



Intrusive Geoenvironmental and Geotechnical Site Assessment

Shinfield Park
Shinfield
Reading
RG2 9FW

26th July 2024

610344.0000.0000

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Executive Summary

TRC Companies Limited (TRC) was commissioned by Wrenbridge Land Limited (the 'Client') to undertake a Tier 2 Geoenvironmental and Geotechnical Site Assessment at Shinfield Park, Shinfield, Reading, RG2 9FW (hereafter referred to as the 'Site').

This Executive Summary is part of the complete report; and findings, opinions or conclusions in this Executive Summary are made in context with the complete report. TRC recommends that the user reads the entire report for all supporting information related to findings opinions and conclusions.

Executive Summary	
Site Details	
Client	Wrenbridge Land Limited
Site Address & Grid Reference	Shinfield Park, Shinfield, Reading, RG2 9FW Easting 472830, Northing 169060
Site Area	5.8 ha
Proposed Development	The proposed development will comprise demolition and clearance of all existing structures and construction of five warehouse units with associated external yards and car parking. A couple of pond features are proposed in the northern area. It is understood that development plans intend to retain much of the existing woodland on the north and west of the Site area.
Site Setting	
Current Site Use	The Site currently comprises a large concrete office building with underground car parking, ancillary buildings and external surface car parking. There is existing woodland to the north and west of the Site.
Site History	The Site was an undeveloped woodland until 1959-1968, when it was developed as a camp (possible military). A tank appeared on-site in 1976-1979. The entire Site appears to have been in its current layout since at least 1984, with footpaths and carparks, and two ponds just off-Site.
Expected Geology	Made Ground – Anticipated to be present due to current and historical land use. Superficial deposits – River Terrace Deposits (present in the north, if at all). Bedrock geology – London Clay Formation
Expected Hydrogeology	Superficial deposits – Secondary (A) Aquifer Bedrock geology - Unproductive Strata The Site does not lie within a groundwater source protection zone. Groundwater is inferred to be flowing to the southwest, based on historical data. Groundwater is considered to be moderately sensitive to contamination where the Site is directly underlain by a permeable Secondary A aquifer.
Expected Hydrology	The nearest surface water feature is a pond on-Site within the building complex, with two more ponds 5m southwest, off-Site. This ponds are possibly in continuity with the groundwater beneath the Site if granular superficial deposits were found to be present across the Site. Surface water is therefore considered to be moderately sensitive to contamination.
Investigation Findings	
Ground Conditions	Made Ground was encountered between ground level and a maximum of 2.20m bgl.

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	Bedrock geology comprising London Clay Formation was encountered between 0.10m bgl and >5.45m bgl.
Groundwater Conditions	Groundwater was only encountered at one location at a depth of 0.20m bgl (seepage) and during subsequent monitoring resting levels of 0.66m and 4.64m bgl were recorded. According to the ground investigation and monitoring data, perched groundwater is anticipated within the Made Gound and sporadically at various levels within the shallower weathered layers of London Clay Formation.
Geotechnical Assessment	
Geotechnical Hazards	The ground investigation has identified a number of geotechnical hazards at the Site which relate to the proposed development. These are locally thick Made Ground, buried obstructions, ground's aggressiveness to buried concrete, medium to high volume change potential of the site soils, soil desiccation in the vicinity of vegetation, sporadic shallow groundwater, settlement prone soils to about 3-4m depth, large variations in site level and need for earthworks and / or retaining walls on Site. These hazards are discussed in detail along with mitigation measures in section 6 of this report.
Foundations	Shallow foundations are feasible for the proposed structures within the London Clay Formation where possible given the significant earthworks proposed. Some form of ground treatment will be required mainly in areas proposed to be loaded by fill, to improve the ground and mitigate the risk of significant ground settlement. Ground treatment should be considered especially in areas of deep Made Ground and for the relatively incompetent weathered soils of London Clay Formation to about 3-4m depth below existing ground levels, as recorded during the preliminary ground investigation. Some ground treatment may also be required in areas passing from fill to cut and in cut areas, to even out any potential differential settlement for proposed future slabs, foundations and structures. The Site is considered likely to be amenable to treatment by the formation of vibro stone columns (VSC). Details of the foundation options including allowable bearing pressures are discussed in sections 6.3 and 6.4.
Floor Slabs	Ground bearing floor slabs are recommended for the proposed buildings following ground improvement, which is likely to be the most cost-effective solution. Details are provided in section 6.5.
Excavations	Excavations for shallow foundations, floor slabs, and laying services should be readily achievable using standard excavation plant. However, hard surfacing, old foundations and relict basement structures will require the use of breaking apparatus. Obstructions were encountered in Made Ground during the ground investigation. According to the ground investigation and monitoring data, perched groundwater is anticipated within the Made Gound and sporadically at various levels within the shallower weathered layers of London Clay Formation. Thus it is considered that excavations will likely encounter some perched groundwater at various levels which could be dealt with localised pumping from a sump.

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	Details for anticipated excavations are provided in section 6.6.
Earthworks	Based on the proposed earthworks plan ("Proposed Earthworks, Option 16", drawing ref.no.: 40237-BGL-XX-XX-DR-C-00201, rev.P04, 19/7/2024, Burrows Graham) maximum earth cut of about 5.06m in the north and maximum fill of about 3.8m in the centre of the Site with associated precast retaining walls, are planned to enable construction of the proposed scheme. Based on the preliminary ground investigation results the site-won materials would classify as Class 1 (Made Ground) and Class 2 (Made Ground and weathered London Clay Formation soils) based on the Specification for Highway Works (SHW 600 series) and will likely be appropriate for use as a general fill. Details for proposed earthworks are provided in section 6.6 of this report.
Pavements	Assuming excavation formation soils to comprise Made Ground and London Clay Formation and based on the formation preparation outlined above, an equilibrium CBR value of 3% is recommended for pavements preliminary design. Confirmatory in-situ CBR testing at final formation level is recommended just prior to pavement construction. Details for proposed pavements are provided in section 6.7 of this report.
Buried Concrete	With reference to BRE Digest SD1 (2005) and based on the results of the concrete classification tests, design sulphate classes of DS-1 for the Made Ground and DS-4 for the London Clay Formation are recommended. Further, considering the pH values, ACEC classes of AC-1 for the Made Ground and AC-4 for the London Clay Formation are recommended.
Soakaways	Soakaway testing did not form part of the scope of works, however given the predominantly cohesive nature of the Site soils shallow soakaways will not be viable for future developments. Detailed recommendations for the soakaway potential of the Site, are presented in section 6.9.
Contaminated Land Assessment	
Human Health	No exceedances of contaminants were detected within the soils underlying the Site, when screened against the GAC for commercial end use. Based upon the proposed development plan it is assumed that there will be a presence of hard standing within the building footprint providing a physical barrier against contact with potential contaminants.
Controlled Waters	The laboratory analysis reported elevated concentrations of nickel and selenium exceeding the UK DWS in three groundwater collected. The exceedances are summarised in the below table. The Site is not within a Groundwater Source Protection Zone (SPZ) and is underlain directly by the London Clay Formation which is designated as Unproductive Strata and is therefore not considered to be sensitive to contamination. The laboratory analysis reported elevated concentrations of cadmium, chromium, copper, nickel and zinc exceeding the EQS in four groundwater samples collected. There is one surface water features on the Site. The Site is underlain by low permeability strata and groundwater is considered unlikely to be in hydraulic

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	connection with surface waters. Exceedances are marginal and are unlikely to present a significant risk.
Ground Gas and Organic Vapour	Elevations of carbon dioxide was recorded in on all three occasions in WS103 is Characteristic Situation 2 (low risk). One visit is outstanding at the time of reporting however, it is unlikely that the classification of the Site will change. The report will be updated following completion of the monitoring. Further monitoring within the proposed building footprint should be undertaken to confirm ground gas classification.
Remediation	Based on the results of this assessment remediation is not required.
Recommendations	
Consultation with a specialist earthworks contractor is recommended at an early stage given the amount of the earthworks proposed. The preliminary ground investigation results and assessment presented in this report should be made available for an informed assessment with regard to earthworks materials suitability. Additional testing for earthworks materials assessment will be required at detailed design stage. Once future development details are finalised post-planning, additional ground investigation and assessment is recommended. The additional ground investigation shall include cable percussion boreholes, window sample boreholes and trial pitting within the footprint of the existing building post-demolition of the existing buildings and at external areas to confirm ground conditions for both environmental and geotechnical purposes. Cone penetration testing is also proposed across the Site to inform ground treatment design. Details for the additional investigation work required for geotechnical purposes are presented in section 6.10.	

1.0 Introduction

1.1 Appointment and Purpose

TRC Companies Limited (TRC) was commissioned by Wrenbridge Land Limited (the 'Client') to undertake a Tier 2 (formerly known as Phase 2) Geoenvironmental and Geotechnical Site Assessment for Shinfield Park, Reading, RG2 9FW (hereafter referred to as the 'Site').

A Site location plan is presented as Figure 1 in Annex A.

