



GROUND INVESTIGATION REPORT FOR BURY INTERCHANGE – PYRAMID PARK AND UNION SQUARE

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FINAL

Prepared for:

Wilmott Dixon on behalf of Transport
for Greater Manchester

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EXECUTIVE SUMMARY

Introduction	Tier Environmental was commissioned by Wilmott Dixon on behalf of Transport for Greater Manchester to undertake a Ground Investigation of Bury Interchange. The purpose of the investigation was to determine the nature and extent of soil, bedrock and groundwater beneath the site for the purposes of environmental and geotechnical assessment.
Proposed land use	The Bury Interchange project comprises two phases: 1. Southern Access - construction of a new pedestrian footbridge with access between Union Square, the existing Metrolink platform and Pyramid Park to enable Bury Tram Stop to continue operating during Phase 2 works. This phase of work also includes refurbishing the existing Metrolink platforms including replacement of the existing platform canopy and enhanced passenger amenities/facilities. 2. Bury Interchange - demolition and replacement of the existing Interchange Building. A planning application for the second phase comprising the interchange is to be prepared for an anticipated submission in early-to-mid 2026.
Site location and surrounding land uses	The site is located at Bury Interchange, Bury, BL9 0AY. The site comprises an active metro station (Bury Interchange) and line of track running south. The application site is bounded by Pyramid Park/Market Street to the east, East Lancashire railway line to the south, Duke Street/Knowsley Place to the west and Bury Interchange to the north (platforms located below interchange building and associated road infrastructure including Angouleme Way). The site comprises three distinct elements: 1. Knowsley Place/Union Square (west of Metrolink) - Premier Inn, offices and Q park 2. Metrolink corridor and platform 3. Pyramid Park (east of Metrolink) - vacant park which is subject to planning permission (LPA ref. 70903/Full) for comprehensive remediation. There is also a small area of the existing surface car park to the west of the interchange building which is identified for the location of a temporary contractor compound. In terms of the wider interchange (second phase of the scheme), this part of the site is bounded by Kay Gardens to the north, Haymarket Street to the west and Angouleme Way to the south.
Site history	The site comprises principally of railway infrastructure including goods sheds and rail lines from 1851 to circa 1976. The site is within an area of shallow earthworks in an 'L' shape from the Old Opera House circa 80m north and extending eastwards in conjunction with the railway lines, with the far north of the site at a higher level with an embankment down to the good sheds and railway level. Major redevelopment by 1980 sees removal of existing buildings, infilling of some land, and construction of the current station and rail layout. The wider site sees a new road layout and redevelopment of land adjacent to the site. The surrounding area has comprised industrial uses including a timber yard and warehouse 80m west of the site and woollen mill from earliest records, and notably an abattoir immediately west from 1851 which expands through to 1976 when it is no longer shown. By 1957 the land to the north of the site has been redeveloped with the expansion of the Market Hall with an open market immediately north, which are removed by 1973 for a car park. A second phase of redevelopment by 1976 sees construction of the approximately present-day layout. By 2013, disused land to the west of the site (now known as union square) is undergoing development into a hotel and offices. Pyramid Park The proposed new Southern Access footbridge lands on to the Pyramid Park site. Bury Council, as applicant, has recently secured full planning permission (LPA ref. 70903/Full) for the remediation of the Pyramid Park site and construction of a new vehicular access road. The Pyramid Park site was formerly a railway station and sidings before being reclaimed as public open space in the 1970s. Planning permission was subsequently granted in December 2024 subject to a suite of planning conditions. The remediation of the site is the first phase in advance of the Council procuring a developer to progress with a residential scheme (subject to separate planning application in due course).
Potential contaminative features	Made Ground associated with historic land uses as railway sidings and goods sheds with potential for associated tank features, and a predominantly off-site abattoir. The Department of the Environment Industry Profile for animal processing works, for the adjacent and partly on-site historic abattoir, suggest pathogens, solvents, bleaches and fuel oils as potential contaminants associated with this industry. Consideration has been given to the widespread redevelopment of the local area from the mid 1970 including construction of a new road (Angouleme Way) and car park within the historic abattoir site whereby a degree of Made Ground removal or remediation may have taken place though no records can confirm this. Local Authority landfill records show a known landfill centred at E 380314 ,N 410400 on the provided plan, which places it within the western boundary of the site, now known as union square. This is understood to be filled with inert



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	subsoil as part of a Reclamation scheme in 1973 and since redeveloped in late 2000s and early 2010s as a hotel, offices and car park with remedial measures.
Mining and quarrying	The site is located within a coal mining area as defined by the Coal Authority. A Consultants Coal Mining Report (CON29M) was ordered to further assess coal mining issues at the site. The report is contained within Appendix C. Results of this report do not indicate the site is at risk from past coal mining activity. Coal was recorded in BH-P2-205 from 18.50-18.30m bgl, and BH-P2-106 between 22.85m and 23.22m bgl (with soft bands/coal seams recorded by the drillers between 22.50m to 23.20m bgl in BH-P2-106). Although the soft bands/coal seams may be indicative of workings within this seam, at these depths and thicknesses, and using 10 times seam thickness to calculate the required thickness of competent rock cover above the coal seam, it is considered that there is sufficient competent cover above the seams encountered within both BH-P2-105 and BH-P2-106 should any workings be present.
Previous investigations	Two previous reports have been produced by Tier Environmental for the site and referenced below: - Preliminary Risk Assessment Report For Bury Interchange Phase 1 (Report Ref: TE1885-TE-00-XX-RP-GE-001-V02 dated 1st April 2025) - Preliminary Risk Assessment Report For Bury Interchange Phase 2 (Report Ref: TE1885-TE-00-XX-RP-GE-002-V02 dated 1st April 2025) A Detailed UXO Desk Study was completed by EOD Contracts Ltd (Ref: EOD/24/24140/DTS, dated November 2024) for the combined Phase 1 and Phase 2 site boundaries.
Fieldwork	The investigation was supervised by a Tier Environmental Geo-environmental Engineer and took place conducted between 26th March and 3rd April 2025. The investigation comprised: 2 No. hand dug pits TP-P2-101 and TP-P2-103) to depths of between 1.00m and 1.10m bgl. 16 No. window sample boreholes (WS-P2-101 to WS-P2-111) to depths between 1.25m and 4.45m bgl. 2 No. cable percussive boreholes with rotary follow on (BH-P2-104 and BH-P2-105) to depths of between 20.30- 25.70m bgl 5 No. machine excavated trial pits (TP-P2-102, TP-P2-104, TP-P2-106 – 108) to depths of between 1.00- 3.00m bgl 1 No. Soakaway pit (SA-P2-101) to 2.30m bgl On 26th October 2025 an additional 1 No. rotary borehole (BH-P2-106) was undertaken to 28.50m bgl located trackside, at the end of the platform and between the tram tracks.
Laboratory testing	Samples of soil and soil leachate were submitted for analysis of a range of metal, other inorganic and organic components including asbestos. Geotechnical testing was scheduled on selected samples. All testing was undertaken at accredited laboratories.
Ground conditions	The site is underlain by Made Ground of either a gravelly Clay or clayey sandy Gravel to depths of typically between 1.25m and 2.00m bgl though locally up to 5.70m bgl in BH-P2-104 in the west, and some shallower horizons in the south east of the site to between 0.27m and 0.40m bgl. Natural soils of Till overlying bedrock of the Lower Pennine Coal Measures was recorded where depth was achieved through the Made Ground and predominantly comprised very high strength Clays. In-situ testing broadly recorded refusal values of SPT N of >50. BH-P2-106 (trackside) recorded Made Ground comprising railway ballast with varying clay and sand content from the surface to a depth of 1.50m bgl, underlain by further granular Made Ground to 3.00m bgl, and possible cohesive Made Ground to 3.50m bgl. Granular superficial deposits comprising sandy gravel were recorded to 5.00m bgl, underlain by cohesive superficial deposits to 8.00m bgl. Extremely weak to medium strong, thinly laminated mudstone, occasionally interbedded with sandstone, was encountered below to beyond the base of the borehole at 28.50m bgl, with soft bands/coal seams recorded by the drillers between 22.50m to 23.20m bgl, overlying an intact coal seam encountered between 22.85m to 23.22m bgl (0.37m thickness).
Foundations	It is understood the existing Metrolink platform and canopy will be refurbished, and therefore the existing foundations for these features will be retained (subject to confirmation from the structural engineer). For the pedestrian access bridge providing access between Union Square, the Metrolink platform and Pyramid park, piled foundations terminating within the competent bedrock are expected to be the most appropriate foundation solution. However, should the footbridge allow for lighter loadings, a micro piled solution could also be considered to bear loads onto competent ground beyond the base of recorded Made Ground, and consultation should be sought from a local contractor. Foundation design should be refined based on any proposed site level changes inclusive of removal of the pyramid mounds.
Sulphate class	It is considered that a Design Sulphate Class of DS-2 and ACEC Class AC-2 is appropriate for buried concrete design purposes within Made Ground and within natural soils. Groundwater sulphate classification will be ascertained as part of future site wider groundwater sampling that shall be conducted upon completion of the remaining ground investigation works within the northern part of the wider site area.



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Contamination – human health	Localised PAH exceedances were identified during sensitivity analysis when comparing against Generic Assessment Criteria (GACs) protective of a more conservative Public Open Space park land use. Following further qualitative assessment of the provenance of those PAHs it was concluded that as they appeared to be attributable to natural coal that they would be unlikely to represent a potential risk to the end users. On this basis , it is not considered that the site represents a potential risk to end-users. Of the 20 No. of Made Ground samples submitted for asbestos screening, 5 No. were reported to contain asbestos in the form of chrysotile and locally amosite fibre bundles, returned with quantification of <0.001% w/w suggesting trace level of asbestos. A total of 3 No. samples of Made Ground from the trackside location BH-P2-106 were screened for asbestos. None recorded asbestos to be present.
Contamination – controlled waters	Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Pennine Lower Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is an artificial lake within a park circa 100m east of the site, in land east of Market Street, though this not considered to be in hydraulic conductivity with local groundwater, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south in conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate. Measured leachable concentrations of nickel, iron and anthracene have been reported only marginally in excess of the WQS protective of the controlled waters environment by the same order of magnitude or up to 1 order of magnitude. Given the marginal nature of these exceedances, the potential for significant dilution within the groundwater beneath the site, the historical commercial / industrial heritage of the wider area surrounding the site, the absence of a continuous groundwater body beneath the site, the Low/Moderate sensitivity of the controlled waters environment, the localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations and the fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils, the exceedances are not considered to pose a risks to controlled water receptors. Measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported in excess of the respective WQS protective of the controlled waters environment by between 2 No. orders of magnitude and 3 No. orders of magnitude. Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and / or benzo(a)pyrene have been reported only marginally in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters by the same order of magnitude / by up to one order of magnitude. As such, and in the absence of viable 'bioaccumulation in fish and consumption of fish by humans' scenario and given the reasonings outline above, it is therefore considered that the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene are unlikely to present a potential risk to the controlled waters environment.
Gas protection	Given the nature of the proposed development and the absence of any proposed enclosed spaces, ground gas protection measures are not required for this proposed element of the development. A detailed ground gas risk assessment will be undertaken during future proposed investigations for other development phases.
Radon requirements	Basic radon protection measures are not currently required for the proposed development on this site. In addition to the above, basements represent areas that are more at risk because the walls are in contact with the ground as well as the floor. This, coupled with reduced natural ventilation below ground level, increases the risk of elevated radon levels. All basements are therefore considered under BR 211 to be at increased risk of elevated levels of radon regardless of geographic location. Currently, no basements or converted cellars / basements are proposed for the development and therefore no additional consideration of potential increased risk needs to be made; however, this should be revisited in the event that the proposals change to include for a basement.
Other issues	Consideration should be given to anecdotal evidence of historic unrecorded tunnels within close vicinity to the site, though there is no evidence these features intercept the Phase 1 site boundary and no evidence of any tunnels was identified during the site investigation works.
Waste soils classification	Basic waste characterisation has determined that Made Ground soils are non-hazardous aside from the sample at SA-P2-10 at 0.80m bgl, in Made Ground of black compacted gravelly Sand (asphalt layer) which is hazardous for Iron (III) oxide. The results of WAC tests have confirmed that: - SA-P2-101 at 0.80m bgl would need to be treated prior to acceptance to a hazardous waste landfill due to elevated TOC and loss on ignition that exceeds the hazardous waste landfill threshold. - WS-P2-106 at 0.70-1.00m bgl would be suitable for disposal to a non-hazardous landfill due to TOC and Sum PAHs in excess of inert landfill threshold, and asbestos at <0.001% w/w. - BH-P2-105 at 1.70-2.00m bgl would be suitable for disposal to a non-hazardous landfill due to TOC in excess of inert landfill threshold, and asbestos at <0.001% w/w.



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	- TP-P2-104 at 0.80m bgl would be suitable for disposal to a non-hazardous landfill due to TOC in excess of inert landfill threshold. - TP-P2-101 at 0.30m bgl would be suitable for disposal to a non-hazardous landfill due to Sum PAHs in excess of inert landfill threshold. - TP-P2-106 at 0.10m bgl, WS-P2-101 at 0.45-0.60m bgl would be suitable for disposal as inert waste. BH-P2-106 (trackside location) at 0.40m and 3.00 to 3.20m bgl would both be suitable for disposal as inert waste. It is anticipated that natural soils will be suitable for disposal to an inert landfill.
Materials re-use	Subject to volumetric cut and fill requirements the majority of Made Ground materials and all of natural soil materials and may be considered chemically suitable for potential re-use subject to careful management and placement of materials and in line with an appropriate end-of-waste protocol such as WRAP Quality Protocol for Aggregates from Inert Waste, U1 Exemption or a Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP). Suitability for re-use would also be subject to confirmation of the geotechnical suitability depending on whether the materials are to be re-used in load bearing areas. This would need to be detailed in a supporting document. Please note that any previously landfilled or mining waste materials may not be appropriately subject to consideration under DoWCoP and may not be re-used under DoWCoP unless sufficient lines of evidence and agreement with the local Environment Agency Waste Team can be sought beforehand. In addition, Section 13.3 of this report includes statements with respect to re-use of excavated and stockpiled clean naturally occurring soils within the site and re-use on other sites. These statements are designed to provide a clear intention to reuse any clean, naturally occurring soils derived from future excavations at this site (which may also include temporary future stockpiling these materials).
Further works	Completion of an Asbestos DQRA to determine suitability for re-use of low-level asbestos impacted soils within the development.



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1. INTRODUCTION

Tier Environmental was commissioned by Wilmott Dixon on behalf of Transport for Greater Manchester, to undertake a ground investigation for an area of land referred to as Pyramid Park and Union Square, Bury Interchange, located at Bury, BL9 0AY (the “site”).

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

Stage 1:

- LCRM Tier 2 Generic Quantitative Risk Assessment Report

This report has been updated following completion of the trackside rotary borehole (BH-P1-106) during the planned shutdown of the metro tracks/station. The updated results from this location will be summarised within separate sections/ paragraphs where relevant.

1.1. Proposed Development

Under current proposals the development will comprise the construction of a new Transport Interchange in Bury Town Centre. The Bury Interchange project comprises two phases:

- 1. Southern Access - construction of a new pedestrian footbridge with access between Union Square, the existing Metrolink platform and Pyramid Park to enable Bury Tram Stop to continue operating during Phase 2 works. This phase of work also includes refurbishing the existing Metrolink platforms including replacement of the existing platform canopy and enhanced passenger amenities/facilities.
- 2. Bury Interchange - demolition and replacement of the existing Interchange Building.

A planning application for the second phase comprising the interchange is to be prepared for an anticipated submission in early-to-mid 2026.

As such, in accordance with the ‘Updated technical background to the CLEA model’ (Environment Agency, 2009) and ‘Suitable 4 Use Levels’ (LQM / CIEH 2015) the proposed generic land use for this development is commercial, acknowledging the proposed development as a new walkway for station access. In this context, we consider the use of commercial land use GACs to be a reasonable and appropriately conservative default scenario, especially when the actual exposure frequency and duration for public users will be less than that assumed for the default commercial worker.

Given the unknown extent of both proposed earthworks and intended areas of soft landscaping, we have taken an additional step of conducting sensitivity analysis by comparing the reported concentrations against Public Open Space (POS) Park GACs. We recognise that areas of soft landscaping present a slightly higher potential for soil contact, particularly if members of the public utilise the area as a ‘park’, which may be beyond an exposure frequency of commercial landscapers/maintenance workers. To account for this, a sensitivity analysis has also been carried out using POS Park GACs, which are based on young children playing daily in parks — a highly conservative scenario.

1.2. Previous Reports

A Detailed UXO Desk Study was completed by EOD Contracts Ltd (Ref: EOD/24/24140/DTS, dated November 2024) for the combined Phase 1 and Phase 2 site boundaries, this is contained within Appendix I.

The following third part reports were provided for review:



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- A Factual Report on Site Investigation for Land at Townside Fields, Bury, by Dunelm Geotechnical and Environmental on behalf of Campbell Reith (Ref: M1062/01, dated April 2022)
- A Geoenvironmental Appraisal of land at Bury Market, for Bury Council, by ID Geoenvironmental Ltd (Ref: 5237-G-R001 Rev A, dated August 2022).
- A Factual Report for Pyramid Park, Bury, by Geotechnics on behalf of Campbell Reith (Ref: PN234595, dated February 2024)

The above factual reports for Townside Fields/Pyramid Park are collated in the following produced by Campbell Reith, which were available on the Bury Council planning portal:

- A Geotechnical and Geoenvironmental Desk Study Report, by Campbell Reith (Ref: 13819-CRG-XX-XX-RP-LQ-0001, dated March 2022).
- A Phase 2 Interpretive Report (Contamination), by Campbell Reith (Ref: 13819-CRG-XX-XX-RP-LQ-0002, dated July 2022).
- A Land Quality Statement by Campbell Reith (Ref: 14111-CRH-XX-XX-RP-LQ-0001, dated April 2024)
- A Remediation Strategy and Quality Statement by Campbell Reith (Ref: 14111-CRH-XX-XX-RP-LQ-0001-P02, dated November 2024)

Tier Environmental reviewed the above as part of a Preliminary Risk Assessment Report for the Phase 1 Area. Tier Environmental have also produced the following reports for the wider Bury Interchange area:

- Preliminary Risk Assessment Report for Bury Interchange Phase 1 (Ref: 16012-TRE-BRY-XXX-RP-EN-000001 Rev. P02, dated April 2025);
- Preliminary Risk Assessment Report for Bury Interchange Phase 2 (Ref: 16012-TRE-BRY-XXX-RP-EN-000002 Rev. P02, dated April 2025);
- Ground Investigation Report for Bury Interchange Trackside Works (Ref: 16012-TRE-BRY-XXX-RP-EN-000003 REV.P02, dated April 2025);
- Ground Investigation Report for Bury Interchange – Pyramid Park and Union Square (Ref: 16012-TRE-BRY-XXX-RP-EN-000004 REV.P02, dated May 2025); and
- Ground Investigation Report for Bury Interchange – Bus Interchange Concourse (Ref: 16012-TRE-BRY-XXX-RP-EN-000006 REV.P01, dated 24 November 2025)

1.3. Objectives

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

- To determine the historical and current land use.
- To establish the environmental setting of the site.
- To evaluate whether past mining or other extractive industries could have an influence on the site.
- To determine current ground and groundwater conditions.
- To determine the potential risks to human health and the wider environment.
- To provide a preliminary waste soils classification.
- To determine potential risks posed to the site from hazardous ground gases and / or vapours.
- Provide preliminary outline remedial measures to manage any identified risks.
- To provide preliminary geotechnical parameters to inform foundation recommendations.

