



GROUND INVESTIGATION REPORT FOR NET WORLD SPORTS, WREXHAM

VERSION 1.3

TE1456GIR1.3

10 JULY 2021

FINAL

Prepared for:

Net World Sports

Prepared by: Eve Rowland

Tier Environmental Ltd

DOCUMENT CONTROL

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EXECUTIVE SUMMARY

Introduction	Tier Environmental was commissioned by Tier Consult Ltd on behalf of Net World Sports Ltd to undertake a Ground Investigation at land off Bryn Lane, Wrexham. The purpose of the investigation was to assess the nature of soil and groundwater beneath the Site for the purposes of environmental and geotechnical assessment.
Proposed land use	It is proposed that the site will be developed as a warehouse/storage unit with associated offices, parking, roadways and soft landscaped areas. Areas of proposed soft landscaping are located mainly in the northern and western areas of the Site; however smaller areas of soft landscaping are present across the site as a whole.
Site location and surrounding land uses	The site is located at Plot 3A, Bryn Lane, Wrexham Industrial Estate, Holt, Wrexham, LL13 9UT. The site is surrounded by agriculture fields to the north (beyond Ridley Wood Road), east and south of the Site. Wrexham Industrial estate is located to the west of Site beyond Bryn Lane. Trees are located immediately to the southern and eastern boundaries of the Site.
Site history	Historical maps and third party information states the Site has been historically undeveloped and has been used for agricultural purposes.
Potential contaminative features	No significant potentially contaminative features have been identified on the Site.
Mining and quarrying	The Site is not located within a mining area or an area subject to historic quarrying.
Previous investigations	A Geo-Environmental Desk Study was conducted for the Site by Shepherd Gilmour Environmental Ltd in October 2011. Conclusions of this desk study identified potential contamination sources associated with Made Ground within infilled ponds, potential ground gas associated with unknown Made Ground deposits and impacts on of Site from trade effluent discharges into the tertiary river adjacent to the southern Site boundary.
Fieldwork	Tier Environmental conducted 3 No. days fieldwork on 6 th , 9 th and 10 th April 2021 which comprised: 1 No. day window sample drilling (WS1 to WS4 and WS6) to depths between 3.50m bgl and 5.45m bgl to determine the nature and extent of soil and groundwater and obtain samples for geo-environmental and geotechnical analysis. 3 No. cable percussive boreholes (CP1 to CP3) to depths between 10.00m bgl and 10.45m bgl to determine the nature and extent of soil and groundwater and obtain samples for geo-environmental and geotechnical analysis. - Excavation of 6 No. hand dug pits (HDP1 to HDP6) to obtain shallow soil samples for geo-environmental analysis.
Laboratory testing	Samples of soil were submitted for analysis of a range of metal, other inorganic and organic components including asbestos. Geotechnical testing was scheduled on selected samples. All testing was undertaken at accredited laboratories.
Ground conditions	Topsoil was encountered at ground level in all exploratory hole locations to depths between 0.23m bgl to 0.38m bgl. Underlying the Topsoil was firm to stiff, locally very stiff clay (Till). Till was encountered in all exploratory hole locations to a maximum depth of 10.45m bgl, however the base of this unit was not encountered
Ground stability	The ground across the Site was stable.
Foundations and floor slabs	The preferred, most economic foundation solution is likely to be shallow spread foundations (pads or strip) within the Till and it is proposed that floor slabs are ground bearing.
Design Sulphate class	It is considered that a Design Sulphate Class of DS-1 and ACEC Class AC-1 is appropriate for buried concrete at the Site within the topsoil and a Design Sulphate Class of DS-2 and ACEC Class AC-2 is appropriate for buried concrete at the Site within the Till.
Human Health Risk Assessment	No measured soil concentrations of potential contaminants of concern have been reported in excess of Generic Assessment Criteria (GACs) protective of human health appropriate to commercial site end use
Ground Gas Risk Assessment	A Gas Screening Value of 0.0045 l/hr has been calculated, derived using the maximum recorded carbon dioxide concentration of 1.5 %v/v and the maximum peak flow rate of 0.3 l/hr. Assessment of this gas screening value alone places the Site in a Characteristic Situation 1 – Very Low risk scenario in accordance with CIRIA C665 for which ground gas protection measures are not required. The results of carbon monoxide and hydrogen sulphide monitoring has determined that neither gas has been detected.
Radon Requirements	Data from UKRadon.org indicates that the majority of the Site lies within an area where less than 1% of the properties lie above the action level, therefore no radon protection measures are required. However, the north-western corner of the Site falls into an area where 1% - 3% of the properties lie above the action level. This is most likely the result of the bedrock Salop Formation, which is shown on the BGS records to be overlain by approx. 30m to 40m of superficial Till, meaning radon is unlikely to affect this area. however, although unlikely, any proposed buildings with basement levels in the north-western corner of the Site which falls into the 1% to 3% action level, should have a Visqueen (or equivalent) barrier membrane installed.



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1. INTRODUCTION

Tier Environmental was commissioned by Tier Consult Ltd on behalf of Net World Sports Ltd to undertake a Ground Investigation Report for an area of land referred to as Net World Sports, Wrexham, located at Plot 3A, Bryn Lane, Holt, Wrexham, LL13 9UT (the "Site").

The title of this report is in accordance with that described in the Land Contamination Risk Management guidance (available at <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm>) which has superseded CLR 11:

Stage 1:

- LCRM Tier 1 Preliminary Risk Assessment Report
- LCRM Tier 2 Generic Quantitative Risk Assessment Report

1.1. Proposed Development

Under current proposals the development will comprise a single-storey warehouse/storage unit with associated offices, parking roadways and soft landscaped areas. Areas of proposed soft landscaping are located mainly in the northern and western areas of the Site; however smaller areas of soft landscaping are present across the site as a whole.) as presented in Appendix A. As such, in accordance with the '*Updated technical background to the CLEA model*' (Environment Agency, 2009) and '*Suitable 4 Use Levels*' (LQM / CIEH 2015) the proposed generic land use for this development is commercial / industrial.

1.2. Previous Reports

The following report was made available to Tier Environmental to review, the findings of the report is presented in Section 3.

- Shepherd Gilmour Environmental Ltd – 'Geo-Environmental Desk study of Plot 3A, Bryn Lane, Wrexham Industrial Estate, Wrexham' (Report reference: T01515 CM (ME1178) dated October 2011).

1.3. Objectives

Taking into account the proposed development of the Site, the objectives of this appraisal were:

- To review previous pertinent third party reports.
- To determine current ground and groundwater conditions.
- To determine the potential risks to human health and the wider environment.
- To determine potential risks posed to the Site from hazardous ground gases and / or vapours.
- Provide preliminary outline remedial measures to manage any identified risks.
- To provide preliminary geotechnical parameters to inform floor slab and foundation recommendations.



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1.4. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or as shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigation has been designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms 'shallow' and 'deep' within this report assume *typically* between ground level to circa 5.00m below ground level (bgl) for 'shallow' and greater than 5.00m bgl regarded as 'deep'.
- The comments and opinions presented in this report are based on the findings of the review of third-party information, ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the Site which have not been revealed by this investigation and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by this investigation. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

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2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview.

Site name	Net World Sports, Wrexham.
Site address	Plot 3A, Bryn Lane, Holt Wrexham Industrial Estate, Wrexham, LL13 9UT. A site location plan is included as Drawing No. TE1456GIR1.0 within Appendix A.
National Grid Reference (NGR)	339265, 350806.
Approximate Site area	20.6 ha.
Site shape	The Site is rectangular in shape.
Current land use on the Site	The Site is currently undeveloped and comprises of 3 No. fields, which have historically been used for agriculture with ponds, hedgerows and trees all present on Site.
Surrounding land uses	The site has agriculture fields to the north beyond Ridley Wood Road, and to the east and south of the Site. Wrexham Industrial estate is located to the west of Site beyond Bryn Lane. Trees are located immediately to the south and south east boundaries of the Site.
General topography and ground levels	The Western part of the Site is approx. 32m AOD dropping to 25m AOD in the east. The Site is accessed by gates (a gate to each separate field) on Ridley Wood Road.

