

Pell Frischmann

Longhurst Road

Land contamination risk management

Generic Quantitative Risk Assessment

Site investigation and risk assessment report

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Executive Summary		
Site name	Longhurst Road	
Location	Longhurst Road, Higher Blackley Manchester	
Development proposals	The proposed development comprises 22 new residential dwellings including two apartment blocks with carparking and soft landscaping, and seven blocks of private semi-detached houses with rear gardens and front lawns.	
Preliminary Risk Assessment (PRA)	Pell Frischmann were provided with a copy of a Preliminary Risk Assessment (PRA) report that was undertaken for the site by a third party in 2021. The PRA report covered a larger land parcel (0.82ha), which includes the subject site (0.35ha) in the north, plus additional land to the southeast. The Conceptual Site Model (CSM) presented in the 2021 PRA has been adapted to provide inform the Conceptual Site Model for the proposed development on the subject site for use in this assessment.	
Site investigation scheme	Pell Frischmann designed a predominantly geotechnical site investigation for the development in August 2022 and the site investigation fieldwork was undertaken in December 2022. Pell Frischmann were subsequently commissioned to prepare this land contamination Generic Quantitative Risk Assessment (GQRA) report based of the available 2022 investigation findings and data.	
	<i>Site investigation details</i>	<i>Number</i>
	<i>Windowless sampling boreholes</i>	3
	<i>Trial pits</i>	4
	<i>Monitoring wells</i>	2
Ground conditions	The site investigation generally encountered a sequence of Topsoil and/or Made Ground over Glacial Till deposits. The Made Ground was typically encountered at depths of less than 0.5mbgl but was recorded up to 2.4m bgl in one location. The base of the Glacial Till was not proven in any of the exploratory holes and the underlying bedrock was not encountered.	
Groundwater conditions	Groundwater levels were recorded between 1.6 and 1.9m below ground level in post fieldwork monitoring.	
Additional data	Pell Frischmann were also provided with a copy of an older third-party site investigation report from 2017. The 2017 investigation data has been used to supplement the risk information for the development.	
Land contamination, generic quantitative risk assessment (GQRA)	Human health risk assessment: The risk assessment has identified Contaminants of Concern (CoC) within the Made Ground onsite based of the findings of the 2022 site investigation (supplemented by the 2017 site investigation data). These contaminants of concern (including arsenic, lead, polyaromatic hydrocarbons and 'asbestos in soils' could present potentially unacceptable risks of harm to human health with respect to the proposed development unless mitigation or remediation measures are undertaken. Remediation will only be required in areas of proposed soft landscaping (including gardens, shared gardens/public open space and perimeter landscaping). The presence of the proposed buildings, road, pavements and other hardstanding will provide suitable mitigation in the remaining parts of the site. The proposed cut and fill earthworks and the final landscaping designs are likely to have a significant influence on the extent, nature and details of the potential remediation requirements for the soft landscaping areas.	
Recommendations for further work	A remediation strategy will need to be prepared for the development and preceded by Remediation Options Appraisal. It is recommended that the remediation options appraisal is developed alongside the earthworks design and specification (including cut and fill design), the materials management strategy (as some of the 'cut' soils will be unsuitable for reuse in parts of the site) and the landscape plans/design to ensure that a complementary, practical, sustainable and cost effectively remediation solution is selected. If the onsite soils are due to be reused in line with the Definition of Waste: Code of Practice (DoWCoP) (CL:AIRE, 2011) then the results of the GQRA indicate that the associated Materials Management Plan (MMP) will need to follow process Route A, which means that the MMP will need to align with the Remediation Strategy for the development.	

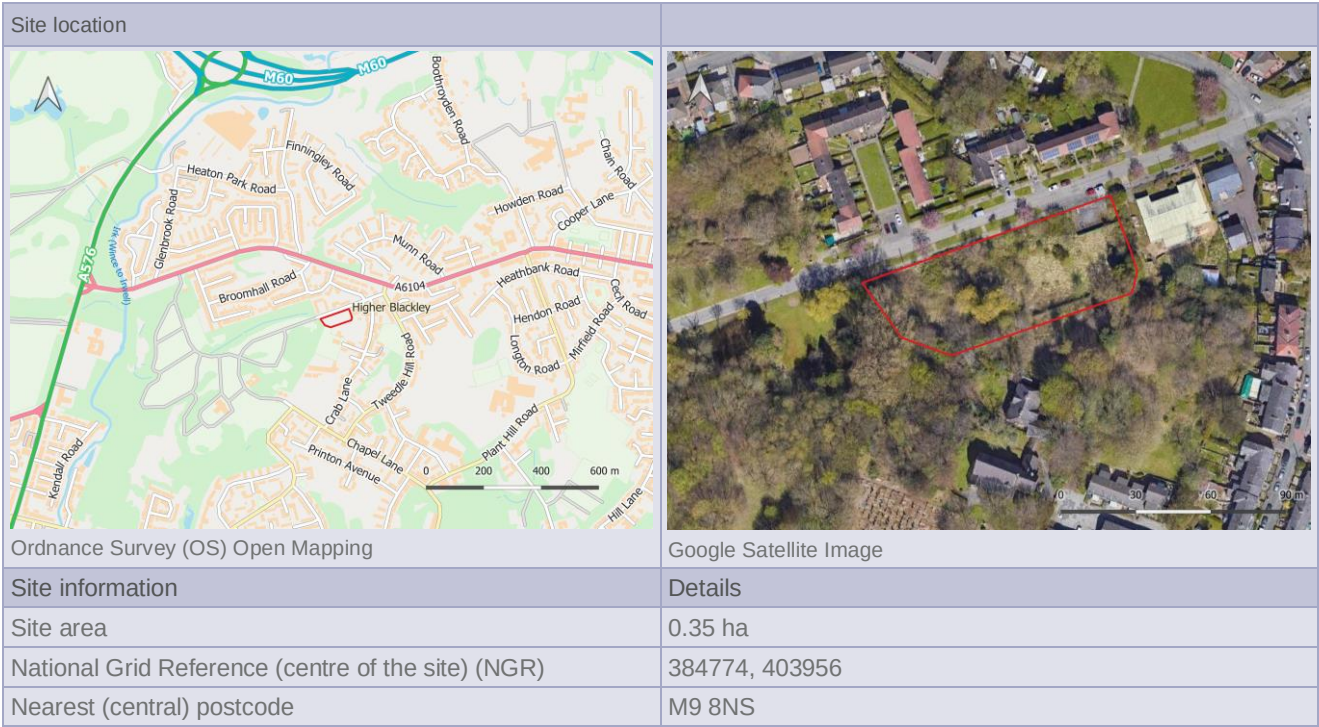
1 Introduction

1.1 Commission

Pell Frischmann have been commissioned by Great Places Housing Group (the client) to prepare this land contamination Generic Quantitative Risk Assessment (GQRA) report for the proposed Longhurst Road development (the site), in Higher Blackley, Manchester (as shown in Figure 1-1).

The overall aim of this risk assessment is to identify and assess whether unacceptable land contamination risks or significant geoenvironmental constraints are likely to exist that will require remediation or mitigation respectively with respect to the proposed development.

Figure 1-1 Site location



1.2 The site and proposed development

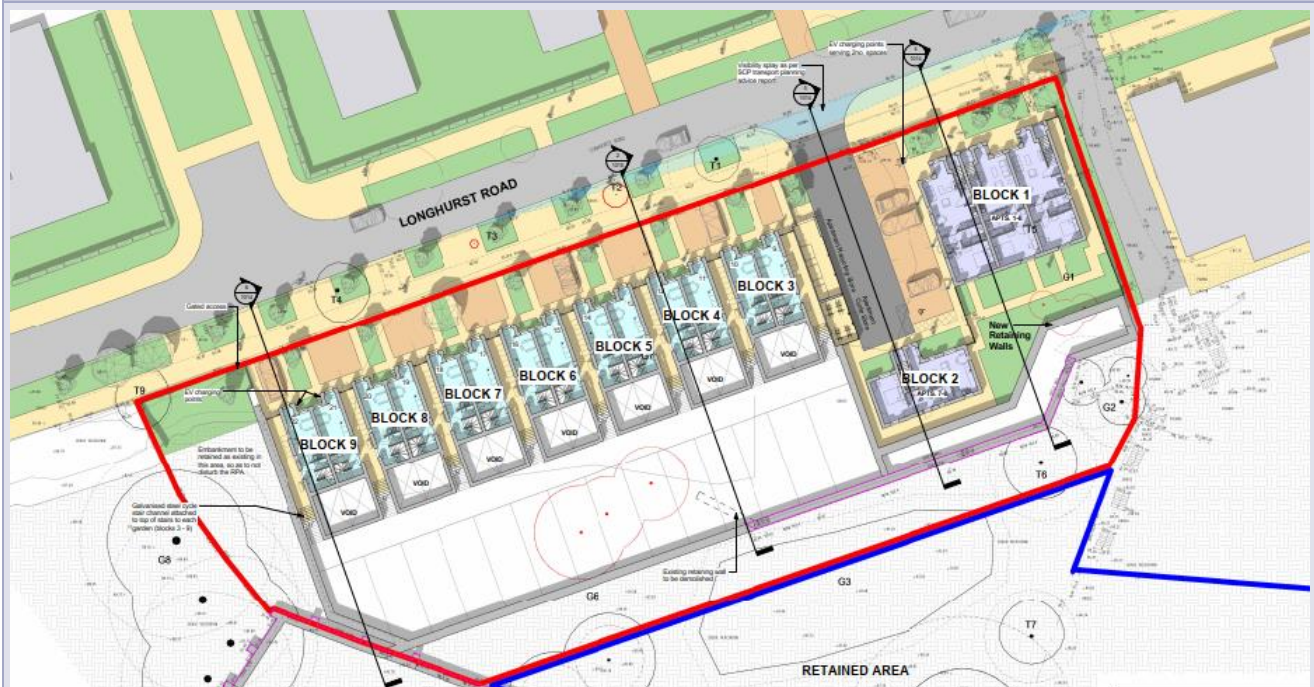
The 0.35 ha site is located on Longhurst Road, east of the A576, in Higher Blackley, Manchester (Figure 1-1). The eastern part of the site comprises an area of hardstanding with a concrete retaining wall (approximately 2m high). The remaining western part of the site is currently grassed and undeveloped with medium to dense vegetation.

The proposed development comprises 22 new residential dwellings including two apartment blocks with carparking and soft landscaping (Blocks 1 and 2), and seven blocks of private semi-detached houses with rear gardens, front lawns (Blocks 3 to 9). The drawings showing the proposed development layout, site sections and 3D model images (prepared by the Architects) are presented in Appendix C and extracts from the drawings are shown in Figure 1-2.

It is understood this report is likely to be submitted to Manchester City Council, as the location planning authority (LPA) to support a planning application for the development. In 2017, planning permission was granted for a similar development on the subject site. The development proposals have since been revised therefore a new planning application will be submitted to the LPA.