1.4. Assumptions

The following assumptions are made in this report:



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- It is assumed that ground levels will not change significantly from those described in this report or as shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigation has been designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms 'shallow' and 'deep' within this report (from a geotechnical perspective) assume *typically* between ground level to circa 3.00m below ground level (bgl) for 'shallow' and greater than 3.00m bgl regarded as 'deep';
- The comments and opinions presented in this report are based on the findings of the desk study, review of third party information, ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the site which have not been revealed by this investigation and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by this investigation. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

This report has been prepared for the sole use of Wilmott Dixon on behalf of Transport for Greater Manchester. No other third party may rely upon or reproduce the contents of this report without the written approval of Tier Environmental. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and the authors do not owe them any Duty of Care or Skill.



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2. SITE DETAILS AND DESCRIPTION

Table 2-1 Current Site Overview.

Site name	Pyramid Park And Union Square, Bury Interchange
Site address	Bury Interchange, Bury, BL9 0AY. The application site is bounded by Pyramid Park/Market Street to the east, East Lancashire railway line to the south, Duke Street/Knowsley Place to the west and Bury Interchange to the north (platforms located below interchange building and associated road infrastructure including Angouleme Way). The site comprises three distinct elements: 1. Knowsley Place/Union Square (west of Metrolink) - Premier Inn, offices and Q park 2. Metrolink corridor and platform 3. Pyramid Park (east of Metrolink) - vacant park which is subject to planning permission (LPA ref. 70903/Full) for comprehensive remediation. There is also a small area of the existing surface car park to the west of the interchange building which is identified for the location of a temporary contractor compound.
National Grid Reference (NGR)	380399 410392
Approximate site area	0.92 ha
Site shape	The site is an irregular elongate shape.
Current land use on the site	The site forms part of Bury Interchange station, with station and platform buildings in the north of the site, and railway lines extending south through the beyond site. Underground service drawings have not been provided to Tier Environmental; however, there remains a potential for such features to be present beneath the site.
Surrounding land uses	The site is set within a mixed commercial and residential area with the wider Bury Interchange to the north, car parking and commercial buildings including a hotel to the west and Bury College and a disused park to the east.
General topography and ground levels	The track level of the Phase 1 area is at approximately 86m AOD. The site is within a cutting with levels to the west at 91.4m AOD and to the east circa 94m AOD; the overpass is at circa 95m AOD.

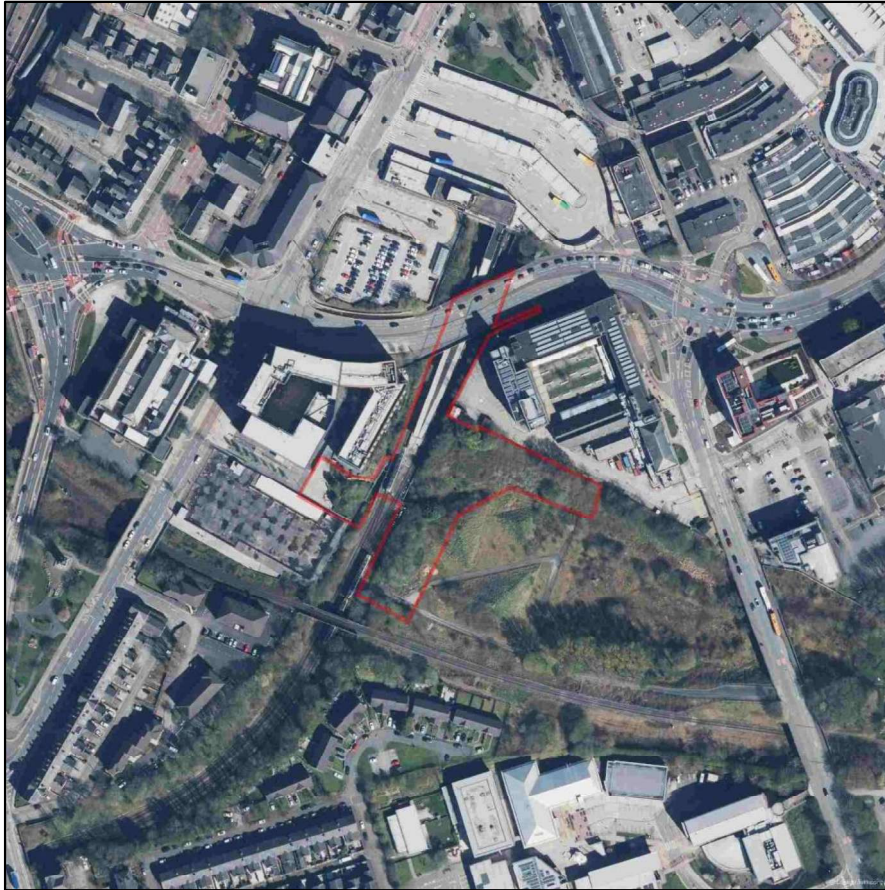
An aerial photograph (from the Groundsure report) of the site and site boundary is shown below. Please note that the works completed as part of this report pertain solely to the area shown below.



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Figure 2.1 Recent Aerial Photograph from Groundsure





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3. PREVIOUS INVESTIGATION FINDINGS

A Detailed UXO Desk Study was completed by EOD Contracts Ltd (Ref: EOD/24/24140/DTS, dated November 2024) for the combined Phase 1 and Phase 2 site boundaries, this is contained within Appendix I.

The following third part reports were provided for review:

- A Factual Report on Site Investigation for Land at Townside Fields, Bury, by Dunelm Geotechnical and Environmental on behalf of Campbell Reith (Ref: M1062/01, dated April 2022)
- A Geoenvironmental Appraisal of land at Bury Market, for Bury Council, by ID Geoenvironmental Ltd (Ref: 5237-G-R001 Rev A, dated August 2022).
- A Factual Report for Pyramid Park, Bury, by Geotechnics on behalf of Campbell Reith (Ref: PN234595, dated February 2024)

The above factual reports for Townside Fields/Pyramid Park are collated in the following produced by Campbell Reith, which were available on the Bury Council planning portal:

- A Geotechnical and Geoenvironmental Desk Study Report, by Campbell Reith (Ref: 13819-CRG-XX-XX-RP-LQ-0001, dated March 2022).
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- A Land Quality Statement by Campbell Reith (Ref: 14111-CRH-XX-XX-RP-LQ-0001, dated April 2024)
- A Remediation Strategy and Quality Statement by Campbell Reith (Ref: 14111-CRH-XX-XX-RP-LQ-0001-P02, dated November 2024)

Tier Environmental reviewed the above as part of a Preliminary Risk Assessment Report for the Phase 1 Area (Ref: 16012-TRE-BRY-XXX-RP-EN-000001 Rev. P02, dated April 2025) which is summarised below.

Table 3-1 Report Review Summary

Site history	The site comprises principally of railway infrastructure including goods sheds and rail lines from 1851 to circa 1976. The site is within an area of shallow earthworks in an 'L' shape from the Old Opera House circa 80m north and extending eastwards in conjunction with the railway lines, with the far north of the site at a higher level with an embankment down to the good sheds and railway level. Major redevelopment by 1980 sees removal of existing buildings, infilling of some land, and construction of the current station and rail layout. The wider site sees a new road layout and redevelopment of land adjacent to the site. The surrounding area has comprised industrial uses including a timber yard and warehouse 80m west of the site and woollen mill from earliest records, and notably an abattoir immediately west from 1851 which expands through to 1976 when it is no longer shown. By 1957 the land to the north of the site has been redeveloped with the expansion of the Market Hall with an open market immediately north, which are removed by 1973 for a car park. A second phase of redevelopment by 1976 sees construction of the approximately present-day layout. By 2013, disused land to the west of the site (now known as union square) is undergoing development into a hotel and offices. Pyramid Park The proposed new Southern Access footbridge lands on to the Pyramid Park site. Bury Council, as applicant, has recently secured full planning permission (LPA ref. 70903/Full) for the remediation of the Pyramid Park site and construction of a new vehicular access road. The Pyramid Park site was formerly a railway station and sidings before being reclaimed as public open space in the 1970's. Planning permission was subsequently granted in December 2024 subject to a suite of planning conditions. The remediation of the site is the first phase in advance of the Council procuring a developer to progress with a residential scheme (subject to separate planning application in due course).
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Potential contaminative features identified	Made Ground associated with historic land uses as railway sidings and goods sheds with potential for associated tank features, and a predominantly off site abattoir. The Department of the Environment Industry Profile for animal processing works, for the adjacent and partly on-site historic abattoir, suggest pathogens, solvents, bleaches and fuel oils as potential contaminants associated with this industry. Consideration has been given to the widespread redevelopment of the local area from the mid 1970 including construction of a new road (Angouleme Way) and car park within the historic abattoir site whereby a degree of Made Ground removal or remediation may have taken place though no records can confirm this. Local Authority landfill records show a known landfill centred at E 380314 ,N 410400 on the provided plan, which places it within the western boundary of the site, now known as union square. This is understood to be filled with inert subsoil as part of a Reclamation scheme in 1973 and since redeveloped in late 2000s and early 2010s as a hotel, offices and car park with remedial measures.
Mining and quarrying	The site is located within a coal mining area as defined by the Coal Authority. A Consultants Coal Mining Report (CON29M) was ordered to further assess coal mining issues at the site. The report is contained within Appendix C. Results of this report do not indicate the site is at risk from past coal mining activity.
Previous investigations referenced in the report	Third party reporting for land to the east of the site, associated with the market redevelopment, and for land within Pyramid Park (planning permission ref. 70903/Full - approved December 2024) in the southeast of the site, have been reviewed. A series of ground investigations and desk studies for each site area were completed. No potential contaminants of concern were recorded within the market area for the proposed continued commercial land use. Asbestos in the form of fibre bundles of amosite or chrysotile were recorded in 8 no. samples of Made Ground in Pyramid Park, in addition to Made Ground with elevated PAH compounds, hydrocarbon odours, and inclusions of clinker, ash, coal and slag within or adjacent to the pyramid structures.
Geology, hydrogeology and hydrology	Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Pennine Lower Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is an artificial lake within a park circa 100m east of the site, in land east of Market Street, though this not considered to be in hydraulic conductivity with local groundwater, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south in conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate.
Potential contaminative features	Made Ground associated with historic land uses as railway sidings and goods sheds with potential for associated tank features, and a predominantly off site abattoir. The Department of the Environment Industry Profile for animal processing works, for the adjacent and partly on-site historic abattoir, suggest pathogens, solvents, bleaches and fuel oils as potential contaminants associated with this industry. Consideration has been given to the widespread redevelopment of the local area from the mid 1970 including construction of a new road (Angouleme Way) and car park within the historic abattoir site whereby a degree of Made Ground removal or remediation may have taken place though no records can confirm this. Local Authority landfill records show a known landfill centred at E 380314 ,N 410400 on the provided plan, which places it within the western boundary of the site, now known as union square. This is understood to be filled with inert subsoil as part of a Reclamation scheme in 1973 and since redeveloped in late 2000s and early 2010s as a hotel, offices and car park with remedial measures.
Ground gases	A sand pit was recorded 30m west of the north of the site from 1849, and a reservoir 50m south, infilled by 1891 and 1976 respectively. The site itself has been subject to significant earthworks, most recently in circa 1973-1976 when the old railway cuttings are infilled, likely associated with the BSG records identifying the site to be underlain by 'worked ground'. On site and nearby landfill records for other railway cuttings indicate use of 'inert' waste, notable in the west of the site in the 1970s during the wider redevelopment cycle. Gas generation potential for any on and off-site sources is considered to be relatively low.
Other issues	Consideration should be given to anecdotal evidence of historic unrecorded tunnels within close vicinity to the site, though there is no evidence these features intercept the Phase 1 site boundary.
Further works	Intrusive works should adhere to the Site Investigation Scope produced by Renaissance (Dated October 2024) presented in drawing BURY-REN-XX-XX-SK-S-01000-P03 and 01001-P03.
Waste Soils Classification	Based on the history of the site and the anticipated potential contaminants of concern it is considered possible that hazardous waste soil materials may be present beneath some areas of the site; however, this will be subject to confirmatory investigation, sampling, laboratory analysis and waste classification in accordance with the Guidance on the Classification and Assessment of Waste (WM3).



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Materials re-use considerations

Subject to volumetric fill requirements and a future assessment of suitability of re-use (both chemically and geotechnically), some materials may be considered for potential re-use in line with an appropriate end-of-waste protocol such as WRAP Quality Protocol for Aggregates from Inert Waste, U1 Exemption or a Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP). Please note that any previously landfilled or mining waste materials may not be appropriately subject to consideration under DoWCoP and may not be re-used under DoWCoP unless sufficient lines of evidence and agreement with the local Environment Agency Waste Team can be sought beforehand.



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4. PRELIMINARY CONCEPTUAL SITE MODEL

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

The potential pollutant linkages identified and the qualitative risk assessment for these are presented in Table 4-1 below. The terms used in the preliminary qualitative risk assessment are defined in Appendix G.

4.1. Uncertainties

The following uncertainties exist in the preliminary conceptual model:

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



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Table 4-1 Preliminary Assessment of Potential Pollutant Linkages (Continued on Next Page).

Justification / Comments	
- From 1849 the site is shown to be part of gardens and a bowling green, with a few small buildings spread across site. By 1851 through to 1891 the site is shown to have railway infrastructure including a central shed and rail lines. The site is within an area of shallow earthworks in an 'L' shape from the Old Opera House circa 80m north and extending eastwards in conjunction with the railway lines, with the far north of the site at a higher level with an embankment down to the good sheds and railway level. The sheds and sidings have expanded slightly by 1930 and cattle pens are recorded in the east and north of the site adjacent to an adjacent abattoir, which possibly expands into site by 1957. The site remains broadly unchanged until circa 1976-1980 when there is major redevelopment including removal of the goods sheds and railway sidings, and replaced with a main north-south rail line in the centre of the site with Bury Interchange station positioned in the northern half of the site. A road overpass, Angouleme Way, passes through the north of the site. Pyramid Park, a public park to the east of the site, encroaches within the site boundary. The site and immediate surrounding land were subject to earthworks through the mid-1970s with regrading/infilling of land of the former railway cuttings. A subway is shown passing from Townside Field to the west of the tracks from the early 1980s. The site remains broadly unchanged to present day. - From earliest records the site is surrounded by a timber yard and warehouse 80m west of the site and woollen mill. Buildings to the west of the site are labelled as abattoirs from 1851 which expands through to 1976 when it is no longer shown. By 1910 wider railway infrastructure has expanded with a new line branching south west and further residential expansion is noted from 100m south of the site. By 1930 a bakery is located 130m east of the site and by 1938 Bury Technical College has been constructed immediately east of the north of the site. Post war aerial photography records indicate an area or housing circa 100m east of the site is derelict land and could possibly be associated with bomb damage. By 1957 the land to the north of the site has been redeveloped with the expansion of the Market Hall with an open market immediately north, which are removed by 1973 for a car park. A new road layout is constructed between 1973 and 1976 and buildings associated with Bury Interchange replace the carpark by the late 1970s. By 1976 the railway sidings to the east of the site have been broadly removed and redeveloped into 'Townside Field' a public park, with a lake, later named Pyramid Park. By 2013 the land to the west of the site is undergoing development into flats (union square) and the park (pyramid park) is disused. - The Department of the Environment Industry Profile for animal processing works, for the adjacent and partly on-site historic abattoir, suggest pathogens, solvents, bleaches and fuel oils are potential contaminants associated with this industry. Consideration has been given to the widespread redevelopment of the local area from the mid 1970 including construction of a new road (Angouleme Way) and car park within the historic abattoir site whereby a degree of Made Ground removal or remediation <i>may</i> have taken place though no records can confirm this. The current layout also contains railway infrastructure including possible electrical components and sources of PolyChlorinated Biphenyls (PCBs). With respect to risk from pathogens, under normal environmental conditions, it is often assumed that most pathogens are no longer viable after 1–2 years in the soil and after 20+ years of dormancy, the biological risk is likely to be negligible and so hasn't been considered further. - Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Middle Pennine Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is a lake within a park circa 100m east of the site though this not considered to be in hydraulic conductivity with local groundwater and has been dry since 2013, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south is conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate. - The site is located within a coal mining area as defined by the Coal Authority. A Consultants Coal Mining Report (CON29M) does not indicate the site is at risk from past coal mining activity. A sand pit was recorded 30m west of the north of the site from 1849, and a reservoir 50m south, infilled by 1891 and 1976 respectively. The site itself has been subject to significant earthworks, most recently in circa 1973-1976 when the old railway cuttings are infilled, likely associated with the BSG records identifying the site to be underlain by 'worked ground'. It should be noted that the current layout comprises a new railway cutting. Nearby and on-site landfill records for other railway cuttings indicate use of 'inert' waste. Bury Council also provided records for a landfill in Townside Fields (in the west of the site) filled with inert subsoil as part of a Reclamation scheme in 1973 and since redeveloped in late 2000s and early 2010s as a hotel, offices and car park with remedial measures. Gas generation potential for any on and off-site sources is considered to be relatively low. - The site is not located within an ecologically sensitive area, notwithstanding the SBI Grade B and SSSI Impact Zone.	