An aerial photograph of the Site and site boundary is shown below. Relevant Site photographs are presented in Appendix F.

Figure 2.1 Recent Aerial Photograph from Google Earth





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3. REVIEW OF SHEPHERD GILMOUR REPORT AND UPDATED PRELIMINARY RISK ASSESSMENT

Shepherd Gilmour Environmental Ltd produced a 'Geo-Environmental Desk study of Plot 3A, Bryn Lane, Wrexham Industrial Estate, Wrexham' (Report reference: T01515 CM (ME1178) dated October 2011). The Shepherd Gilmour Report included a strip of land to the south and is no longer part of the revised redline boundary as presented in Figure 2.1.

The table below summarises the desk study and incorporates updated preliminary risk assessment by Tier Environmental where appropriate.

Table 3.1 Report Review Summary

Site history	The historical plans show that the Site has been undeveloped (open fields) since earliest available mapping (1873).
Potential contaminative features identified	The following summarises potential contamination on Site: • Unknown Made Ground or Made Ground within infilled ponds. • Potential ground gases associated with unknown Made Ground on Site
Mining and quarrying	A coal mining report (Coal and Brine Report) was obtained from the Coal Authority for the Site immediately south of the study area which indicates that the Site is not likely within the zone of influence on the surface from past or present mine workings. The property is not in an area where coal is believed to exist at or close to the surface which may have been worked in the past. A review of the Coal Authority interactive map confirms the site is not in a High-Risk Development Area or there are recorded mine entries. The Environmental Database Search does not report any significant issued as a result of collapsible ground, ground dissolution, landslides, running sand, shrinking, swelling clay or compressible ground.
Geology	The site is underlain with drift deposits comprising Glacial Till deposits which overly the solid geology of the Lower Mottled Sandstone and the Sandstone/Mudstone/Conglomerate of the Salop Formation for the western part of the site and Kinnerton Sandstone Formation for the eastern part of the site.
Hydrogeology and Hydrology	The nearest water course is an unnamed tertiary river forming the southern boundary of the main development area and there are a number of drainage ponds and ditches on Site. There are no recorded potable water abstractions within 1km of the Site. The Site is located over both a Principal and Secondary A Aquifer (bedrock formations). The Glacial Till deposits are classed as an unproductive aquifer. The Site is not within 250m of a Source Protection Zone.
Landfills	Information obtained within the Environmental Database Search as part of the Shepherd Gilmour desk study indicates that there are no licensed landfill sites within 250m of the Site. There is an Environment Agency licensed waste site located 121m south of the Site operated by Waste Recycling Group and this receives less than 25,000 tonnes of household, industrial and commercial waste. The review of historical maps indicate that former ponds present on Site may have been infilled. Tier Environmental has reviewed the historical maps which show 5 No. potential infilled ponds; 2 No. in the centre of the northern field, 2 No. in the centre of the middle field (shown to be potentially existing) and 1 No. in the centre of the southern field.
Fuel/Chemical storage	No fuel or chemical storage has been identified within 250m of the Site, however, the Shepherd Gilmour report identifies a number of tanks in close proximity of the Site. The current Site outline has now changed meaning these tanks are no longer in close proximity or pertinent to the Site. Below is an excerpt from the Shepherd Gilmour report: "Historical plans and Site layout plans show a number of tanks located between 40m and 100m south and west of the main development area. The contents of these tanks are unknown. The Environmental Database Search indicates 1 No. fuel station entry within 250m of the Site. The details of it are as follows: • Cpl Petroleum Wrexham – 20m west of the Site."



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Ground Gas	There is potential for ground gas generation (especially localised in the areas of potential infilled ponds) within the Made Ground and sub-surface Soils which may pose a risk to future site users and any proposed buildings on site through vapour/gas inhalation and vapour/gas ingress and accumulation within buildings.
Geotechnical risks	A low potential for compressible and collapsible ground was identified in the Environmental Database Search, and further investigation of the potential hazards associated with potential areas of Made Ground, the location of on-Site ponds/drainage ditches in relation to the proposed development, and differential settlement from the proposed structure are considered necessary due to the size and potential loadings of the proposed development. Prior to future phases of development, a full geotechnical assessment of the soils underlying would be required.
Radon Requirements	Shepherd Gilmour states "The Site does not lie within an area where radon protection measures are required." However, Tier Environmental has reviewed Radon information from UKRadon.org which "shows the majority of the Site lies in an area where less than 1% of the properties lie above the action level with the exception of the north-western corner of the Site falls into an area where 1% - 3% of properties lie above the action level. Based on this assessment no radon protection measures are required.



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4. PRELIMINARY CONCEPTUAL SITE MODEL

Based on the information provided in the previous sections of this report a combined preliminary conceptual site model and conceptual exposure model has been developed for the proposed future land use. This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors. In assessing the likely contaminants of concern present at the Site, reference has also been made to Defra and Environment Agency supporting documentation. A preliminary qualitative risk assessment has also been made of the likelihood of the linkage operating and its potential significance in accordance with CIRIA C552.

The potential pollutant linkages identified and the qualitative risk assessment for these are presented in Table 4.1 below. The terms used in the preliminary qualitative risk assessment are defined in Appendix H.

4.1. Uncertainties

The following uncertainties exist in the preliminary conceptual model:

- The presence of any features unrecorded by the historic maps.
- Any unrecorded geological features.
- Any unrecorded pollution events during the Site's history.

Table 4.1 Preliminary Assessment of Potential Pollutant Linkages.

Justification / Comments	Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
The information included in the preliminary conceptual site model has been obtained from publicly available sources (British Geological Survey, Geolindex, The Coal Authority and The Environment Agency, along with reviewed information obtained from third party reports. - The Site is located at Plot 3A, Bryn Road, Holt, Wrexham Industrial Estate, Wrexham, LL19UT. The surrounding land uses to the Site are commercial/Industrial; - The Site has remained undeveloped since earliest available mapping (1873) and comprises open fields, possibly historically used for agricultural purposes. - The Site has agriculture fields to the north beyond Ridley Wood Road, and to the east and south of the Site. Wrexham Industrial estate is located to the west of Site beyond Bryn Lane. Trees are located immediately to the south and south east boundaries of the Site. - The Site's superficial geology comprises of Glacial (Diamictic) Till, an Unproductive Aquifer, overlying the Lower Mottled Sandstone Formation (Shrewwood Sandstone Group) and the Salop Formation (Westphalian D) comprising sandstones, mudstones and conglomerate. The bedrock formations are a Principal Aquifer and Secondary A Aquifer respectively. - The nearest water course is an unnamed tertiary river forming the southern boundary of the main development area and there are a number of drainage ponds and ditches on Site. There are no recorded portable water abstractions within 1km of the Site. The Site is located over both a Principal and Secondary A Aquifer (bedrock formations). The Glacial Till deposits are not afforded an aquifer classification. The Site is not within 250m of a Source Protection Zone. - Information obtained within the Environmental Database Search indicates that there are no licensed landfill sites within 250m of the Site. There is an Environment Agency licensed waste site located 121m south of the Site operated by Waste Recycling Group and this receives less than 25,000 tonnes of household, industrial and commercial waste. The review of historical maps indicate that former ponds present on Site may have been infilled. - Data from UKRadon.org shows that the majority of the Site lies within an area where less than 1% of the properties lie above the action level, therefore no radon protection measures are required. However, the north western corner of the Site falls into an area where 1% - 3% of the properties lie above the action level. - There is potential for localised ground gas generation within the Made Ground and sub-surface Soils from historical backfilled ponds which may pose a risk to future site users and any proposed buildings on site through vapour/gas inhalation and vapour/gas ingress and accumulation within buildings. - The Site is not located within an ecologically sensitive area.	Anticipated localised Made Ground contamination associated with Made Ground general, at the Site entrance gates and potential infilled pond deposits present on Site.	Metals	Direct contact, ingestion and inhalation of dust	Future Site end users	Medium	Low Likelihood	Moderate / low risk
		PAHs	Leaching and migration via groundwater	Ground/Site workers	Medium	Low Likelihood	
		Phenols	Lateral and vertical migration of mobile contaminants	Adjacent properties	Medium	Unlikely	
		pH		Underlying Aquifers	Medium	Unlikely	
	Potential for asbestos contamination within the Made Ground deposits of former backfilled ponds (localised)	Asbestos	Direct contact, ingestion and inhalation of dust	Future Site end users	Medium	Low Likelihood	Moderate / low risk
			Dust migration	Ground/Site workers	Medium	Low Likelihood	
	Potential for ground gas generated from assumed backfilled Ponds or potential Made Ground on Site.		Vapour inhalation	Future Site end users	Medium	Unlikely	
			Lateral and vertical migration of mobile contaminants	Ground/Site workers	Medium	Unlikely	
		Hazardous Ground Gas					Moderate / low risk
				Proposed buildings on Site	Severe	Unlikely	

