



7.3. Ground Conditions

The ground conditions encountered during the recent A2SI ground investigation for the Deansgate level are summarised in Table 7.1.

Table 7.1 Summary ground conditions

Unit	Depth to Top of Stratum (m bgl)	Thickness (m)	Generalised Description
Made Ground	0.0 (Deansgate level)	1.7 – 2.8	Pavement slab over medium dense greyish brown slightly clayey silty gravelly fine to coarse SAND with occasional clay pockets. Gravel is typically angular to subangular, fine to coarse concrete, quartzite, concrete and brick.
Glaciofluvial Sheet Deposits (only encountered at WS02)	2.8	0.8	Firm to stiff reddish brown sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is angular to subangular of flint and quartzite.
			Dense reddish brown poorly cemented fine to medium SAND.
Chester Formation	1.7 – 2.8	>8.0	From 5.8 m bgl... Weak thinly to medium laminated reddish brown medium to coarse grained cemented SANDSTONE.

No groundwater inflows were encountered within the rotary borehole BH01. Due to the use of flush as part of the rotary drilling process, groundwater strikes/inflows could not be recorded for BH01. Based on the E3P Phase 2 Assessment and other ground investigation data available for the site, shallow groundwater is anticipated approximately 1.4 to 3.7 metres below wider site level (i.e. ground level at the base of the existing retaining wall).

Soil sample VOC head-space readings are all recorded as <0.1 part per million (ppm).

No visual or olfactory evidence of contamination was identified.

7.4. Generic Quantitative Risk Assessment

7.4.1. Human Health (Dermal Contact, Ingestion and Inhalation)

The soil sample laboratory analytical results have been compared to GAC appropriate for assessing risks to the specifically proposed development. The selected human health GAC include the LQM/CIEH S4ULs. The S4ULs are based on Health Criteria Values that represent minimal or tolerable levels of risks to health as described in the Environment Agency's SR2 guidance, ensuring that the resulting assessment criteria are 'suitable for use' under Planning.

For each chemical substance, S4ULs include individual GAC for 6 no. generic land-uses (residential with home grown produce, residential without home grown produce, allotments, commercial and 2no. public open space land uses) and a range of SOM contents. All toxicological and physical-chemical parameters used in the derivation of the S4ULs are presented and discussed in the source publication.

In some instances, selected human health GAC have been applied from the DEFRA C4SLs, CL:AIRE GAC, EA Soil Guideline Values and Atkins AtRisk Soil Screening Values. The source reference used for the human health GAC for each chemical determinant is presented in the screening tables included in Appendix H. DEFRA C4SLs have been used preferentially where available.

The human health GAC have been applied to each chemical determined for the 'residential with home grown produce' land-use scenario. In future, should the site redevelopment plans change from those considered herein then the geo-environmental risk assessments presented herein need to be reconsidered. The GAC for mercury assumes the presence of methyl mercury as a conservative worst-case assumption based on the site history.

There is no published human health GAC with respect to asbestos or ACMs in soil. Industry best practice document '*Asbestos in soil and made ground: a guide to understanding and managing risks*', CIRIA C733, 2014, identifies that soils containing asbestos concentrations of 0.001 % w/w may be able to liberate airborne fibre concentrations that exceed the contemporary occupational exposure limit for nuisance dust. However, as detailed in other research, including publications such as the *CAR-SOIL Industry Guidance (2016)*, in circumstances where very low concentrations of asbestos are identified in soils, the associated risks are considered low. In this study A-squared adopt an asbestos human health GAC of <0.001 % w/w i.e. mitigation or further assessment is required if asbestos in soil is detected at or above <0.001 % w/w.

Screening tables comparing the soil sample laboratory analytical results to the selected human health GAC are provided in Appendix H. All soil samples which underwent laboratory analysis for geo-environmental purposes were collected from Made Ground or the underlying natural soils. A single minor exceedance for beryllium is identified and this is considered further in Section 7.6 and Section 7.7.

7.4.2. Controlled Waters

Soil leachate laboratory analytical results have been compared to GAC appropriate for assessing controlled waters risks. Controlled waters GAC have been selected to assess risks to drinking water quality and the aquatic environment in surface waters.

The selected drinking water quality GAC are based on DWS published by the UK and EU, as well as GVs published by the WHO. The DWS and GVs are used as values indicative of low risk to drinking water quality and have been selected given the aquifer status of the sandstone bedrock beneath the site (Principal Aquifer).

The selected aquatic environment GAC are based on EQS published by the UK and EU, as well as operational targets published by the EA. The EQS and operational targets are used as values indicative of low risk to the aquatic surface water environment and have been selected given the location of the River Irwell immediately west of the site.

The soil leachate laboratory analytical results are presented in a screening table comparing the detected chemical concentrations to the selected controlled waters GAC in Appendix H. The identified exceedances of the selected controlled waters GAC are considered further in Section 7.6 and Section 7.7. For determinants not included in the laboratory leachate analysis, a qualitative assessment based on the detected bulk soil concentrations has been made.

7.5. Conceptual Site Model (CSM) for Piling from the Deansgate Level

A CSM has been developed for the purpose of assessing the potential risks to human health and controlled waters receptors as a direct result of the proposed piling works from the Deansgate level.

A potential pollutant linkage exists where the following three criteria are satisfied:

- 1.0 A potential source of contamination has been identified;
- 2.0 A receptor for the contamination is present; and
- 3.0 A viable pathway can be identified between a potential source and receptor.

Sources

The known sources considered relevant to this assessment are limited to shallow Made Ground where piling is to take place, including heavy metals and metalloids, PAHs and heavy TPHs based on the recent soil sampling undertaken. No source of VOCs has been identified in the area where piling is proposed for the contiguous pile wall.



Migration Pathways

Piling has the potential to create the following contaminant migration pathways:

- Creation of preferential pathways through an aquitard.
- Creation of preferential pathways through a low permeability surface layer.
- Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.
- Direct contact of the piles or engineered structures with contaminated soil or leachate.
- The driving of solid contaminants down into the Chester Formation (Principal Aquifer) during pile driving.
- Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

It is considered reasonable to assume that, following redevelopment, the area of the pile wall will be almost entirely covered in buildings or hardstanding with associated surface water drainage. This being the case it is considered reasonable to conclude that the potential for infiltration, mobilisation of theoretically leachable contaminants in Made Ground, and subsequent migration to groundwater can be discounted. Human exposure as part of the completed redevelopment via direct contact, ingestion and soil inhalation can also be discounted on this basis.

Key Receptors

The following controlled waters receptors and human health receptors have been identified (note that built structures and ecological receptors have not been considered within the scope of this assessment):

- Groundwater within the Chester Formation (Principal Aquifer). There is a groundwater abstraction point located approximately 65m north-west of the site licenced for “Other industrial/commercial/public services: general cooling (existing licenses only) (High Loss)”;
- Surface water within the River Irwell 5 m west of the site. The river is classified by the EA to have a river quality of E (poor); and
- Site workers involved with the formation of the proposed pile walls.

Glaciofluvial Sheet Deposits (Secondary A Aquifer) are not considered a receptor as the ground investigation indicates there is not a coherent groundwater body associated with these deposits beneath the site. These deposits are also widely absent beneath the site and have only been recorded at WS02.

7.6. Foundation Works Risk Assessment and Mitigation Measures

This FWRA is restricted to an assessment of the issues associated with the potential use of piling techniques for the construction of a contiguous pile wall from the Deansgate level in the north-east of the site.

EA documents ‘*Piling into Contaminated Sites*’ and ‘*Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*’ present guidance on the potential contamination risks that different piling techniques can have on groundwater and, additionally, the potential risks posed to human health.

The guidance presents six potential Source-Pathway-Receptor (S-P-R) linkages to be considered as part of a foundation risk assessment.

S-P-R Scenario 1: Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.

S-P-R Scenario 2: Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.

S-P-R Scenario 3: Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.

S-P-R Scenario 4: Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.

S-P-R Scenario 5: The driving of solid contaminants down into an aquifer during pile driving.

S-P-R Scenario 6: Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

Consideration of each of these areas within the context of the provisional piling methods identified is discussed in Table 7.2. The provisional piling methods include continuous flight auger (CFA) piling or other rotary bored piling technique.

Table 7.2 Review of Piling Options against S-P-R Scenarios

S-P-R Scenarios	CFA Piling or Other Rotary Bored Piling Technique
Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.	The method of construction is likely to result in an intimate contact between the concrete of the pile and surrounding soils such that a preferential pathway is unlikely to be present post-construction. Short-term liquid migration risks are discounted given that shallow groundwater in the Made Ground or superficial deposits has not been identified. Groundwater is considered to be primarily present with the bedrock Principal Aquifer and the superficial deposits are not continuous across the site (they are typically not present and do not represent an aquitard).
Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.	Discounted given that there is no identified low permeability layer through which the proposed piles would penetrate.
Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.	The soil sample chemical laboratory results from the ground investigation recently undertaken indicate generally low concentrations with respect to construction site health and safety. The risks can be appropriately managed by appropriate construction phase RAMS and CPP using typical methods. No asbestos has been detected in the available samples.
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.	Unlikely. Piles should be constructed from concrete with an appropriate Design Sulphate Class and ACEC Class.
The driving of solid contaminants down into an aquifer during pile driving.	Reduced potential due to non-displacement nature of piling (minimal requirement for driving of soils).
Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.	Increased potential due to proposed used of cast in-situ concrete for piles, pile caps and foundations.

As replacement (non-displacement) piling methods, CFA piles and rotary bored piles require the removal of soils to create a void which is then filled with concrete to form the piled foundation. Consequently, there is potentially a greater opportunity for the creation of contaminant pathways to be formed during the excavation process. Any pathways arising through this process should, however, be mitigated (at least in part) by the placement of the concrete to form the pile.

The use of wet cast in-situ concrete results in the placing of material with a positive lateral pressure being exerted on the sides of the pile bore. This prevents voids and pathways being created along the soil / concrete interface, and the irregular pile surface (in comparison to a driven pile) would mitigate against downward migration of contaminants.

In addition, the removal of soils during the process results in the potential for exposure of site workers to any contamination in excavated materials. Excavated soils (i.e. piling arisings) may require off-site disposal in accordance with current waste management legislation, although it may be possible to incorporate these materials into the wider landscaping works across the site via a Materials Management Plan operated under the Contaminated Land: Applications in Real Environments (CL:AIRE) initiative ‘*The Definition of Waste: Development Industry Code of Practice*’.



It is noted that shallow soils are predominantly heterogeneous granular Made Ground comprising demolition materials, over Chester Formation bedrock. These materials likely have relatively high permeability, and the installation of CFA or rotary bored piles is considered unlikely to significantly increase in the number of such pathways through the Made Ground. Theoretically, there may be preferential migration of perched water (delayed infiltration) to deeper groundwater, however such incremental risks are likely to be limited due to (almost entire) extent of hardstanding (and associated surface water drainage) that will be present on completion of the proposed development, and that the process of casting the piles will result in an intimate contact between such that a preferential pathway is not present.

A summary of the site-specific risks from CFA and rotary bored piles advanced from the Deansgate level is provided as Table 7.3.

Table 7.3 Summary of Risks from CFA and Rotary Bored Piles Advanced from Deansgate Level

S-P-R Scenarios	Risk Associated with Pile Design	Magnitude of Risk	Summary of Risk	Does Pile Design Sufficiently Mitigate Risk	Requirement for Alternative Pile Design
Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.	N	NA	No aquitard identified so creation of a preferential pathway not viable.	Y	N
Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.	N	NA	No low permeability surface layer identified so creation of a preferential pathway not viable.	Y	N
Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.	Y	Low to moderate	The soil sample chemical laboratory results indicate typical mitigation measures which can be specified in the RAMS and CPP should be implemented during the construction phase.	Y	N (risk reduced by appropriate mitigation measures)
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.	Y	Low to moderate	Piles should be constructed from concrete with an appropriate Design Sulphate Class and ACEC Class to mitigate the risk.	Y	N (risk reduced by appropriate mitigation measures)
The driving of solid contaminants down into an aquifer during pile driving.	N	NA	Not viable given the proposed non-displacement piling technique.	Y	N
Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.	Y	Low	The risk is reduced since groundwater transmission through the Chester Formation will be via intergranular flow. The Chester Formation has been logged as a SANDSTONE without significant gravel bands or fractures / joints which would increase migration potential. The existing river wall further restricts the available pathways.	Y	N

In terms of the proposed piling options, CFA or rotary bored piles are unlikely to present a significant risk with the aforementioned mitigation in place.

During construction, any surplus materials excavated should suitably managed (either off-site disposal or incorporation into a suitable remediation strategy) to mitigate risks to future site users.

It is recommended that Quality Assurance (QA) and Quality Control (QC) measures are identified and adopted prior to piling and ground improvement works being undertaken. These are primarily for construction quality and structural performance; however, they are also equally relevant to mitigate environmental risk, for example ensuring that any material imported to site for use as a piling mat is not contaminated and so does not add to the contaminant burden on site. The relevant measures should ensure that the foundation solution techniques are carried out correctly and in an appropriate manner so that the risk assessment and conclusions remains valid.

CL:AIRE Definition of Waste: Development Industry Code of Practice may be used in support of attempts to de-classify excavated materials as ‘waste’ if they can be sustainably re-used. Should materials require, however, off-site disposal, the developer has a statutory responsibility to ensure that contaminated soil and water is disposed of off-site to a suitably licensed waste management facility in a safe and approved manner. If any soil arisings produced by the piling are to be disposed of to landfill then the available site instigation information from the areas where such arisings are anticipated to be produced should be provided to the landfill in advance of the works to assist in ensuring the appropriate characterisation of waste streams. Waste Acceptance Criteria (WAC) testing would be required to determine the limit values for waste destined to various classes of landfill.