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Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Anticipated widespread Made Ground across the site associated with historic land uses including railway sidings, goods sheds, part of an abattoir in the north of the site, and earthworks associated with landfilling records associated with the infilling of railway cuttings in the east and west of the site.	Metals PAHs pH Hexavalent chromium Acids Alkalis	Direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk
			Adjacent site users (commercial)	Medium	Unlikely	Low Risk
			Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Devensian Till and Glacialfluvial Deposits	Medium	Low Likelihood	Moderate / Low Risk
		Vapour inhalation, direct contact, dust inhalation and ingestion	Aquifer 2 - Secondary A Aquifer associated with Chester Formation Sandstone	Medium	Unlikely	Low Risk
			Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Adjacent site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk
Naphthalene (a semi-volatile PAH) TPH / BTEX / MTBE VOCs / SVOCs Phenols PolyChlorinated Biphenyls (PCBs) Cyanides Glycols Coal tar Free phase product Asbestos	Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits Migration via water pipes Lateral and/or vertical migration of mobile contaminants. (Dust migration and) dust inhalation	Adjacent site users (commercial)	Medium	Unlikely	Low Risk	
		Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk	
		Aquifer 1 - Secondary A Aquifer associated with Devensian Till and Glacialfluvial Deposits	Medium	Low Likelihood	Moderate / Low Risk	
		Aquifer 2 - Secondary A Aquifer associated with Chester Formation Sandstone	Medium	Unlikely	Low Risk	
		Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk	
		Adjacent site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk	
		Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk	
		Future site users (commercial)	Severe	Unlikely	Moderate / Low Risk	
		Adjacent site users (commercial)	Medium	Unlikely	Low Risk	
		Construction, site investigation, demolition and future maintenance workers	Severe	Unlikely	Moderate / Low Risk	
Made Ground located beneath the site including landfilling understood to be inert waste.	Hazardous ground gases (methane, carbon dioxide, hydrogen sulphide, carbon monoxide and depleted oxygen)	Adjacent site users (commercial)	Medium	Unlikely	Low Risk	
		Buildings and services	Severe	Unlikely	Moderate / Low Risk	
		Migration of ground gas / explosion				

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



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5. FIELDWORK

The information contained in this report is limited to areas of land accessible during the ground investigation within the site boundary, as indicated on the site plan, presented in Appendix A as Drawing No.TE1885-TE-00-DR-GE-006-V03.

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

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

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

5.1. Scope of Ground Investigation

The main ground investigation was conducted between 26th March and 3rd April 2025 and was supervised by a suitably qualified Tier Environmental engineer. Table 5-1 below provides a summary of the exploratory holes completed and rationale. Exploratory hole locations are presented on Drawing No.TE1885-TE-00-DR-GE-006-V03.

Table 5-1 Scope of Ground Investigation and Rationale

Exploratory Hole Type	Exploratory Hole Reference	Exploratory Hole Depths (m bgl)	Rationale
Trial pits	TP-P2-102; TP-P2-104; TP-P2-106 - 108	1.00-3.00m bgl	To confirm the shallow ground conditions across the site, relatively shallow groundwater presence and rate of inflow, stability of excavations, and to enable shallow soil sampling for geotechnical and geoenvironmental parameters.
Window sample boreholes	WS-P2-101-107; WS-P2-109-111	1.25-4.45m bgl	To confirm the shallow ground conditions across the site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and geoenvironmental parameters and installation of gas/groundwater monitoring wells.
Cable percussion and Rotary boreholes	BH-P2-104 to BH-P2-106	20.30- 28.50m bgl	To confirm the deep ground conditions across the site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and geoenvironmental parameters and installation of gas/groundwater monitoring wells.
Hand dug pits	TP-P2-101 TP-P2-103	1.00-1.10m bgl	To confirm the shallow ground conditions across the site, relatively shallow groundwater presence and rate of inflow, stability of excavations, and to enable shallow soil sampling for geotechnical and geoenvironmental parameters.
Soakaway pits	SA-P2-101	2.30m bgl	To assess the infiltration characteristics of the underlying soils for the purpose of surface water drainage, including determination of soil permeability, identification of groundwater presence or perched water tables and to inform suitability and sizing of sustainable drainage systems.



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Table 5-2 Scope of Monitoring Installations

Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
BH-P2-104	Bedrock	13.00-25.00m	Targeting deeper groundwater body.
BH-P2-105	Bedrock	6.00-20.00	Targeting deeper groundwater body.
WS-P2-106	Made Ground	1.00-3.00	Targeting shallow Made Ground gas source
WS-P2-107	Made Ground	1.00-2.00	Targeting shallow Made Ground gas source
WS-P2-109E	Made Ground	1.00-2.00	Targeting shallow Made Ground gas source
WS-P2-110	Made Ground	1.00-4.00	Targeting shallow Made Ground gas source
WS-P2-111	Made Ground	0.50-1.00	Targeting shallow Made Ground gas source

Additional fieldwork was undertaken between 27th October and 29th October 2025 for the 'trackside' element of the works that could only be undertaken during the planned shutdown of the metro tracks and platform during this time period. This was supervised by a suitably qualified Tier Environmental engineer. Originally 2 No. rotary boreholes were planned during the planned shutdown period, however due to access and time constraints during the planned shutdown period, only location BH-P2-106 could be undertaken.

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

5.2. Geoenvironmental Testing

Sampling and QA/QC protocols are presented in Appendix K. Tier Environmental's schedule of chemical laboratory testing is presented in Table 5-3. and Table 5-4. The testing was carried out by Element Materials Technology, a UKAS and MCerts (where appropriate for soils analysis) accredited laboratory.

Human Health and Preliminary Waste Classification Laboratory Testing

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

- Determine the concentration and spatial distribution of potential contaminants of concern in the Made Ground;
- Determine the chemical composition and properties of the shallow natural soils;
- Undertake a *preliminary* soils waste classification and waste disposal route determination.

Table 5-3 Schedule of Chemical Testing for Human Health Risk Assessment and Preliminary Waste Soils Assessment.

Laboratory analysis	Asphalt	MG11	MG2	MG3	MG4	MG5	Trackside Borehole
Tier Environmental soil suite*	0	6	2	2	1	0	2
Additional metals (Mn, B, Fe)	0	6	2	2	1	0	2
Asbestos screen	0	12	3	3	2	1	3



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Laboratory analysis	Asphalt	MG11	MG2	MG3	MG4	MG5	Trackside Borehole
Speciated TPH / BTEX / MTBE	0	3	1	1	0	0	2
VOCs / SVOCs	0	3	1	1	0	0	0
PCBs	0	3	1	1	0	0	1
Total, free and complex cyanides	0	6	2	2	1	0	2
Organochlorine and Organophosphorus Pesticides	0	1	0	0	0	0	1
Acid Herbicides	0	1	0	0	0	0	1
Triazine Group (inc. atrazine and simazine)	0	1	0	0	0	0	1
Ammoniacal Nitrogen as N	0	6	2	2	1	0	2
Waste Acceptance Criteria (WAC)	0	5	1	2	1	0	2
Coal tar suite	1	0	0	0	0	0	0

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

Controlled Waters Laboratory Testing

Based upon the conclusions of the preliminary risk assessment, Tier Environmental scheduled chemical laboratory testing on selected soil leachate samples. The purpose of the testing was to determine the concentration and spatial distribution of potential leachable contaminants of concern in the Made Ground.

Table 5-4 Schedule of Chemical Testing for Controlled Waters Risk Assessment.

Laboratory analysis	MG3	MG4	Trackside Borehole
Tier Environmental leachate suite*	1	1	1
Leachate: Additional metals (Mn, B, Fe), TPH CWG, pH, Free, Total and Complex Cyanide & Ammoniacal Nitrogen as N	1	1	1

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

5.3. Geotechnical Testing

Geotechnical laboratory testing was scheduled by Tier Environmental on selected samples as presented in Table 5-5. The testing was performed by Murray Rix Laboratories, a UKAS accredited laboratory. Test certificates including details of appropriate testing standards are presented in Appendix D and discussed in Section 7, below.

Table 5-5 Geotechnical Laboratory Testing Schedule.

Test	Stratum type	Number of tests	Rationale
1. Classification			
Moisture content & Atterberg limit	Made Ground	11	a) Volume change potential.
	Till (Clay)	3	b) Plasticity assessment (comply with Eurocode 7 description)
	Mudstone	1	c) Consistency Index. d) Determine soil type (e.g., clay/silt). e) Use as an empirical guide to soil shear strength



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Test	Stratum type	Number of tests	Rationale
Particle size distribution (wet/dry sieve)	Made Ground	2	a) Classify soils for earthworks purposes. b) Establish type of soil (comply with Eurocode 7 description).
	Till (Clay)	3	
Particle size distribution (sedimentation)	Till (Clay)	1	
2. Chemical tests			
BRE SD1 Suite	Made Ground	5	Determine correct class of concrete for both natural and made ground with specific tests for sites potentially containing sulphides (e.g., pyrites) or at low ph.
	Till (Clay)	3	
	Mudstone	3	
Calorific Value	Mudstone	1	
	Coal	1	
3. Compaction			
2.5 kg rammer dry density/moisture content relationship test	Made Ground	1	Establish maximum dry density and optimum moisture content of materials to assess suitability for reuse within earthworks
	Till (Clay)	1	
4 .Compressibility			
One-dimensional consolidation	Till (Clay)	2	Determine the long term consolidation behaviour of cohesive soils.
5. Shear strength (total stress)			
Unconsolidated undrained triaxial (“quick undrained triaxial”)	Till (Clay)	2	Quantitative means of determining undrained shear strength of soils for: a) use in bearing capacity calculations; b) modelling the short term behaviour of slopes and retaining structures; c) pile design; d) determining suitability of cohesive materials for vibro-replacement ground improvement techniques.
Unconsolidated undrained triaxial - multistage	Till (Clay)	1	
6. Rock Testing			
Point Load Test	Mudstone	32	Quantitative or index means of determining rock strength for: a) use in bearing capacity calculations; b) pile design c) Suitability of pile types during boring through rock
Unconfined Compressive Strength Testing	Mudstone	6	



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6. GROUND CONDITIONS

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

6.1. Strata Descriptions

Made Ground – Hardstanding

Concrete	
Locations encountered	WS-P2-101 to 103, BH-P2-104
Depths encountered from top of stratum (range)	Ground level to 0.20m bgl
Depths encountered to base of stratum (range)	0.42m to 0.55m bgl
Thickness (range)	0.25m to 0.55m
Spatial location on site	Encountered in the west within the pavilion, under the tramway and on walkways. Overlain by block paving in 3 No. locations.
Asphalt	
Locations encountered	WS-P2-111, SA-P2-101
Depths encountered from top of stratum (range)	Ground level to 0.75m bgl
Depths encountered to base of stratum (range)	0.15m to 1.30m bgl
Thickness (range)	0.15m to 0.55m
Spatial location on site	Along the central walkway.

Made Ground – MG1

Locations encountered	WS-P2-101 to 110, BH-P2-104, 105, TP-P2-104 to 107, TP-WS-P2-108, SA-P2-101
Depths encountered from top of stratum (range)	Ground Level to 3.10m bgl
Depths encountered to base of stratum (range)	0.27m to 5.70m bgl
Thickness (range)	0.27m to 3.40m
Spatial location on site	Widespread across the site, thickest in the area of the walkway.
General description	Typically a brown to grey gravelly silty variably sandy Clay with slag, clinker, brick, limestone and concrete, and variable cobble content of brick, sandstone and concrete.

Made Ground – MG2

Locations encountered	WS-P2-104 to 105C, WS-P2-109E to 110, BH-P2-104 to 105, TP-P2-101 to 103
Depths encountered from top of stratum (range)	Ground level to 2.70m bgl
Depths encountered to base of stratum (range)	0.90m to 3.10m bgl



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Thickness (range)	0.30m to 1.00m
Spatial location on site	Encountered within the walkway and paved parking area, locally within the pavilion.
General description	Orange brown to brown and locally black clayey sandy Gravel of brick, coal, mudstone, clinker, concrete and sandstone.

Made Ground – MG3

Locations encountered	BH-P2-105, TP-P2-101, TP-P2-103, SA-P2-101
Depths encountered from top of stratum (range)	Ground level
Depths encountered to base of stratum (range)	0.12m to 0.50m bgl
Thickness (range)	0.12m to 0.50
Spatial location on site	Located mainly in the paved parking area, and locally in the eastern walkway and pavilion.
General description	Dark greyish brown slightly gravelly, clayey Snad with brick, mudstone and other mixed lithologies.

Made Ground – MG4

Locations encountered	WS-P2-101, WS-P2-111
Depths encountered from top of stratum (range)	0.15m to 0.42m bgl
Depths encountered to base of stratum (range)	0.60m to 2.25m bgl
Thickness (range)	0.18m to 2.25m
Spatial location on site	Recorded thickest under the tramway in the centre of the site.
General description	A subbase type material of grey clayey sandy Gravel of sandstone and limestone.

Made Ground – MG5

Locations encountered	TP-WS-P2-108
Depths encountered from top of stratum (range)	2.35m bgl
Depths encountered to base of stratum (range)	2.60m bgl
Thickness (range)	0.25m
Spatial location on site	Located in one area of the walkway
General description	Dark grey sandy Silt with organic odour.



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Drift Deposits – DD1

Till - Clay	
Locations encountered	WS-P2-104, 107, 109E, BH-P2-104, BH-P2-105, TP-P2-102, 106, TP-WS-P2-108
Depths encountered from top of stratum (range)	0.27m to 13.70m bgl
Depths encountered to base of stratum (range)	>1.50m to 15.20m bgl
Thickness (range)	>0.40m to 7.30m
Spatial location on site	Anticipated to underly the entire site
General description	Brownish grey variably sandy and gravelly Clay where the gravel is sandstone and quartzite.

Drift Deposits – DD2

Till - Gravel	
Locations encountered	BH-P2-104, BH-P2-105, TP-P2-107
Depths encountered from top of stratum (range)	0.40m to 13.00m bgl
Depths encountered to base of stratum (range)	1.00m to 14.70m bgl
Thickness (range)	>0.60m to 2.40m
Spatial location on site	Interbedded within the wider cohesive Till
General description	Very dense lightly brown clayey Gravel of sandstone and cobble of sandstone.

Bedrock – BR1

Lower Pennine Coal Measures	
Locations encountered	BH-P2-104, BH-P2-105
Depths encountered from top of stratum (range)	9.50m to 15.20m bgl
Depths encountered to base of stratum (range)	25.70m to 30.00m bgl
Thickness (range)	>10.50m to >20.50m (base not proven)
Spatial location on site	Anticipated to underly the entire site
Description of dip	Not determined
Voids / recovery	Good recovery throughout
General description	Generally weak to extremely weak thinly laminated dark grey Mudstone, with hard grey Sandstone from circa 20-26m bgl in BH-P2-105. Initially weathered from 15.20m to 16.20m bgl in BH-P2-104.

6.2. Strata Description – Trackside (BH-P2-106)

BH-P2-106 recorded Made Ground comprising railway ballast with varying clay and sand content from the surface to a depth of 1.50m bgl, underlain by further Made Ground comprising clayey, slightly gravelly fine to medium grained sand, with gravel comprising sandstone to 3.00m bgl. It should



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be noted that a trial pit had been reported to have been excavated to approximately 1.60m bgl in this location previously by the client for possible service location (none found), and that due to the dense gravel causing repeated refusal of the dynamic sampler rotary openhole had to be undertaken between 1.20m and 3.00m bgl, with strata descriptions obtained from SPT samples only. Further possible Made Ground was encountered from 3.00m bgl to 3.50m bgl, comprising stiff sandy, gravelly clay.

Granular superficial deposits comprising sandy gravel were recorded from 3.50m bgl to 5.00m bgl, underlain by cohesive superficial deposits comprising stiff to very stiff slightly gravelly clay to a depth of 8.00m bgl. Extremely weak to medium strong, thinly laminated mudstone, occasionally interbedded with sandstone, was encountered from 8.00m bgl to the base of the borehole at 28.50m bgl, with an intact coal seam encountered between 22.85m to 23.22m bgl (0.37m thickness).

No obstructions or evidence of contamination was encountered within BH-P2-106, and the groundwater strikes could not be recorded due to the use of water flush during drilling.

6.3. Obstructions

The following potential underground Services / obstructions were encountered during the ground investigation works.

Table 6-1 Underground Services / Obstructions Summary Table

Exploratory Hole Location	Location on Site	Depths recorded from (m bgl)	Depth of Base of Feature (m bgl)	General description and comments
TP-P2-104	East/Central	1.40	1.60	Brick wall and paving slabs recorded
TP-P2-107	East/Central	1.00	N/A	Service
WS-P2-109A	East	0.80	ND	Concrete cobble
WS-P2-109B	East	0.76	ND	Concrete cobble
WS-P2-109C	East	0.62	ND	Concrete cobble
WS-P2-109D	East	0.38	ND	Concrete cobble
WS-P2-109E	East	0.60	0.90	Large concrete cobble

ND Not Determined

6.4. Visual and Olfactory Evidence of Contamination

A summary of visual and/or olfactory evidence of contamination noted during Tier Environmental investigations is summarised in Table 6-2 below:

Table 6-2 Visual and/or Olfactory Evidence of Contamination Summary

Exploratory Hole Location	Depth Range (m bgl) Encountered From	Depth Range (m bgl) Encountered To	Location on Site	Description
WS-P2-109E	1.30	2.00	East	Strong hydrocarbon odour
SA-P2-101	0.60	0.75	East	Slight organic odour associated with timber
	0.75	1.30	East	Slight hydrocarbon odour



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6.5. Groundwater Observations During Fieldwork

Table 6-3 below provides a summary of the groundwater observations during the fieldworks. Further information of groundwater observed is presented in the exploratory hole logs in Appendix B.

Table 6-3 Field Observations of Groundwater.

Exploratory hole	Strike (m bgl)	Rise in groundwater after 20 mins. (m bgl)	Formation	Observations
BH-P2-104	13.00	Undetermined	Granular Till	Rose to ground level overnight
BH-P2-105	7.50	No rise	Cohesive Till	None
	9.50	8.50	Mudstone	None
SA-P2-101	1.40	No rise	Made Ground	Seepage
WS-P2-103	Ground level	-	Made Ground	Flowing out at surface
WS-P2-104	1.80	No rise	Made Ground	None
WS-P2-110	3.70	No rise	Made Ground	None
WS-P2-111	0.60	No rise	Made Ground	None

6.6. Groundwater Monitoring

Table 6-4 below provides a summary of the groundwater monitoring results conducted to date. In total, 1 No. visit has been carried out on the 4th April 2025.

Table 6-4 Groundwater Monitoring Results Summary

Exploratory hole	Response Zone	Depth range (m bgl)	Formation
BH-P2-104	13.00-25.00m	12.29	Till
BH-P2-105	6.00-20.00	7.31	Till
WS-P2-111	0.50-1.00	0.78	Made Ground
WS-P2-109E	1.00-2.00	1.13	Made Ground
WS-P2-110	1.00-4.00	Dry	N/A
WS-P2-106	1.00-3.00	Dry	N/A
WS-P2-107	1.00-2.00	Dry	N/A



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7. COAL MINING RISK ASSESSMENT

7.1. Review of Available Historical Information

Geology

The published geological maps of the area show the site to be underlain Till Deposits and Glaciofluvial Deposits. The site is shown to be located within an area of 'worked ground' with areas of 'infilled ground' in the east and western edges of the south of the site. Bedrock comprises the Pennine Lower Coal Measures consisting of a sequence of mudstones, siltstones and sandstones, locally with horizons of coal. Generally, the mudstone comprises dark grey fissile organic rich fine-grained sediments.

7.2. Faulting

The wider Bury region contains multiple faults trending in a northwest to southeast direction. There are no faults shown directly underlying the site, the closest fault is located approximately 125m to the east. None are recorded within the immediate vicinity of the site; however, it is considered likely that further smaller faults are present. Faulting is therefore not considered to present any potential significant risk to the development.

7.3. Bedrock Inclination

Based on the Memoirs of the Geologic Survey of Great Britain for the Bury District (1911) and the BGS Maps show the strata recorded as having a 1 in 5 inclination to the southwest and west regionally.