Figure 1-2 Proposed development

Development Proposals



Proposed development plan



3D model image – street elevation on Longhurst Road



3D model image – aerial view from northeast



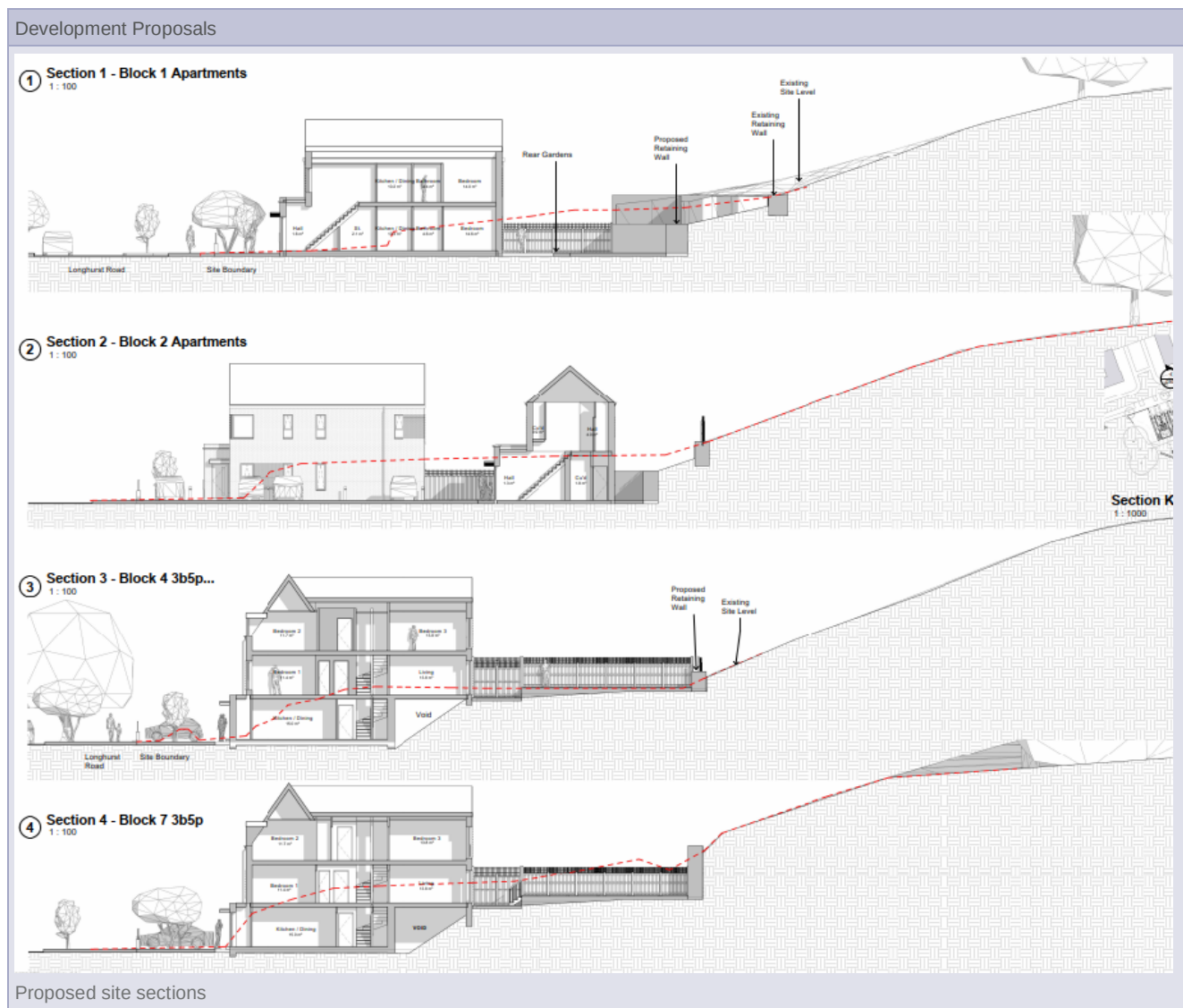
3D model image – aerial view from northwest



View from Longhurst Road towards the apartments



View from Longhurst Road towards semi-detached houses



1.3 Scope of Work

The Environment Agency 'Land Contamination Risk Management' guidance (LCRM, 2020) sets out the process for managing risks from land contamination to ensure that a site will be 'suitable for its proposed use' in line with National Planning Policy (NPPF). The process of LCRM should be used to:

- *Identify and assess if there is an unacceptable risk*
- *Assess what remediation options are suitable to manage the risk*
- *Plan and carry out remediation*
- *Verify that remediation has worked*

LCRM includes three risk-based stages (1) risk assessment, (2) options appraisal, and (3) remediation and verification. Table 1-1 presents Pell Frischmann's simplified summary of the LCRM process.

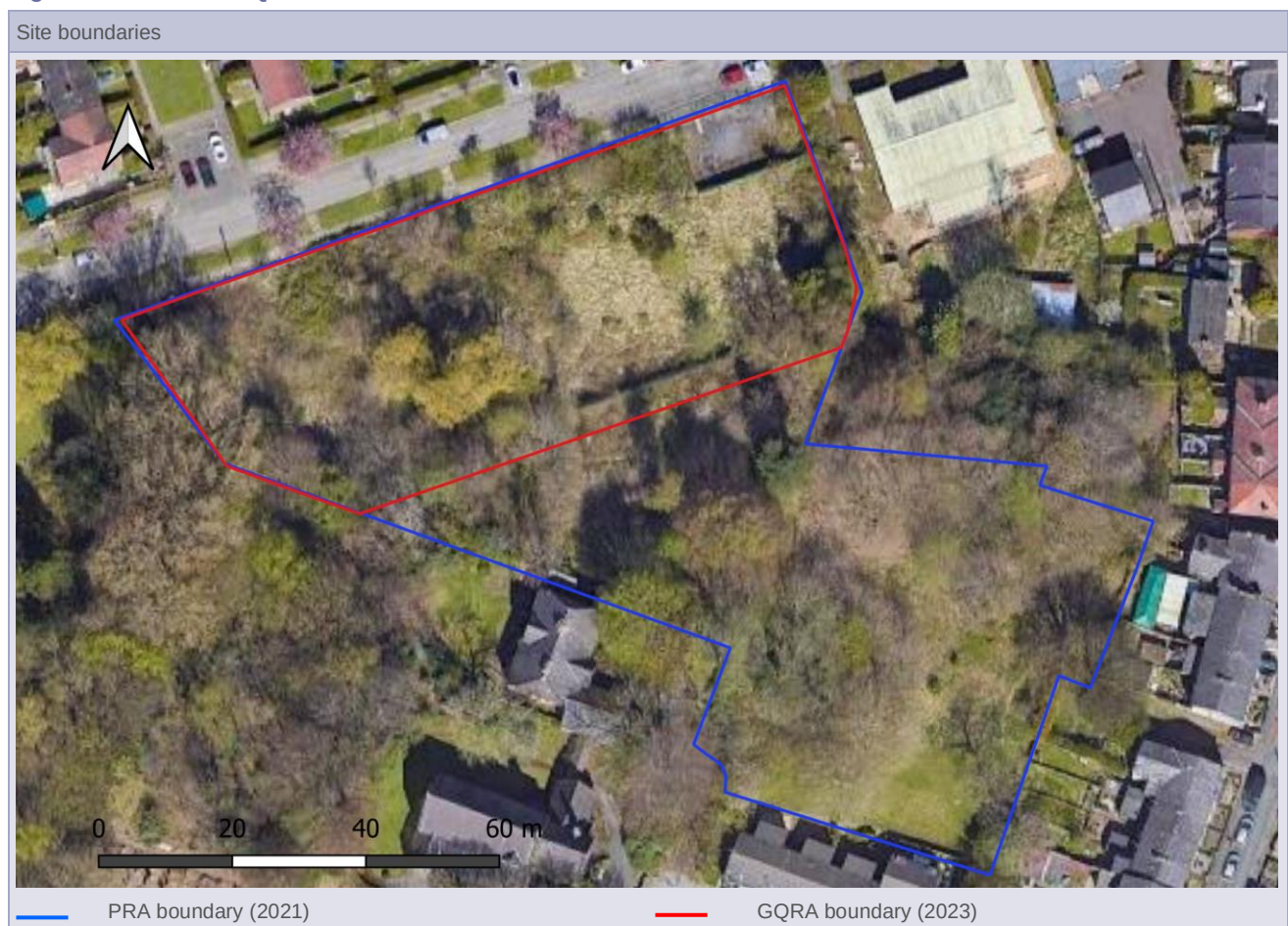
Table 1-1 Land contamination risk management - simplified

1 Risk Assessment			2 Options appraisal	3 Remediation and verification	
Preliminary risk assessment Site investigation scheme Quantitative risk assessment			Remediation options appraisal	Remediation strategy & verification plan	Remediation Verification
PRA	Quantitative risk assessment		LCROA	LCRS	LCRV
Desk study to identify sources of contamination and sensitive receptors. PRA to identify potential S-P-R contamination linkages (CLs)	SIS: Investigate potential sources and receptors	GQRA/DQRA: Quantitative risk assessment to assess risks for each CL to identify and assess unacceptable risks	Identify remediation option to address unacceptable risks	Strategy: steps and measures required to implement remediation onsite. Verification plan: activities and records that must be kept during remediation	Record of all remediation activities as evidence that remediation has been successful
	[this report]				

1.3.1 Preliminary risk assessment

The Client provided Pell Frischmann with a copy of a Preliminary Risk Assessment (PRA) report for the site from 2021: *Longhurst Road Phase 1 Preliminary Risk Assessment, (Curtins Consulting Ltd, ref: 077873-CUR-00-XX-RP-GE-005, April 2021)*. The PRA report covered a larger land parcel (0.82ha), which includes the subject site (0.35ha) in the north, plus additional land to the southeast. The PRA site boundary is outlined in blue in Figure 1-3 and the GQRA boundary (for this report) is outlined in red.

Figure 1-3 PRA and GQRA boundaries



The 2021 report included desk study information and a preliminary Conceptual Site Model (CSM), which has been reviewed and adapted to provide a Conceptual Site Model for the proposed development within the revised site boundary for reference as part of this generic quantitative risk assessment.

1.3.2 Generic quantitative risk assessment

Quantitative land contamination risk assessment typically starts with Generic Quantitative Risk Assessment (GQRA) which uses site investigation findings/data, generic assessment criteria and assumptions to quantitatively estimate land contamination risk; in line with LCRM. Based on the outcomes of the quantitative risk assessment, the risks for each Contaminant Linkage (identified by the Preliminary Risk Assessment) are qualitatively reassessed before deciding whether the risk for any of the CLs is likely to be '*unacceptable*'.

1.4 Referenced reports

The 2021 Preliminary Risk Assessment and 2023 Factual Ground Investigation report have been referenced as part of this commission, as listed in Table 1-2.