All wastes taken off site, in solid or liquid form, must be handled by a registered waste carrier and be accompanied by an appropriate waste transfer note or consignment note which describes the waste.



8. Foundation Works Risk Assessment – Excluding Deansgate Level

8.1. Introduction

Section 8 presents a FWRA for the proposed development at the application boundary. The FWRA has been informed by the E3P ground investigation and A2SI ground investigation phase 2.

Piles proposed for the site will extend through shallow soils and terminate below shallow groundwater level in the Chester Formation.

Please be aware that this FWRA excludes the contiguous pile wall which may be constructed along the eastern boundary of the site from the Deansgate level. A specific FWRA for the Deansgate level is presented in Section 7.

8.2. Conceptual Site Model (CSM) for Piling

A CSM has been developed for the purpose of assessing the potential risks to human health and controlled waters receptors as a direct result of the proposed piling works.

A potential pollutant linkage exists where the following three criteria are satisfied:

- 1.0 A potential source of contamination has been identified;
- 2.0 A receptor for the contamination is present; and
- 3.0 A viable pathway can be identified between a potential source and receptor.

Sources

The known sources considered relevant to this assessment are limited to shallow Made Ground where piling is to take place, including heavy metals and metalloids, PAHs, heavy TPHs and VOCs based on the recent soil sampling undertaken.

Migration Pathways

Piling has the potential to create the following contaminant migration pathways:

- Creation of preferential pathways through an aquitard.
- Creation of preferential pathways through a low permeability surface layer.
- Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.
- Direct contact of the piles or engineered structures with contaminated soil or leachate.
- The driving of solid contaminants down into the Chester Formation (Principal Aquifer) during pile driving.
- Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

Following redevelopment, the areas to be piled will be almost entirely covered in buildings or hardstanding with associated surface water drainage. This being the case it is considered reasonable to conclude that the potential for infiltration, mobilisation of theoretically leachable contaminants in Made Ground, and subsequent migration to groundwater can be discounted. Human exposure as part of the completed redevelopment via direct contact, ingestion and soil inhalation can also be discounted on this basis that the limited areas of proposed soft-landscaping will have a clean capping layer constructed at the ground surface.

Key Receptors

The following controlled waters receptors and human health receptors have been identified (note that built structures and ecological receptors have not been considered within the scope of this assessment):

- Groundwater within the Chester Formation (Principal Aquifer). There is a groundwater abstraction point located approximately 65m north-west of the site licenced for “Other industrial/commercial/public services: general cooling (existing licenses only) (High Loss)”;
- Surface water within the River Irwell 5 m west of the site. The river is classified by the EA to have a river quality of E (poor); and
- Site workers involved with the formation of the proposed pile walls.

Glaciofluvial Sheet Deposits (Secondary A Aquifer) are not considered a receptor as the ground investigation indicates there is not a coherent groundwater body associated with these deposits beneath the site. These deposits are also widely absent beneath the site and have only been recorded at WS09A.

8.3. Foundation Works Risk Assessment and Mitigation Measures

EA documents ‘*Piling into Contaminated Sites*’ and ‘*Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*’ present guidance on the potential contamination risks that different piling techniques can have on groundwater and, additionally, the potential risks posed to human health.

The guidance presents six potential Source-Pathway-Receptor (S-P-R) linkages to be considered as part of a foundation risk assessment.

S-P-R Scenario 1: Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.

S-P-R Scenario 2: Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.

S-P-R Scenario 3: Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.

S-P-R Scenario 4: Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.

S-P-R Scenario 5: The driving of solid contaminants down into an aquifer during pile driving.

S-P-R Scenario 6: Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.

Consideration of each of these areas within the context of the provisional piling methods identified is discussed in Table 8.1. The provisional piling methods include CFA piling or other rotary bored piling technique.

Table 8.1 Review of Piling Options against S-P-R Scenarios

S-P-R Scenarios	CFA Piling or Other Rotary Bored Piling Technique
Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.	The Chester Formation is encountered at shallow depth beneath the site and soils in the thin unsaturated zone (including Made Ground) are typically granular. No cohesive layers which may be punctured by piling have been identified. It is considered that water, and potentially contamination, can freely percolate towards the shallow groundwater table via the unsaturated zone in the absence of piling. Installation of piles will not change this. The method of construction is likely to result in an intimate contact between the concrete of the pile and surrounding soils such that a preferential pathway is unlikely to be present post-construction.
Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.	Discounted given that there is no identified low permeability layer through which the proposed piles would penetrate.
Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.	The soil sample chemical laboratory results from the ground investigation recently undertaken indicate generally low concentrations with respect to construction site health and safety. The risks can be appropriately managed by appropriate construction phase RAMS and construction phase plan CPP using typical methods. The asbestos



S-P-R Scenarios	CFA Piling or Other Rotary Bored Piling Technique				
	identified at TP104 should be considered in the preparation of the RAMS and CPP although it is understood that piling is unlikely to be required in this area.				
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.	Unlikely. Piles should be constructed from concrete with an appropriate Design Sulphate Class and ACEC Class.				
The driving of solid contaminants down into an aquifer during pile driving.	Reduced potential due to non-displacement nature of piling (minimal requirement for driving of soils).				
Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.	Increased potential due to proposed used of cast in-situ concrete for piles, pile caps and foundations.				

As replacement (non-displacement) piling methods, CFA piles and rotary bored piles require the removal of soils to create a void which is then filled with concrete to form the piled foundation. Consequently, there is potentially a greater opportunity for the creation of contaminant pathways to be formed during the excavation process. Any pathways arising through this process should, however, be mitigated (at least in part) by the placement of the concrete to form the pile.

The use of wet cast in-situ concrete results in the placing of material with a positive lateral pressure being exerted on the sides of the pile bore. This prevents voids and pathways being created along the soil / concrete interface, and the irregular pile surface (in comparison to a driven pile) would mitigate against downward migration of contaminants.

In addition, the removal of soils during the process results in the potential for exposure of site workers to any contamination in excavated materials. Excavated soils (i.e. piling arisings) may require off-site disposal in accordance with current waste management legislation, although it may be possible to incorporate these materials into the wider landscaping works across the site via a Materials Management Plan operated under the CL:AIRE initiative ‘*The Definition of Waste: Development Industry Code of Practice*’.

It is noted that shallow soils are predominantly heterogeneous granular Made Ground comprising demolition materials, over Chester Formation bedrock. These materials likely have relatively high permeability, and the installation of CFA or rotary bored piles is considered unlikely to significantly increase in the number of such pathways through the Made Ground. Theoretically, there may be preferential migration of perched water (delayed infiltration) to deeper groundwater, however such incremental risks are likely to be limited due to (almost entire) extent of hardstanding (and associated surface water drainage) that will be present on completion of the proposed development, and that the process of casting the piles will result in an intimate contact between such that a preferential pathway is not present.

A summary of the site-specific risks from CFA and rotary bored piles is provided as Table 8.2.

Table 8.2 Summary of Risks from CFA and Rotary Bored Piles

S-P-R Scenarios	Risk Associated with Pile Design	Magnitude of Risk	Summary of Risk	Does Pile Design Sufficiently Mitigate Risk	Requirement for Alternative Pile Design
Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.	N	NA	No aquitard identified so creation of a preferential pathway not viable.	Y	N

S-P-R Scenarios	Risk Associated with Pile Design	Magnitude of Risk	Summary of Risk	Does Pile Design Sufficiently Mitigate Risk	Requirement for Alternative Pile Design
Creation of preferential pathways through a low permeability surface layer, allowing migration of ground gas, soil gas or contaminant vapours to the surface.	N	NA	No low permeability surface layer identified so creation of a preferential pathway not viable.	Y	N
Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface.	Y	Low to moderate	The soil sample chemical laboratory results indicate typical mitigation measures which can be specified in the RAMS and CPP should be implemented during the construction phase. The asbestos identified at TP104 should be considered in the preparation of the RAMS and CPP although it is understood that piling is unlikely to be required in this area.	Y	N (risk reduced by appropriate mitigation measures)
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials.	Y	Low to moderate	Piles should be constructed from concrete with an appropriate Design Sulphate Class and ACEC Class to mitigate the risk.	Y	N (risk reduced by appropriate mitigation measures)
The driving of solid contaminants down into an aquifer during pile driving.	N	NA	Not viable given the proposed non-displacement piling technique.	Y	N
Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste or grout.	Y	Low	The risk is reduced since groundwater transmission through the Chester Formation will be via intergranular flow. The Chester Formation has been logged as a SANDSTONE without significant gravel bands or fractures / joints which would increase migration potential. The existing river wall further restricts the available pathways.	Y	N

In terms of the proposed piling options, CFA or rotary bored piles are unlikely to present a significant risk with the aforementioned mitigation in place.

During construction, any surplus materials excavated should suitably managed (either off-site disposal or incorporation into a suitable remediation strategy) to mitigate risks to future site users.

It is recommended that QA and QC measures are identified and adopted prior to piling and ground improvement works being undertaken. These are primarily for construction quality and structural performance; however, they are also equally relevant to mitigate environmental risk, for example ensuring that any material imported to site for use as a piling mat is not contaminated and so does not add to the contaminant burden on site. The relevant measures should ensure that the foundation solution techniques are carried out correctly and in an appropriate manner so that the risk assessment and conclusions remains valid.

CL:AIRE Definition of Waste: Development Industry Code of Practice may be used in support of attempts to de-classify excavated materials as ‘waste’ if they can be sustainably re-used. Should materials require, however, off-site disposal, the developer has a statutory responsibility to ensure that contaminated soil and water is disposed of off-site to a suitably licensed waste management facility in a safe and approved manner. If any soil arisings produced by the piling are to be disposed of to landfill then the available site instigation



information from the areas where such arisings are anticipated to be produced should be provided to the landfill in advance of the works to assist in ensuring the appropriate characterisation of waste streams. WAC testing would be required to determine the limit values for waste destined to various classes of landfill.

All wastes taken off site, in solid or liquid form, must be handled by a registered waste carrier and be accompanied by an appropriate waste transfer note or consignment note which describes the waste.



9. Updated Conceptual Site Model and Risk Assessment Summary

Table 9.1 updates the E3P GQRA (see summary in Section 3.5) based on the ground investigation results and supplementary assessments presented herein. No ground conditions were encountered which required an update to the PRA prior to undertaking the quantitative risk assessments. The risk assessment matrix used in preparing Table 9.1 is provided as Appendix D.

Please be aware that Table 9.1 relates to the wider site boundary (see Figure 1.1) including the application boundary. The site boundary extends beyond the application boundary.

Risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase RAMS. The associated construction phase risks from potential contamination are not considered further in this document but should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and CPP. The Principal Contractor should be made aware that asbestos has been identified in Made Ground at TP104.

Table 9.1 Updated Risk Assessment Summary

Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway	Risk Level Classification
On-site	Direct contact with soil	Proposed site end users	Yes	Low to moderate †
	Inhalation of windblown soil		(unacceptable risk is present in areas of proposed soft-landscaping and if new underground services are installed in the vicinity of TP104 where asbestos has been identified in Made Ground)	Low to moderate †
	Ingestion of soil		(Remediation Strategy required)	Low to moderate †
	Impact to water supply pipes followed by ingestion of contaminated water supply		Yes	Low
	Ground gas generation and inhalation		Yes	Low
	Soil vapour generation and inhalation		(unacceptable risk has been identified for the residential development in the north of the site due to dissolved phase VOCs detected in shallow groundwater, although the potential for this to be from an off-site source should be noted)	Low to moderate †
	Inhalation of windblown soil from the site	Off-site human health receptors	Yes	Low
	Off-site migration and direct contact with impacted soil		Yes	Low
	Off-site migration and ingestion of impacted soil		(no open ground is located nearby which is likely to be impacted at shallow depth by contamination sourced from the site)	Low



Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway		Risk Level Classification
	Impact to water supply pipes followed by ingestion of contaminated water supply		Yes (no contamination has been identified in a form which will continue migrating through the unsaturated zone at shallow depth on completion of the proposed development)		Low
	Ground gas generation, off-site migration and inhalation		Yes (no unacceptable risk identified following GQRA)		Low
	Soil vapour generation, off-site migration and inhalation		Yes (the relatively mild vapour impacts to shallow groundwater do not indicate an unacceptable risk to off-site human health)		Low
	Direct contact	On-site buildings and below ground structures (proposed)	Yes (geotechnical assessment falls outside the scope of this report)		Low <i>(assuming an appropriate sulphate design class is suitably implemented)</i>
	Migration followed by ignition of ground gas		Yes (no unacceptable risk identified following GQRA)		Low
	Migration followed by ignition of soil vapour		Yes (the soil vapours identified beneath the site have low flashpoint values)		Low
	Off-site migration followed by direct contact	Off-site buildings and below ground structures	Yes (no gross contamination has been identified with the potential to migrate off-site and damage structures by direct contact)		Very low
	Off-site migration followed by migration followed by ignition of ground gas		Yes (no unacceptable risk identified following GQRA)		Low
	Off-site migration followed by migration followed by ignition of soil vapour		Yes (the soil vapours identified beneath the site have low flashpoint values)		Low
	Leaching and migration to groundwater via the unsaturated zone; Perched water percolation or lateral migration; Migration via advection and diffusion in the saturated zone; Vertical and lateral migration of free-phase product in the unsaturated and saturated zones; and Preferential pathways created by piling.	Controlled waters – Underlying bedrock Principal Aquifer (Chester Formation)	Yes (no unacceptable risk identified following GQRA) (FWRA included herein)		Low
Off-site	On-site migration followed by direct contact or ingestion of soil	Controlled waters – Surface waters (River Irwell)	Yes (no unacceptable risk identified following GQRA) (FWRA included herein)		
		Proposed site end users	Yes (the identified asbestos contamination is due to an on-site source and no other contamination in the unsaturated zone)		Low



Potential Site Contaminant Sources	Potential Pathways	Potential Receptors	Potential for Complete Pathway	Risk Level Classification
			has been identified exceeding the selected human health GACs)	
	Inhalation of windblown soil from off-site		Yes (no notable potential sources of contaminated windblown soil / dust have been identified in the vicinity of the site)	Very low
	On-site migration followed by impact to water supply pipes and ingestion of the water supply		Yes (there are likely no restrictions on the new water supply pipe construction which can be safely installed, although the final specification of water supply pipe to be installed should be agreed with the utility provider)	Low
	Ground gas generation, on-site migration and inhalation		No (the E3P Desk Study identifies no potential off-site sources of ground gas)	Low
	Soil vapour generation, on-site migration and inhalation		Yes (unacceptable risk has been identified for the residential development in the north of the site due to dissolved phase VOCs detected in shallow groundwater) (Remediation Strategy required)	Low to moderate †
	On-site migration followed by direct contact	On-site buildings and below ground structures (proposed)	Yes (no gross contamination has been identified with the potential to damage structures by direct contact)	Very low
	On-site migration followed by ignition of ground gas		No (the E3P Desk Study identifies no potential off-site sources of ground gas)	Low
	On-site migration followed by ignition of soil vapour		Yes (the soil vapours identified beneath the site have low flashpoint values)	Low

† - unacceptable risk (ref. *LCRM*)

In summary, the GQRA presented in this report shows that there may be unacceptable risk to proposed on-site human health in soft-landscaping areas and due to the potential for vapour inhalation at the residential scheme. A suitable Remediation Strategy is required to mitigate the risk. The Remediation Strategy should also include appropriate verification protocols. The proposed Remediation Strategy should be formulated specifically for the application boundary.

