benzo(b)fluoranthene	2.6	3.4
	Benzo(a)pyrene	2.2	2.6
	Dibenz(a,h)anthracene	0.24	0.53
	Lead	200	320
WS1 0.04m	Benzo(b)fluoranthene	2.6	8.1
	Benzo(a)pyrene	2.2	7.0
	Dibenz(a,h)anthracene	0.24	1.1
	Lead	200	310
WS10 0.40m	Lead	200	250

*Fibres identified during screen however not quantifiable.

Geotechnical Properties

7.55 The October 2021 report from Enzygo includes a geotechnical assessment. In this report it has recommended a series of parameters based on the ground conditions encountered. The report states that it is considered that conventional strip foundations should be suitable for low rise buildings with wall loadings of 75kN/m or less assuming an allowable bearing capacity of 100kN/m2 for natural soils at depths of 1.5m bgl. Within the natural firm clay or medium dense sand and gravel. An assessment of likely settlements has been undertaken and these are estimated to be less than 25mm.

7.56 Foundations may need to be stepped down locally where Made Ground is deeper. Foundations may also need to be deepened in accordance with NHBC requirements for

buildings near trees. Foundations should be designed assuming soils of moderate shrinkage potential. It is recommended that foundations are reinforced to allow them to span both clay and granular soils.

7.57 It is likely that the apartment blocks and structures with wall loadings above 75kN per m will require piled foundations. For preliminary purposes and an initial pile assessment has been undertaken using the following assumptions:

- Upper 1.5m is ignored.
- Soil properties have been taken from the ground investigation and laboratory testing.
- A global factor of safety of 2.5 has been used, together with factors of 1.5 on shaft resistance and 3 on base resistance.

Table 7.8 Preliminary Pile Working Loads (Enzygo Geoenvironmental, October 2021)

Pile Depth (mbgl)	Working Load (kN)					
	200mm	250mm	300mm	350mm	450mm	600mm
10	80	100	125	150	200	300
15	150	180	235	280	370	530
20	220	290	350	420	560	770
25	320	400	500	590	780	1080

Unexploded Ordnance (UXO)

7.58 The Regional Unexploded Bomb Risk map (Zetica, 2021) for this area of Richmond, shows the site to lie in an area of Low risk of unexploded ordnance. However, the presence of ruins on post World War II mapping indicates that the site may have suffered some bomb damage around that time.

Future Baseline

7.59 The geo-environmental baseline is not expected to change up until the start of construction of the development as there is currently no activity on the site and it is vacant with no waste generation, no fuel/chemical storage or use, limited fly-tipping possibilities.

POTENTIAL IMPACTS

Mitigation with Submitted Design

7.60 The following information sets out the specific scheme design features considered in the impact assessment. The base environmental effects assessment, reported within this

ES chapter, assumes the project will be constructed in accordance with industry standard techniques and mandatory minimum standards and assumes suitably experienced contractors will be appointed to design, construct and commission the proposed development. Key standard working techniques/practices and design features which mitigate potential adverse effects are considered in the assessment and are provided in the following for clarity.

Design

7.61 The site investigations undertaken in 2021 (Appendix 7.1) that gathered the above geotechnical properties have enabled the raw data to be obtained and a basis for the design to be completed. The Basement Impact Assessment and SUDS report (Appendix 7.3) and deeper boreholes undertaken in the latter of the two ground investigations (Appendix 7.1) will enable a specialist piling contractor who can use the data alongside case studies to create the most economic and suitable pile designs.

7.62 Based on the current data, which has identified limited evidence of potential contamination, it is unlikely that extensive removal or modification of sources of contamination will be required. More likely refinements to the finished design will be incorporated based on breaking potential linkages by rendering contaminant sources less mobile or less likely to reach a receptor. This may be achieved through the selection of appropriate materials, clean soils cover for garden/landscape areas in any areas of current Made Ground, and potentially the inclusion of gas resistant membranes.