For definition of the terms used in the qualitative risk assessment, please see Appendix H.



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5. FIELDWORK

The information contained in this report is limited to areas of land accessible during the ground investigation within the Site boundary, as indicated on the Site plan, presented in Appendix A as Drawing No. TE1456GIR1.0.

Tier Environmental scoped the intrusive ground investigation using guidance presented in:

- BS 10175:2011+A2:2017;
- Land Contamination Risk Management (LCRM) - <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm>;
- BS 5930:2015+A1:2020;
- BS EN 1997:2004 and 2007.

Tier Environmental's standard strata description criteria are compliant with the above guidance.

5.1. Scope of Ground Investigation

The ground investigation was conducted between 6th and 10th April 2021 and was supervised by a suitably qualified Tier Environmental engineer. Table 5.1 below provides a summary of the exploratory holes completed and rationale. Exploratory hole locations are presented on Drawing No. TE1456GIE2.0.

Table 5.1 Scope of Ground Investigation and Rationale

Exploratory Hole Type	Exploratory Hole Reference	Exploratory Hole Depths (m bgl)	Rationale
Window sample boreholes	WS1 to WS4 and WS6.	3.50m bgl to 5.45m bgl.	To confirm the shallow ground conditions across the Site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and geo-environmental parameters and installation of combined gas and groundwater monitoring wells.
Cable percussion boreholes	CP1 to CP3	10.00m bgl to 10.45m bgl	To confirm the shallow and deeper ground conditions across the Site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and geo-environmental parameters and installation of combined gas and groundwater monitoring wells.
Hand dug pits	HDP1 to HDP6	0.60m bgl to 1.00 bgl	To confirm the shallow ground conditions across the Site and facilitate soil sampling for and geo-environmental parameters

No constraints were encountered during the ground investigation.

Table 5.2 Scope of Monitoring Installations

Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
WS3	Till	0.50m bgl to 3.00m bgl.	Targeting shallow ground gas and potential shallow groundwater body.
WS6	Till	0.50m bgl to 5.00m bgl	Targeting shallow ground gas and potential shallow groundwater body.



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Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
CP1	Till	1.00m bgl to 10.00m bgl	Targeting shallow ground gas and potential groundwater body.
CP2	Till	1.00m bgl to 10.00m bgl	Targeting shallow ground gas and potential groundwater body.
CP3	Till	1.00m bgl to 10.00m bgl	Targeting shallow ground gas and potential groundwater body.

Depths and accurate descriptions of strata and groundwater observations made during investigation works, together with details of the samples recovered, are presented on the Engineer's exploratory hole records in Appendix B.

5.2. Geo-environmental Testing

Sampling and QA/QC protocols are presented in Appendix K. Tier Environmental's schedule of chemical laboratory testing is presented in Table 5.3. The testing was carried out by Element Materials Technology, a UKAS and MCerts (where appropriate for soils analysis) accredited laboratory.

Human Health and Preliminary Waste Classification Laboratory Testing

Based upon the conclusions of the preliminary risk assessment, Tier Environmental scheduled chemical laboratory testing on selected soil samples. The purpose of the testing was to:

- Determine the concentration and spatial distribution of potential contaminants of concern in the Made Ground.
- Determine the chemical composition and properties of the shallow natural soils.

Table 5.3 Schedule of Chemical Testing for Human Health Risk Assessment and Preliminary Waste Soils Assessment.

Laboratory analysis	Made Ground	Natural Soils (Till)
Tier Environmental soil suite*	6	5
Asbestos screen	6	NA
Speciated TPH / BTEX / MTBE	5	5
WAC	2	NA
BRE SD1	4	NA

*For definition of Tier Environmental analytical suites, please see Appendix K. NA - not applicable.

5.3. Geotechnical Testing

Geotechnical laboratory testing was scheduled by Tier Environmental on selected samples as presented in Table 5.4. The testing was performed by Murray Rix (UCAS accredited) Test certificates including details of appropriate testing standards are presented in Appendix D and discussed in Section 7, below.



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Table 5.4 Geotechnical Laboratory Testing Schedule.

Test	Stratum type	Number of tests	Rationale
1. General			
Moisture content	Made Ground and Natural	10	a) Assist with the determination of consistency of soil with depth. b) Assess desiccation of soils. c) Suitability of materials for reuse within earthworks.
2. Classification			
Atterberg limit	Made Ground and Natural	6	a) Volume change potential. b) Plasticity assessment (comply with Eurocode 7 description) c) Consistency Index. d) Determine soil type (e.g., clay/silt). e) Use as an empirical guide to soil shear strength
2. Compaction			
2.5 kg rammer dry density/moisture content relationship test	Natural	2	Establish maximum dry density and optimum moisture content of materials to assess suitability for reuse within earthworks
3. Shear strength (effective stress)			
Consolidated undrained triaxial with porewater pressure measurement	Natural	6	Performed on cohesive samples, to quantify effective stress parameters for modelling long term behaviour of slopes and retaining structures.



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6. GROUND CONDITIONS

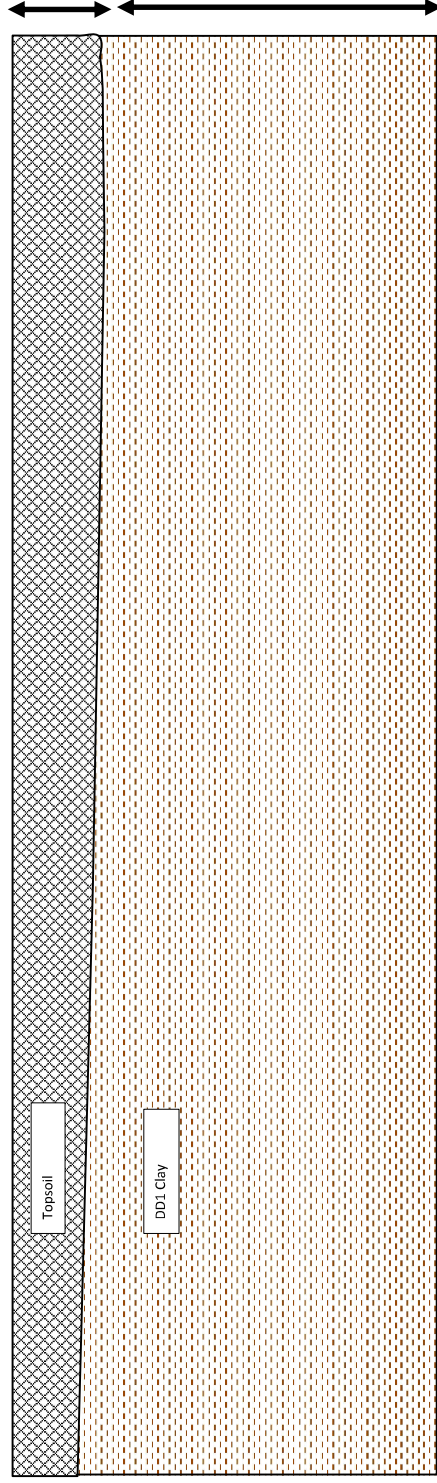
The following section provides a summary of the ground conditions encountered during the ground investigation including strata profile, obstructions and visual / olfactory evidence of contamination. Exploratory hole logs are provided in Appendix B.