New water supply pipe construction should be agreed with the utility provider.

Piling can proceed in accordance with the FWRA included herein.

The risks to maintenance workers during the operational phase of the proposed development can be managed by preparing a site operational Health & Safety File. This Supplementary Geo-environmental Assessment Report should be made available to those preparing the Health & Safety File.



10. Closing Remarks

In summary, the GQRA presented in this report shows that there may be unacceptable risk to proposed on-site human health in soft-landscaping areas and due to the potential for vapour inhalation at the residential scheme. A suitable Remediation Strategy is required to mitigate the risk. Outline recommendations for the remediation include installation of a clean cover layer in soft landscaping areas and installation of soil vapour protection for relevant areas of the residential scheme proposed in the north of the site. Other recommendations include:

- Where soft-landscaping is to be constructed at a raised level (e.g. suspended deck), soils imported to these areas should be verified.
- Oversized clean service corridors should be installed if underground services are to be laid through the identified asbestos impacted soils at TP104.
- Unexpected contamination protocols should be implemented.
- New water supply pipe construction should be agreed with the utility provider.
- Piling can proceed in accordance with the FWRA included herein.

The outline recommendations for remediation are in relation to the site boundary but the proposed Remediation Strategy should be formulated specifically for the application boundary.

Risks to site workers and the environment during the construction phase of the proposed redevelopment can be appropriately managed by successful implementation of construction phase RAMS. The associated construction phase risks from potential contamination should be appropriately considered and mitigated by the Principal Contractor in their preparation and implementation of construction phase RAMS and CPP. The Principal Contractor should be made aware that asbestos has been identified in Made Ground at TP104.

The risks to maintenance workers during the operational phase of the proposed development can be managed by preparing a site operational Health & Safety File. This Supplementary Geo-environmental Assessment Report should be made available to those preparing the Health & Safety File.

Should any changes be made to the proposed development compared to the details presented herein, or should any new information become available, then the assessments included in this Supplementary Geo-environmental Assessment Report must be updated.

The recommendations presented herein can be implemented for the proposed development following acceptance of this report by the Local Planning Authority.



Appendix A: E3P (2021) Phase II Geoenvironmental Site Assessment



Phase II Geoenvironmental Site Assessment
Renaissance, Manchester

Reference: 14-261-R2-1
Date: 21st May 2021



PHASE II GEOENVIRONMENTAL SITE ASSESSMENT

Renaissance
Deansgate
Manchester
M3 2FE

Prepared for:
Property Alliance Group Ltd



Report Ref: 14-261-R2-1
Date Issued: 21st May 2021

Renaissance, Deansgate

Phase II Geoenvironmental Site Assessment
May 2021

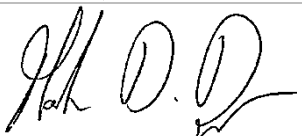
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QUALITY ASSURANCE

PROJECT NUMBER	14-261		
VERSION	Version 1		
REMARKS	Issue 1		
DATE	21 st May 2021		
PREPARED BY	N Sellars		
QUALIFICATIONS	MSci (Hons), FGS		
SIGNATURE			
CHECKED BY	S Ellis		
QUALIFICATIONS	BSc (Hons), FGS, CEnv		
SIGNATURE			
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QUALIFICATIONS	BSc (Hons), FGS, AIEMA, MIEEnvSc, CEnv		
SIGNATURE			



Cert No 18890

ISO 9001 (2015)
ISO 14001 (2015)
ISO 45001 (2018)



EXECUTIVE SUMMARY

Site Address	Land to the west of Deansgate, Manchester, M3 2FE	
Grid Reference	E383745, N398616	
Site Area	0.53 Hectares	
Proposed Development	E3P understands that the proposed development will comprise offices and residential apartments with associated car parking.	
Current Site Use	The subject site currently has several land uses; the Renaissance Hotel, Premier House, Doms Tavola Calda restaurant and an NCP car park. The site comprises a multi-storey building of varying heights with a lower level car park. Externally to the building, there are areas of hardstanding used for walkways and entrance and exit roads for the lower level multi-storey car park. There are retaining walls at the bottom level of the car park.	
Site History	The site has been developed since pre 1848. Historic town plans from 1850-1851 show a Copper Roller Works and a Cotton Finishing Works in the centre of the site and a Wind Turning Mill in the south, with a section of the Water Side Mill in the south west. The historic town plan from 1891 shows an old quarry in the centre of the site. A hotel was recorded in the north of the site pre 1891, with other unspecified buildings recorded across the footprint. From 1908 a building named the Temperance Hotel was in the centre of the site until 1948 until it was named as a ruin which may indicate bomb damage. An access road named Grosvenor Avenue was also present from 1948 along the west of the buildings. From 1973 a larger hotel building and a car park are recorded as present. The site has remained relatively unchanged since 1973.	
Environmental Setting	Drift Geology	Glaciofluvial Sheet Deposits (Devensian) – Sand and Gravel.
	Bedrock Geology	Chester Formation – Sandstone.
	Faults	No faults are mapped on site.
	Hydrogeology	Secondary A aquifer strata (drift geology) overlying a principal aquifer (bedrock geology).
	Hydrology	The River Irwell is located 5 m west of the site and forms the western boundary. The river is classified by the EA to have a river quality of E (poor).
	Flood Risk	The site is located within Flood Risk Zone 1 and is considered unaffected by river flooding.
Previous Reports	The following previous reports have been completed for the site:  E3P – Phase I Geoenvironmental Report (Ref: 14261-R1-1, September 2020). The E3P Phase I Report should be read in conjunction with this report.	
Utility Locations	Overflow sewers (culverts) are present in the south-west corner and adjacent to the north. A low-pressure gas main is located through the centre of the site, in the basement. LV and 6 to 6.6 kV electricity cables and BT connections are also present.	
Landfill Sites and Ground Gases	There are no BGS recorded landfill sites located within 500 m of the site boundary. There were also no historical landfill sites located within 500 m of the site.	



Radon	Unaffected – no special precautions required.
Coal Mining/Land Stability	The site is not situated within a development high risk area. There are no mine entries recorded within 500 m of the site boundary. There are also no past shallow coal mine workings or probable shallow coal mine workings or coal outcrops within 500 m of the site boundary.
Brine Workings	The site is not located within an area deemed to be at risk from ground instability arising from historic brine pumping activities and/or salt extraction
Hazardous Installations	No hazardous installations that could potentially prejudice the proposed construction of highly sensitive residential dwellings have been identified within influencing distance of the subject site.

GROUND INVESTIGATION

Ground Investigation Works	E3P has completed an intrusive ground investigation comprising:  4 x mechanically excavated trial pits  2 x wall cores,  6 x rotary boreholes  Construction of environmental monitoring installations.
Ground Conditions	Made Ground – 0.00 m bgl to 1.50 m bgl Made Ground deposits were encountered within all exploratory hole locations to a maximum proven depth of 1.50 m bgl. Made Ground deposits generally comprise concrete to circa 0.35 m bgl underlain by grey sandy gravel of limestone (Type 1 MOT). In addition, RBH102 identified a brick wall between 0.70 m and 1.50 m bgl. RBH104 identified a brick wall between 0.35 m and 0.80 m bgl. The full depth is not proven due to the limitations of the scope and access. TP101–TP104 identified concrete with a rubber membrane, over brown gravelly fine to medium sand with concrete and brick to 0.70 m bgl. There is the potential for deep Made Ground to be present in the location of the former quarry. DRIFT Drift deposits were not encountered during the ground investigation. There is the potential for drift deposits to be present in areas that have not been investigated to date. SOLID – 0.35 m bgl to >10.00 m bgl The solid bedrock geology was encountered between 0.45 m and 10.00 m bgl. The solid geology comprises dense to very dense SANDSTONE. The bedrock will be weathered and the actual depth can only be profiled after the post demolition ground investigation. Weathered sandstone bedrock was encountered as reddish brown medium SAND between 0.35 m and 1.50 m bgl in RBH101 and between 0.70 m and 0.80 m bgl in TP101, TP103 and TP104. A former quarry is present in the centre of the site, therefore there is the potential for notable changes in the depth of bedrock.



Ground Conditions	GROUNDWATER – Groundwater strikes were not encountered during the ground investigation. Subsequent monitoring recorded groundwater between 1.40 m and 3.68 m bgl.
Foundation Pits	TP101, TP103 and TP104 identified the foundation slab within the SANDSTONE from 700 mm, the full depth was not determined. TP102 identified the foundation slab from 400 mm to 700 m within the Made Ground.
Rotary Core into Retaining Walls	WC101 went through 300 mm of the brick wall and then a service void to 1.30 m bgl and then 200 mm into the concrete retaining wall. The core could not penetrate the water membrane within the concrete retaining wall. WC102 was cored through a service void and then 200 mm into the concrete retaining wall. The core could not penetrate the water membrane within the concrete retaining wall.

CONTAMINATED LAND ASSESSMENT

Human Health	The Tier I assessment identified a single exceedance for asbestos. Loose chrysotile fibres were identified in the granular Made Ground in TP104 at <0.001 %. No visual signs of ACM were encountered during the ground investigation and it is, therefore, likely that only trace fibres are present. Impacted soils should be managed according to the asbestos risk mitigation conceptual site model. The installation of a suitable cover system in all landscaping and public open space will remove any potential for direct exposure to impacted soils. The specific design and installation process for the appropriate cover systems should be defined within a site remediation and enabling works strategy. Chemical analysis of the natural granular deposits has identified these soils to be acceptable for use as subsoil within the proposed landscaped areas; however, further chemical validation samples will be required to confirm this. There are no suitable sources of topsoil available on the site. Further post-demolition investigations are required to confirm the findings of this initial assessment as and when full and unrestricted access is available.
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Controlled Waters	Leachate and groundwater analysis has identified exceedances of the EQS for chromium, copper, mercury, trichloromethane and pH. Historically, the site has been occupied by a Cotton Finishing Works, Copper Roller Works and Mills which are potential sources of mobile contamination. However, the initial soil analysis has not identified a risk to controlled waters. The site is underlain by shallow sandstone bedrock which is classified as a principal aquifer. However, the majority of the identified inorganic compounds are of low solubility. The sensitivity of the principal aquifer in the bedrock is reduced given the closest potable groundwater abstraction is located 507 m north. Trichloromethane has been recorded above the limit of detection in all three groundwater samples from the rotary boreholes which have monitoring wells set within the sandstone bedrock. All other VOCs are less than the limit of detection. It is unlikely that this relates to residual contamination from the former works and mills located on site as these land uses were historical and the compounds would have degraded. It is considered possible that this compound may have migrated from commercial sites further afield. The site is topographically lower than the land to the east, therefore it is likely that groundwater will flow towards the site and towards the River Irwell. The results of the groundwater analysis indicate a higher concentration of trichloromethane at RBH101 in the north east as opposed to RBH105 located in the south west. An additional round of groundwater sampling and surface water analysis is recommended to further assess the risk to controlled waters. The results will be issued in an addendum report.
Ground Gas	Ground gas monitoring thus far has indicated the site would be classed as Characteristic Situation 1, suggesting no gas protection measures will be required. However, the final ground gas regime will be confirmed following the completion of the ground gas monitoring programme.
Potable Water Infrastructure	This will need to be confirmed following the completion of a UKWIR risk assessment. Post-remediation and enabling works ground conditions may be different from those identified during this site investigation. Current indications suggest that PE pipe will be suitable.

GEOTECHNICAL ASSESSMENT

Underground Obstructions	Significant concrete and brick obstructions have been encountered within the Made Ground, indicative of relict foundations from the former buildings. A culvert is located in the south-west corner of the site and significant obstructions will be present beneath the existing buildings. An infilled quarry is also located in the centre of the site. During a phase of cut-and-fill enabling works to create the development platform, all below-ground obstructions will require grubbing out to the base of the Made Ground to enable the construction of proposed plots.
Allowable Bearing Pressure	The natural SAND (weathered bedrock) has been assessed as being very dense with a net allowable bearing pressure (ABP) in the order of 504 kN/m² at circa 1 m bgl. The underlying SANDSTONE has a net ABP of 403-505 kN/m² between 1.00 m and 9.00 m bgl. Due to the highly fractured nature of the bedrock only one Unconfined Compressive Strength (UCS) test could be undertaken from the core recovered.