Table 1-2 Reports referenced

Report title and reference	Source	Date
Ground Investigation Factual Report. Longhurst Road, Blackley ground investigation report. (<i>Document no. 077873-CUR-00-XX-RP-GE-005</i>)	Soiltechnics Ltd	Mar-2023
Longhurst Road Phase 1 Preliminary Risk Assessment (<i>Report ref. 077873-CUR-00-XX-RP-GE-005</i>)	Curtins Consulting Limited	Apr-2021
Phase 1 and Phase 2 Geoenvironmental Report, Longhurst Road, Blackley. (<i>Report ref. 3025-CAU-XX-XX-RP-V-0307.A0-C1</i>)	Caulmert Limited	Apr-2017

2 Site investigation

2.1 Introduction

Pell Frischmann designed a predominantly geotechnical site investigation for the development in August 2022. The site investigation fieldwork was subsequently undertaken by Soiltechnics Ltd (*the Contractor*) between 13 and 14 December 2022, followed by groundwater level monitoring and ground gas monitoring between 23 January and 24 March 2023. Pell Frischmann's geoenvironmental team were subsequently commissioned to prepare this generic quantitative risk assessment based on the available information from the site investigation and subsequent monitoring.

2.2 Fieldwork

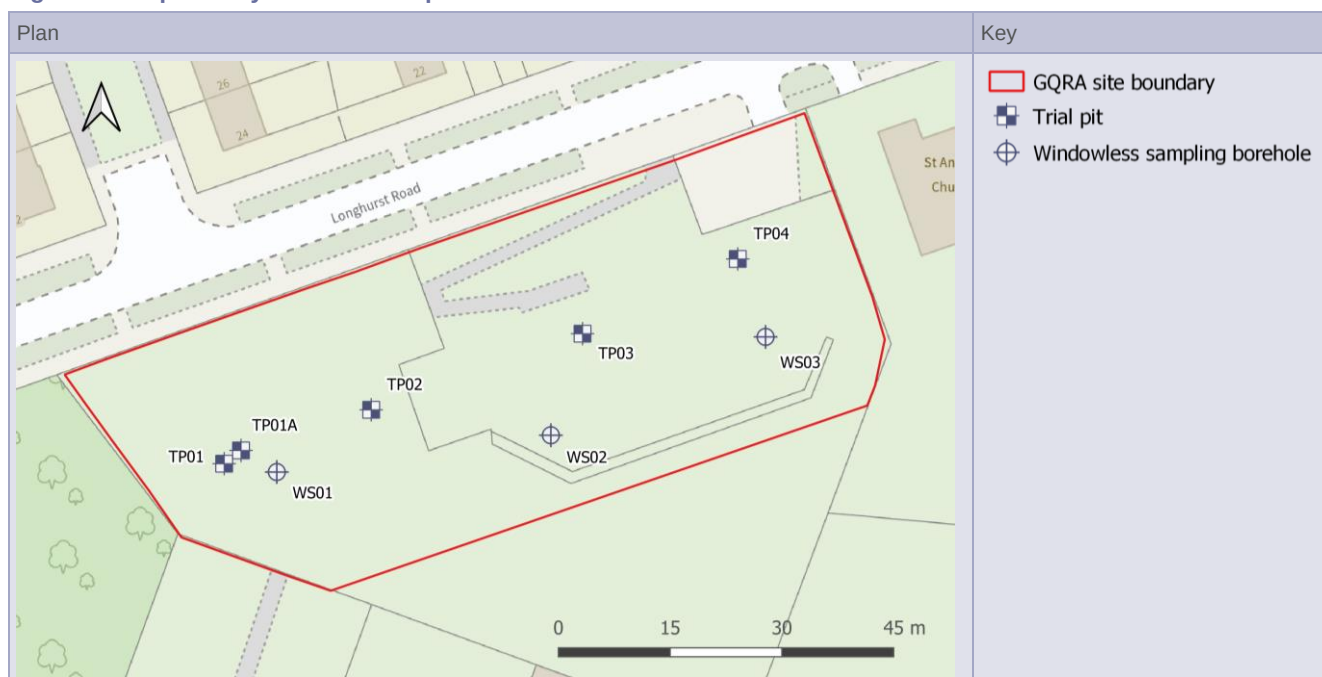
The main site investigation activities are summarised in Table 2-1 and an exploratory hole location plan is presented in Figure 2-1. A copy of the Contractor's factual report '*Ground Investigation Factual Report Longhurst Road, Blackley, April 2023*' is included in Appendix E

Table 2-1 Site investigation activities

Site investigation item	Included in site investigation		
Exploratory Holes (fieldwork)	Included	Number	Reference
<i>Trial pits</i>	Yes	5	TP01 to TP04 and TP01A*
<i>Windowless sampling boreholes</i>	Yes	3	WS01 to WS03
Monitoring			
Monitoring wells	Yes	2	WS01 & WS03
Groundwater and ground gas monitoring	Yes	5 rounds	-
Sampling and analysis (post initial fieldwork)			
Soakaway / permeability testing	Yes	Not assessed or described in this report.	
Geotechnical soil sampling and laboratory testing	Yes	Not assessed or described in this report.	
Geochemical soil sampling and laboratory analysis	Yes	-	
Geochemical groundwater sampling and laboratory analysis	Yes	-	

*TP01 was terminated at 0.9m bgl due to suspected buried services and relocated to TP01A

Figure 2-1 Exploratory hole location plan



Two monitoring wells were installed as part of the site investigation. The response zone details and the monitored strata are summarised in Table 2-4.

Table 2-2 Monitoring well response zones

Location	Strata	Top depth (mbgl)	Base depth (mbgl)	Top elevation (mAOD)	Base elevation (mAOD)
WS01	Glacial Till	1.00	5.50	90.02	85.52
WS03	Glacial Till	1.00	5.00	88.11	84.11

Soil samples (collected by the contractor during the site investigation) were scheduled for geochemical laboratory analysis, including nine soil samples from the trial pits. Insufficient soil volume was available from the windowless boreholes to enable geochemical analysis (following geotechnical sampling requirements). Pell Frischmann scheduled the analysis which was arranged by the contractor with their preferred laboratory.

2.3 Ground conditions

The site investigation typically encountered a sequence of Topsoil and/or Made Ground over Glacial Till deposits. The constituents of the Made Ground encountered varied significantly across the site and has been sub-divided into four categories as summarised in Table 2-3. The base of the Glacial Till was not proven in any of the exploratory holes and the underlying bedrock was not encountered.

Table 2-3 Ground conditions summary

Location	Base of strata (mbgl), (thickness, m)					
	Topsoil	Made Ground 1	Made Ground 2	Made Ground 3	Pea gravel bed	Glacial Till
TP01	-	0.4mbgl (0.4m)	-	-	>0.9mbgl (>0.5m)	-
TP01A	-	0.4mbgl (0.4m)	-	-	-	>2.50 mbgl (>2.10 m)
TP02	-	0.4mbgl (0.4m)	-	-	-	>4.00 mbgl (>2.10)
TP03	-	-	1.2mbgl (1.2m)	-	-	>2.50 mbgl (>1.30 m)
TP04	-	-	2.4mbgl (2.4m)	-	-	>4.00 mbgl (>1.60 m)
WS01	0.3mbgl (0.3m)	-	-	-	-	>6.05 mbgl (>5.75 m)
WS02	0.3mbgl (0.3m)	-	-	1.00 mbgl (0.70m)	-	>6.05 mbgl (>5.05 m)
WS03	-	-	-	0.9 mbgl (0.9 m)	-	>6.05 mbgl (>5.15 m)
Ground conditions typical description						
Stratum	Typical description				Stratum base (mbgl)	Stratum thickness
Topsoil	Described as “dark brown clayey sand with frequent rootlets”. Encountered in WS01 and WS01 in the western and central areas.				0.30	0.30m
Made Ground 1	Classified as “Topsoil – Made Ground” and described as “dark brown to grey slightly gravelly clayey SAND with frequent rootlets. Gravel of fine to medium ash”. Encountered in TP01, TP01A and TP02 mainly in the western area of the site				0.40	0.40m
Made Ground 2	Described as “Grass over slightly sandy GRAVEL of fine to coarse brick, concrete, ash and slate”. Encountered in TP03 and TP04				1.20 to 2.40	1.20 to 2.40m
Made Ground 3	Generally described as brown and grey very sandy gravelly clay. Gravel of fine to medium angular brick concrete and limestone.				0.90 to 1.00	0.70 to 0.90m
Glacial Till	Comprises alternating layers of: Brown mottled grey clayey sand OR brown very sandy clay. Encountered in all locations which penetrated the base of Made Ground.				>6.05	>5.75m

Pea gravel was encountered in TP01 at 0.9m bgl described as “Grey very clayey SAND with pea gravel bed in part of the pit from 0.6m depth. Gravel is medium to coarse angular limestone”. The TP was terminated when this gravel was encountered and it is considered that this gravel represents bedding/surround typically encountered around underground services.

2.4 Groundwater conditions

During the site investigation the following groundwater observations were recorded

- TP04: Groundwater seepage at 3.7m bgl during drilling
- WS01: Standing groundwater level at 3m bgl on completion of the borehole
- WS02: Standing groundwater level at 3m bgl on completion of the borehole
- WS03: Standing groundwater level at 3m bgl on completion of the borehole

Groundwater level monitoring was undertaken on six occasions between 23 January and 24 March 2023, the results are summarised in Table 2-4.

Table 2-4 Groundwater level monitoring

Location	Ground elevation	Strata	Average depth (mbgl)	Average head (mAOD)
WS01	91.02mAOD	Glacial Till	1.63	89.39
WS03	89.11mAOD	Glacial Till	1.96	87.15

2.5 Visual and olfactory evidence of contamination

The following visual and olfactory evidence of contamination was recorded in the exploratory hole records:

- TP03 0.7m bgl – hydrocarbon odour and black staining.
- TP04 2.7m bgl – hydrocarbon odour and black staining.

3 Generic quantitative risk assessment (GQRA)

3.1 Introduction

Land contamination Generic Quantitative Risk Assessment (GQRA) uses site investigation findings/data, Generic Assessment Criteria (GAC) and assumptions to quantitatively estimate land contamination risk before judging whether particular harm or pollution needs further assessment or is 'unacceptable'. The GQRA summarised in this report include the following steps:

- Confirm the Contaminant Linkages being assessed and identify appropriate generic assessment criteria,
- Screen the data to identify *potential* Contaminants of Concern (pCoC)
- Assess pCoC to identify residual 'Contaminants of Concern' (that may require remediation)
- Identify unacceptable risks of harm or pollution or the need for further assessment
- Update the Conceptual Site Model including the qualitative risk ratings for each Contaminant Linkage (CL)
- Update the status of a contaminant linkage/s from '*potential*' to '*relevant* contaminant linkages' (where appropriate)

3.2 Human health risk assessment

3.2.1 Potential contaminant linkage

Table 3-1 summarises the potential source-pathway-receptor relationship that has been extracted and adapted from the 2021 PRA and will be assessed in this section.