This Tier 2 report has been commissioned to assess environmental and geotechnical considerations, predominantly with respect to ground conditions at the Site, which will be used to aid due diligence, and subsequent stages of planning and design for the proposed redevelopment works.

1.2 Proposed Development

The proposed development will comprise demolition and clearance of all existing structures and construction of five warehouse units with associated external yards and car parking. A couple of pond features are proposed in the northern area. It is understood that the development plans intend to retain much of the existing woodland in the north and west of the Site area.

Based on the above, the proposed development is considered to fall into geotechnical category 2 with respect to BS EN 1997 (Eurocode 7).

The end user sensitivity is considered low for the proposed industrial end use.

A proposed development plan is presented as Figure 2 in Annex A.

1.3 Available Information & Standards

This report is based on the following information:

- Historical uses of the Site and surroundings;
- Current use and condition of the Site;
- Environmental setting in terms of geology, hydrogeology, hydrology and surrounding land uses;
- Relevant publicly available environmental records;
- Previous reports for the Site as listed in Section 2.6; and,
- Intrusive investigation including geoenvironmental and geotechnical sampling and testing.

This report was conducted with due regard to the following guidance and standards:

- The National Planning Policy Framework;
- BS5930:2015 (+A1:2020) Code of Practice for Ground Investigations;
- BS EN 1997 Eurocode 7;
- BS8485:2015 (+A1:2019) Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings;
- BS8576:2013 Guidance on Investigations for Ground Gas – Permanent Gases and Volatile Organic Compounds (VOCs);
- BS10175:2011 (+A2:2017) Investigation of Potentially Contaminated Sites – Code of Practice; and,
- Land Contamination Risk Management (LCRM) 2020 (updated in 2023).

The geotechnical appraisal has been carried out in accordance with Eurocode 7. Sections 1 to 5, together with Annexes A to E, comprise the Ground Investigation Report.

Preliminary geotechnical recommendations are presented in Section 6 and these may need to be verified in a Geotechnical Design Report once structural details of the proposed development are confirmed.

1.4 Significant Assumptions

This report presents TRC's observations, findings, and conclusions as they existed on the date that this report was issued. This report is subject to modification if TRC becomes aware of additional information after the date of issue of this report that is material to its findings and conclusions.

The reliability of information provided by others to TRC cannot be guaranteed to be accurate or complete. Performance of this Tier 2 Geoenvironmental and Geotechnical Site Assessment is intended to reduce, but not eliminate, uncertainty of geoenvironmental and geotechnical conditions associated with the subject site; therefore, the findings and conclusions made in this report should not be construed to warrant or guarantee the subject site, or express or imply, including without limitation, warranties as to its marketability for a particular use. TRC found no reason to question the validity of information received unless explicitly noted elsewhere in this report.

1.5 User Reliance

This report was prepared for Wrenbridge Land Limited. Reliance on this report by any other third party is subject to requesting and fully executing a reliance letter between TRC and the third party that acknowledges the TRC Standard Terms and Conditions with the Client, to the same extent as if they were the Client thereunder.

TRC has been provided with information from third parties for information purposes only and without representation or warranty, express or implied as to its accuracy or completeness and without any liability on such third parties part to revise or update the information. Where reliance has been provided by third parties to potential purchasers this is noted in our report.

2.0 The Site

2.1 Location

The Site comprises an approximate 5.8 ha plot of land located at Shinfield Park, Shinfield, Reading, RG2 9FW, centred on National Grid Reference Easting 472830, Northing 169060, situated approximately 4.85km south of Reading Train Station.

The Site location is presented as Figure 1 in Annex A.

2.2 Site Description

The Site is surrounded by vegetated local wildlife sites in the south, east and west, ancient woodland in the northwest, and a vegetated area in the north with residential land use beyond.

The 5.8 hectare site is irregular in shape and is located approximately 160m to the north of the M4.

The Site was active at the time of the walkover undertaken by TRC in June 2024 during the Tier 1 phase, and was occupied by a large office block, ancillary buildings and car parking both below and at ground level. There were semi-mature and mature woodland areas to the north and west of the Site, which were accessed via various walkways. A pond was present to the west of the main office building.

The main office building was occupied by a consultancy company. The Site Representative indicated that the Site had been previously occupied by the Royal Air Force (RAF), but the use of the property was not fully known.

According to the Site Representative, the current main office building was designed in 1975 and the build was completed in 1980. The original intention for the building was a council office for the south of England, but at that time councils were subdivided into county level administrations which meant that the office was never fully occupied. The building was occupied by several administrative and private companies before being occupied by the engineering consultancy Foster Wheeler, which subsequently became Wood Group (the Occupier).

The Site Representative indicated that the building had been previously owned by the occupier but was sold and leased back.

The main office building was constructed from concrete. It included office accommodation with two levels of underground car parking and plant rooms. There was a smaller steel framed office block constructed prior to 2020 to accommodate office workforce. The Site Representative noted that working habits have changed since the 2020 pandemic and the offices were no longer operating at full occupancy.

There were additional ancillary buildings located to the north of the Site near the woodland area. These were garage and workshop type structures associated with former council operations. No access was gained to that part of the Site.

There were three hardstanding areas designated for car parking in the north, northeast and southwest of the Site. There were a couple of ponds at the southwest of the Site. There were several areas of soft landscaping across the Site.

The main office block was built up from the road. The underground car parking was approximately at road level at its lowest point. Access to the Site was from the B3270 road in the east.

The Site has an average elevation of approximately 75m above Ordnance Datum (aOD). Topographically the Site slopes downwards from north to south.

2.3 Surrounding Area

The Site is surrounded by vegetated local wildlife sites in the south, east and west, ancient woodland in the northwest, and a vegetated area in the north with residential land use beyond. Land uses in the immediate vicinity include the following principal features.

Table 2.1: Summary of Surrounding Land Use

Direction	Land Use
North	The Site is bound to the north by a vegetated area and residential buildings.
East	The Site is bound to the east by Whitley Wood Lane and B3270. Beyond these roads is greenspace.
South	The Site is bound to the south by a vegetated area.
West	The Site is bound to the west by a vegetated area.

2.4 Site Environmental Setting

2.4.1 Geology

The Site is underlain by variable thickness of Made Ground over London Clay Formation, with potential River Terrace Deposits located in the north of the Site.

2.4.2 Hydrogeology

The British Geological Survey (BGS) geological mapping and hydrogeological mapping presented by DEFRA (MAGIC website) indicate the following hydrogeological information for the Site:

Table 2.2: Summary of Hydrogeology

Geology	Geological Description	Aquifer Status	Aquifer Description
Superficial Deposits: River Terrace Deposits	Sand and Gravel	Secondary (A) Aquifer	Permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers, lakes or wetlands.
Bedrock Deposits: London Clay Formation	Clay, Silt, and Sand	Unproductive Strata	Geological strata with low permeability that have negligible significance for water supply or river base flow. They consist of deposits that naturally offer protection to any aquifers that may be present beneath.

The Site does not lie within a groundwater Source Protection Zone (SPZ).

2.4.3 Hydrology

The nearest surface water feature is one surface water body (pond) located within the current building complex. This pond is likely artificial and therefore likely to be lined. It is possible the pond is in continuity with the groundwater beneath the Site if granular superficial deposits are found to be present and there is no pond lining.

2.5 Summary of Site History

A review of historical maps undertaken as part of the TRC desk study report that the Site comprised undeveloped woodland in earliest available mapping (1872). The Site was an undeveloped woodland until 1959-1968, when the building on-site was possibly already in its current layout. A tank appeared on-site in 1976-1979. The entire Site appears to have been in its current layout since at least 1984, with a pond, footpaths and carparks on-site.

2.6 Previous Investigations, Reports or Remediation

The following Site specific assessment has been reviewed and is referred to in this report:

Table 2.3: Summary of Previous Site Assessments

Report Details	Summary of Geoenvironmental and Geotechnical Findings
Tier 1 Report titled 'Desk Based Geoenvironmental and Geotechnical Site Assessment' issued by TRC, dated 25/07/2024, report ref.no.: 610344	The TRC Tier 1 assessment detailed the current Site use after a Site walkover and detailed the history of the Site from earliest available historical mapping. The Tier 1 highlighted the likely presence of asbestos, heavy metals, PAHs, TPHs and ground gas due to historical land use. The anticipated geology from the desk based assessment was Made Ground to at least 0.45m bgl over London Clay Formation, with the potential for River Terrace Deposits in the north of the Site. The bedrock was noted as being Unproductive Strata, with the River Terrace Deposits being classed as a Secondary (A) Aquifer. Groundwater was expected to be encountered between depths of 1.07m and 6.50m below ground level (bgl) and is expected to flow towards the southwest of the Site. The Site does not lie within a groundwater source protection zone. The nearest surface water feature was noted as two ponds approximately 5m south of the Site. Foundry Brook is located approximately 85m south of the Site. Surface waters are unlikely to be in hydraulic continuity with groundwater beneath the Site due to the presence of low permeability soils and the distance between the Site and Foundry Brook, however if River Terrace Deposits are present then these are likely to be in hydraulic connectivity with groundwater. Surface water is therefore considered to be moderately sensitive to contamination. The Site was an undeveloped woodland until 1959-1968, when the Site was developed as a camp (possibly military). This is supported by anecdotal comments provided by the Site Representative who indicated that prior to current development, the Site was occupied by the RAF. The land use was not fully known and military land use may not be fully recorded on mapping. A tank appeared on-site at some time during 1976-1979. The entire Site appears to have been in its current layout since at least 1984, including footpaths and carparks on-site, with two ponds located just off-Site. This is supported by anecdotal information provided by the Site Representative who noted that the main building was designed in 1975 and constructed by 1980. The original intention was to house council offices, but later became occupied by the engineering consultancy Foster Wheeler, who later became Wood Group. These historical land uses in the area have the potential to cause contamination across the Site. Potential contaminants of concern include asbestos fibres in soil, heavy metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH) and ground gases.