Allowable Bearing Pressure	The results indicate that at a depth of between 6.63–6.98 m bgl the sandstone recorded a strength of 3.3 (MPa) which equates to 3300 kN/m ² .
Foundation Options	Given the significant obstructions, prior to the construction of any foundation solution, a programme of remediation and enabling works will be required to remove existing foundation and slab structures and re-engineer the site to provide suitable development platform levels. The Made Ground is not considered a suitable target founding stratum. In respect of the proposed development, E3P consider it feasible to construct the proposed residential apartment blocks utilising piled foundations set within the underlying sandstone bedrock. The final foundation solution will be dependent on the structural loadings, elevation and should be designed by a suitably qualified structural engineer with detailed designs from a specialist piling contractor. Post demolition boreholes are required to further inform the foundation and sub-structure design.
Building Floor Slabs	A ground-bearing slab will be viable; however, it will need to be constructed utilising a sub-base with the thickness designed by a structural engineer to ensure that settlement tolerances are taken into consideration.
Heave Precautions	The site is underlain by granular soils, therefore heave precautions are not required.
Soakaway Drainage	The presence of substantial depths of Made Ground across the site may result in settlement. It is therefore recommended that drain runs are designed using steeper gradients and flexible joints to allow for some differential settlement. The presence of deep Made Ground across the site will preclude the use of soakaway drainage. If soakaway drainage is to be considered, full BRE365 testing must be completed to inform the detailed design.
Sulphate Assessment	Concrete classification will be DS1 AC1s.
CBR Design %	Granular soils can be re-engineered to ensure 5% within the subgrade during favourable climatic conditions.
Cut/Fill	Development levels unknown at this time; however, an element of cut-and-fill works will be required to prepare the development platform.
Civil Engineering Excavations	The E3P Intrusive Ground Investigation has identified the presence of weathered/competent bedrock at a shallow depth, the presence of which will impede the excavation materials to form sewerage and drainage infrastructure and foundations. A former quarry is present in the centre of the site, therefore there is the potential for notable changes in the depth of bedrock. Due to the depth and variability of the Made Ground and the likelihood of trench collapse, it is considered that all excavations are supported or battered back in accordance with the guidance contained in CIRIA R97. Furthermore, the site is topographically lower than the adjacent roadways, consideration must be given to retaining being constructed or current wall adapted to ensure the stability of the soils around the periphery of the site.



Waste Characterisation	Any material that is to be disposed off-site should undergo assessment using Technical Guidance WM3: <i>Waste Classification – Guidance on the classification and assessment of waste</i>. Samples of the Made Ground in TP101 at 0.65 m and TP103 at 0.45 m were compared to the Waste Acceptance Criteria. The WAC analysis suggests that the soils would be classified as stable non-reactive.
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RECOMMENDATIONS

Based on the findings of the geoenvironmental site assessment, the following additional works are recommended to be completed in due course:

- ✚ Further investigation of inaccessible areas and extensive post demolition ground investigation.
- ✚ An additional round of groundwater and surface water analysis.
- ✚ Further geotechnical testing to determine the settlement characteristics for ground bearing floor slab (upon completion of the reduced level dig) and pavement design.
- ✚ Foundations to be designed by suitably qualified Structural Engineer.
- ✚ Geotechnical earthworks strategy (infrastructure).
- ✚ Remediation and enabling works strategy.
- ✚ Construction phase Surface Water Management Plan.



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DRAWING LIST

14-261-001 - Site Location Plan
14-261-002 - Proposed Development Plan
14-261-003 - Historical Features Plan
14-261-004 - Site Features Plan
14-261-005 - Exploratory Hole Location Plan
14-261-006 - Depth of Made Ground Plan
14-261-008 - Depth to Founding Strata Plan
14-261-010 - Conceptual Site Model
14-261-012 - Depth to Bedrock Plan
14-261-018 - Contamination Issues Plan-Human Health
14-261-019 - Contamination Issues Plan-Controlled Waters
14-261-023 - Foundation Pit Details
14-261-025 - Wall Core Details



1. INTRODUCTION

1.1. BACKGROUND

E3P has been commissioned by Property Alliance Group to undertake a detailed Phase II Geoenvironmental Site Assessment for a parcel of land at Renaissance, Deansgate, Manchester.

This report is required to determine potential contaminated land liabilities, remediation requirements and geotechnical engineering works that will be required as part of the proposed development for a proposed low-rise residential development.

1.2. PROPOSED DEVELOPMENT

E3P understands that the proposed development will comprise offices and residential apartments with associated car parking.

A snapshot of the proposed development layout is indicated in Figure 1.1.

FIGURE 1.1 SNAPSHOT OF PROPOSED DEVELOPMENT



1.3. OBJECTIVES

The objectives of the geoenvironmental assessment are as follows:

- ✧ Review historical plans, geology, hydrogeology, site sensitivity, floodplain issues, mining records and any local authority information available in order to complete a desk study in line with Environment Agency (EA) document *Land Contamination: Risk Management (LCRM) (2019)*.
- ✧ Undertake a preliminary stage of sampling and analysis to provide an overview of environmental issues identified.
- ✧ Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors.
- ✧ Assess the geotechnical information and provide preliminary recommendations in relation to foundations, pavement construction and floor slabs.
- ✧ Provide recommendations regarding future works required.

1.4. SCOPE OF WORKS

The scope of work includes the following elements:

- ✧ Design of suitable intrusive ground investigation;
- ✧ Rotary boreholes;
- ✧ Mechanically excavated trial pits;
- ✧ Wall cores;
- ✧ In-situ geotechnical testing;
- ✧ Chemical and geotechnical laboratory analysis;
- ✧ Groundwater monitoring and sampling;
- ✧ Ground gas monitoring;
- ✧ Contamination risk assessment and conceptual site model;
- ✧ Geotechnical assessment and interpretation; and
- ✧ Factual and interpretive reporting.

1.5. LIMITATIONS

The limitations of this report are presented in Appendix I.



1.6. CONFIDENTIALITY

E3P has prepared this report solely for the use of the client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from E3P; a charge may be levied against such approval.



2. GROUND INVESTIGATION

2.1. GENERAL OVERVIEW

A ground investigation has been designed based on the findings of the E3P desk study, with exploratory holes advanced to target specific potential contaminant sources. The investigation has also been used to collect geotechnical information to assist in the design and construction of the proposed development.

Exploratory fieldwork was completed between 19th February and 26th February 2021. The works are summarised in Table 2.1.

2.2. LIMITATIONS OF THE INVESTIGATION

Access was limited by the existing buildings on site.

2.3. SCOPE OF INVESTIGATION

TABLE 2.1 SUMMARY OF FIELDWORK

POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (m bgl)	MONITORING WELLS RESPONSE ZONE (m bgl)
General Ground Conditions/ To investigate the existing foundations in the south.	TP101	Mechanically Excavated Trial Pit	0.80	N/A
	TP102		0.70	N/A
	TP103		0.80	N/A
	TP104		0.80	N/A
To investigate the depth and nature of the bedrock and to provide detailed geotechnical information. To permit the installation of deep groundwater monitoring wells.	RBH101	Rotary Borehole	10.00	2.0–10.0
	RBH102		10.00	0.5–1.5
	RBH103		10.00	2.0–10.0
	RBH104		10.00	2.0–10.0
	RBH105		10.00	2.0–10.0
	RBH105		10.00	2.0–10.0
To establish the thickness of the brick wall/concrete retaining wall.	WC101	Wall Core	1.50	N/A
	WC102		0.20	N/A

Mechanically excavated trial pits were advanced to investigate the current footings for the building.

The series of rotary boreholes were advanced to investigate the depth and nature of the underlying bedrock, to complete detailed geotechnical testing and to permit the installation of deep groundwater monitoring wells.

Two concrete cores were completed through the brick wall and concrete retaining wall in the east of the site. The full thickness of the concrete retaining wall could not be determined due to the presence of a rubber membrane. The findings are detailed on Drawing 14-261-025 (Appendix III).



The sampling locations are illustrated in Drawing 14-261-005 (Appendix III). The ground conditions encountered are indicated on the logs, which are provided in Appendix V.

Return visits were made to monitor installations for groundwater level and gas concentrations. In addition, selected wells were purged and samples of groundwater recovered for chemical analysis.

2.4. IN-SITU STANDARD PENETRATION TESTING (SPT)

In-situ geotechnical testing was conducted using the standard penetration test (SPT) and, where the ground is granular, a 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the probehole logs in Appendix V and presented in Table 3.2 and discussed in Section 5.

2.5. LABORATORY ANALYSIS

Selected soil samples were submitted for a range of chemical analysis comprising:

-  Metals.
-  pH, total sulphate, water-soluble sulphate (2:1 extract).
-  Sulphide.
-  Cyanide.
-  Phenols.
-  Total and speciated polycyclic aromatic hydrocarbons (PAHs).
-  Asbestos identification and quantification.
-  Banded total petroleum hydrocarbon (TPH).

I2 Analytical undertook the analytical work and the testing results are included in Appendix VI and discussed in Section 4.

Selected samples were submitted to PSL Laboratory where the following geotechnical tests were undertaken:

-  Dry density/moisture content relationship under 4.5 kg compaction;
-  Point load tests; and
-  Unconfined compressive strength.

Laboratory analysis sheets are included in Appendix VIII and are summarised in Section 9.



3. GROUND AND GROUNDWATER CONDITIONS

3.1. SUMMARY OF GROUND CONDITIONS

The ground investigation generally confirms the published geology and identifies the strata set out in Table 3.1.

TABLE 3.1 SUMMARY OF STRATA

HOLE	DEPTH TO STRATUM (m bgl)			
	MADE GROUND CONCRETE	MADE GROUND	SAND (WEATHERED BEDROCK)	BEDROCK
TP101	0.00–0.35	0.35–0.70	0.70–0.80	–
TP102	0.00–0.35	0.35–0.70	–	–
TP103	0.00–0.35	0.35–0.70	0.70–0.80	–
TP104	0.00–0.35	0.35–0.70	0.70–0.80	–
RBH101	0.00–0.25 0.27–0.35	0.25–0.27	0.35–1.50	1.50–>10.00
RBH102	0.00–0.35	0.35–1.50	–	1.50–>10.00
RBH103	0.00–0.25 0.27–0.33	0.25–0.27 0.33–0.70	–	0.70–>10.00
RBH104	0.00–0.25 0.27–0.35	0.25–0.27 0.35–0.80	–	0.80–>10.00
RBH105	0.00–0.35	0.35–0.45	–	0.45–>10.00
RBH106	0.00–0.26 0.28–1.50	0.26–0.28	–	1.50–>10.00

Note: The bedrock will be weathered and the actual depth can only be profiled after the post demolition ground investigation.

3.2. MADE GROUND

Made Ground deposits were encountered within all exploratory hole locations to a maximum proven depth of 1.50 m bgl.

Made Ground deposits generally comprised concrete to circa 0.35 m bgl underlain by grey sandy gravel of limestone (Type 1 MOT). In addition, RBH102 identified a brick wall between 0.70 m and 1.50 m bgl. RBH104 identified a brick wall between 0.35 m and 0.80 m bgl.

TP101-TP104 identified concrete with a rubber membrane over brown gravelly fine to medium sand with concrete and brick to 0.70 m bgl.

There is the potential for deep Made Ground in the location of the former quarry.

A Depth of Made Ground Plan is presented as Drawing 14-261-006 in Appendix III.



3.3. DRIFT DEPOSITS

Drift deposits were not encountered during the ground investigation. There is the potential for drift deposits to be present in areas that have not been investigated to date.

3.4. SOLID GEOLOGY

The solid bedrock geology was encountered between 0.45 m and 10.00 m bgl. The solid geology comprises dense to very dense SANDSTONE. The bedrock will be weathered and the actual depth can only be profiled after the post demolition ground investigation.

Weathered sandstone bedrock was encountered as reddish brown medium SAND between 0.35 m and 1.50 m bgl in RBH101 and between 0.70 m and 0.80 m bgl in TP101, TP103 and TP104.

A former quarry is present in the centre of the site, therefore there is the potential for notable changes in the depth of bedrock.

3.5. GROUNDWATER

Groundwater strikes were not encountered during the ground investigation. Subsequent monitoring recorded groundwater between 1.40 and 3.68 m bgl.

Monitoring was undertaken using an electronic dip meter and interface probe to record the depth to groundwater and the thickness of any free-phase hydrocarbon product, if present. These results are summarised in Table 4.7.

3.6. VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

Visual and olfactory evidence of potential contamination has not been identified during the site investigation.

3.7. SOIL CONSISTENCY

Results of the standard penetration tests, including undrained shear strengths derived from SPTs are included in Table 3.2.

3.8. SIDE STABILITY AND EASE OF EXCAVATION

The sides of the exploratory trial pit excavations appeared to be stable during excavation.

The presence of brick and concrete cobbles within the Made Ground deposits meant that in certain places, excavation was slow through the Made Ground. The natural sand (weathered bedrock) was excavated with relative ease.

3.9. ROTARY CORE INTO RETAINING WALL FINDINGS

WC101 went through 300 mm of the brick wall and then a service void to 1.30 m bgl and then 200 mm into the concrete retaining wall. The core could not penetrate the water membrane within the concrete retaining wall.