7.63 The proposed development has been designed to be undertaken in three phases (Phase 1 is approximately the western third of the proposed development, Phase 2 the eastern third and Phase 3 the remaining central portion of the development). Therefore, mitigation will be undertaken in a phased approach with remediation works on Phase 1 informing the investigations for Phase 2 and 3.

During Construction

7.64 Several specific mitigation measures are expected during the construction phase of the proposed development, these are listed below:

- Prior to the commencement of construction, an adequately developed Principal Contractor's 'Construction Phase Plan' will be prepared in accordance with the CDM Regulations (2015).
- Appropriate PPE and RPE will be used to prevent harm to human health.
- A detailed Construction Environmental Management Plan (CEMP) will be developed.
- Design, installation and maintenance of secant bored pile wall into the underlying impermeable clay to seal out groundwater during basement excavation which will minimise the volume of water requiring removal.

- A Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice will be used to control the re-use of 'waste' materials.
- The Developer and Principal Contractor will ensure that all consents and licences are in place before works commence.
- The construction works will be monitored by an Employer's Agent/Representative, who will also liaise with the various environmental and other advisers who will have input into the project.
- Attention will be given to the storage and use of fuels for the plant on site. All storage and use of fuels and oils will be in accordance with best practice guidelines (as may be updated) Environment Agency Pollution Prevention Guidelines (PPG 2 Above Ground Oil Storage Tanks, and PPG 8 Safe Storage and Disposal of used Oils). This is regarded as industry standard practice and also includes mandatory legal requirements which are considered as integral to the development being assessed in this ES. Therefore, the ES identifies the additional mitigation to be considered and incorporated in relation to ensuring soil quality protection, (surface water quality) and groundwater quality protection.
- Where other containers are brought onto site, including the storage and handling of drums and Intermediate Bulk Containers (IBCs), these will be required to comply with the Environmental Protection Act (1990) and the Environment Act (1995). Reference should be made to Environment Agency Pollution Prevention Guidance (PPG 26 Drums and intermediate bulk containers) for suitable guidance.
- Any storage and handling of flammable liquids (defined as any liquid with a flash point of 55°C and below) will be required to conform to the Chemicals (Hazardous Information and Packaging for Supply) Regulations and HSG51 (HSE, 1998). Reference should be made to Environment Agency HSG140 for suitable guidance. The PPG series of guidance was withdrawn on the 14th December 2015 but may contain relevant guidance.
- EA Regulatory Position Statement (June 2011): Managing concrete wash waters on construction sites: good practice and temporary discharges to the ground or to surface waters, should be followed.

During Operation

7.65 It is assumed that any activities at the site will be undertaken in accordance with the relevant environmental permits and follow the stipulated standards of these permits. Waste arising from the operation of the proposed development (e.g, domestic refuse) will also be stored in accordance with good practice (e.g, waterproof units on hardstanding) and any minor quantities of fuels or chemicals (e.g., cleaning products) stored in accordance with best practice to avoid leaks or spills entering the environment.

The managed drainage system installed across the hard surfaced areas of the site will also include interceptors in car parking areas so contaminated water, minor fuel leaks etc, are not able to infiltrate into the ground.

Expected Activity as Part of Development

7.66 During the construction phase it is anticipated that the activities listed below will cause a change to the baseline conditions by disturbance and modification of the ground. Activities during construction are likely to include cut and fill and potential ground improvements with remediation of Made Ground, construction of new utilities, shallow foundations and hardcover where stated within the development plan. Construction compounds and embankments will also be developed as part of the construction.

7.67 During the operational phase of the proposed development, is it expected that open recreational space, landscaping, private car parking and potential community facility services will be present.

Construction Effects

7.68 Based upon the proposed development and known ground conditions at the application site, the following receptors have been anticipated during the construction phase of the proposed development:

- Construction/ Site workers
- Controlled Waters: Secondary A Aquifers (Kempton Park Gravels)
- Air Quality
- Landfill
- Surrounding Site Users (including users of completed phases).