Report Details	Summary of Geoenvironmental and Geotechnical Findings
	Several potential geotechnical hazards were identified in the Tier 1 report, such as Made Ground, buried obstructions, ground aggressive to buried concrete, volume change potential soils, soil desiccation, shallow groundwater and variations in site level and consequent need for earthworks and/or retaining walls.

3.0 Ground Investigation

3.1 Scheduled Scope of Works

The scheduled TRC Tier 2 investigation scope of works comprised the following:

- 12 No. windowless sample boreholes (WS101 to WS112) to a maximum depth of 5m with follow-on dynamic probing to 10m at three locations;
- In-situ logging, ground sampling and testing;
- Field screening for contamination using a Photo-Ionisation Detector (PID);
- Construction of 5 No. gas and groundwater monitoring wells;
- Field monitoring of bulk ground gases and groundwater levels on 4 occasions post-drilling; and,
- Collection of groundwater samples for laboratory testing.

3.2 Investigation Rationale

The ground investigation was designed by TRC on behalf of the Client to gather information on the geoenvironmental and geotechnical ground, groundwater and ground-borne gas conditions at the Site.

The TRC investigation aimed to gain good general coverage of the Site.

Table 3.1: Summary of Exploratory Hole Locations

Exploratory Hole	Location
WS101	Located in the northeast portion of the Site in an area of hardstanding. Located within the footprint of one of the proposed warehouse units.
WS102	Located in the northeast portion of the Site in an area of hardstanding. Located within the footprint of one of the proposed warehouse units.
WS103	Located to the north of the small steel framed unoccupied office building in an area of brick paving. Located within an area of proposed hardstanding.
WS104	Located in the west of the Site in an area of hardstanding. Located within the footprint of one of the proposed warehousing units.
WS105	Located in the west of the Site in an area of hardstanding. Located within an area of proposed hardstanding. Targeting potential Made Ground fill by a retaining wall.
WS106	Located within a loading bay in the sub-basement. Located within an area of hardstanding in the proposed development. Targeting the underlying soils of the current development.
WS107	Located on an embankment in the southeastern portion of the Site in an area of soft landscaping. Located at the boundary of the largest proposed warehouse unit. Targeting potential fill materials within the embankment.
WS108	Located within the underground car parking.
WS109	Located in an area of soft landscaping to the north of the concrete office block. Targeting potential Made Ground associated with previous developments.
WS110	Located in the south of the Site in the underground car park. Located within the footprint of a proposed warehouse unit. Targeting the underlying soils of the current development.
WS111	Located in the east of the Site in an area of soft landscaping.
WS112	Located slightly south of the steel framed building in an area of hardstanding. Located within an area of proposed hardstanding.

3.3 Investigation Methodology

3.3.1 Ground Investigation

The TRC Tier 2 investigation was conducted at the Site from 19th to 21st June 2024.

TRC commissioned Oakland Site Investigation Ltd (drilling contractor) to undertake the windowless sampling at the Site. Each exploratory hole was advanced using a Premier 110 RP. The drilling works were overseen by a TRC engineer who performed field assessment and logging of the exploratory holes.

The works included the following key actions:

- Review of available underground services plans for the Site;
- Each of the proposed exploratory hole locations was cleared using a Cable Avoidance Tool (CAT) and ground penetrating radar (GPR) by an independent utilities surveyor;
- Windowless sampling was performed at each location by the drilling contractor, including in-situ geotechnical testing;
- Follow-on dynamic probing from selected windowless sample locations;
- On-site ground logging, testing, and assessment of potential indicators of contamination;
- Field screening using a PID;
- Collection of soil and groundwater samples for environmental and geotechnical laboratory analysis;
- Construction of gas and groundwater monitoring wells in 5 No. borehole locations namely WS101, WS102, WS103, WS105 and WS107;
- Boreholes WS104, WS106, WS108, WS109, WS110 and WS112 were backfilled with arisings; and,
- Surveying of the exploratory holes final locations.

The following alterations to exploratory hole depths and positions were made during the course of the ground investigation:

- WS108 was terminated at 1.20m bgl due to encountering a concrete obstruction. The location was not moved due to time constraints;
- WS109 was terminated at 1.20m bgl due to encountering a concrete slab. The location was not moved due to time constraints;
- WS110 was terminated at 0.65m bgl due to insufficient headspace for the windowless sampling rig within the underground car park. The location was not moved due to time constraints; and,
- WS111 was not drilled due to time constraints and lack of space for the drilling rig.

The exploratory hole location plan for the ground investigation undertaken, is presented as Figure 3 in Annex A.

The exploratory hole logs are presented in Annex C and include the in-situ sampling and testing undertaken at the Site.

3.3.2 Groundwater and Ground Gas Monitoring

The ground conditions encountered with respect to the response zone of the monitoring installations are summarised in the table below.

Table 3.2: Monitoring Wells Summary

Exploratory Hole	Response Zone (m bgl)	Response Zone Strata (m bgl)	
WS101	1.00 - 5.45	1.00 – 5.45	London Clay Formation
WS102	1.00 - 5.45	1.00 – 5.45	London Clay Formation
WS103	1.00 - 5.45	1.00 – 1.10	Made Ground
		1.10 – 5.45	London Clay Formation
WS105	1.00 - 2.20	1.00 – 2.20	Made Ground
WS107	1.00 - 5.45	1.00 – 5.45	London Clay Formation

Groundwater and ground gas monitoring was conducted by a TRC technician on three occasions; at the time of reporting, one visit was outstanding. The dates of the monitoring visits were 5th, 12th and 23rd July 2024.

During each visit, groundwater elevation and potential presence of any free phase oils was measured using an oil/water interface probe. Gas monitoring was undertaken using a portable gas analyser at each monitoring well head. The field assessment gathered data relating to the concentrations of permanent ground gases (e.g. methane, carbon dioxide, carbon monoxide and oxygen).

Groundwater sampling was also undertaken in boreholes WS101, WS102, WS103 and WS107 using a dedicated disposable bailer.

3.4 Geotechnical In-Situ Testing

In-situ testing was undertaken for geotechnical purposes. The details of the in-situ test results are presented in the logs within Annex C and in the field data within Annex D.

The Site based geotechnical testing is summarised in the table below.

Table 3.3: In-situ Tests (Geotechnical)

Test Type and Standard	Number
Standard penetration test (BS EN ISO 22476-3:2005+A1:2011)	41
Hand penetrometer (manufacturer's manual)	93
Dynamic probing (BS EN ISO 22476-2:2005+A1:2011)	4

Any limitations to the in-situ testing that require consideration during the evaluation of the data are described in the following paragraphs.

Although the Standard Penetration Test (SPT) is a standardised test, uncorrected SPT 'N' values display a considerable amount of scatter. Calibrated SPT hammers were used during the ground investigation and in our evaluation, presented in Section 5, the results have been normalised to 'N₆₀' in accordance with Eurocode 7.

The following SPTs straddle two strata and so are considered to be representative of neither and have been discounted from subsequent analysis:

- WS103 at 1m bgl
- WS104 at 1m bgl
- WS105 at 2m bgl

The pocket penetrometer apparatus, due to operational reasons, provides only an estimate of the unconfined compressive strength and the undrained shear strength as it is less precise than other test methods, especially when undertaken on samples obtained from dynamic sampling equipment. Given the limitations of this test method, in isolation, it is only considered indicative of the undrained shear strength for foundation purposes. However, it can provide useful information on the relative intact strength of soils so as to assist with the assessment of desiccation.

The above factors have been considered in the appraisal of geotechnical results presented in Section 5.

3.5 Geotechnical Laboratory Testing

Laboratory testing was undertaken for geotechnical purposes.

The geotechnical laboratory testing is summarised in the table below.

Table 3.4: Laboratory Tests (Geotechnical)

Test Type and Standard (BS 1377 unless stated differently)	Number
Water (moisture) content (BS EN ISO 17892-1)	9
Liquid and plastic limits and plasticity index (BS EN ISO 17892-12)	9
Particle size distribution - wet sieving (BS EN ISO 17892-4)	12
Water soluble sulphate content 2:1 aqueous extract (BRE SD1 2005)	4
Total sulphur content (BRE SD1 2005)	4
Acid soluble sulphate content (BRE SD1 2005)	4
Soil pH (BRE SD1 2005)	4

As with in-situ testing, it is necessary to consider the limitations associated with any laboratory testing and to review any potentially anomalous results. In all geotechnical tests the specimen is selected from a much larger volume of material which may have an inherent degree of variability, particularly in Made Ground.