Photographs of ground investigation works are provided in Appendix F.

6.1. Strata Profile

Figure 6.1 presented below provide a schematic summary of the ground conditions beneath the Site. The distinct populations of strata identified have been numbered and correspond with the more detailed descriptions below.

Figure 6.1 Schematic Drawing of Ground Conditions





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6.2. Strata Descriptions

Locations encountered	All exploratory hole locations
Depths encountered from top of stratum (range)	Ground level
Depths encountered to base of stratum (range)	0.23m bgl to 0.38m bgl
Thickness (range)	0.23m to 0.38m
Spatial location on site	Widespread across the Site reported to be thickest in the East
General description	Dark brown or brown, slightly sandy to sandy, slightly gravelly, clayey TOPSOIL, the gravel was fine to medium or fine to coarse, of mixed natural lithologies.

Drift Deposits – DD1

Cohesive Till - Clay	
Locations encountered	All exploratory hole locations
Depths encountered from top of stratum (range)	0.23m bgl to 0.38m bgl
Depths encountered to base of stratum (range)	10.00m bgl to 10.45m bgl
Thickness (range)	9.77m to 10.07m (base not encountered)
Spatial location on site	Widespread across the Site.
General description	Firm to stiff, locally very stiff, dark brown or brown, slightly sandy, slightly gravelly CLAY. Sand is fine to coarse; gravel is fine to coarse of sandstone, coal and mudstone

6.3. Obstructions

No obstructions were encountered during drilling works.

6.4. Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of contamination was encountered during drilling works.

6.5. Groundwater Observations During Fieldwork

No groundwater was encountered in any exploratory hole location during drilling works.



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7. PRELIMINARY GEOTECHNICAL ASSESSMENT

7.1. Mining and Quarrying

The site is not considered to be at risk from shallow mining. Historical plans do not indicate any quarries, clay pits or other extractive industries in the vicinity of the site. Localised workings of shallow strata cannot be wholly discounted but given the historical use of the Site this is considered unlikely.

7.2. Determination of pH and Water-Soluble Sulphate

Representative samples of the soils encountered during the Tier Environmental ground investigation, were tested to determine their pH and concentrations of water-soluble sulphate (SO_4^{2-}). The results are presented in Appendix C and summarised in the Table 7.1 below. It is assumed that the Site is a natural ground site, and the groundwater is 'static' in accordance with BRE SD1.

The conclusion of the assessment is that a DS-1 and ACEC Class AC-1 is appropriate for buried concrete design purposes within the Topsoil present at Site and that a DS-2 and ACEC Class AC-2 is appropriate for buried concrete design purposes within the natural Till deposits.

Whilst no evidence of gross hydrocarbon contamination has been observed at the Site, it is a concrete specialist should review the TPH results and ground conditions summary within this report to ensure appropriate concrete design against retardation / degradation due to hydrocarbons.

Table 7.1 Results of Soil pH Testing and Water-Soluble Sulphate Determination.

Exploratory Hole Location	Depth (m bgl)	pH	Water-soluble sulphate (mg/l)	Design sulphate class	ACEC sulphate class
TOPSOIL					
HDP1	0.05	7.14	34.4	DS-1	AC-1
HDP2	0.10	6.49	21.3		
HDP4	0.15	5.97	26.4		
WS1	0.20	7.75	17.1		
WS3	0.20	7.11	11.4		
WS6	0.10	8.76	79.7		
DRIFT DEPOSITS – TILL					
CP1	0.80	8.07	97.5	DS-2	AC-2
CP2	1.40	8.76	170.9		
CP3	2.90	8.13	1334.3		
HDP6	0.60	8.36	1374.9		
WS4	1.80	8.65	166.2		

ACEC - Aggressive Chemical Environment for Concrete (see BRE, 2005).

7.3. Geotechnical Parameters

The data obtained during the Ground Investigation has been assessed for the recorded soil types in order to provide characteristic values in order to aid the final foundation design Table 7.2 below shows soil classification results for cohesive soils.



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Table 7.3 Soil Classification Test Results for Cohesive Till.

Exploratory hole	Depth (m bgl)	Stratum	MC (%)	LL (%)	PL (%)	PI (%) (Modified)	Volume Change Potential
CP1	0.40	TOPSOIL	27	40	20	18.4	Low
CP2	5.00	TILL	20	44	21	23	Medium
CP2	1.50	TILL	20	43	20	23	Medium
WS3	2.00	TILL	20	45	20	25	Medium
WS6	4.00	TILL	21	45	19	25	Medium
WS3	1.20	TILL	18	45	19	26	Medium

ND - Not determined; MC - Moisture content, LL - Liquid limit, PL - Plastic limit, PI - Plasticity index.

Consistency index (CI) is obtained from Atterberg limits and is allowed by Eurocode 7 as a scientific means of determining consistency of clays over and above an engineer merely sticking a thumb in ($CI = 1 - (mc - (PL/PI))$) using unmodified PI).



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Soil Classification

Cohesive Soils

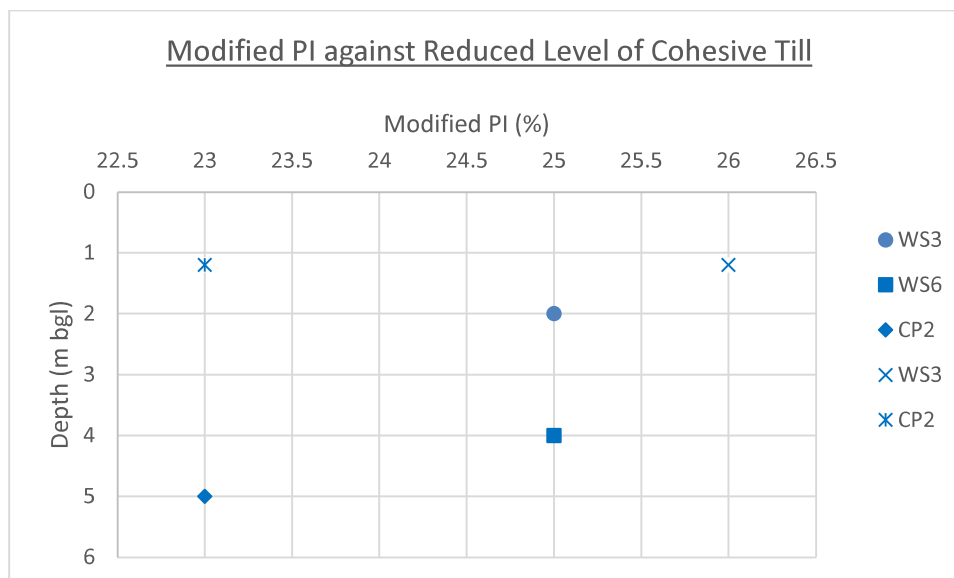
Moisture content and Atterberg Limit testing was undertaken on samples from cohesive superficial material at the site. A summary of the results is shown in Table 7.4 below.