Table 3-1 Potential contaminant linkages (pCLs)

pCL	Source/s	Pathway/s	Receptor/s
101	Contaminants within the Made Ground onsite	Ingestion, inhalation and dermal contact	Human health of end users

3.2.2 Generic assessment criteria

The LCRM guidance references published Generic assessment criteria (GAC) 'for assessing risk to human health from exposure to contaminants' for a series of land-use scenarios including: residential (with or without homegrown produce, (RwHP and RwoHP)) and public open space (residential (POS_{resi}). Each land-use scenario is based on a pre-defined series of exposure pathways and a 'critical receptor'. These GAC are '*the levels in soil above which may present an unacceptable risk of harm to human health*' (LCRM). Exposure pathways are the routes by which a receptor is or could be affected by a contaminant.

The Longhurst Road development comprises two land-use scenarios:

- Residential houses with private gardens** in the west, outlined in purple in Figure 3-1.
- Residential apartments with soft landscape areas** in the east, outlined in blue in Figure 3-1.

(a) Residential houses (west): The development masterplan indicates that the low-rise, semi-detached houses (Blocks 3 – 9) will have private gardens at the rear (south) and areas of soft landscaping (including front lawns and trees) adjacent to the road, (north). This scenario aligns with the Residential with Homegrown Produce (RwHP) land-use scenario.

(b) Residential apartments (east): The two blocks of apartments (Blocks 1 and 2, containing 8 flats in total) will be surrounded by external hard standing areas (including onsite roads, carpark areas, amenity spaces) and areas of soft landscaping (including shared gardens and public open space). With respect to viable exposure pathways this scenario broadly aligns with the Public Open Space (POS_{resi}) land use, except for the 'inhalation of vapours (indoors)' exposure pathway.

Residential with homegrown produce (RwHP): this land-use considers private residential properties with private gardens where the assumption that children aged 1 to 6 years are exposed to soil and soil-derived dust at their home 365 days per year. The GACs for RwHP also consider exposure pathways associated with the consumption of home grown produce specifically 'ingestion of soil attached to home grown fruit/vegetables' and 'ingestion of fruit/vegetables' grown in the garden soil. The critical receptor is a female child (age range 0 to <6 years).

Public Open Space – residential (POS_{resi}): this land-use considers predominantly grassed areas or green spaces close to housing that are likely to be used by children playing including for informal sport; up to 500m² (0.05 ha) and up to 50% of the area may be bare soils. The exposure pathways include tracking back of soils to residential properties. The critical receptor is a female child (age range 3 to <9 years). This land-use scenario does not consider buildings. Therefore, a supplemental risk assessment stage will need to be undertaken to consider the 'inhalation of vapours (indoors)' exposure pathway.

Figure 3-1 Development land use types



3.2.3 Risk assessment methodology

The risk assessment will be undertaken in a series of sequential steps, with each step aimed at refining, screening and focusing the risk assessment process. The human health risk assessment methodology and key assessment criteria and information are summarised in Table 3-2.

Table 3-2 Human health GQRA information

Assessment sequence				
Screening assessment: The recorded concentrations for each contaminant will be compared with their respective GACs as an initial screening exercise to identify potential contaminants of concern (CoC). ➤ If all concentrations are below the GAC, it is considered that these contaminants would be highly unlikely to represent a significant risk to human health and no further assessment or action is considered necessary. ➤ If a contaminant records one or more concentration above GAC threshold they will be identified as <i>potential</i> contaminants of concern (CoC).				
Site specific considerations: Each <i>potential</i> CoC will be reviewed in more detail to consider whether potentially unacceptable risks may exist with respect to the proposed scheme, or whether further assessment or site investigation is likely to be required to determine the level of risk.				
Risk assessment criteria	Details			
Published generic assessment criteria (GAC)	Category 4 Screening Levels (C4SLs) (Defra); or Suitable 4 Use Levels (LQM/CIEH), where C4SLs are not available.			
GAC land use scenarios	Residential with homegrown produce (RwHP) & Public open space - residential (POSresi)			
Soil organic matter (%)	2.5% soil organic matter (SOM) C4SLs/S4ULs have been referenced, based on site data.			
	Strata	Minimum	Average	Maximum
	Topsoil / Made Ground	1.55%	6.59%	20.12%
	Glacial Till	1.03%	2.41%	3.78%

3.2.4 Geochemical laboratory analysis data

Soil samples collected from the exploratory holes were sent to a laboratory selected by the Contractor - Derwent Environmental Testing Services Ltd (DETS) for geochemical laboratory analysis. Table 3-3 summarised the available geochemical data included in the Contractor's Factual Report.

Table 3-3 Geochemical soil samples

Strata	Number of samples analysed
Topsoil / Made Ground	7
Glacial Till	2
Total	9

3.2.5 Screening Assessment

As part of the initial screening assessment the soil concentrations for each contaminant (for all nine soil samples) have been compared with their respective GACs for Residential with Homegrown Produce (RwHP) and Residential Public Open Space (POSresi) end-uses. The results of the screening assessment are summarised in Table 3-4.

Most results **passed** i.e. the recorded soil concentrations were lower than the respective GAC or the contaminants were 'not detected' (based on the laboratory method's minimum limit of detection, LoD). These contaminants have been discounted as potential contaminants of concern (CoC) (see Table 3-4).

Failures: one or more soil concentrations of arsenic, lead and two PAH compounds (benzo(b)fluoranthene and dibenzo(a,h)anthracene) exceeded their respective GAC for Residential with Homegrown Produce end-use in two out of nine soil samples (see Table 3-4). These contaminants have been identified as potential contaminants of concern (CoCs).

Table 3-4 Screening assessment summary

Contaminant	RwHP GAC	POS _{resi} GAC
Metals/ metalloids		
Arsenic	Fail (2 samples)	Pass
Cadmium	Pass	Pass
Chromium and hexavalent chromium	Pass	Pass
Copper	Pass	Pass
Lead	Fail (1 sample)	Pass
Mercury	Pass	Pass
Nickel	Pass	Pass
Selenium	Pass	Pass
Vanadium	Pass	Pass
Zinc	Pass	Pass
Organics/ other contaminants		
Polyaromatic hydrocarbons (PAH)	14 out of 16 PAHs pass	14 out of 16 PAHs pass
PAH: Benzo(b)fluoranthene	Fail (1 sample)	Pass
PAH: Dibenzo(a,h)anthracene	Fail (1 sample)	Pass
Total petroleum hydrocarbons (TPH)	Pass	Pass
BTEX (Benzene, Toluene, Ethylbenzene, Xylene)	Pass	Pass
MTBE (methyl tertiary butyl ether)	Pass - not detected	Pass - not detected
Phenol	Pass	Pass
Volatile Organic Compounds (VOCs)	Pass - not detected	Pass - not detected
Polychlorinated biphenyls (PCBs)	Pass - not detected	Pass - not detected

In summary,

- **POS_{resi}**: potential contaminants of concern have not been identified with respect to POS_{resi} GAC.
- **RwHP**: arsenic, lead and two PAH compounds (benzo(b)fluoranthene and dibenzo(a,h)anthracene) have been identified as potential Contaminants of Concern with respect to RwHP GACs.

3.2.6 Screening assessment – Inhalation on vapours (indoors)

The POS_{resi} GACs do not consider indoor air vapour inhalation pathways for volatile contaminants. The potential Source-Pathway-Receptor contaminant linkage (pCL) 'Made Ground – inhalation of vapours indoors – human health of end users' has therefore been considered and assessed separately.

The Preliminary Risk Assessment did not identify volatile organic compounds (VOCs) as likely contaminants onsite. Concentrations of BTEX and MTBE were either recorded below the GAC or were not detected above their respective laboratory detection limits as highlighted in Table 3-4. The more volatile PAH compounds have been conservatively screened against the residential without homegrown produce (RwoHP) GAC (based on 2.5% soil organic matter). The results were all below the RwoHP GAC.

Based on the geochemical analysis results and the site-specific considerations discussed above, potential contaminants of concern have not been identified with respect to the Source-Pathway-Receptor CL 'Made Ground – inhalation of vapours indoors – human health of end users'.

3.2.7 Potential contaminants of concern and site-specific considerations

The screening assessment identified four potential Contaminants of Concern (CoC) with respect to RwHP GACs. The concentration ranges for these contaminants are summarised in Table 3-5.

Table 3-5 Potential CoC concentration ranges (mg/kg)

Contaminant	No. of samples	No. >LOD	Min (mg/kg)	Avg (mg/kg)	Max (mg/kg)	RwHP GAC	No. above GAC
Arsenic	9	9	5	19.2	55	37	2
Lead	9	9	15	104.7	322	200	1
PAH Benzo(b)fluoranthene	9	7	0.1	1.2	3.96	3.3	1
PAH Dibenzo(a,h)anthracene	9	6	0.1	0.2	0.46	0.28	1

These potential CoC were identified in two soil samples collected from the same layer of 'ashy' Made Ground in TP01A, in the west of the site:

- TP01A @0.2mbgl: recorded elevated concentrations of arsenic, lead and two Polyaromatic Hydrocarbons (PAH) compounds (benzo(b)fluoranthene and dibenzo(a,h)anthracene).
- TP01A @0.5mbgl: also recorded an elevated arsenic concentration.

The lead and PAH concentrations were notable lower in the deeper sample (TP01A @0.5mbgl) and all below the GAC, the arsenic concentration was marginally higher in the deeper sample (52mg/kg @0.2mbgl and 55mg/kg @0.5mbgl).

3.3 Asbestos in soils

The soil samples were screened for 'asbestos in soils' as part of the laboratory analysis, asbestos was not detected in the nine soil samples screened. Visually identifiable pieces of asbestos containing material (ACM) are not recorded in the exploratory hole records.

3.4 Controlled waters

The 2021 preliminary risk assessment (PRA) and conceptual site model (see Appendix B) indicated that the risk to controlled waters receptors range from 'Very Low' to 'Low' and the report concluded no further action was required with respect to controlled waters. Therefore, groundwater sampling and analysis was not part of the site investigation scope.

3.5 Ground gas risk assessment

3.5.1 Potential contaminant linkage

Ground gas monitoring data from the 2022 site investigation have been used to undertake a ground gas risk assessment to assess potential risks associated with the ground gases methane (CH₄) and carbon dioxide (CO₂). Table 3-6 summarises the potential ground gas source-pathway-receptor relationships identified by the PRA, which have been adapted to reflect the subject site and then assessed in this risk assessment section.

Table 3-6 Potential contaminant linkages (pCLs) from the PRA

pCL	Source/s	Pathway/s	Receptor/s
301	Ground gas (from offsite sources)	Migration and accumulation	Building and structures
302		Migration and accumulation followed by inhalation of indoor air	Human health of end users

The PRA identified 'moderate' risks associated with offsite sources of ground gas primarily a historic landfill within 250m of the 2021 site boundary and a neighbouring graveyard. The revised site boundary means that the historic landfill is now greater than 250m from the site boundary, which would lower the risk rating.