Water content determinations on disturbed samples may not be representative due to the disturbance arising from the sampling process. Moisture content results can be influenced by climatic factors and it cannot be guaranteed that the values determined at the time of investigation will be the same as those at the time of construction.

Obtaining coarse grained soils from cable tool or windowless boreholes can result in a loss of materials due to the nature of the sampling process. This can have an influence on the results of particle size distribution analyses.

The above factors have been considered in the appraisal of the geotechnical results given in Section 5.

The full set of laboratory geotechnical results is presented in Annex E.

3.6 Environmental Laboratory Analysis

A total of twenty two soil samples was collected for environmental analysis during the investigation works. All soil samples were packed in laboratory provided containers and delivered to I2 Analytical (I2) for chemical analysis.

All soil samples were collected in order to provide environmental data on the quality of near surface and shallow soils beneath the Site. Representative samples of Made Ground / Fill and natural deposits were collected where feasible. The analytical suite of soils included the following parameters:

- Asbestos (Made Ground/Fill Materials only);
- Heavy metals suite;
- Polycyclic aromatic hydrocarbons (PAH); and,
- Total petroleum hydrocarbons – Criteria Working Group (TPH-CWG).

Groundwater samples were collected from four of the boreholes. The samples were sent to I2 Analytical (I2) and analysed for the following:

- Heavy metals suite;
- Polycyclic aromatic hydrocarbons (PAH); and,
- Total petroleum hydrocarbons – Criteria Working Group (TPH-CWG).

The full set of chemical results are presented in Annex F.

4.0 Ground Conditions

4.1 Ground Profile

The investigation observed that the soils underlying the Site generally comprised the following:

Table 4.1: Ground Profile

Stratum	From		To		Thickness (m)
	m bgl	m aOD ¹	m bgl	m aOD ¹	
Made Ground	0.00	79.32/71.79	0.10/2.20	78.22/71.24	0.10/2.20
London Clay Formation	0.10/2.20	78.22/71.24	>5.45	<66.34	>5.35

The ground conditions encountered across the Site correspond with the publicly available records of ground conditions published by BGS and reported in previous reports for the Site. Published BGS borehole records within or near the Site area found similar results.

River Terrace Deposits were not reported within the British Geological Survey (BGS) maps of the Site area, but were mapped approximately 50m to the north. The River Terrace Deposits were not encountered on Site during this preliminary ground investigation.

4.2 Made Ground

The Made Ground was encountered in all of the exploratory holes from ground level to a maximum recorded depth of 2.20m bgl. Deeper Made Ground cannot be ruled out to be present at the Site, especially in the proximity of existing structures such as basements and retaining walls.

The Made Ground was heterogenous in nature but generally comprised brownish yellow or orangish brown very gravelly SAND or yellow brown clayey sandy GRAVEL or firm brown slightly gravelly CLAY. Sand was fine to coarse. Gravel was sub-angular to rounded, fine to coarse grained. Gravel consisted of Type 1, asphalt, bitumen, concrete and flint.

Shallow refusal occurred within Made Ground at WS108 and WS109 due to encountering concrete obstructions. Bituminous surfacing, brick paving and concrete up to 0.20m thick were encountered across the Site in areas of existing hardstanding. Concrete up to 0.65m thick was encountered at WS106, WS108 and WS110 which were undertaken within the existing building footprint.

4.3 London Clay Formation

The London Clay Formation was recorded in all exploratory holes that were not terminated in Made Ground, from 0.10m to >5.45m bgl.

The London Clay Formation at shallower depths to about 3-4m bgl, comprised weathered firm to stiff orangish brown slightly sandy slightly gravelly CLAY. Sand was fine to coarse. Gravel was sub-angular to rounded, fine to coarse grained. Gravel consisted of claystone and flint. At greater depth, the less weathered London Clay Formation comprised stiff to very stiff brown to grey silty CLAY.

Crystals likely of selenite/gypsum were encountered in London Clay Formation at 2m bgl in WS101 and at 3m bgl in WS106.

4.4 Groundwater

Water strikes observed during the site works and the results of the monitoring visits are summarised in the table below.

Table 4.2: Groundwater Observations

Exploratory Hole	Water Strikes				Standing Water Level During Monitoring			
	Struck		Rose to		Shallowest		Deepest	
	m bgl	m aOD	m bgl	m aOD	m bgl	m aOD	m bgl	m aOD
WS101	-	-	-	-	0.57	74.73	0.92	74.38
WS102	0.20	73.40	n/a	n/a	0.66	72.94	0.98	72.62
WS103	-	-	-	-	2.56	76.76	4.64	74.68
WS104	-	-	-	-	-	-	-	-
WS105	-	-	-	-	2.17	71.27	Dry	70.94
WS106	-	-	-	-	-	-	-	-
WS107	-	-	-	-	2.91	68.88	3.67	68.12
WS108	-	-	-	-	-	-	-	-
WS109	-	-	-	-	-	-	-	-
WS110	-	-	-	-	-	-	-	-
WS112	-	-	-	-	-	-	-	-

During the ground investigation, groundwater was not encountered except for a seepage in Made Ground at 0.20m bgl in WS102.

During subsequent monitoring, groundwater was encountered at various levels within the shallower weathered London Clay Formation.

The groundwater monitoring data are presented in Annex D. Three visits of four have been undertaken to date.

According to the ground investigation and monitoring data, perched groundwater is anticipated within the Made Ground and sporadically at various levels within the shallower weathered layers of London Clay Formation.

Groundwater may be subject to seasonal variations especially after periods of prolonged rain or drought.

4.5 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of contamination was encountered during the ground investigation.

5.0 Geotechnical Assessment

5.1 Strata Properties

5.1.1 Made Ground

The Made Ground was heterogenous in nature but generally comprised brownish yellow or orangish brown very gravelly SAND or yellow brown clayey sandy GRAVEL or firm brown slightly gravelly CLAY. Sand was fine to coarse. Gravel was sub-angular to rounded, fine to coarse grained. Gravel consisted of Type 1, asphalt, bitumen, concrete and flint.

Shallow refusal occurred within Made Ground at WS108 and WS109 due to encountering concrete obstructions. Bituminous surfacing, brick paving and concrete up to 0.20m thick were encountered across the Site in areas of existing hardstanding. Concrete up to 0.65m thick was encountered at WS106, WS108 and WS110 which were undertaken within the existing building footprint.

Three SPTs conducted in the Made Ground, yielded N_{60} values ranging between 9 and refusal, highlighting the variable strength nature of the material. The SPT N_{60} results are shown versus depth on Figure 4, Annex A.

Five particle size distribution (PSD) tests undertaken on samples of the Made Ground recorded 0% cobbles, 23% to 73.5% gravel, 10% to 35% sand and 9.5% to 67% clay/silt. These results indicate the high fractional variability of the soil particles in the stratum. The PSD test results are shown per lithology on Figure 5, Annex A.

One moisture content test undertaken on a sample of the Made Ground recorded a value of 24.5%. The moisture content results are shown versus depth per lithology on Figure 6, Annex A.

One Atterberg limits test undertaken on a cohesive sample of the Made Ground recorded a value of 55% for the liquid limit, 19% for the plastic limit, and 36% for the plasticity index. The modified plasticity index was 23%. The results indicate that the cohesive Made Ground is of high plasticity and medium volume change potential (VCP) in accordance with NHBC Standards. Desiccation could exist at the Site, given the dense vegetation and woodland surrounding the Site. The limited water content and Atterberg limits tests undertaken do not suggest that a moisture content deficit exists within the cohesive Made Ground. The plasticity chart is shown on Figure 7, Annex A.

A total of four pocket penetrometer tests were performed on the Made Ground, which indicated results in the range of 54kPa – 152kPa. The results are shown on Figure 8, Annex A.

TABLE 5.1: Summary of Ground Parameters for Made Ground (cohesive)

Soil Parameters	Number of Tests	Range of Results	Characteristic Value ¹
Liquid Limit (%)	1	55	55
Plastic Limit (%)	1	19	19
Plasticity Index (%)	1	36	36
Modified Plasticity Index (%)	1	23	23
Plasticity	1	CH	CH
Volume Change Potential (NHBC)	1	Medium	Medium
Moisture Content (%)	1	24.5	-
SPT N_{60} Values	3	9-50	Refer to Figure 4 in Annex A
Undrained Shear Strength (kN/m ²) (based on pocket penetrometer)	4	54-152	Refer to Figure 8 in Annex A

1. Cautious estimate

5.1.2 London Clay Formation

The London Clay Formation at shallower depths to about 3-4m bgl, comprised weathered firm to stiff orangish brown slightly sandy slightly gravelly CLAY. Sand was fine to coarse. Gravel was sub-angular to rounded, fine to coarse grained. Gravel consisted of claystone and flint. At greater depth, the less weathered London Clay Formation comprised stiff to very stiff brown to grey silty CLAY.