7.69 These Receptors are considered in Table 7.9.

Operational Effects

7.70 Based upon the proposed development and known ground conditions at the application site, the following receptors have been anticipated during the operational phase of the proposed development:

- Future Site users
- Controlled Waters: Secondary A Aquifer
- Land and soil quality.
- Infrastructure- Buildings, materials and services (water pipes).

7.71 These Receptors are considered in table 7.10.

Table 7.9 Impacts During Construction

Activity	Receptor/ (sensitivity)	Impact	Impact Magnitude	Effect	Significance
During Construction					
Earth works including ground improvement, service trenches and foundation construction, remediation	Construction/ site workers (Very High)	Assuming no use of PPE, workers could be exposed to low level contaminants within Made Ground, by direct contact, accidental ingestion and by inhalation of asbestos fibres, dusts or vapours.	Slight, short-term	Direct	Intermediate
	Surrounding Site users including occupants of completed phases (Very High)	Potential release of fugitive contaminated dusts and fibres from within the site.	Slight, short-term	Indirect	Intermediate
	Controlled waters – Surface Waters (High)	Disturbing and mobilising contaminants within Made Ground causing impacts to shallow aquifer.	Negligible, short-term	Direct	Minor
		Disturbing/ blocking flow of groundwater with secant wall and basement construction affecting surface water recharge.	Negligible, Permanent	Direct	Minor
		Leaks and spills of stored onsite fuels/ oils used for plant.	Negligible, temporary, and short-term	Direct	Minor
	Controlled waters – Groundwater (Secondary A Aquifers) (High)	Disturbing and mobilising contaminants within Made Ground, causing impacts to groundwater.	Slight, short-term	Direct	Minor
		Leaks and spills of stored onsite fuels/ oils used for plant.	Slight, short-term	Direct	Minor

		Piling through poor quality Made Ground down into the aquifer.	Slight, short-term	Direct	Minor
	Landfill (Low)	Excavated soil not suitable for re-use on site, may require removal to landfill.	Negligible, long-term	Indirect	Neutral
	Ground quality	Improvement in ground quality by identification of poor quality soils or hazardous materials and their subsequent remediation/removal.	Slight, long-term	Direct, beneficial	Minor

Table 7.10 Impacts During Operation

Activity	Receptor/ (sensitivity)	Impact	Impact Magnitude	Effect	Significance
During Operation					
Use of soft standing on site	Future site users including users of earlier completed phases (Very high)	Assuming no clean imported soils, direct contact (including inhalation) with contaminants (notably asbestos fibres) in Made Ground. Also potential indirect ingestion of low level contaminants through consumption of home-grown vegetables.	Slight, short-term, long- term	Direct	Intermediate
Use of onsite services and infrastructure	Controlled waters (Surface water and Groundwater) (High)	Service corridors / soakaways could act as preferential pathways via which contaminants might migrate and impact deeper strata and groundwater or surface waters. However, no significant mobile contamination identified.	Negligible, short-term, medium term.	Indirect	Neutral
Fuel leaks from residents' vehicles.	Controlled waters (Surface Water and Groundwater).	Mobile hydrocarbons migrating through drainage or soft standing surface percolating down to groundwater.	Slight, temporary	Direct	Minor

	(High)				
	Soil and land quality (Low)	Release of hydrocarbon product to ground causing contaminants to sorb to the soil particles and leaving residual contamination.	Slight, short-term to medium-term	Direct	Minor
Occupation of buildings	Future site occupants (Very High)	No significant sources of landgas identified (CS1) and no pathways within buildings for occupants to come into contact with underlying Made Ground.	Negligible, long-term	Direct	Neutral
Use of water from supply pipes	Future site users (Very High)	Significant hydrocarbon/other contamination has not been identified on site.	Negligible, long-term	Indirect	Neutral