3.5.2 Ground gas monitoring data

Two monitoring wells (WS01 and WS03) were subject to five rounds of ground gas monitoring between 23 January and 24 March 2023. During the monitoring the following information and ground gas concentrations were recorded:

- Atmospheric pressure, relative pressure and ground gas flow rates.
- Ground gases: methane (CH₄) and carbon dioxide (CO₂), hydrogen sulphide (H₂S), carbon monoxide (CO) and oxygen (O₂)

The ground gas monitoring data has been used to undertake a ground gas risk assessment to assess potential risks associated with the ground gases methane (CH₄) and carbon dioxide (CO₂).

3.5.3 Risk assessment methodology

The ground gas risk assessment has been undertaken in line with BS8485:2015(+A1:2019) 'Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings' (BS8485), guidelines from CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' (C665) and the NHBC 'Guidance on evaluation of development proposal on sites where methane and carbon dioxide are present', Report Edition No.4, 2007 (NHBC).

As part of the ground gas risk assessment the maximum recorded gas concentrations and flow rates have been used to derive Gas Screening Values (GSVs) which are used to characterise the gas regime for a site (as outlined below):

- A 'Characteristic Situation' is then assigned (in line with C665 and BS8485); or
- A traffic light green-amber-red classification is then assigned (in line with C665 and NHBC guidance).

The Characteristic Situation and traffic light classification are then used to inform the requirements and nature of likely gas mitigation measures (if required). The risk assessment sequence and key criteria used in this assessment are summarised in Table 3-7.

Table 3-7 Ground gas risk assessment sequence, criteria and methodology

Risk assessment sequence				
Type of Development Situation A or B (C655) Building Type (BS8485)		Calculate Gas Screening Value & additional factors (BS8485/C665)	Characteristic Situation (BS8485) Traffic Light Classification (NHBC)	Are gas protection measures required? (BS8485)
Title	Criteria	Details	Site Details	
Development proposals (C655)	Situation A	All forms of development (residential and industrial/commercial development, other low risk residential development)	Proposed buildings	
	Situation B	Low-rise residential housing	Proposed buildings	
Building type (BS84858)	Type B	Private, or commercial, public, possible multiple	Proposed buildings	
	Type A	Private	Proposed buildings	
GSV calculation				
GSV (l/hr)	Gas screening values have been calculated for methane and carbon dioxide both for individual wells and where appropriate for the site. GSV (l/hr) = borehole flow rate (l/hr) x gas concentration (%v/v)			
Clarifications				
The NHBC guidance is intended for use of residential developments only and typically applies to Type A Buildings utilising beam and block floor constructions with clear void ventilation. The NHBC Traffic Light system is based on a 'typical house' which is defined as "a house (up to 3 storeys) with <100m2 footprint and minimum 150mm depth clean ventilated void achieving sub-slab ventilation on one complete air exchange per day". The NHBC guidance has been considered in addition to BS8485 considering the Type A low rise residential houses that are proposed in the west of the site.				

3.5.4 Risk assessment results

Gas screening values have been calculated and the results have been used to identify a Characteristic Situation (CS) hazard potential classification and a traffic light classification in line with BS84858 and the NHBC Guidance respectively for each monitored location, as summarised in Table 3-8.

Table 3-8 Ground gas risk assessment

Hole ID	Max Flow Rate l/hr	Maximum (Peak) Concentration %		Gas Screening Values l/hr		Characteristic situation		Traffic light classification	
		CH ₄	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂	CH ₄	CO ₂
WS01	0.2	0.2	2.6	0.0004	0.0052	CS1	CS1	Green	Green
WS03	0.2	0.9	2.7	0.0018	0.0054	CS1	CS1	Green	Green

The risk results indicate that GSV fall within Characteristic Situation 1 (BS8485) and the 'Green' traffic light classification (NHBC), where the respective guidance indicates that 'no special precautions' are required and 'ground gas protection measures are not required' respectively.

3.6 Water supply pipes review

The geochemical results from the site investigation have also been used to undertake a preliminary review with respect to the selection of water supply pipes for the proposed development, in line with guidance published by United Kingdom Water Industry Research (UKWIR) (2011).

The site investigation encountered Made Ground across the site to depths of between 0.30m and 2.40m bgl. "Hydrocarbon odour and black staining" was noted on the exploratory hole records for TP03 @0.7m bgl and TP04 @2.7m bgl. No other visual or olfactory evidence of contamination was noted. Detectable TPH concentrations were recorded in five samples of Made Ground in the west and east of the site. The detectable TPH concentrations were recorded in aliphatic bands >16-21 and >21-35; and aromatic >12-16, >16-21 and >21-35; and Total TPH aliphatic & aromatic bands >C5-C35, as shown by Table 3-9.

On this basis, hydrocarbons have been detected at low concentrations within the Made Ground (and not the underlying natural soil). Due to the presence of these low but detectable concentrations plastic pipes including PE may not be suitable for the development and barrier pipes may instead be required. Pipe selection should be determined in line with United Utilities' new mains and connections processes and guidance.

Table 3-9 Detectable TPH concentrations in Made Ground

Location and sample depth	Units	Aliphatic >16-21	Aliphatic >21-35	Aromatic >12-16	Aromatic >16-21	Aromatic >21-35	Total TPH Aliphatic & Aromatic >C5-C35
TP01A @0.2mbgl	mg/kg	-	-	11	40	85	143
TP01A @0.5mbgl	mg/kg	-	-	5	28	40	76
TP03 @0.5mbgl	mg/kg	-	-	-	13	32	45
TP03 @0.7mbgl	mg/kg	4	56	4	23	52	140
TP04 @0.5mbgl	mg/kg	-	49	3	19	75	145

3.7 Previous site investigation 2017

3.7.1 Introduction

The client has also provided Pell Frischmann with a copy of an earlier geoenvironmental report from 2017, *Phase I and Phase II Geo-environmental Report Longhurst Road, Blackley (Caulmert Limited, ref: 3025-CAU-XX-XX-RP-V-0307.A0-C1, April 2017)*; which includes site investigation data for the site. The site investigation fieldwork appears to have comprised the following:

- Two hand excavated pits (HP1-7 and HP2-7) to 1.10m and 1m depths respectively,
- Four windowless sampling boreholes (WS3-7 to WS6-7) to depths between 4.45m and 5.00m,
- And the installation of two groundwater/ground gas monitoring wells in WS4-7 and WS5-7.

The findings of the 2017 site investigation have been reviewed to supplement the 2022 risk assessment for the proposed development.

3.7.2 Human health risk assessment supplemental information

The 2017 report includes geochemical analysis results for three soil samples collected from the Made Ground onsite. When screened against the Residential with Homegrown Produce (RwHP) and Residential Public Open Space (POS_{resi}) GACs two out of three soil samples recorded elevated concentrations/potential Contaminants of Concern (CoC):

- **WS5-7 @0.1mbg** recorded elevated arsenic (53mg/kg, >RwHP) and lead (1,400mg/kg, >RwHP and POS_{resi}) concentrations.
- **WS6-7 @0.3-0.45mbgl** recorded an elevated lead concentration (390mg/kg).

Table 3-10 Contaminants of Concern based on 2017 data only

Contaminant	No. of samples	No. >LOD	Min (mg/kg)	Avg (mg/kg)	Max (mg/kg)	RwHP GAC	No. above RwHP GAC	POS _{resi} GAC	No. above POS _{resi} GAC
Arsenic	3	3	12	30.67	53	37	1	79	0
Lead	3	3	40	610	1400	200	2	230	1

Asbestos in soils: the report also includes 'Asbestos in soils' (AiS) screening data for the 3nr Made Ground samples. Asbestos in soils was detected in one out of the three Made Ground sample, as follows:

- **WS5-7 @0.1mbg:** 'Amosite fibres' were identified at a quantity of <0.001%. Amosite is also known as brown asbestos.

3.7.3 Groundwater supplemental information

The 2017 report includes groundwater level monitoring data which recorded groundwater at a depth of 0.67mbgl (88.34mAOD) in WS4-7. Groundwater was not recorded in WS5-7. The report indicates that groundwater sampling and analysis was not undertaken as part of the 2017 site investigation.

3.7.4 Ground gas

The 2017 report includes two rounds of ground gas monitoring data from 21 and 30 March 2017.

- WS4-7: Methane and carbon dioxide were not recorded in this well (on either occasion).
- WS5-7: Methane (0.3 – 0.9% v/v) and carbon dioxide (3.7 – 4.5%) were detected in this well on both occasions. Depleted oxygen concentrations were also recorded (8.9% 21-Mar and 6.8% 30-Mar-2017, respectively). The report does not provide any comments on the recorded oxygen concentrations.

The ground gas monitoring results have been used to calculate gas screening values for WS5-7. The results for methane and carbon dioxide fall within Characteristic Situation 1 (BS8485) and the 'Green' traffic light classification (NHBC).

3.8 Human health residual Contaminants of Concern (CoC), combined findings

The 2022 and 2017 results indicate the presence of up to five Contaminants of Concern (CoC) within the Made Ground onsite, depending on the land use scenario and the respective published GACs.

- Arsenic, lead and two PAH compounds have been identified as CoC compared to the RwHP GACs.
- Lead has also been identified as a CoC compared to the POS_{resi} GAC.
- There isn't a published GAC for Asbestos in Soils – however AiS has been added to the list of CoC for both scenarios due to the identification of brown asbestos within the Made Ground in one location (WS5-7).