Thirty five SPTs conducted in the London Clay Formation, yielded N_{60} values ranging between 10 and 32, highlighting the stiff to very stiff nature of the material. The SPT N_{60} results are shown versus depth on Figure 4, Annex A.

Seven particle size distribution tests undertaken on samples of the London Clay Formation recorded 0% cobbles, 0% to 2% gravel, 2.5% to 12.5% sand and 87.5% to 97.5% clay/silt. These results indicate the low lithological variability of the stratum. The results are shown on Figure 5, Annex A.

Eight moisture content tests undertaken on samples of the London Clay Formation recorded values in the range of 22.5% to 28.5%. The results are shown versus depth on Figure 6, Annex A.

Eight Atterberg limits tests undertaken on samples of the London Clay Formation recorded values in the range of 47% to 57% for the liquid limit, 16% to 25% for the plastic limit, and 27% to 41% for the plasticity index. The modified plasticity index was 27% to 41%. The results indicate that the London Clay Formation is of intermediate to high plasticity and of medium to high volume change potential (VCP) in accordance with NHBC Standards. Desiccation could exist within the London Clay Formation, given the dense vegetation and woodland surrounding the Site. The water content and Atterberg limits tests undertaken suggest that a moisture content deficit may locally exist at the Site, in the vicinity of vegetation. The plasticity chart is shown on Figure 7, Annex A.

Based on the correlation between N_{60} and the undrained shear strength (C_u) and plasticity index for insensitive clays (after Stroud and Butler, 1975) a conservative relationship of $C_u = 4.5 \times \text{SPT } N_{60}$ has been considered appropriate for the London Clay Formation. The SPT (in terms of C_u) test results from the investigation are represented graphically in Figure 8 in Annex A from which C_u values of between 46kPa and 145kPa are indicated for the stratum.

Also, a total of 89 pocket penetrometer tests were performed on samples retrieved from London Clay Formation, which yielded results in the range of 54kPa – 245kPa.

Table 5.2: Summary of Ground Parameters for London Clay Formation

Soil Parameters	Number of Tests	Range of Results	Characteristic Value ¹
Liquid Limit (%)	8	47-57	57
Plastic Limit (%)	8	16-25	16
Plasticity Index (%)	8	27-41	41
Modified Plasticity Index (%)	8	27-41	41
Plasticity	8	CI - CH	CH
Volume Change Potential (NHBC)	8	Medium - High	High
Moisture Content (%)	8	22.5-28.5	-
SPT N_{60} Values	35	10-32	Depth dependent - Refer to Figure 4 in Annex A
Undrained Shear Strength (kN/m^2)	124	46-245	Depth dependent - Refer to Figure 8 in Annex A

1. Cautious estimate

5.2 Buried Concrete

Four soil samples, comprising one from the Made Ground and three from the London Clay Formation, were subjected to pH and water soluble sulphate determinations.

The characteristic value of water soluble sulphate was 36 mg/l for Made Ground, and 1,600 mg/l for the London Clay Formation.

Four soil samples, comprising one from the Made Ground and three from the London Clay Formation, were subjected to total sulphur and acid soluble sulphate content testing to allow a preliminary assessment to be made in relation to the potential thaumasite form of concrete attack. One of the oxidisable sulphides values calculated for the London Clay Formation were in excess of 0.3% (at 1.04%). Consequently, the results are considered indicative of significant risk from this form of concrete attack. A modification to DS class is therefore proposed for the London Clay Formation.

The characteristic value of pH was 8.4 for Made Ground, and 8.0 for the London Clay Formation.

Four samples of groundwater obtained during the monitoring programme were subjected to sulphate and pH determinations. The highest recorded value of sulphate was 1,830 mg/l and measured pH values ranged from 7.3-7.6. The characteristic value of pH for groundwater was 7.3.

Overall, with reference to the BRE Digest SD1 (2005), and considering the results of both soil and groundwater samples, design sulphate class of DS-1 and ACEC class of AC-1 is appropriate for the Made Ground; design sulphate class of DS-4 and ACEC class of AC-4 is appropriate for the London Clay Formation. However, due to the preliminary nature of the ground investigation and the limited number of tests undertaken, additional testing is recommended at a later stage to inform the design.

Mobile groundwater and brownfield conditions have been considered in this assessment in accordance with the ground investigation findings.

6.0 Preliminary Geotechnical Recommendations

6.1 General

It is proposed to redevelop the Site with five warehouse units. Current proposals are indicated in Figure 2 in Annex A.

Details of the proposed structures, anticipated loadings and serviceability criteria were under development at the time of the writing of this report, which is based on a preliminary investigation only. Further investigation will be required once proposals are fully developed and a detailed Geotechnical Design Report may need to be prepared.

The primary purpose of this report is to aid the due diligence process, identify risk and inform cost estimates. This report does not constitute a detailed design report for the proposed development.

A preliminary cut and fill plan ("Proposed Earthworks, Option 16", drawing ref.no.: 40237-BGL-XX-XX-DR-C-00201, rev.P04, 19/7/2024, Burrows Graham) was made available to TRC and has been considered in the recommendations discussed in the following sections.

6.2 Geotechnical Hazards

The preliminary ground investigation has identified a number of geotechnical hazards at the Site which relate to the proposed development. These are summarised below and are discussed in more detail in the following sections along with mitigation measures where appropriate.

- Made Ground recorded to depths of at least 2.20m. Thicker Made Ground cannot be ruled out across the Site especially in areas within the existing building footprint which was not fully accessible at this time;
- Buried obstructions, such as existing foundations, basements and retaining walls, old floor slabs and hardstanding, and large gravels and cobbles within Made Ground and potential claystones in London Clay Formation at depth;
- Ground conditions aggressive to buried concrete;
- Medium and high volume change potential of cohesive Made Ground and London Clay Formation soils respectively;
- Soil desiccation in the vicinity of vegetation;
- Sporadic shallow groundwater mainly of a perched nature within the Made Ground and the shallower weathered London Clay Formation soils; and
- Settlement prone natural soils to about 3-4m depth comprising the shallower weathered London Clay Formation soils, especially when under significant loading of proposed fill areas; and,
- Large variations in Site level and consequent need for earthworks and/or retaining walls.

6.3 Foundations

As described in section 4, the Site is underlain by up to 2.20m of Made Ground over London Clay Formation to at least 5.45m bgl.

The Made Ground unless treated to an appropriate specification, is not considered a competent foundation stratum due to its lithological variability and poor engineering properties.

Shallow pad or strip foundations founded below any Made Ground and within the London Clay Formation will be appropriate to support the proposed structures at a minimum foundation depth of 1.50m bgl and at least 100mm within that stratum, where an allowable bearing pressure (ABP) of 100kN/m² is available. The ABP increases to 125kPa at 2.50m bgl.

The foundations should also be taken below any desiccated soils and 300mm below any live roots, as may be encountered during excavation. It is recommended that final foundation depths and heave protection

measures for foundations be determined in accordance with Chapter 4.2 of the NHBC Standards, based on a high volume change (shrink-swell) potential.

The allowable bearing pressure values provided in this report comply with the presumed bearing resistance described in BS EN 1997-1 and includes an overall safety factor of 3 against bearing capacity failure. The anticipated foundation settlement associated with the presumed bearing resistance will be less than 25mm assuming the foundation recommendations provided in this report are adhered to.

6.4 Ground Improvement

According to the available preliminary cut and fill plan ("Proposed Earthworks, Option 16", drawing ref.no.: 40237-BGL-XX-XX-DR-C-00201, rev.P04, 19/7/2024, Burrows Graham) maximum earth cut of approximately 5.06m in the north and maximum fill of about 3.8m in the centre of the Site with associated precast retaining walls, are planned to enable construction of the proposed scheme.

Some form of ground treatment will be required mainly in areas proposed to be loaded by fill, to improve the ground and mitigate the risk of significant ground settlement. Ground treatment should be considered especially in areas of deep Made Ground and for the relatively incompetent weathered soils of London Clay Formation to about 3-4m depth below existing ground levels, recorded during the preliminary ground investigation. Some ground treatment may also be required in areas passing from fill to cut and in cut areas, to even out any potential differential settlement for proposed future slabs, foundations and structures.

For a suitable ground improvement technique, the advice of reputable specialist contractors experienced in the ground conditions discussed in this report should be sought. They should be responsible for the selection of appropriate equipment and the final design of the treatment.

The Site is considered likely to be amenable to treatment by the formation of vibro stone columns (VSC). Upon treatment an allowable bearing capacity in the region of 125-150kN/m² is anticipated subject to confirmation by a specialist contractor.

Other dynamic compaction methods such as the Rapid Impact Compaction could also be effective in loose granular Made Ground soils where present but would be less or non-effective in soft cohesive soils, especially below the water table.

The presence of obstructions such as existing foundations, basements and retaining walls, old floor slabs and hardstanding, and large gravels and cobbles within Made Ground and potential claystones in London Clay Formation at depth, should be considered in the selection of the most appropriate treatment method.