MITIGATION

During Construction

7.72 Mitigations that are required to reduce the identified impacts during the construction phase will need to include:

- Development of a detailed Construction phase Environmental Management Plan (CEMP), secured through a planning condition, covering the following:
    - Dust management and suppression techniques to mitigate potential spread of dust to prevent impacts to construction works and off-site users (including those of completed phases) during construction.
    - Construction and site workers equipped with appropriate PPE and RPE in compliance with the construction phase plan, which will state other health and safety requirements specific to this site and previous site investigations.
    - Validation and implementation of appropriately designed SUDs, attenuation basins and Swales to avoid mobilisation of contamination. Porous material underlying the basement area and 150mm threshold level (above surrounding ground / floor level) at all new external entry points to the basement to mitigate flood risk.
    - Obtaining and working under all necessary permits.
    - Derivation of Acceptance Criteria for any material imported or re-use of excavated made ground onsite.
    - Storage of any fuels/chemicals used during construction in appropriately bunded areas to prevent contamination by leaks and spills.
- Avoidance of removal of materials to landfill, where of suitable quality to remain on site, by implementation of a Materials Management Plan. A Materials Management Plan would be a planning condition.
- A reactive strategy to be implemented during groundworks so that Construction Workers are advised on being vigilant for any anomalous ground conditions and evidence of contamination (e.g, visible asbestos fragments/materials discoloured, odorous or oily soils/groundwater) that are uncovered during earthworks. In the event that suspected contamination is uncovered, the advice of a contaminated land expert to be sought and the affected materials removed, treated or encapsulated as appropriate. This will result in an overall improvement in local ground quality. A reactive remediation strategy would be a planning condition.

During Operation

7.73 Mitigations that are required to reduce the identified impacts during the operational phase will need to include:

- Where impacted Made Ground is present, import of clean topsoil and subsoils over a geotextile membrane in areas of soft landscaping. This cover will need to be a minimum of 600mm thickness in any private gardens (circa 300mm in communal landscaped areas) and deeper for any trees.
- Piling Risk Assessment to assess potential impact to controlled waters, the deeper Chalk and Lambeth aquifers at depth.
- Upgraded materials where required to protect against ground conditions – e.g. upgraded water supply pipes, higher concrete classification.
- Use of interceptors in the drainage system to capture any minor fuel leaks from car parking areas.

Table 7.11 Summary of Mitigation Measures During Construction and Operation

Identified effect where additional mitigation has been identified.	Type of mitigation measure.	Means by which mitigation measures may be secured.
During Construction		
Impact to health of Construction site workers	Construction Phase Plan (CPP) and Environmental management Plan (EMP). Stockpile Management. The use of appropriate PPE, RPE combined with good house-keeping and hygiene. Vigilance for any unexpected ground contamination, notably gross asbestos. Dust management and suppression. (avoidance)	Construction Environmental Management plan.
Surrounding site users' (including those of completed phases) health impacts and nuisance.	CPP and EMP. Stockpile Management. Dust management and suppression and boundary monitoring. (avoidance)	Construction Environmental Management plan.
Contamination impact to Controlled waters.	Storage of all fuels and raw/ waste materials in line with best practice (on impermeable surfacing, bunded etc) with all relevant environmental permits. Contingency action plans if contamination is discovered including remediation if required.	Construction Environmental Management plan. Reactive Remediation Strategy
Disposal of materials at landfill and depletion of finite landfill space.	Maximise re-use of materials on site through appropriate assessment and development of Materials Management Plan.	Appropriate level of assessment, Adherence to sustainability Guidance and development of Materials Management Plan. Remediation Strategy

During Operation		
Future site user's health impacts.	Further assessment to confirm suitability of Made Ground for retention / re-use on site. Placement of clean topsoil for soft cover areas. (Assessment / remediation)	Further assessment Reactive remediation strategy Construction Environmental Management plan.
Migration of contaminants through utilities.	Appropriate design of services and SUDs preventing formation of new pathways. (Avoidance)	Construction design.
Fuel leaks from residents' vehicles.	Appropriate design for all hardstanding areas, such as car parks, roads and private drives and including appropriate design and maintenance of interceptors.	Construction design and maintenance of drainage infrastructure.
Migration of/mobilisation of contamination to deeper aquifers.	If piling is required through Made Ground to underlying aquifers, suitable piling techniques will be required to prevent creation of a vertical pathway.	EA approved Piling Risk Assessment