WC102 was cored through a service void and then 200 mm into the concrete retaining wall. The core could not penetrate the water membrane within the concrete retaining wall.



3.10. TRIAL PIT EXCAVATION FINDINGS

TP101, TP103 and TP104 identified the foundation slab within the SANDSTONE from 700 mm, the full depth was not determined.

TP102 identified the foundation slab from 400 mm to 700 m within the Made Ground



TABLE 3.2 STANDARD/CONE PENETRATION TEST RESULTS

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING PRESSURE (kN/m ²)*
RBH101	1.00	SAND	50	50.41	Very Dense	N/A	N/A	N/A	504.07
	2.00	SANDSTONE	46	42.02	Dense	N/A	N/A	N/A	420.23
	3.00	SANDSTONE	50	43.48	Dense	N/A	N/A	N/A	434.83
	4.00	SANDSTONE	50	42.24	Dense	N/A	N/A	N/A	422.43
	5.00	SANDSTONE	50	41.48	Dense	N/A	N/A	N/A	414.81
	6.00	SANDSTONE	50	40.99	Dense	N/A	N/A	N/A	409.94
RBH102	2.00	SANDSTONE	50	45.68	Dense	N/A	N/A	N/A	456.77
	3.00	SANDSTONE	50	43.48	Dense	N/A	N/A	N/A	434.83
	4.00	SANDSTONE	50	42.24	Dense	N/A	N/A	N/A	422.43
	5.00	SANDSTONE	50	41.48	Dense	N/A	N/A	N/A	414.81
	6.00	SANDSTONE	50	40.99	Dense	N/A	N/A	N/A	409.94
	7.00	SANDSTONE	50	40.68	Dense	N/A	N/A	N/A	406.78
	8.00	SANDSTONE	50	40.47	Dense	N/A	N/A	N/A	404.73
RBH103	1.00	SANDSTONE	50	50.41	Very Dense	N/A	N/A	N/A	504.07
	2.00	SANDSTONE	50	45.68	Dense	N/A	N/A	N/A	456.77
	3.00	SANDSTONE	50	43.48	Dense	N/A	N/A	N/A	434.83
	4.00	SANDSTONE	50	42.24	Dense	N/A	N/A	N/A	422.43
RBH104	1.00	SANDSTONE	50	50.41	Very Dense	N/A	N/A	N/A	504.07



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BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING PRESSURE (kN/m ²)*
RBH104	2.00	SANDSTONE	50	45.68	Dense	N/A	N/A	N/A	456.77
	3.00	SANDSTONE	50	43.48	Dense	N/A	N/A	N/A	434.83
	4.00	SANDSTONE	50	42.24	Dense	N/A	N/A	N/A	422.43
	5.00	SANDSTONE	50	41.48	Dense	N/A	N/A	N/A	414.81
	6.00	SANDSTONE	50	40.99	Dense	N/A	N/A	N/A	409.94
	7.00	SANDSTONE	50	40.68	Dense	N/A	N/A	N/A	406.78
RBH105	3.00	SANDSTONE	50	43.48	Dense	N/A	N/A	N/A	434.83
	4.00	SANDSTONE	50	42.24	Dense	N/A	N/A	N/A	422.43
	6.00	SANDSTONE	50	40.99	Dense	N/A	N/A	N/A	409.94
	7.00	SANDSTONE	50	40.68	Dense	N/A	N/A	N/A	406.78
	8.00	SANDSTONE	50	40.47	Dense	N/A	N/A	N/A	404.73
RBH106	1.00	SANDSTONE	50	50.41	Very Dense	N/A	N/A	N/A	504.07
	2.80	SANDSTONE	50	43.82	Dense	N/A	N/A	N/A	438.21
	3.80	SANDSTONE	50	42.44	Dense	N/A	N/A	N/A	424.43
	4.50	SANDSTONE	50	41.82	Dense	N/A	N/A	N/A	418.18
	5.40	SANDSTONE	50	41.26	Dense	N/A	N/A	N/A	412.61
	6.20	SANDSTONE	50	40.92	Dense	N/A	N/A	N/A	409.20
	7.20	SANDSTONE	50	40.63	Dense	N/A	N/A	N/A	406.30



Renaissance, Deansgate

Phase II Geoenvironmental Site Assessment

May 2021

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING PRESSURE (kN/m ²)*
RBH106	8.20	SANDSTONE	50	40.44	Dense	N/A	N/A	N/A	404.42
	9.00	SANDSTONE	50	40.34	Dense	N/A	N/A	N/A	403.42

NOTES

* The Allowable Bearing Pressure (ABP) should be considered indicative.

The interpretation of in situ mass undrained shear strength (cu) data from SPT Blow Count (N) results and the influence of the Plasticity Index (PI) was reported in Standard Penetration Test in Insensitive Clays and Soft Rocks. Stroud (1974). The standard penetration test and the engineering properties of glacial materials subsequently. Stroud and Butler (1975) and (1989).

Allowable bearing pressure on sands. Soil Mechanics in Engineering Practice Terzaghi, K. & Peck, R.B. 1996.



3.11. SOIL DENSITY/MOISTURE CONTENT RELATIONSHIP

Dry density / moisture content relationship analysis has been conducted on soils using via utilising proctor compaction tests utilising a 4.5 kg rammer. The results of the tests have been summarised in Table 3.3. The full test results can be found in Appendix VIII.

TABLE 3.3 SUMMARY DRY DENSITY AND MOISTURE CONTENT

LOCATION	LABORATORY DESCRIPTION	TOP DEPTH (m)	METHOD OF COMPACTION	INITIAL MOISTURE CONTENT (%)	OPTIMUM MOISTURE CONTENT (%)	MATERIAL RETAINED ON 37.5 mm SIEVE (%)	MAX DRY DENSITY (mg/m ³)	MATERIAL RETAINED ON 20.0 mm TEST SIEVE (%)
RBH101	Brown gravelly slightly clayey silty SAND.	0.80	4.5 kg	22	12	0	1.89	0

The proctor compaction tests have indicated that the material in RBH101 is wet of the optimum. It should be noted that if this material is excavated for use in a cut/fill operation careful consideration should be taken in the stabilisation of this material.

Engineering of this type of material will need to be completed during dry weather periods only.

3.12. POINT LOAD TESTS

Point index load tests were performed on samples of sandstone obtained from the rotary boreholes advanced across site to assess the suitability of the sandstone bedrock. The results of which are presented within Appendix VIII and are summarised in Table 3.4.

TABLE 3.4 SUMMARY OF POINT LOAD TEST DATA

LOCATION	DEPTH (m)	TEST TYPE	ORIENTATION	FAILURE LOAD (kN)	UNCORRECTED POINT LOAD STRENGTH INDEX (Is) - MPa	POINT LOAD STRENGTH INDEX (Is50) - MPa
RBH101	2.30	A	Perpendicular	0.21	0.04	0.04
RBH101	6.28	A	Perpendicular	1.01	0.18	0.22
RBH101	7.47	A	Perpendicular	1.43	0.26	0.31
RBH101	8.82	A	Perpendicular	0.99	0.16	0.20
RBH101	6.71	A	Perpendicular	0.81	0.18	0.20
RBH102	7.23	A	Perpendicular	1.59	0.27	0.33
RBH102	1.86	A	Perpendicular	0.97	0.18	0.21
RBH102	8.82	A	Perpendicular	0.77	0.16	0.18
RBH102	9.65	A	Perpendicular	0.69	0.12	0.15



LOCATION	DEPTH (m)	TEST TYPE	ORIENTATION	FAILURE LOAD (kN)	UNCORRECTED POINT LOAD STRENGTH INDEX (Is) - MPa	POINT LOAD STRENGTH INDEX (Is50) - MPa
RBH102	9.30	A	Perpendicular	0.48	0.10	0.11
RBH102	8.64	A	Perpendicular	1.12	0.30	0.33
RBH103	1.50	A	Perpendicular	1.59	0.38	0.43
RBH103	3.40	A	Perpendicular	2.01	0.32	0.40
RBH103	8.60	A	Perpendicular	0.84	0.18	0.21
RBH104	2.43	A	Perpendicular	0.47	0.10	0.11
RBH104	3.36	A	Perpendicular	1.45	0.29	0.34
RBH104	5.60	A	Perpendicular	0.83	0.19	0.21
RBH104	7.26	A	Perpendicular	2.06	0.40	0.47
RBH105	1.10	A	Perpendicular	0.63	0.13	0.15
RBH105	5.00	A	Perpendicular	1.46	0.34	0.38
RBH105	6.80	A	Perpendicular	1.12	0.20	0.24
RBH105	9.73	A	Perpendicular	1.45	0.25	0.31
RBH106	3.10	A	Perpendicular	2.62	0.39	0.48
RBH106	3.37	A	Perpendicular	0.60	0.18	0.19
RBH106	5.40	A	Perpendicular	0.99	0.22	0.25
RBH106	7.20	A	Perpendicular	1.23	0.29	0.33
RBH106	9.80	A	Perpendicular	0.93	0.18	0.21
RBH101	2.30	D	Parallel	0.33	0.043	0.05
RBH101	6.28	D	Parallel	0.72	0.093	0.12
RBH101	7.47	D	Parallel	1.09	0.141	0.18
RBH101	8.82	D	Parallel	0.69	0.089	0.11
RBH101	6.71	D	Parallel	0.68	0.086	0.11
RBH102	7.23	D	Parallel	0.73	0.094	0.12
RBH102	1.86	D	Parallel	0.85	0.118	0.15
RBH102	8.82	D	Parallel	0.54	0.070	0.09



LOCATION	DEPTH (m)	TEST TYPE	ORIENTATION	FAILURE LOAD (kN)	UNCORRECTED POINT LOAD STRENGTH INDEX (Is) - MPa	POINT LOAD STRENGTH INDEX (Is50) - MPa
RBH102	9.65	D	Parallel	0.45	0.057	0.07
RBH102	9.30	D	Parallel	0.48	0.065	0.08
RBH102	8.64	D	Parallel	1.28	0.162	0.21
RBH103	1.50	D	Parallel	1.06	0.134	0.17
RBH103	3.40	D	Parallel	1.11	0.140	0.18
RBH103	8.60	D	Parallel	1.10	0.139	0.18
RBH104	2.43	D	Parallel	0.41	0.057	0.07
RBH104	3.36	D	Parallel	1.01	0.130	0.17
RBH104	5.60	D	Parallel	0.76	0.100	0.13
RBH104	7.26	D	Parallel	1.44	0.190	0.24
RBH105	1.10	D	Parallel	0.43	0.056	0.07
RBH105	5.00	D	Parallel	0.33	0.048	0.06
RBH105	6.80	D	Parallel	0.61	0.077	0.10
RBH105	9.73	D	Parallel	1.51	0.204	0.26

The results of the point load tests indicate that at a depth of between 1.10–9.73 m bgl the sandstone bedrock recorded a strength of between 0.05 and 0.48 (MPa) which equates to 50–480 kN/m².

3.13. UNCONFINED COMPRESSIVE STRENGTH

An unconfined compressive strength test was performed on a sample of sandstone obtained from RBH103. The results of which are presented within Appendix VIII and are summarised in Table 3.5.

TABLE 3.5 SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH

LOCATION	DEPTH (m)	INITIAL MASS (g)	Bulk Density (Mg/m)	Moisture Content (%)	Dry Density (Mg/m)	Load Failure (kN)	UCS (MPa)	Failure Mode
RBH103	6.63-6.98	1840	2.19	15	1.91	20.1	3.3	Brittle

The results indicate that at a depth of between 6.63-6.98 m bgl the sandstone recorded a strength of 3.3 (MPa) which equates to 3300 kN/m².



3.14. pH AND SULPHATE

Chemical analyses for pH and soluble sulphate content contained in Appendix VI (summarised in Table 3.6), shows that the soils at the site meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE *Special Digest 1* (2005).

TABLE 3.6 SUMMARY OF pH AND SULPHATE DATA

LOCATION	DEPTH (m)	SO ₄ IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
TP101	0.40	0.031	11.5	DS-1, AC-1s
TP102	0.40	0.0047	12.3	
TP103	0.45	0.077	11.2	
TP104	0.45	0.027	11.3	
RBH101	0.80	0.014	9.2	
RBH102	0.60	0.015	12.4	
RBH103	0.80	0.083	9.2	
RBH103	0.40	0.011	12.3	
RBH104	0.30	0.42	7.8	
RBH104	0.90	0.0095	9.1	
RBH105	0.30	0.02	11.5	
RBH105	0.50	0.014	9.5	
RBH106	0.35	0.017	11.7	



4. TIER I QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

E3P has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

4.1. HUMAN HEALTH RISK ASSESSMENT

At Tier 1 stage, the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published in LQM/CIEH S4UL (S4UL3267).

The results of this comparison have been summarised within Table 4.1.