Unless the finally selected treatment scheme deals with the volume change potential of the soils on-site, in the vicinity of retained, removed or proposed vegetation, final foundation depths and heave precautions are recommended to be determined in accordance with Chapter 4.2 of the NHBC Standards, based on a high volume change (shrink-swell) potential. The foundations should also be taken below any desiccated soils and 300mm below any live roots, as may be encountered during construction.

Given the significant amount of earthworks proposed at the Site, sequencing and integration of any ground improvement works should be thoroughly considered within the overall scheme from a project management efficiency perspective that will also achieve the geotechnical and structural requirements.

6.5 Floor Slabs

Use of ground-bearing floor slabs following a ground improvement technique is likely to be the most cost-effective solution for the proposed structures, provided that the required settlement tolerances can be achieved and the finally selected ground treatment solution deals with the high volume change potential of the Site soils in the vicinity of any retained/removed/proposed vegetation. Advice from a specialist ground treatment contractor should be sought once the required floor loadings and settlement tolerances are known.

For a ground-bearing floor slab, the load bearing formation should be carefully inspected to ensure placement of the floor slab on competent strata. The formation should be proof rolled and any soft spots removed and replaced with compacted fill to an appropriate specification.

6.6 Earthworks

Excavations for shallow foundations, floor slabs, and laying services should be readily achievable using standard excavation plant. However, hard surfacing, old foundations and relict basement structures will require the use of breaking apparatus. Obstructions were encountered in Made Ground during the ground investigation.

For any load bearing formations, careful inspection should be undertaken to ensure placement in competent natural strata unless ground treatment has been carried out and properly validated. Any soft spots identified should be excavated and replaced with compacted granular fill or lean mix concrete. Concrete should be placed as soon as possible following excavation to avoid softening of the ground. A similar recommendation is also made for road pavement formations, although compacted granular fill could be used instead of concrete.

Any relict foundations or other subterranean structures beneath the footprint of the proposed buildings should be fully grubbed out. Such excavations should be surveyed and backfilled with an acceptable granular fill, placed and compacted to an engineering specification. The same recommendations are made for excavations that may be required to remove soil contamination, if required.

In areas of road pavements and hard standing, relict subterranean structures should be broken down to around 1m below finished Site level to minimise the risk of differential settlement due to the presence of hard spots. In soft landscaped areas it may be possible to limit such operations to 0.50m bgl.

Stability in excavation faces in Made Ground cannot be relied on and allowance should be made for battering faces back to a safe angle of repose, or providing shuttering. Support or battering of the excavation faces to a safe angle of repose will be required for all excavations where man entry is necessary, the nature and extent of which will need to be evaluated under CDM regulations.

According to the ground investigation and monitoring data, perched groundwater is anticipated within the Made Ground and sporadically at various levels within the shallower weathered layers of London Clay Formation. Thus it is considered that excavations will likely encounter some perched groundwater at various levels which could be dealt with localised pumping from a sump.

Groundwater levels vary seasonally and the timing of the construction programme may influence the volumes of groundwater that need to be managed. The developer should also consider the impact of weather and potential for rainwater and surface run-off to accumulate within excavations.

Water pumped from excavations may require pre-treatment prior to discharge. This could include settlement tanks to reduce silt and suspended solids. No significant contamination has been identified at the Site, therefore further filtration or other such treatment during the construction stage is considered unlikely. The contractor should consult with the local water authority and/or Environment Agency to obtain necessary discharge consents and agree the scope of pre-treatment prior to any discharge might be required.

Based on the proposed earthworks plan ("Proposed Earthworks, Option 16", drawing ref.no.: 40237-BGL-XX-XX-DR-C-00201, rev.P04, 19/07/2024, Burrows Graham) presented as Figure 9, Annex A maximum earth cut of about 5.06m in the north and maximum fill of about 3.8m in the centre of the Site with associated precast retaining walls, are planned to enable construction of the proposed scheme.

The proposed unit on the western side of the Site (unit 2) will be founded on natural soils following the reduced level excavation for the majority of the footprint. The design intent is to found these structures on the underlying London Clay Formation via shallow pad/strip foundations.

The rest of the proposed units (units 1, 3, 4, 5A and 5B) are to be mainly founded on a development platform raised using site won materials arising from other areas of the Site, primarily the north and west; unit 1 is proposed to be founded on fill material within the centre of the building footprint. The ground conditions here will be subject to vibro- ground improvement, as discussed previously, to improve engineering properties for construction.

Based on the preliminary ground investigation results the site-won materials would classify as Class 1 (Made Ground) and Class 2 (Made Ground and weathered London Clay Formation soils) based on the Specification for Highway Works (SHW 600 series) and will likely be appropriate for use as a general fill.

In areas of proposed cut, slopes as steep as 1v:3h (c.18.5°) are proposed based on the proposed earthworks plan which are anticipated to be stable, given the friction angle of the shallow ground comprising mainly Made Ground and London Clay Formation is expected to be greater than 18.5°. However, control of surface water and some form of erosion protection of the exposed cut slopes will be important especially in the long term.

Consultation with a specialist earthworks contractor is recommended at an early stage given the magnitude of the earthworks proposed. The preliminary ground investigation results and assessment presented in this report should be made available for an informed assessment with regard to earthworks materials suitability. Additional testing for earthworks materials assessment will be required at detailed design stage.

6.7 Pavements

Due to the variability of the natural ground conditions and the proposal for cut and fill earthworks which may create settlement issues at the Site, pavement surfaces in light loaded car park areas should be constructed in flexible materials such as bituminous compounds or block paving which are more easily able to accommodate ground movement and can be more easily repaired. Heavily loaded areas such as concrete yards and loading areas where less ground settlement can be tolerated, could be constructed on previously treated ground and/or reinforced subbase with geogrids/geotextiles to satisfy design criteria.

It is recommended that any fill proposed is placed and compacted in accordance with a suitable specification based on the Specification for Highway Works (SHW 600 series). The formation level should be rolled and inspected for any soft or loose material. These materials should be removed and replaced with granular fill placed and compacted in accordance with a suitable specification.

Assuming excavation formation soils will comprise Made Ground and London Clay Formation, an equilibrium CBR value of 3% is recommended for preliminary design purposes, based on a qualitative assessment and the findings of the preliminary ground investigation.

In-situ CBR testing at formation level prior to construction is recommended to confirm the design CBR values adopted.

6.8 Buried Concrete

In the consideration of sulphate attack on buried concrete, reference has been made to BRE Digest SD1 (2005) which classifies the Site as a brownfield site with mobile groundwater conditions. Additionally, as London Clay Formation can be pyrite bearing, it has also been necessary to assess the potential for the thaumasite form of attack in case these strata are disturbed.

Based on the results of the concrete classification tests design sulphate classes of DS-1 for the Made Ground, and DS-4 for the London Clay Formation are recommended. Further, considering the pH values, ACEC classes of AC-1 for the Made Ground, and AC-4 for the London Clay Formation are recommended.

The above assessment assumes that London Clay Formation will be disturbed as per the definition of BRE Digest SD1 – Appendix A1. This assumption is in accordance with the development drawings, which indicate that cut and fill within London Clay Formation and backfilling with London Clay Formation arisings is proposed.

Mobile groundwater and brownfield conditions have been considered in this assessment in accordance with the ground investigation findings and as a worst-case assumption.

Due to the preliminary nature of the ground investigation and the limited number of tests undertaken, additional testing is recommended at a later stage to inform the design.

6.9 Soakaway Potential

Soakaway testing did not form part of the scope of works, however given the predominantly cohesive nature of the Site soils, shallow soakaways will not be viable for future developments.

6.10 Recommendations for Further Work for Geotechnical Purposes

The preceding sections have attempted to provide geotechnical recommendations to aid due diligence, but further work will be required to fully quantify the risks and allow detailed design of the proposed development.

Further ground investigation work for geotechnical purposes should comprise additional exploratory holes to delineate and further assess the sequence and properties of strata beneath the current building and beneath the proposed development, and to obtain samples for further geotechnical testing including earthworks testing.

The additional ground investigation should include as a minimum (indicative at this stage) deep cable percussive boreholes to about 12-15m depth in areas of proposed deep cut and fill, trial pitting for earthworks testing, and cone penetration testing to circa 12-15m depth to inform ground improvement design. Installation of piezometers and further monitoring is recommended at the existing and additional exploratory hole locations to further clarify the groundwater regime at the Site.

7.0 Human Health Risk Assessment

7.1 Soil Assessment

In order to appraise the significance of the concentrations reported by laboratory testing, TRC has assessed each contaminant species that is elevated above the laboratory method detection limits (MDL) against published screening criteria referred to as Generic Assessment Criteria (GAC). GACs are derived from the following reference material:

- Land Quality Management Limited and Chartered Institute of Environmental Health (November 2014), the LQM/CIEH S4ULs for Human Health Risk Assessment. Document reference: S4UL3435;
- Development of Category 4 Screening Levels for assessment of land affected by contamination – SP1010 (September 2014);
- LQM S4ULs: evaluation of 2017USEPA Toxicological Review of Benzo(a)pyrene; and,
- LQM/CIEH S4ULs for Nickel according to land use (Revised August 2015).