RESIDUAL EFFECTS

During Construction

7.74 For the construction phase, the most significant impacts relating to ground conditions are perceived to be potential harm to construction workers, release of dust / fibres and potential impacts to off-site users and potential impacts to Controlled Waters (groundwater and surface water). Key mitigation measures will include a reactive strategy for any unexpected contamination that is uncovered during the earthworks and the implementation of controls (to minimise release of contaminants and to prevent exposures) in accordance with the Construction Phase Plan and Environmental Management Plan. If the works identify any gross contamination or hazardous materials, remediation or additional mitigation measures may be required. After the implementation of the mitigation described above the residual effects for all receptors are anticipated to be **Neutral** (Not Significant).

During Operation

7.75 During the operational phase, the biggest potential effects are perceived as relating to potential harm to future site users through exposure to contaminants in Made Ground in areas of soft cover as noted above and can be mitigated by breaking the pathway between site occupiers and the Made Ground soils (i.e. clean soil cover for garden/landscape areas). After the implementation of the mitigation described above the residual effects for all receptors are anticipated to be **Neutral** (Not Significant).

Table 7.12 Assessment Summary and Residual Environmental Effects (Ground Conditions)

Summary description of the identified impact	Senstivitiy of a receptor	Impact magnitude	Significance and nature of effect	Additional mitigation	Residual impact magnitude	Residual significance ad nature of effect	Confidence level
Construction							
Exposure of receptors to contaminants mobilised due to earthworks, ground improvements, service trenches and foundation construction	Construction Workers (Very High)	Slight Short Term	Intermediate short-term Adverse	CPP and EMP. The use of appropriate PPE / RPE combined with good housekeeping and hygiene. Dust management and suppression.	Negligible	Neutral Indirect Temporary/ short-term Beneficial	High
	Surrounding site users (including those of completed phases) (Very High)	Slight Short-term	Intermediate Indirect temporary, short-term Adverse	CPP and EMP. Stockpile Management. Dust management and suppression and boundary monitoring.	Negligible	Neutral Indirect Temporary/ short-term Beneficial	High
	Controlled waters (High)	Slight Short Term	Minor Direct short-term Adverse	EMP. Stockpile Management. Storage of all fuels and raw/ waste materials in line with best practice with all relevant environmental permits. Contingency action plans if contamination is discovered.	Negligible	Neutral Indirect Temporary/ short-term Beneficial	High
Earth works including localised removal and off-site disposal of Made Ground	Landfill (Low)	Negligible / Long term	Neutral Indirect Long term	Maximise re-use of materials on site through appropriate assessment and development of Materials Management Plan.	Negligible	Neutral Indirect Long-term Beneficial	High

Operation							
Contact with residual contamination in Made Ground	Future site users (Very High)	Slight	Major Direct, Short-term/ Long-term Adverse	Reactive remediation strategy for any unexpected contamination to remove/treat/encapsulate during earthworks. Placement of clean topsoil for soft cover areas. (assessment / remediation)	Negligible	Neutral Direct Long-term beneficial	High
Migration of contamination through utilities / drainage	Controlled Waters (High)	Slight	Minor Direct / Indirect Medium -term	Appropriate design of services and SUDs preventing formation of new pathways.	Negligible	Neutral Direct / Indirect Medium-term beneficial	High
Fuel leaks and spills from vehicles parked and traveling onsite.	Soil and land quality (High)	Slight	Minor Direct Short-term/ long-term Adverse	Appropriate design for all hardstanding areas, such as car parks, roads and private drives and including appropriate design and maintenance of interceptors.	Negligible	Neutral Direct Long-term Beneficial	Moderate

CUMULATIVE IMPACTS

Design

7.76 There is not expected to be any cumulative impacts with the design.

During Construction

7.77 Localised removal of the Made Ground onsite may be required on site due to inadequate engineering properties for shallow foundations and/or to remove contamination risks. This could have minor impact on landfills and deplete the unsustainable finite landfill space.