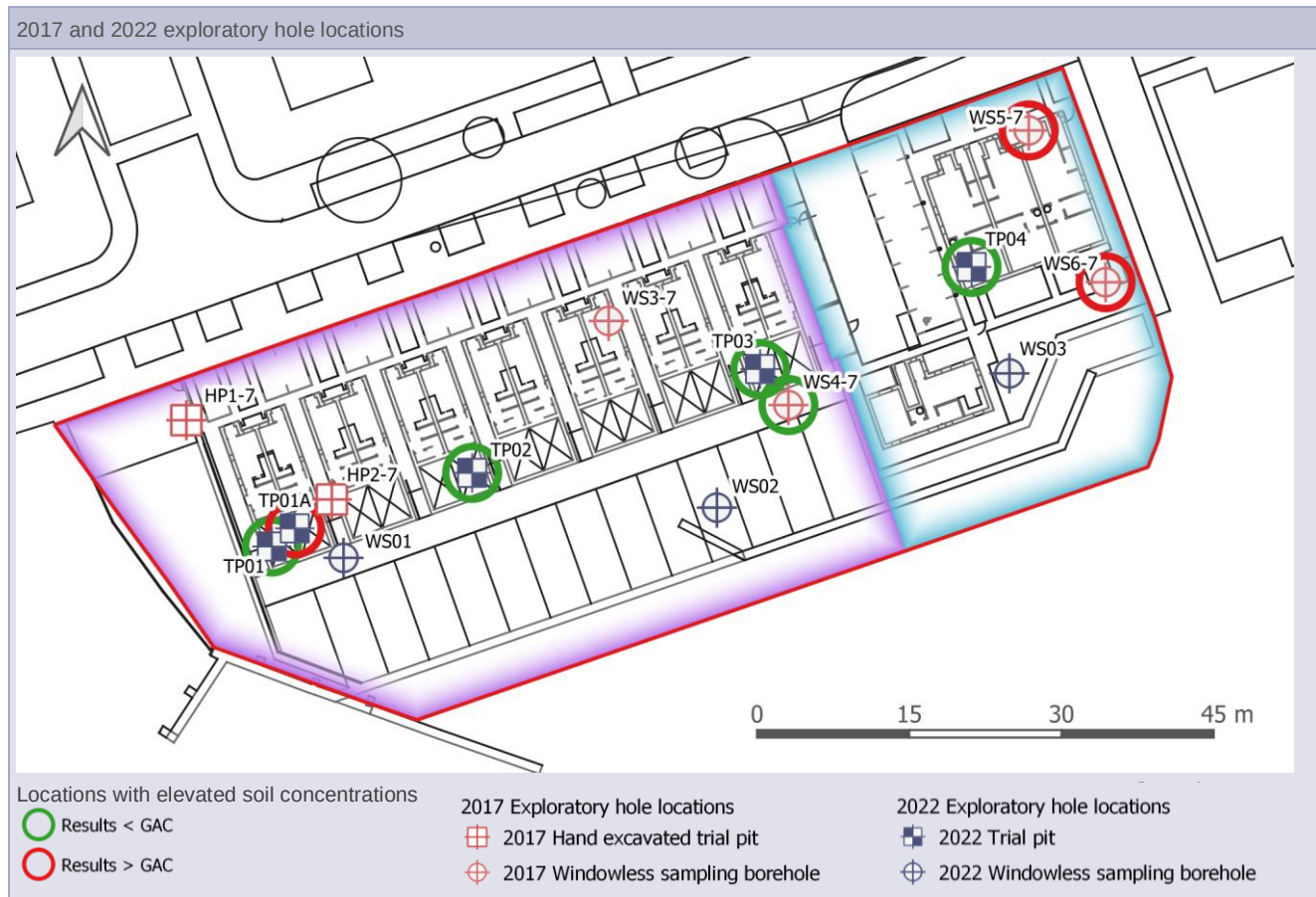
Elevated concentrations of these CoC have been identified in four soil samples that were collected from three out of a total of eight exploratory hole locations (TP01A, WS5-7 and WS6-7), as summarised in Table 3-11. (Note: two samples of Made Ground were analysed from TA01A). TP01A was formed in the west of the site where the residential (semi-detached) housing blocks are proposed. WS5-7 and WS6-7 were formed in the east of the site where the apartment blocks are proposed.

Table 3-11 Geochemical assessment extract

Contaminants of Concern	Zone	Residential	Residential	Apartments	Apartments	Data Summary		Generic Assessment Criteria 2.5% SOM			GQRA 2.5% SOM	
	Strata	Made Ground	Made Ground	Made Ground	Made Ground							
	Location	TP01A	TP01A	WS5-7	WS6-7	No Samples		GAC		Source	Exceedances	
	Depth (mbgl)	0.2	0.5	0.00 - 0.10	0.30 - 0.45							
	Date	13/12/22	13/12/22	2017	2017	No	< LoD	RwHP	POS(resi)	GAC	RwHP	POS(resi)
Asbestos												
ACM result	No units	ND	ND	Detected, <0.001%	ND	12	11	Detected	Detected	N/A	1	1
Metals/ metalloids												
Arsenic	mg/kg	52	55	53	27	12	0	37	79	C4SL	3	0
Lead	mg/kg	322	77	1400	390	12	0	200	630	C4SL	3	1
Polyaromatic Hydrocarbons (PAHs)												
Benzo(b)fluoranthene	mg/kg	3.96	2.15	<1.0	0.5	12	4	3.3	7.20	S4UL	1	0
Dibenzo(a,h)anthracene	mg/kg	0.46	0.25	<1.0	<0.1	12	8	0.28	0.57	S4UL	1	0

A combined exploratory hole location plan is shown in Figure 3-2, which has been annotated so show the locations where these CoC have been identified based on the combined 2017 and 2022 data.

Figure 3-2 Soil Sample Results compared with RwHP and POSresi GACs



3.9 Health and safety of site preparation and construction workers

With respect to the health and safety of site preparation and construction; the following observations are made:

- Notable concentrations of arsenic, lead and the PAH compounds - benzo(b)fluoranthene and dibenzo(a,h)anthracene, have been identified in shallow Made Ground onsite.
- Asbestos in soils (AiS) was detected in a sample of Made Ground from the 2017 investigation.

Potential ground contamination risks to construction and site maintenance workers can typically be mitigated by the adoption of suitable working methods, utilising appropriate personal protective equipment, maintaining good hygiene and minimising dust generation.

3.10 Additional considerations (cut and fill)

Contaminants of concern have been identified within the Made Ground onsite. The depth of Made Ground appears to vary from just under 0.5m thick to up to 2.4m thick. Based on the soil descriptions and the 2017 reporting, the information to date indicates that the CoC were predominantly recorded in Made Ground that includes ash/clinker, which indicates that it may be possible to visually identify/differentiate this material onsite including during construction.

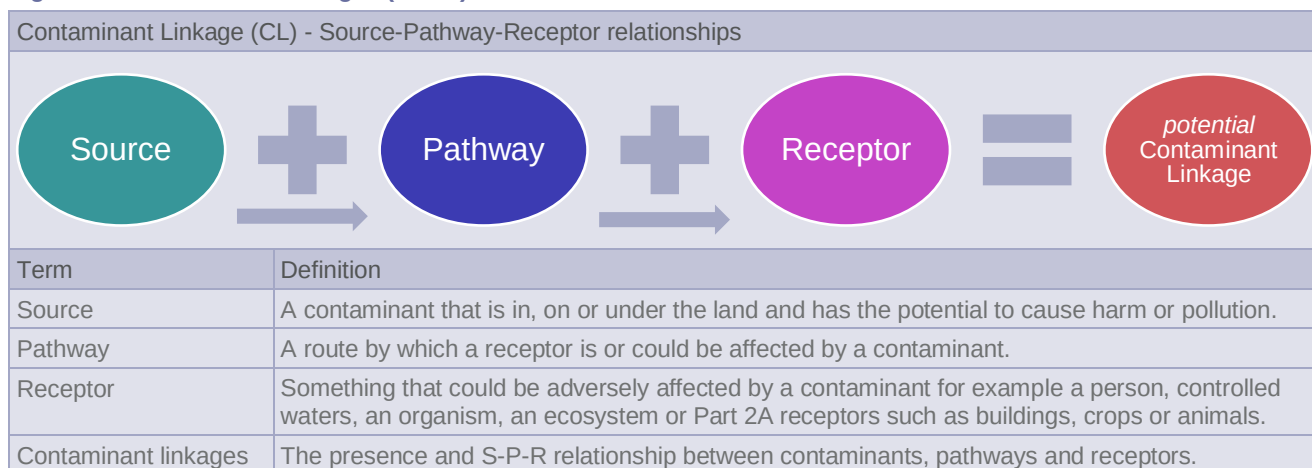
Cut and fill earthworks are proposed as part of site preparation works for the development. The proposed cut and fill plan indicates that some of the shallow Made Ground onsite including within the locations of TP01A (in the west) and WS6-7 (in the east) will be cut (see Appendix C). The cut and fill earthworks have the potential to reduce the quantity of Made Ground onsite and potential to remove the contaminated Made Ground. This will need to form part of the remediation strategy for the site.

4 Conceptual site model

4.1 Introduction

Land Contamination Risk Management (LCRM) is an iterative process. Conceptual Site Models are used to represent and summarise the geoenvironmental characteristics of a site by showing the possible relationships between contaminants, pathways and receptors (based on the source-pathway-receptor (S-P-R) approach summarised in Figure 4-1). CSMs are used to inform the basis of the initial preliminary risk assessment (PRA) and are then updated throughout the LCRM process.

Figure 4-1 Contaminant linkages (S-P-R)



All three elements of a contaminant linkage (S+P+R) must be present for there to be a S-P-R relationship. If any one element is missing/absent there is no linkage and as stated in LCRM *“without a linkage, there is not a risk... even if a contaminant is present”*.

4.2 Revised conceptual site model

The 2022 (and 2017) site investigation findings and data have been used to undertake a Generic Quantitative Risk Assessment to enable the Conceptual Site Model to be revised and updated for the proposed development. The tabulated Conceptual Site Model is presented in Table 4-1.

Table 4-1 Conceptual site model and qualitative risk ratings (GQRA stage)

Ref.	Source/s	Pathway/s	Receptor/s	Probability	Consequence	Risk rating	CL status	Comments
101	Arsenic, lead, PAH compounds within Made Ground onsite	Ingestion, inhalation and dermal contact	Harm to human health end-users - linked to private residential gardens (RwHP)	Likely	Medium	Moderate	Relevant	Made Ground has been recorded across the site at depths ranging between 0.4m and up to 2.4mbgl. The risk assessments identified arsenic, lead, and two PAH compounds (benzo(b)fluoranthene and dibenzo(a,h) anthracene) as residual contaminants of concern (CoC) within the Made Ground with respect to RwHP GACs and lead as a residual CoC with respect to the POSresi GAC. In the future, the Made Ground source will only be accessible in areas of proposed soft landscaping including private residential gardens, public open space and perimeter landscaping. The presence of hardstanding (including building footprints, roads and pavements) will effectively 'cap' the Made Ground in other areas of the site. Remediation required: remediation options could include excavating and removing the Made Ground (linked to the proposed cut and fill) with verification sampling, analysis and assessment, or the design and introduction of a clean 'cover system' in gardens and areas of soft landscaping.
102	Lead within Made Ground onsite	Ingestion, inhalation and dermal contact	Harm to human health - linked to areas of soft-landscaping (POS _{resi})	Likely	Medium	Moderate	Relevant	
201	Asbestos in soils (AiS) within the Made Ground onsite	Inhalation of liberated respirable fibres	Harm to human health of end users - linked to areas of private gardens and soft landscaping	Likely	Medium	Moderate	Relevant	Brown 'Asbestos in Soils' (AiS) was detected in one out of 12 soil samples from the Made Ground (based on the 2017 and 2022 data). Demolition type rubble/Made Ground was encountered in some of the exploratory hole locations and the former buildings onsite were constructed as a time where asbestos was a common building material. The potential for AiS to be present in the Made Ground in locations not covered by the 2017 or 2022 site investigations should not be discounted. Remediation required: the same remediation options for CL101 and CL102 could be considered.
301	Ground gas (offsite sourced)	Migration and accumulation	Building and structures	Unlikely	Medium	Low	-	Only limited concentrations of carbon dioxide and methane have been recorded in some of the gas wells onsite. The ground gas GQRA indicates that the site falls under Characteristic Situation 1 – (very low risk) and 'Green' traffic light classification which indicates that ground gas protection measures are not required.
302		Inhalation of indoor air	Human health of end users	Unlikely	Medium	Low	-	
401	Contaminants within Made Ground onsite	Ingestion, inhalation and dermal contact	Health and safety (H&S) of site preparation and construction workers	Likely to low likelihood	Mild	Moderate/ Low	-	Notable concentrations of arsenic, lead and the PAH compounds - benzo(b)fluoranthene and dibenzo(a,h)anthracene, have been identified in shallow Made Ground onsite. Recommend: Geochemical laboratory data to be shared with the contractor for use as part of their risk assessment processed.
501	Asbestos containing soils (ACSSs)	Inhalation of liberated respirable fibres	H&S of site preparation and construction workers	Likely	Medium	Moderate	-	Brown 'Asbestos in Soils' (AiS) was detected in one out of 12 soil samples from the Made Ground (based on the 2017 and 2022 data). Demolition type rubble/Made Ground was encountered in some of the exploratory hole locations and the former buildings onsite were constructed as a time where asbestos was a common building material. The potential for AiS to be present in Made Ground in locations not covered by the 2017 or 2022 site investigations should not be discounted. Recommend: The 2017 laboratory reports should be shared with the Contractor for use as part of their risk assessment processes.
n/a	Hydrocarbon contamination within Made Ground	Migration through water supply pipes (depending on material type) into potable water.	Health of end-users following consumption of potable water	A thickness of Made Ground is present onsite, TPH concentrations were above the laboratory detection limit in five out of nine samples. The maximum detectable concentrations of some TPH fractions exceeded their respective UKWIR thresholds therefore plastic pipes including PE may not be suitable for the development. Alternative pipe materials (for example barrier pipes) may be required. Pipe selection should be determined in line with United Utilities' new mains and connections processes and guidance. Recommend: consult with United Utilities.				