Table 7.4 Summary of Natural Moisture Content and Atterberg Limits

Parameter	No. Tests	Minimum	Maximum	Average
Natural MC %	11	14	21	18.81
Plastic Limit %	5	19	21	19.8
Liquid Limit %	5	43	45	44.4
Plasticity Index	5	23	26	24.6

5 No. Atterberg Limit Tests were performed on samples of identified cohesive soil. All samples returned results which confirm that the material is clay.

Figure 7.1 Plot of Modified Plasticity Index against reduced level



Shear Strength Parameters

A total of 6 No. total stress undrained triaxial tests were performed on the natural clay strata encountered within the exploratory holes. Single stage tests were performed and these yielded values of undrained shear strength (C_u). A summary of the test results obtained for the natural clay strata is given in Table 7.5 below.



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Table 7.5 Summary of undrained shear strength values for natural clay strata

Borehole ID	Depth (m bgl)	Material Type	Shear Strength Cu (kPa)
CP1	1.70	Stiff, brown, silty sandy Clay	178
CP2	1.50	Stiff, brown, silty sandy Clay	195
CP2	2.10	Stiff, brown, silty sandy Clay	313
CP3	5.1	Stiff, brown, silty sandy Clay	141
WS1	2.00	Stiff, brown, silty sandy Clay	403
WS2	2.00	Stiff, brown, silty sandy Clay	1353

The test results show a reasonable variation with no clear increase with depth and from the triaxial test data, a moderately conservative undrained shear strength of 100 kPa at 1.50m bgl, increasing to 150kPa at 3.00m bgl is assessed for the natural clay Till stratum.

Standard Penetration Tests (SPT) were carried out in all of the boreholes. The undrained shear strength of the natural clay strata tested has been estimated using the relationship developed by Stroud, where:

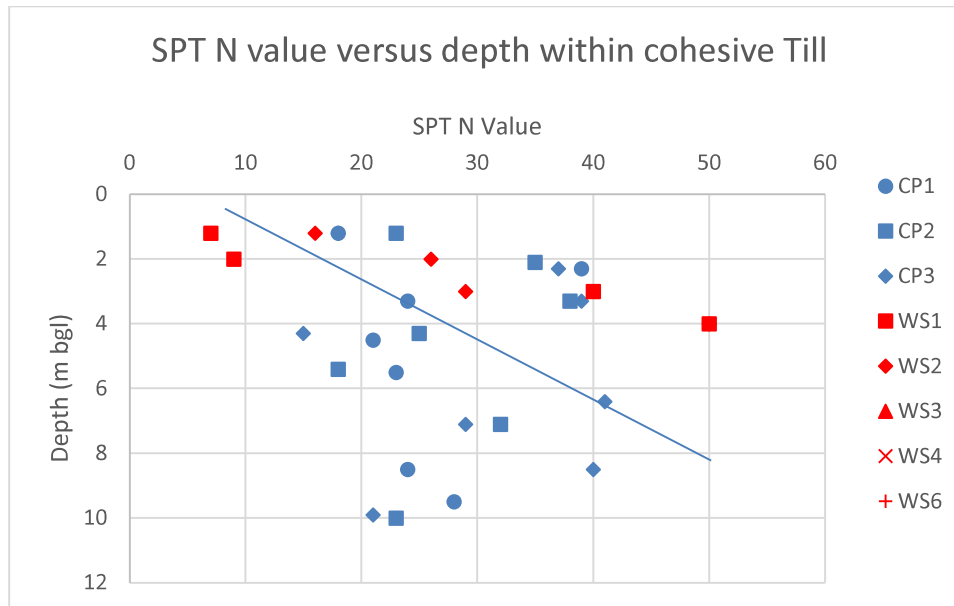
$$C_u = f_1 \times \text{SPT N60 value}$$

The value of f_1 is dependent on the Plasticity Index (Ip). By using the moderately conservative Plasticity Index of 17%, a characteristic value of $f_1 = 6.5$ has been derived.

Results from 42 No. SPT N values in the natural clay Till stratum suggest that the majority of the material is the high to very high strength category with shear strengths varying from 50kPa to 300kPa. All the shear strengths calculated from SPT N values are shown in the figure below, in which they are plotted against reduced level. The test results show a reasonable variation but also an increase with depth.

From the standard penetration test data, a moderately conservative undrained shear strength of 75kPa at 1.00m bgl, increasing to 150 kPa at 3.00m bgl is assessed for the natural clay Till stratum.

Figure 7.2 SPT N value vs reduced depth



Both show some variation but also an increase with depth and this broadly agrees with the variation in moisture content for this stratum. Based on these results a moderately conservative design undrained shear strength 75kPa at 1.00m bgl, increasing to 200 kPa at 3.00m bgl is assessed for the natural clay Till stratum.

Foundation Recommendations

The proposed development at the Site consists of a single storey warehouse unit with associated office space, roadways, parking and soft landscaping. Ground conditions encountered are consistent across the whole Site, with topsoil at surface underlain by firm to very stiff clay to a maximum depth of 10.45m bgl (base not encountered). No groundwater ingress was encountered at Site during drilling works. Geotechnical testing at the Site shows the clay to be high to very high strength.

The clay Till stratum is suitable for founding on, local deepening may be required in areas of former ponds. The preferred, most economic foundation solution is likely to be shallow spread foundations (pads or strip) within the Till. The following safe bearing resistances are recommended for shallow spread foundations:

- Firm undisturbed clay Till: 80kPa
- Stiff undisturbed clay Till: 130kPa

7.4. Floors

Atterberg tests undertaken within the shallow soils suggest that these soils have a 23% to 26% plasticity and low to medium volume change potential. Based on the results of laboratory and in situ geotechnical tests, field observations and the high to very high strength of the clay soils underneath the area of the proposed facility, it is proposed that floor slabs are ground bearing, but that the Topsoil/any potentially unidentified Made Ground beneath



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the floors is removed in order to prevent excessive cracking or differential settlements. If a ground bearing floor slab is incorporated into the design, a capping layer should be included which would then proof rolled to the desired specification.

7.5. Groundworks, Excavation Stability and Groundwater Dewatering

In our opinion, there should be no particular difficulties in excavating the strata indicated in the boreholes utilising an appropriate and suitably sized mechanical excavator. Excavations into existing Made Ground and the underlying natural soils should be assumed to be unstable. No man entry into unsupported excavations should be allowed without an appropriate risk assessment. Reference to CIRIA report 097 (1983) should be made to establish suitable means of support or battering of excavation sides.

It is recommended that all excavations to greater than 1.20 metres depth, or for shallower excavations where groundwater is encountered above this level are closely supported, especially where man entry is required. Alternatively, where space permits, the excavations might be battered back to an appropriate angle. No Standing groundwater was encountered in the boreholes / trial pits. Should groundwater seepages occur, and water accumulate in shallow excavations it should be able to be removed by pumping from a filtered sump. However, groundwater control by more robust means, such as well pointing, may be required locally.

It should be noted that should deep basements be constructed as part of the development then we would recommend that the standpipes are monitored for groundwater levels for an extended period of time and take into consideration seasonal variations and periods of very wet weather to measure the fluctuation of the standing water levels. It should be noted that groundwater inflows and levels are likely to be subject to seasonal and climatic variations.

Great care will need to be taken if reducing groundwater levels to ensure that adjoining nearby buildings, structures and services are not affected.



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8. HUMAN HEALTH RISK ASSESSMENT

Tier environmental tested selected soil samples for a number of determinands to conduct a human health risk assessment of the Site.

Results of chemical analysis are presented in full in Appendix C.