During Operation

7.78 Increased hardstanding across the site has the potential to disrupt natural infiltration and increase overland flow, inflicting changes to groundwater recharge and discharge to surrounding areas and streams.

SUMMARY AND CONCLUSION

7.79 The site is currently comprised of residential apartment blocks with associated green space, landscaped areas, access roads and parking with garages. There is also a youth centre, town hall and clinic on the site.

7.80 The site contains Made Ground deposits across the entirety of the site to depths of up to 1.20m bgl. Underlying the Made Ground is superficial deposits of the Kempton Park Gravels down to depths of approximately 5.30m bgl. Beneath this unit is the London Clay Formation which continues to depths of greater than 20.00m bgl. The Kempton Park Gravel is classed as a Secondary A Aquifer.

7.81 The maximum thickness of 1.20m of Made Ground was recorded in the centre of the site in WS17. Elsewhere Made Ground was generally between 0.40 and 0.60m thick in the majority of exploratory locations. The Made Ground was typically comprising brown and grey clayey fine sand and flint gravel with fragments of brick concrete and ash, likely sourced from previous residential developments on site. The Enzygo Geoenvironmental Report (2021) recorded slightly elevated Lead, Arsenic, PAH and asbestos fibres which may be of a concern if direct contact were to be made with these soils by construction workers or future residents within garden areas. The use of PPE by construction workers, when handling the Made Ground, and the placement of a clean cap of imported topsoils will effectively break these pollutant pathways reducing the magnitude and likelihood of impact occurring.

7.82 Asbestos contaminated material has been identified during the ground investigation and it is possible that further material could be encountered during construction works. The use of clean cover soils discussed above will provide remediation to protect future site

users. Measures should be incorporated in to the Contractors Construction Stage Health and Safety Plan and asbestos management plan as required under the Construction Design and Management (CDM) Regulations to mitigate risk to construction works.

7.83 Anticipated activities during construction will include: earth works including potential cut and fill activities, ground improvements, installation of services and shallow foundations. During the operational phase, the proposed development expected activities include, the use of recreational space, landscaping, private car parking and potential community facility services, use of service corridors including drainage and possible SUDs. Identified receptors during construction also include Controlled Waters (groundwater in the Secondary A aquifer), air quality, construction site workers and surrounding site users air quality, construction site workers and surrounding site users (including site users of completed phases). During the operational phase, receptors are anticipated to be: Future site users, Controlled Waters and land and soil quality.

7.84 A range of potential impacts arising from the proposed development have been identified and assessed.

7.85 For the construction phase, the most significant impacts relating to ground conditions are perceived to be potential harm to construction workers, release of dust / fibres and potential impacts to off-site users and potential impacts to Controlled Waters (groundwater and surface water). Key mitigation measures will include a reactive strategy for any unexpected contamination that is uncovered during the earthworks and the implementation of controls (to minimise release of contaminants and to prevent exposures) in accordance with the Construction Phase Plan and Environmental Management Plan. If the works identify any gross contamination or hazardous materials, remediation or additional mitigation measures may be required. After the implementation of the mitigation described above the residual effects for all receptors are anticipated to be **Neutral** (Not Significant).

7.86 During the operational phase, the biggest potential effects are perceived as relating to potential harm to future site users through exposure to contaminants in Made Ground in areas of soft cover as noted above and can be mitigated by breaking the pathway between site occupiers and the Made Ground soils (i.e. clean soil cover for garden/landscape areas). After the implementation of the mitigation described above the residual effects for all receptors are anticipated to be **Neutral** (Not Significant).

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