7.4. Arley Mine

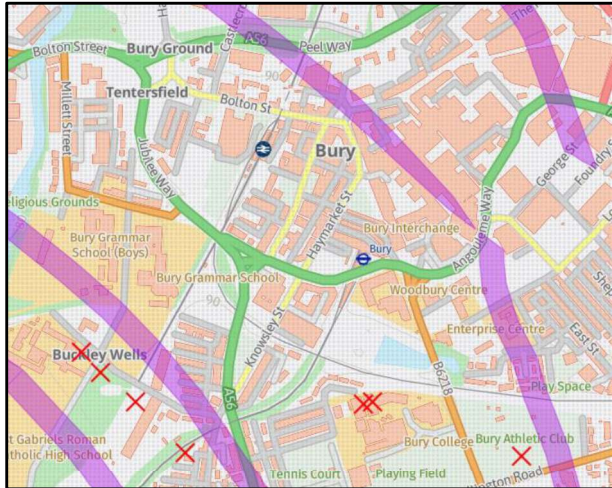
The Arley Mine Coal Seam, is present subcropping 140m east of the site with a NNW-SSE strike. The seam is not recorded as worked in this vicinity; however it appears to be worked 200-300m south of the site. The seam is recorded at 1.20m thick. The average thickness throughout the wider coalfield was 3 feet (0.91 m) to 4 feet (1.2 m). It is recorded in the geological memoirs as producing excellent quality coal for coking, house and steam coal. The Arley Mine was worked throughout the coalfield and around Tyldesley was a hot mine.



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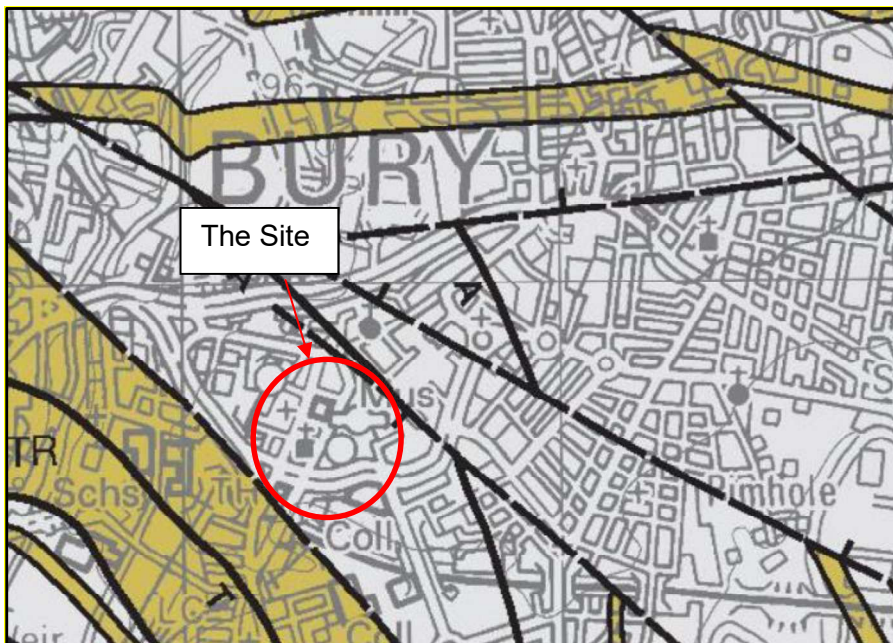
Figure 7-1 Mining Remediation Authority Map Showing Outcrop of Arley Mine Seam



The coal from the Arley Mine is considered to be of economic importance in the area and has been extensively worked across the wider region. The Mining Remediation Authority do not record the Arley Mine Seam as having a history of spontaneous combustion.

7.5. BGS Mapping Records

Figure 7-2 BGS 1:50,000 Map Manchester

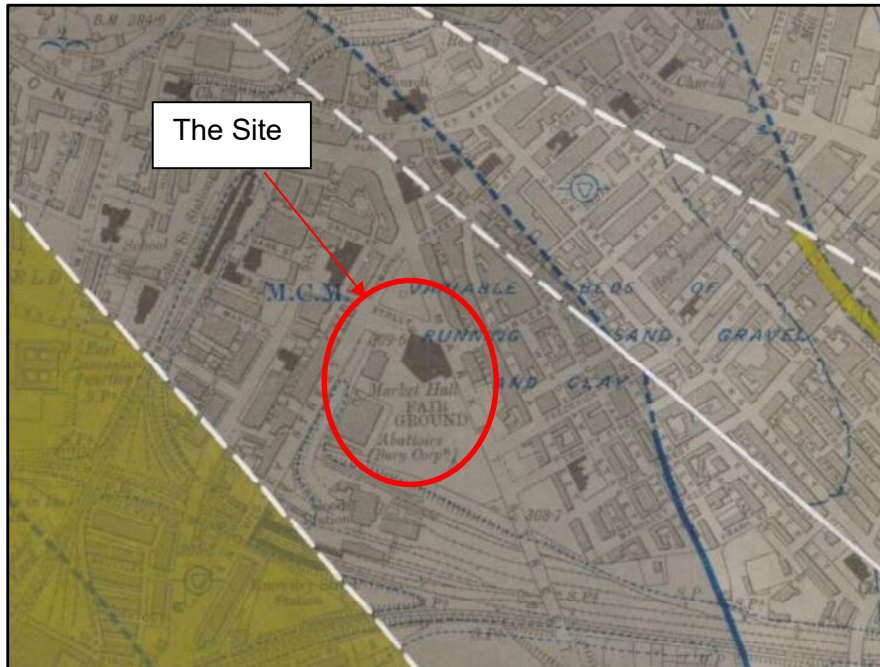




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Figure 7-3 BGS 1:10,560 County Series Lancashire 88SW



7.6. Mining Remediation Authority Records

Tier obtained a CON29M (Ref. 51003464039001) from the Mining Remediation Authority. A summary of this is provided below.

Table 7-1 Coal Mining Report Summary

	Yes/No	Comments
Past underground mining	No	The property is not within a surface area that could be affected by any past recorded underground coal mining
Mine entries	No	There are no recorded coal mine entries known to the Mining Remediation Authority within, or within 20 metres, of the boundary of the property. It is noted on the Mining Remediation Authority viewer that a mine entry is recorded circa 100m south of the site.
Opencast mines	No	The property is not within the boundary of an opencast site from which coal has been removed by opencast methods.
Coal mining subsidence	No	The Mining Remediation Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994.
Mine gas	No	The Mining Remediation Authority has no record of a mine gas emission requiring action.



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	Yes/No	Comments
Future underground mining	No	The property is not in an area where the Mining Remediation Authority has received an application for, and is currently considering whether to grant a licence to remove or work coal by underground methods. It is acknowledged that reserves of coal exist in the local area which could be worked at some time in the future however this scenario is unlikely.
Withdrawal of support notices	No	The property is not in an area where a notice to withdraw support has been given. The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.
Payments to owners of former copyhold land	No	The property is not in an area where a relevant notice has been published under the Coal Industry Act 1975/Coal Industry Act 1994.

Table 7-2 Coal Mining Activities.

	Yes/No	Comments
Is the site in an area of potential shallow coal workings?	Yes	The wider site is within an area of potential shallow coal workings.
Is the site in a high risk development area?	No	Source: The Mining Remediation Authority
Are there any known shafts, adits, tips, lagoons, or opencast workings likely to affect the site?	No	Source: The Mining Remediation Authority
Is exploratory work required to investigate the potential risk from shallow mining or quarrying?	No	None required.

Subcrops

The Arley Seam is shown to subcrop 140m east of the site with a bearing of 126°, the seam is recorded as having a workable thickness. The proximity of this subcrops increases the possibility of unrecorded mine workings and unrecorded mine entries in the vicinity of the site.

Mine Entries

No mine entries are recorded within 100 metres of the site. The closest mine shafts are a series of 3 No. shafts south of the site. Shafts No. 380410-002 and 380410-003 are located 250m south of the site. Shaft No. 380410-004 is located 500m south of the site. The BGS county series map shows the Arley Mine depth in shaft 380410-004 at 91.5 ft (28m). This indicates the shaft was a minimum of 28m deep and it is likely that the shaft was used to retrieve coal from the Arley Mine. All 3 No. shafts are located within the same fault block as the site. No further details are provided within Mining Remediation Authority records or on BGS records relating to these mine entries.

Opencast Mines

The Mining Remediation Authority records, and historical Ordnance Survey plans do not show any opencast coal mines within 500 metres of the site boundary.



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Investigation and Remedial Works

No site investigations were recorded within 50m of the enquiry boundary.

A search on the planning portal did not yield any useful information or previous reports.

No remedial works are recorded by the Mining Remediation Authority within 50m of the site.

Coal Mining Subsidence

The Mining Remediation Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994.

There is no current Stop Notice delaying the start of remedial works or repairs to the property.

The Mining Remediation Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.

Mine Gas Management Schemes and Emissions

The Mining Remediation Authority does not have any records of mine gas management schemes within 500m of the site.

The Mining Remediation Authority has no record of mines gas emission requiring action.

Mine Water Treatment Schemes

The Mining Remediation Authority does not have any records of mine water treatment schemes within 500m of the site.

Licensing and Future Mining Activity

The Mining Remediation Authority does not have any records pertaining to any planned future underground mining, coal mining licences, court orders, Section 47 notices (stating that the land is at risk of subsidence) or payments to owners of former copyhold land.

7.7. Intrusive Investigations

General

The Mining Remediation Authority records indicate that a total of 1 No. coal seam is outcropping in the vicinity of the site, 140m east with a NNW-SSE strike. It is considered that the risk of unrecorded shallow coal mining subsidence relating to this coal seam is low, with the potential of having an influence at surface for the proposed development. At this distance from site the coal seam should pass beneath the site in excess of 20m below rockhead.

To confirm the low risk, a series of rotary boreholes were undertaken, to identify the nature and extent of any unrecorded shallow coal mining. For the purpose of this investigation, these boreholes were taken to a minimum depth of 20m below rockhead in line with industry best practice and providing in excess of 10x seam thickness of bedrock cover, should any worked seams be present in excess of that depth.



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The ground investigation was targeted using the proposed layout and prevailing geological conditions underlying the site.

Coal Seams Encountered

A summary of the encountered intact coal seams encountered during all the known investigations for the site is given in Table 7-3.

Table 7-3 Summary of Observed Coal Seams

Borehole ID	Depth of Coal Seam (bgl/m AOD)	Thickness (m)	Observations/ Descriptions
BH-P2-105	18.50-18.80 / 69.60- 69.30	0.30	Extremely weak, thinly laminated, dark greyish black COAL
BH-P2-106	22.50 to 23.22 / 68.50 to 67.80	0.70	Soft bands / coal seams
	22.85 to 23.22 / 68.15 to 67.78	0.37	Extremely weak to weak, black shiny COAL recovered as fine to coarse, angular gravel sized pieces

Coal was not encountered within BH-P2-104, which was drilled to 25.70m bgl.

Evidence of Potential Shallow Mineworkings

A summary of the evidence of potential shallow mineworkings is presented in Table 7-4.

Table 7-4 Summary of Possible Evidence of Mineworkings

Borehole ID	Depth of Evidence (m bgl / m AOD)	Observations / Drillers Notes
BH-P2-105	18.50-18.80 / 69.60- 69.30	60% flush returns recorded within coal seam
BH-P2-106	22.50 to 23.22 / 68.50 to 67.78	95% flush returns. Soft bands reported by drillers above the coal seam recorded at 22.85 to 23.22m bgl

Surface Subsidence

No evidence of surface subsidence was observed at the site.

Opencast Workings

During investigations, no evidence of opencast workings has been identified.

Unrecorded Mine Entries

During investigations, no unrecorded mine shafts have been identified. However, due to the subcropping coal seam, it is considered possible that unrecorded mine entries (bells pits, shafts or adits) are present at the site.



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Gas and Minewaters

During site works no emissions of ground gas or minewaters were recorded.

7.8. Coal Mining Risk Assessment

Based on the available information, the following possible hazards are shown to be potentially present and have been considered in detail:

- Subcropping Coal Seam;
- Unrecorded Shallow Coal Mineworkings; and,
- Unrecorded Mine Entries.

Detailed consideration has been given to the severity of these hazards and is discussed below.

Arley Mine Seam

The Arley Mine, is shown on BGS Maps as subcropping 140m east of the site with a NNW-SSE strike and recorded as dipping towards the south-west and west with an average dip of 11°. Therefore, the coal seam is present at greater depths in the south and southwest of the site. It is considered that approximately 65m southwest of the inferred outcrop seam location that there would be sufficient depth of overburden/bedrock to mitigate the risk from any workings within the seam. On BGS maps the location of the Arley Mine due southeast and east of the site is marked in a solid line, indicating the position is known with some confidence, further north the Arley Seam is marked with a dotted line indicating the position of the seam is inferred. Due to the mine shafts present south of the site that intercept the Arley Mine and the confirmed position of the seam, it is considered likely that the Arley Mine has been worked south and east of the site.

Within borehole BH-P2-105, a thickness of 0.30m coal was encountered between 18.50m and 18.80m bgl, with flush returns dropping to 60%. Within borehole BH-P2-106, soft bands/coal seams were recorded by the drillers between 22.50m and 23.20m, overlying coal with a thickness of 0.37m, with 95% flush returns recorded throughout both. It is considered unlikely that the coal encountered at these locations is the Arley mine as it appears around 300m west of the location shown on geological maps, but it is possible that the fault to the north of the site has faulted the position of the seam. Notwithstanding the above and even if the aforementioned seam is not the Arley Mine, it is still a coal seam of workable thickness present subcropping within the site.

However, at these depths and thicknesses, and using 10 times seam thickness to calculate the required thickness of competent rock cover above the coal seam, it is considered that there is sufficient competent cover above the seams encountered within both BH-P2-105 and BH-P2-106 should any workings be present, as detailed within Table 7-5 below.

Table 7-5 Competent Cover Between Rockhead and Coal Seams

Location	Depth to Rockhead (m bgl)	Depth to Coal Seam (m bgl)	Thickness of Coal Seam (m)	Thickness of Competent Cover Required Between Rockhead and Coal Seam (m)	Thickness of Competent Cover Present Between Rockhead and Coal Seam (m)
BH-P2-105	9.50 (78.60m AOD)	18.50 (69.60m AOD)	0.30	3.00	9.00
BH-P2-106	8.00 (83.00m AOD)	22.50 (68.50m AOD)	1.07 (including soft bands/coal seams recorded above coal	10.70	14.50



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As competent cover is present above the coal seam, remedial works such as grouting are not considered necessary for the Pyramid Park, Trackside and Union Square locations of the site. It should be noted that grouting is required elsewhere within the wider site, for which the Ground Investigation Report for Bury Interchange – Bus Interchange Concourse (Ref: 16012-TRE-BRY-XXX-RP-EN-000006 REV.P01, dated 24 November 2025) should be referred to for further information.

Unrecorded Mineworkings

No definitive evidence of unrecorded workings was identified during the ground investigation; however, loss of flush and poor recovery was observed and is summarised in Table 7-4. These observations alone do not provide enough evidence to confirm the presence or absence of unrecorded workings. The observations could also be indicative of fractures and weak rock. The solid coal recovered varied in thicknesses and with soft ground/coal seams recorded immediately above in BH-P2-106, implying the coal could have historically been removed, or alternatively, this may be representative of local geological thickening and thinning.

As detailed above, there have been multiple observations that indicate it is possible that there are unrecorded shallow mineworkings present underlying the site and within the wider site. Due to the high risk associated with shallow mineworkings from crown hole collapse and large differential settlements, a precautionary approach must be undertaken if the presence of shallow mineworkings cannot be categorically ruled out. Taking into account the similar depth that the features were observed in the boreholes, the varying thickness and depth that coal was encountered in each borehole, the loss of flush, the areas of no recovery and very poor recovery, the similarity with assumed coal depths and evidence of workings, the highly fractured nature of this rock horizon and the shallow recorded coal seams, it is considered possible that there are shallow unrecorded mineworkings present underlying the site.

As a precautionary measure and to try to confirm whether mineworkings are present, it is recommended to undertake an additional phase of ground investigation. Advancing further rotary open hole boreholes to obtain more evidence to assist this risk assessment.

Local geological thickening, faulting and folding cannot be discounted so a risk remains of additional unrecorded coal seams underlying the site and therefore further potential unrecorded workings.

Unrecorded Mine Entries

There are no mine entries recorded within 100m of the site. The closest recorded mine entries lay 250m southwest of the site; no records of treatment or capping of these features are held by the Mining Remediation Authority.

Due to the shallow depth of the coal seam and potential mineworkings present underlying the site, the risk of further unrecorded mine entries remain.

All mine shafts that remain untreated should be assumed to have a high risk of collapse, especially older shafts. Furthermore, even infilled shafts may have been incorrectly stabilised and should be identified during the exploratory works. At a minimum, attempts should be made to identify the shaft prior to development. Furthermore, due to the history of coal mining in the wider area, it is considered that there is a moderate risk of unrecorded shafts being present within the site boundary, as such:

The developer should be aware of the risk of unrecorded shafts being present and be aware that any shaft found could result in construction delays, treatment (infilling and capping) and/or modifications to the intended layout.

Inspections of all attenuation and service excavations should be undertaken where possible.



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Opencast Mining

There are no records of any opencast mining at the site. Due to the vicinity of the site in Bury town centre it is considered unlikely that the site has been opencast at any time in the past. Due to the thickness of superficial soils, it would also be very difficult to opencast the site. Therefore the risk associated with opencast mining is very low.



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Table 7-6 Summary of Coal Mining Risk Assessment and Mitigation

Issue	Hazard	Site Affected (Yes/No) (Detail where appropriate)	Consequences (Where appropriate)	Recommended Mitigation Measures (Where appropriate)
Are there any recorded coal mine entries within the site or within 20m of the site boundary?	Catastrophic collapse of mine entry leading to ground instability or voids at the ground surface. Settlement of the ground surface above/adjacent to the mine entry. Mine gas emissions.	No	N/A	N/A
Is there a possibility of unrecorded mine entries?	Ground subsidence. Ground instability, loss of ground, generation of crown holes. Catastrophic collapse of mine entry leading to ground instability or voids at the ground surface. Settlement of the ground surface above/adjacent to the mine entry. Mine gas emissions.	Yes	Catastrophic ground loss above and in the vicinity of the mine entry.	Development works should anticipate unrecorded mine entries within the site's boundaries. If encountered, the locations should be accurately recorded, and they should be treated according to the condition of the entry and proposed end use. All excavations should be inspected for the potential presence of unrecorded mine entries. The potential for unrecorded mine entries to be present should be considered by all parties involved with intrusive works on site. Appropriate methods of working should be adopted. Appropriate contingency plans should be prepared in the event that an unrecorded mine entry is located.
Is the proposed development in the likely zone of influence of any present unrecorded underground mine workings?	Ground subsidence. Ground instability, loss of ground, generation of crown holes.	No	Ground subsidence associated with unrecorded shallow underground mining may result in ground instability and damage to property, new structures and infrastructure. Harm to human health, injury or death of maintenance operatives or construction workers using the site.	A minimum of 10 times seam thickness is present above the encountered coal seams, and therefore if this unknown seam has been worked sufficient competent cover is present for remedial works not to be required.