Table 4-2 Risk matrix

Risk = probability x consequence		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very high	High risk	Moderate	Moderate/ low
	Likely	High	Moderate	Moderate/ low	Low
	Low likelihood	Moderate	Moderate/ low	Low risk	Very low
	Unlikely	Moderate/ low	Low risk	Very low	Very low
	No linkage	Without a linkage, there is not a risk – even if a contaminant is present (LCRM 2020)			

Based on the CIRIA good practice guide (C552, 2001).

5 Conclusions and recommendations

5.1 Conclusions

Made Ground has been identified onsite, including Made Ground associated with the former buildings in the east of the site and Made Ground that was encountered across the site and likely predates the former buildings onsite. The soil descriptions for this older Made Ground typically included the presence of ash and clinker within the soil matrix. The thickness of Made Ground onsite ranged from 0.4m to 2.4mbgl.

The 2022 and 2017 results indicate the presence of up to five Contaminants of Concern (CoC) within the Made Ground onsite, depending on the land use scenario and the respective published GACs.

- Arsenic, lead and two PAH compounds have been identified as CoC compared to the RwHP GACs.
- Lead has also been identified as a COC compared to the POS_{resi} GAC.
- Asbestos in Soils has been added to the list of CoC for both scenarios due to the identification of brown asbestos within the Made Ground in one location (WS5-7).

Elevated concentrations of the CoC summarised above were identified in four Made Ground samples that were collected from three exploratory hole locations (TP01A, WS5-7 and WS6-7, including two soil samples from TP01A @0.2 and @0.5mbgl).

While the presence of the buildings, access roads, pavements and other areas of hardstanding will mitigate the risks in part of the site, residual and potentially 'unacceptable' land contamination risks may exist onsite associated with areas of soft landscaping including residential gardens, shared gardens/public open space and perimeter landscaping.

The results of the risk assessment indicate that remediation will be required in these soft landscaping areas. The proposed cut and fill earthworks and the final landscaping designs are likely to significantly influence the extent, nature and details of the remediation requirements for these areas.

5.2 Recommendations

The risk assessment has identified three contaminant linkages (summarised in Table 5-1) that could present 'unacceptable' land contamination risks for the proposed development, in line with LCRM. These Source-Pathway-Receptor relationships have been updated from '*potential*' to '**relevant**' contaminant linkages (CLs) based on the GQRA results. Remediation will be required for these contaminant linkages.

Table 5-1 Relevant contaminant linkages

Ref.	Source/s	Pathway/s	Receptor/s	Risk rating	CL status
101	Arsenic, lead, PAH compounds within Made Ground onsite	Ingestion, inhalation and dermal contact	Harm to human health end-users linked to private residential gardens (RwHP)	Moderate	Relevant
102	Lead within Made Ground onsite	Ingestion, inhalation and dermal contact	Harm to human health linked to areas of soft-landscaping (POS _{resi})	Moderate	Relevant
201	Asbestos in soils (AiS) within the Made Ground onsite	Inhalation of liberated respirable fibres	Harm to human health of end users linked to areas of private gardens and soft landscaping	Moderate	Relevant

The remediations strategy will need to be preceded by a Remediation Options Appraisal. It is recommended that the remediation options appraisal is developed alongside the earthworks design and specification (including cut and fill design), the materials management strategy (as some of the 'cut' soils are unlikely to be suitable for reuse onsite) and the landscape plans/design to ensure that a complementary, practical, sustainable and cost effectively remediation solution is selected.

If the onsite soils are due to be reused as in line with the Definition of Waste: Code of Practice (DoWCoP) (CL:AIRE, 2011) then the results of the GQRA indicate that the associated Materials Management Plan (MMP) will need to follow process Route A, which means that the MMP will need to align with the Remediation Strategy for the development.

6 Limitations and Liabilities

This report has been prepared by Pell Frischmann with reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the Client in accordance to the agreed scope of services.

This report has been prepared to provide pre-development geoenvironmental and land contamination information for the redevelopment of the Longhurst Road site. The report contents should only be used in that context and Pell Frischmann disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

The report details the findings of work carried out by Pell Frischmann during a study period from April to May 2023. The report has been prepared based on available information obtained during that study period. Information provided by the referenced third parties has been used in good faith and is taken at face value; however, Pell Frischmann cannot guarantee its accuracy or completeness.

Although every reasonable effort has been made to gather all relevant information within the context of the agreed scope of work, all potential environmental constraints or liabilities associated with the site may not have been revealed. Should additional information become available (including new legislation and changed practices), after the date of the report submission, Pell Frischmann reserves the right to reconsider the recommendations and alter the report accordingly.

Notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal or specific survey of these potential development hazards. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance.

Appendix A Land Contamination Risk Management

Generic Assessment Criteria (GAC) - human health

The LCRM guidance references published Generic assessment criteria (GAC) 'for assessing risk to human health from exposure to contaminants' for a series of land-use scenarios: residential (with or without homegrown produce, (RwHP and RwoHP)), allotments, public open space (residential (POS_{resi}) and park (POS_{park})) and commercial. Each land-use scenario is based on a pre-defined series of exposure pathways and a 'critical receptor'. These GAC are '*the levels in soil above which may present an unacceptable risk of harm to human health*' (LCRM).

Residential without homegrown produce (RwoHP): this land-use considers private residential properties with private gardens where the assumption that children aged 1 to 6 years are exposed to soil and soil-derived dust at their home 365 days per year and the critical receptor is a female child (age range 0 to <6 years).

Residential with homegrown produce (RwHP): this land-use considers private residential properties with private gardens where the assumption that children aged 1 to 6 years are exposed to soil and soil-derived dust at their home 365 days per year. The GACs for RwHP also consider exposure pathways associated with the consumption of home grown produce specifically 'ingestion of soil attached to home grown fruit/vegetables' and 'ingestion of fruit/vegetables' grown in the garden soil. The critical receptor is a female child (age range 0 to <6 years).

Allotments: This land-use considers allotments where the consumption of homegrown produce is a key exposure pathway (specifically 'ingestion of soil attached to produce' and 'uptake of contaminants into produce which are then consumed'); children may have a greater regular contact with soil compared to a residential garden and exposure via direct ingestion of soil and soil-derived dust only occurs whilst at the allotment (i.e. the tracking back of soil to the residential property is negligible) and dermal contact with soil and inhalation of dust derived from soil and the inhalation of vapours occurs outdoors. The critical receptor is a female child (age range 0 to <6 years).

Commercial: This land use defined a workplace used by adults over a typical working life (5 days per week for 46 weeks of the year) where most of the time is spent indoors and where a worker could be exposed to soil (outdoors) and soil derived dust and vapours (indoors and outdoors). The areas of land and the nature of the properties can be highly variable (e.g. small offices, commercial properties and light industrial properties to larger warehouses). This land-use considered light-uses (i.e. not heavy manual labour) where most of the site typically comprises hard-standing with areas of landscaping/soil around the buildings or nearby (80:20). This land-use is not designed to cover sites that are 100% hard cover. The critical receptor is a female worker (age range 16 to <65 years).

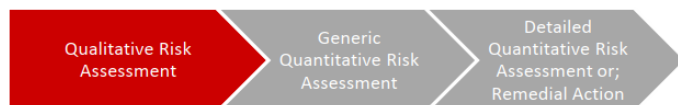
Public Open Space – residential (POS_{resi}): this land-use considers predominantly grassed areas or green spaces close to housing that are likely to be used by children playing including for informal sport; up to 500m² (0.05 ha) and up to 50% of the area may be bare soils. The exposure pathways include tracking back of soils to residential properties. The critical receptor is a female child (age range 3 to <9 years).

Public Open Space – park (POS_{park}): this land-use considers a public park-type scenario, where the park is predominantly grassed open space (with trees and bushes) with no more than 25% exposed soil and likely to be used for a wide range of activities including family visits and picnics, children's play areas, sporting activities (without a dedicated pitch) and dog walking. The park is at a sufficient distant from the home that there is negligible tracking back of soil and the ingestion of soil-derived dust indoors is no considered to be significant. The critical receptor is a female child (age range 0 to <6 years).

Technical note: Lifetime averaging is applied when generating GACs for cadmium therefore the critical receptor for cadmium for residential, allotments, POS_{resi} is a female child/adult (age range 0-74), and POS_{park} female child/adult (age range 3-74).

Appendix B *Preliminary* conceptual site model

(extracted from Curtins' 2021 PRA)



- The table below represents the first stage in the land quality risk assessment process: The Qualitative Risk Assessment.
- For a development site to be deemed 'suitable for use', the level of risk needs to be brought down to acceptable levels, i.e. low to very low risk. The purpose of each stage of risk assessment is ultimately to establish, if there is a requirement for additional levels of assessment to be made to have sufficient confidence to support a risk characterisation or management decision, e.g. remedial action.
- In the absence of specific site data, a Generic Quantitative Risk Assessment is invariably recommended.