TRC has selected GACs for a commercial or industrial, based on the proposed development comprising a commercial end use.

A conservative value of 1% of soil organic matter (SOM) has been assumed based on the soil type.

A summary of the laboratory data and the screening tables with relevant GACs is presented in Annex G.

7.2 Heavy Metals

Minor concentrations of heavy metals were detected in soil samples (both Made Ground and natural soils). None of the concentrations exceeded the GACs.

7.3 Hydrocarbons

Minor concentrations of hydrocarbons were detected in soil samples (both Made Ground and natural soils). None of the concentrations exceed the GACs.

7.4 Asbestos

Asbestos fibres were not identified in any of the 15 No. soil samples tested.

7.5 Discussion

Contaminant concentrations were generally low and no exceedances were identified when screened against the GACs. Further investigation is recommended under the existing building footprint post demolition.

There are three known above ground fuel tanks associated with three backup generators located in the plant rooms. Whilst there is no evidence to suggest widespread hydrocarbon contamination is present, there may be localised impacts in the immediate vicinity of the tanks. The tank will need to be appropriately decommissioned and removed to facilitate development and verification sampling and testing of soils from around the tanks will need to be undertaken.

8.0 Controlled Waters Risk Assessment

In order to appraise the significance of the groundwater/soil leachate concentrations recorded, TRC has assessed each contaminant species that is elevated above the laboratory LOD against the following published guidance values:

- Drinking Water Standards England and Wales (2000) (amended);
- Environmental Quality Standards (EQS) for freshwater; and,
- World Health Organisation (WHO) Guidelines.

Groundwater monitoring recorded groundwater in all five monitoring wells ranging from 0.57 m bgl to 4.64 m bgl, WS105 was dry on the first monitoring visit. No free phase oils or hydrocarbons odours were identified. Groundwater samples were taken from each borehole was sent to I2 Analytical for laboratory analysis.

8.1 Groundwater Assessment

The laboratory analysis reported elevated concentrations of nickel and selenium exceeding the UK DWS in three groundwater collected. The exceedances are summarised in the below table.

Table 8.1: Summary of Groundwater Exceedances

Contaminant	DWS (µg/l)	Maximum Concentration (µg/l)	Location of Maximum Concentration	No. of Exceedances
Nickel	20	22	WS103	1
Selenium	10	59	WS103	3

The Site is not within a groundwater SPZ and is therefore not considered to be sensitive to contamination.

The nearest active groundwater abstraction is located greater than 500m south-east of the Site.

The Site is underlain directly by the London Clay Formation which is designated as Unproductive Strata and is therefore not considered to be sensitive to contamination.

8.2 Surface Water Assessment

The laboratory analysis reported elevated concentrations of cadmium, chromium, copper, nickel and zinc exceeding the EQS in four groundwater samples collected. The exceedances are summarised in the below table.

Table 8.2: Summary of Groundwater Exceedances

Contaminant	EQS (µg/l)	Maximum Concentration (µg/l)	Location of Maximum Concentration	No. of Exceedances
Cadmium	0.08	0.16	WS103	1
Chromium	4.7	7.7	WS103	3
Copper	1	8.2	WS103	4
Nickel	4	22	WS103	3
Zinc	10.9	23	WS107	2

There are three surface water features on the Site. The Site is underlain by low permeability strata and groundwater is considered unlikely to be in hydraulic connection with surface waters. Exceedances are minor and are unlikely to present a significant risk.

8.3 Discussion

TRC consider that the groundwater data reflects the history of commercial land use at the Site. The underlying soils strata are designated by the EA as an Unproductive Strata which decreases environmental sensitivity. Although concentrations of heavy metals exceeded the DWS and EQS in the samples collected, the exceedances are considered to be fairly marginal against conservative standards and unlikely to pose a significant risk to controlled waters.

On this basis, TRC consider that it would be unlikely that remediation would be required to facilitate redevelopment of the Site.

9.0 Ground Gas and Organic Vapour Risk Assessment

A preliminary ground gas risk assessment has been undertaken in accordance with British Standard BS 8485:2015+A1:2019 to assess the impact of permanent ground gases upon the proposed development.

Three of four visits have been undertaken at the time of reporting; this report will be updated once the final round of monitoring has been undertaken..

9.1 Ground Gas Assessment

Field monitoring for permanent ground gases was performed at five monitoring well locations on three occasions at the time of reporting, between 5th and 23rd July 2024, one visit is outstanding. The maximum concentrations are summarised in the table below and the complete monitoring data are provided within Annex D.

Table 9.1: Summary of Gas Monitoring Results

Location	Maximum Methane Concentration (%v/v)	Maximum Carbon Dioxide Concentration (%v/v)	Minimum Oxygen Concentration (%v/v)	Maximum Flow Rate (l/hr)
WS101	< 0.1	0.1	19.6	0.3
WS102	< 0.1	0.4	17.5	0.3
WS103	< 0.1	20.2	8.0	0.5
WS105	< 0.1	2.5	17.7	0.4
WS107	< 0.1	1.9	18.7	0.4

Methane was not detected during the monitoring visits.

Carbon dioxide was detected in all of the monitoring wells with concentrations ranging from 0.1% to 20.2%.

Oxygen concentrations were depleted in WS103 and this was noted to correlated to higher carbon dioxide concentrations in theses monitoring wells.

Flow was detected in all of the monitoring wells with a maximum 0.5 l/hr in WS103.

TRC has preliminarily assessed the permanent ground gas concentrations in accordance with current guidance (BS8485:2015). Based on the results, a gas screening value (GSV) of 0.0005 l/hr for methane and a GSV of 0.101 l/hr for carbon dioxide were calculated, which would classify the Site as Characteristic Situation 2 (low risk).

Falling pressure was recorded on the first visit and is considered reflective of worst case scenario.

9.2 Organic Vapour from Soil Assessment

For hydrocarbons and other volatile organic carbons (VOC) the LQM S4ULs are considered to be protective of human health from indoor inhalation of organic vapour. Based on the results presented in section 7, there were no exceedances of volatile contaminants and further assessment will be required.

Field monitoring detected elevated PID readings in any of the boreholes. The highest concentration was identified within WS101 (0.9 ppm). The results are consistent with the results of the soil analysis.

Organic vapour protection measures are not considered to be required.

9.3 Organic Vapour from Groundwater Assessment

In order to appraise the significance of volatile substances in groundwater to human health, TRC has assessed each contaminant species that is elevated above the laboratory LOD against the following published guidance values:

- SoBRA, Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater, Version 1 (2017).

There are no exceedances of the SoBRA GAC indicating there is not a risk to human health from volatile contaminants.

Organic vapour protection measures are not considered to be required.

9.4 Discussion

Elevations of carbon dioxide was recorded in on all three occasions in WS103 is Characteristic Situation 2 (low risk). However, WS103 was located under an area of carparking.

One visit is outstanding at the time of reporting however, it is unlikely that the classification of the Site will change. The report will be updated following completion of the monitoring.

Further monitoring within the proposed building footprint should be undertaken to confirm ground gas classification.

10.0 Contaminated Land Risk Assessment

The methodology of this risk assessment uses the source-pathway-receptor pollutant linkage to provide a qualitative appraisal of environmental risks and potential liabilities associated with soil and groundwater contamination at the Site. The conceptual site model (CSM) has been prepared considering the proposed end use as a commercial end usage

10.1 Sources of Contamination

The ground investigation performed at the Site by TRC identified the following sources of contamination:

- Concentrations of nickel and selenium in excess of EQS in groundwater
- Concentrations of cadmium, chromium, copper, nickel and zinc in excess of DWS in groundwater
- Elevated carbon dioxide concentrations

10.2 Pathways

Based on the information presented in this report the following potentially active pathways have been identified. Consider both construction phase and operational phase.

- Dermal contact or ingestion with soil and groundwater
- Contact with buried services
- Migration of ground gas and ingress into buildings

10.3 Receptors

Based on the information presented in this report the following receptors have been identified.

- Construction and maintenance workers could be exposed to contamination during groundworks and future maintenance works
- Construction materials could come into contact with contamination in the ground

10.4 Revised Conceptual Site Model

The following CSM has been prepared to take into consideration the findings from the intrusive investigation.

Table 10.1: Revised Conceptual Site Model

Source	Pathway	Receptor	Risk
Heavy metals across much of the site in groundwater	Leaching of contaminants and vertical migration into groundwater	Groundwater (unproductive strata)	Low The Site is underlain by the London Clay Formation which is designated as Unproductive Strata and is not considered to be sensitive to contamination.
	Lateral migration in groundwater	Surface water features on Site	Low The Site is directly underlain by low permeability clays of the London Clay Formation and groundwater is considered unlikely to be in hydraulic connection with off-site surface water features.

Source	Pathway	Receptor	Risk
Elevated concentrations of carbon dioxide	Migration of ground gases/organic vapour within granular strata and ingress into buildings and confined spaces	Future site users	Low Area of the Site is classified as Characteristic Situation Level 2 (Low Risk). Ground gas protection measures will be required in proposed new buildings.
		Construction workers	Low Pathway to be managed through good construction practices and mitigation of risks when working in confined spaces.