8.1. Data Interpretation Approach

The analytical data obtained were reviewed for completeness and consistency. The data for each sample type was then compiled, screened against the Generic Assessment Criteria (GACs) for a commercial/industrial land use and those potential contaminants of concern which were found to exceed the GACs were then subjected to detailed analysis as described below.

Previously, it was possible for results from soil (and leachate) samples to be subject to statistical assessment in accordance with a 2008 guidance document (CL:AIRE / CIEH Guidance on Comparing Soil Contamination Data with a Critical Concentration). This guidance has now been withdrawn and replaced with the following document:

- Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration (CL:AIRE 2020)

The purpose behind statistical assessment is ultimately to determine whether concentrations of contaminants are at levels that present potential risk to the future site users (and the wider environment if the statistical assessment is conducted on leachate test results).

The new guidance places even greater emphasis and reliance on the desk study being carried out first, appropriately detailed sampling strategies, collection and testing of samples for contamination and use of appropriate screening criteria.

The guidance requires an increased number of criteria to be met before a robust statistical assessment can be conducted and introduces the principal of the Central Limit Theorem (CLT); a key tool of statistics that is used in the comparison of confidence intervals with the critical concentration. A common 'rule of thumb' is that the CLT will apply provided your sample size is between 20 and 50.

On this basis, Tier Environmental considers that statistical assessment in accordance with the CL:AIRE 2020 guidance may not be applied in this instance given that the number of samples obtained is below 20 No. for any given identified soil population.

Due consideration of the ground conditions, distinct identifiable populations of soil and proposed development layout has been undertaken and, where appropriate, laboratory results associated with discrete populations or 'hotspots' have been assessed separately.

8.2. Selection of Generic Assessment Criteria (GAC)

In short, for the majority of the contaminants of concern, LQM/CIEH Suitable 4 Use Levels (S4ULs) published recently in 2015 have been adopted as GACs for a commercial/industrial land use; however, further details on the hierarchal approach for the selection of the GACs used as screening criteria for this assessment is provided in Appendix I.

These values are considered as appropriate screening criteria as they incorporate updated assumption exposures derived for the production of C4SLs but within the context of deriving screening criteria above which assessment of the risks or remedial action may be needed (i.e. within the context of the planning regime rather than Part 2A context for which C4SLs were derived).



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For those potential contaminants of concern where the selected GAC is dependent on Soil Organic Matter content (SOM), an assumed SOM of 1% has been selected based on the reported Total Organic Carbon (TOC) concentrations (which have been converted to SOM by dividing by a conversion factor of 0.58). It should be noted; however, that for any soil samples where the TOC may be artificially driven by the presence of petroleum hydrocarbons, that these TOC results have been removed from the data set when determining an appropriate characteristic SOM. For this purpose, Tier Environmental have notionally considered that any TOC results from soil samples where the measured total TPH concentration exceeds 500mg/kg should be removed.

8.3. Human Health Risk Assessment

No measured concentrations of potential contaminants of concern have been reported in excess of the respective GACs protective of human health for a commercial/industrial land use.

Asbestos

During the fieldwork no suspected ACMs were identified.

Of the 6 No. of Made Ground samples submitted for asbestos screening, none were reported to contain asbestos.

Asbestos can be present in soil as fragments of bulk Asbestos Containing Materials (ACMs) (e.g. asbestos cement sheeting) and also as discrete asbestos fibres within the soil matrix. This investigation has carried out assessments to determine whether both bulk fragments and / or fibres are present in the soil at the site. The asbestos assessment commenced on site with inspection of the Made Ground by our suitably qualified supervising engineer for the presence of bulk ACMs.

8.4. Utilities

It is recommended that the results of the chemical testing and details of the proposed remedial works are provided to the appropriate utility companies to determine the necessity for service protection.

8.5. Construction and Maintenance Workers

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislative requirements and follow appropriate guidance (e.g., HSE, 1991; CIRIA, 1996).

On the basis of the results obtained, the following potential exposure risks to construction and maintenance workers have been highlighted:

- Asbestos **has not** been reported during the ground investigation works; however, in the event that previously unidentified asbestos is identified during future earthworks / construction works at concentrations above 0.001% w/w (i.e. above 'trace' levels), the Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is provided in Appendix L is provided for reference.



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9. GROUND GAS RISK ASSESSMENT

9.1. Introduction

The ground gas risk assessment has been undertaken in accordance with the following guidance:

- BS 8485:2015+A1:2019;
- CIRIA C665, 2007;
- Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide Are Present, NHBC, 2007;
- A Pragmatic Approach to Ground Gas Risk Assessment RB17. CL:AIRE, 2012; and,
- Ground Gas Monitoring and 'Worst-Case' Conditions TB17, CL:AIRE, 2018

The ground gas risk assessment has been conducted with full consideration of the viable sources, pathways and receptors included within the Preliminary Conceptual Site Model presented in Section 4.

Ground gas monitoring was conducted in conjunction with groundwater monitoring (and sampling); however, it should be noted during the gas monitoring was conducted first, prior to any groundwater monitoring / sampling works. The monitoring well locations and construction were designed with due consideration of the proposed development layout and preliminary conceptual site model. Further information pertaining to monitoring wells is provided in Table 5.2.

9.2. Ground Gas Monitoring Results

The ground gas monitoring is complete with four visits and the results are presented in Appendix E and summarised below:



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Table 9.1 Ground Gas Monitoring Results Summary (4 No. visits)

Strata targeted by response zone	Monitoring well reference	Maximum peak CO ₂ (%v/v)	Maximum steady state CO ₂ (%v/v)	Maximum peak CH ₄ (%v/v)	Maximum steady state CH ₄ (%v/v)	Lowest O ₂ recorded (%v/v)	Maximum peak gas flow rate (l/h)	Maximum steady state gas flow (l/h)
Till	CP01	1.5	1.5	0.1	0.1	15.6	15.6	ND
Till	CP02	1.3	1.3	0.1	0.1	18.1	0.2	0.2
Till	CP03	0.7	0.7	ND	0.1	18.0	0.1	ND
Till	WS03	0.8	0.8	0.1	0.1	18.0	12.0	ND
Till	WS06	1.2	1.2	0.1	0.1	17.4	17.9	ND

Bold = maximum value reported across all visits. Please note – during monitoring on visit 3, CP02, CP03 and WS03, the monitoring well was flooded so gas readings were unable to be taken. On monitoring visit 4, CP02 was inaccessible due to vegetation and CP03 and WS03 were flooded..



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9.3. Ground Gas Risk Assessment

Table 9.2 and Table 9.3 demonstrate how, in accordance with CIRIA C665, the periods and frequency of monitoring have been selected for the Site.

Table 9.2 From Table 5.5a CIRIA C665 - Typical/idealised periods of monitoring (after Wilson et al, 2005)

		Generation Potential of the Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of development	Low (commercial)	1 month	2 months	3 months	6 months	12 months
	Moderate (flats)	2 months	3 months	6 months	12 months	24 months
	High (residential with gardens)	3 months ¹	6 months	6 months	12 months ¹	24 months

Notes:

1 NHBC guidance also recommends this period of monitoring (Boyle and Witherington, 2007).

2 There is no industry consent over "high", "medium" or "low" generation potential of source.

Table 9.3 From Table 5.5b CIRIA C665 - Typical/idealised frequency of monitoring (after Wilson et al, 2005)

		Generation Potential of the Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of development	Low (commercial)	4	6	6	12	12
	Moderate (flats)	6	6	9	12	24
	High (residential with gardens)	6 ¹	9	12	24 ¹	24

Notes:

1 NHBC guidance also recommends this period of monitoring (Boyle and Witherington, 2007).

2 There is no industry consent over "high", "medium" or "low" generation potential of source.

The ground gas monitoring has been completed with four visits in total.. The total atmospheric pressure range of the ground gas monitoring data included in this report was between 1001 mbar and 1027 mbar. This range covers high (>1015 mbar) to medium (1000 – 1015 mbar) atmospheric pressures. Monitoring events included periods of falling, stable and rising pressure trends. Atmospheric pressure graphs from Hawarden Airport (the closest weather station to the Site) are presented in the appendices highlighting the pressure trends during the 4 No. gas visits conducted to date.



