

PHASE 2 GEO-ENVIRONMENTAL AND GEOTECHNICAL REPORT

Land at Alchemy Way, Knowsley Industrial Park, Kirby, L33 7AQ



JER9563
Phase 2 Environmental and
Geotechnical Site
Investigation Report
2
6 October 2022

NETWORK SPACE – LAND PARCEL 1 AT ALCHEMY WAY

PHASE 2 GEO-ENVIRONMENTAL & GEOTECHNICAL REPORT COVER NOTE

RPS Consulting Services Ltd (RPS) was commissioned by Network Space to undertake a Phase 2 Geo-Environmental and Geotechnical Site Investigation of Land at Alchemy Way, Knowsley Industrial Park, Kirby, L33 7AQ. The report has been commissioned prior to the proposed redevelopment of the site.

Both development plots are covered by this Phase 2 Geo-Environmental and Geotechnical report however, the Planning Application relates to Parcel 01 (Northwest Plot) which is located on land to the northwest of Alchemy Business Park..

The two sites cumulatively cover approximately 4.77 hectares with Parcel 1 occupying 3.55 ha and Parcel 2 occupying 1.22 ha The proposed development within the 'Land Parcel 1' site is understood to comprise the construction of two large commercial buildings, with external yard and car parking areas. The development plot is understood to form part of a wider development area that is intended to be developed in phases.

REPORT

Quality Management

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EXECUTIVE SUMMARY

RPS Consulting Services Ltd (RPS) was commissioned by Network Space to undertake a Phase 2 Geo-Environmental and Geotechnical Site Investigation of Land at Alchemy Way, Knowsley Industrial Park, Kirby, L33 7AQ. The report has been commissioned prior to the proposed redevelopment of the site.

The two sites cumulatively cover approximately 4.77 hectares with Parcel 1 occupying 3.55 ha and Parcel 2 occupying 1.22 ha. Both sites currently comprise undeveloped land surfaced with grass and vegetation.

The site investigation was carried out between the 1st of August 2022 and 4th August 2022 and comprised:

Parcel 1: Drilling of two boreholes to depths of approximately 10.00m below ground level (bgl) using cable percussion techniques (CP03 to CP04); drilling of four boreholes to depths of up to approximately 5.00m bgl using window sample techniques (WS04 to WS07); and excavation of six trial pits to depths of up to approximately 3.50m bgl using a mechanical excavator (TP04 to TP09), two of which were utilised for Building Research Establishment (BRE) Digest 365 infiltration testing.

Parcel 2: Drilling of two boreholes to depths of approximately 10.00m below ground level (bgl) using cable percussion techniques (CP01 to CP02); drilling of three boreholes to depths of up to approximately 5.00m bgl using window sample techniques (WS01 to WS03); and excavation of three trial pits to depths of up to approximately 3.50m bgl using a mechanical excavator (TP01 to TP03), two of which were utilised for Building Research Establishment (BRE) Digest 365 infiltration testing.

Ground conditions at the sites comprise Made Ground to depths of between 1.20 and 3.80m bgl where fully penetrated. This was underlain locally in Parcel 1 by Sediment Deposits at thickness of 0.10 to 0.30m and locally in Parcel 2 by Glacial Till at thickness of 0.60 to 1.8m. The Chester Formation was encountered underlying the Made Ground, Sediment Deposits and Glacial Till at depths of 1.65m to 3.30m bgl and was not fully penetrated in any location.

Groundwater was encountered within the Chester Formation at depths of 3.60m to 9.00m bgl during the drilling and within the Made Ground at depths of 1.10m and 1.90m bgl during excavation of the trial pits. During the subsequent monitoring period standing levels were recorded at depths between 0.90m and 4.63m bgl and is considered to potentially represent a continuous groundwater body.

The quantitative risk assessment has identified a potential risk to human health associated with presence of asbestos in shallow soils. Following redevelopment, hardstanding and building cover will provide an effective barrier to break the pathways of dermal contact, ingestion and inhalation of contaminated dust to future site users. This would also prevent the migration of contaminated dust towards off-site receptors. However, for any areas of proposed soft landscaping a 300mm cover of certified clean topsoil cover should be provided to break these pathways.

Several speciated PAH compounds and total cyanide were recorded at concentrations above their EQS AC within the groundwater sample collected from the shallow groundwater body encountered within the Made Ground in WS02. Groundwater encountered across the site is considered to be a continuous body and is likely in hydraulic connectivity with the underlying Principal Aquifer. The local cohesive deposits within the Made Ground and the Glacial Till may potentially limited lateral and vertical migration where present. The Made Ground across the site is described as containing clinker, coal and other man-made constituents which are known to be high in PAHs, therefore the source of the elevated PAHs may be the presence of these materials within the Made Ground. However, it should be noted that the exceedances are limited to a single borehole located in the centre of the site and are not wide spread. Concentrations are also considered to be marginal in nature.

Given the distance to the surface water receptors and the closest groundwater abstraction point and the presence of these cohesive layers within the strata, it is not considered that the groundwater beneath the site poses a significant risk to controlled waters in the vicinity of the site. In addition, the proposed development, which comprises covering the site largely in hardstanding and buildings, will reduce the infiltration and therefore leaching of the potential source within the Made Ground.

Based on the ground gas monitoring undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 2.

Based on the ground gas monitoring, undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 1. However significant concentrations of methane and carbon dioxide were recorded consistently throughout the monitoring. Therefore, it is recommended that further monitoring is undertaken to determine the long-term gas generation at the site and to enable further assessment of the potential risk to be undertaken prior to confirmation of the gas characterisation situation and design of the gas protection measures.

Based on an earthworks acceptability criterion of achieving 95% of Maximum Dry Density (determined by 2.5kg hammer method), and setting a maximum air voids content of 5%, a maximum moisture content of 23% would be deemed appropriate, and as such some limited moisture conditioning may be necessary.

It is expected if the redevelopment platform levels allow, then shallow spread footings founded within the undisturbed near-surface Glacial Till/ Chester Formation are likely to be an appropriate option for founding lightly to moderate loaded structures. Based on this loading criteria it is anticipated that the bearing capacity of the Glacial Till will be up to 100kN/m² whilst the Chester Formation stratum is anticipated to have a bearing capacity of up to 220kN/m².

If heavier structural loads are required, then anticipated pile foundations will be adopted where the piles are terminated within the deeper deposits of Glacial Till or socketed into the Chester Formation.

It is recommended that a preliminary design CBR value of 2% (subgrade modulus of 27MPa) be selected with a minimum thickness of pavement of 450 mm provided to limit deterioration of the sub grade by frost action. Any soft spots should be excavated and replaced by suitable engineered fill. A geotextile should be placed to ensure separation of the granular fill from the underlying formation.

A Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC-2z would be appropriate for all buried concrete structures.

Based on the undertaken soakaway tests across the site infiltration drainage will not be a viable solution for this site.

Given the variable presence of groundwater at shallow depths throughout the site, dewatering measures may be required for the construction excavation works.

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1 INTRODUCTION

1.1 Preamble

- 1.1.1 RPS Consulting Services Ltd (RPS) was commissioned by Network Space to undertake a Phase 2 Geo-Environmental and Geotechnical Site Investigation of two sites on land at Alchemy Way, Knowsley Industrial Park, Kirby, L33 7AQ. A site location plan encompassing both parcels is provided as Figure 1. The report has been commissioned prior to the proposed redevelopment of the site.
- 1.1.2 The two sites cumulatively cover approximately 4.77 hectares with Parcel 1 occupying 3.55 ha and Parcel 2 occupying 1.22 ha. Both sites currently comprise undeveloped land surfaced with grass and vegetation. Site boundary plans are presented as Figures 2 and 3. The proposed development on the two parcels of land is understood to comprise the construction of light industrial buildings (split into several units), with external yard and car parking areas. Proposed development plans are provided in Appendix C.
- 1.1.3 RPS have previously prepared two Phase 1 Preliminary Geo-Environmental and Geotechnical Risk Assessments (ref. 220607 R JER9563 NW Parcel 1 Phase 1 Geo-Environmental Preliminary Risk Assessment V2 R0 and ref. 220609 R JER9563 NW Parcel 2 Phase 1 Geo-Environmental Preliminary Risk Assessment V2 R0), the desk study element of which is based upon a review of published information available from local, regional, and national agencies. These assessments also comprised a review of previous reports for the site including:
- WYG: Phase I Geo-environmental Desk Study Report for Land at Alchemy, Knowsley, ref. A094359. This report covers a wider site including both the subject sites.
 - WYG: Alchemy, Knowsley – Japanese Knotweed Encapsulation Strategy and associated plan ref: A094359/JK001. This report covers a wider site including the Parcel 1 subject site.
- 1.1.4 The two RPS Preliminary Risk Assessments (PRA) contained outline Conceptual Site Models (CSM) detailing how any contamination could impact the identified receptors via pollutant linkages, respective to each parcel of land.
- 1.1.5 The PRAs also included a preliminary geotechnical risk assessment to identify potential geotechnical constraints associated with the development, enabling the design of the Phase 2 Site Investigation.
- 1.1.6 This report includes the Phase 2 assessment for both Parcel 1 and Parcel 2 and makes further reference to the available previous reports in determining a geological model of the site based upon encountered ground conditions.

1.2 Objectives

- 1.2.1 The principal objectives of this assessment were as follows:
- To determine the contamination status of soil and/or groundwater beneath the site;
 - To assess whether contamination is present within soil and/or groundwater beneath the site at concentrations which could impact future site uses/occupiers and the wider environment;
 - To assess the general suitability of the site for its assumed proposed use in the context of the National Planning Policy Framework (NPPF) in support of any future planning application for redevelopment of the site; and
 - To determine the engineering properties of the underlying soils and to provide geotechnical parameters to assist preliminary foundation, ground slab and external hard-standing design.

1.3 Legislation and Guidance

- 1.3.1 The assessment has been undertaken in general accordance with British Standard BS EN ISO 21365:2020 and is considered suitable to meet the initial requirements of planning as outlined within the National Planning Policy Framework (NPPF). The assessment also reflects the recommendations of Environmental Agency guidance, Land Contamination: Risk Management, (LCRM 2020).
- 1.3.2 This report has been produced in general accordance with:
- Contaminated Land (England) Regulations 2006 (as amended);
 - DEFRA Environmental Protection Act 1990: Part 2A - *Contaminated Land Statutory Guidance (2012)*;
 - CIRIA Document C665: *Assessing Risks Posed by Hazardous Ground Gases to Buildings*;
 - British Standard requirements for the '*Investigation of potentially contaminated sites - Code of practice*' (ref. BS10175:2011+A1:2017);
 - British Standard requirements for the '*Code of practice for ground investigations*' (ref. BS5930:2015+A1:2020);
 - British Standard requirements for the '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*' (ref BS8485:2015+A1:2019);
 - EN 1997-1 (2004): Eurocode 7: *Geotechnical design - Part 1: General rules*;
 - EN 1997-2 (2007): Eurocode 7: *Geotechnical design - Part 2: Ground investigation and testing*; and
 - BRE 365 Soakaway Design
- 1.3.3 Details of the limitations of this type of assessment are described in Appendix A.

2 PHASE 1 PRELIMINARY RISK ASSESSMENT SUMMARY

2.1 Site Description

- 2.1.1 The sites consist of two parcels of land off Alchemy Way, Knowsley, Parcel 1 to the north and west and Parcel 2 to the south-east.
- 2.1.2 Both sites consist of undeveloped land covered by grass and vegetation. Parcel 1 is roughly 'L' shaped and, with the exception of earth bunds situated along the northern and eastern site boundaries, the site was noted to be relatively flat. Parcel 2 is roughly rectangular in shape is a flat elevated platform with pedestrian access gained off Alchemy Way in the north-west, via a grassed embankment. The site was previously densely vegetated which was cleared prior to intrusive ground investigation.

2.2 Site History

- 2.2.1 A review of historical maps indicates that Parcel 1 remained largely undeveloped until present day. Two streams were present between 1867 to 1956, both of which were orientated roughly east to west flowing to the west, one located in the north and one through the southern part of the site. However, these were no longer shown on the 1960 plan, and therefore may have potentially been infilled. A pond was briefly present in the western portion of the site in 2022 and was infilled possibly within the same year.
- 2.2.2 Historical maps indicate that the following are potential sources of contaminants of concern: a dismantled tramway (adjacent south), a paper works (150m south-east), an engineering works (200m east), an electrical substation with associated tanks (250m south-east), and a food factory (200m west), in the surrounding area.
- 2.2.3 Parcel 2 has remained largely undeveloped until the present day. A stream ran through the centre of the site from 1892 to 1956, which may potentially have been infilled prior to development of the sports ground. From the 1960s the site is associated with the wider sports ground annotated to the north.
- 2.2.4 Historical maps indicate that the following are potential sources of contaminants of concern: a dismantled tramway (adjacent south), paper works (50m south-east), engineering works (100m east), electrical substation with associated tanks (100m south-east), food factory (200m west), and tanks (200m west), in the surrounding area.