11.0 Summary and Conclusions

11.1 Findings

The 5.8-hectare Site is irregular in shape and is located at Shinfield Park, Shinfield, Reading, RG2 9FW. The Site comprises a large concrete office block with two-storey underground car park; also present is a smaller steel framed warehouse or temporary office block. Three hardstanding areas are present for car parking, there is also a pond in the southwest of the Site and several areas of soft landscaping.

The ground conditions comprised Made Ground to 2.20m bgl over the London Clay Formation to at least 5.45m bgl, where the exploratory holes terminated. The base of the London Clay Formation was not confirmed during the investigation.

During the ground investigation, groundwater was encountered within the Made Ground as a seepage in WS102 at 0.20m bgl. During groundwater monitoring, groundwater was encountered 0.66m and 4.64m bgl, within the Made Ground and London Clay Formation. In brief, perched groundwater is anticipated within the Made Gound and sporadically at various levels within the shallower weathered layers of London Clay Formation.

11.2 Summary of Geotechnical Assessment

The primary purpose of this assessment is to aid the due diligence process identify geotechnical risk, and inform cost estimates. This report does not constitute a detailed geotechnical design report for the proposed development.

The ground investigation has identified a number of geotechnical hazards at the Site which relate to the proposed development. These are locally thick Made Ground, buried obstructions, ground's aggressiveness to buried concrete, medium to high volume change potential of the site soils, soil desiccation in the vicinity of vegetation, sporadic shallow groundwater, settlement prone soils to about 3-4m depth, large variations in site level and need for earthworks and / or retaining walls on Site. These hazards are discussed in detail along with mitigation measures in section 6 of this report.

Shallow foundations are possible for the proposed structures within the London Clay Formation where feasible given the significant earthworks proposed. Some form of ground treatment will be required mainly in areas proposed to be loaded by fill, to improve the ground and mitigate the risk of significant ground settlement. Ground treatment should be considered especially in areas of deep Made Ground and for the relatively incompetent weathered soils of London Clay Formation to about 3-4m depth below existing ground levels, as recorded during the preliminary ground investigation. Some ground treatment may also be required in areas passing from fill to cut and in cut areas, to even out any potential differential settlement for proposed future slabs, foundations and structures. Details of the foundation options including allowable bearing pressures are discussed in sections 6.3 and 6.4.

Ground bearing slabs on previously treated Made Ground and weathered London Clay Formation soils to a suitable specification could be adopted. Details are provided in section 6.5 of this report.

Preliminary recommendations about proposed earthworks, classification for buried concrete design, and proposed pavements for the development are given in sections 6.6 to 6.8.

Soakaway drainage is unlikely to be suitable for this Site, due to the cohesive nature of the site soils, as discussed in section 6.9.

Additional ground investigation work and assessment is recommended to further clarify matters related to geotechnical hazards and inform later stages of the development, as discussed in detail in section 6.10.

11.3 Summary of Contaminated Land Risk Assessment

11.3.1 Soil

There were no exceedances of the GAC in soils for the proposed commercial end use and there is not considered to be a potential risk to human health receptors.

11.3.2 Groundwater

The laboratory analysis reported elevated concentrations of nickel and selenium exceeding the UK DWS in three groundwater collected. The exceedances are summarised in the below table.

The Site is not within a Groundwater Source Protection Zone (SPZ) and is underlain directly by the London Clay Formation which is designated as Unproductive Strata and is therefore not considered to be sensitive to contamination.

The laboratory analysis reported elevated concentrations of cadmium, chromium, copper, nickel and zinc exceeding the EQS in four groundwater samples collected.

There are three surface water features on the Site. The Site is underlain by low permeability strata and groundwater is considered unlikely to be in hydraulic connection with surface waters. Exceedances are minor and are unlikely to present a significant risk.

11.3.3 Ground Gas and Organic Vapour

Elevations of carbon dioxide was recorded in on all three occasions in WS103 is Characteristic Situation 2 (low risk).

One visit is outstanding at the time of reporting however, it is unlikely that the classification of the Site will change. The report will be updated following completion of the monitoring.

Further monitoring within the proposed building footprint should be undertaken to confirm ground gas classification.

11.3.4 Remediation and Mitigation Measures

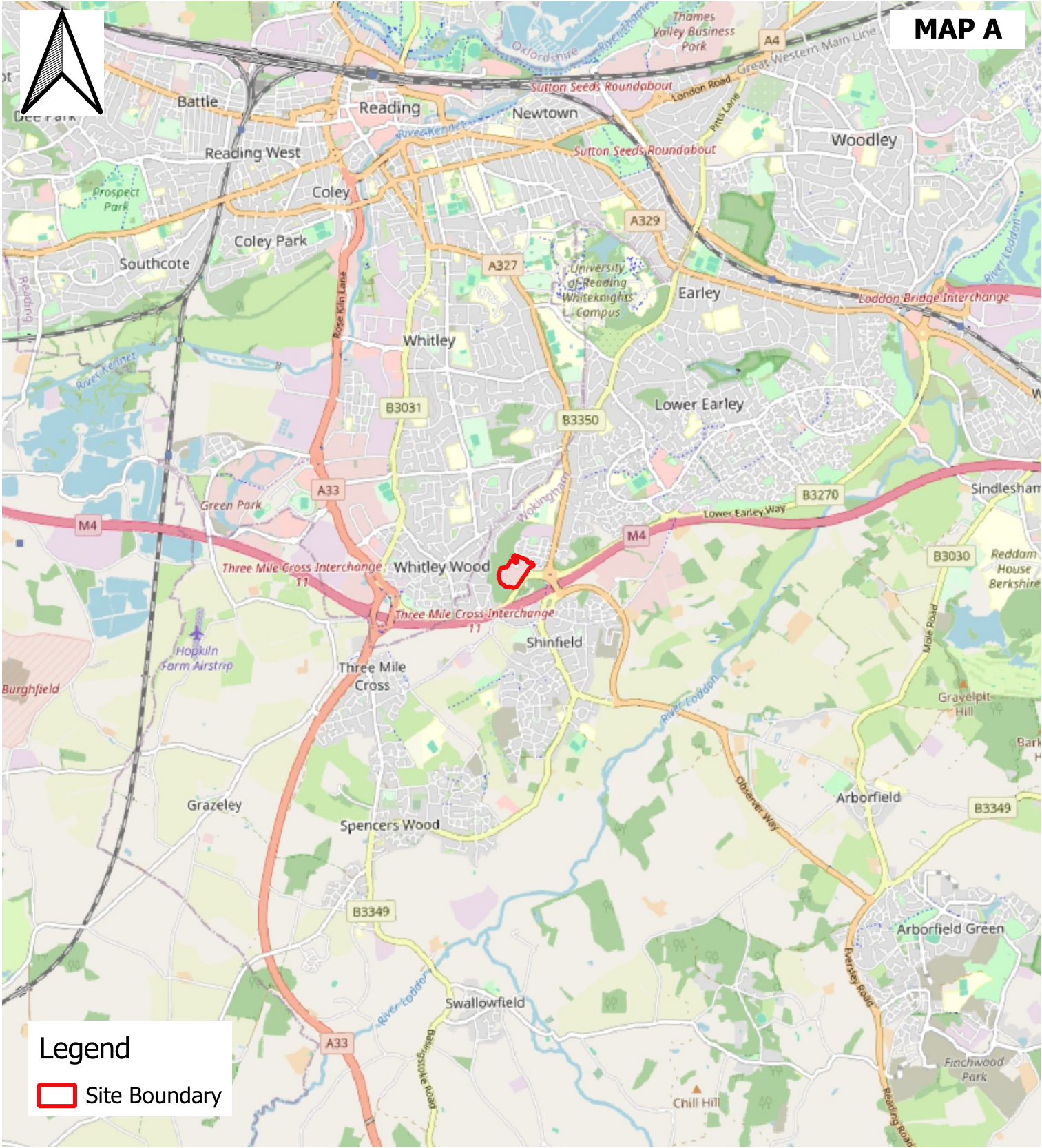
Based on the results of the results of the generic risk assessments undertaken remediation is not considered necessary.

The selection of appropriate water supply pipework should be confirmed by the local water supply company.

Materials destined for off-site disposal to landfill may require further assessment in accordance with WM3 'Guidance on the classification and assessment of waste' (1st edition version 1.2 GB 2021) to determine their waste classification.

If materials are to be re-used on site or imported from another development site, a materials management plan may be required in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice in order to demonstrate that the material is not a waste.

Annex A: Figures



NOTES	COPYRIGHT NOTES			REVISIONS			 Work.Life, 20 Red Lion St, London WC1R 4PQ		TITLE	
	Google Imagery January 2024								SITE LOCATION PLAN	
	© OpenStreetMap contributors - Data is available under the Open Database License. Cartography licensed as CC BY-SA.						TRC PROJECT NO.		SCALE	
							610344		MAP A: 50,000:1 MAP B: 2,000:1	