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Consideration of Groundwater Effects

An assessment has been made to determine whether groundwater levels beneath the Site lie at a shallow depth at, or above, the plain section of the monitoring well. In those instances where shallow groundwater is located within the plain section of the monitoring well pipe this can result in 'groundwater pumping' where the measured peak (and in some cases steady) flow rates reported at these monitoring well locations are significantly (and artificially) influenced by the pressures formed in the void above the groundwater in the plain section of the pipe, as opposed to being truly representative of the ground gas flow rates. In such instances, this scenario can create 'artificial' negative and /or relatively high peak positive readings depending on whether the groundwater levels have increased or decreased in between monitoring events or since installation of the monitoring wells.

The results of the ground gas monitoring within this report have indicates where groundwater pumping is likely to have influenced the measured gas flow rated such that they may be reasonably discounted from the Gas Screening Criteria (GSV) calculation.

- On the third gas monitoring visit, CP01, WS03 and WS06 recorded abnormally high peak flow rates, which swiftly dropped to no detected steady flow rates. CP02 and CP03 had also flooded due to the high groundwater levels.
- There were no significant concentrations of ground gases observed within the 3 No. wells with the high peak flow rates. This supports the interpretation that groundwater pumping is occurring within the well pipes.
- Based on the previous gas monitoring visits conducted, the groundwater levels on the third and fourth visit have risen significantly.

Therefore, as groundwater pumping is likely causing abnormally high and unrepresentative peak flow rates during the third visit, these flow rates have not been used in the GSV calculation, with the next highest representative peak flow value used.

The results of the ground gas monitoring have been assessed in accordance with the criteria specified for this Site, which were derived as described in Appendix J.

Initial 'Worst-Case' GSV Calculation – Carbon Dioxide and Methane

An initial conservative assessment has been made by calculating a 'worst-case' Gas Screening Value (GSV) for the Site by using:

- the maximum reported methane or carbon dioxide concentration (whichever is highest) from any monitoring well and during any ground gas monitoring visit; and,
- the remaining maximum peak positive flow rate (after any negative flow rates or 'artificially' high flow rates have been discounted as described above) from any monitoring well and during any ground gas monitoring visit.

Table 9.4 Initial Worst-Case GSV Calculation

Ground Gas	Maximum Reported Peak Concentration (% v/v)				Selected Concentration used in GSV Calculation (% v/v)	Maximum Appropriately Selected Gas Flow Rate (l/hr)	'Worst case' GSV (l/hr)
Methane (CH ₄)	0.1	}	→	X	1.5	0.3	= 0.0045
Carbon dioxide (CO ₂)	1.5						



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CIRIA C665 provides two separate methods to 'characterise' a site that firstly requires the assessor to distinguish between two fundamental development 'situations':

- **Situation A** - Any development other than Situation B (e.g. factories, shops, commercial, warehouses, schools, cinemas, sports centres, stadiums, high rise housing, housing with basements, etc) for which the **Modified Wilson and Card 'Characteristic Situation' classification system** is applied; and,
- **Situation B** - Low rise building with minimum ventilated under floor void (min 150 mm) for which the **NHBC Traffic light classification system** is applied

In this instance, as the Site is due to be developed as commercial warehouse unit with associated office spaces, it shall be regarded as a 'Situation A' scenario for the purposes of the ground gas risk assessment.

Table 9.4 demonstrates that the Site is placed in a Characteristic Situation 1– **VERY LOW RISK** / scenario on the basis of the 'worst case' GSV alone.

CIRIA C665 indicates that in the event that the reported methane concentrations are 'typically' >1% v/v and/or the reported carbon dioxide concentrations are 'typically' >5% then consideration should be made to increase the determination of the Site to a Characteristic Situation 2 – Low Risk scenario.

In this instance, as no maximum peak or steady methane or carbon dioxide concentrations have been reported in excess of 1% v/v or 5% v/v respectively, the Site can be reasonably classified as a Characteristic Situation 1 – Very Low Risk scenario for which no basic ground gas protection measures are required.

Carbon Monoxide and Hydrogen Sulphide

There is no current UK risk assessment guidance available for carbon monoxide and hydrogen sulphide derived from ground gases.

No measured concentrations of carbon monoxide or hydrogen sulphide have been reported in excess of the instrument's detection limit. As such, there is no evidence to suggest that the Site presents a potential risk to future land users from either carbon monoxide or hydrogen sulphide.

9.4. Radon Gas

Data from UKRadon.org shows the majority of the Site lies in an area where less than 1% of the properties lie above the action level, therefore no radon protection measures are required. However, the north western corner of the Site falls into an area where 1% - 3% of properties lie above the action level. This is most likely the result of the bedrock Salop Formation, which is shown on BGS records to be overlain by approx. 30-40m of superficial Till, meaning radon is unlikely to affect this area of Site.

Review of the third party report obtained by Tier "Geo-Environmental Desk Study of Plot 3A, Bryn Lane, Wrexham Industrial Estate, Wrexham" references 'The Building Research Establishment report "Radon: Guidance on Protective Measures for New Dwellings" BR211, 2007 edition)' and shows that:

"No protection is needed against radon gas and that further geological assessment is not required. The health Protection Agency publication 'Indicative Atlas of Radon in England and Wales' (Ref: HPA-RPD-033, November 2007) indicates that less than 1% of properties are above the radon gas action level."



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However, although unlikely, any proposed buildings with basement levels in the north-western corner of the Site which falls into the 1% to 3% action level, should have a Visqueen (or equivalent) barrier membrane installed.

Table 9.5 Ground Gas Protection Measure Requirements

Ground Gas Characteristic Situation	Vapour Membrane Required?	Building Type (in accordance with BS8485)	Gas Protection Score by Characteristic Situation and Type of Building	Proposed Ground Gas Protection Measures																																												
Characteristic Situation 1 – Very Low Risk Scenario	No	The proposed building type is considered to be Type C for the office spaces and Type D for the warehouse spaces in accordance with the BS8485 description: Type C building: commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels). Type D building: industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses. (Small rooms within these style buildings should be separately categorized as Type B or Type C).	The red ellipse below has been added to show the appropriate point score, based on the Characteristic Situation that has been determined for the Site and Building type in accordance with BS8485. From Table 4 in BS 8485:2015+A1:2019 – Gas Protection Score by CS and Type of Building <table border="1"> <thead> <tr> <th rowspan="2">CS</th><th colspan="4">Minimum gas protection score (points)</th></tr> <tr> <th>High risk</th><th colspan="2">Medium risk</th><th>Low risk</th></tr> <tr> <th></th><th>Type A Building</th><th>Type B Building</th><th>Type C Building</th><th>Type D Building</th></tr> </thead> <tbody> <tr> <td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr> <td>2</td><td>3.5</td><td>3.5</td><td>2.5</td><td>1.5</td></tr> <tr> <td>3</td><td>4.5</td><td>4</td><td>3</td><td>2.5</td></tr> <tr> <td>4</td><td>6.5^{A)}</td><td>5.5^{A)}</td><td>4.5</td><td>3.5</td></tr> <tr> <td>5</td><td>–^{B)}</td><td>6^{A)}</td><td>5.5</td><td>4.5</td></tr> <tr> <td>6</td><td>–^{B)}</td><td>–^{B)}</td><td>–^{B)}</td><td>6</td></tr> </tbody> </table> A) Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations. B) The gas hazard is too high for this empirical method to be used to define the gas protection measures.	CS	Minimum gas protection score (points)				High risk	Medium risk		Low risk		Type A Building	Type B Building	Type C Building	Type D Building	1	0	0	0	0	2	3.5	3.5	2.5	1.5	3	4.5	4	3	2.5	4	6.5 ^{A)}	5.5 ^{A)}	4.5	3.5	5	– ^{B)}	6 ^{A)}	5.5	4.5	6	– ^{B)}	– ^{B)}	– ^{B)}	6	Selection of appropriate ground gas protection measures has been conducted in accordance with Section 7.2 of BS8485 that states gas protection measures are not required for the development.
CS	Minimum gas protection score (points)																																															
	High risk	Medium risk		Low risk																																												
	Type A Building	Type B Building	Type C Building	Type D Building																																												
1	0	0	0	0																																												
2	3.5	3.5	2.5	1.5																																												
3	4.5	4	3	2.5																																												
4	6.5 ^{A)}	5.5 ^{A)}	4.5	3.5																																												
5	– ^{B)}	6 ^{A)}	5.5	4.5																																												
6	– ^{B)}	– ^{B)}	– ^{B)}	6																																												