Conceptual Site Model			Qualitative Risk Assessment			Recommended Actions
Source	Pathway(s)	Receptor(s)	Consequence	Likelihood of Occurrence	Risk Rating	
Potential sources of on-site contamination: • Made Ground of unknown composition from uncontrolled deposition of materials onsite during the construction of the properties onsite • In addition, as detailed within previous investigation data concentrations of lead and Arsenic within the Made Ground above Residential screening criteria and presence of Asbestos. Potential sources of off-site contamination: • No potential sources of mobile or gross phase contamination highlighted within historical surrounding land uses.	Direct contact, ingestion, inhalation (dust and vapours)	End-user of site (Residents) & Construction Workers	Medium Chronic health risk	Likely Historically the site has had a single phase of development and investigation data has highlighted limited Made Ground on-site. However the Made Ground is noted to comprise solid-phase contaminants (i.e. ash and clinker) and concentrations of contaminants which given the sensitivity of the site (residential) is likely to present a potential risk to future site users within areas of soft landscaping. Likelihood of construction workers coming into contact with contamination on site can be reduced by appropriate PPE.	Moderate	Generic Quantitative Risk Assessment Recommended as part of the ground investigation.
	Vertical migration through the superficial deposits (soils) May occur due to existing service corridors and physical processes including; capillary action and downwards into the natural deposits through infiltration.	Controlled Waters (Groundwater) Principal Aquifer (Bedrock), overlain by Glacial Till Deposits (Secondary Aquifer – Undifferentiated). There are no potable groundwater abstraction points within 5km. The site is not within a designated Source Protection Zone.	Medium Pollution of sensitive water resources	Unlikely While there is the potential for localised contamination to migrate vertically through the superficial deposits to the bedrock Secondary A Aquifer, there is a low likelihood of significant contamination being present in the Made Ground due to lack of historical industrial land use and taking into account the lack of an SPZ or abstraction points within 1km.	Low	No further action required
	Horizontal migration over and through the superficial deposits (soils)	Controlled Waters (Surface Water) Nearest surface water feature is a brook 47m-west. No surface water abstraction points within 1km.	Mild Pollution of non-sensitive water resources	Unlikely Considering the distance from the site to the nearest surface water receptor and the expected low levels of contamination within the Made Ground (i.e. no gross or mobile phase contamination), this pathway is considered unlikely.	Very Low	No further action required
Potential sources of ground gas (on-site and off-site): • Historical graveyard to the south-west • Historical landfill 218m west of the site.	Vertical and horizontal migration through existing service corridors and the underlying superficial deposits	End-user of site (Residents)	Medium Human health risk	Likely There is potential for gas generation from any localised off-site organic material associated with graveyard and historical landfill which could migrate onto site.	Moderate	Generic Quantitative Risk Assessment Recommended as part of the ground investigation.

Appendix C Plans/drawings

Appendix D Geochemical analysis results

Geochemical summary (for full results see contract's factual report)		Residential	Residential	Residential	Residential	Residential	Residential	Residential	Residential	Residential	Apartments	Apartments	Apartments	Apartments	Data Summary	GAC 1.5% SOM				GQRA 2.5% SOM								
	Strata Location	Made Ground	Made Ground	Made Ground	Made Ground	Glacial Till	Made Ground	Made Ground	Made Ground	Made Ground	Made Ground	Glacial Till	Made Ground	Made Ground														
	TP01	TP01A	TP01A	TP02	TP02	TP03	TP03	WS4-7	TP04	TP04	WS5-7	WS6-7																
	Depth (mbgl)	0.5	0.2	0.5	0.2	0.5	0.5	0.7	0.30 - 0.40	0.5	2.7	0.00 - 0.10	0.30 - 0.45															
	Sampled Date	13/12/22	13/12/22	13/12/22	13/12/22	13/12/22	13/12/22	13/12/22	2017	13/12/22	13/12/22	2017	2017															
Asbestos															No Samples	Inc. <LOD			Generic Assessment Criteria				Source	Exceedances				
ACM result	No units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Detected	ND	No	< LoD	> LoD	Min	Ave	Max	RwHP 2.5%	Detected	Detected	Detected	GAC	RwHP 2.5%	RwoHP 2.5%	POS(resi) 2.5%
ACM result	No units												<0.001		12	11	1				Detected	Detected	Detected	N/A	1	1	1	
Carbon and Inorganics															1	1	0				Detected	Detected	Detected	N/A	0	0	0	
Total Organic Carbon	%	1.3	11.7	6.2	2	0.6	1.9	0.9		2.8	2.2		7.2	10	0	10	0.6	3.68	11.7									
Soil Organic Matter (calculated)	%	2.24	20.124	10.66	3.44	1.03	3.27	1.55		4.82	3.78		12.38	10	0	10	1.032	6.33	20.124									
Loss on Ignition	%	3.4	26.7	6.5	6.9	1.8	8	11.2		5.8	7			9	0	9	1.8	8.59	26.7									
pH	pH Units	7.4	7.2	7.1	7.2	7.7	7.8	7.3	8.1	8	7.1	7.6	7.6	12	0	12	7.1	7.51	8.1									
Metals - (Solids)																												
Antimony	mg/kg	3.2	11.3	9.4	3.9	<1	4.2	2.5		4.4	2.1			9	1	8	1	4.67	11.3									
Arsenic	mg/kg	7	52	55	10	6	18	5	12	14	6	53	27	12	0	12	5	22.08	55	37	40	79	C4SL	3	3	0		
Barium	mg/kg	52	494	147	135	37	204	89	100	210	37	94	350	12	0	12	37	178.50	494									
Cadmium	mg/kg	< 0.2	1.5	0.9	0.3	< 0.2	0.3	< 0.2	<1	0.6	< 0.2	<1	<1	12	7	5	0.2	0.62	1.5	26	149	220	C4SL	0	0	0		
Chromium, Hexavalent	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	9	9	0	2	2.00	2	21	21	23	C4SL	0	0	0		
Chromium	mg/kg	9	49	29	14	6	22	12		13	15		26	12	0	12	6	19.17	49	910	910	1500	S4UL	0	0	0		
Copper	mg/kg	17	133	45	35	8	25	13		23	20		91	12	0	12	8	45.25	133	2400	7100	12000	S4UL	0	0	0		
Lead	mg/kg	32	322	77	105	15	142	49	40	129	71	1400	390	12	0	12	15	231.00	1400	200	310	630	C4SL	3	3	1		
Mercury	mg/kg	<1	4.3	2.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	12	10	2	1	1.37	4.3	11	15	40	S4UL	0	0	0		
Molybdenum	mg/kg	<1	3.3	2.8	1	<1	1.9	<1		1.7	1.2			9	3	6	1	1.66	3.3									
Nickel	mg/kg	9	24	15	15	9	16	10	18	17	11		46	12	0	12	9	17.92	46	180	180	230	S4UL	0	0	0		
Selenium	mg/kg	<2	<2	<2	<2	<2	<2	<2	<3	<2	<2	<3	<3	12	12	0	2	2.25	3	250	430	1100	S4UL	0	0	0		
Vanadium	mg/kg	11	31	19	16	7	19	12	19	23	13		65	12	0	12	7	22.42	65	410	1200	2000	S4UL	0	0	0		
Zinc	mg/kg	39	375	92	87	30	68	34	76	106	52		210	12	0	12	30	155.75	700	3700	40000	81000	S4UL	0	0	0		
Polyaromatic Hydrocarbons (PAHs)																												
Naphthalene	mg/kg	< 0.1	0.96	0.4	< 0.1	< 0.1	0.16	0.18	<0.1	0.18	< 0.1	<1.0	<0.1	12	7	5	0.1	0.29	1	5.6	5.6	4900	S4UL	0	0	0		
Acenaphthylene	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1	< 0.1	< 0.1	<1.0	<0.1	12	12	0	0.1	0.18	1	420	4600	15000	S4UL	0	0	0		
Acenaphthene	mg/kg	< 0.1	0.68	0.36	< 0.1	< 0.1	0.2	0.13	<0.1	0.22	< 0.1	<1.0	<0.1	12	7	5	0.1	0.27	1	510	4700	15000	S4UL	0	0	0		
Fluorene	mg/kg	< 0.1	0.42	0.15	< 0.1	< 0.1	0.15	0.27	<0.1	0.14	< 0.1	<1.0	<0.1	12	7	5	0.1	0.23	1	400	3800	9900	S4UL	0	0	0		
Phenanthrene	mg/kg	0.17	4.86	2.8	< 0.1	< 0.1	1.67	1.15	<0.1	1.51	0.16	<1.0	0.4	12	5	7	0.1	1.17	4.86	220	1500	3100	S4UL	0	0	0		
Anthracene	mg/kg	< 0.1	1.01	0.5	< 0.1	< 0.1	0.36	0.21	<0.1	0.34	< 0.1	<1.0	<0.1	12	7	5	0.1	0.34	1.01	5400	35000	74000	S4UL	0	0	0		
Fluoranthene	mg/kg	0.3	6.79	4.29	< 0.1	< 0.1	2.74	1.58	<0.1	2.83	0.37	<1.0	0.8	12	5	7	0.1	1.75	6.79	560	1600	3100	S4UL	0	0	0		
Pyrene	mg/kg	0.29	6.08	3.69	< 0.1	< 0.1	2.69	1.17	<0.1	2.67	0.41	<1.0	0.8	12	5	7	0.1	1.59	6.08	1200	3800	7400	S4UL	0	0	0		
Benz(a)anthracene	mg/kg	0.18	3.81	2.4	< 0.1	< 0.1	1.6	0.56	<0.1	1.67	0.24	<1.0	0.4	12	5	7	0.1	1.01	3.81	11	14	29	S4UL	0	0	0		
Chrysene	mg/kg	0.19	3.62	2.23	< 0.1	< 0.1	1.51	0.52	<0.1	1.5	0.25	<1.0	0.4	12	5	7	0.1	0.96	3.62	22	31	57	S4UL	0	0	0		
Benzo(b)fluoranthene	mg/kg	0.18	3.96	2.15	< 0.1	< 0.1	1.6	0.42	<0.1	1.74	0.24	<1.0	0.5	12	5	7	0.1	1.01	3.96	3.3	4.00	7.2	S4UL	1	0	0		
Benzo(k)fluoranthene	mg/kg	< 0.1	1.31	0.77	< 0.1	< 0.1	0.53	0.14	<0.1	0.61	< 0.1	<1.0	0.3	12	7	5	0.1	0.43	1.31	93	110	190	S4UL	0	0	0		
Benzo(a)pyrene	mg/kg	0.18	3.64	1.98	< 0.1	< 0.1	1.5	0.32	<0.1	1.78	0.22	<1.0	0.3	12	5	7	0.1	0.94	3.64	5	5.3	10	C4SL	0	0	0		
Indeno(1,2,3-cd)pyrene	mg/kg	0.11	2.09	1.1	< 0.1	< 0.1	0.91	0.21	<0.1	1.04	0.13	<1.0	0.2	12	5	7	0.1	0.59	2.09	36	46	82	S4UL	0	0	0		
Dibenzo(a,h)anthracene	mg/kg	< 0.1	0.46	0.25	< 0.1	< 0.1	0.26	< 0.1	<0.1	0.24	< 0.1	<1.0	<0.1	12	8	4	0.1	0.24	1	0.28	0.32	0.57	S4UL	1	1	0		
Benzo(g,h,i)perylene	mg/kg	< 0.1	1.87	0.92	< 0.1	< 0.1	0.82	0.18	<0.1	0.92	0.12	<1.0	0.2	12	6	6	0.1	0.54	1.87	340	360	640	S4UL	0				

Appendix E Contractor's factual report