TABLE 4.1 SUMMARY OF INORGANIC AND HYDROCARBON TOXICITY ASSESSMENT FOR A RESIDENTIAL END USE WITHOUT PLANT UPTAKE

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PAT H-WAY	ASSESSMENT
Arsenic	mg/kg	40	13	3.9	-	1	No Further Action
Cadmium	mg/kg	85	13	0.6	-	1	No Further Action
Chromium (VI)	mg/kg	6	13	<4.0	-	1	No Further Action
Lead	mg/kg	200	13	16	-	1	No Further Action
Mercury	mg/kg	1.2	13	<0.3	-	3	No Further Action
Nickel	mg/kg	180	13	11	-	1	No Further Action
Selenium	mg/kg	430	13	<1.0	-	1	No Further Action
Copper	mg/kg	7100	13	30	-	1	No Further Action
Zinc	mg/kg	40000	13	65	-	1	No Further Action
Cyanide – Total	mg/kg	791	13	<1.0	-	1	No Further Action
Phenols – Total	mg/kg	210	13	<1.0	-	1	No Further Action
Asbestos	Fibres	NFD	13	<0.001 %	TP104 0.45 m	3	Further Action
Naphthalene	mg/kg	2.3	13	<0.05	-	4	No Further Action
Acenaphthylene	mg/kg	2900	13	<0.05	-	2	No Further Action
Acenaphthene	mg/kg	3000	13	<0.05	-	1	No Further Action
Fluorene	mg/kg	2800	13	<0.05	-	1	No Further Action
Phenanthrene	mg/kg	1300	13	0.4	-	2	No Further Action
Anthracene	mg/kg	31000	13	<0.05	-	2	No Further Action
Fluoranthene	mg/kg	1500	13	0.44	-	2	No Further Action
Pyrene	mg/kg	3700	13	0.42	-	2	No Further Action
Benzo(a)Anthracene	mg/kg	11	13	0.33	-	2	No Further Action
Chrysene	mg/kg	30	13	0.23	-	2	No Further Action
Benzo(b)Fluoranthene	mg/kg	3.9	13	<0.05	-	2	No Further Action
Benzo(k)Fluoranthene	mg/kg	110	13	<0.05	-	2	No Further Action
Benzo(a)Pyrene	mg/kg	3.2	13	<0.05	-	2	No Further Action
Indeno(123-cd)Pyrene	mg/kg	45	13	<0.05	-	2	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.31	13	<0.05	-	2	No Further Action
Benzo(ghi)Perylene	mg/kg	360	13	<0.05	-	2	No Further Action
TPH C5-C6 (aliphatic)*	mg/kg	42	13	<1.0	-	4	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	13	<0.1	-	4	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	13	<0.1	-	4	No Further Action
TPH C10-C12 (aromatic)*	mg/kg	250	13	<2.0	-	4	No Further Action
TPH C12-C16 (aromatic)*	mg/kg	1800	13	<4.0	-	4	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	1900	13	16	-	1	No Further Action



DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PAT H-WAY	ASSESSMENT
TPH C21-C35 (aromatic)*	mg/kg	1900	13	51	-	1	No Further Action

Notes

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants

Abbreviations: GAC = general assessment criteria, n = number of samples, MC = maximum concentration; Loc of Ex = location of exceedance; NFD = no fibres detected.

* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. E3P has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C5-C12) and the Tier 1 values for aromatic compound for the non-volatile fractions (C12-C35). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

Referring to Table 4.1, the results of this direct comparison indicates that the data exceeds the screening criteria for a residential end use for the following contaminant:

 Chrysotile.

Asbestos in the form of loose chrysotile fibres has been identified in the granular Made Ground in TP104 at <0.001 %.

In relation to this exceedance, the following can be determined:

 The main exposure pathway is:

- Fibre/dust inhalation.

 The exceedance for asbestos is associated with shallow Made Ground deposits in TP104.

Samples of the Made Ground in TP101 at 0.65 m and TP103 at 0.45 m were compared to the Waste Acceptance Criteria. The WAC analysis suggests that the soils would be classified as stable non-reactive. A WM3 waste assessment is still required to confirm the waste classification but based on an initial review of the available data, any soil arisings are likely to be inert.

HUMAN HEALTH RISK ASSESSMENT AND MITIGATION

No visual signs of ACM were encountered during the ground investigation; it is therefore likely that only trace fibres are present. Impacted soils should be managed according to the asbestos risk mitigation conceptual site model shown in Figure 4.1.

The installation of a suitable cover system in all landscaping and public open space will remove any potential for direct exposure to impacted soils.

The specific design and installation process for the appropriate cover systems should be defined within a site remediation and enabling works strategy.



FIGURE 4.1 ASBESTOS RISK MITIGATION CONCEPTUAL SITE MODEL



Notes

ND None Detect

0.001% Soils may contain $\leq 0.001\%$ asbestos using composite testing to ensure there is no potential risk to human health. This value is present within areas where there may be a short term low level exposure of soils containing trace asbestos fibres by construction workers where an appropriate level of asbestos management is employed (dust suppression)

0.1% Soils at a depth of $>1.00\text{m}$ bgl may contain $<0.1\%$ asbestos using composite testing where they will not be likely to be disturbed in the future and will therefore be in an area of low sensitivity. Risk assessment completed in accordance with Asbestos JIWG risk assessment tools.

Undefined- this will be dependent upon soils encountered during earthworks, which may be placed at these depths to ensure no potential risk to human health.

Chemical analysis of the natural granular deposits has identified these soils to be acceptable for use as subsoil within the proposed landscaped areas; however, further chemical validation samples will be required to confirm this. There are no suitable sources of topsoil available on the site.

Further post demolition ground investigation will be required to confirm the absence of any significant contamination.



4.2. CONTROLLED WATERS RISK ASSESSMENT

E3P has undertaken a controlled waters risk assessment for the site based on the consideration of the conceptual site model and the sensitive receptors which are summarised in Table 4.2.

TABLE 4.2 CONTROLLED WATERS CONCEPTUAL MODEL AND SENSITIVITY PROFILE

DISCUSSION		SENSITIVITY RATING
Contaminant Source		
Made Ground Made Ground infill material from historical construction and demolition activities is present. No significant contamination has been identified, with the exception of asbestos in TP104.		Low
Historic Copper Roller Works, Cotton Finishing Works, Mills It is unlikely that the former works and mills are a potential source as the land uses were historical.		Low
Pathway		
Vertical Migration Due to the majority of the site being underlain by shallow sandstone bedrock, vertical migration of contaminants is likely to occur as there are no drift deposits overlying the bedrock.		High
Lateral migration Lateral migration of contaminants is considered possible due to the presence of shallow bedrock across the site.		High
Receptor		
Aquifer Classification in Superficial Drift Deposits	Secondary A aquifer (drift deposits appear to be absent).	Low
Aquifer Classification in Bedrock	Principal aquifer.	High
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is not affected.	Low
Distance to the Closest Groundwater Abstraction Point	There is a groundwater abstraction point located 65 m north west of the site licensed to British Telecoms Plc for "Other industrial/commercial/public services: general cooling (existing licenses only) (High Loss)". The closest potable abstraction is 507 m north.	Medium
Is the Site Located Within 50 m of a Surface Watercourse?	The River Irwell is located 5 m west of the site and forms the western boundary. A culvert is present in the south west corner of the site.	High
The ICSM developed within the context of the site setting has identified viable pollutant pathways, which would be the downward migration of potentially mobile phase-soluble contaminants towards the underlying principal aquifer and the lateral migration towards the River Irwell.		



To ensure a robust appraisal of the identified risk to controlled waters, E3P has identified the sources of potential contamination that represent a risk to controlled waters from the initial CSM, we have then assessed the availability of ground investigation data in the form of analysis of the solid phase (soil) and dissolved phase within the perched groundwater or aquifer. The results of this assessment are presented in Table 4.3.

TABLE 4.3 QUALITATIVE RISK TO CONTROLLED WATERS FROM SOIL ANALYTICAL RESULTS

CONTAMINANT	ASSESSMENT RATING	DISCUSSION
BTEX > 1 mg/kg	The soil data analysis has not identified any TPH C5 to C6 that might otherwise be indicative of VOC impact.	None
Total VOC > 1 mg/kg		
Total SVOC > 1 mg/kg	As above.	None
C5-C10 > 5 mg/kg	All concentrations are below the laboratory LOD.	None
C10-C12 > 10 mg/kg	All concentrations are below the laboratory LOD.	None
C12-C16 > 50 mg/kg	All concentrations are below the laboratory LOD.	None
Phenols > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Naphthalene > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Total PAH > 10 mg/kg	Total concentrations of low-solubility PAH compounds greater than 10 mg/kg have not been detected.	None
PCB > 1 mg/kg	No potential sources of PCB have been identified.	None
Heavy metals > 500 mg/kg	Concentrations of heavy metals above 500 mg/kg have not been recorded.	None

The Tier I assessment has included a comparison of leachate analysis from a sample of the Made Ground and groundwater to drinking water standards and environmental quality standards (EQS).

These are presented in Table 4.4.



TABLE 4.4 COMPARISON OF GROUNDWATER AND LEACHATE ANALYSIS WITH TIER 1 SCREENING LEVELS

DETERMINAND	UNIT	EQS ^{1,2,3}	DWS ^{3,4,5}	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA								
Arsenic	µg/l	50	10	3	2.93	-	1	<1.0		No Further Action
Cadmium	µg/l	0.08-0.25	5	3	0.03	-	1	<0.08		No Further Action
Chromium (VI)	µg/l	3.4	-	3	-	-	1	11	TP101 0.4 m	Further Action
Chromium (III)	µg/l	4.7	50	3	3.8	-	1	12	TP101 0.4 m	Further Action
Copper	µg/l	1	2000	3	8.4 3.1 2.9	RBH104 RBH101 RBH105	1	14	TP101 0.4 m	Further Action
Total Cyanide	µg/l	1	50	3	<1.0	-	1	<1.0	-	No Further Action
Lead	µg/l	1.2	10	3	0.2	-	1	1.2	-	No Further Action
Mercury	µg/l	-	1.0	3	1.22	RBH104	1	<0.5	-	Further Action
Nickel	µg/l	4	20	3	2.1	-	1	2.5	-	No Further Action
Selenium	µg/l	-	10	3	2.8	-	1	<4.0	-	No Further Action
Zinc	µg/l	10.9	-	3	7.8	-	1	9.5	-	No Further Action
pH		6-9		3	10.0 10.2	RBH105 RBH104	1	12	TP101 0.4 m	Further Action
Naphthalene	µg/l	2	10*	3	<0.01	-	1	<0.01	-	No Further Action
Anthracene	µg/l	0.1	10*	3	<0.01	-	1	<0.01	-	No Further Action
Benzo[b]fluoranthene	µg/l	0.00017*	10*	3	<0.01	-	1	<0.01	-	No Further Action
Benzo[k]fluoranthene	µg/l	0.00017*	10*	3	<0.01	-	1	<0.01	-	No Further Action
Benzo(a)pyrene	µg/l	0.00017*	10*	3	<0.01	-	1	<0.01	-	No Further Action
Indeno(123-cd)pyrene	µg/l	0.00017*	10*	3	<0.01	-	1	<0.01	-	No Further Action



DETERMINAND	UNIT	EQS ^{1,2,3}	DWS _{3,4,5}	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA								
Fluoranthene	µg/l	0.0063	10*	3	<0.01	-	1	<0.01	-	No Further Action
Benzo(ghi)perylene	µg/l	1.7–4	10*	3	<0.01	-	1	<0.01	-	
TPH C5-C6 (benzene)	µg/l	10	1	3	<1.0	-	1	<1.0	-	
TPH C6-C8 (toluene)	µg/l	74	700	3	<1.0	-	1	<1.0	-	
TPH C8-C10 (ethyl benzene)	µg/l	20	300	3	<1.0	-	1	<1.0	-	
TPH C10-C12 (xylene)	µg/l	30	500	3	<10	-	1	<10	-	
TPH C10-C12 (xylene)	µg/l	30	500	3	<10	-	1	<10	-	
TPH C12-C16	µg/l	2	90 ⁵	3	<10	-	1	<10	-	
TPH C16-C35	µg/l	50#	90 ⁵	3	<10	-	1	<10	-	
TPH C5-C6	µg/l	–	15000	3	<1.0	-	1	<1.0	-	
TPH C6-C8	µg/l	–	15000	3	<1.0	-	1	<1.0	-	
TPH C8-C10	µg/l	–	300	3	<1.0	-	1	<1.0	-	
TPH C10-C12	µg/l	–	300	3	<10	-	1	<10	-	
TPH C12-C16	µg/l	–	300	3	<10	-	1	<10	-	
TPH C16-C21	µg/l	–	300**	3	<10	-	1	<10	-	
TPH C21-C35	µg/l	–	300**	3	<10	-	1	<10	-	
Tetrachloroethylene	µg/l	0.4	10	3	<1.0	-	0	-	-	
Trichloroethylene	µg/l	10	10	3	<1.0	-	0	-	-	
Trichlorobenzene	µg/l	0.4	–	3	<1.0	-	0	-	-	



DETERMINAND	UNIT	EQS 1,2,3	DWS 3,4,5	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA								
Trichloromethane	µg/l	2.5	–	3	18.8 8.6 7.9	RBH101 RBH104 RBH105	0	-	-	No Further Action
Dichloromethane	µg/l	20	200	3	<1.0	-	0	-	-	
Carbon Tetrachloride	µg/l	12	3	3	<1.0	-	0	-	-	
Vinyl Chloride	µg/l	–	0.3	3	<1.0	-	0	-	-	

Notes

Solubility <0.01µg/l

AA – Annual Average

MAC- Maximum Admissible Concentration

* Polyaromatic hydrocarbons (PAH) - Benzo(a)pyrene (BaP), Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)-perylene and Indeno(1,2,3-cd)-pyrene. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water

** There are no WHO Guideline Values for aliphatic fractions C16-C21 and C21-C35, therefore the guideline value for aliphatic fractions inclusive of C8-C16 (300µg/l) has been applied.

1. The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations (2015)
2. Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)
3. Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances
4. Council Directive on the quality of water intended for human consumption (Drinking Water Directive)
5. WHO Guidelines for Drinking Water Quality. Third edition (2004)



4.2.1. CONTROLLED WATER RISK ASSESSMENT AND MITIGATION

This comparison indicates that the data exceeds the EQS values for the following inorganic compounds:

-  Chromium (VI)
-  Chromium (III)
-  Copper
-  Mercury
-  pH
-  Trichloromethane

Where leachate analysis has been undertaken, this can overstate the risk and is not wholly representative of the site characterisation.

4.2.2. M-BAT ASSESSMENT

Due to exceedances in both soil and leachate samples for copper, an m-BAT assessment has been completed to assess the bioavailability of the metals with respect to surface water receptors (River Irwell, Culvert). The chemical values from the groundwater analysis have been input into the assessment.

Where the Risk Characterisation Ratio (RCR) is greater than 1, this indicates the bioavailable concentration is above the EQS and the receptor is therefore at risk. In this instance, groundwater chemical data for DOC was input into the m-BAT for the onsite locations. The following exceed the RCR:

1. RBH105
 - Copper (1.76)

The m-BAT assessment has confirmed that the RCR is marginally above 1 in the groundwater sample from RBH105. The RCR was below 1 in the other groundwater samples.

In light of the above assessment, E3P do not consider the site to pose an unacceptable level of risk to surface waters for copper.

However, further analysis of the surface water in the River Irwell should be undertaken as groundworks progress, to ensure no future mobilisation of contaminants is caused, which may pose a risk to the watercourse.

4.2.3. DISCUSSION OF CONTROLLED WATERS RISK ASSESSMENT

Historically, the site has been occupied by a Cotton Finishing Works, Copper Roller Works and Mills which are potential sources of mobile contamination. However, the initial soil analysis has not identified a risk to controlled waters.

The site is underlain by shallow sandstone bedrock which is classified as a principal aquifer. However, the majority of the identified inorganic compounds are of low solubility. The sensitivity of the principal aquifer in the bedrock is reduced given the closest potable groundwater abstraction is located 507 m north.



Trichloromethane has been recorded above the limit of detection in all three groundwater samples from the rotary boreholes which have monitoring wells set within the sandstone bedrock. All other VOCs are less than the limit of detection. It is unlikely that this relates to residual contamination from the former works and mills located on site as these land uses were historical and the compounds would have degraded.. It is considered possible that this compound may have migrated from commercial sites further afield. The site is topographically lower than the land to the east, therefore it is likely that groundwater will flow towards the site and towards the River Irwell. The results of the groundwater analysis indicate a higher concentration of trichloromethane at RBH101 in the north east as opposed to RBH105 located in the south west.

The site is encapsulated in hardstanding, therefore infiltration will be limited.

Based on the above, there is considered to be a low risk to controlled waters.

An additional round of groundwater sampling and surface water analysis is recommended to further assess the risk to controlled waters. The results will be issued in an addendum report.

4.3. GROUND GAS

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in CIRIA Report 665 – *Assessing risks posed by hazardous ground gases to buildings* (2007). However, it is recommended that the full ground gas assessment and recommended protection measures are agreed with the local authority prior to their adoption on site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

4.1. INVESTIGATION RATIONALE

The ICSM has identified that the underlying Made Ground, infilled quarry and former works and mills may represent a potential source of ground gas generation. Based on the identification of these sources, E3P has determined that the site represents a low ground gas source generation potential.

Within the context of the proposed residential end use and ground gas generation potential, the gas assessment requires that six visits are required over three months, with at least two sets of readings at low or falling atmospheric pressure as set out within CIRIA 665 Tables 5.5a and 5.5b.

The spacing requirements for monitoring wells are detailed within CIRIA 665 Table 4.2, which indicates that for low gas hazard sites (Made Ground with limited degradable material, organic clay of limited thickness) and a high sensitivity development, nominal well spacing should be between 25 m and 50 m.

Table 4.5 Ground Gas Monitoring Location Rationale

LOCATION	GROUND GAS SOURCE	DEPTH OF MONITORING WELL (m)
RBH101	Bedrock	2.0–10.0
RBH102	Made Ground	0.5–1.5
RBH103	Bedrock	2.0–10.0
RBH104	Bedrock	2.0–10.0
RBH105	Bedrock	2.0–10.0
RBH106	Bedrock	2.0–10.0



4.2. MONITORING METHODOLOGY

Concentrations of methane (CH₄), carbon dioxide (CO₂) and oxygen (O₂) were measured using a calibrated infra-red gas analyser (GFM435) with gas flow rates were measured using an integrated flow meter.

Gas measurements were recorded for a minimum of 60 seconds at each location, at which point the maximum concentration of CH₄ and CO₂, together with the lowest concentration of O₂ were recorded. The results of the ground gas monitoring are presented in Table 4.7.

CIRIA C665 provides assessments for carbon dioxide and methane based upon gas screening values (GSVs) utilising flow rates and concentrations. The site-based GSVs for steady state methane and carbon dioxide are based upon the following equation:

$$GSV = \frac{\text{concentration (by vol)}}{100} \times \text{flowrate (1 / hr)}$$

The GSVs within CIRIA C665 are based upon all buildings other than standard residential houses. The thresholds for GSVs based upon CIRIA guidance are provided within Table 4.6.

TABLE 4.6 RESIDENTIAL THRESHOLDS FOR GAS SCREENING VALUES (GSV) IN ACCORDANCE WITH CIRIA C665– COMMERCIAL END USE

CIRIA – NO SUBFLOOR VOID	
CLASSIFICATION	GSV (METHANE AND CARBON DIOXIDE)
CS1	< 0.07
CS2	< 0.70
CS3	< 3.5
CS4	< 15
CS5	< 70
CS6	> 70

4.2.1. SUMMARY OF MONITORING RESULTS

Table 4.7 presents of the ground gas and groundwater monitoring results to date.



TABLE 4.7 SUMMARY OF GROUND GAS MONITORING RESULTS

WELL	DATE	CH ₄ INITIAL (%V/V)	CH ₄ STEADY (%V/V)	CH ₄ GSV (l/hr)	CO ₂ INITIAL (%V/V)	CO ₂ STEADY (%V/V)	CO ₂ GSV (l/hr)	O ₂ (%V/V)	ATMOS (mb)	ATMOS. DYNAMIC	FLOW (l/hr)	RESPONSE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
RBH101	09/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	20.5	1013	Falling	0.1	2.0–10.0	6.70	2.20
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	1017	Falling	0.1		6.40	2.85
RBH102	09/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	19.3	1013	Falling	0.1	0.5–1.5	1.40	1.40
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	20.3	1017	Falling	0.1		1.40	1.40
RBH103	09/03/21	-0.1	-0.1	-0.0031	-0.1	-0.1	-0.0031	19.8	1013	Falling	3.1	2.0–10.0	7.45	3.20
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	19.9	1017	Falling	0.1		7.45	3.68
RBH104	09/03/21	-0.2	-0.2	-0.0044	-0.1	-0.1	-0.0022	16.8	1013	Falling	2.2	2.0–10.0	5.62	2.00
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	19.5	1017	Falling	0.1		5.62	2.15
RBH105	09/03/21	-0.1	-0.1	-0.0001	-0.1	-0.1	-0.0001	20.3	1013	Falling	0.1	2.0–10.0	5.40	1.75
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	20.1	1017	Falling	0.1		5.40	1.80
RBH106	09/03/21	-0.1	-0.1	-0.0001	-0.1	-0.1	-0.0001	19.6	1010	Falling	0.1	2.0–10.0	4.90	1.75
	23/03/21	0.1	0.1	0.0001	0.1	0.1	0.0001	20.6	1017	Falling	0.1		4.90	1.81



4.2.2. SOURCES OF GROUND GAS

The Phase I report and subsequent ground investigation has identified the following potential sources of ground gas:

- ✳ Made Ground deposits.
- ✳ Infilled quarry.
- ✳ Former works and mills.

4.2.3. GROUNDWATER

Monitoring wells RBH105 and RBH106 were flooded during the first two monitoring visits and cannot therefore be included within the gas assessment. RBH104 was also flooded on the first monitoring visit.

Groundwater levels were observed between 1.40 m and 3.68 m bgl.

4.2.4. GAS FLOW

During the monitoring a positive flow was noted in all boreholes. The measure of positive flow is considered to be the result of groundwater fluctuations and flooding of the well causing compression – as opposed to gas generation – as the highest flows are recorded during periods of high groundwater levels.

4.2.5. GAS CONCENTRATIONS

No elevated concentrations of methane or carbon dioxide were recorded during the initial monitoring visits.

4.2.6. GAS ASSESSMENT

In accordance with the methodology outlined with the CIRIA publication C665, E3P have utilised the results of the ground gas monitoring surveys to calculate a tentative gas screening value (GSV). The GSVs for the monitoring positions are summarised in Table 4.8.

TABLE 4.8 GAS RISK PROFILE AND LOCATION

LOCATION	MAX CH ₄ (% v/v)	GSV (l/hr)	MAX CO ₂ (% v/v)	GSV (l/hr)	CLASSIFICATION
RBH101	0.1	0.0001	0.1	0.0001	CS1
RBH102	0.1	0.0001	0.1	0.0001	CS1
RBH103	0.1	-0.0031	0.1	0.0001	CS1
RBH104	0.2	-0.0044	0.1	-0.0022	CS1
RBH105	0.1	0.0001	0.1	0.0001	CS1
RBH106	0.1	0.0001	0.1	0.0001	CS1

The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.



Preliminary ground gas monitoring suggests that the site can be classified as CS1, and it is considered that gas protection measures will not be required. This will be confirmed on completion of the monitoring.

4.3. POTABLE WATER SUPPLY

This section provides a summary of the site investigation data with reference to the selection of potable water supply pipework. The assessment is made with reference to the UK Water Industry Research (UKWIR) publication "Guidance on the selection of Water Supply Pipes to be used in Brownfield Sites"

TABLE 4.9 PIPELINE SELECTION PE THRESHOLD CONCENTRATIONS

Contaminant Group	PE-threshold (mg/kg)	Concentrations at <u>Current</u> pipeline depth (mg/kg)
Total VOC	0.5	<1.0
Total BTEX And MTBE	0.1	N/A
Total SVOCs (Excluding PAH and those substances marked with an *)	2	N/A
EC5-EC10 Aliphatic and Aromatic Hydrocarbons	2	<1.0
EC10-EC16- Aliphatic and Aromatic Hydrocarbons	10	<4.0
EC16-EC40 Aliphatic and Aromatic Hydrocarbons	500	67
Phenols (From SVOC Analysis)*	2	N/A
Cresols and Chlorinated Phenols (From SVOC Analysis)	2	NA
Ethers*	0.5	NA
Nitrobenzene*	0.5	NA
Ketones*	0.5	NA
Aldehydes*	0.5	NA
Amines	Fail	NA
Other Consideration		
Are there any exceedances of the PE threshold outside of the pipeline depth?	No	
Is free product present in soil and groundwater?	None	
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	No hydrocarbon impact has been identified.	
Will soils impacted with above determinands likely be utilised elsewhere on site?	No	
Will soils be imported to site as part of any future earth works	Currently unknown. The importation of materials may affect the WIR Risk Assessment which should be updated after completion.	

Notes - Pipe line depth normally between 0.75m–1.35m

Based on the assessment of current site conditions it is likely that PE pipe will be suitable for the proposed development.



4.4. CONCEPTUAL SITE MODEL

Following the completion of the intrusive site investigation, chemical analysis and risk assessment, the conceptual model shown in Table 4.10 has been prepared for the site.

TABLE 4.10 CONCEPTUAL MODEL

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL1 PL2	Heavy Metals, non-volatile PAH (Made Ground, Former Works and Mills, Infilled Quarry)	Dermal contact. Dermal contact and ingestion.	Future site users. Off-site receptors.	Low Likelihood	Low	LOW
Assessment: No exceedances have been identified in the chemical testing completed.						
Recommendation: Due to the presence of Made Ground, construction works should be completed with PPE and provision of welfare. A clean cover system should be installed in areas of soft landscaping to prevent direct exposure to the underlying Made Ground.						
PL3	ACM in Made Ground	Inhalation of dust.	Future site users. Buildings. Off-site land users.	Likely	High	LOW
Assessment: Asbestos in the form of loose chrysotile fibres has been identified in the granular Made Ground in TP104 at <0.001 %.						
Recommendation: Asbestos impacted soils should be managed in accordance with the asbestos CSM, A cover system to landscaped areas will prevent exposure to future site users. Construction works completed with PPE and provision of welfare.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL4	Volatile contaminants such as hydrocarbons, (Made Ground, Former Works and Mills)	Inhalation of vapours. Migration through permeable strata and preferential pathways.	Future site users. Off-site receptors.	Low Likelihood	Low	LOW
Assessment: No exceedances have been identified in the chemical testing completed.						
Recommendation: Due to the presence of Made Ground, construction works should be completed with PPE and provision of welfare. If any unidentified contamination is uncovered during remediation and enabling works, the soils may require localised excavation and validation.						
PL4	Methane, carbon dioxide (Made Ground, Infilled Quarry, Former Works and Mills)	Inhalation of gas. Migration through permeable strata and preferential pathways. Explosion in confined spaces.	Future site users. Buildings. Off-site land users.	Low likelihood	Low	LOW
Assessment: Monitoring completed to date suggests CS1.						
Recommendation: Completion of ground gas monitoring.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL5	Mobile contaminants such as metals, PAHs, hydrocarbons, volatile compounds (Made Ground, Infilled Quarry, Former Works and Mills)	Surface runoff. Migration through permeable strata and preferential pathways. Perched waters migration.	Groundwater (Principal aquifer in bedrock). Surface water (River Irwell).	Low Likelihood	Low	TBC

Assessment:

Leachate and groundwater analysis has identified exceedances of the EQS for chromium, copper, mercury, trichloromethane and pH.

Historically, the site has been occupied by a Cotton Finishing Works, Copper Roller Works and Mills. The initial soil analysis has not identified a risk to controlled waters.

The site is underlain by shallow sandstone bedrock which is classified as a principal aquifer. However, the majority of the identified inorganic compounds are of low solubility. The sensitivity of the principal aquifer in the bedrock is reduced given the closest potable groundwater abstraction is located 507 m north.

Trichloromethane has been recorded above the limit of detection in all three groundwater samples from the rotary boreholes which have monitoring wells set within the sandstone bedrock. All other VOCs are less than the limit of detection. It is unlikely that this relates to residual contamination from the former works and mills located on site as these land uses were historical and the compounds would have degraded. It is considered possible that this compound may have migrated from commercial sites further afield. The site is topographically lower than the land to the east, therefore it is likely that groundwater will flow towards the site and towards the River Irwell. The results of the groundwater analysis indicate a higher concentration of trichloromethane at RBH101 in the north east as opposed to RBH105 located in the south west.

The site is encapsulated in hardstanding, therefore infiltration will be limited.

Recommendation:

An additional round of groundwater sampling and surface water analysis is recommended to further assess the risk to controlled waters. The results will be issued in an addendum report



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL6	Sulphate (potential ash within Made Ground)	Sulphate attack on concrete.	Building structure.	Low likelihood	Low	LOW
Assessment: The soils at the site meet class DS-1, AC-1s.						
Recommendation: Concrete should be designed in accordance with the chemical testing results.						
PL7	Organic contaminants such as hydrocarbons, solvents (Made Ground, Former Works and Mills)	Ingestion of tainted water supply.	Future site users. Water pipes.	Low likelihood	Low	LOW
Assessment: Low likelihood as no significant contamination anticipated at pipeline depth across the site (0.75–1.35 m). Current chemical analysis indicates that PE pipe will be suitable for the site.						
Recommendation: A pipeline risk assessment should be completed following a process of remediation and enabling works. Post-remediation and enabling works ground conditions may be different from those identified during this site investigation.						
PL8	Phytotoxic contaminants (Made Ground, Former Works and Mills)	Direct Contact (plant uptake).	Flora.	Low Likelihood	Low	LOW
Assessment: No exceedances have been identified in the chemical testing completed.						
Recommendation Due to the presence of Made Ground impacted by asbestos, a clean cover system should be installed in areas of proposed planting/soft landscaping.						



Main exposure pathways: PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants;



5. GEOTECHNICAL ASSESSMENT

5.1. PROPOSED DEVELOPMENT

E3P understands that the proposed development will comprise offices and residential apartments with associated car parking.

5.2. SUMMARY OF GROUND CONDITIONS

Made Ground

- Made Ground deposits were encountered within all exploratory hole locations to a maximum proven depth of 1.50 m bgl.
- Made Ground deposits generally comprised concrete to circa 0.35 m bgl underlain by grey sandy gravel of limestone (Type 1 MOT).
- In addition, RBH102 identified a brick wall between 0.70 m and 1.50 m bgl. RBH104 identified a brick wall between 0.35 m and 0.80 m bgl.
- TP101-TP104 identified concrete with a rubber membrane over brown gravelly fine to medium sand with concrete and brick to 0.70 m bgl.

Drift

- Drift deposits were not encountered during the ground investigation.

Solid

- The solid bedrock geology was encountered between 0.45 m and 10.00 m bgl. The solid geology comprises dense to very dense SANDSTONE.
- Weathered sandstone bedrock was encountered as reddish brown medium SAND between 0.35 m and 1.50 m bgl in RBH101 and between 0.70 m and 0.80 m bgl in TP101, TP103 and TP104.
- A former quarry is present in the centre of the site, therefore there is the potential for notable changes in the depth of bedrock.

Groundwater

- Groundwater strikes were not encountered during the ground investigation. Subsequent monitoring recorded groundwater between 1.40 and 3.68 m bgl.

5.3. SITE PREPARATION

The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the *Manual of Contract Documents for Highway Works (MCHW)*. This should include the following:



- ✿ Roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill.
- ✿ Demolition of all existing buildings and removal of all concrete hardstanding (where applicable).
- ✿ Redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill.
- ✿ Buried structures and old foundations have been encountered on site. These should be excavated from below the proposed development footprint with the resulting void backfilled.

5.4. FOUNDATION CONDITIONS AND ASSESSMENT OF POTENTIAL BEARING CAPACITIES

In due consideration of the identified ground conditions, in-situ and laboratory geotechnical testing, E3P has undertaken an assessment of the net safe allowable bearing pressure (ABP) within the underlying natural stratum to assist in the detailed design of foundations and infrastructure and determine the target founding stratum. The results of this assessment are summarised in Table 5.1.

TABLE 5.1 SUMMARY OF ABP

GRANULAR SOILS			
Description	Depth (Range m bgl)	Relative Density	Allowable Bearing Pressure (kN/m ²)
SAND (Weathered Bedrock)	1.00	Very Dense	504
SANDSTONE	1.00-9.00	Dense – Very Dense	403 - 505
SANDSTONE	6.63-6.98	Dense – Very Dense	3.3 MPa (3300 kN/m ²)

Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net allowable bearing pressure, the suitable target founding stratum has been identified as the underlying sandstone bedrock.

Due to the highly fractured nature of the bedrock, only one Unconfined Compressive Strength (UCS) test could be undertaken from the core recovered. The results indicate that at a depth of between 6.63–6.98 m bgl the sandstone recorded a strength of 3.3 (MPa) which equates to 3300 kN/m².

A culvert is located in the south-west corner of the site and significant obstructions will be present beneath the existing buildings. All obstructions would need to be removed as part of the enabling works prior to any piling.

While a detailed assessment of pile depths and bearing capacity is beyond the scope of this report, it is likely that piles would achieve a 'set' within the sandstone. Consideration of the effects of negative skin friction due to variability on the Made Ground and natural drift strata will be required.

A specialist piling contractor should be contacted to obtain detailed designs and costs for a specialist piling technique and to allow them to reduce the factor of safety based on their extensive pile testing data.



Post demolition boreholes are required to further inform the foundation and sub-structure design.

Table 5.2 outlines the anticipated depth to suitable founding strata from existing levels at each E3P location.

TABLE 5.2 ANTICIPATED FOUNDATIONS

LOCATION	ANTICIPATED FOUNDING STRATA DEPTH (m bgl)	GROUND WATER (m bgl)	TARGET STRATUM	TREES	FOUNDATION TYPE	TYPE OF CONCRETE
TP101	1.05	N/A	Dense SAND	N	Pile	DS-1 AC-1s
TP102	>1.00	N/A	Dense SAND	N	Pile	DS-1 AC-1s
TP103	1.05	N/A	Dense SAND	N	Pile	DS-1 AC-1s
TP104	1.05	N/A	Dense SAND	N	Pile	DS-1 AC-1s
RBH101	0.90	N/A	Dense SAND	N	Pile	DS-1 AC-1s
RBH102	1.85	N/A	SANDSTONE	N	Pile	DS-1 AC-1s
RBH103	1.05	N/A	SANDSTONE	N	Pile	DS-1 AC-1s
RBH104	1.15	N/A	SANDSTONE	N	Pile	DS-1 AC-1s
RBH105	0.90	N/A	SANDSTONE	N	Pile	DS-1 AC-1s
RBH106	1.85	N/A	SANDSTONE	N	Pile	DS-1 AC-1s

5.5. GROUND FLOOR SLABS

Given the nature of the proposed high-rise residential development it is recommended that a ground bearing floor slab be utilised.

In order to accommodate for differential settlement and slab failure, it is recommended further Plate Load Testing is undertaken on the sub-grade following the breaking out of hardstand and reduced level dig to understand settlement characteristics and inform a geotechnical design specification in order to engineer to the required level to support a proposed ground bearing slab.

5.6. HEAVE PRECAUTIONS

The site has been proven to be underlain by shallow bedrock and no clay soils have been identified, therefore heave precautions are not required.

5.7. HIGHWAYS CONSTRUCTION

A programme of remediation and enabling works will be required to remediate the proposed road subgrade in accordance with the requirements of the Manual of Contract Documents for Highway Works Volume 1 Specification for Highway Works (Series 600-Earthworks) for a method compaction.

It is considered that the material can be re-engineered using method compaction to achieve a CBR in excess of 5% if works are completed in favourable climatic conditions.



5.8. DRAINAGE

The presence of substantial depths of Made Ground across some areas of the site may result in settlement. It is therefore recommended that drain runs are designed using steeper gradients and flexible joints to allow for some differential settlement.

The presence of deep Made Ground across the site will preclude the use of soakaway drainage. If soakaway drainage is to be considered, full BRE365 testing must be completed to inform the detailed design.

5.9. CONCRETE DURABILITY

Based upon the results of the chemical analyses it is considered that subsurface concrete can be designed in accordance with Design Sulphate Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with the recommendations provided in BRE *Special Digest 1* (2005).

5.10. EXCAVATIONS

Trial pits were generally stable; as such, it is considered that near-surface excavations will be feasible.

Site observations indicated that excavations should be feasible in the near-surface with normal plant; however, obstructions were identified, including former foundations and former floor slabs. It is anticipated that any obstructions will be grubbed out during the reduced-level dig for the substructure works. Shallow bedrock has been identified, therefore larger plant may be required.

However, due to the depth and variability of the Made Ground and the likelihood of trench collapse, it is considered that all excavations are supported or battered back in accordance with the guidance contained in CIRIA R97. Furthermore, the site is topographically lower than the adjacent roadways, consideration must be given to retaining being constructed or current wall adapted to ensure the stability of the soils around the periphery of the site.

If local pumping of groundwater is required during the advancement of excavations for the proposed foundations then consideration should be given to the potential for dewatering gravels in the surrounding areas that may cause structural damage to building substructures in close proximity to the site.

TABLE 5.3 CIVIL ENGINEERING EXCAVATION RISK MATRIX

RISK ITEM	PRESENT	COMMENT
Running Sands	No	No running sand has been identified.
Minor Water Ingress	Yes	Minor water ingress will require localised dewatering/sump pumping during the construction of site drainage infrastructure. Ingress of water into foundation excavation will potentially flood foundation excavations, limiting the viability of spread foundations to be constructed.
Shallow Bedrock	Yes	Shallow bedrock has been identified. The presence of bedrock will impede excavation for drainage infrastructure using traditional excavation plant and equipment.



5.11. CONSTRUCTION ACTIVITY AND INSPECTION

The following activities and inspections should be incorporated into the site works:

- ✿ Due to the variability of the soils at the site, it is recommended that sufficient allowance is made for the inspection of formations and sub-formations to foundations and pavement construction.
- ✿ Excavations where access is required should be subject to a risk assessment from a competent person and, where appropriate, mitigation measures such as benching back the sides or use of support systems in accordance with CIRIA R97 should be utilised.
- ✿ It is considered that dewatering may be required, especially following periods of heavy rainfall. Removal of surface water and water within trenches should be possible with conventional sump pumping. Discharge of any water should be agreed with the relevant regulatory body and be undertaken under a trade effluent discharge, where required. Measures to remove silt and suspended solids may be required and consideration should be given to the provision of space for settling tanks or an attenuation pond.
- ✿ Where access to confined spaces is required, appropriate mitigation measures should be addressed within the construction stage health and safety plan. Particular account should be taken of the gas results.
- ✿ The presence of potential contamination and mitigation measures should be addressed as part of the construction stage health and safety plan and should include measures to design out the risks, reduce their impact and, finally, include the use of personnel protective equipment (PPE).



5.12. GEOTECHNICAL RISK REGISTER

POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON-SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Remediation of contaminated soils		On-site	TBC	Asbestos should be managed according to the asbestos CSM. Should significant backfill be needed deeper or specialist foundations may be required in those areas.
Bedrock		On-site	100	Shallow bedrock is identified, this represents a significant risk in terms of the viability for excavations to install infrastructure using standard construction equipment. The actual depth is currently unprofiled across the site.
Obstructions		All	100	Significant obstructions are present under the existing buildings.
Artificially levelled and filled platforms		On-site	100	The site appears to have been levelled and artificially backfilled. An infilled quarry is present in the centre of the site.
Retaining walls		On-site	100	There are retaining walls on all boundaries of the site. These will need to be considered during the phased demolition of the site.
Trench collapse		All	100	Made Ground present beneath the site is likely to be loosely compacted and possibly prone to collapse.
Volume change potential clay		N/A	N/A	No clay soils have been identified, therefore heave precautions are not required.
Running sands		N/A	N/A	Data searches indicate low risk.
Ground dissolution		N/A	N/A	Data searches indicate no hazard.
Concrete design		On-site	100	The soils meet class DS-1, AC-1s.
Low-permeability ground		On-site	N/A	The presence of deep Made Ground across the site will preclude the use of soakaway drainage. If soakaway drainage is to be considered, full BRE365 testing must be completed to inform the detailed design.



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POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON-SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Services/sensitive structures	-	-	-	A review of online services has identified a number of services within the site boundary including a culvert in the south-west. Piling may not be possible within close proximity to any sensitive infrastructure.
Abnormal foundation solutions	On-site	100	100	A piled foundation will be required due to the imposed loads, presence of deep Made Ground and obstructions.
Areas not investigated	On-site	60	60	Further investigation will be required once the existing buildings have been demolished.



5.13. FURTHER WORKS

Based on the findings of the intrusive site investigation, the following additional works are recommended to be completed in due course:

-  Further investigation of inaccessible areas and extensive post demolition ground investigation.
-  Additional round of groundwater and surface water sampling.
-  Further geotechnical testing to determine the settlement characteristics for ground bearing floor slab (upon completion of the reduced level dig) and pavement design.
-  Foundations to be designed by suitably qualified Structural Engineer.
-  Geotechnical earthworks strategy (infrastructure).
-  Remediation and enabling works strategy.
-  Construction phase Surface Water Management Plan.