2.3 Previous Reports

- 2.3.1 RPS has obtained copies of the following reports that relate to the sites:
- WYG: Phase I Geo-environmental Desk Study Report for Land at Alchemy, Knowsley, reference A094359). This report covers a wider site including the subject site.
 - WYG: Alchemy, Knowsley – Japanese Knotweed Encapsulation Strategy and associated plan ref: A094359/JK001. This report covers Parcel 1 area of the site only.
- 2.3.2 RPS cannot vouch for the accuracy or validity of the information provided within third party reports and the following opinion is based solely upon the reports. Legal reliance should be sought from the original authors of these reports where their content is considered material to the characterisation of the site.

WYG: Phase I Geo-environmental Desk Study Report, dated June 2016

- 2.3.3 The Phase I Geo-environmental Desk Study report, which was prepared by White Young Green (WYG) in June 2016 was undertaken for the wider development site. The report was prepared to support potential planning application.
- 2.3.4 From a review of the information contained within the WYG report it is understood that:
- The 'Land Parcel 1' site formerly comprised undeveloped open land with two streams intersecting the northern and southern sections from circa 1850. By 1959, both streams were shown to have been infilled and were no longer present. The site remained unchanged in subsequent maps.
 - The 'Land Parcel 2' site formerly comprised undeveloped open land with a stream traversing the area. By 1959, the site is shown to have been developed with part of a wider sports ground until 2016 when it is no longer shown to be present.
- 2.3.5 The WYG report also includes a review of various phases of site investigation works that had been undertaken across the wider development site between 2001 and 2002 which included exploratory holes within the 'Land Parcel 1 and 2' site. During these investigations Made Ground deposits comprising gravel ash and clinker and re-worked Glacial Till were recorded within the 'Land Parcel 1' site to a maximum depth of 2.70m bgl. Made Ground deposits comprising gravel of brick rubble, ash and clinker and re-worked Glacial Till were encountered to a maximum depth of 2.00m bgl. A thin band of peat was encountered in the north of the site between 1.99m and 2.20m bgl.
- 2.3.6 A slight hydrocarbon film was observed on perched water encountered in the north-western part of the 'Land Parcel 1' Site.
- 2.3.7 Visual evidence of potential asbestos / cement roof sheeting was noted in the eastern part of the site including the 'Land Parcel 2' area.
- 2.3.8 WYG considered that potential contaminative sources had been primarily identified in association with Made Ground from historical infilling, of the wider site area, which includes 'Land Parcels 1 and 2'.
- 2.3.9 On the basis of the available information WYG considered that the contamination risk posed by the site would be low to moderate.
- 2.3.10 Although previous site investigation works had been completed at the site, WYG recommended that a comprehensive ground investigation is undertaken at the site in order to establish the extent of any contamination issues that may be present and to assess geotechnical conditions and land stability.

WYG: Japanese Knotweed Encapsulation Strategy

- 2.3.11 It is understood that Japanese Knotweed was encountered on the wider development area and that as part of the treatment the soil arising generate were transferred to the existing bund on the northern boundary of the 'Land Parcel 1' site, which consisted of unclassified general fill (arising). These works should have been completed when the area to the south of the 'Land Parcel 1' site was developed, however, no information is currently unavailable to confirm that the proposed encapsulation works have been completed in accordance with the proposed strategy and to the satisfaction of the local authority.

2.4 Environmental Setting

- 2.4.1 BGS mapping, a review of historical boreholes and a review of previous reports indicate both sites to be underlain by Made Ground which itself is underlain by a Secondary Undifferentiated Aquifer relating to the Glacial Till. Underlying the Glacial Till is a Principal Aquifer relating to the Chester

Formation – Sandstone is present. Both sites are located in a groundwater Source Protection Zone (SPZ). This relates to a Zone 3 (total catchment) - The total catchment is the total area needed to support removal of water from the borehole, and to support any discharge from the borehole. The Source Protection Zone 3 potentially relates to both potable drinking water abstractions, located approximately 1160m east and 1588m west.

- 2.4.2 The nearest surface water feature is the Knowsley Brook, which is partially culverted, located approximately 80m south of the Parcel 1 site and has an overall quality classification as moderate.
- 2.4.3 Natural England data indicates that there are no ecologically sensitive sites, that constitute environmental receptors as defined within Table 1 of the DEFRA Environmental Protection Act 1990: Part 2A - Contaminated Land Statutory Guidance (2012), located within a 1km radius of the sites.
- 2.4.4 The Interactive Map Viewer on the Coal Authority website indicate that the sites are not located in a coal mining reporting area. In addition, the sites are not located in an area of known or probably underground works and there are no nearby mine entries.

2.5 Preliminary Conceptual Site Model

- 2.5.1 Preliminary CSM's were developed on the basis of the site reconnaissance's and desk studies. The CSM is used to identify potential sources, pathways and receptors (i.e. potential pollutant linkages) on site. The desk studies identified the potential for contamination to be present across the sites associated with the Made Ground that was shown to be mapped as being present on both sites and encountered during the previous investigations undertaken on site. Although there is no significant development history on either site, there is the potential the land was upfilled to form a development platform. Therefore, the presence of Made Ground is considered to potentially be present at significant thicknesses. It was therefore recommended that the potential for these linkages to be active is assessed through an intrusive Phase 2 Site Investigation.
- 2.5.2 Historical investigations in Parcel 2 identified visual evidence of asbestos / cement roof sheeting.
- 2.5.3 Potentially active pollutant linkages could impact the underlying Principal Aquifer which is located within a groundwater SPZ 3 (total catchment). However, there are no active drinking water abstractions recorded within close proximity to the sites (i.e. within 1km) and the presence of cohesive superficial deposits above the bedrock strata will act as an aquitard, limiting vertical migration and therefore protecting the bedrock aquifer. Groundwater within granular horizons of the Made Ground and the underlying superficial deposits may also constitute a potential pathway for the on or off-site migration of contaminants of concern.
- 2.5.4 The CSMs identified a number of potentially active pollutant linkages potentially affecting on and off-site human health receptors, however these would be largely mitigated by the proposed introduction of hardstanding across the majority of the site. There is the potential for ground gas and volatile contaminants of concern in soil and/or groundwater (if present) beneath the site to impact future site users via the inhalation pathway in indoor areas.
- 2.5.5 The outline CSM for each site is provided in the following tables:

Table 2.1: Preliminary Conceptual Site Model Parcel 1

Potential Source	Contaminants of Concern	Via	Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
On site – current: Made Ground, and localised hydrocarbon impacted shallow perched water.	Metals, hydrocarbons, solvents and asbestos	Direct	contact/ingestion	✓	Future site users	Low to moderate	No significant sources of contamination identified. Post development risks minimised by buildings, hardstanding and manged landscaping. Residual risk in areas of soft landscaping, if soils are exposed or disturbed.
On site – historical: N/A				✗		N/A	No sources of volatile contaminants identified.
Soil				✓	Future site users	Low	No significant sources of contamination identified.
				✓	Off-site users		Post development risks minimised by buildings, hardstanding and manged landscaping.
							Residual risk in areas of soft landscaping, if soils are exposed or disturbed
Groundwater				✓	Secondary Undifferentiated Aquifer	Low	Potential for soils leaching and verical and lateral migration of contaminant if present in shallow groundwater. However, migration will be reduced by the largely cohesive nature of the superficial deposits. Following developmnet the presence of hardstanding and building cover which reduce infiltration.
				✓	Future site users	Low	Very shallow groundwater unlikely to be present.
				✗	Off-site users		
				✗	Future site users	N/A	No sources of volatile contaminants identified, however, localised potentially impacted perched groundwater was encountered during the previous site investigations.
				✗	Off-site users		

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Potential Source	Contaminants of Concern	Via Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
Off-site – current: Industrial parks with vehicle servicing and a woodworking machinery factory Off site – historical: Dismantled tramway, paper works, engineering works, electrical substation, food factory, several tanks	Metals, hydrocarbons, solvent and Polychlorinated biphenyls (PCBs)	Vertical and lateral migration in permeable strata	✓	Principal Aquifer	Low	There is limited potential for significant contamination and no shallow groundwater encountered as part of previous investigation. The presence of cohesive superficial deposits will limited vertical and lateral migration of any contaminant offering some protection to the deeper underlying principal aquifer.
		Direct contact/ingestion	✗	Future site users	Low	
On and off-site – Made Ground	Carbon dioxide and methane	Inhalation of volatiles	✓	Future site users	Low	There is a potential for contaminants to migrate beneath the site from off-site sources in any shallow groundwater present in the Made Ground or granular soils within the superficial deposits. However, the largely cohesive nature of the superficial deposits will limit migration.
		Inhalation of ground gas	✓	Future site users	Low to moderate	
On and off-site – Made Ground	Carbon dioxide and methane	Explosive risks	✓	Future site users	Low to moderate	No significant ground gas sources identified other than potential for localised Made ground.
			✓	Off-site users Future and off-site Structures		

Table 2.2: Preliminary Conceptual Site Model Parcel 2

Potential Source	Contaminants of Concern	Via	Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
On site – current: Made Ground, Potential cement bound asbestos sheeting was encountered in the east of the site during historical site investigation.	Metals, hydrocarbons, solvents and asbestos		Direct contact/ingestion	✓	Future site users	Low to moderate	No significant sources of contamination identified. Post development risks will be minimised by the presence of buildings, hardstanding and manged landscaping. Residual risk in areas of soft landscaping, if soils are exposed or disturbed.
				✗		N/A	No potentially significant sources of volatile contaminants identified.
				✓	Future site users	Low to moderate	Post development risks will be minimised by the presence of buildings, hardstanding and manged landscaping.
				✓	Off-site users		Residual risk in areas of soft landscaping, if soils are exposed or disturbed
On site – historical: N/A			Soil				
			Airborne migration of soil or dust	✓	Future site users	Low to moderate	Post development risks will be minimised by the presence of buildings, hardstanding and manged landscaping.
			Leaching of mobile contaminants	✗	Secondary Undifferentiated Aquifer	Low	Potential for soils leaching and vertical and lateral migration of contaminant if present in shallow groundwater. However, migration will be reduced by the largely cohesive nature of the superficial deposits. Following development the presence of hardstanding and building cover which reduce infiltration.
			Direct contact/ingestion	✓	Future site users	Low	Very shallow groundwater unlikely to be present.
			Inhalation of volatiles	✓	Off-site users		
			Vertical and lateral migration in permeable strata	✗	Future site users	N/A	Limited potential for significant volatile contamination in groundwater.
				✗	Off-site users		
				✗	Principal Aquifer	Low	There is limited potential for significant contamination and no shallow groundwater encountered as part of previous investigation.
				✗	Knowsley Brook		The presence of cohesive superficial deposits will limited vertical and lateral migration of any contaminant offering some protection to the deeper underlying principal aquifer.

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Potential Source	Contaminants of Concern	Via	Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
Off-site – current: Industrial park with vehicle servicing and a woodworking machinery factory Off site – historical: Dismantled tramway, paper works, engineering works, electrical substation, food factory, several tanks	Metals, hydrocarbons, solvent and Polychlorinated biphenyls (PCBs)	Groundwater	Direct contact/ingestion	x	Future site users	Low	There is a potential for contaminants to migrate beneath the site from off-site sources in any shallow groundwater present in the Made Ground or granular soils within the superficial deposits. However, the largely cohesive nature of the superficial deposits will limit migration.
			Inhalation of volatiles	x	Future site users	Low	
On and off-site – Made Ground	Carbon dioxide and methane	Ground Gas	Inhalation of ground gas	✓	Future site users Off-site users	Low to moderate	No significant ground gas sources identified other than potential for localised Made ground.
			Explosive risks	✓	Future site users Off-site users Future and off-site Structures	Low to moderate	

2.5.6 Based on the identified potential sources and the site setting there is not considered to be a significant risk to ecological receptors, crops/vegetation or archaeological receptors.

3 INTRUSIVE SITE INVESTIGATION

3.1 Introduction

- 3.1.1 A number of potential pollutant linkages have been identified as associated with the site within the outline CSMs presented as Table 2.1 and Table 2.2. An intrusive site investigation has been carried out in order to provide preliminary assessment of whether pollutant linkages identified within the outline CSM are currently active or will be made active upon redevelopment of the site.
- 3.1.2 The investigation also provided information on ground conditions and data for the assessment geotechnical properties of strata underlying the site.

3.2 Description of Works

- 3.2.1 The site investigation was carried out between the 1st of August 2022 and 4th August 2022 and comprised:

Parcel 1

- Drilling of two boreholes to depths of approximately 10.00m below ground level (bgl) using cable percussion techniques (CP03 to CP04);
- Drilling of four boreholes to depths of up to approximately 5.00m bgl using window sample techniques (WS04 to WS07);
- Excavation of six trial pits to depths of up to approximately 3.50m bgl using a mechanical excavator (TP04 to TP09), two of which were utilised for Building Research Establishment (BRE) Digest 365 infiltration testing;
- In-situ geotechnical testing throughout the depth of all boreholes;
- Installation of groundwater and ground gas monitoring standpipes in each borehole;
- Reinstatement of all trial pits and infiltration pits using uncompacted arisings.

Parcel 2

- Drilling of two boreholes to depths of approximately 10.00m below ground level (bgl) using cable percussion techniques (CP01 to CP02);
- Drilling of three boreholes to depths of up to approximately 5.00m bgl using window sample techniques (WS01 to WS03);
- Excavation of three trial pits to depths of up to approximately 3.50m bgl using a mechanical excavator (TP01 to TP03), two of which were utilised for Building Research Establishment (BRE) Digest 365 infiltration testing;
- In-situ geotechnical testing throughout the depth of all boreholes;
- Installation of groundwater and ground gas monitoring standpipes in each borehole;
- Reinstatement of all trial pits and infiltration pits using uncompacted arisings.

- 3.2.2 Exploratory hole location plans are provided as Figures 4 and 5.

- 3.2.3 The soil arisings from each exploratory hole were carefully examined for visual and olfactory evidence of contamination. Headspace testing was undertaken on site for ionisable volatile organic compounds (iVOCs) using a portable Photo-Ionisation Detector (PID).

- 3.2.4 A return visit for groundwater sampling was carried out on 22nd August 2022. The monitoring wells were inspected for the presence of free-phase hydrocarbon product using an oil/water interface probe and the depth to groundwater was recorded prior to sampling.
- 3.2.5 Ground gas monitoring was undertaken on three occasions, from 15th August 2022 to 5th September 2022. Installations were monitored for concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide, oxygen and iVOCs. In addition, the flow rate and barometric pressure were recorded.

3.3 Investigation Rationale

3.3.1 The rationale behind each of the site investigation locations is summarised in the table below.

Table 3.1: Parcel 1 Exploratory Location Rationale

Exploratory Location ID	Location on Site	Rationale
WS04	East of site	To provide geo-environmental information for the assessment of soil and groundwater contamination and groundwater and ground gas monitoring. To provide geotechnical data to support the design of proposed structures and foundations.
WS05	Centre of site	
WS06	South of site	Within footprint of former pond utilised to locate possible pond sediment.
WS07	South-west of site	To the west of footprint of former pond utilised for delineation of pond sediment.
CP03	West of site	To provide geo-environmental information for the assessment of soil and groundwater contamination and groundwater and ground gas monitoring.
CP04	East of site	
TP04	North-east of site	To provide geotechnical data to support the design of proposed structures and foundations.
TP05	Centre of site	
TP06	North of site	To the west of footprint of former pond utilised for delineation of pond sediment.
TP07	North-west of site	
TP08	South of site	
TP09	South of site	To the west of footprint of former pond utilised for delineation of pond sediment. To allow for infiltration test to be undertaken.

Table 3.2: Parcel 2 Exploratory Location Rationale

Exploratory Location ID	Location on Site	Rationale
WS01	South-west of site	To provide geo-environmental information for the assessment of soil and groundwater contamination and groundwater and ground gas monitoring.
WS02	Centre of site	
WS03	East of site	To provide geotechnical data to support the design of proposed structures and foundations.
CP01	East of site	
CP02	West of site	To provide geotechnical data to support the design of proposed structures and foundations.
TP01	North-west of site	
TP02	South of site	
TP03	North-east of site	

3.4 Site Restrictions

- 3.4.1 Along the northern boundary of the Parcel 1 site an earth bund was present, containing encapsulated Japanese Knotweed from the previously redeveloped adjacent site. This area of the site was avoided throughout the entirety of the site investigation aside from the final day when four Made Ground samples were taken.
- 3.4.2 Another earth bund was present along the eastern site boundary adjacent to Alchemy Way which was removed on the first day of site works to allow rig and vehicle access and reinstated on the final day.

3.5 Laboratory Testing

Geo-Environmental Laboratory Testing - Soil

- 3.5.1 25 samples of Made Ground and one sample of natural strata were submitted to a UKAS/MCERTS accredited laboratory and analysed for a number of determinands including:
- Inorganic Determinands:***
- 3.5.2 pH, arsenic, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, sulphide, total cyanide, sulphate, sulphur, selenium, zinc and asbestos (quantification in cases of positive identification).
- Organic Determinands:***
- 3.5.3 Speciated polyaromatic hydrocarbons (PAH), speciated total petroleum hydrocarbons (TPH CWG) including benzene, toluene, ethylbenzene and xylenes (BTEX) and methyl tert-butyl ether (MTBE), volatile organic compounds (VOCs) and monohydric phenol.
- 3.5.4 WAC testing was undertaken within two samples from the Made Ground, taken from the earth bund encapsulating Japanese Knotweed along the northern site boundary of the Parcel 1 site. The results of this were to aid in the waste disposal of the earth bund upon the sites redevelopment.

Geo-Environmental Laboratory Testing - Groundwater

- 3.5.5 Five groundwater samples were collected during the first monitoring visit to site and submitted to a UKAS/MCERTS accredited laboratory and analysed for number of determinands:
- Inorganic Determinands:***
- 3.5.6 pH, organic matter, arsenic, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, zinc, sulphide, sulphate and total cyanide.
- Organic Determinands:***
- 3.5.7 Speciated PAH, TPH CWG including BTEX and MTBE, VOC, and monohydric phenol.

Geotechnical Laboratory Testing

- 3.5.8 Samples of the Glacial Till and Chester Member were submitted to a UKAS accredited geotechnical testing laboratory and analysed for Moisture Content, Atterberg Limit, Particle Size Distribution (wet sieve), pH and BRE Special Digest 1 sulphate testing, California Bearing Ratio (CBR) and compaction tests.

4 SITE INVESTIGATION FINDINGS

4.1 Geology

- 4.1.1 The strata encountered during the intrusive investigation are summarised in the table below, and described in the following section. The ground conditions across both parcels of land have been discussed as a single site area.
- 4.1.2 One historical borehole log ref: SJ49NW1079 located approximately in the region of proposed Parcel 2 development have been provided on the BGS website. The geology and stratification that are presented on the BGS website logs are similar to the current site investigations findings summarised in table below.

Table 4.1: Encountered Strata During Current Site Investigation

Strata	Depth to top of strata m BGL (m AOD)	Thickness (m)
Made Ground	Ground Level (31.75 to 27.13)	1.20 to 3.80 (where proven*)
Sediment	1.45 – 3.10 (25.90- 24.73)	0.10 to 0.30 (where proven)
Glacial Till	1.20 to 2.15 (29.51 to 28.85)	0.60 to 1.80 (where proven)
Chester Formation	1.65 to 3.30 (25.7 to 24.53)	0.10 to 6.00 (where proven)

*Borehole TP02, 07 and 08 were terminated at 3.5m, 1.8m and 3.5m bgl respectively depth within the Made Ground.

- 4.1.3 Ground level in the proposed Parcel 2 is slightly variable across the site in the range of approximately 31.75m AOD in the northeast to 30.05m AOD in the south-west whilst based on the ground level at the locations of exploratory holes. Ground level in proposed Parcel 1 varies from approximately 28.35m AOD in the northeast to 27.13m AOD in the south-west based on the ground level at the locations of exploratory holes.
- 4.1.4 A geological cross-section in the approximate direction of northeast to south-west for the Parcel 1 site is presented in Figure 6 and for the Parcel 2 site in approximate direction of east to west is presented in Figure 7 respectively.
- 4.1.5 The Glacial Till and the completely weathered Chester Formation are very similar in nature and therefore distinguishing between these two strata can be difficult. For the purposes of this report where strata was encountered which was red brown in colour and is stiff in nature this has been classified as weathered Chester Formation. Whereas where the strata was brown, mottled brown or orange brown and has a consistency of less than stiff, this has been classified as Glacial Till.
- 4.1.6 General descriptions of the strata encountered during the intrusive investigation are summarised below. Reference should be made to the exploratory hole logs within Appendix E of this report for full descriptions of ground conditions underlying the site.
- 4.1.7 Geotechnical laboratory results are provided as Appendix H.
- 4.1.8 Surface covering across both parcels of land generally comprised grass and rough vegetation. In Parcel 2 localised Glacial Till was encountered underlaying the Made Ground, whereas similar strata was not encountered in Parcel 1.
- 4.1.9 Historically there are two streams which ran through Parcel 1 and a pond mapped on the 2022 plan. During the site investigation black organic rich material was encountered in a number of boreholes. This was located in a few exploratory holes beneath the Made Ground in areas where historically the streams may have run. Therefore, this may potentially relate to organic rich sediment within the streams and ponds.

Made Ground

- 4.1.10 Made Ground was generally present at ground level, ranging in thickness from approximately 1.20m to 3.80m where proven. Three of the trial pits TP02, 07 and 08, were terminated within Made Ground. A weak concrete was encountered in TP02 in Parcel 2, at a depth of 0.75 to 1.00m bgl.
- 4.1.11 Made Ground thickness is variable in both Parcels. Although the site has not had a significant development history, it is considered likely that the sites have been uplifted, therefore there is likely to be variability associated with the historical site topography. Historically across Parcel 1, two streams and a pond have been mapped, which have potentially been infilled as part of site upfilling. There was a historical stream across parcel 2, which may also have been infilled.
- 4.1.12 The stratum is variable in nature, but generally comprised brown sandy gravelly silt or brown mottled light to dark grey sandy gravelly clay on some occasions with high organic content and strong hydrocarbon odour. Sands are fine to coarse and gravel fragments are very angular to subangular fine to coarse of brick, coal, clinker, metal, concrete, mudstone, and sandstone and locally pottery and timber. The man-made constituents were relatively consistent across both development parcels.
- 4.1.13 Atterberg Limit testing was undertaken on three soil samples collected from the Made Ground material at depths ranging from approximately 0.80 m to 1.20 m bgl. This testing was undertaken to determine values for Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI). The results for LL ranged from 29% to 33%, for PL ranged from 14% to 16%, and for PI ranged from 15% to 17% respectively which is indicative of a material comprising low plasticity clay. The modified Plasticity Index value ranged from 15.3% to 23.6%, indicates the samples has a low to medium volume change potential. The natural moisture content of the samples of 14% and 18%, which is not indicative of the samples tested being desiccated.
- 4.1.14 Nine Standard Penetration Tests (SPTs) were undertaken within the Made Ground across the Parcel 1 site at depths ranging from approximately 1.20 m to 2.00 m bgl giving N_{60} values in the range of 1 to 22. This is indicative of a low to medium strength cohesive material.
- 4.1.15 The N_{60} values have been calculated from SPT N values using an energy ratio of 64% in cable percussion boreholes and 61% in window sample boreholes respectively. A graph showing SPT N_{60} vs depth is presented as Figure 8.
- 4.1.16 Using the correlation by Stroud, whereby undrained shear strength $C_u = f_1 \times N_{60}$ an $f_1 = 4.5$ is considered as a conservative value based on the Plasticity Index results. This corresponds approximately to undrained shear strength values in the range of 5kN/m² to 99N/m², which is indicative of a low to medium strength cohesive material.
- 4.1.17 Seven SPTs undertaken within the Made Ground on Parcel 2 site at depths ranging from 1.20m to 2.00m bgl gave N_{60} values in the range of 7 to 38. A graph showing SPT N_{60} vs depth is presented as Figure 9.
- 4.1.18 Using the correlation by Stroud, whereby undrained shear strength $C_u = f_1 \times N_{60}$ an $f_1 = 4.5$ is considered as a conservative value based on the Plasticity Index results. This corresponds approximately to undrained shear strength values in the range of 31N/m² to 171N/m², which is indicative of a medium to high strength cohesive material. A graph showing undrained shear strength vs depth is presented as Figure 10.
- 4.1.19 Particle Size Distribution (PSD) testing was undertaken on five samples collected from the Made Ground at depths ranging from approximately 0.80m to 3.00m bgl. The constituents of the sample are summarised below:
- Gravel: 6% to 28%;
 - Sand: 40% to 63%; and

- Silt & Clay: 23% to 41%;

4.1.20 The results indicate a slightly gravelly to gravelly sandy silt/clay to a slightly gravelly to gravelly clayey/silty sand which generally agrees with the field description.

Sediment

4.1.21 In Parcel 1 black organic rich deposits were encountered at the base on the Made Ground. The locations where this was encountered are in similar locations to the former streams and ponds on site. This material is considered likely to be an organic rich Sediment deposit from the streams and ponds. Organic rich soils may also represent a former topsoil, on which the Made Ground may have been placed during upfilling. There is the potential for organic rich soils to be present across the site.

4.1.22 This stratum was generally encountered at depths of 1.45m to 3.1m bgl (25.9 m to 24.73 m AOD) and at a thickness of between 0.10 and 0.30m.

4.1.23 One SPT undertaken within the Sediment at a depth of 2.00 m bgl in WS07 gave N_{60} value of 33.

Glacial Till

4.1.24 Glacial Till was generally encountered underlying Made Ground in a number of locations in Parcel 2 only, at depths ranging from approximately 1.20m to 2.15m bgl (28.85m to 28.51m AOD). No Glacial Till was encountered in Parcel 1.

4.1.25 The thickness of the stratum ranges from approximately 0.60m to 1.80m. Glacial Till was variable in nature but generally comprised soft to firm brown mottled light grey and brown sandy slightly gravelly clay. The sands are fine to coarse, and gravel is subangular to subrounded fine to coarse of sandstone and mudstone.

4.1.26 Atterberg Limit testing was undertaken on two soil samples collected from the Glacial Till at depths of approximately 2.00 m and 3.00 m bgl. The results for LL of 25% to 29%. The results for PL of 12%. The results for PI of 13% to 14%. This is indicative of comprising medium plasticity clay. Modified Plasticity Index values of 14.0% to 16.3%, which indicates that these samples have a moderate volume change potential. The natural moisture content of these samples ranged from 7.1% to 16%, which is indicative of the samples tested being desiccated in one location.

4.1.27 Four SPTs undertaken within the Glacial Till in Parcel 2 site at depths ranging from 1.20 m to 3.00m bgl gave N_{60} values ranged from 13 to 51. A graph showing N_{60} versus depth is presents in Figure 9.

4.1.28 Using the correlation by Stroud and quoted by Trenter¹, whereby undrained shear strength $C_u = f_1 \times N_{60}$ and $f_1 = 5$ is considered appropriate based on the Plasticity Index results. This corresponds approximately to undrained shear strength values in the range of 71kN/m² to 255kN/m², which is indicative of a medium to high strength cohesive material. A graph showing C_u versus depth is presents in Figure 10.

Chester Formation – Sandstone

4.1.29 The Chester Formation Sandstone Member was encountered beneath the Made Ground and Glacial Till at depths ranging from approximately 1.65 m to 2.40 m bgl (29.35 m to 24.97 m AOD). The thickness of the stratum ranged from approximately 0.10m to 6.00m. The Chester Formation

¹ Trenter N.A. Engineering in Devensian tills CIRIA C504, 1999

was encountered at various depths across the site, however, in general the bedrock was shallower in the Parcel 1 site.

- 4.1.30 The stratum was recovered generally as red brown slightly clayey gravelly sand and red brown sandy gravelly clay. Locally weathered red and brown sandstone and mudstone were encountered at depth. Gravel is subangular to subrounded fine to coarse of sandstone and mudstone.
- 4.1.31 Twenty Standard Penetration Tests (SPTs) undertaken within the Chester Formation Sandstone in Parcel 1 and Parcel 2 sites at depths ranging from approximately 2.00 m to 9.00 m bgl gave N_{60} values ranged from 22 to greater than 100, which is indicative of a dense to very dense sand/weak rock. Graphs showing N_{60} versus depth are present in Figure 8 and Figure 9.
- 4.1.32 Particle Size Distribution (PSD) testing was undertaken on six samples collected from the Chester Formation Sandstone at depths ranged from 1.20 m to 5.00 m bgl. The constituents of the sample are summarised below:
- Gravel: 11% to 55%;
 - Sand: 28% to 57%;
 - Silt: 12% to 24%; and
 - Clay: 5% to 18%.
- 4.1.33 The results indicate a slightly silty clayey sand and gravel which generally agrees with the field description.

4.2 Groundwater

- 4.2.1 During drilling, groundwater was encountered within the Chester Formation at depths ranging from approximately 3.60m bgl (24.46m AOD) to 9.00m bgl (21.05m AOD).
- 4.2.2 During trial pitting, groundwater was also encountered within the Made Ground at depths ranging from approximately 1.10m bgl (29.51m AOD) to 1.90m bgl (28.71m AOD).
- 4.2.3 Groundwater levels recorded during subsequent monitoring visits to site are summarised in the table below:

Table 4.2: Groundwater Level Data

Site	Monitoring Well ID	Well Screen Depth (m bgl) [m AOD]	Strata Screened	Depth to Water m bgl [m AOD]		
				15/08/2022	22/08/2022	05/09/2022
Parcel 1	CP03	3.60m to 5.60m bgl	Glacial Till and Chester Formation	1.39 [26.67]	1.21 [26.85]	1.43 [28.06]
	CP04	3.00m to 4.60m bgl	Glacial Till	2.34 [24.92]	2.58 [24.68]	2.72 [24.54]
	WS04	2.00m to 3.00 bgl	Made Ground and Glacial Till	1.27 [27.01]	1.30 [26.98]	1.63 [26.65]
	WS05	1.70m to 2.70m bgl	Made Ground, Sediment and Glacial Till	2.37 [25.38]	2.41 [25.34]	2.45 [25.30]
	WS06	2.00m to 3.00m bgl	Made Ground	3.02 [24.81]	3.05 [24.78]	3.00 [24.83]
	WS07	1.50m to 3.00m bgl	Made Ground	2.68 [24.67]	2.77 [24.58]	2.84 [24.51]
Parcel 2	WS01	0.20m to 0.90m bgl	Made Ground	0.90 [29.19]	0.90 [29.19]	0.90 [29.19]

Site	Monitoring Well ID	Well Screen Depth (m bgl) [m AOD]	Strata Screened	Depth to Water m bgl [m AOD]		
				15/08/2022	22/08/2022	05/09/2022
	WS02	1.00m to 2.00m bgl	Made Ground	1.02 [29.99]	1.07 [29.94]	1.76 [29.25]
	WS03	0.80m to 2.80m bgl	Made Ground and Chester Formation	2.73 [28.78]	2.74 [28.77]	2.77 [28.74]
	CP01	5.00m to 9.00m bgl	Glacial Till	4.17 [25.88]	4.20 [25.85]	4.24 [25.81]
	CP02	3.00m to 5.00m bgl	Glacial Till and Chester Formation	4.55 [27.06]	4.63 [26.98]	4.62 [26.99]

4.2.4 Groundwater encountered during the intrusive works and the subsequent monitoring is considered to be at a similar elevation and it cannot be distinguished into separate groundwater bodies. Therefore, it is considered that groundwater across the site is effectively forming one body of groundwater, with the water in the Made Ground, Secondary Undifferentiated Aquifer (Glacial Till) and Principal Aquifer (Chester Formation) in hydraulic connectivity.

4.2.5 Groundwater depth within the shallow soils is variable across the site, however, flow direction is likely to be towards the south-west.

4.3 Field Evidence of Contamination

Visual and Olfactory Evidence of Contamination

4.3.1 No visual or olfactory evidence of contamination was noted within soil or groundwater during the intrusive investigation.

Photo-Ionisation Detector (PID) Readings

4.3.2 Soil arisings from each exploratory hole were screened for the presence of iVOCs using a PID. No elevated concentrations of volatile contaminants (>100 parts per million (ppm)) were recorded.

4.3.3 PID readings from soil samples collected from the boreholes ranged from below limit of detection (<0.1ppm) and 13.8ppm.

4.3.4 Full records of PID readings are presented on the exploratory logs within Appendix E.

4.3.5 During subsequent ground gas and groundwater monitoring visits, PID readings generally ranged from below limit of detection (<0.1ppm) and 4.8ppm. PID readings did not exceed 10ppm on any occasion, which would potentially indicate the presence of Volatile Organic Compounds.

5 SOIL CONTAMINATION ASSESSMENT

5.1 Human Health

- 5.1.1 The following section summarises the soil analytical data and provides a comparison to published assessment criteria (AC) derived to support the assessment of chronic risk to human health receptors.
- 5.1.2 The selected AC are Suitable 4 Use Levels (S4UL) published by Land Quality Management: Chartered Institute of Environmental Health (LQM:CIEH) in 2015. *In accordance with the copyright notice, the Publication Number for RPS Group is S4UL3177.*
- 5.1.3 Given the proposed use of the site as a location for industrial units the assessment has been based on a conservative commercial use.
- 5.1.4 Soil Organic Matter (SOM) for samples of Made Ground ranged from 0.2% to 40.7%. In order to provide a conservative assessment, concentrations of contaminants of concern have been compared to AC derived for an SOM value of 1.0%.
- 5.1.5 A notable exclusion from the S4ULs is lead. In the absence of a S4UL for lead, the Category 4 Screening Level (C4SL) has been selected, published by DEFRA in 2014. It is noted that the C4SL are based on the acceptance of a low level of toxicological concern, rather than the more conservative standard adopted in the derivation of S4ULs, which are based on a tolerable or minimal level of risk.
- 5.1.6 The potential risk posed to controlled waters from contaminants of concern within soils beneath the site is not addressed by these screening criteria. Please refer to Section 6 of this report for comment on the risk to controlled waters receptors.

5.2 Comparison of Soil Analyses to Assessment Criteria

- 5.2.1 Chemical analysis by a UKAS/MCERTS accredited laboratory was undertaken on 25 samples of Made Ground and one sample of the natural strata. A comparison of soil analyses to the relevant AC is summarised below and presented as Appendix J. Analytical certificates for soils are presented in Appendix K.
- 5.2.2 No contaminants of concern were recorded at concentrations above their respective AC within the soil samples collected from either Made Ground or natural strata.
- 5.2.3 25 samples of Made Ground were submitted for an asbestos screen. Asbestos was identified as free fibres within three of the 25 samples submitted for screening. All three positive identifications were recorded within Made Ground samples taken from TP01 (0.85m bgl), CP02 (0.70m bgl) and CP03 (0.50m bgl). Two of the locations TP01 and CP02 are located in Parcel 2 and CP03 is located in the north-west of Parcel 1.
- 5.2.4 Subsequent asbestos quantification analysis undertaken on the three samples did not identify asbestos above the limit of detection (0.001%).

6 GROUNDWATER CONTAMINATION ASSESSMENT

6.1 Controlled Waters

- 6.1.1 The following section summarises the groundwater analytical data and provides a comparison to published assessment criteria (AC).
- 6.1.2 Based on the outline conceptual site model, the primary controlled waters receptor is considered to be the underlying Secondary Undifferentiated Aquifer relating to the Glacial Till which in turn is underlain by the Principal Aquifer relating to the Chester Formation – Sandstone. Groundwater was encountered across the site and strata during the intrusive works and subsequent monitoring which indicate that the Secondary Undifferentiated Aquifer and the Principal Aquifer are in hydraulic connectivity and are effectively forming one body of groundwater.
- 6.1.3 The nearest surface water is the part-culverted Knowsley Brook which is 80m to the south at its closest point. This is potentially in hydraulic connectivity with the groundwater beneath the site.
- 6.1.4 Therefore, the groundwater analytical data have been compared to Environmental Quality Standards (EQS) for freshwater values and UK Drinking Water Standards (DWS).
- 6.1.5 For a number of chemicals of concern the EQS and DWS are less than the laboratory limit of detection. For the purpose of this preliminary assessment, where all samples are recorded at less than the laboratory limit of detection no further assessment is considered necessary.
- 6.1.6 The potential risk to on site human health receptors from contaminants of concern in groundwater is not addressed by these screening criteria.

Comparison of Groundwater Analyses to Controlled Waters Assessment Criteria

- 6.1.7 Chemical analysis was undertaken on two groundwater samples collected from monitoring wells with response zones targeting the Made Ground and two samples collected from Glacial Till and a sample collected from a well where the response zone targeted the Glacial Till and Chester Formation. A comparison of groundwater analyses to the relevant assessment criteria is summarised below and presented as Appendix J. Analytical certificates for groundwater samples are presented in Appendix K.

Table 6.1: Contaminants in Groundwater at Concentrations Exceeding the AC

Contaminant of Concern	Location	Assessment Criteria (µg/l)	Concentration (µg/l)
Nickel (dissolved)	WS04	20 (EQS)	22
Benzo(a)pyrene	WS02	0.05 (EQS)	0.108
Benzo(b)fluoranthene	WS02	0.03 (EQS)	0.12
Benzo(ghi)perylene	WS02	0.002 (EQS)	0.043
Benzo(k)fluoranthene	WS02	0.03 (EQS)	0.046
Fluoranthene	WS02	0.10 (EQS)	0.267
	CP04		0.105
Indeno(1,2,3-cd) pyrene	WS02	0.002 (EQS)	0.053
Total Cyanide	WS02	10 (EQS)	20

- 6.1.8 As shown in Table 6.1, a marginal exceedance of the assessment criteria have been detected for Nickel, a heavy metal, in one groundwater sample collected from WS04.

- 6.1.9 Exceedances of the assessment criteria have been detected for multiple PAH compounds in the groundwater sample taken from WS02 including benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, fluoranthene and indeno(1,2,3-cd)pyrene. The greatest exceedance consisted of 0.053 µg/l of indeno(1,2,3-cd)pyrene, 0.051 µg/l over the EQS of 0.002 µg/l. A marginal exceedance was detected for Fluoranthene in the groundwater sample CP04.
- 6.1.10 Concentrations of individual aliphatic and aromatic TPH fractions and VOC compounds were not detected in excess of the laboratory detection limit in either of the groundwater samples analysed.

6.2 Human Health

- 6.2.1 In order to assess risks to future site users via the inhalation of vapours arising from groundwater, potentially volatile concentrations of contaminants of concern within groundwater sampled from beneath the site have been compared to generic assessment criteria (GACgwvap) published by the Society of Brownfield Risk Assessment (SoBRA) in February 2017. The GACgwvap based upon a commercial end-use have been utilised in this assessment.

Comparison of Groundwater Analyses to Human Health Assessment Criteria

- 6.2.2 A comparison of groundwater analyses to the relevant human health assessment criteria is summarised below and presented as Appendix J. Analytical certificates for groundwater samples are presented in Appendix K.
- 6.2.3 No contaminants of concern were recorded at concentrations above their respective Human Health AC within the collected groundwater samples.

6.3 Summary of Groundwater Contamination

- 6.3.1 Several speciated PAH compounds and total cyanide were recorded at concentrations above their EQS within the groundwater sample collected from the shallow groundwater body encountered within the Made Ground in WS02. Albeit elevated the majority are considered to be marginal at less than 3 times the assessment criteria.
- 6.3.2 A marginal exceedance of assessment criteria was detected for Nickel in one groundwater sample collected from WS04, given the marginal nature of the exceedance is not considered to be of significant concern.
- 6.3.3 No concentrations of any volatile contaminants were recorded at concentrations above the laboratory limit of detection and therefore are not considered to pose a risk to controlled waters of human health.

7 GROUND GAS RISK ASSESSMENT

7.1 Ground Gas Monitoring Data

7.1.1 Ground gas monitoring was undertaken on three occasions between 15th August 2022 and 5th September 2022. Monitoring wells were monitored for concentrations of methane, carbon dioxide and oxygen. In addition, the flow rate and barometric pressure were recorded. The results of the ground gas monitoring are presented in Appendix I.

7.1.2 Atmospheric pressures are presented in Table 7.1 below:

Table 7.1: Atmospheric Pressure Summary

Monitoring Date	Atmospheric Pressure Range (m Bar)	Pressure Trend
15/08/2022	997 to 998	Rising
22/08/2022	1006 to 1008	Steady
05/09/2022	1009 to	Rising

7.1.3 Methane was recorded at a maximum concentration of 65.3% volume/volume (v/v) in monitoring well WS05, screened within the Made Ground, Sediment Deposits and Glacial Till, on 15th August 2022. Methane concentration within this borehole were consistently high with readings between 61.5 and 65.3% v/v recorded throughout. In addition, high methane concentrations were recorded in WS06 (8.4 to 46.1% v/v), WS07 (28.5 to 35.8% v/v), and CP02 (3.9 to 8.5% v/v). Borehole WS06 and WS07 were screened within the Made Ground and CP02 was screened in the Glacial Till and Chester Formation.

7.1.4 Carbon dioxide was recorded at a maximum concentration of 32.5% v/v within monitoring well WS05, screened within the Made Ground, Sediment Deposits and Glacial Till, on 5th September 2022. Carbon dioxide concentration within this borehole were consistently high with readings between 32.5 to 33.1% v/v. In addition, high carbon dioxide concentrations were recorded in WS06 (14.1 to 28.7 % v/v) and WS07 (14.1 to 13.4% v/v). Carbon dioxide concentrations above 10% was also recorded in WS02, screened within the Made Ground, on the 22nd August 2022.

7.1.5 The maximum recorded steady ground gas flow rate was 0.8l/hr, recorded in monitoring well CP02, screened within the Glacial Till and Chester Formation, on 5th September 2022. There is no significant change in gas flow recorded throughout the monitoring period.

7.1.6 The lowest recorded oxygen concentration was below detection limit (0.1% v/v) within monitoring well WS05 screened within the Made Ground, Sediment Deposits and Glacial Till, on 15th August 2022 and 22nd August 2022. Depleted oxygen (concentrations less than 16%) was recorded in a number of boreholes throughout the monitoring period (WS03, WS05, WS06, WS07, CP01, CP02, CP03 and CP04).

7.1.7 Atmospheric pressure ranged from 997mb to 1011mb during the three monitoring periods.

7.1.8 Monitoring wells in WS04, CP01, CP03 and CP04 were fully flooded throughout the monitoring period and WS02 was partially flooded during the first two rounds of gas monitoring. Therefore, the reading from these boreholes may not be reflected of the ground gas regime and therefore have been discounted from the assessment.

7.1.9 Given the significant variation in gas monitoring for boreholes in Parcel 1 and those in Parcel 2, the assessment below has been separated to assess each development plot separately.

7.1.10 The ground gas monitoring data is presented in full as part of Appendix I.

7.2 Ground Gas Risk Assessment

- 7.2.1 CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' outlines indicative guideline concentrations for carbon dioxide and methane in association with gas flow rates for which gas protection measures may be required in new residential or commercial developments. The methodology is based on the Modified Wilson and Card approach that characterises the gas regime into a series of Characteristic Situations (1 to 5), with corresponding indicative gas protection measures.
- 7.2.2 BS8485:2015+A1:2019 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*' recommends calculation of borehole hazardous gas flow rates (Borehole Qhg) for each individual borehole and for each monitoring event multiplying the maximum recorded stabilised flow in any standpipe in a strata with the maximum peak gas concentration. BS8485 also indicates that the worst case Qhg should be calculated for each hazardous gas by multiplying the maximum recorded stabilised flow in any standpipe in a strata (and zone) with the maximum peak gas concentration in any other standpipe in that strata (and zone).
- 7.2.3 Based on the ground gas monitoring associated with this site investigation, the maximum Borehole Qhg for the site as a whole and for each parcel separately is provided in the following table.

Table 7.2: Atmospheric Pressure Summary

Site Area	Maximum Borehole Qhg	
	Methane	Carbon dioxide
Whole Site	0.0653	0.0696
Parcel 1	0.0653	0.0331
Parcel 2	0.0312	0.0696

- 7.2.4 The worst case Qhg is calculated by combining the characteristic steady flow rate from any standpipe with the highest gas concentrations from any borehole. For parcel 1 this is calculated using the characteristic steady flow rate of 0.1 and the highest gas concentration for methane of 65.3%, therefore giving a Qhg of 0.0653. For Parcel 2 this is calculated using the characteristic steady flow rate of 0.8 and the highest gas concentration for carbon dioxide of 13.9, therefore giving a Qhg of 0.1112.
- 7.2.5 For parcel 2 the Qhg is within the gas screening value range indicative of Characteristic Situation 2 (CS2), whereby basic gas protection measures are required.
- 7.2.6 For Parcel 1, the Qhg is within the gas screening value range indicative of Characteristic Situation 2 (CS2). However, it should be noted that the consistently significantly high methane and carbon dioxide concentrations were recorded during the site investigation. Within Parcel 1 black organic rich soils were identified and also the Made Ground across the site also contains locally high organic content, timber and hydrocarbon odour. It is considered that these deposits may be the source of the elevated Methane and Carbon Dioxide. It is recommended that further monitoring to determine the long-term gas generation at the site and further assessment of potential risk is undertaken prior to confirmation of the gas Characterisation Situation and design of the gas protection measures.
- 7.2.7 Gas protection measures should be designed and implemented in accordance with the requirements of BS 8485:2015+A1:2019 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*'.

8 REVISED CONCEPTUAL SITE MODEL

8.1 Introduction

- 8.1.1 The UK approach to the management of land contamination through the development process is risk based.
- 8.1.2 Local Planning Authorities implement the National Planning Policy Framework in relation to land contamination using the approach set out by EA guidance Land Contamination: Risk Management 2020 (LCRM).
- 8.1.3 The risk assessment methodology suggested by LCRM reflects that set out within Part 2A of the Environmental Protection Act 1990. Part 2A identifies that harm to human health and the environment arises not solely from the presence of contaminating substances or 'sources', but from their migration along a 'pathway' to where they can impact a 'receptor'.
- 8.1.4 The potential pollutant linkages identified as part of the outline CSM have been assessed in light of the findings of the site investigation and are discussed below for each of the potential post development individual receptors identified but the Outline Conceptual Model.

8.2 Human Health Receptors

Post Development Site Users

- 8.2.1 Asbestos fibres were identified within samples for Made Ground from TP01 (0.85m bgl), CP02 (0.70m bgl) in parcel 2 and CP03 (0.50m bgl) in Parcel 1. Subsequent asbestos quantification analysis undertaken on the three samples did not identify asbestos above the limit of detection (0.001%).
- 8.2.2 No contaminants of concern were recorded at concentrations above their respective Human Health AC within the collected groundwater samples. It is considered highly unlikely that future site users will be exposed to groundwater beneath the site given the sites proposed use.
- 8.2.3 No potentially volatile compounds were detected at concentrations considered to represent a potential risk to future site users via the volatilisation pathway.
- 8.2.4 According to current development plans, building cover and hardstanding are proposed in areas of the site where these exceedances have been identified, therefore mitigating potential risk to future site users from these contaminants of concern. There is the potential for residual risk in areas of existing soft landscaping, if soils are exposed or disturbed.
- 8.2.5 Gas monitoring undertaken as part of the current investigation identified significant concentration of methane and carbon dioxide in Parcel 1. On the monitoring to date the site is classified as CS2, however it is recommended that further monitoring is undertaken to determine the long-term gas generation at the site and to enable further assessment of the potential risk to be undertaken prior to confirmation of the gas characterisation situation and design of the gas protection measures.
- 8.2.6 Gas monitoring undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 2, whereby basic gas protection measures are required.
- 8.2.7 On the basis of the above, and providing that all discussed and recommended mitigation measures are included in the development, the potential risk to future site users from contaminants of concern identified within soil and groundwater sampled from beneath the site, is considered to be **Low**.

Off-site Human Health Receptors

- 8.2.8 Upon redevelopment, it is understood that all areas of the site will be covered by building footprint or hardstanding, and there is therefore limited potential for the air-borne migration of soil or dust to impact neighbouring receptors. In any proposed areas of soft landscaping, clean topsoil cover should be provided to break this pathway.
- 8.2.9 Concentrations of contaminants of concern considered to represent a significant risk to human health receptors were not recorded within groundwater samples analysed from beneath the site.
- 8.2.10 The potential risk to off-site human health receptors from these concentrations of contaminants of concern is therefore considered to be **Low**.

Construction/ Maintenance Workers

- 8.2.11 S4ULs or C4SLs cannot be used to assess the acute (short term exposure) risk that personnel in close contact with exposed soils may experience during demolition, redevelopment or site maintenance duties.
- 8.2.12 Potential risks to construction workers can be controlled in most site areas by appropriate risk assessment and adoption of appropriate control measures, including the use of suitable personal protective equipment (disposable coveralls, gloves, and particulate/vapour masks) and by maintaining high levels of personal hygiene.
- 8.2.13 Asbestos fibres were detected in seven samples of Made Ground collected from exploratory holes across the site. No Asbestos Containing Materials (ACM) were encountered. An asbestos management plan should be implemented for the proposed redevelopment. Should significant quantities of asbestos be detected in soils during any site redevelopment, a specialist contractor should be approached to advise on removal and disposal.
- 8.2.14 Providing contractors undertake and implement a site-specific risk assessment and resulting mitigation measures are taken, based on the available information, the potential risk to ground workers is considered to be **Low**.

8.3 Controlled Waters Receptors

- 8.3.1 Several speciated PAH compounds and total cyanide were recorded at concentrations above their EQS AC within the groundwater sample collected from the shallow groundwater body encountered within the Made Ground in WS02.
- 8.3.2 Groundwater encountered across the site is considered to be a continuous body and is likely in hydraulic connectivity with the underlying Principal Aquifer. The local cohesive deposits within the Made Ground and the Glacial Till may potentially limited lateral and vertical migration where present. The Made Ground across the site is described as containing clinker, coal and other man-made constituents which are known to be high in PAHs, therefore the source of the elevated PAHs may be the presence of these materials within the Made Ground. However, it should be noted that the exceedances are limited to a single borehole located in the centre of the site and are not wide spread.
- 8.3.3 Given the distance to the surface water receptors and the closest groundwater abstraction point, and the presence of these cohesive layers within the strata, it is not considered that the groundwater beneath the site poses a significant risk to controlled waters in the vicinity of the site. In addition, the proposed development, which comprises covering the site largely in hardstanding and buildings, will reduce the infiltration and therefore leaching of the potential source within the Made Ground.
- 8.3.4 On the basis of the above, the potential risk to groundwater from contaminants of concern originating from the site is considered to be **Low**.

8.4 Structures and Infrastructure

Buildings (on site and off site)

- 8.4.1 Based on the ground gas monitoring undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 2.
- 8.4.2 Based on the ground gas monitoring, undertaken on site as part of the current investigation, the site can be classified as CIRIA CS2. However, consistently significantly high methane and carbon dioxide concentrations were recorded during the site investigation. It is likely that the source of these gas is the Made Ground and localised organic rich strata underlying the site. Therefore, it is recommended that further monitoring to determine the long-term gas generation at the site and further assessment of potential risk is undertaken prior to confirmation of the gas Characterisation Situation and design of the gas protection measures. I.
- 8.4.3 Assuming appropriate mitigation measures are adopted, the risk posed by ground gas to human health receptors and infrastructure is considered to be **Low**.

Polymeric Utility Pipes

- 8.4.4 Elevated concentrations of PAH contamination were recorded in the shallow groundwater beneath Parcel 2. Standard polymeric utility pipes may therefore be unsuitable for the proposed development. Barriers may be required for new underground utilities, or service pipes laid in dedicated trenches and backfilled with clean, inert material.
- 8.4.5 Requirements for buried utility pipes should be discussed with service providers before the development stage. Provided the recommended mitigation measures are adopted, the risk posed to buried services is not considered to be significant.

8.5 Revised Conceptual Model

- 8.5.1 The potential source-pathway-receptor linkages and associated risks upon completion of the proposed development at the site, as identified following completion of the assessment, are summarised in the revised CSM below.
- 8.5.2 The risk assessment is based upon the available information relating to the site and recommended mitigation measures being implemented. Should ground conditions inconsistent with those outlined in this report be encountered RPS should be contacted to enable further assessment.

Table 8.1: Revised Conceptual Site Model – Parcel 1

Potential Source	Contaminants of Concern	Via Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
On site – current: Made Ground, and localised hydrocarbon impacted shallow perched water.	Asbestos	Direct contact/ingestion	x	Future site users	Low	No chemical exceedances within sampled soils. Asbestos identified within soil samples is unlikely to be mobilised post development once covered by buildings, hardstanding, and manged landscaping.
On site – historical: N/A						
		Inhalation of volatiles	x		Low	No volatile contamination exceedances recorded.
		Airborne migration of soil or dust	x	Off-site users	Low	Post development cover will prevent airborne migration of potential contaminants.
		Leaching of mobile contaminants	x	Secondary Undifferentiated Aquifer Principal Aquifer	Low	Presence of hardstanding across the site will reduce rainfall infiltration into the shallow soils across the site
		Direct contact/ingestion	x	Future site users Off-site users	Low	Presence of hardstanding will prevent direct contact with any contaminants.
		Inhalation of volatiles	x	Future site users Off-site users	Low	No volatile contamination exceedances recorded.
		Vertical and lateral migration in permeable strata	x	Secondary Undifferentiated Aquifer Principal Aquifer Knowsley Brook	Low	Given the distance to the surface water receptors and the closest groundwater abstraction point, and the presence of these cohesive layers within the strata, the risk to more sensitive receptor is reduced.

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Potential Source	Contaminants of Concern	Via Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
Off-site – current: Industrial parks with vehicle servicing and a woodworking machinery factory Off site – historical: Dismantled tramway, paper works, engineering works, electrical substation, food factory, several tanks	PAHs	Direct contact/ingestion	✗	Future site users	Low	Post development cover will prevent exposure. Limited shallow groundwater present.
		Inhalation of volatiles	✗	Future site users	Low	No volatile contamination exceedances recorded.
On and off-site – Made Ground	Carbon dioxide and methane	Inhalation of ground gas	✓ ✓	Future site users Off-site users	Low to Moderate	Significantly elevated methane and carbon dioxide concentrations were recorded on site which pose a risk to end users. CIRIA CS2 is applicable to the site however further assessment is recommended to confirm this.
		Explosive risks	✓ ✓ ✓	Future site users Off-site users Future and off-site Structures	Low to Moderate	Potentially explosive gases were not recorded at elevated concentrations during ground gas monitoring. However, it should be noted that significant concentrations of methane were detected, albeit at concentrations above the upper explosive limit. Therefore, there is potential for methane to be present within the explosive limit range beneath the site.

Table 8.2: Revised Conceptual Site Model – Parcel 2

Potential Source	Contaminants of Concern	Via	Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
On site – current: Made Ground, Potential cement bound asbestos sheeting was encountered in the east of the site during historical site investigation.	Asbestos		Direct contact/ingestion	x	Future site users	Low	No chemical exceedances within sampled soils. Asbestos identified within soil samples is unlikely to be mobilised post development once covered by buildings, hardstanding, and manged landscaping.
On site – historical: N/A		Soil	Inhalation of volatiles	x		Low	No volatile contamination exceedances recorded.
			Airborne migration of soil or dust	x	Off-site users	Low	Post development cover will prevent airborne migration of potential contaminants.
			Leaching of mobile contaminants	x	Secondary Undifferentiated Aquifer Principal Aquifer	Low	Presence of hardstanding across the site will reduce rainfall infiltration into the shallow soils across the site
			Direct contact/ingestion	x x	Future site users Off-site users	Low	Presence of hardstanding will prevent direct contact with any contaminants.
		Groundwater	Inhalation of volatiles	x x	Future site users Off-site users	Low	No volatile contamination exceedances recorded.
			Vertical and lateral migration in permeable strata	x x x	Secondary Undifferentiated Aquifer Principal Aquifer Knowsley Brook	Low	Given the distance to the surface water receptors and the closest groundwater abstraction point, and the presence of these cohesive layers within the strata, the risk to more sensitive receptor is reduced.

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Potential Source	Contaminants of Concern	Via	Potential Pathways	Linkage Potentially Active?	Receptors	Qualitative Risk Rating	Notes
Off-site – current: Industrial park with vehicle servicing and a woodworking machinery factory Off site – historical: Dismantled tramway, paper works, engineering works, electrical substation, food factory, several tanks	PAH	Groundwater	Direct contact/ingestion	x	Future site users	Low	Post development cover will prevent exposure. Limited shallow groundwater present.
			Inhalation of volatiles	x	Future site users	Low	No volatile contamination exceedances recorded.
On and off-site – Made Ground	Carbon dioxide and methane	Ground Gas	Inhalation of ground gas	x x	Future site users Off-site users	Low	CIRIA CS2 is applicable to the site, whereby basic ground gas protection may be required. Where installed, gas protection measures will break this pathway.
			Explosive risks	x x	Future site users Off-site users Future and off-site Structures	Low	Potentially explosive gases were not recorded at elevated concentrations during ground gas monitoring.

8.5.3 The risk assessment is based upon the available information relating to the site and recommended mitigation measures being implemented. Should ground conditions inconsistent with those outlined in this report be encountered RPS should be contacted to enable further assessment.

9 GEOTECHNICAL ASSESSMENT

9.1 Introduction

- 9.1.1 It is proposed to redevelop the site as two parcels. The Parcel 1 site is understood to comprise the construction of two light industrial buildings, with external loading bay, dock levellers and car parking areas. A proposed development plan is presented in Appendix C.
- 9.1.2 The Parcel 2 site is understood to comprises the construction of two light industrial buildings (both split into several units), with external yard and car parking areas. A proposed development plan is presented in Appendix C.
- 9.1.3 No preliminary structural loads have been received. Therefore, the preliminary recommendations below will need to be reviewed in light of subsequent detailed design.

9.2 Preliminary Geotechnical Risk Register

- 9.2.1 The table below summarises the potential geotechnical hazards associated with the development. The table provides an assessment of whether the site is likely to be affected by the hazard and the possible consequences and engineering considerations.

Table 9.1: Geotechnical Risk Register

Hazard Description	Potential for Hazard	Comments / Possible Engineering Requirements
Sudden lateral / vertical changes in ground conditions	Low to Moderate	The ground conditions from existing ground level are generally consistent with Made Ground of shallow to medium depth overlying the Glacial Till and Chester Formation. The Glacial Till and Chester Formation will provide a suitable bearing stratum for low to moderate loads, where this is at least medium strength clay or medium dense sand. For more heavily loaded structures, piled foundations, socketed within Chester Formation will be required.
Highly compressible / low bearing capacity soils, (including peat and soft clay)	Low to Moderate	Thickness of Made Ground was encountered across the site is highly variable from 0.90m to 3.80m.
Ground dissolution features / natural cavities	Low	Ground conditions beneath the site are not consistent with these conditions.
Shrinking and swelling clays	Moderate	Based on the Atterberg Test results Glacial Till is considered a material subject to low to medium volume change potential. Based on the moisture content results there does appear to be evidence of a desiccation zone of Glacial Till in some locations in the Parcel 2 site. Mature trees have been identified adjacent to the site. The potential effect of these on the depth required for foundations should be assessed in accordance with the NHBC Standards.
Slope stability issues	Low	Whilst no significant slopes are present on site (maximum differential level across the sites is less than 2.00m), any temporary slopes created as part of the development should be subject to appropriate geotechnical design based on available site investigation information.

Hazard Description	Potential for Hazard	Comments / Possible Engineering Requirements
High groundwater table (including waterlogged ground)	Moderate to High	Groundwater seepage was encountered at depths from 1.10 m to 1.90 m bgl within the Made Ground and at 3.60m bgl to 9.00 m bgl within the Chester Formation during the site works and from 0.90 m to 4.63 m bgl (29.19 m to 24.98 m AOD) during the subsequent monitoring visits. Excavations below this depth may be unstable and excavation support as well as groundwater control measures may be required. Particular attention should go to potential contamination of Principal Aquifer within bedrock due to excavation and pile installation.
Filled and Made Ground (including embankments)	Moderate	Made Ground was encountered with a variable thickness up to 3.80m beneath both sites.
Obstructions (including foundations, services, basements, tunnels and adjacent sub-structures)	Low to Moderate	The site does not have a significant development history and it is considered unlikely that relic structures will be present beneath the site. However, if present it is likely these obstructions, may be removed using standard construction plant.
Underground mining	Low	Ground conditions beneath the site are not consistent with these conditions.
Concrete classification	Low	Testing has indicated a Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC-2z would be appropriate for all buried concrete structures.
Seismic Activity	Low	The Eurocode 8 seismic hazard zoning maps for the UK (Musson and Sargeant, 2007) indicate that horizontal Peak Ground Acceleration (PGA) values with 10% probability of being exceeded in 50 years (475 year return period) are between 0.00 and 0.02g, which is considered very low.

9.2.2 The potential risks are given one of the following classifications:

- **Low risk** - it is considered unlikely that issues within the category will give rise to significant damage in relation to the proposed development.
- **Moderate risk** - it is possible, but not certain that issues within the category will give rise to significant damage in relation to the proposed development.
- **High risk** - there is a high potential that issues within the category will give rise to significant damage in relation to the proposed development.
- **N/A** - The anticipated ground conditions are not consistent with this hazard.

9.3 Preliminary Geotechnical Parameters

9.3.1 The following table shows the preliminary anticipated ground model and geotechnical parameters based on the findings of the preliminary intrusive investigation and subsequent testing.

Table 9.2: Preliminary Ground Model and Geotechnical Parameters

Stratum	Depth to Top of Stratum (m bgl) [m AOD]	Bulk Unit Weight, γ_b (kN/m ³)	Effective Friction Angle, ϕ' (°)	Undrained Shear Strength, C_u (kPa)	Undrained Elastic Modulus (MPa)	Drained Elastic Modulus (MPa)
Parcel 1 Land						
Made Ground	Ground Level [28.35 to 27.13]	18 ^(I)	-	30 ^(I)	10 ^(I)	7 ^(I)
Chester Formation Sandstone/Mudstone	1.65 to 3.30 [25.70 to 24.53]	19 ^(I)	34 ^(I)	-	-	100 ^(IV)
Parcel 2 Land						
Made Ground	Ground Level [31.75 to 30.05]	18 ^(I)	-	30 ^(I)	10 ^(I)	7 ^(I)
Glacial Till	1.20 to 2.15 [28.85 to 28.51]	19 ^(I)	-	30+50z ^(II)	10.8+18z ^(II, III)	8.1+13.5z ^(II, III)
Chester Formation Sandstone/Mudstone	2.40 to 3.00 [29.35 to 27.05]	19 ^(I)	34 ^(I)	-	-	100 ^(IV)

I. Conservative estimate.

II. z = depth below surface of the Glacial Till (2 m bgl) to 4 m bgl.

III. Trenter N.A. Engineering in Devensian tills CIRIA C504, 1999, based on $E_u=360C_u$ and $E'=0.75E_u$.

IV. C.R.I. Clayton (1995) - The Standard Penetration Test (SPT): Method and Use, CIRIA R143, based on $E'=N(\text{MPa})$

9.4 Temporary Works and Excavations

- 9.4.1 Groundwater was encountered at depths from approximately 1.10 m bgl during intrusive works and 0.90 m bgl during subsequent monitoring visits. Therefore, groundwater exclusion and control measures may be required for proposed foundation excavations. It is considered that groundwater inflows should not be excessive and likely to be controlled via localised sump and pumping. If stronger inflows are encountered, recourse to a temporary groundwater exclusion system may be required, such as sheet piling.
- 9.4.2 If groundwater is encountered during excavation, degradation of the formation may occur. The formation should therefore be adequately protected from seepages and protected from adverse weather conditions. If the formation layer becomes wet resulting in loosening of the surface materials, then excavation may have to be taken deeper in order to find a suitable bearing layer.
- 9.4.3 The requirement for suitable shoring measures or battering of excavations must be assessed by a competent person. All excavations must be inspected regularly by a competent person, especially during and after periods of adverse weather. Reference should be made to CIRIA Report 97 – Trenching Practice with respect to temporary safe slope angles for excavations.

9.5 Reuse of Excavated Material

- 9.5.1 Based on the site topographical conditions, approximate ground levels vary up to approximately from 1.20 m across the Parcel 1 site to 1.70m across the Parcel 2 site, thus some degree of cut and fill may be required to build a platform enabling the installation of the proposed structures.
- 9.5.2 In the absence of the final formation level and cut and fill drawings, identifying the locations to collect soil samples for earthworks purposes will not be accurate, however, two samples from Made Ground across the sites were collected to undertake compaction testing.
- 9.5.3 One sample was collected from CP01 in Parcel 2 site and compacted in the Standard Proctor mould with 2.5kg hammer. Another sample was collected from CP04 in Parcel 1 site and was compacted with 4.5kg hammer. The compaction results are presented in Appendix F. The results

of the testing gave the Optimum Moisture Content (OMC) for the Made Ground as 14% and 24% and Maximum Dry Density (MDD) of 1.49Mg/m³ and 1.88Mg/m³.

- 9.5.4 The natural moisture content of samples tested from the Made Ground ranged between 13% and 27%, with an average of 17.5%. As such some limited moisture conditioning may be required to enable compaction to less than 5% air voids and greater than 95% Maximum Dry Density i.e. a maximum acceptable moisture content of circa 13% to 23%.
- 9.5.5 Based on the findings of the current site investigation and considering the Made Ground descriptions, it is likely that Made Ground material cannot be reused as an engineered fill due to high organic contents but may be reused as a Class 4 Fill to landscape areas material.

9.6 Foundation Solutions

Traditional Foundations

- 9.6.1 Due to the inherent textural, compositional variability and compressibility of the Made Ground, this is considered unsuitable as a bearing stratum for shallow foundations.
- 9.6.2 Based on SPTs, the Glacial Till and Chester Formation is likely to provide a suitable bearing stratum for shallow foundations supporting lightly to moderate loaded structures it is considered that strip or pad foundations may be adopted to support the structural loads.
- 9.6.3 In accordance with the guidance set out in Eurocode 7, a 1.00m concrete square pad foundation placed at a typical depth of 2.00m bgl (or at least 300mm into the Glacial Till) should be capable of supporting building loads of up to 100kN/m² where the stratum is at least medium strength cohesive material.
- 9.6.4 In accordance with the guidance set out in Eurocode 7, a 1.00m concrete square pad foundation placed at a typical depth of 2.00m bgl (or at least 300mm into the Chester formation) should be capable of supporting building loads of up to 220kN/m² where the stratum is at medium dense sand and gravel.
- 9.6.5 In accordance with the guidance set out in Eurocode 7 to satisfy Ultimate Limit State (ULS) and Serviceability Limit State (SLS) design, settlement underlying a 1.00m concrete square pad foundation, loaded at 100kN/m², bearing within the Glacial Till is anticipated to be less than 25mm. Settlements within the Glacial Till would be expected to be complete within a few years following completion of the construction of the building whilst settlement within Chester Formation is considered as immediate short term settlement and no residual settlement is anticipated.
- 9.6.6 The foundation excavations should be inspected by the site engineer before placing foundation concrete. If Made Ground, low strength cohesive material or loose granular material is encountered at the target bearing depth, foundations should be taken deeper to an appropriate formation level or the unsuitable material should be excavated and replaced with compacted granular fill.

Ground Improvement

- 9.6.7 Ground improvement could be utilised to densify shallow soils beneath proposed structures in order to achieve suitable allowable bearing pressures and reduce the potential for differential settlement beneath traditional foundations and ground bearing floor slabs. Suggested ground improvement options may include Vibro Stone Columns (VSCs), Vibro Concrete Columns (VCCs), rigid inclusions, dynamic compaction using a dynamic roller, or soil mixing.
- 9.6.8 VSCs, VCCs or Rigid Inclusions improve the near surface ground conditions by creating a column of material to laterally displace or replace the near surface soils to thereby stiffening the soil mass and reducing post construction settlements. These columns would need to be installed on a closely spaced grid, within and partially beyond the footprint of the proposed structures to be

supported and extend down to the Glacial Till. Such techniques however may be of limited effectiveness in shallow thicknesses of Made Ground and specialist contractor advice should be sought in that regard.

- 9.6.9 It should be noted that the thickness of Made Ground across the site is variable and as described in Section 4.1.10 above, was shown to range in thickness from approximately 1.20m to 3.80m where proven. Three of the trial pits TP02, 07 and 08, were terminated within Made Ground, and as such the thickness of the made ground was not proven in some areas. As such Made Ground improvement by means of VSCs or VCCs may be a viable solution in perspective of the stratum thickness. However, it is recommended to seek specialist advice from an experienced ground treatment contractor.
- 9.6.10 It should be noted, if VSC are considered the effects of contaminant and/or ground gas migration should also be considered, as the technique may provide preferential pathways which would preclude its potential use. Particularly given that high organic contents were shown to exist within the Made Ground particularly in Parcel 1, and the results of laboratory analysis and ground gas monitoring would suggest potential gas and contamination risks (see sections 7.2.6 and section 6.3 respectively). It is recommended that further site investigation is undertaken such that further assessment of the organic content and ground gas regime within the made ground can be made, following which further assessment of the viability of VSC can be made and specialist advice sought from an experienced ground treatment contractor.
- 9.6.11 For VCC /VSC techniques an appropriate working platform should be designed and constructed in accordance with BRE Digest 470 (Working Platforms for Tracked Plant) if such techniques are to be employed.
- 9.6.12 As an alternative ground improvement via soil mixing in conjunction with a load transfer platform to improve the strength characteristics of the loose / low strength shallow soils would allow the adoption of traditional foundations bearing within these strata for more lightly loaded structures. This would also reduce the potential for excessive total and/or differential settlement. Soil mixing improves the strength characteristics of strata using a hollow stem auger, which penetrates the ground to the required depth. A cement mix is then introduced into the ground via the hollow stem and mixed with the surrounding ground to form a column of stiff soil. Soil mixing should extend to a depth sufficient to encapsulate the pressure bulb of footings from the proposed development. However, the presence of organic material within the made ground may preclude this form of ground improvement and extensive processing may be required before such techniques are considered viable. However, further investigation and consultation with a specialist contractor should be undertaken to assess the viability and costs effectiveness of such methods.
- 9.6.13 As such due to variations in installation technique of all the options presented above, it is recommended that a ground improvement contractor be consulted to determine suitability of the ground conditions, the nature of the most suitable improvement technique, and the likely improvement which may be achieved and costs for the differing techniques.

Piled Foundations

- 9.6.14 It is understood the proposed development is for light industrial use, comprising warehouse units that is assumed to be used as a conventional commercial/industrial structure which are subjected to range of a light to medium loads.
- 9.6.15 Should the shallow foundations mentioned above not prove suitable at the site then a piled foundation solution may be required. Based on the setting of the site and ground conditions, it is anticipated that rotary bored or Continuous Flight Auger (CFA) piles, terminating in the underlying Glacial Till or socketed within Chester Formation would be most suitable on the subject site from a geotechnical viewpoint. Given the presence of a principal aquifer, particular attention should go to the installation of piles.

- 9.6.16 In the absence of sufficient depth of the ground investigations within Chester Formation - sandstone/mudstone, this stratum's geotechnical properties were adopted conservatively to provide a preliminary pile assessment. It is strongly recommended that further investigation with adopting proper techniques for sufficient penetration within this stratum together with appropriate in-situ and lab testing.
- 9.6.17 Preliminary pile capacities for a range of pile diameters between 300mm and 600mm are presented in the table below based on CFA or bored cast in place piles constructed on site.

Table 9.3: Preliminary Total Design Resistance (kN) of CFA/Bored Piles (No Pile Tests)

Pile Diameter (mm)	Pile Toe Depth (m bgl)		
	6	10	14
300	131	229	345
	<i>29</i>	<i>62</i>	<i>109</i>
450	267	457	675
	<i>44</i>	<i>93</i>	<i>164</i>
600	451	761	1109
	<i>59</i>	<i>124</i>	<i>219</i>

Tensile resistances shown in italics.

- 9.6.18 The preliminary pile capacities provided are based on the parameters outlined in Table 9.2 and the following:
- No contribution from ground level to 3.8m bgl in the region of the Made Ground;
 - No consideration of negative skin friction induced from any settlement of the overlying Made Ground;
 - An adhesion value of 0.50 in the Glacial Till;
 - Groundwater at 0.9 m bgl;
 - Piles terminating within three pile diameters of the depth of the investigation; and
 - Geotechnical properties of Chester Formation in deeper sections (below maximum depth of the current site investigations) have been assumed to be the same as the upper sections.
- 9.6.19 Partial safety factors have been applied to the calculated pile capacities above in accordance with Design Approach 1: Combination 2, as detailed within Tables A.6, A.7 and A.8 of Annex A in BS EN 1997-1. The capacities provided assume a model factor of 1.4. Should preliminary pile tests be carried out, a reduced model factor of 1.2 can be adopted.
- 9.6.20 The loads provided should be compared against appropriately factored actions.
- 9.6.21 Loads are based on single piles only and do not take into account the action of groups of piles. This should be considered at the detailed design stage. The pile capacity estimates presented above are preliminary and are based on a conservative soil profile derived from exploratory holes undertaken on site.
- 9.6.22 Should a ground bearing floor slab be adopted or the build-up of site levels be undertaken, the potential for this to load the near surface soils and induce negative skin friction on foundation piles would need to be assessed.
- 9.6.23 Consideration should be given to the presence of groundwater at approximately 0.9 m bgl during pile construction. Groundwater may cause instability with an open bored hole, therefore, a CFA method of drilling may be deemed more appropriate or, alternatively, casing installed during drilling.
- 9.6.24 Early consultation with an appropriate piling contractor is recommended to confirm pile working capacities and to ensure the contractor can achieve the required depths and capacities. Specialist

piling contractors may potentially show greater load capacities than those shown above based on specific knowledge of their piling equipment, supported by testing evidence that may be acceptable to the Local Authority.

- 9.6.25 An appropriate piling platform should be designed and constructed in accordance with BRE 470 (Working Platforms for Tracked Plant).

9.7 Floor Slabs

- 9.7.1 If the Made Ground is present at floor slab formation level beneath the proposed development then ground bearing slabs unlikely to be suitable without the use of the ground improvement.
- 9.7.2 If the ground improvement is not feasible within the Made Ground to support a ground bearing floor slab then, suspended floor slabs would be required to prevent excessive total and differential settlement, whereby settlement beneath the slab would be controlled by the foundations of the building. Additional loads from suspended floor slabs should be taken into account when designing foundations for the proposed development.
- 9.7.3 It should be noted that the gas monitoring carried out to date indicates a characteristic situation 2 (CS2) in Parcel 2 and CS2 in Parcel 1, subject to further assessment. accordance with CIRIA document C665. Gas protection measures should be designed in line with BS 8485:2015+A1:2019 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*'.

9.8 Pavements

- 9.8.1 It is understood areas of hardstanding car parking and access roads will be present across the site. Finished levels have not been provided at the time of writing this report.
- 9.8.2 19 in-situ California Bearing Ratio (CBR) were undertaken at the exploratory hole locations across the sites to assess of shallow deposit up to 1.0 m bgl, for roads and hardstanding using the TRL² guideline Dynamic Cone Penetrometer (DCP) cone plunger method in order to facilitate pavement design at approximately 0.90m bgl. The results of the testing are presented in Appendix F.
- 9.8.3 Equivalent calculated CBR versus depth are highly variable in the range of 2% to 93% in Parcel 1 site and 2% to 29% in Parcel 2 site respectively.
- 9.8.4 Remoulded CBR testing were undertaken on four samples collected from boreholes in various depths ranging from 0.8 m to 1.2 m bgl. Test results are presented in Appendix F and summarised in below table.

Table 9.4: California Bearing Ratio Test Results Summary

Test Reference	Formation Soil	Depth of Sampling (m bgl)	Moisture Content (%)	Unsoaked CBR value (%)	Soaked CBR value (%)
CP01	Made Ground	0.0 to 0.8	27	4.4	3.1
CP02	Made Ground	0.0 to 1.2	15	3.8	-
CP03	Made Ground	0.8 to 1.2	18	2.2	1.3
CP04	Made Ground	0.0 to 1.2	18	20.2	-

² Colin Jones (2004) - Dynamic Cone Penetrometer tests and analysis: Technical Information Note, TRL PROJECT REPORT PR/INT/277/04

9.8.5 Given the variable nature of the Made Ground encountered across the site and the results of the insitu testing and laboratory test results, it is recommended that a preliminary design CBR value of 2% for the Made Ground is adopted.

9.8.6 It would be prudent to undertake further plate load tests to determine CBR values when final road levels are known, prior to construction, to advise the design process.

9.8.7 The subgrade surface modulus E, can be derived from the CBR using the following equation:

$$E = 17.6 (\text{CBR})^{0.64} \text{ MPa, where CBR is given as a \% value}$$

9.8.8 Thus, for a CBR values of 2%, the corresponding subgrade surface modulus values E, are 27Mpa for the Made Ground.

9.9 Ground Infiltration

9.9.1 Three soakaway tests were undertaken in Trial Pits TP03, TP06 and TP09 in accordance with BRE Digest 365 (2016). TP03 and TP06 were excavated within Made Ground and the Chester Formation and TP09 was within Made Ground, Sediment Deposits and the Chester Formation (see the borehole logs in Appendix E). Soakaway test results were presented in Appendix G. No successful infiltration was observed and as such infiltration drainage is not considered viable for the site development.

9.10 Chemical Attack on Buried Concrete

9.10.1 Samples collected from the Made Ground, Glacial Till and Chester Formation were tested for pH and for sulphate content. The results are presented below:

Table 9.5: pH and Sulphate Analytical Data

Strata	No. of Samples	pH Range	Characteristic pH	Sulphate Range (mg/l)	Characteristic Sulphate (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	4	5.9 - 8.5	5.9	25 - 65	65	DS-1	AC-2z
Glacial Till	1	8.4	8.4	16	16	DS-1	AC-1
Chester Formation (Mudstone)	1	7.2	7.2	58	58	DS-1	AC-1

9.10.2 The data was used to assess appropriate classification for buried concrete in accordance with BRE Special Digest 1, based on the following assumptions:

- Brownfield ground conditions; and
- Mobile groundwater conditions.

9.10.3 Based on the above, it is considered that a Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC-2z would be appropriate for all buried concrete structures.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Geo-Environmental

- 10.1.1 The quantitative risk assessment has identified a potential risk to human health associated with presence of asbestos in shallow soils. Following redevelopment, hardstanding and building cover will provide an effective barrier to break the pathways of dermal contact, ingestion and inhalation of contaminated dust to future site users. This would also prevent the migration of contaminated dust towards off-site receptors. However, any areas of proposed soft landscaping a 300mm cover of certified clean topsoil cover should be provided to break these pathways.
- 10.1.2 On the basis that the mitigation measures described above are implemented, the potential risk to human health receptors from concentrations of contaminants of concern identified within soil and groundwater sampled from beneath the site upon completion of the development would not be considered to be significant.
- 10.1.3 Several speciated PAH compounds and total cyanide were recorded at concentrations above their EQS AC within the groundwater sample collected from the shallow groundwater body encountered within the Made Ground in WS02. Groundwater encountered across the site is considered to be a continuous body and is likely in hydraulic connectivity with the underlying Principal Aquifer. The local cohesive deposits within the Made Ground and the Glacial Till may potentially limited lateral and vertical migration where present. The Made Ground across the site is describe as containing clinker, coal and other man-made constituents which are known to be high in PAHs, therefore the source of the elevated PAHs may be the presence of these materials within the Made Ground. However, it should be noted that the exceedances are limited to a single borehole located in the centre of the site and are not wide spread. Concentration are also considered to be marginal in nature.
- 10.1.4 Given the distance to the surface water receptors and the closest groundwater abstraction point, and the presence of these cohesive layers within the strata, it is not considered that the groundwater beneath the site poses a significant risk to controlled waters in the vicinity of the site. In addition, the proposed development, which comprises covering the site largely in hardstanding and buildings, will reduce the infiltration and therefore leaching of the potential source within the Made Ground.
- 10.1.5 Based on the ground gas monitoring undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 2.
- 10.1.6 Based on the ground gas monitoring, undertaken on site as part of the current investigation CIRIA CS2 is considered applicable for Parcel 1. However significant concentrations of methane and carbon dioxide were recorded consistently throughout the monitoring. Therefore, it is recommended that that further monitoring is undertaken to determine the long-term gas generation at the site and to enable further assessment of the potential risk to be undertaken prior to confirmation of the gas Characterisation Situation and design of the gas protection measures.
- 10.1.7 During the redevelopment, mitigation measures must be implemented to prevent the mobilisation of asbestos fibres from soil to air. An Asbestos in Soils Management Plan can be provided for an additional fee upon request.
- 10.1.8 If excavated soils show visual or olfactory evidence of gross organic contamination the impacted soils should be segregated from soils not obviously impacted to prevent mixing and cross contamination. Impacted soils should be handled and stored in a manner to prevent contamination and either disposed of off-site (in accordance with statutory obligations) or remediated for re-use on site in an appropriate manner in accordance with a materials management plan.
- 10.1.9 Any specific soils that are to be disposed of off-site should be subject to waste characterisation prior to removal from site.

10.2 Geotechnical

- 10.2.1 Based on an earthworks acceptability criterion of achieving 95% of Maximum Dry Density (determined by 2.5kg hammer method), and setting a maximum air voids content of 5%, a maximum moisture content of 23% would be deemed appropriate, and as such some limited moisture conditioning may be necessary.
- 10.2.2 It is expected if the redevelopment platform levels allow, then shallow spread footings founded within the undisturbed near-surface Glacial Till/ Chester Formation are likely to be an appropriate option for founding lightly to moderate loaded structures. The Glacial Till stratum is anticipated bearing light to intermediate loads and its bearing capacity can be considered up to 100kN/m² whilst the Chester Formation stratum is anticipated bearing intermediate loads and its bearing capacity can be considered up to 220kN/m². Once structure loadings and development levels have been confirmed an assessment of the need for ground treatment can be undertaken and an assessment of the type of foundation necessary for the deployment be ascertained.
- 10.2.3 If heavier structural loads are required, then anticipated pile foundations will be adopted where the piles are terminated within the deeper deposits of Glacial Till or socketed into the Chester Formation. A preliminary assessment of pile bearing capacity in accordance with EC7 requirements for various pile diameters and length have been provided.
- 10.2.4 It is recommended that a preliminary design CBR value of 2% (equivalent subgrade modulus of 27MPa) be selected with a minimum thickness of pavement of 450 mm provided to limit deterioration of the subgrade by frost action. Any soft spots should be excavated and replaced by suitable engineered fill. It should be recognised that the near surface materials and materials to be used for fill are moisture susceptible and hence may affect the anticipated CBR value of the subgrade. Subgrade testing should therefore be undertaken to confirm the CBR values / Stiffness Modulus prior to placement of subbase and pavement construction materials. A geotextile should be placed to ensure separation of the granular fill from the underlying formation. It is noted that the formation will likely deteriorate rapidly in inclement weather conditions and appropriate construction practice should be adopted with all formations exposed only for the minimum time period.
- 10.2.5 A Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC-2z would be appropriate for all buried concrete structures.
- 10.2.6 Based on the undertaken soakaway tests across the site infiltration drainage will not be a viable solution in this site.
- 10.2.7 Given the variable presence of groundwater at shallow depths throughout the site, dewatering measures may be required for the construction excavation works. It is anticipated that seepage water within the trenches and pad foundation pits can be controlled with conventional methods such as utilising pumps and localised sumps.

10.3 Recommendations for Additional Work

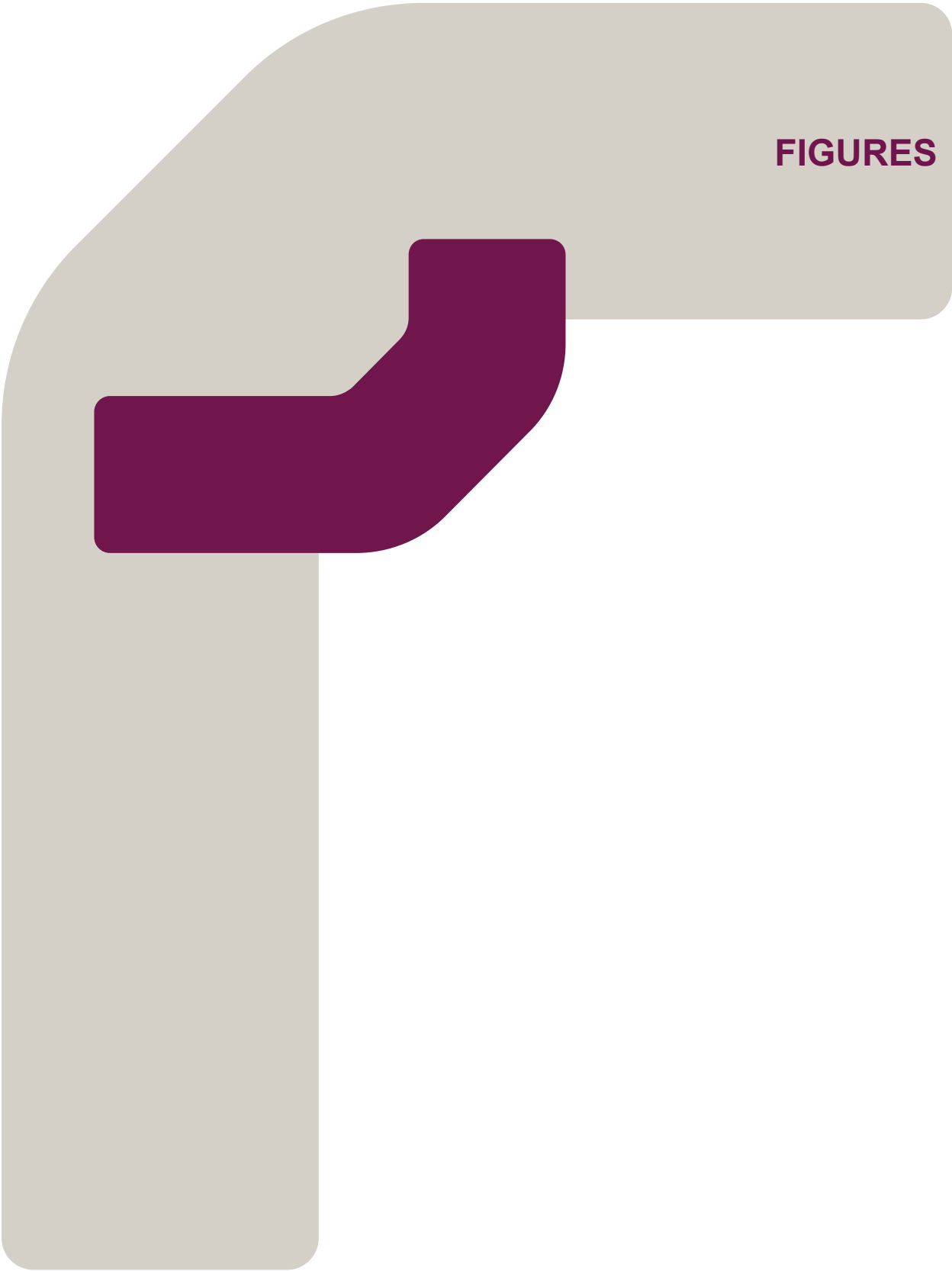
- 10.3.1 It is recommended that further gas monitoring is undertaken at the site, with at least one monitoring round undertaken at a period of low and falling atmospheric pressure. In addition, it is recommended consideration is given to installing additional monitoring wells across the site to determine the extent of any gas generating strata.

10.4 Further Considerations

- 10.4.1 Any waste soils arising from redevelopment of the site should be disposed of in accordance with the relevant statutes and Duty of Care regulations. Waste Acceptance Criteria (WAC) testing should be undertaken prior to the disposal of soil or fill materials.

- 10.4.2 Given the mitigation measures outlines within the report it is likely that a Remediation Strategy will be required as part of the planning application.
- 10.4.3 Any monitoring wells present within the development site should be formally decommissioned prior to the onset of works. Appropriate methodologies should be set out within the Remediation Strategy.

FIGURES



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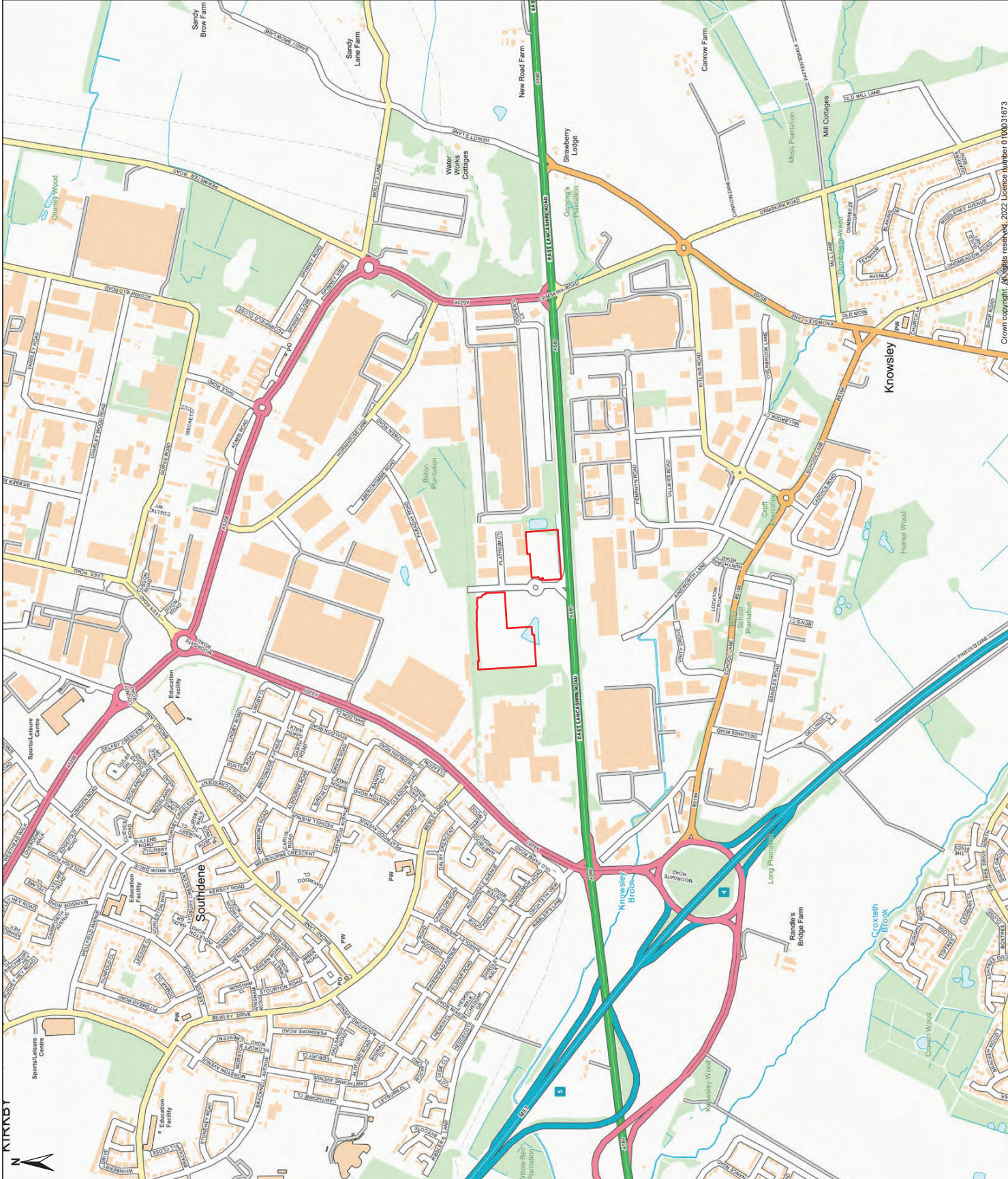
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Project Alchemy, Knowsley

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