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Issue	Hazard	Site Affected (Yes/No) (Detail where appropriate)	Consequences (Where appropriate)	Recommended Mitigation Measures (Where appropriate)
Is the proposed development within the likely zone of influence of recorded underground workings at shallow depth (depths of less than 30m below rockhead)?	Ground subsidence. Ground instability, loss of ground, generation of crown holes.	No recorded workings underlying the site	N/A	N/A
Is the proposed development in the likely zone of influence of past deep underground mining?	Ground subsidence. Ground instability.	No recorded workings underlying the site	N/A	N/A
Is there a record of mine gas emissions within the site boundary?	Mixtures of noxious of explosive gases reaching the ground surface via superficial deposits, faulted/broken strata or poorly filled mine entries and entering structures, services, confined spaces, etc, when an explosive or asphyxiating hazard may be generated.	There are no records by the Mining Remediation Authority; however, the presence of potential shallow coal workings, means there is a risk of ground gas emissions within the site.	Harm to human health, injury or death of construction workers and site maintenance personnel. Damage to property and infrastructure.	As there are no proposed enclosed spaces, a Mine Gas Risk Assessment is not necessary.
Is the proposed development in an area for which the Mining Remediation Authority is determining or has granted a license to remove coal by underground methods?	Ground subsidence. Ground instability.	No	N/A	N/A
Are there known faults or other lines of weakness (e.g. fissures) due to mining at the site?	Ground subsidence. Mixtures of noxious of explosive gases reaching the ground surface via faulted/broken strata and entering buildings, structures, confined spaces etc, when an explosive or asphyxiating hazard may be generated. Stepped rockhead profiles where there has been subsidence across faults, impacting settlement of proposed structures.	No	N/A	N/A
Is there a risk of spontaneous combustion?	Spontaneous combustion of opencast backfills materials if they include significant volumes of coal.	No	N/A	N/A
Has the site been subject to remedial works by, or on behalf of, the Mining Remediation	Ground subsidence.	No	N/A	N/A



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Issue	Hazard	Site Affected (Yes/No) (Detail where appropriate)	Consequences (Where appropriate)	Recommended Mitigation Measures (Where appropriate)
Authority under its surface hazard call out procedures?				
Is the proposed development within the boundary of a surface mining/opencast site from which minerals have been removed by surface mining/opencast methods?	Ground subsidence. Mixtures of noxious of explosive gases reaching the ground surface via superficial deposits, faulted/broken strata or poorly filled mine entries and entering structures, confined spaces etc, when an explosive or asphyxiating hazard may be generated.	No	N/A	N/A
Is the proposed development within 200m of a surface mining/opencast site from which minerals are being removed?	Development constraints associated with environment/noise/dust.	No	N/A	N/A
Assessment of Cumulative Impact Coal Mining Issues: The site is not situated within a development high risk area. There is a subcropping coal seam that passes under the site, unrecorded workings and unrecorded mine entries cannot be ruled out. Coal seams of workable thickness are known to be present at underlying the site, however competent rock cover in excess of 10 times the seam thickness is present between rockhead and the coal seam in both locations and therefore remedial measures such as grouting are not considered necessary. The potential presence of workings within these seams and the associated ground stability hazard is therefore considered to present a low risk to future development in parts of the site. There are no records of mine gas emissions requiring action by the Mining Remediation Authority within the boundary of the property. Good engineering practice developed for mining areas should be applied at all stages of the development. The sensitivity of the proposed development and any mitigating factors are, however, recommended to be considered in regard to the identified potential risks presented by the mining issues at the site. The following investigation actions are therefore identified: The potential for unrecorded mine entries that may exist on the site should be considered by all parties involved with any intrusive works on-site. Risks associated with unrecorded mine entries should also be considered during any construction work on site and appropriate methods of working and management should be adopted. Prior to carrying out any works which may intersect, disturb or enter any coal seams, coal mine workings or mine entries (within the ownership of the Mining Remediation Authority), the written permission of the Mining Remediation Authority shall be obtained (www.coal.gov.uk/services/permissions/index.cfm). Notes: N/A = Not Applicable				



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7.9. Conclusions

It is considered that the following coal mining activities present potential constraints to the proposed development:

- Low risk of unrecorded shallow mine workings;
- Low risk of unrecorded mine entries; and,
- Very Low risk associated with the unrecorded opencast coal workings.

7.10. Recommendations

Tier Environmental consider that there is currently a low risk posed by the potential shallow mineworkings and the shallow position of the Coal Seam underlying the site. As competent rock cover in excess of 10 times the seam thickness has been proven between rockhead and the coal seam in both locations where coal was encountered, remedial measures such as grouting are not considered necessary for the proposed development.



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9. PRELIMINARY GEOTECHNICAL ASSESSMENT

9.1. Determination of pH and Water-Soluble Sulphate

Consideration of Chloride and Nitrate

In accordance with BRE SD1 for ground suspected of containing mineral acids of industrial origin, a determination must be made as to whether Chloride (Cl) and Nitrate (NO₃) need to be analysed. In the event that they do, and elevated concentrations of Cl and NO₃ are reported, this may indicate that hydrochloric and nitric acids (HCl and HNO₃) are present. The effect of these acids on concrete is likely to be similar to that of sulfuric acid; so, for classification purposes, their chemically equivalent sulphate concentration should be calculated and added to any actual soluble sulphate present (as SO₄ mg/l) in the respective samples: SO₄ equivalent of Cl = Cl x 1.35mg/l SO₄ equivalent of NO₃ = NO₃ x 0.77mg/l.

Firstly a determination has been made as to whether a significant number of reported pH values are lower than pH 5.5. If they are, then amounts of chloride and nitrate (NO₃) should also be determined (in mg/l) in addition to sulphate content.

The conclusion of this assessment is that a significant number of pH values are not lower than pH 5.5 and so no further consideration of Chloride (Cl) and Nitrate (NO₃) needs to be conducted.

Consideration of Magnesium Levels

In accordance with BRE SD1, when the water soluble sulphate concentration or groundwater sulphate concentration is greater than 3000mg/l, an additional consideration of the level of magnesium is required.

In this instance, no reported concentrations of water soluble sulphate have been reported above 3,000mg/l and therefore no further consideration of magnesium has been made.

In accordance with BRE SD1, there is no need to take magnesium levels into account for natural ground – the ‘m’ suffix Design Sulphate Classes only apply to brownfield locations. This is because, in natural ground conditions in the UK, magnesium levels are invariably well below values that may significantly affect concrete.

Sulphide Bearing / Pyritic Ground Assessment

In accordance with ‘Concrete in aggressive ground’ Special Digest 1:2005 (Third Edition), Tier Environmental has first sought to establish whether the site lies within an area where pyrite bearing natural ground exists that could result in additional sulphate being converted from sulphides (particularly pyrite) during enabling works, earthworks and/or construction activities.

Firstly, the site location has been plotted on the extracted figure from BRE SD1 that shows the Principal Sulphate and Sulphide Bearing Strata in England and Wales, as shown on Figure 9.1 below.



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Figure 9.1 Site Location Plotted on Principal Sulphate and Sulphide Bearing Strata in England and Wales (Extracted from BRE SD1)

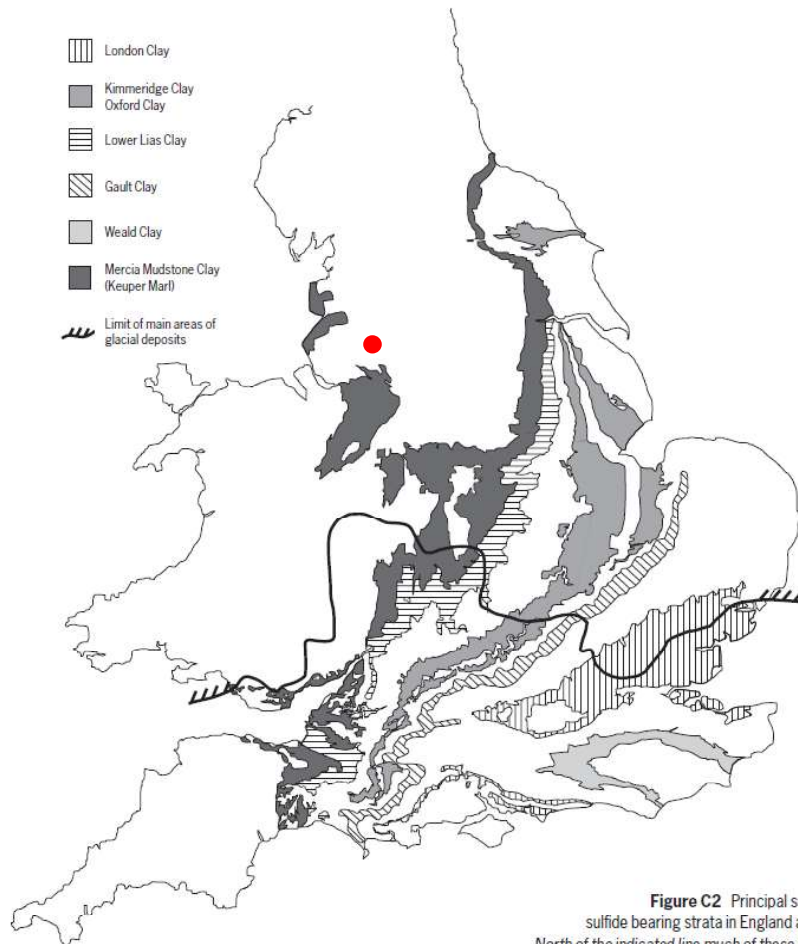


Figure C2 Principal sulfate and sulfide bearing strata in England and Wales
 North of the indicated line much of these strata are covered by glacial deposits which, if partly derived from the indicated strata, may also contain sulfates and sulfides

Secondly, an assessment has been made of the site's location relative to coal mining areas of Great Britain on the figure below. This has been done because these represent areas where sulphate bearing coal mining wastes and metal processing slags are most likely to be encountered.



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Figure 9.2 Site Location Plotted Relative to Coal Mining Areas of Great Britain (Extracted from BRE SD1)

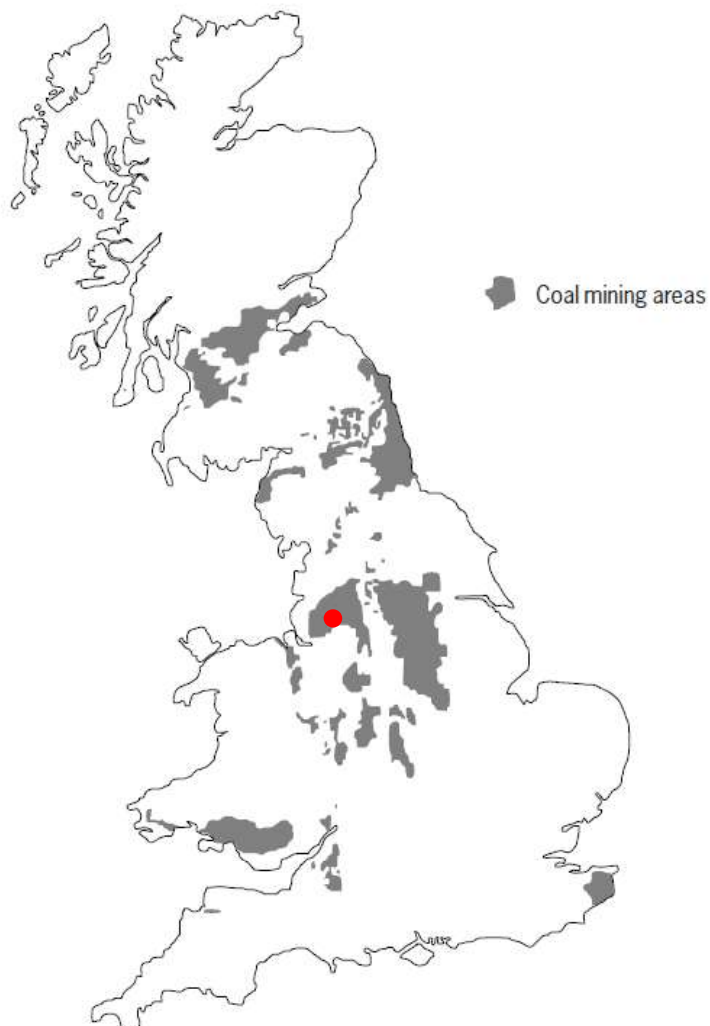


Figure C3 Coal mining areas of
Great Britain where sulfate bearing, coal mining wastes
and metal processing slags are most likely to be encountered

The table below has been developed to determine whether, based on the above assessment whether there is a possibility of sulphides in the ground (e.g. pyritic ground) that may be disturbed:



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Table 9-1 Assessment for Potential Sulphide Bearing (e.g. Pyritic) Ground

Question 1:	Question 2:	Question 3 (only relevant if answer to Question 2 is 'Yes'):	Question 4:	Question 5	Question 6	Conclusion of Assessment for Potential Sulphide Bearing Ground
From Figure 9.1, Does the Site Lie Within a Principal Sulphate and Sulphide Bearing Area?	From Figure 9.1, Does the Site Lie North of the Black Line Indicating Extent of Glacial Deposits ?	Is it considered that the Glacial Deposits beneath the Site are Partly Derived from a Sulphide Bearing Area (even if the answer to Question 1 is 'No')?	From Figure 9.2, Does the Site Lie Within a Coal Mining Area?	Is there any evidence of coal mining wastes beneath the site or metal processing slags (i.e. within the Made Ground)?	Does the proposed piled solution represent a scenario where the Coal Measures bedrock would be defined as 'disturbed ground' in accordance with BRE SD1 definition in Appendix A1?	The conclusion of the assessment is that there is not the potential for sulphide (e.g. pyritic) bearing ground to be 'disturbed' within the bedrock and therefore no further assessment of oxidisable sulphides in bedrock is required in accordance with BRE SD-1.
No	Yes	No	Yes	No	No. The definition of 'disturbed ground' specifically excludes "cutting through ground without opening up the ground beyond the cut face (e.g. piling operations or excavation without backfill)". It is understood that the proposed design for the lift shaft would require excavation to approx. 930mm below track level, and therefore would not expose/disturb bedrock. There will be no excavation within the bedrock for drainage, attenuation tanks, or other features.	



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Oxidisable Sulphides Calculation

Table 9-1 above has demonstrated that as there are no proposed excavations into the bedrock, the bedrock will not be disturbed and therefore there is not the potential for sulphide (pyritic) bearing ground to be disturbed within the bedrock. However, the Made Ground and Superficial Deposits will be disturbed, and therefore there is the potential for sulphide (e.g. pyritic) bearing ground to be 'disturbed' within both the Made Ground and Superficial Deposits. The table below has been prepared in order to further assess, based on the laboratory data, whether there is likely to be pyrite present which may oxidise if the Made Ground and Superficial Deposits are disturbed:

Table 9-2 Oxidisable Sulphides Calculations

Exploratory Hole Location	Depth (m bgl)	Total Sulphur (TS) Concentration (%)	Calculated Total Potential Sulphate (TPS) (%)*	Acid-Soluble Sulfate (AS) Concentration (%)	Calculated Oxidisable Sulphides (OS) (%)#
Made Ground					
WS-P2-105C	0.50-0.70	0.11	0.33	0.07	0.26
WS-P2-106	0.70-1.00	0.04	0.12	0.03	0.09
WS-P2-107	0.30-0.50	0.03	0.09	0.03	0.06
BH-P2-105	1.70-2.00	0.12	0.36	0.06	0.3
WS-P2-110	1.30-1.50	0.02	0.06	0.02	0.04
BH-P2-104	1.10-1.30	0.17	0.51	0.36	0.15
Superficial Deposits					
WS-P2-104	3.50-3.90	0.05	0.15	0.02	0.13
WS-P2-109E	2.50-3.00	0.04	0.12	0.02	0.1
BH-P2-105	8.10-8.50	0.16	0.48	0.03	0.45

Note: * TPS = 3 x total sulphur (TS % S). # OS = TPS - AS

Conclusion

A determination has been made as to whether the calculated Oxidisable Sulphides (%) are "greater than 0.3% for a significant number of samples", in accordance with BRE SD1 for the Made Ground and Superficial Deposits. The conclusion of this assessment is that a significant number of the samples of superficial deposits are in excess of 0.3% with respect to calculated Oxidisable Sulphides (%).

On this basis, this does indicate pyrite is present within the superficial deposits which may oxidise if ground is disturbed.

Design Sulphate Classification

Representative samples of the soils encountered during the Tier Environmental ground investigations, were tested to determine their pH and concentrations of water-soluble sulphate (SO_4^{2-}). The results are presented in Appendix C and summarised in Table 9-3 below. It is assumed that the site is a 'brownfield' site, and the groundwater is 'mobile' in accordance with BRE SD1.

The conclusion of the assessment is that a DS-2 and ACEC Class AC-2 is appropriate for buried concrete design purposes within Made Ground and natural soils, with due consideration of the sub-sections above (which include consideration of chloride, nitrate, magnesium and potential for sulphide bearing (e.g. pyritic) ground).

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



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Table 9-3 Results of Soil pH Testing and Water-Soluble Sulphate Determination

Exploratory Hole Location	Depth (m bgl)	pH	Water-soluble sulphate (mg/l)	Design sulphate class	ACEC sulphate class
Made Ground					
WS-P2-105C	0.50-0.70	7.97	105.6	>10 No. samples so mean of the highest 20% samples used as the characteristic value: 659 mg/l DS-2	>10 No. samples so mean of the lowest 20% samples used as the characteristic value: 7.3 AC-2
WS-P2-106	0.70-1.00	8.18	6.2		
WS-P2-107	0.30-0.50	8.21	15.2		
BH-P2-105	1.70-2.00	7.52	60.4		
SA-P2-101	0.80	7.06	94.9		
TP-P2-104	0.80	7.86	16.9		
TP-P2-106	0.10	7.42	48		
TP-P2-101	0.30	7.96	24.3		
WS-P2-101	0.45-0.60	10.12	1344.8		
WS-P2-110	1.30-1.50	8.06	19.4		
BH-P2-104	1.10-1.30	11.4	455		
BH-P2-104	3.20-3.50	10.14	179.9		
Till					
WS-P2-104	3.50-3.90	8.41	39.3	<5 No. results so highest value used: 39.3 mg/IDS-1 TPS value of 0.48% increase to DS-2	<5 No. results so lowest value used: 7.5 AC-1 TPS value of 0.48% increase to AC-2
WS-P2-109E	2.50-3.00	8.48	27.1		
BH-P2-105	8.10-8.50	7.5	29.5		
Mudstone (Wider Site)					
BH-P2-104	13.70-14.00	7.18	20.4	>10 No. results so mean of the highest 20% samples used as the characteristic value: 649 mg/l DS-2	>10 No. results so mean of the lowest 20% samples used as the characteristic value: 6.01 AC-2
BH-P1-101	22.10	9.12	15.6		
BH-P1-101	46.80	8.26	9.3		
BH-P1-103	25.00	8.07	470.1		
BH-P1-104	22.10	7.29	35.6		
BH-P1-104	23.00	8.55	6.5		
BH-P1-104	26.00	8.36	61.6		
BH-P1-105	17.60	8.49	24		
BH-P1-105	39.00	4.84	827.9		
BH-P1-107	16.70	7.88	148.4		
BH-P1-108	15.40	8.1	7.3		

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

9.2. Geotechnical Parameters

The data obtained during the Ground Investigation has been assessed for the recorded soil and rock types in order to provide characteristic values in order to aid the final foundation design.



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Table 9-4 Soil Classification Test Results for Cohesive Soils

Exploratory hole	Depth (m bgl)	Stratum	MC (%)	LL (%)	PL (%)	PI (%) (Modified)	Class	Volume Change Potential	Consistency Index
BH-P2-104	2.30	Made Ground	34.8	42	16	20.02	Medium	Medium	0.27
BH-P2-104	4.50-4.95	Made Ground	14.7	36	13	18.86	Medium	Low	0.92
BH-P2-105	1.20	Made Ground	15.9	39	14	17.00	Medium	Low	0.92
BH-P2-105	9.80	Weathered bedrock	13.3	35	13	18.75	Low	Low	0.98
BH-P2-106	1.00-1.45	Made Ground	9.8	34	13	12.18	Low	Low	1.15
BH-P2-106	2.00-2.45	Made Ground	12.8	34	14	10.60	Low	Low	1.06
BH-P2-106	3.00-3.45	Made Ground	16.3	36	13	17.71	Medium	Low	0.87
BH-P2-106	5.00-5.45	Made Ground	13.9	38	13	21.00	Medium	Medium	0.96
BH-P2-106	6.25-6.50	Made Ground	14.1	35	12	20.70	Medium	Low	0.91
BH-P2-106	6.50-6.95	Made Ground	15.6	33	12	17.43	Medium	Low	0.83
BH-P2-106	8.00-8.45	Mudstone	12.7	31	12	17.10	Medium	Low	0.96
WS-P2-106	1.20	Made Ground	20.5	40	15	21.5	Medium	Medium	0.78
WS-P2-107	2.00	Made Ground	12.8	38	13	20	Medium	Medium	1.00
WS-P2-110	1.20	Made Ground	14.8	37	13	20.16	Medium	Medium	0.92
WS-P2-110	3.00	Made Ground	11.0	34	12	15.18	Low	Low	1.04

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

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



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Soil Classification

Cohesive Soils

Moisture content and Atterberg Limit testing was undertaken on samples from cohesive material at the site. Of the 7 No. tests completed within cohesive Made Ground soils, results indicate low to medium plasticity clays with a low to medium volume change potential. The 1 No. natural soil tested, within the weathered bedrock, recorded a low plasticity and low volume change potential.

A total of 3 No. samples of cohesive Till soils were subjected to Particle Size Distribution and Hydrometer Sedimentation analysis. The result of these tests indicates the material was predominantly classified as a silty slightly sandy slightly gravelly CLAY. The results show the material is relatively homogenous.

Cohesive Soils – Trackside (BH-P2-106)

Moisture content and Atterberg Limit testing was undertaken on samples from cohesive material from BH-P2-106. Of the 5 No. tests completed within cohesive Made Ground soils, results indicate low to medium plasticity clays with a low to medium volume change potential. The 1 No. natural sample tested, within the bedrock, recorded a low plasticity and low volume change potential.

Granular Soils

A total of 2 No. samples of granular Made Ground were submitted for Particle Size Distribution tests. The result of these tests indicates the material was predominantly classified as a silty sandy GRAVEL or a silty SAND & GRAVEL. The results show the material is relatively homogenous.

Shear Strength Parameters

Total stress undrained triaxial tests were performed on the natural clay strata encountered within the exploratory holes. Results record a shear strength of 213kPa for a sample at 3.00m bgl within the Till soils.

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

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

The value of f_1 is dependent on the Plasticity Index (Ip). By using the moderately conservative Plasticity Index of 20%, a characteristic value of $f_1 = 5$ has been derived.

Results from 22 No. SPT N values in the natural clay strata indicate shear strengths of between 30-250kPa suggesting low to very high strength.

Density Parameters

The results of Standard Penetration Tests undertaken within the granular Made Ground are also considered to be very variable. Whilst the majority indicate very dense soils with $N=50$ between 1.20m and 2.00m bgl, 3 No. locations record values of $N=18$ to $N=24$ between the same depth range, with BH-P2-106 (trackside location) recording N values of $N=43$ and $N=40$ at these depths. Notably, 9 No. exploratory hole locations refused within Made Ground soils.

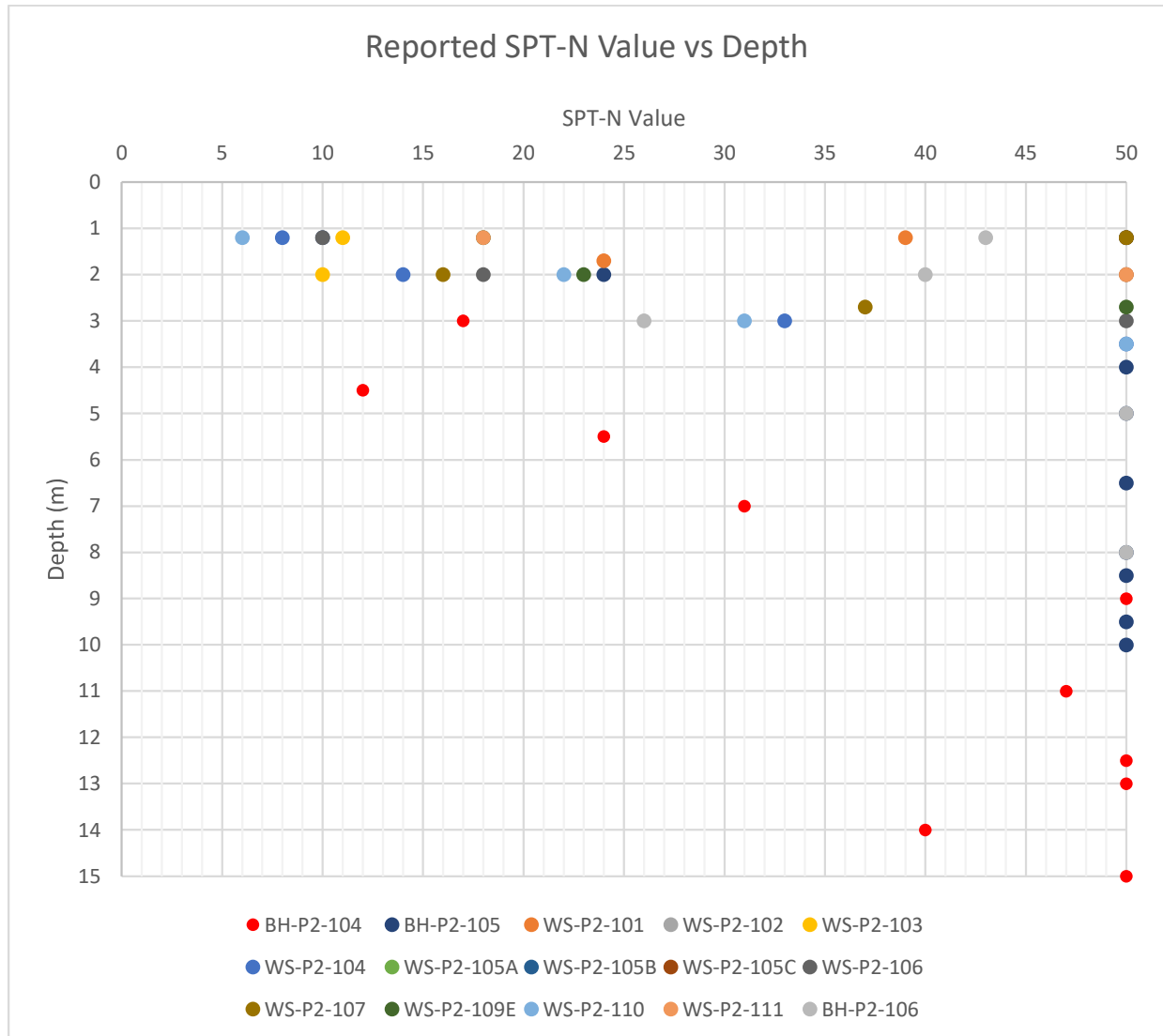


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Figure 9.3 below presents the recorded SPT-N value against depth for each borehole. Results within the natural soils recorded values of between N=26 to N=50 suggesting very high strength cohesive soils, and very dense granular soils where these were locally encountered.

Figure 9.3 Reported SPT-N Value vs Depth



Rock Classification

Point Load Tests

Point Load testing was performed on a number of rock core samples with both axial and diametric testing being undertaken. Results show considerable variation but little increase with depth. Point load test data indicates axial Is50 values in the top 10m of sandstone rock strata are in the range of 0.03MPa to 0.22MPa for the 8 No. tests that were performed.



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Point Load Tests – Trackside (BH-P2-106)

Point Load testing was performed on a total of 24 No. of rock core samples from trackside location BH-P2-106 with both axial and diametric testing being undertaken. Results show considerable variation but little increase with depth. Point load test data indicates axial I_{s50} values in the top 20m of mudstone rock strata are in the range of 0.04MPa to 0.40MPa for the 22 No. tests that were performed.

Unconfined Compressive Strength Tests

UCS testing was performed on 3 No. rock core samples which were recovered as intact pieces with a length which was at least 2 times the diameter of the core. Results ranged between 0.8-1.1 N/mm².

Unconfined Compressive Strength Tests – Trackside (BH-P2-106)

UCS testing was performed on 3 No. rock core samples from trackside location BH-P2-106 which were recovered as intact pieces with a length which was at least 2 times the diameter of the core. Results for the mudstone were recorded as 2.3 N/mm² and 5.4 N/mm², with the 1 No. result for the sandstone band recorded between 13.14m and 13.63m bgl recorded as 16.7 N/mm². This corresponds with the variations in field descriptions for strength throughout the depth of the borehole.

Foundation Recommendations

The site is underlain by Made Ground of either a gravelly Clay or clayey sandy Gravel to depths of typically between 1.25m and 2.00m bgl though locally up to 5.70m bgl in BH-P2-104 in the eastern walkway, and some shallower horizons in the south east of the site to between 0.27m and 0.40m bgl.

Natural soils of Till overlying bedrock of the Lower Pennine Coal Measures were recorded where depth was achieved through the Made Ground and predominantly comprised very high strength Clays. In-situ testing broadly recorded refusal values of SPT N of >50.

It is understood the existing Metrolink platform and canopy will be refurbished, and therefore the existing foundations for these features will be retained (subject to confirmation from the structural engineer). For the pedestrian access bridge providing access between Union Square, the Metrolink platform and Pyramid park, piled foundations terminating within the competent bedrock are expected to be the most appropriate foundation solution. However, should the footbridge allow for lighter loadings, a micro piled solution could also be considered to bear loads onto competent ground beyond the base of recorded Made Ground, and consultation should be sought from a local contractor. Foundation design should be refined based on any proposed site level changes inclusive of removal of the pyramid mounds.

9.3. Soakaways

Soakaway testing was completed in one location (SA-P2-101) to assess the infiltration characteristics of the underlying soils to inform suitability and sizing of sustainable drainage systems. The trial pit was excavated to 2.30m bgl, backfilled with gravel, and filled with clean potable water to a depth of 0.71m bgl. The reduction in water level was then measured over time, via a standpipe, for a period of 1650 minutes to a level of 1.41m bgl. As the 75% effective depth was not achieved within the test period, no infiltration rate could be calculated, and it is estimated that it would take 37 hours to drain. It should be noted only one test cycle was completed.

Results are included in Appendix D.



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9.4. Earthworks

Compaction data has been assessed by comparing the results against criteria commonly used in earthworks to achieve an adequate density for engineered fills. The criteria indicate whether the samples could achieve in excess of 95% of Maximum Dry Density (MDD – a requirement often included in highways specifications) and whether they could be compacted to less than 5% air voids ratio (a requirement applied where raft foundations are to be adopted).

The results of compaction testing undertaken on samples of Made Ground indicate that it could be recompacted to achieve >95% of MDD and <5% air voids. Based upon the results obtained, the Made Ground could be used as an engineered fill, subject to other suitability considerations. It should be noted that suitability for compaction is highly dependent on the initial moisture content of the material to be compacted. Some processing of the material (including screening and crushing of unsuitable elements) may be required during the enabling works phase to remove over-sized or unsuitable material, such as metal, plastic, fabric and timber. Where Made Ground is to be reused as an engineered fill, it would be sensible to select granular fills only and subject them to a confirmatory testing regime where they were required to achieve a compaction specification as a structural fill.

Construction plant should be provided with an adequate working platform in line with the requirements of BRE report, “BR 470: Working Platforms for Tracked Plant”. Again, further advice should be sought from the temporary works designer.

9.5. Groundworks, Excavation Stability and Groundwater Dewatering

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

It is recommended that all excavations to greater than 1.20 metres depth, or for shallower excavations where groundwater is encountered above this level are closely supported, especially where man entry is required. Alternatively, where space permits, the excavations might be battered back to an appropriate angle. Standing groundwater levels of between 0.78m and 12.29m bgl were encountered in the boreholes during monitoring. Should groundwater seepages occur, and water accumulate in shallow excavations it should be able to be removed by pumping from a filtered sump. However, groundwater control by more robust means, such as well pointing, may be required locally.

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



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10.HUMAN HEALTH RISK ASSESSMENT

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

10.1. Data Interpretation Approach

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

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

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

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

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

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

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

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

10.2. Selection of Generic Assessment Criteria (GAC)

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

The current human health risk assessment applied GACs derived for a commercial land use scenario acknowledging the proposed development as a new walkway for station access. In this context, we consider the use of commercial land use GACs to be a reasonable and appropriately conservative default scenario, especially when the actual exposure frequency and duration for public users will be less than that assumed for the default commercial worker.



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Given the unknown extent of both proposed earthworks and intended areas of soft landscaping, we have taken an additional step of conducting sensitivity analysis by comparing the reported concentrations against Public Open Space (POS) Park GACs. We recognise that areas of soft landscaping present a slightly higher potential for soil contact, particularly if members of the public utilise the area as a 'park', which may be beyond an exposure frequency of commercial landscapers/maintenance workers. To account for this, a sensitivity analysis was carried out using POS Park GACs, which are based on young children playing daily in parks — a highly conservative scenario.

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

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

10.3. Human Health Risk Assessment

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

The comparison against the more stringent POS (Park) criteria has recorded measured concentrations of the following contaminants of concern in excess of the respective GACs:



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Table 10-1 Measured Concentrations of Potential Contaminants of Concern Reported in Excess of the Respective GACs

Contaminant of Concern	Exploratory Hole Location	Depth (m bgl)	Soil Population	Units	Measured Concentration	GAC	Comments
PAHs							
Benzo(a)pyrene	WS-P2-106	0.70-1.00	MG1	mg/kg	19.87	11	Tier have conducted further analysis in the form of PAH Double Ratio Plots, which revealed the PAHs to be coal derived when compared to the Jones Environmental Laboratory (now Element Deeside) guidance presented in Figure 10.1 with further discussion overleaf.
	TP-P2-101	0.30	MG3	mg/kg	16.64		
Dibenzo(ah)anthracene	WS-P2-106	0.70-1.00	MG1	mg/kg	2.31	1.1	
	TP-P2-101	0.30	MG3	mg/kg	2.46		
Benzo(b)fluoranthene	WS-P2-106	0.70-1.00	MG1	mg/kg	22.08	13	
	TP-P2-101	0.30	MG3	mg/kg	18.1		



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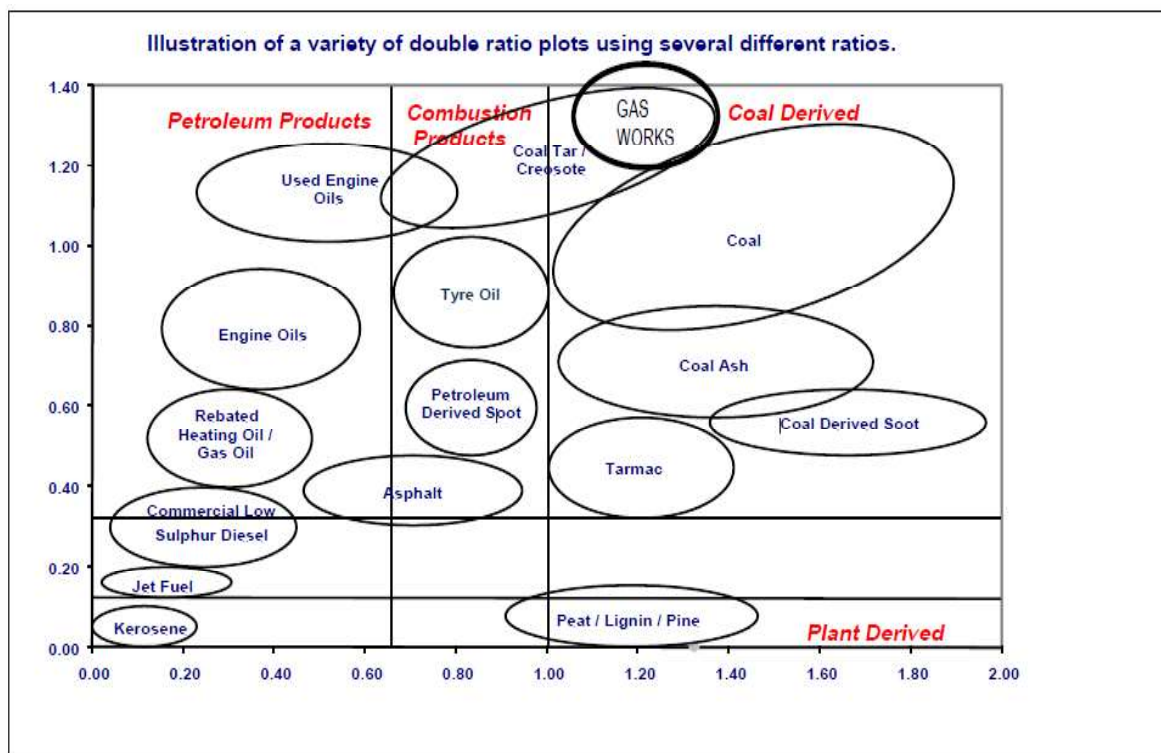
Localised Impacts

Measured localised concentrations of select PAHs including benzo(a)pyrene, dibenzo(ah)anthracene, and benzo(b)fluoranthene have been reported in excess of the GAC protective of human health for a POS (Park) land use.

Due to the presence of fine coal fragments noted within the Made Ground, further analysis was undertaken by Tier Environmental in the form of PAH Double Ratio Plots in Figure 10.2, which revealed the PAHs to be coal derived when compared to the Jones Environmental Laboratory (now Element Deeside) guidance presented in Figure 10.1 below.

The forensic assessment confirms the provenance of the PAHs as derived from possible coal inclusions observed and recorded within a number of exploratory holes. Coal is a common naturally occurring rock present as a bedrock unit within the Pennine Lower Coal Measures Formation, and widely distributed within natural drift strata of glacial origin within the north of England. Coal fragments have significantly reduced exposure pathways compared to petroleum and combustion derived PAHs such as ash and clinker. Coal fragments will not have the same form of exposure pathways as the fines within general soils and would not be inhaled as dusts. This is one of the primary exposure pathways within CLEA for combustion and petroleum derived PAHs within shallow soils. It is therefore considered that, with the reduced exposure pathways, the natural coal inclusions are considered to not pose a significant risk to any future residents (primary human health receptors).

Figure 10.1 Jones Environmental Laboratory (now Element Deeside) PAH Double Ratio Plot Guidance

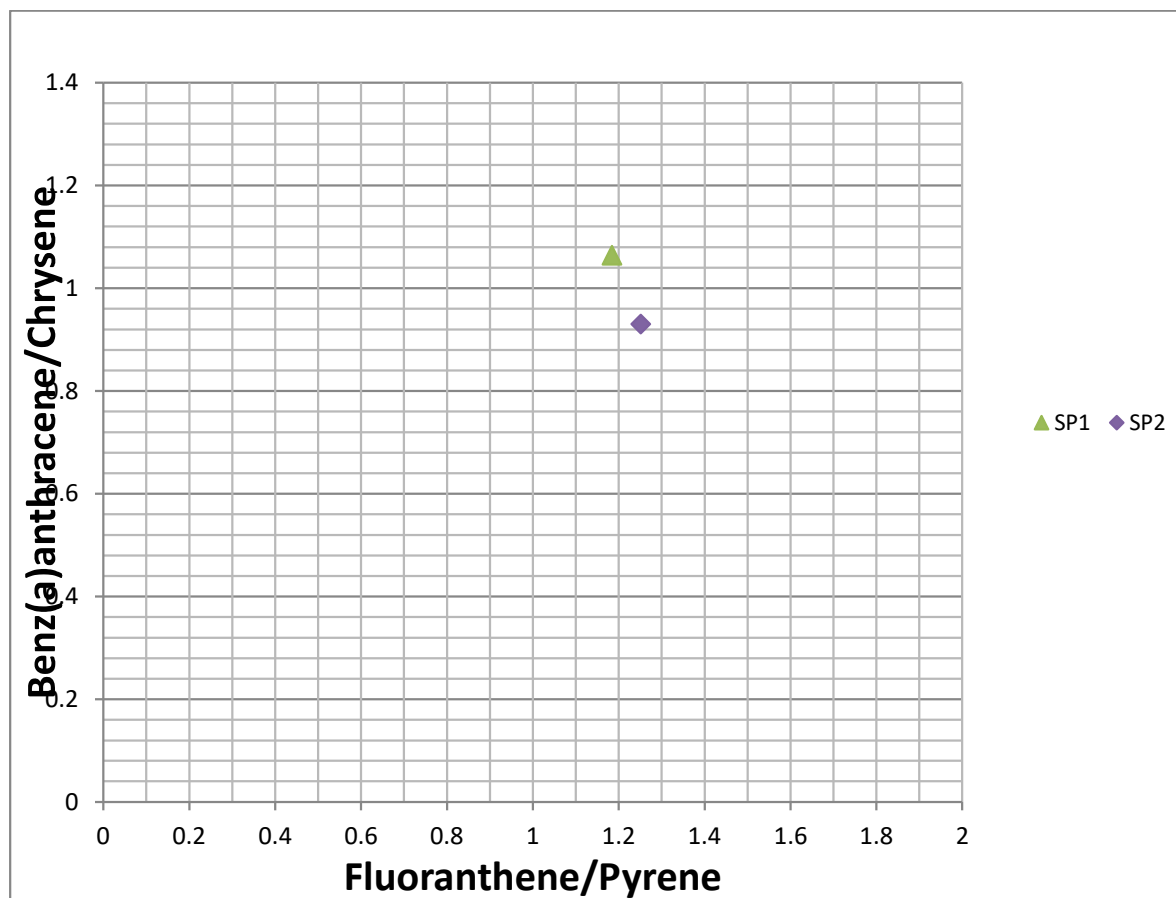




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Figure 10.2 PAH Double Ratio Plot: Benzo(a)anthracene/Chrysene and Fluoranthene/Pyrene



10.4. TPH Assessment

In accordance with the 'The LQM/CIEH S4ULs for Human Health Risk Assessment' (2015), in order to consider the additive effects of all the hydrocarbon fractions, the LQM/CIEH S4ULs should be used to calculate an individual Hazard Quotient (HQ) for each fraction. The HQs can then be added to form a Hazard Index (HI) for petroleum hydrocarbon. Where the HI exceeds unity this can indicate a potentially significant risk to human health. Due consideration has also been given of 'The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soils' (reference: Science Report P5-080/TR3, Environment Agency, dated 2005) which states ""Depending on circumstances, where a [GAC] is exceeded the site assessment can proceed to a site-specific risk assessment and/or directly to remediation. However, even where SGVs for individual fractions are not exceeded, potential additivity of toxicological effects between the fractions means that a significant possibility of significant harm could exist.....Where the HI exceeds unity, this can indicate a potentially significant risk to human health and the investigation proceeds to the next stage (remediation or further assessment)"".

In order to conduct ""further assessment"", Tier Environmental has considered the text included in the Environment Agency 2005 document that states ""Fractions exhibiting different toxicological properties might be excluded from the hazard index"". Calculating separate hazard indices for different TPH fractions is a recognized and legitimate approach supported by the TPHCWG guidance and other regulatory frameworks. It allows for a more accurate assessment of potential health risks, given the varied properties of the hydrocarbon fractions.



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Tier Environmental has therefore considered the following fractions separately owing to their toxicological relevance and risk-based prioritisation:

- Aliphatic (ali) C8-C16 Fraction: This range includes hydrocarbons that are relatively more volatile and may present a risk through inhalation exposure, dermal contact, and ingestion. This fraction is often considered when evaluating the potential for acute and chronic health effects due to its intermediate volatility and mobility
- Aromatic (aro) C8-C16 and C16-C35 Fractions: Aromatic hydrocarbons are generally more toxic than aliphatic hydrocarbons. The C8-C16 range includes lighter aromatics, which can be more volatile and potentially more hazardous in terms of inhalation risk. The C16-C35 range includes heavier, less volatile aromatics, which may present different exposure risks, primarily through soil ingestion or dermal contact."

The hazard index calculated considering the additive effects of all the hydrocarbon fractions does not exceed 1. Therefore, it is considered that TPH does not present a risk to human health for the proposed land use for either a commercial or POS park scenario.

Measured Potential Contaminant of Concern Concentrations without Publicly Available GACs

Table 10-2 summarises the measured concentrations of potential contaminants of concern have been reported in excess of the laboratory method detection limit for which there are no current publicly available GACs and provides qualitative commentary / discussion as to whether they may represent a potential risk to human health with due consideration of the Conceptual Site Model.



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Table 10-2 Measured Concentrations of Potential Contaminants of Concern Reported in Excess of the Laboratory Method Detection Limit

Contaminant of Concern	Exploratory Hole Location	Depth (m bgl)	Soil Population	Units	Measured Concentration	Comments
VOCs/SVOCs						
1,3,4-Trimethylbenzene	BH-P2-104	1.10-1.30	MG1	mg/kg	0.008	An assessment has been made of VOCs/SVOCs for which there are publicly available GACs. Comparison of reported measured concentrations of 2-methylnaphthalene, 1,3,4-Trimethylbenzene, and dibenzofuran are all below residential and industrial RSL and/or appropriate Dutch Intervention values.
	BH-P2-105	1.70-2.00	MG1	mg/kg	0.124	
	TP-P2-104	0.80	MG2	mg/kg	0.057	
	BH-P2-104	1.10-1.30	MG1	mg/kg	0.062	
Carbazole	BH-P2-105	1.70-2.00	MG1	mg/kg	0.317	Preliminary research has indicated that for carbazole, Texas PCLs are the only up-to-date numerical soil criteria published for carbazole as a discrete analyte. No other national scheme now carries carbazole values. Most agencies streamlined their tables to the 16-PAH set or rely on indicator compounds (BaP), and heterocyclic PAHs such as carbazole were removed.
	TP-P2-104	0.80	MG2	mg/kg	0.084	
	BH-P2-104	1.10-1.30	MG1	mg/kg	0.111	
Dibenzofuran	BH-P2-105	1.70-2.00	MG1	mg/kg	0.279	The maximum reported carbazole concentration of 0.317mg/kg is below the Texas residential PCL value of 230 mg/kg. On the basis of the above and the discussion included within our report, it is not considered that the measured concentrations of potential contaminants of concern reported (for which there are no UK-based publicly available GACs) represent a potential risk to the proposed end-users. In addition, given the absence of viable indoor air due to the nature of the proposed development, there is not considered to be a viable vapour inhalation pathway.
	TP-P2-104	0.80	MG2	mg/kg	0.073	
	BH-P2-104	1.10-1.30	MG1	mg/kg	0.11	



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Asbestos

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

During the fieldwork no suspected ACMs were identified.

Of the 20 No. of Made Ground samples submitted for asbestos screening, 5 No. were reported to contain asbestos. Those positive identifications are summarised in Table 10-3, below.

Table 10-3 Summary of Asbestos Assessment

Exploratory Hole Location	Depth (m bgl)	Location on Site Description	Soil Population	Asbestos Type	Quantification (% w/w)
Asbestos in Soil Samples					
WS-P2-106	0.70-1.00	East/North	MG1	Chrysotile fibre bundles	<0.001%
BH-P2-105	1.70-2.00	East/Central	MG1	Chrysotile and amosite fibre bundles	<0.001%
WS-P2-104	1.00-1.50	East/Central	MG1	Chrysotile and amosite fibre bundles	<0.001%
WS-P2-102	0.50-1.00	West	MG1	Chrysotile fibre bundles	<0.001%
WS-P2-110	0.30-0.50	East/North	MG1	Chrysotile fibre bundles	<0.001%

Whilst asbestos has been reported during the ground investigation works, the measured concentrations have been reported <0.001% w/w i.e. at 'trace' levels which are unlikely to trigger requirements during earthworks / construction works in accordance Control of Asbestos Regulations 2012. However, in the event that previously unidentified asbestos is identified during future earthworks / construction works at concentrations above 0.001% w/w (i.e. above 'trace' levels), the Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is therefore provided in Appendix M.

Asbestos – Trackside (BH-P2-106)

A total of 3 No. samples of Made Ground from the trackside location BH-P2-106 were screened for asbestos. None recorded asbestos to be present.

10.5. Utilities

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



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10.6. Construction and Maintenance Workers

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

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

- Chrysotile and amosite asbestos fibre bundles within Made Ground soils.

Whilst asbestos has been reported during the ground investigation works, the measured concentrations have been reported <0.001% w/w i.e. at 'trace' levels which are unlikely to trigger requirements during earthworks / construction works in accordance Control of Asbestos Regulations 2012. However, in the event that previously unidentified asbestos is identified during future earthworks / construction works at concentrations above 0.001% w/w (i.e. above 'trace' levels), the Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is therefore provided in Appendix M.



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11.CONTROLLED WATERS RISK ASSESSMENT

11.1. Introduction

In order to assess whether there is a potentially unacceptable risk of pollution of controlled waters, samples of soil leachate have been submitted for laboratory chemical analysis as per the summary presented in Table 5-4 within this report. Analytical data from soil leachate sample testing undertaken by Tier Environmental have been evaluated against Water Quality Standard (WQS) values appropriate to the Conceptual Site Model.

In accordance with Part 2A of the Environmental Protection Act 1990, Tier Environmental has made regard to all of the WQS values that are relevant to the site and a judgment has been made against the most stringent of those relevant standards. Further details are provided, along with the approach for selection of TPH / BTEX WQS values, in Appendix I.

In some instances, the laboratory method detection limit is greater than the appropriate WQS value. In these instances, only measured concentrations in excess of the laboratory method detection limit have been considered likely to potentially represent a possible significant risk to controlled waters.

11.2. Controlled Waters Environment Conceptual Site Model Summary

Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Pennine Lower Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is an artificial lake within a park circa 100m east of the site though this not considered to be in hydraulic conductivity with local groundwater, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south in conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate.

11.3. Soil Leachate Testing

Table 11-1 below summarises the measured concentrations of contaminants of concern from soil leachate samples at the site that have been reported in excess of the respective WQS values.

Table 11-1 Summary of Measured Concentrations of Soil Leachate Potential Contaminants of Concern in Excess of WQS Values

Potential Contaminant of Concern	Units	LoD*	WQS	Maximum concentration	No. samples >WQS	Exploratory Hole Location	Depth (m bgl)	Soil Population
Nickel	µg/l	<2	4	8	1 of 2	SA-P2-101	0.80	MG1
Iron	µg/l	<20	1	100	2 of 2	SA-P2-101	0.80	MG1 and MG4
Anthracene	µg/l	<0.005	0.1	0.294	2 of 2	SA-P2-101	0.80	MG1
Fluoranthene	µg/l	<0.005	0.0063	1.61	2 of 2	SA-P2-101	0.80	MG1 and MG4
Benzo(a)pyrene	µg/l	<0.005	0.00017	0.824	2 of 2	SA-P2-101	0.80	MG1 and MG4

* LOD= Laboratory Method Limit of Detection

Measured leachable concentrations of nickel, iron and anthracene have been reported only *marginally* in excess of the WQS protective of the controlled waters environment by the same order of magnitude or up to 1 order of magnitude. Given the marginal nature of these exceedances, the potential for significant dilution within the groundwater beneath the site, the historical commercial / industrial heritage of the wider area surrounding the site, the absence of a continuous groundwater body beneath the site, the Low/Moderate sensitivity of the controlled waters environment as



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described in Section 11.2 above, the localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations and the fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils, the exceedances are not considered to pose a risks to controlled waters.

Measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported in excess of the respective WQS protective of the controlled waters environment by between 2 No. orders of magnitude and 3 No. orders of magnitude. Further specific consideration of the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene concentrations have been made.

The EQS values for fluoranthene and benzo(a)pyrene are derived assuming bioaccumulation in fish and ultimately consumption of the fish by humans which is an exposure scenario that is not viable for this site given the absence of a nearby viable surface water body where this will scenario be realised.

Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and / or benzo(a)pyrene have been reported only *marginally* in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters by the same order of magnitude / by up to one order of magnitude. As such, and in the absence of viable 'bioaccumulation in fish and consumption of fish by humans' scenario and given the reasonings outline above, it is therefore considered that the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene are unlikely to present a potential risk to the controlled waters environment.

Soil Leachate – Trackside (BH-P2-106)

A total of 2 No. samples of Made Ground from the trackside location BH-P2-106 were submitted for soil leachate testing. Table 11-2 summarises the measured concentrations of contaminants of concern from soil leachate samples from the Trackside location BH-P2-106 that have been reported in excess of the respective WQS values.

Table 11-2 Summary of Measured Concentrations of Soil Leachate Potential Contaminants of Concern in Excess of WQS Values at BH-P2-106

Potential Contaminant of Concern	Units	LoD*	WQS	Maximum concentration	No. samples >WQS	Exploratory Hole Location	Depth (m bgl)	Soil Population
Fluoranthene	µg/l	<0.005	0.0063	0.046	1 of 2	BH-P2-106	0.80	MG Railway Ballast
Benzo(a)pyrene	µg/l	<0.005	0.00017	0.022	1 of 2	BH-P2-106	0.80	MG Railway Ballast

* LOD= Laboratory Method Limit of Detection

Measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported in excess of the respective WQS protective of the controlled waters environment by between 1 No. orders of magnitude and 2 No. orders of magnitude. Further specific consideration of the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene concentrations have been made.

The EQS values for fluoranthene and benzo(a)pyrene are derived assuming bioaccumulation in fish and ultimately consumption of the fish by humans which is an exposure scenario that is not viable for this site given the absence of a nearby viable surface water body where this will scenario be realised.

Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported below the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters by the same order of magnitude / by up to one order of magnitude. As such, and in the absence of viable 'bioaccumulation in fish and consumption of fish by humans' scenario and given the marginal nature of these exceedances, the potential for significant dilution within the groundwater beneath the site, the historical commercial / industrial heritage of the wider area surrounding the site, the absence of a continuous groundwater body beneath the site, the Low/Moderate



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sensitivity of the controlled waters environment as described in Section 11.2 above, the localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations and the fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils, it is therefore considered that the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene are unlikely to present a potential risk to the controlled waters environment.



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

The preliminary combined conceptual site model and conceptual exposure model, developed from the desk study information and presented in Section 0, has been revised in light of the ground investigation and the chemical analysis results presented above in Table 12-1, below.

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



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Table 12-1 Revised Assessment of Potential Pollutant Linkages (Continued on Next Page).

Justification / Comments
• The site is underlain by Made Ground of either a gravelly Clay or clayey sandy Gravel to depths of typically between 1.25m and 2.00m bgl though locally up to 5.70m bgl in BH-P2-104 in the eastern walkway, and some shallower horizons in the south east of the site to between 0.27m and 0.40m bgl. Natural soils of Till overlying bedrock of the Lower Pennine Coal Measures was recorded where depth was achieved through the Made Ground and predominantly comprised very high strength Clays. In-situ testing broadly recorded refusal values of SPT N of >50. • No measured soil concentrations of potential contaminants of concern have been reported in excess of Generic Assessment Criteria (GACs) protective of human health appropriate to the proposed land use. On this basis, it is not considered that the site represents a potential risk to end-users. • Of the 23 No. of Made Ground samples submitted for asbestos screening, 5 No. were reported to contain asbestos in the form of chrysotile and locally amosite fibre bundles, returned with quantification of <0.001% w/w suggesting trace level of asbestos. • Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Pennine Lower Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is an artificial lake within a park circa 100m east of the site, in land east of Market Street, though this is not considered to be in hydraulic conductivity with local groundwater, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south in conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate. • Measured leachable concentrations of nickel, iron and anthracene have been reported only marginally in excess of the WQS protective of the controlled waters environment by the same order of magnitude or up to 1 order of magnitude. Given the marginal nature of these exceedances, the potential for significant dilution within the groundwater beneath the site, the historical commercial / industrial heritage of the wider area surrounding the site, the absence of a continuous groundwater body beneath the site, the Low/Moderate sensitivity of the controlled waters environment, the localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations and the fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils, the exceedances are not considered to pose a risks to controlled waters. • Measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported in excess of the respective WQS protective of the controlled waters environment by between 2 No. orders of magnitude and 3 No. orders of magnitude. Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and / or benzo(a)pyrene have been reported only marginally in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters by the same order of magnitude / by up to one order of magnitude. As such, and in the absence of viable 'bioaccumulation in fish and consumption of fish by humans' scenario and given the reasonings outline above, it is therefore considered that the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene are unlikely to present a potential risk to the controlled waters environment. • Given the nature of the proposed development and the absence of any proposed enclosed spaces, ground gas protection measures are not required for this proposed element of the development. • Basic radon protection measures are not currently required for the proposed development on this site.



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Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Asbestos fibre bundles in Made Ground	Asbestos (Chrysotile and amosite)	(Dust migration and) dust inhalation	Future site users (Public Open Space – Park)	Medium	Low Likelihood	Moderate / Low Risk
			Adjacent site users (Public Open Space – Park)	Medium	Unlikely	Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Low Likelihood	Moderate / Low Risk

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



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13. PRELIMINARY WASTE MATERIALS CLASSIFICATION AND WASTE DISPOSAL ROUTE DETERMINATION

13.1. Introduction

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

There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the Soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils. Mixing of hazardous and non-hazardous waste is not permitted. For any hazardous wastes, a consignment note shall be completed, signed, and retained by all parties involved. The consignment note shall state the volume of waste, a physical description of the material and statement of its chemical composition. The waste consignment notes shall be kept by the contractor for a period of at least two years. For non-hazardous wastes, a Waste Transfer Note (WTN) shall be completed. The WTN should be signed and a copies should be kept by the contractor for a period of at least two years. Finally, consignment notes and WTNs shall be shown to an enforcement officer from the local council or the Environment Agency, if asked.

Approach to Assessing Hazard Properties

Flammability and Oxidisability

For any samples flagged as possessing hazardous properties flammability and oxidisability, for which there are no thresholds, Tier Environmental has used professional judgment and on-site observations to decide whether the waste soil, as a whole, is likely to be flammable or oxidising. It should be noted that flammability/oxidisability alone are unlikely to result in a hazardous classification for waste soil.

Worst Case Metal Compounds

The choice of an appropriate worst case metal compound in soil has been made on the basis of the available lines of evidence. For example, if laboratory chemical analysis has demonstrated that no measured concentrations of hexavalent chromium have been reported in excess of the laboratory method detection limit, there it would be regarded as evidence of an absence of a soil source of hexavalent chromium. In such an instance, the worst case metal chromates may be replaced in favour of the next worst case metal compound.

pH

For samples that have been determined as hazardous based on pH alone and cement/concrete has been identified in the sample, Tier Environmental may assume that the high pH was due to the crushing process in the laboratory and is not representative of the waste as a whole. If further detailed determination of this is required then Tier Environmental recommend that such assessment is carried out on these results in a manner described in the AGS Waste Classification for Soils – A Practitioners' Guide (dated 2019):

- Consideration of the acid/alkali reserve to be conducted (as described in WM3 Appendix C4 and C8).
- If large enough, the cement/concrete fraction may be separated manually before testing. Waste concrete from construction and demolition which doesn't contain hazardous substances is non-hazardous (LoW code 17-01-01).
- If cement/concrete has been identified in the sample, a second analysis may be conducted on an 'as received' sample, avoiding the need for crushing before testing. The high pH is typically associated with the finer fractions of cement. If the 'as received' sample has an



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acceptable pH, this provides additional confidence that the high pH was due to the crushing process and is not representative of the waste as a whole.

Asbestos

With respect to asbestos, If the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% w/w or more asbestos in accordance with WM3. If the waste contains any identifiable pieces of suspected asbestos containing material (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then these pieces must be assessed separately. The waste is hazardous if the concentration of asbestos in the piece of asbestos containing material is 0.1% w/w or more. The waste shall then be regarded as a mixed waste and classified accordingly.

The following codes will then be assigned to the asbestos waste as appropriate:

- 17 06 05* Construction material containing asbestos.
- 17 06 01* Insulation material containing asbestos.

17 06 05* would normally be used in preference to 17 06 01* for the asbestos in asbestos contaminated soil and stones in accordance with WM3.

Tier Environmental Geoenvironmental engineers hold up to date UKATA Asbestos Awareness training certificates in order to demonstrate 'competence' that is required as described in WM3.

Flammable Liquid Waste

Tier Environmental consider that such a hazard property would apply if free phase product has been reported in the sample. As such, in those instances where materials are classified as hazardous based on this alone and no free phase product is encountered, it is considered that the materials may be regarded as being non-hazardous. Please note that the table below includes a column to show whether free phase product has been encountered within the sample location.

13.2. Preliminary Waste Materials Classification and Waste Disposal Route Determination

Tier Environmental have assessed the chemical results in terms of basic waste characterisation of materials on site. This provides a preliminary assessment of whether a material is potentially non-hazardous or hazardous waste. In addition, Waste Acceptance Criteria (WAC) testing has been carried out on selected samples with a determination made as to the appropriate waste disposal route in each case.

The results of this preliminary assessment are summarised in the following table.

Natural Soils / Bedrock

Representative samples of natural soils have not been obtained during the investigation.

It is likely that any natural soils (that are not impacted by any known contamination from shallow Made Ground, or unexpected contamination) would be suitable for disposal to an inert waste landfill. It is recommended that the landfill is approached to confirm this position prior to off-site disposal. Otherwise, additional testing will be required to confirm the waste disposal route for natural soils beneath the site.



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Table 13-1 Preliminary Materials Waste Classification and Waste Disposal Route Determination

Exploratory Hole Location	Sample Depth (m bgl)	Simplified Description of the Sample	Basic Waste Characterisation Result	If 'Potentially Hazardous': Is it Possible to Demonstrate the Material is Non-Hazardous?	If the material is Hazardous – What is the Driver for Hazardous Waste Classification?	Asbestos Presence, Type and Quantification	WAC Sample Available?	Soil Waste Disposal Route Determination
WS-P2-106	0.70-1.00	Made Ground: Dark brown slightly sandy gravelly Clay.	Non-Hazardous	N/A	N/A	<0.001% w/w chrysotile fibre bundles	Yes	Non-hazardous landfill due to TOC and Sum PAHs in excess of inert landfill threshold.
BH-P2-105	1.70-2.00	Made Ground: Dark greyish brown gravelly Clay.	'Potentially hazardous' but can be downgraded to non-hazardous (see next column for details).	Yes. Driven by 'HP 3(i): Flammable "flammable liquid waste"' (hazard statement: Flam. Liq. 3; H226 "Flammable liquid and vapour."). However, Tier Environmental consider that such a hazard property would apply if free phase product has been reported in the sample. As no free phase product was encountered, it is considered that the materials above may be regarded as being non-hazardous .	N/A	<0.001% w/w chrysotile and amosite fibre bundles	Yes	Non-hazardous landfill due to TOC in excess of inert landfill threshold.
SA-P2-101	0.80	Made Ground: Black compacted gravelly Sand (asphalt layer)	Hazardous	N/A	Iron (III) oxide	None detected	Yes	WAC testing indicates that the materials would need to be treated prior to acceptance to a hazardous waste landfill due to elevated TOC and loss on ignition that exceeds the hazardous waste landfill threshold.
TP-P2-104	0.80	Made Ground: Dark greyish brown sandy gravelly Clay.	'Potentially hazardous' but can be downgraded to non-hazardous (see next column for details).	Yes. Driven by 'HP 3(i): Flammable "flammable liquid waste"' (hazard statement: Flam. Liq. 3; H226 "Flammable liquid and vapour."). However, Tier Environmental consider that such a hazard property would apply if free phase product has been reported in the sample. As no free phase product was encountered, it is considered that the materials above may be regarded as being non-hazardous .	N/A	None detected	Yes	Non-hazardous landfill due to TOC in excess of inert landfill threshold.
TP-P2-106	0.10	Made Ground: Dark brown sandy gravelly Clay.	Non-Hazardous	N/A	N/A	None detected	Yes	Suitable for disposal as inert waste
TP-P2-101	0.30	Made Ground: Dark brown silty gravelly Sand.	Non-Hazardous	N/A	N/A	None detected	Yes	Non-hazardous landfill due to Sum PAHs in excess of inert landfill threshold.
WS-P2-101	0.45-0.60	Made Ground: Dark grey clayey sandy Gravel.	Non-Hazardous	N/A	N/A	None detected	Yes	Suitable for disposal as inert waste
BH-P2-104	1.10-1.30	Made Ground: Dark greyish brown sandy gravelly Clay.	'Potentially hazardous' but can be downgraded to non-hazardous (see next column for details).	Yes. Driven by 'HP 3(i): Flammable "flammable liquid waste"' (hazard statement: Flam. Liq. 3; H226 "Flammable liquid and vapour."). However, Tier Environmental consider that such a hazard property would apply if free phase product has been reported in the sample. As no free phase product was encountered, it is considered that the materials above may be regarded as being non-hazardous .	N/A	None detected	Yes	Suitable for disposal as inert waste
BH-P2-104	3.20-3.50	Made Ground: Greyish brown sandy Clay.	Non-Hazardous	N/A	N/A	None detected	No	No WAC sample obtained.
BH-P2-106 (trackside)	0.40	Made Ground: Grey slightly clayey sandy Gravel.	Non-Hazardous	N/A	N/A	None detected	No	Suitable for disposal as inert waste
BH-P2-106 (trackside)	3.00-3.20	Possible Made Ground: Stiff brownish orange sandy gravelly Clay.	Non-Hazardous	N/A	N/A	None detected	No	Suitable for disposal as inert waste



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Table 13-2 Preliminary Asphalt Materials Waste Classification

Exploratory Hole Location	Sample Depth (m bgl)	Is the sample Representative of 'Black Top' (Road Surface) Waste?	Coal Tar Concentration (%)	Concentration of Benzo(a)pyrene	Benzo(a)pyrene Units (µg/kg or mg/kg)	Does the Reported Concentration of Benzo(a)pyrene exceed 50ppm (50mg/kg)	If Coal Tar Concentration Greater Than, or Equal To, 0.1%: Is Concentration of Benzo(a)pyrene less than 0.005% of the Concentration of the Coal Tar?	Asphalt Waste Classification
WS-P2-111	0.0-0.15	Yes	<0.1	234	µg/kg	No	No	The coal tar concentration is <0.1% and the benzo(a)pyrene concentration is <50 ppm (mg/kg), therefore the asphalt would be classed as NON-HAZARDOUS WASTE in accordance with WM3. The non-hazardous EWC code 17 03 02 (bituminous mixtures other than those mentioned in 17 03 01), therefore applies.



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13.3. Materials Re-Use

Subject to volumetric fill requirements and a future assessment of suitability of re-use (both chemically and geotechnically), some materials may be considered for potential re-use in line with an appropriate end-of-waste protocol such as WRAP Quality Protocol for Aggregates from Inert Waste, U1 Exemption or a Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP). Please note that any previously landfilled or mining waste materials may not be appropriately subject to consideration under DoWCoP and may not be re-used under DoWCoP unless sufficient lines of evidence and agreement with the local Environment Agency Waste Team can be sought beforehand.

Re-Use of Excavated and Stockpiled Clean Naturally Occurring Soils on Other Sites

In addition, Tier Environmental are aware that CL:AIRE is classing stockpiled clean, naturally occurring soils as waste, unless their final destination is identified in a Materials Management Plan, before they are excavated. However, Tier Environmental consider that any clean naturally occurring soils arising from enabling works, earthworks or construction activities would be regarded as an asset and the default assumption for this site (prior to excavation and stockpiling) is not the intention to discard these materials where they may be reasonably re-used on this, or another, development site. Stockpiling is a recognised, recommended means of safely storing soils. Whilst there may be advantages to leaving soils in-situ, stripping topsoil and subsoil prior to earthworks is a routine construction activity. Tier Environmental consider that it is not unreasonable to state that in the event that the developer owns another site where the construction phase is ongoing, soils can be transferred between their sites as an owned product and never become waste.

The above paragraph above is therefore considered a clear intention to reuse any clean, naturally occurring soils derived from excavations at this site (which may also include temporary stockpiling these materials). It is considered; however, that in addition to this the following must be adhered to:

- Reuse does need to occur within a 'reasonable' timeframe (12 No. months); and,
- If soils are transferred to a third party (another developer), there needs to be some contractual agreement in place, as in this situation it is important to have something in place confirming that surplus soils are required by the third party.

Re-Use of Excavated and Stockpiled Clean Naturally Occurring Soils Within The Site They Are Excavated From

Further to the above, where soils are naturally occurring, uncontaminated and re-used on the site they are excavated from, they fall outside of the Waste Framework Directive (WFD) i.e. they will not be classified as a waste. Currently the CL:AIRE Definition of Waste Code of Practice states the following which appears to support this position: *"If the material is waste an Environmental Permit will be required to lawfully deposit or re-use it unless the material is "uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated", which is excluded from waste regulation by the Waste Framework Directive (2008)."*



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14.CONCLUSIONS AND RECOMMENDATIONS

14.1. Conclusions

- The site is underlain by Made Ground of either a gravelly Clay or clayey sandy Gravel to depths of typically between 1.25m and 2.00m bgl though locally up to 5.70m bgl in BH-P2-104 in the eastern walkway, and some shallower horizons in the south east of the site to between 0.27m and 0.40m bgl. Natural soils of Till overlying bedrock of the Lower Pennine Coal Measures was recorded where depth was achieved through the Made Ground and predominantly comprised very high strength Clays. In-situ testing broadly recoded refusal values of SPT N of >50.
- BH-P2-106 (trackside) recorded Made Ground comprising railway ballast with varying clay and sand content from the surface to a depth of 1.50m bgl, underlain by further granular Made Ground to 3.00m bgl, and possible cohesive Made Ground to 3.50m bgl. Granular superficial deposits comprising sandy gravel were recorded to 5.00m bgl, underlain by cohesive superficial deposits to 8.00m bgl. Extremely weak to medium strong, thinly laminated mudstone, occasionally interbedded with sandstone, was encountered below to beyond the base of the borehole at 28.50m bgl, with an intact coal seam encountered between 22.85m to 23.22m bgl (0.37m thickness).
- It is understood the existing Metrolink platform and canopy will be refurbished, and therefore the existing foundations for these features will be retained (subject to confirmation from the structural engineer). For the pedestrian access bridge providing access between Union Square, the Metrolink platform and Pyramid park, piled foundations terminating within the competent bedrock are expected to be the most appropriate foundation solution. However, should the footbridge allow for lighter loadings, a micro piled solution could also be considered to bear loads onto competent ground beyond the base of recorded Made Ground, and consultation should be sought from a local contactor. Foundation design should be refined based on any proposed site level changes inclusive of removal of the pyramid mounds.
- It is considered that a Design Sulphate Class of DS-2 and ACEC Class AC-2 is appropriate for buried concrete design purposes within Made Ground and natural soils,
- No measured soil concentrations of potential contaminants of concern have been reported in excess of Generic Assessment Criteria (GACs) protective of human health appropriate to the proposed land use. On this basis, it is not considered that the site represents a potential risk to end-users.
- Of the 20 No. of Made Ground samples submitted for asbestos screening, 5 No. were reported to contain asbestos in the form of chrysotile and locally amosite fibre bundles, returned with quantification of <0.001% w/w suggesting trace level of asbestos. **A total of 3 No. samples of Made Ground from the trackside location BH-P2-106 were screened for asbestos. None recorded asbestos to be present.**
- Superficial deposits (Devensian Till and Glaciofluvial Deposits), and the bedrock (Pennine Lower Coal Measures Formation) are both classified as Secondary A Aquifers. The site is not within a Source Protection Zone and there are no active potable abstraction wells within 2km. The nearest surface water feature is an artificial lake within a park circa 100m east of the site, in land east of Market Street, though this not considered to be in hydraulic conductivity with local groundwater, and the River Irwell located 675m west. Groundwater flow is anticipated to be towards the south in conjunction with the flow of the River Irwell. On this basis the controlled waters sensitivity is regarded as being low/moderate.
- Measured leachable concentrations of nickel, iron and anthracene have been reported only marginally in excess of the WQS protective of the controlled waters environment by the same order of magnitude or up to 1 order of magnitude. Given the marginal nature of these exceedances, the potential for significant dilution within the groundwater beneath the site, the historical commercial / industrial heritage of the wider area surrounding the site, the absence of a continuous groundwater body beneath the site, the Low/Moderate sensitivity of the controlled waters environment, the localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations and the fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils, the exceedances are not considered to pose a risks to controlled waters.



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- Measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported in excess of the respective WQS protective of the controlled waters environment by between 2 No. orders of magnitude and 3 No. orders of magnitude. Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and / or benzo(a)pyrene have been reported only marginally in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters by the same order of magnitude / by up to one order of magnitude. As such, and in the absence of viable 'bioaccumulation in fish and consumption of fish by humans' scenario and given the reasonings outline above, it is therefore considered that the reported soil leachate concentrations of fluoranthene and benzo(a)pyrene are unlikely to present a potential risk to the controlled waters environment.
- Given the nature of the proposed development and the absence of any proposed enclosed spaces, ground gas protection measures are not required for this proposed element of the development.
- Basic radon protection measures are not currently required for the proposed development on this site.
- Basic waste characterisation has determined that Made Ground soils are non-hazardous aside from the sample at SA-P2-10 at 0.80m bgl, in Made Ground of black compacted gravelly Sand (asphalt layer) which is hazardous for Iron (III) oxide.
- The results of WAC tests have confirmed that:
 - WS-P2-106 at 0.70-1.00m bgl would be suitable for disposal to a non-hazardous landfill due to TOC and Sum PAHs in excess of inert landfill threshold, and asbestos at <0.001% w/w.
 - BH-P2-105 at 1.70-2.00m bgl would be suitable for disposal to a non-hazardous landfill due to TOC in excess of inert landfill threshold, and asbestos at <0.001% w/w.
 - SA-P2-101 at 0.80m bgl would need to be treated prior to acceptance to a hazardous waste landfill due to elevated TOC and loss on ignition that exceeds the hazardous waste landfill threshold.
 - TP-P2-104 at 0.80m bgl would be suitable for disposal to a non-hazardous landfill due to TOC in excess of inert landfill threshold.
 - TP-P2-101 at 0.30m bgl would be suitable for disposal to a non-hazardous landfill due to Sum PAHs in excess of inert landfill threshold.
 - TP-P2-106 at 0.10m bgl, WS-P2-101 at 0.45-0.60m bgl would be suitable for disposal as inert waste.
 - **BH-P2-106 (trackside location) at 0.40m and 3.00 to 3.20m bgl would both be suitable for disposal as inert waste.**

14.2. Recommendations

- Completion of an Asbestos DQRA to determine suitability for re-use of low-level asbestos impacted soils within the development.
- Intrusive works across the wider site area should be undertaken and should adhere to the Site Investigation Scope produced by Renaissance (Dated October 2024) presented in drawing BURY-REN-XX-XX-SK-S-01000-P03 and 01001-P03.



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15.REGULATORY APPROVALS

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

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



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17.GLOSSARY OF TERMS

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



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