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10. REVISED CONCEPTUAL MODEL AND GENERIC QUANTITATIVE RISK ASSESSMENT OF POLLUTANT LINKAGES

The preliminary combined conceptual site model and conceptual exposure model, developed from the desk study information and presented in Section 4, has been revised in light of the ground investigation and the chemical analysis results presented above in Table 10.1, below.

A revised qualitative risk assessment has also been made of the likelihood of the linkage operating and its potential significance in accordance with CIRIA C552.

Table 10.1 Revised Assessment of Pollutant Linkages.

Justification / Comments	Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment	
• Topsoil was encountered across the whole Site in all exploratory/ hole locations, underlain by firm to stiff locally very stiff clay. • No Groundwater ingress was encountered during ground investigation works. Groundwater has been encountered in CP01, CP02, and CP03 on monitoring visit 2 and in all wells on visit 3. • Topsoil and Clay samples were analysed for metals, metalloids, TPH, and asbestos. No measured concentrations above the respective GACs for each determinand were identified. • Based on the 4 No. ground gas monitoring visits conducted, the Site is characterised as a Characteristic Situation 1 - Very Low Risk Scenario meaning no gas protection measured are required.	Anticipated localised Made Ground contamination associated with Made Ground (general, at the Site entrance gates and potential infilled pond deposits) present on Site.	Metals	Direct contact, ingestion and inhalation of dust	Future Site end users	Medium	Unlikely	Low Risk	
		PAHs	Leaching and migration via groundwater	Ground/Site workers	Medium	Unlikely		
		Phenols	Lateral and vertical migration of mobile contaminants	Adjacent properties	Medium	Unlikely		
				Underlying Aquifers	Medium	Unlikely		
	pH	Proposed buildings on Site	Medium	Unlikely				
			Asbestos	Direct contact, ingestion and inhalation of dust	Future Site end users	Medium	Unlikely	Low Risk
				Dust migration	Ground/Site workers	Medium	Unlikely	
		Potential for ground gas generated from assumed backfilled Ponds or potential Made Ground on Site.	Hazardous Ground Gas	Vapour inhalation	Future Site end users	Severe	Unlikely	Low risk
				Lateral and vertical migration of mobile contaminants	Ground/Site workers			
				Proposed buildings on Site				

For definition of the terms used in the qualitative risk assessment, please see Appendix H.



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11. PRELIMINARY WASTE SOILS CLASSIFICATION AND WASTE DISPOSAL ROUTE DETERMINATION

If the Site is to be redeveloped and materials are disposed off Site, the material exported from the Site to Landfill should be hauled by a register waste character in accordance with Duty of Care Regulations 1991 and the Hazardous Waste Regulations 2005.

It will be necessary to register the Site in advance of the intended reclamation works with the Environment Agency before disposal to landfill can take place. There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the Soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils. A consignment note shall be completed, signed and retained by all parties involved. The consignment note shall state the volume of waste, a physical description of the material and statement of its chemical composition. The waste consignment notes shall be kept by the contractor for a period of at least two years.

Tier Environmental have assessed the chemical results in terms of basic characterisation of soils for waste. This provides a preliminary assessment of whether a material is potentially inert/non-hazardous or hazardous waste, with the final outcome being determined by WAC testing.

Basic waste characterisation has demonstrated that all 11 No. of the samples of the material tested have been classified as non-hazardous waste:

- CP01 at 0.80m bgl.
- CP02 at 1.40m bgl.
- CP03 at 2.90m bgl.
- HDP01 at 0.05m bgl.
- HDP02 at 0.10m bgl.
- HDP04 at 0.15m bgl.
- HDP06 at 0.60m bgl.
- WS01 at 0.20m bgl.
- WS03 at 0.20m bgl.
- WS04 at 1.80m bgl.
- WS06 at 0.10m bgl.

Based on Waste Acceptance Criteria testing, all samples are suitable for disposal at an inert waste landfill. Natural soils are likely to be suitable for disposal to an inert waste landfill.



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12.CONCLUSIONS AND RECOMMENDATIONS

12.1. Conclusions

- No exceedances above the relevant GACs were identified in respect to human health for a commercial site end use for the soils tested on site.
- Based on the 4 No. ground gas visits conducted, the site is considered at Characteristic situation 1 – Very Low Risk Scenario with no gas protection measures required.
- Shallow strips and pad foundations are deemed suitable for this site subject to the loading of the structure, localised deepening may be required for areas of former ponds.
- Data from UKRadon.org shows the majority of the Site lies in an area where less than 1% of the properties lie above the action level, therefore no radon protection measures are required. However, the north western corner of the Site falls into an area where 1% - 3% of properties lie above the action level. This is most likely the result of the bedrock Salop Formation, which is shown on BGS records to be overlain by approx. 30-40m of superficial Till, meaning radon is unlikely to affect this area of Site.
- The conclusion of the pH and Water-Soluble Sulphate assessment is that a DS-1 and ACEC Class AC-1 is appropriate for buried concrete design purposes within the Topsoil present at Site and that a DS-2 and ACEC Class AC-2 is appropriate for buried concrete design purposes within the natural Till deposits.

12.2. Recommendations

- Any proposed buildings with basement levels in the north-western corner of the Site which falls into the 1% to 3% action level, should have a Visqueen (or equivalent) barrier membrane installed.



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13.REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval prior to undertaking any works on site.

It is recommended that conditions placed on any planning permission are discharged prior to commencement of site works.



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15.GLOSSARY OF TERMS

ACEC	Aggressive Chemical Environment for Concrete (classification)
aOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
Designated location	Site (and the ecosystem on that site) protected under national or international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.
DQA	Data Quality Assessment
DQO	Data Quality Objective
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment (Environment Agency)
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
K _{ow}	Octanol-water partition coefficient
LEL	Lower Explosive Limit
LL	Liquid Limit
LoD	Limit of Detection (analytical)
LoQ	Limit of Quantification (analytical)
Mean Value Test	Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria.
Maximum Value Test	Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.
MC	Moisture Content
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
PI	Plasticity Index
PID	Photoionisation Detector
PL	Plastic Limit
ppm	Parts per million
ppmv	Parts per million by volume
QA	Quality Assurance
QC	Quality Control
SAC	Special Area of Conservation
SOM	Soil Organic Matter



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SPT	Standard Penetration Test
SPZ	Source Protection Zone
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest
SVOC	Semi-Volatile Organic Compound
TEF	Toxicity Equivalent Factor
TPH	Total Petroleum Hydrocarbons
TWA	Time Weighted Average
US95	95 th percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound