



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

TE1880-TE-00-XX-RP-GE-002-V02

03 MARCH 2025

FINAL

Prepared for:

Wilmott Dixon Construction Ltd

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Report No. :	TE1880-TE-00-XX-RP-GE-002-V02
Report Status:	FINAL
Project Engineer:	Stefani Ellis
Date of Issue:	03/03/2025

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Version No.	Description of Issue / Revision	Date of Issue	Author	Reviewed By	Approved By
1	FIRST DRAFT – to be updated with final ground gas and groundwater monitoring results in due course	05/02/2025	Stefani Ellis	Adrian Read	Adrian Read
2	Final	03/03/2025	Adrian Read	Sean Lee	Sean Lee



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : i of viii

Engineer: Stefani Ellis

Date: 03/03/2025

CONTENTS

1.	INTRODUCTION.....	1
1.1.	Proposed Development.....	1
1.2.	Previous Reports.....	1
1.3.	Objectives.....	2
1.4.	Assumptions	2
2.	SITE DETAILS AND DESCRIPTION	3
3.	GROUND GAS CONCEPTUAL SITE MODEL CONSIDERATION.....	5
4.	PRELIMINARY CONCEPTUAL SITE MODEL.....	6
4.1.	Uncertainties	6
5.	FIELDWORK.....	11
5.1.	Scope of Ground Investigation	11
5.2.	Geoenvironmental Testing	13
5.3.	Geotechnical Testing.....	14
6.	GROUND CONDITIONS	17
6.1.	Strata Profile.....	17
6.2.	Obstructions	21
6.3.	Visual and Olfactory Evidence of Contamination.....	23
6.4.	Groundwater Observations During Fieldwork.....	23
6.5.	Groundwater Monitoring	24
7.	PRELIMINARY GEOTECHNICAL ASSESSMENT	26
7.1.	Mining and Quarrying	26
7.2.	Determination of pH and Water-Soluble Sulphate	26
7.3.	Geotechnical Parameters	31
7.4.	Piling Risk Assessment.....	34
7.5.	Floors.....	34
7.6.	Earthworks	35
7.7.	Retaining Structures.....	35
7.8.	Groundworks, Excavation Stability and Groundwater Dewatering.....	35
7.9.	Pavements and Highways.....	36
7.10.	Infiltration Testing.....	36
8.	HUMAN HEALTH RISK ASSESSMENT	37
8.1.	Data Interpretation Approach	37
8.2.	Selection of Generic Assessment Criteria (GAC)	37



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : ii of viii
Engineer: Stefani Ellis
Date: 03/03/2025

8.3.	Human Health Risk Assessment.....	38
8.4.	Utilities	45
8.5.	Construction and Maintenance Workers	45
9.	CONTROLLED WATERS RISK ASSESSMENT	46
9.1.	Introduction.....	46
9.2.	Controlled Waters Environment Conceptual Site Model Summary.....	46
9.3.	Soil Leachate Testing.....	46
9.4.	Groundwater Testing	47
10.	GROUND GAS RISK ASSESSMENT	50
10.1.	Introduction.....	50
10.2.	Groundwater Conditions.....	50
10.3.	Gas Monitoring Data Quality	51
10.4.	Ground Gas Monitoring Results.....	51
10.5.	Ground Gas Risk Assessment.....	53
11.	REVISED CONCEPTUAL SITE MODEL AND GENERIC QUANTITATIVE RISK ASSESSMENT OF POLLUTANT LINKAGES	64
12.	PRELIMINARY WASTE MATERIALS CLASSIFICATION AND WASTE DISPOSAL ROUTE DETERMINATION	67
12.1.	Introduction.....	67
12.2.	Preliminary Waste Materials Classification and Waste Disposal Route Determination.....	68
12.3.	Materials Re-Use.....	72
13.	CONCLUSIONS AND RECOMMENDATIONS	73
13.1.	Conclusions.....	73
13.2.	Recommendations	74
14.	REGULATORY APPROVALS.....	76
15.	REFERENCES	77
16.	GLOSSARY OF TERMS	80

TABLES

Table 2.1 Current Site Overview.....	3
Table 4.1 Preliminary Assessment of Potential Pollutant Linkages (Continued on Next Page).	7
Table 5.1 Scope of Ground Investigation and Rationale	11
Table 5.2 Scope of Monitoring Installations	12
Table 5.3 Schedule of Chemical Testing for Human Health Risk Assessment and Preliminary Waste Soils Assessment.....	13



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : iii of viii
Engineer: Stefani Ellis
Date: 03/03/2025

Table 5.4 Schedule of Chemical Testing for Controlled Waters Risk Assessment.....	14
Table 5.5 Geotechnical Laboratory Testing Schedule.	14
Table 6.1 Recorded Coal.....	21
Table 6.2 Obstructions Summary Table	22
Table 6.3 Visual and/or Olfactory Evidence of Contamination and/or Pertinent Anthropogenics Summary	23
Table 6.4 Field Observations of Groundwater.....	23
Table 6.5 Groundwater Monitoring Results Summary.....	24
Table 7.1 Assessment for Potential Sulphide Bearing (e.g. Pyritic) Ground	29
Table 7.2 Oxidisable Sulphides Calculations.....	29
Table 7.3 Results of Soil pH Testing and Water-Soluble Sulphate Determination.....	30
Table 7.4 Summary of Natural Moisture Content and Atterberg Limits	32
Table 7.5 Summary of point load Is50 test results.....	33
Table 7.6 Summary of UCS test results	33
Table 8.1 Measured Concentrations of Potential Contaminants of Concern Reported in Excess of the Respective GACs	39
Table 8.2 Measured Concentrations of Potential Contaminants of Concern Reported in Excess of the Laboratory Method Detection Limit	41
Table 8.3 Summary of Asbestos Assessment.....	44
Table 9.1 Summary of Measured Concentrations of Soil Leachate Potential Contaminants of Concern in Excess of WQS Values	46
Table 9.2 Summary of Measured Concentrations of Dissolved Phase Groundwater and Surface Water Potential Contaminants of Concern in Excess of WQS Values.....	48
Table 10.1 Ground Gas Monitoring Results Summary –6 No. Visits of Proposed Monitoring Programme of 6 No. Visits.....	52
Table 10.2 Worst-Case GSV Check Calculation	57
Table 10.3 Groundwater Depth Summary (after and Anticipated Depth to Possible Mine Workings.....	60
Table 11.1 Revised Assessment of Potential Pollutant Linkages (Continued on Next Page).	65
Table 12.1 Preliminary Materials Waste Classification and Waste Disposal Route Determination.....	69
Table 12.2 Preliminary Asphalt Materials Waste Classification.....	71

FIGURES

Figure 2.1 Recent Aerial Photograph from Groundsure.....	4
Figure 7.1 Site Location Plotted on Principal Sulphate and Sulphide Bearing Strata in England and Wales (Extracted from BRE SD1).....	27
Figure 7.2 Site Location Plotted Relative to Coal Mining Areas of Great Britain (Extracted from BRE SD1)	28



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : iv of viii
Engineer: Stefani Ellis
Date: 03/03/2025

Figure 10.1 Ternary Plots for Ground Gases.....61

APPENDICES

Appendix A - Drawings

Appendix B - Exploratory Hole Logs

Appendix C - Geoenvironmental Soil Laboratory Results

Appendix D - Geoenvironmental Groundwater Laboratory Results

Appendix E - Geotechnical In Situ Fieldwork and Laboratory Results

Appendix F - Groundwater and Gas Monitoring Results & Gas Analyser Calibration Certificate

Appendix G - Photographs

Appendix H – Infiltration Test Results

Appendix I - Definitions of Terms Used in Qualitative and Quantitative Risk Assessments

Appendix J - Human Health Assessment Criteria

Appendix K - Controlled Waters Risk Assessment

Appendix L - Assessment Criteria Applied for Ground Gas

Appendix M - Chemical and Geotechnical Test Sampling

Appendix N - Coal Tar Containing Asphalt Considerations

Appendix O - Complying With Control of Asbestos Regulations 2012



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : v of viii
Engineer: Stefani Ellis
Date: 03/03/2025

EXECUTIVE SUMMARY

Introduction	Tier Environmental was commissioned by Willmott Dixon to undertake a Ground Investigation of Hopwood Hall College, Rochdale Campus, St Mary's Gate, Rochdale OL12 6RY. 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.
Access Constraints	Some areas of the site were not accessible due to pre-existing site activities, buildings or safe access. Nevertheless, it is considered that the ground investigation works have provided good coverage of the site so as to characterise the ground conditions in key areas which are due to be redeveloped.
Proposed land use	Under current proposals the development will comprise the partial demolition of the existing college buildings in the east of the site, with construction of the new proposed 4 No. storey college building in the north, a water tank and small ancillary building in the centre, and a substation in the northwest of the site. The remainder of the site will comprise car parking and soft landscaped areas.
Surrounding land uses	The site is set within a mixed commercial and residential area, with Rochdale Town centre located approximately 500m northeast of the site.
Site history	The River Roch once ran through the site, with a weir near the centre-west and occasional stockpiling on its northwestern bank. A large mill (with pump) stood in the east; smaller mills and dyeworks (with tank) were in the west. Holland Street and possible residences (with basements) lay in the northeast. By the 1960s, Rochdale Technical College replaced the large mill, while some smaller mills/works remained in the northwest. During late 1960s/early 1970s, the river was diverted south, site levels were raised, and a large college complex was built, later demolished by 2012 and replaced by parking and landscaping. Nearby land was predominantly industrial/commercial (mills, dyeworks, cattle market), with some terraced housing. By the 1960s–1980s, most industries were demolished, replaced by an embankment and high-rise residential to the north and possible ground raising east. By 2000, the former cricket ground and industrial areas south of the river were redeveloped into a supermarket and petrol station.
Potential contaminative features	Potential Contaminative Features and Sources - Widespread Made Ground across the site, extending deeper along the former watercourse and containing asbestos (chrysotile and amosite). - Former Historical Uses including mills, dyeworks, unspecified works, a weir, and a former watercourse. - Current College Building in the east with two oil tanks, reportedly unused and partially emptied but not fully decommissioned, situated in a locked, bunded room with no visible leaks. - Car Park covering most of the site, with an interceptor in the northeast. - Electric Substation in the northeast. - Historical Landfill 204 m west, infilled before the Control of Pollution Act 1974, plus other infilled features within 250 m.
Mining and quarrying	Tier Environmental has prepared a separate Coal Mining Risk Assessment should be referred to for further details of the risk of coal mining to the site. Tier Environmental consider that due to the moderate / high risk posed by the potential shallow mineworkings and the shallow position of the Arley Mine Coal Seam underlying the site there is a risk of unacceptable differential settlements that could affect the development. Due to this the building footprint, drainage/attenuation and service corridors will require stabilisation via proof grouting. The full extent of these works will be detailed within a specification to be produced by Tier in due course.
Previous investigations	A previous third party ground investigation has been undertaken for the site. However it is understood that reliance on these reports cannot be assumed, and therefore these reports have been referred to for information purposes only.
Fieldwork	Window Sample Boreholes (26 No.) to depths between 0.43 m to 5.45 m bgl. To confirm shallow ground conditions, perform in situ geotechnical tests, obtain soil samples for geotechnical/geoenvironmental analysis, and install shallow gas/groundwater monitoring wells. Falling head tests were carried out in selected locations. Cable Percussion Boreholes (5 No.) to depths between 4.20 m to 7.59 m bgl. To confirm deeper ground conditions, carry out in situ geotechnical tests, collect soil samples for geotechnical/geoenvironmental parameters, and install deep gas/groundwater monitoring wells. Rotary Boreholes (7 No.) to depths between 0.30 m to 40.00 m bgl. To investigate deeper ground conditions, conduct in situ geotechnical tests, undertake rock sampling, assess potential coal mine workings, and install deep gas/groundwater monitoring wells. Hand Dug Pits (4 No.) to depths between 0.86 m to 1.52 m bgl to determine the extent and condition of existing retaining wall foundations. Soakaway Pit (1 No.) to 1.98 m bgl To perform targeted infiltration testing.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : vi of viii

Engineer: Stefani Ellis

Date: 03/03/2025

Laboratory testing	Samples of soil, soil leachate and groundwater 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	Hardstanding Hardstanding comprising asphalt was encountered in the car park, access road, and footpaths across the site to depths between 0.05m and 0.35m bgl. A concrete slab was encountered across the footprint of the former building which occupied the present-day car park, comprising thicknesses between 0.21m and 0.47m. Made Ground Made Ground has been reported to a maximum depth of 6.50m bgl and was found to be thickest towards the southwest and central west of the site within the former infilled watercourse. Made Ground was found to comprise both granular and cohesive deposits, with a layer of suspected Pulverised Fuel Ash (PFA) identified across the site, thickest beneath the former building footprint within the present-day car park area. Other anthropogenic materials encountered within the Made Ground include brick, concrete, sandstone, limestone, clinker/slag, plastic, metal, glass, timber, and occasional rebar. Superficial Deposits The Made Ground was found to be underlain by superficial deposits in some instances, comprising Alluvium (clay) and Glaciofluvial Deposits (silty sand). Bedrock The Made Ground and superficial deposits were found to be underlain at depths between 3.30m and 6.50m bgl by bedrock of the Pennine Lower Coal Measures, found to comprise mudstone with interbedded sandstone and siltstone. Coal Coal was reported at depths between 6m and 40m bgl within rotary boreholes, with evidence of probable workings within the Arley Mine seam. Specific coal seams encountered include: • RH101: 30.30m to 30.80m bgl (0.50m thick, hard coal) • CP104/RH102: 34.20m to 34.40m bgl (0.20m thick, possible coal/shale) • RH103: 16.80m to 17.00m bgl (0.20m thick, coal flash), 29.00m to 29.30m bgl (0.20m thick, hard coal)
Groundwater	Shallow groundwater has been monitored across the site at depths between 0.10m and 4.14m bgl and a separate deeper confined, locally artesian, groundwater body has been reported within the deep sandstone bands at RH101 and RH103C (sandstone bands present from depths of 28.50m bgl and 32.00m bgl). The head of water reported during one groundwater monitoring visit at RH103C was reported as 0.04m.
Ground stability	Given the nature and depth of the Made Ground, excavations should be assumed to be unstable.
Foundations and floor slabs	It is understood that a CFA piled solution will be implemented at the site with preliminary consideration of socketing Circa 5m into the bedrock; however, the final design of the piles will be subject to a specialist piling contractor and due consideration will need to be made with respect to the probable shallow coal mining workings encountered. To obviate any significant damaging settlements we would recommend using a suspended floor slab with intermediate support designed on the same basis as the main foundations where the spans are too large for economical single suspended slab design. Ground bearing floor slabs may be suitable subject to a turnover, proof rolling and confirmatory testing of the Made Ground.
CBR tests	CBR values derived from DCPs have been presented for preliminary purposes only and should not be relied on for final design purposes. We would recommend that confirmatory CBRs derived from full Plate Bearing Tests are conducted once the final formation levels have been achieved. The results indicate a range of values reported between 0.52% to >25%. Of the 49 results, 41 No. CBR values were reported >5%, 1 No. was reported between 2.5 and 5% and 7 No. were reported <2.5%.
Sulphate class	It is considered that a Design Sulphate Class of DS-2 and ACEC Class AC-2 is appropriate for buried concrete at the site.
Contamination – human health	Justification has been provided for screening measured soil concentrations of potential contaminants of concern against commercial / industrial GACs. No measured concentrations of potential contaminants of concern have been reported in excess of these GACs. Sensitivity analysis via comparison against POS Park GACs has reported a single measured concentration of benzo(a)pyrene in Made Ground in the northeast of the site. Overall, it is not considered that the site presents a risk from potential <i>chemical</i> contaminants of concern for the proposed areas of hardstanding, buildings or peripheral soft landscaping; however, it is recommended that additional, post-demolition, soil sampling and risk assessment is conducted in the vicinity of the proposed contoured landscaped area in the east of the site. Asbestos has been reported in the Made Ground across the site (in 56% of those samples analysed) at concentrations between <0.001% and 0.03% w/w (amosite and chrysotile - fibre bundles, ACM debris and locally,



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : vii of viii

Engineer: Stefani Ellis

Date: 03/03/2025

	bitumen products). Further detailed risk assessment is recommended for asbestos at the site in accordance with CIRIA C733.
Contamination – controlled waters	Results from controlled waters risk assessment has demonstrated that measured groundwater concentrations of cadmium, copper, nickel, zinc, fluoranthene, and ammonia reported in excess of relevant Water Quality Standards and localised measured concentrations of glycols do not present a significant risk to the controlled waters environment when factors including the hydraulic upgradient and downgradient concentrations, aquifer sensitivity, wider commercial and industrial use of the surrounding land and surface water sample results are taken into account.
Gas protection	Due consideration of the conceptual site model (including ground gas generation potential of possible sources) has been considered alongside the results from ground gas monitoring works conducted to date. Based on the information, it is considered that the site may be regarded as a Characteristic Situation 1 – Very Low Risk scenario for which no ground gas protection measures are required. In addition, separate consideration has been made for potential coal mine gas risk. Multiple lines of evidence have demonstrated a low risk for which no protection measures are required. these include: • Workings are shallow but permanently flooded; • Mine entries are >50m from the site boundary according to the Coal Authority information for the shaft; • Additional lines of evidence include - o The significant age of the mine workings (pre 1808); - o No reports of any historical ground related issues in nearby adjacent college building structures developed pre-1977 (at which time gas protection measures were not a standard practice in UK building practices); - o The absence of any significant ground gases or flow rates monitored at the site and determination of the site based on available data as a Characteristic Situation 1 - Very Low Risk scenario; - o The ternary plot produced for the steady gas concentrations (see below) does not indicate the presence of thermogenic methane (mine gas) in any wells monitored (either in saturated or unsaturated zone); - o The shallow flooded mine workings are to be grouted as part of the development works thereby significantly reducing ground gas risks even further by sealing potential migration pathways, reducing void space, and mitigating the risk of any gas displacement. Tier Environmental reserves the right to update the risk assessment in the event that any unrecorded mine shafts , adits or associated features are identified during earthworks / construction works.
Radon requirements	Less than 1% of properties are recorded to be above the Action Level for Radon, therefore no radon protection measures are required.
Soakaways	The results of soakaway testing (failed test) and prevalence of deep Made Ground across the site indicates that soakaways are not suitable for the site.
Other issues	Tier Environmental considers that further discussions are held with the structural engineers regarding the interaction between the former floor slab and the river-side retaining wall. Tier Environmental has studied photographs taken during the former building demolition works and these suggest that the slab is not tied into the retaining wall. Tier Environmental also has noticed some evidence of resin repairs to the river-side retaining wall and so further discussion and consideration of this should be made by the structural engineer.
Waste soils classification	Basic waste characterisation has determined that Made Ground soils are non-hazardous with the following exceptions: • Made Ground at WS105 (0.60m bgl) due to elevated TPH; • Made Ground at WS117 (0.40m bgl) due to elevated TPH. The results of WAC testing demonstrate that the localised hazardous soils are suitable for disposal as hazardous waste to a Stable Non-Reactive Hazardous Waste Cell in a Non-Hazardous Landfill. For the non-hazardous Made Ground and Topsoil, WAC testing (and the presence of asbestos <0.1% w/w) has demonstrated that these materials are not suitable for disposal to an inert waste landfill and therefore should be disposed to a non-hazardous landfill. Natural soils (other than any organic rich materials with TOC >3%) are suitable for disposal to an inert waste landfill.
Asphalt Testing	the results from asphalt testing have indicated coal tar concentrations consistently >0.1% w/w/ indicating that these materials would be hazardous waste. However, further assessment has demonstrated that in some (but not all) cases that the concentration of benzo(a)pyrene is low such that the classification may be downgraded to non-hazardous. It is recommended that further detailed consideration of asphalt is conducted to determine potential re-use opportunities and further refine the waste classification. In the meantime, it is recommended that all asphalt is considered to be coal-tar containing until such additional works are carried out.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : viii of viii

Engineer: Stefani Ellis

Date: 03/03/2025

Materials re-use	Subject to volumetric cut and fill requirements, and the results of any future asbestos DQRA, the majority of Made Ground materials and natural soil materials and may be considered chemically suitable for potential re-use subject to careful management and placement of materials due to the presence of asbestos (CAR 2012 would need to be followed) 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 12.3 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	It is recommended that further works are conducted to confirm that the former concrete slab associated with the building is not tied into the river-side retaining wall. It is recommended that further soil sampling and human health risk assessment is conducted post-demolition in the vicinity of the proposed contoured landscaped area in the east of the site. It is recommended that an asbestos Detailed Quantitative Risk Assessment is carried out for the asbestos concentrations reported at the site. If this is not carried out or if a potential risk is identified following any future risk assessment, then a remediation strategy will be required for a clean cover system at the site. It is recommended that an Asbestos Management Plan is prepared for the site. Tier consider that due to the moderate / high risk posed by the potential shallow mineworkings and the shallow position of the Arley Mine Coal Seam underlying the site there is a risk of unacceptable differential settlements that could affect the development. Due to this the building footprint, drainage/attenuation and service corridors will require stabilisation via proof grouting. The full extent of these works will be detailed within a specification to be produced by Tier in due course. It is recommended that further detailed consideration of asphalt is conducted to determine potential re-use opportunities and further refine the waste classification. An earthworks specification is recommended that taken into consideration any proposed re-use / earthworks of the PFA materials which may degrade in inclement weather.
Outline remediation strategy	No ground gas protection measures are considered necessary for the site (subject to identification during earthworks of any unrecorded mine shaft, adit or associated coal mining features that may present preferential pathways). An asbestos DQRA is recommended in accordance with CIRIA C733; however, in the event that an unacceptable risk is identified then a clean cover system will likely be required for the soft landscaped areas. If the results of the risk assessment demonstrate a minimal risk from asbestos, then a clean cover system will not be required. Treatment / grouting works will be required associated with probable shallow coal mine workings identified beneath the site. Please see the separate Coal Mining Risk Assessment report for more details. A grouting specification will therefore be required.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 1 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

1. INTRODUCTION

Tier Environmental was commissioned by Wilmott Dixon Construction Ltd to undertake a Land Contamination Risk Management (LCRM) Ground Investigation for an area of land referred to as Hopwood Hall College, located at Hopwood Hall College, Rochdale Campus, St Mary's Gate, Rochdale OL12 6RY (the "site").

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

Stage 1:

- LCRM Tier 1 Preliminary Risk Assessment Report
- LCRM Tier 2 Generic Quantitative Risk Assessment Report
- LCRM Tier 3 Detailed Quantitative Risk Assessment Report (not included within this document)

1.1. Proposed Development

Under current proposals the development will comprise the partial demolition of the existing college buildings in the east of the site, with construction of the new proposed 4 No. storey college building in the north, a water tank and small ancillary building in the centre, and a substation in the northwest of the site. The remainder of the site will comprise car parking and soft landscaped areas, as presented in Appendix A. As such, in accordance with the 'Updated technical background to the CLEA model' (Environment Agency, 2009) and 'Suitable 4 Use Levels' (LQM / CIEH 2015) the proposed generic land use for this development is commercial, which is deemed to be the most appropriate due to the activities that are likely to be undertaken on site (educational) and the limited frequency and duration of time end users are likely to spend on site.

1.2. Previous Reports

Tier Environmental have been provided with the previous third party reports for the site:

- Geotechnics Ltd – 'Geoenvironmental and Geotechnical Desk Study Report' (Report reference: PC218240, dated 30th July 2021);
- Geotechnics Ltd – 'Preliminary Ground Investigation Report with Interpretative Chapter' (Report reference PN214280, dated November 2021);
- Tier Environmental – 'Preliminary Risk Assessment Report for Hopwood Hall College, Rochdale' (Report reference TE1880-TE-00-XX-RP-GE-001-V01, dated 30th January 2025);
- Tier Environmental – 'Coal Mining Risk Assessment Report for Hopwood Hall College, Rochdale' (Report reference TE1880-TE-00-XX-RP-GE-003-V01, dated 30 January 2025); dated February 2025).

It is understood that Wilmott Dixon do not have reliance on the previous Geotechnics reports. Information from the previous Geotechnics reports has been included within this report for information purposes only.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 2 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

1.3. Objectives

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

- To summarise the Preliminary Conceptual Site Model determined during the Preliminary Risk Assessment (inclusive of a summary of historical and current land use and 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 further works and /or remedial measures to manage any identified risks.
- To provide preliminary geotechnical parameters to inform floor slab and foundation recommendations.
- To conduct a preliminary assessment of suitability of materials for re-use.
- To assess suitability of the site for infiltration testing for SuDS (including soakaways) design.

1.4. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or as shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigation has been designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms 'shallow' and 'deep' within this report (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, and 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.
- Recommendations with respect to ground gas risks / coal mine gas risks are subject to being updated upon discovery of any presently unrecorded coal mine shafts, adits or associated features.

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GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 3 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview.

Site name	Hopwood Hall College
Site address	Hopwood Hall College, Rochdale Campus, St Mary's Gate, Rochdale OL12 6RY. A site location plan is included as Drawing No. TE1880-TE-00-XX-DR-GE-001-V01 within Appendix A.
National Grid Reference (NGR)	389299 413363
Approximate site area	1.75 ha
Site shape	The site is approximately triangular in shape
Current land use on the site	The site currently comprises a college with a building of several storeys (including a basement/undercroft) present in the east of the site, and an asphalt surfaced car park across the majority of the remainder of the site and a drop off lane present along the northern and western boundaries. It is understood that an interceptor is present in the northeastern corner of the car park/drop off lane. Metal fencing around 2m height is present at the northern and western extent of the car park, with a brick retaining wall of between approx. 1.00m and 2.00m height present at the northern boundary of the drop off lane, marking the site boundary with College Road. A second brick retaining wall is present at the south of the car park, separating the car park from the river embankment which lies approx. 1.00m to 2.00m below the car park. No cracks or visible signs of stress were visible on either of the retaining walls. Limited soft landscaped areas are present, including a small sloped grass verge in the northwest of the site, a grassed embankment between the car park/college buildings and the river in the south of the site, and as a grassed terraced area to the north east of the building, which steps down to the basement floor level. The basement/ undercroft area is accessible from the car park and is understood to comprise storage, waste disposal areas (bins/skips) and a plant room. The plant room contains the heating infrastructure for the building, including 2 no. oil tanks, both of which are understood to no longer be used with one understood to have been emptied via tanker (but not decommissioned) in the past couple of years. These oil tanks are present within a separate concrete bunded room, only accessible via locked ladder access. From the limited viewpoint accessible during the walkover, no spills or leakages were observed. An electric substation is present in the northeast of the site, to the northwest of the existing college building. Underground services are known to be present beneath the site, including electricity, gas, water and drainage. There is limited surface water drainage around the car park area, observed only to be present at the car park boundaries. Vehicular access for deliveries and disabled parking is present from College Road close to the centre north of the site, leading to the drop off lane, a small parking area and the basement/undercroft access. An access road for the main car park is present in the northwest of the site, with a smaller car park present to the west of this access road. This smaller car park is understood to be let out and was not accessible during the ground investigation. During college opening hours, pedestrian access is freely available. A hedge of approximately 1m height is present surrounding the northeastern soft landscaped area, with limited shrubs present elsewhere around site. Mature trees are present in the far northwest of the site, surrounding the smaller car park (it is understood that development is to be undertaken in this area). It should be noted that the car park in the northwest of the site and the terraced soft landscaping in the east of the site were not accessible during the walkover, and are unlikely to be accessible for any ground investigation.
Surrounding land uses	The site is set within a mixed commercial and residential area, with Rochdale Town centre located approximately 500m northeast of the site.
General topography and ground levels	The main car park area of the site is generally level at around 119m AOD. However, College Road to the north of the site lies between approx. the same level as the site in the northeast (120m AOD) rising to around 1.0m higher than the site in the northwest (120m AOD), separated from the site by a brick retaining wall. Similarly, in the south of the site the highest level of the grassed banks of the River Roch lies between 0.5m to 1.00m below the car park level at around 118m AOD, separated by a brick retaining wall. Site levels between the existing building and St. Mary's Gate also vary, with grassed terraces leading from road level (120m AOD) in the northeast to 116m AOD in the centre east and back up to 120m AOD in the southeast. Again, a brick and concrete retaining wall was present at the site boundary (this area was not accessible during the walkover).



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

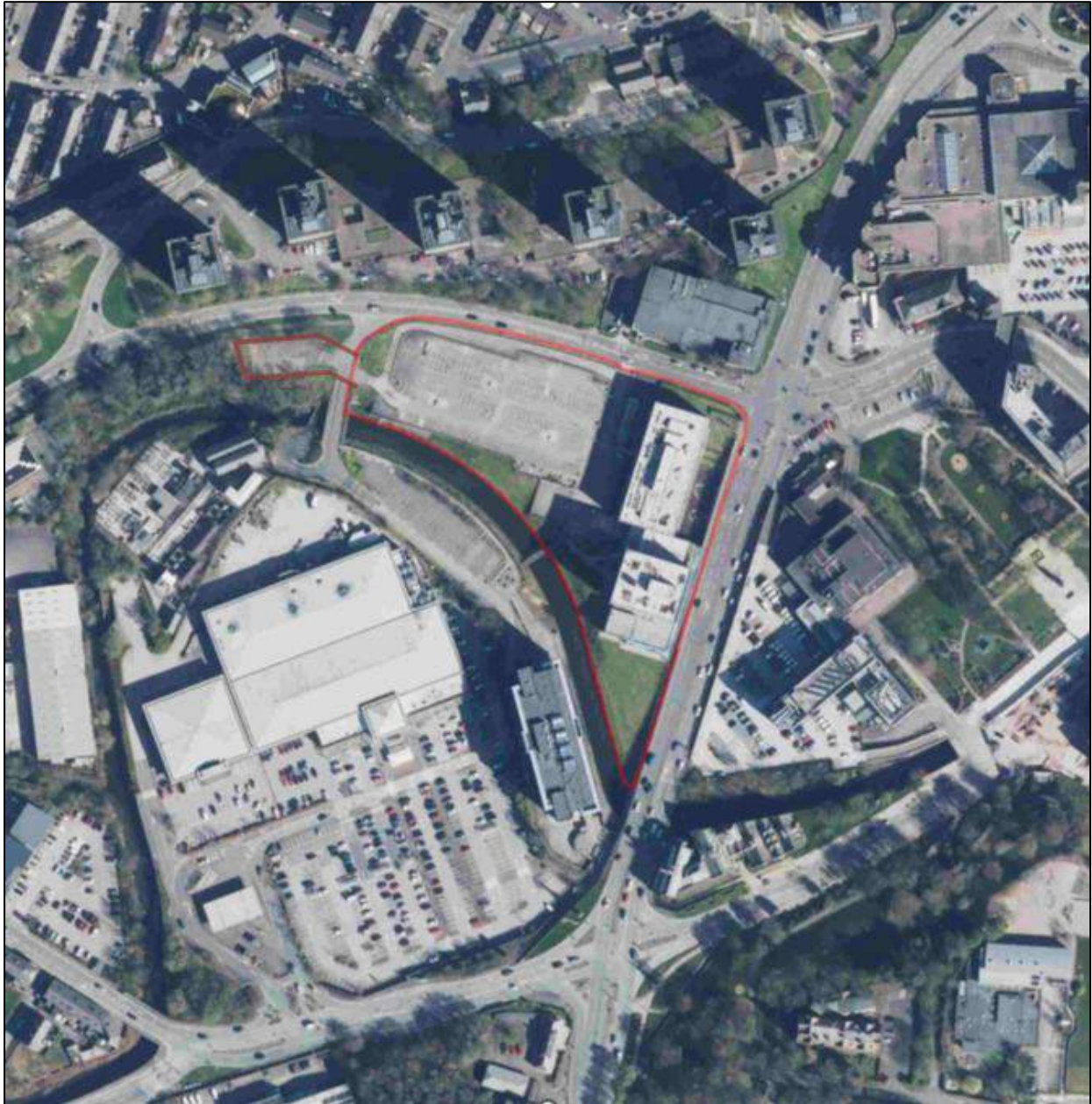
Page No : 4 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

An aerial photograph (from the Groundsure report) of the site and site boundary is shown below. Relevant site photographs are presented in Appendix G.

Figure 2.1 Recent Aerial Photograph from Groundsure





**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 5 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

3. GROUND GAS CONCEPTUAL SITE MODEL CONSIDERATION

Detailed consideration of conceptual site model considerations with respect to ground gases can be found in Section 6 of the Preliminary Risk Assessment and reference to this should be made, accordingly.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 6 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

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 I.

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.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 7 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 4.1 Preliminary Assessment of Potential Pollutant Linkages (Continued on Next Page).

Justification / Comments
• The site currently comprises an asphalt surfaced car park for Hopwood Hall College, with a drop off lane located in the north of the site and limited soft landscaped areas (grassed) present in the northwest, northeast, east (terraced levels) and southeast of the site. Hopwood Hall College is located in the east of the site, split over varying levels and with an undercroft maintenance/service area, within which oil tanks were noted to be present (one of which has been emptied but not decommissioned, the other of which is filled with heating oil but not used). An electric substation is present in the east of the site (to the west of the college building). A second smaller car park is located in the northwest of the site, although this area was not accessible during the ground investigation. The main car park is relatively level at 119m AOD, although a brick retaining wall of approx. 1.0m to 1.5m height separates the car park from the higher level of College Road at the northern site boundary, and a similar retaining wall separates the car park from the grassed banks of the River Roch in the south. • Historically the River Roch meandered through the centre of the site, with a weir present close to the centre west of the site. Excavation/building up/stockpiling of materials is shown on its northwestern bank at several points in history. The remainder of the site has historically been occupied by a large mill (including a pump) in the east of the site, and several smaller mills and dyeworks (including a tank) in the west of the site at extending offsite beyond the site boundaries. Holland Street and presumed residential properties (which may have contained basements) were mapped in the northeastern corner of the site. By the 1960s the mill in the east of the site had been replaced with Rochdale Technical College, although some of the smaller mills/works were still shown in the northwest of the site at this time, alongside allotment gardens. By the late 1960s/early 1970s the River Roch had been diverted along the southern boundary of the site, with the former watercourse on site infilled. Embankments are shown along the watercourse at the southern site boundary, suggesting site levels may have been raised. Allotments and buildings in the northwest of the site were demolished during this time, with a large building labelled as Rochdale College now present across the majority of the west and centre of the site, and additional college buildings shown in the southeast of the site and an access road and car park created in the northwestern corner of the site. Holland Street was rerouted to the north of the site and renamed as Bury Street and later College Road, with the buildings alongside it demolished. The large college building in the west and centre of the site is last shown in 2008, by 2012 this and the smaller buildings in the southeast of the site have been demolished. The west/centre of the site was resurfaced for car parking (it is understood the concrete floor slab was left in situ beneath the asphalt) and the southeastern area was soft landscaped. • The immediate surrounding area predominantly comprised industrial/commercial land uses including mills and dyeworks, a cattle market, warehouses, unnamed works, with some terraced residential properties. The majority of the surrounding industry was demolished by the 1960s to 1980s, with an embankment and high rise residential constructed from 10m to the north of the site (potentially on built up land) and possible raising of levels shown in the former cattle market area approx. 20m east of the site during the 1970s. By 2000, the former cricket ground and industry to the south of the river was replaced with a supermarket and associated petrol station. • The previous third party investigation recorded the Made Ground deposits in CP02 at 5.30m bgl (northeast of the site) were stained black with a strong hydrocarbon odour. Asbestos (chrysotile fibres, amosite loose fibrous debris) was recorded in numerous locations within the Made Ground across the site, at concentrations of up to 0.003% w/w. No other contaminants were recorded in excess of public open space (park) assessment criteria. • An electric substation is recorded 94m W and a petrol station is recorded 106m SW of the site. Both are located hydraulically downgradient of the site and therefore are not likely to impact the site. • There are 2 no. licensed industrial processes located 176m E of the site, at Newhey Bleach works. These are for the pre-treating/dyeing fibres/ textiles and for coating/printing textiles. Both are recorded as superseded in 2024, and it is unclear whether these industrial processes are still occurring. There is also a recent industrial land use involving paints, varnishes and lacquers located 164m north. • Made Ground has been recorded to depths of between 0.95m and 6.80m bgl (the deeper Made Ground being recorded within the former infilled watercourse) within a previous third party ground investigation. Superficial Deposits comprising Alluvium (Secondary A aquifer) are recorded in the north of the site, with Glaciofluvial deposits (Secondary A aquifer) recorded across the remainder of the site. The solid geology is recorded as the Pennine Lower Coal Measures (Secondary A aquifer). • There are no Source Protection Zones, potable, non-potable or surface water abstractions recorded within 250m of the site. The nearest surface water feature is the River Roch located beyond the southern site boundary, with the River Spodden also located 209m southwest of the site. No further surface water features are located within 250m of the site. Groundwater flow is anticipated to be towards the southwest based on surrounding topography and the presence of the River Roch. There is understood to be limited surface water drainage in the form of ACO drains at the main car park perimeters, with an interceptor located in the northeast of the car park.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 8 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

- A historical landfill is located 204m W, with no information on the waste accepted or any dates of operation given, although the Environment Agency have stated that it was infilled before 'controls imposed under the Control of Pollution Act 1974'.
- As well as a general presence of shallow Made Ground, a significant depth of infilled ground is present on site within the route of the former watercourse, recorded to a depth of 6.80m bgl in the previous third party investigation. Infilled Made Ground is likely to include organic rich materials. It is also likely that the site has been raised following the rerouting of the watercourse. Possible unrecorded shallow workings may also be present beneath the site. Land in the immediate surrounding vicinity has also possibly been infilled/built up in recent history.
- Less than 1% of properties are recorded to be above the Action Level for Radon, therefore no radon protection measures are required.
- A storm overflow sewage discharge consent to the River Roch is present on site (revoked 2020), and a pollution incident involving crude sewage released to the River Roch (Category 3 minor impact) has been recorded in July 2023. Neither is expected to have a lasting impact on the site.
- Whilst the Fire Service have recorded 3 no. fires to have occurred on the site, they have confirmed that PFAS containing firefighting foam was not used in any of the incidents.
- The site is not located within an ecologically sensitive area.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 9 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Anticipated widespread Made Ground; Infilled former watercourse located through the centre of the site and possible raising of site levels; Residential properties in the northeast of the site that may have had basements infilled during demolition; Former cotton mills, dyeworks, mills, unspecified works, college, tanks and works located on site and in immediate vicinity Demolished college buildings in the centre west and southeast of the site;	Metals PAHs pH Hexavalent chromium Acids Alkalies	Direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Likely	Moderate Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Likely	Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Alluvium	Medium	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Glaciofluvial Deposits	Medium	Likely	Moderate Risk
			Aquifer 3 - Secondary A Aquifer associated with Pennine Lower Coal Measures	Medium	Likely	Moderate Risk
			River Roch located beyond southwestern boundary	Medium	High Likelihood	High Risk
	Naphthalene (a semi-volatile PAH) TPH / BTEX / MTBE VOCs / SVOCs Phenols PolyChlorinated Biphenyls (PCBs) Cyanides Glycols Free phase product	Vapour inhalation, direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Likely	Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Alluvium	Medium	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Glaciofluvial Deposits	Medium	Likely	Moderate Risk
			Aquifer 3 - Secondary A Aquifer associated with Pennine Lower Coal Measures	Medium	Likely	Moderate Risk
			River Roch located beyond southwestern boundary	Medium	High Likelihood	High Risk
	Asbestos	(Dust migration and) dust inhalation	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
Current use of the majority of the site as a car park Below ground storage tanks in the southeastern part of the existing college building Interceptor located in the northeast of the car park area Black stained material with hydrocarbon odour recorded in the northeast of the site within the previous third party ground investigation	Naphthalene (a semi-volatile PAH) TPH / BTEX / MTBE Glycols Free phase product	Vapour inhalation, direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Likely	Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Alluvium	Medium	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Glaciofluvial Deposits	Medium	Likely	Moderate Risk
			Aquifer 3 - Secondary A Aquifer associated with Pennine Lower Coal Measures	Medium	Likely	Moderate Risk
			River Roch located beyond southwestern boundary	Medium	High Likelihood	High Risk
Asphalt surfacing (if crushed and re-used)	Coal tar	Vapour inhalation, direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Likely	Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Alluvium	Medium	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Glaciofluvial Deposits	Medium	Likely	Moderate Risk



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 10 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Electricity substation present in the east of the site and 94m W	PolyChlorinated Biphenyls (PCBs)	Vapour inhalation, direct contact, dust inhalation and ingestion	Aquifer 3 - Secondary A Aquifer associated with Pennine Lower Coal Measures	Medium	Likely	Moderate Risk
			River Roch located beyond southwestern boundary	Medium	High Likelihood	High Risk
			Future site users (commercial)	Medium	Likely	Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	High Likelihood	High Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Likely	Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary A Aquifer associated with Alluvium	Medium	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Glaciofluvial Deposits	Medium	Likely	Moderate Risk
			Aquifer 3 - Secondary A Aquifer associated with Pennine Lower Coal Measures	Medium	Likely	Moderate Risk
Previously recorded widespread asbestos within Made Ground (chrysotile fibres, amosite loose fibrous debris, at concentrations of up to 0.003% w/w)	Asbestos	(Dust migration and) dust inhalation	River Roch located beyond southwestern boundary	Medium	High Likelihood	High Risk
			Future site users (commercial)	Severe	High Likelihood	Very High Risk
			Adjacent site users (residential and commercial)	Severe	High Likelihood	Very High Risk
Made Ground located beneath the site, including to a significant depth within the route of the former watercourse and possible infilled basements of residential properties in the northeast. Possible organic rich deposits associated with former watercourse. Alluvium beneath the site. Coal measures located beneath the site, including possible unrecorded shallow workings. Numerous possible infilled features and raising of levels in the close surrounding area. Historical landfill 204m W of the site.	Hazardous ground gasses (methane, carbon dioxide, hydrogen sulphide, carbon monoxide and depleted oxygen)	Inhalation (indoor and outdoor)	Construction, site investigation, demolition and future maintenance workers	Severe	High Likelihood	Very High Risk
			Future site users (commercial)	Severe	Likely	High Risk
			Adjacent site users (residential and commercial)	Severe	Likely	High Risk
		Migration of hazardous ground gases from beneath the site to adjacent sites along services or other preferential conduits	Construction, site investigation, demolition and future maintenance workers	Severe	Likely	High Risk
		Migration of ground gas / explosion	Adjacent site users (residential and commercial)	Severe	Likely	High Risk
			Buildings and services	Severe	Likely	High Risk

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



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 11 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

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. TE1880-TE-00-XX-DR-GE-008-V05.

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

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

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

5.1. Scope of Ground Investigation

The ground investigation was conducted between 18th November and 4th December 2024 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. TE1880-TE-00-XX-DR-GE-008-V05.

Table 5.1 Scope of Ground Investigation and Rationale

Exploratory Hole Type	Exploratory Hole Reference	Exploratory Hole Depths (m bgl)	Rationale
Window sample boreholes	WS102 WS102A, WS103, WS103A, WS103B, WS104 to WS113, WS113B, WS114, WS115, WS115B, WS116 to WS118, WS118A, WS118B	0.43m to 5.45m bgl	To confirm the shallow ground conditions across the site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and/or geoenvironmental parameters and installation of gas/groundwater monitoring wells. Falling head tests were undertaken within WS112 and WS116.
Cable percussion boreholes	CP101 to CP105	4.20m to 7.59m bgl	To confirm the deep ground conditions across the site, conduct <i>in situ</i> geotechnical tests, facilitate soil sampling for geotechnical and/or geoenvironmental parameters and installation of deep gas/groundwater monitoring wells.
Rotary boreholes	RH101, RH101A, RH102, RH103, RH103A, RH103B, RH103C	0.30m to 40.00m bgl	To confirm the deep ground conditions across the site, conduct <i>in situ</i> geotechnical tests, facilitate rock sampling for geotechnical parameters, investigate potential coal mine workings and installation of deep gas/groundwater monitoring wells.
Hand dug pits	HD101, HD102, HD104, HD105	0.86m to 1.52m bgl	To understand extent and condition of existing retaining wall foundations
Soakaway pits	SA01	1.98m bgl	To undertake infiltration testing

The following constraints were identified during the ground investigation works:

- WS101 was located within the smaller western car park which could not be accessed during the ground investigation;



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 12 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

- HP103 was located along the southwestern extent of the retaining wall within the main car park. However due to the presence of a safety railing set back from the wall edge, a hand dug pit to expose the foundations could not be excavated here;
- The soft landscaped area to the east of the existing college building could not be accessed due to safety concerns due to rotten wooden steps providing access between terraces;
- Existing buildings and ongoing use of the car parking areas (and general use of the site as an active college) meant that some areas of the site could not be investigated;
- Investigation was limited within the disabled parking area immediately west of the existing building due to ongoing college usage requirements;
- A phased approach had to be undertaken when fencing off areas of investigation within the main college car park, to keep as many spaces available for use as possible;
- The drop off lane to the north of the site could only be accessed for investigation between the hours of 10.30am and 3.00pm due to required use within rush hour;
- An existing sewer (with easement) is present within the deliveries access road within the east of the site. other services including gas and electric are present within the main car park area;
- All works within Made Ground had to be undertaken in accordance with CAR:2012 due to the presence of asbestos (up to 0.003%w/w) recorded within the previous third party ground investigation.

Table 5.2 Scope of Monitoring Installations

Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
WS104	Made Ground	0.50 to 1.00	Targeting shallow ground gas Made Ground source.
WS107	Made Ground	0.50 to 1.00	Targeting shallow ground gas Made Ground source.
WS108	Made Ground	0.50 to 0.70	Targeting shallow ground gas Made Ground source.
WS109	Made Ground	0.50 to 0.60	Targeting shallow ground gas Made Ground source.
WS111	Made Ground	0.50 to 0.70	Targeting shallow ground gas Made Ground source.
WS112	Made Ground and Alluvium	1.00 to 4.00	Targeting shallow ground gas Made Ground and underlying Alluvium sources.
WS116	Made Ground and Alluvium	1.00 to 2.50	Targeting shallow ground gas Made Ground source.
WS117	Made Ground	1.00 to 1.60	Targeting shallow ground gas Made Ground source.
CP101	Made Ground, Alluvium and Pennine Lower Coal Measures	2.00 to 4.50	Targeting groundwater monitoring body and above probable flooded shallow coal mine workings.
CP102	Made Ground and Pennine Lower Coal Measures	2.00 to 6.00	Targeting groundwater and probable flooded shallow coal mine workings.
CP103	Made Ground	2.00 to 6.00	Targeting shallow ground gas Made Ground source and perched groundwater body within former infilled watercourse.
CP104/RH102	Made Ground	2.00 to 3.50	Targeting shallow ground gas Made Ground source and perched groundwater body.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 13 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
CP105	Made Ground and Pennine Lower Coal Measures	1.00 to 4.00	Targeting shallow ground gas Made Ground source and perched groundwater body.
RH101	Pennine Lower Coal Measures (coal)	28.00 to 33.00	Targeting deep coal gas source.
RH103C	Pennine Lower Coal Measures (coal)	28.00 to 32.00	Targeting deep coal gas source.

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 M. 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 Surfacing	Made Ground 1 Topsoil	Made Ground 2 Gravel	Made Ground 3 Silt	Made Ground 4 Clay	Made Ground 5 Sand and Gravel	Natural Soils Alluvium	Groundwater
Tier Environmental soil suite*	-	2	7	5	1	3	2	NA
Asbestos screen	-	2	7	5	1	3	-	NA
Speciated TPH / BTEX / MTBE	-	-	3	4	1	2	-	6
VOCs / SVOCs	-	-	4	3	1	2	-	6
PCBs	-	1	2	4	-	-	-	-
Total, free and complex cyanides	-	2	7	6	1	3	-	6
Glycols	-	-	1	2	-	-	-	6
Tier Environmental groundwater suite*	NA	NA	NA	NA	NA	NA	NA	6
Waste Acceptance Criteria (WAC)	-	1	1	3	-	-	-	NA



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 14 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Laboratory analysis	Asphalt Surfacing	Made Ground 1 Topsoil	Made Ground 2 Gravel	Made Ground 3 Silt	Made Ground 4 Clay	Made Ground 5 Sand and Gravel	Natural Soils Alluvium	Groundwater
Coal tar suite	5	-	-	-	-	-	-	NA

*For definition of Tier Environmental analytical suites, please see Appendix M. 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 and groundwater samples. The purpose of the testing was to:

- Determine the concentration and spatial distribution of potential leachable contaminants of concern in the Made Ground;
- Determine the dissolved phase concentrations of potential contaminants of concern within groundwater beneath the site;

Table 5.4 Schedule of Chemical Testing for Controlled Waters Risk Assessment.

Laboratory analysis	Made Ground 1 Topsoil	Made Ground 2 Gravel	Made Ground 3 Silt	Made Ground 4 Clay	Made Ground 5 Sand and Gravel	Natural Soils Alluvium	Groundwater	Surface Water
Tier Environmental water suite*	-	-	-	-	-	-	6	3
Tier Environmental leachate suite*	1	2	5	1	-	-	-	-
Speciated TPH / BTEX / MTBE	-	-	-	-	-	-	6	3
VOCs / SVOCs	-	-	-	-	-	-	6	3
Total, free and complex cyanides	-	-	-	-	-	-	6	3
Glycols	-	-	-	-	-	-	6	3

*For definition of Tier Environmental analytical suites, please see Appendix M. 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 Ltd, who are UKAS accredited. Test certificates including details of appropriate testing standards are presented in Appendix E and discussed in Section 7, below.

Table 5.5 Geotechnical Laboratory Testing Schedule.

Test	Stratum type	Number of tests	Rationale
1. General			
Moisture content	MG2 (clayey gravel)	1	a) Assist with the determination of consistency of soil with depth. b) Assess desiccation of soils. c) Suitability of materials for reuse within earthworks.
	MG3 (Silt)	2	
	Natural clay	1	
	Mudstone	2	



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 15 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Test	Stratum type	Number of tests	Rationale
2. Classification			
Atterberg limit	MG2 (clayey gravel)	1	a) Volume change potential.
	MG3 (Silt)	2	b) Plasticity assessment (comply with Eurocode 7 description)
	Natural clay	1	c) Consistency Index.
	Mudstone	2	d) Determine soil type (e.g., clay/silt). e) Use as an empirical guide to soil shear strength
Particle size distribution (wet/dry sieve)	MG2 (gravel)	2	a) Classify soils for earthworks purposes.
	MG3 (Silt)	2	b) Establish type of soil (comply with Eurocode 7 description).
	Natural clay	1	
3. Chemical tests			
pH (soil and groundwater)	MG2 (gravel)	12	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.
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
	Sandstone	1	
Water-soluble sulphate (soil and groundwater)	MG2 (gravel)	12	
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
	Sandstone	1	
Acid-soluble sulphate (soil only)	MG2 (gravel)	12	
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
	Sandstone	1	
Total sulphur (total potential sulphur; soil only)	MG2 (gravel)	12	
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
	Sandstone	1	
Chloride and nitrate (soil and groundwater)	MG2 (gravel)	12	
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
	Sandstone	1	



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 16 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Test	Stratum type	Number of tests	Rationale
Magnesium (soil and groundwater)	MG2 (gravel)	12	
	MG3 (Silt)	6	
	MG4 (clay)	2	
	Natural clay	1	
	Natural sand	2	
	Mudstone	4	
8. Rock Testing			
Point Load Test	Mudstone/sandstone bedrock	37	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/sandstone bedrock	5	



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 17 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

6. GROUND CONDITIONS

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

Photographs of ground investigation works are provided in Appendix G.

6.1. Strata Profile

The ground conditions beneath the site have been summarised within the following drawings included within Appendix A:

- TE1880-TE-00-XX-DR-GE-017-V01 - Depth of Made Ground
- TE1880-TE-00-XX-DR-GE-018-V01 - Bedrock Elevation
- TE1880-TE-00-XX-DR-GE-019-V01 - Groundwater Contours - Monitoring Visit 1 - 17.12.24
- TE1880-TE-00-XX-DR-GE-020-V01 - Groundwater Contours - Monitoring Visit 2 - 07.01.2025
- TE1880-TE-00-XX-DR-GE-021-V01 - Groundwater Contours - Monitoring Visit 3 - 15.01.2025
- TE1880-TE-00-XX-DR-GE-022-V01 - Groundwater Contours - Monitoring Visit 4 - 24.01.2025
- TE1880-TE-00-XX-DR-GE-023-V01 - Thickness of PFA

The above drawings should be referenced in conjunction with the below information.

Made Ground – Hardstanding

Asphalt Black medium to high aggregate ASPHALT. Aggregate is medium to coarse angular to subangular of limestone. Generally present in one layer only.	
Locations encountered	CP101 to CP104/RH02, CP105, HDP101, HDP102, HDP104, HDP105, RH101, RH101A, RH102, RH103, RH103A, RH103B, RH103C, WS104 to WS112, WS114, WS116
Depths encountered from top of stratum (range)	Ground level
Depths encountered to base of stratum (range)	0.05m to 0.35bgl (generally less than 0.20m bgl)
Thickness (range)	0.05m to 0.35bgl (generally less than 0.20m bgl)
Spatial location on site	Within the car park, access road and footpaths across the site
Concrete Grey to dark grey, medium to high aggregate CONCRETE. Aggregate is medium to coarse, subangular of limestone. Low to medium air voids, occasional rebar approx >10mm in diameter. Underlain by a second layer of grey or bluish grey, medium to high aggregate CONCRETE. Aggregate is fine to medium, angular of limestone with low to medium air voids, occasional rebar approx >25mm in diameter. Often with plastic sheeting at base.	
Locations encountered	CP101 to CP103, CP105, HDP104, HDP105, RH101, RH101A, RH103, RH103A, RH103B, RH103C, WS104, WS105, WS107 to WS112
Depths encountered from top of stratum (range)	0.05m to 0.67m bgl
Depths encountered to base of stratum (range)	0.21m to >1.07m bgl (base not encountered)
Thickness (range)	0.21m to 0.47m



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 18 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Spatial location on site	Generally beneath car park area of the site (possible floor slab of former building)
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Made Ground – MG1 (Made Ground Topsoil)

Locations encountered	WS102, WS102A, WS103, WS103A, WS103B, WS113, WS113B, WS115, WS115B, WS117 WS118, S118A, WS118B, SA01
Depths encountered from top of stratum (range)	Ground level
Depths encountered to base of stratum (range)	0.12m to 0.56m bgl
Thickness (range)	0.12m to 0.56m bgl
Spatial location on site	Within soft landscaped areas of the site
General description	Grass over, dark brown, slightly silty, sandy LOAM with occasional gravel of brick, sandstone and timber and occasional rootlets. Cobbles of sandstone and brick within WS115.

Made Ground – MG2 (Gravel)

Locations encountered	CP101 to CP103, CP04/RH102, CP105, HDP101, HDP102, HDP104, RH103, RH103A, RH103C, WS104 to WS108, WS110 to WS112, WS114, WS116, WS117
Depths encountered from top of stratum (range)	0.07m to 3.40m bgl
Depths encountered to base of stratum (range)	0.45m to 6.50m bgl
Thickness (range)	0.09m to 4.75m
Spatial location on site	Widespread across the site, thickest within the route of the former infilled watercourse
General description	Dark brown to greyish brown, slightly clayey, sandy GRAVEL of fine to coarse, angular to subangular of brick, concrete, sandstone, limestone, occasional clinker/slag, rare plastic and metal. Compacted/medium dense, reddish brown to dark brownish grey, slightly sandy to sandy, slightly clayey to clayey, slightly ashy to ashy, GRAVEL of fine to coarse, angular to subangular mixed lithologies including brick, concrete, limestone and occasional clinker. Reddish brown, fine to coarse, angular GRAVEL of crushed brick and rare concrete. Grey, fine to coarse, subangular to subrounded GRAVEL of concrete and limestone (generally recorded as subbase beneath concrete) Gravel often recorded to contain occasional cobbles of concrete, brick, sandstone

Made Ground – MG3 (Silt – Possible PFA)

Locations encountered	CP101 to CP103, CP104/RH102, CP105, RH101, RH101A, RH103, RH103A, RH103C, WS104 to WS107, WS109, WS111, WS114, WS115B, WS116, WS117
Depths encountered from top of stratum (range)	0.27m to 2.10m bgl
Depths encountered to base of stratum (range)	1.40m to >3.80m bgl (base not encountered)
Thickness (range)	0.40m to >2.00m (base not encountered)



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 19 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Spatial location on site	Generally beneath car park area of the site (possible previous ground improvement layer)
General description	Medium dense to dense, grey slightly sandy SILT. Often causing refusal within window sample locations. Possible former PFA ground improvement layer. It is anticipated that the Made Ground Silt may represent a former PFA ground improvement layer for the former building within the car park area, which may have been cement stabilised to provide a suitable development platform following the infilling of the former watercourse.

Made Ground – MG4 (Clay)

Locations encountered	HDP101, HDP102, HDP105, RH101, RH103, SA01, WS13, WS113B, WS115, WS115B
Depths encountered from top of stratum (range)	0.12m to 3.00m bgl
Depths encountered to base of stratum (range)	0.55m to 4.00m bgl, (>1.98m bgl - base not encountered within HDP101, HDP102, HDP105, SA01)
Thickness (range)	0.30m to >1.66m bgl (base not proven)
Spatial location on site	North of site
General description	Soft to firm, dark brown, slightly sandy to sandy, slightly gravelly to gravelly CLAY. Gravel is fine to coarse, angular to subangular of brick and occasional sandstone. Friable brownish grey, gravelly CLAY with frequent cobbles of brick and sandstone. Gravel is fine to coarse, angular to subangular of brick. POSSIBLE MADE GROUND: Firm to stiff, reddish brown, silty CLAY with occasional cobbles of sandstone.

Made Ground – MG5 (sand/sand and gravel)

Locations encountered	CP102, CP105, RH103, WS102, WS102A, WS103, WS103A, WS103B, WS112, WS116, WS117, WS118B
Depths encountered from top of stratum (range)	0.08m to 2.50m bgl
Depths encountered to base of stratum (range)	0.48m to 3.40m bgl
Thickness (range)	0.20m to 2.30m
Spatial location on site	Eastern half of site and localised within northwestern soft landscaped area
General description	Dark greyish brown, clayey, gravelly SAND. Gravel is fine to coarse, angular to subangular of brick, sandstone, occasional glass and timber. Medium dense, brownish grey, clayey SAND and GRAVEL. Gravel is fine to medium, subangular to subrounded of sandstone, occasional mudstone and rare brick. Sand is fine to medium grained. POSSIBLE MADE GROUND: Very loose, grey, mottled dark grey, clayey, silty SAND.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 20 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Superficial Deposits – Cohesive

Alluvium – Clay	
Locations encountered	CP101, CP104/RH102, RH101, RH103
Depths encountered from top of stratum (range)	3.00m to 5.35m bgl
Depths encountered to base of stratum (range)	3.90m to 5.66m bgl
Thickness (range)	0.20m to 0.90m
Spatial location on site	No strong spatial correlation observed (only encountered in deep boreholes)
General description	Stiff, dark grey, gravelly CLAY. Gravel is fine to medium angular of mudstone. Stiff, reddish brown, silty CLAY.

Superficial Deposits – Granular

Glaciofluvial Deposits – Silty sand	
Locations encountered	WS112, WS116
Depths encountered from top of stratum (range)	3.30m to 3.40m bgl
Depths encountered to base of stratum (range)	>5.45m bgl (base not encountered)
Thickness (range)	>2.05m (base not encountered)
Spatial location on site	No strong spatial correlation observed (only encountered in localised boreholes)
General description	Very loose to loose, greyish brown, silty, fine grained SAND

Weathered Bedrock – Pennine Lower Coal Measures

Weathered Pennine Lower Coal Measures – generally recovered as mudstone or sandstone gravel.	
Locations encountered	CP101, CP104/RH102, CP105, RH101, RH103
Depths encountered from top of stratum (range)	3.40m to 6.00m bgl
Depths encountered to base of stratum (range)	4.80m to 6.25m bgl (base not proven in CP101 and CP105)
Thickness (range)	0.25m to >1.15m (base not proven in CP101 and CP105)
Spatial location on site	North of site
General description	Brownish grey, fine to coarse, angular GRAVEL of sandstone. Extremely weak, dark grey MUDSTONE, recovered as angular gravel and clayey gravel.

Bedrock – Pennine Lower Coal Measures

Pennine Lower Coal Measures – mudstone with interbedded sandstone and siltstone	
Locations encountered	RH101, RH102, RH103, RH103A



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 21 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Depths encountered from top of stratum (range)	4.50m to 6.25m
Depths encountered to base of stratum (range)	Base not encountered
Thickness (range)	Unknown, base not encountered
Spatial location on site	Encountered within all deep exploratory holes
Description of dip	Bedrock was encountered at its shallowest in the north of the site, deepening towards the south. Bedrock elevation has been modelled and presented within Drawing ref TE1880-TE-00-XX-DR-GE-014-V01 included within Appendix A.
Voids / recovery	Frequent loss of flush or partial flush due to highly fractured bedrock but generally good recovery. Loss of flush and core barrel stuck at 6.50m bgl within RH103, loss of flush and drilling rods dropped (indicating a void) from 6.00m to 6.50m bgl within RH103A.
General description	Weak to medium strong, narrowly laminated MUDSTONE. Discontinuities are 10° to 50°, very closely to closely spaced, planar striated to undulating striated, wall strength weak to medium strong, clean to slight clay infill. Medium strong, greyish brown, fine grained SANDSTONE. Discontinuities are horizontal to 20°, closely to very closely spaced, smooth stepped, wall strength strong, clean infill.

Coal – Arley Mine and Unnamed Seam

Loss of flush was encountered generally around 6 to 10m bgl within the rotary boreholes, which may be indicative of workings within the Arley Mine seam. This is discussed in further detail within the separate Coal Mining Risk Assessment.

Coal was also encountered at depth within all 3no. rotary boreholes that extended to 40.00m bgl, as presented in Table 6.1 below.

Table 6.1 Recorded Coal

Borehole	Depth (m bgl)	Thickness (m)	Coal Recorded
RH101	30.30 to 30.80	0.50	Hard coal
CP104/RH102	34.20 to 34.40	0.20	Possible coal/shale
RH103	16.80 to 17.00	0.20	Coal flash
	29.00 to 29.30	0.20	Hard coal

The results of the deep exploratory boreholes in regards to the recorded coal and loss of flush are discussed further within the separate Coal Mining Risk Assessment for the site, which should be referred to for further detail.

6.2. Obstructions

A concrete slab was recorded below the asphalt surfacing, with possible PFA Silt recorded below, as reported above. It should be noted that the shallower window sample holes often refused within this material, with SPTs recording refusals. The following potential obstructions were encountered below this slab during the ground investigation works.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 22 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Table 6.2 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
HDP102	Northeast	0.60	0.87	Concrete footing of retaining wall from 0.60m to 0.87m in north face of pit.
HDP104	Southeast	0.05	>1.07	Concrete from 0.05m to beyond base of pit at 1.07m in southern pit wall.
		0.67	1.07	Grey CONCRETE. Hand drilled through to find base of concrete slab.
HDP105	East	0.82	1.52	Concrete foundation of brick wall encountered from 0.82 to 1.52m bgl. Hand dug pit terminated at 1.20m bgl, hand drilled through concrete final base.
RH101	Northwest	0.50	0.70	Red brick.
RH101A	Northwest	0.45	0.54	Red brick.
		2.20		Possible metal reported by drillers, drill bit slipping, can't grip to cut through. SPT refusal, no progress. Terminated on possible metal obstruction.
RH103	Northeast	6.50		Loss of flush. Core barrel stuck and loss of drill bit (possible cast iron).
RH103A	Northeast	6.00	6.50	Loss of flush, drilling rods dropped to 6.50m bgl, core barrel sticking on possible cast iron.
RH103B	Northeast	0.28	>0.30	Red BRICK (possible footing)
SA01	Northwest	1.98		Possible cobbles and boulders at base of pit
WS102	Northwest	0.61	>0.82	Brick cobbles
WS102A	Northwest	0.67	>0.69	Brick cobbles
WS103	Northwest	0.52	>0.61	Sandstone cobbles
WS103A	Northwest	0.80	>0.85	Sandstone cobbles
WS103B	Northwest	0.80	>0.82	Brick cobbles
WS106	North	3.80	4.10	No recovery, assumed Made Ground cobbles
WS107	North	1.33	>1.34	Possible brick/concrete obstruction
WS108	Centre	0.79		Refusal on possible obstruction
WS110	Centre	0.65	0.66	Brick
WS113	Northeast	0.55	>0.61	Cobbles of brick and occasional concrete
WS113B	Northeast	0.67	>0.71	Cobbles of concrete and brick
WS115	Northeast	0.60	>0.62	Cobbles of concrete and brick
WS115B	Northeast	1.40	>1.46	Cobbles of sandstone and concrete
WS116	East	0.90	1.10	Brick cobbles
		2.60	3.00	
WS117	Southeast	2.10	2.38	Red crushed brick
		2.89	>2.90	Refusal on suspected brick
WS118	Southeast	0.42	>0.43	Concrete cobbles
WS118A	Southeast	0.56	>0.57	Concrete cobbles
WS118B	Southeast	0.52	>0.56	Cobbles of sandstone, brick and concrete

A geophysics survey has also been undertaken for the site which has recorded areas of potential obstructions other than those encountered in the table above, and is included within Appendix A.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 23 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

6.3. Visual and Olfactory Evidence of Contamination

A summary of visual and/or olfactory evidence of contamination and/or pertinent anthropogenics noted during Tier Environmental investigations is summarised in Table 6.3 below:

Table 6.3 Visual and/or Olfactory Evidence of Contamination and/or Pertinent Anthropogenics Summary

Exploratory Hole Location	Location on Site	Depth Range (m bgl) Encountered From	Depth Range (m bgl) Encountered To	Description
CP101	Centre	0.21	0.50	Frequent gravel sized silt pockets with white coating.
CP102	East	4.20	5.40	Ashy gravel
CP103	Southwest	2.20	3.40	Rare gravel of coal/ash
		5.10	6.50	Ashy gravel with slight organic odour
CP104/RH102	Centre	0.35	0.80	Frequent gravel sized silt pockets with white coating.
HDP101	Northwest	0.13	0.54	Ashy gravel
HDP102	Northeast	0.15	0.45	Ashy gravel
WS111	Centre east	0.50	0.65	Ashy gravel
WS112	Southeast	0.60	1.10	Slightly ashy gravel
		2.15	2.40	Gravel of brick, ash, possible clinker
WS116	East	1.10	1.85	Slightly ashy gravel

The previous Geotechnics ground investigation recorded black stained material with a strong hydrocarbon odour at 5.30 m bgl within CP02 in the northeast of the site. Tier have undertaken several boreholes have been undertaken surrounding this area, with no further evidence of hydrocarbon contamination observed.

6.4. Groundwater Observations During Fieldwork

Table 6.4 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 6.4 Field Observations of Groundwater.

Exploratory hole	Strike (m bgl)	Rise in groundwater after 20 mins. (m bgl)	Formation	Observations
CP101	3.50	3.20	Made Ground	Perched groundwater within Made Ground
CP102	3.40	-	Made Ground	Perched groundwater within Made Ground
CP103	3.40	3.20	Made Ground	Perched groundwater within Made Ground
CP104/RH102	3.50	-	Made Ground	Perched groundwater within Made Ground
	4.35	4.20	Made Ground	Perched groundwater within Made Ground
	No strike recorded	1.70 (overnight)	Pennine Lower Coal Measures	No strike recorded within Pennine Lower Coal Measures, but groundwater levels rising to 1.70m bgl overnight suggesting possible sub artesian groundwater body within Pennine Lower Coal Measures



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 24 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Exploratory hole	Strike (m bgl)	Rise in groundwater after 20 mins. (m bgl)	Formation	Observations
CP105	3.40	3.00	Made Ground	Perched groundwater within Made Ground
HDP101	0.86	-	Made Ground	Localised shallower perched groundwater within Made Ground. Slow seepage at base of pit
RH101	3.20	-	Made Ground	Perched groundwater within Made Ground
RH103	3.00	1.80	Made Ground	Perched groundwater within Made Ground
RH103A	3.00	1.80	Made Ground	Perched groundwater within Made Ground
RH103C	No strike	1.80m (overnight), round level (overnight on second night)	Pennine Lower Coal Measures	No strike recorded within Pennine Lower Coal Measures, but groundwater levels rising to 1.80m bgl overnight suggesting possible sub artesian groundwater body within Pennine Lower Coal Measures. The following day water was recorded to be at ground level, however dropped when drilling started.
WS106	1.50	-		Localised shallower perched groundwater within Made Ground
WS116	3.30	-	Glaciofluvial Deposits	Wet material encountered
	4.00	-		Localised shallow groundwater

6.5. Groundwater Monitoring

Table 6.5 below provides a summary of the groundwater monitoring results conducted to date. In total, 4 No. visits have been carried out between 17th December 2024 and 24th January 2025.

Table 6.5 Groundwater Monitoring Results Summary

Exploratory hole	Response Zone (m bgl)	Depth range (m bgl)	Formation	Observations
RH101	28.00 to 33.00	None detected to 0.32	Deep Pennine Coal Measures (inc. coal)	Well head flooded during first visit. Water rising slowly but stopped at top of well head. Near-artesian water observed likely associated with deep confined groundwater body within sandstone bands in the Pennine Lower Coal Measures.
CP104/RH102	7.00 to 10.00	1.89 to 2.10	Shallow Pennine Coal Measures	No observations
RH103C	28.00 to 32.00	None detected to 0.85	Deep Pennine Coal Measures (inc. coal)	Well head flooded during first visit, water continued to flow out of well and did not stop. During second visit an extra pipe was added to well to determine extent of sub artesian head. Water level stabilised at 0.04m above ground level. Artesian water observed likely associated with deep confined groundwater body within sandstone bands in the Pennine Lower Coal Measures.
CP101	2.00 to 4.00	3.01 to 3.11	Made Ground / Alluvium / Pennine Coal Measures	No observations
CP102	2.00 to 6.00	3.43 to 3.77	Made Ground / Pennine Coal Measures	No observations
CP103	0.50 to 2.50	3.77 to 4.14	Made Ground	No observations



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 25 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Exploratory hole	Response Zone (m bgl)	Depth range (m bgl)	Formation	Observations
CP105	1.00 to 4.00	1.28 to 2.19	Made Ground / Pennine Coal Measures	No observations
WS104	0.50 to 1.00	None detected	Made Ground	No observations
WS107	0.50 to 1.00	None detected	Made Ground	No observations
WS108	0.50 to 0.70	0.58 to 0.67	Made Ground	No observations
WS109	0.40 to 0.60	0.10 to 0.35	Made Ground	No observations
WS112	1.00 to 4.00	3.44 to 3.76	Made Ground / Glaciofluvial Deposits	No observations
WS116	1.00 to 2.50	None detected	Made Ground	No observations
WS111	0.50 to 0.70	0.64 to None detected	Made Ground	No observations

Groundwater contours from each monitoring visit have been plotted on plan, and are included within Appendix A.



7. PRELIMINARY GEOTECHNICAL ASSESSMENT

7.1. Mining and Quarrying

The risk to the site from historical mining is discussed in further detail within the Coal Mining Risk Assessment.

No evidence of historical quarrying or other surface abstraction on site was encountered during the ground investigation.

7.2. 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 or sulphate in groundwater have been reported above 3,000mg/l and therefore no further consideration of magnesium has been made.

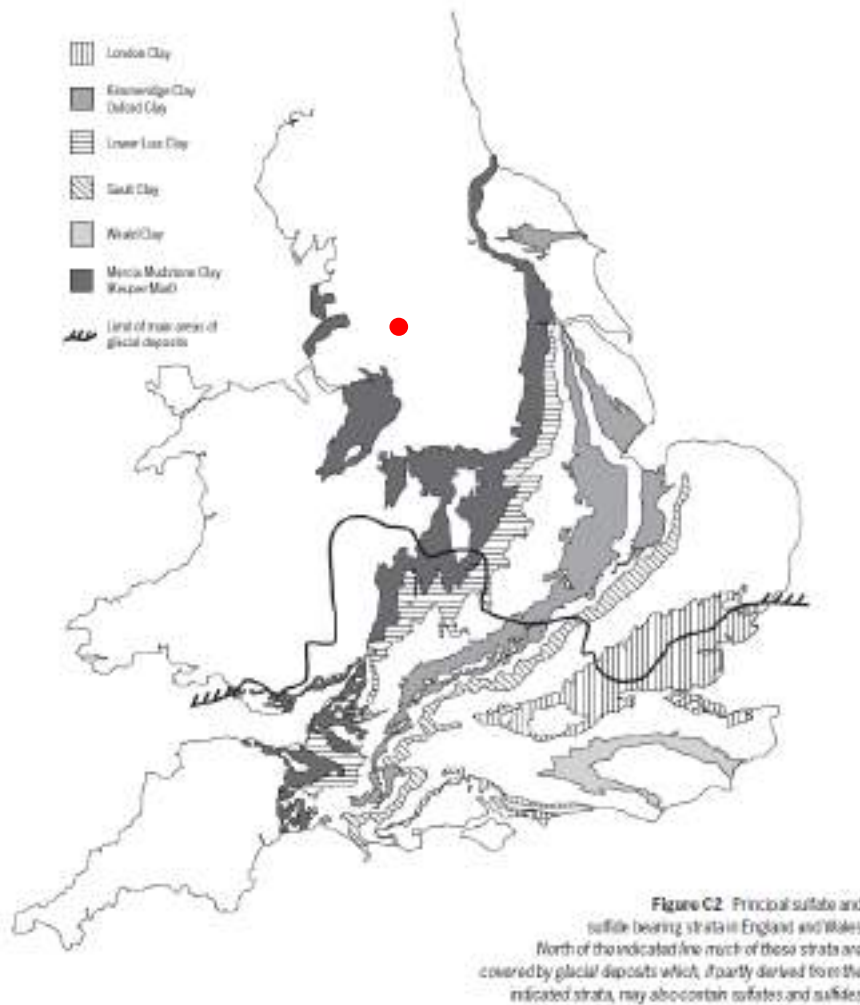
In accordance with BRE SD1, there is no need to take magnesium levels into account for natural ground – the 'm' suffix Design Sulphate Classes only apply to brownfield locations. This is because, in natural ground conditions in the UK, magnesium levels are invariably well below values that may significantly 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 7.1 below.

Figure 7.1 Site Location Plotted on Principal Sulphate and Sulphide Bearing Strata in England and Wales (Extracted from BRE SD1)



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.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 28 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Figure 7.2 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):



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 29 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Table 7.1 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:	Conclusion of Assessment for Potential Sulphide Bearing Ground
From Figure 7.1, Does the Site Lie Within a Principal Sulphate and Sulphide Bearing Area?	From Figure 7.1, Does the Site Lie <u>North</u> of the Black Line Indicating Extent of Glacial Deposits ?	Is it considered that the Glacial Deposits beneath the Site are Derived from Principal Sulphate and Sulphide Bearing Strata (even if the answer to Question 1 is 'No')?	From Figure 7.2, Does the Site Lie Within a Coal Mining Area?	
No	Yes	Potentially	Yes	The conclusion of the assessment is that there <u>is</u> the potential for sulphide (e.g. pyritic) bearing ground and further assessment of this is required in accordance with BRE SD-1.

Oxidisable Sulphides Calculation

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 ground is disturbed:

Table 7.2 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					
WS105	0.75	0.04	0.12	0.06	0.06
WS111	0.80	0.06	0.18	0.13	0.05
WS116	1.9	0.08	0.24	0.15	0.09
CP103	0.70	0.04	0.12	0.10	0.02
CP102	1.70	0.18	0.54	0.49	0.05
CP101	2.70	0.07	0.21	0.18	0.03
CP101	0.70	0.17	0.51	0.44	0.07
RH103C	3.00	0.14	0.42	0.41	0.01
RH101	3.50	0.04	0.12	0.04	0.08
Superficial Deposits					
WS112	3.35	0.03	0.09	0.02	0.07
WS116	3.40	0.04	0.12	0.02	0.10
RH103C	3.10	0.06	0.18	0.04	0.14
Bedrock					
RH103C	15.11	0.06	0.18	<0.02	0.16
RH102	8.00	<0.01	<0.03	<0.02	<0.01
CP104	5.50	0.06	0.18	<0.04	0.14
CP103	7.20	0.12	0.36	0.04	0.32
CP101	5.20	0.10	0.30	0.02	0.28

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



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 30 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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. The conclusion of this assessment is that a significant number of samples are **not** in excess of 0.3% with respect to calculated Oxidisable Sulphides (%).

This does **not** indicate the presence of pyrite (which would otherwise oxidise if ground were disturbed) and in which case the design sulphate class may be determined solely on soil and groundwater sulphate concentrations and pH in accordance with BRE SD-1.

Design Sulphate Classification

Representative samples of the soils and groundwater 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 Appendix D and summarised in Table 7.3 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-1 is appropriate for buried concrete design purposes, 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.

Table 7.3 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					
WS105	0.75	9.88	47.3	Mean of the highest two water soluble sulphate results = 680mg/l DS-2	Mean of the lowest two pH = 8.26 pH AC-2
WS111	0.80	8.97	140.1		
WS116	1.90	8.42	391.6		
CP103	0.70	9.08	117		
CP102	1.70	9.63	505		
CP101	2.70	11.07	132		
CP101	0.70	9.29	546		
RH103C	3.00	9.26	814		
RH101	3.50	8.12	52		
SUPERFICIAL DEPOSITS					
WS112	3.35	7.1	19.3	Mean of the highest two water soluble sulphate results = 66.7mg/l DS-1	Mean of the lowest two pH = 7.4 pH AC-1
WS116	3.40	7.71	99.4		
RH103C	3.10	8.69	34		
BEDROCK					
RH103C	15.11	8.77	24	Mean of the highest two water soluble sulphate results = 80mg/l DS-1	Mean of the lowest two pH = 8.67 pH AC-1
RH102	8.00	8.83	<10		
CP104	5.50	8.82	15		
CP103	7.20	8.66	89		
CP101	5.20	8.68	71		



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 31 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Exploratory Hole Location	Depth (m bgl)	pH	Water-soluble sulphate (mg/l)	Design sulphate class	ACEC sulphate class
GROUNDWATER					
CP101	3.50	7.37	81.7	Mean of the highest two water soluble sulphate results = 163.7mg/l DS-1	Mean of the lowest two pH = 7.27 pH AC-1
CP102	4.50	7.5	137.7		
CP103	5.50	7.41	67.8		
CP4 (Geotechnics)	4.00	7.43	57.3		
RH102	5.00	8.06	93.9		
WS112	4.00	7.16	189.7		

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

7.3. Geotechnical Parameters

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

Soil Classification

Cohesive Soils

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



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 32 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 7.4 Summary of Natural Moisture Content and Atterberg Limits

Parameter	Material	No. Tests	Result	Comments
Natural MC %	Natural clay	1	23.7	-
	Mudstone	2	Non-plastic	-
	MG3 PFA silt	3	41.2	1 no. sample recorded as plastic, 2no. samples recorded as non-plastic
Plastic Limit %	Natural clay	1	21	-
	Mudstone	2	Non-plastic	-
	MG3 PFA silt	3	34	1 no. sample recorded as plastic, 2no. samples recorded as non-plastic
Liquid Limit %	Natural clay	1	33	-
	Mudstone	2	Non-plastic	-
	MG3 PFA silt	3	45	1 no. sample recorded as plastic, 2no. samples recorded as non-plastic
Plasticity Index	Natural clay	1	12	-
	Mudstone	2	Non-plastic	-
	MG3 PFA silt	3	11	1 no. sample recorded as plastic, 2no. samples recorded as non-plastic
Modified Plasticity Index	Natural clay	1	10.68	-
	Mudstone	2	Non-plastic	-
	MG3 PFA silt	3	11	1 no. sample recorded as plastic, 2no. samples recorded as non-plastic

The modified plasticity index of the natural clay indicates that it should be classed as low volume change potential. Whilst 2no. samples of the MG3 PFA Silt were recorded as non-plastic, the third sample was recorded to be plastic, with a modified plasticity index indicating that it should be classed as low volume change potential. It would therefore be prudent to assume that the MG3 PFA Silt should be assumed to be a worst case of low volume change potential.

A total of 1no. sample of natural clay was submitted for Particle Size Distribution test. The results recorded that this material could be classed as 2C/7A/7F in accordance with Series 600 Specification For Highways Work.

Granular Soils

A total of 4 No. samples of granular strata were submitted for Particle Size Distribution tests, including 2 No. samples of Made Ground Silt and 2 No. samples of Made Ground gravel. The tests show a distinction between the stratum types, as recorded in the table below.

Sample Location	Depth (m bgl)	Material Type	Classification in accordance with Series 600 SFHW
CP102	1.7-2.0	MG3 PFA Silt	2A&2B, 2C, 7A, 7E, 7F, 7I
CP101	2.7-3.0	MG2 Gravel	2C, 7A, 7D, 7F
CP101	0.7-1.2	MG3 PFA Silt	2A&2B, 7A, 7E, 7F, 7I
RH103C	2.0-3.0	MG2 Gravel	2C, 7A, 7E, 7F, 7I



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 33 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Rock Classification

Point Load Tests

Point Load testing was performed on a number of rock core samples of the Pennine Lower Coal Measures. A total of 37 No. tests were performed on the Pennine Lower Coal Measures, with both axial and diametric testing being undertaken. The results of these tests are shown in Table 7.5 below.

Table 7.5 Summary of point load Is50 test results

Strata Type	Axial / Diametric	Minimum Is50 (MN/m ²)	Maximum Is50 (MN/m ²)	Average Is50 (MN/m ²)
Pennine Lower Coal Measures	Axial	0.10	5.26	1.35
Pennine Lower Coal Measures	Diametric	0.18	0.54	0.36

The results show considerable variation but little increase with depth. Point load test data indicates axial Is50 values in the top approx. 5m of Pennine Lower Coal Measures strata are in the range of 0.49MPa to 5.26MPa for the 35 No. tests that were performed.

A correlation factor of 10 between point load Is50 values and unconfined compressive strength has been assumed. Outlying strength values have been eliminated by ignoring the lowest and highest 10% of values, and when this is applied Is50 values lie in the range 0.49MPa to 2.65MPa with an average of 1.16MPa and by applying the assumed correlation factor of 10, this would give equivalent UCS values in the range 4.9 MPa to 26.5 MPa with an average of 11.6MPa.

Unconfined Compressive Strength Tests

UCS testing was performed on a number of rock core samples of Pennine Lower Coal Measures which were recovered as intact pieces with a length which was at least 2.5 times the diameter of the core. A total of 5 No. tests were performed on the Pennine Lower Coal Measures. The results of these tests are shown in Table 7.6 below.

Table 7.6 Summary of UCS test results

Strata Type	Minimum Compressive Strength (N/mm ²)	Maximum Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
Pennine Lower Coal Measures	30.2	44.0	36.8

The results show variation but little increase with depth.

Foundation Recommendations

Made Ground was recorded to be present across the site, extending to a depth of between 3.40m and 6.50m bgl (and recorded to 6.80m bgl within the previous third party report). This is underlain by a thin band of Alluvium in the north and Glaciofluvial Deposits in the southeast, over mudstone with interbedded sandstone and siltstone of the Pennine Lower Coal Measures.

Portions of the site are covered by former or existing facilities on the site, including asphalt hard standing over a possible relict floor slab of the former building and possible underlying foundations. This material is unsuitable for foundations and relict foundations and floor slabs should be broken out



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 34 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

to avoid the formation of hard spots. Additional possible obstructions/ subsurface features have been identified during a geophysical survey, with a possible void and loss of flush indicative of probable mine workings recorded around 6.00m bgl which will require grouting / treatment (see separate Cola Mining Risk Assessment Report for details).

It is understood based on preliminary discussion with the piling contractors that a piled foundation will be utilised, with preliminary consideration of rock sockets Circa 5m into the bedrock. It is likely that CFA piles will be used.

7.4. Piling Risk Assessment

Continuous Flight Auger (CFA) Piles

The CFA piling method involves constructing the piles with a CFA piling rig which has a full length hollow stem auger. The pile is bored in a continuous downward movement to the requisite founding depth. As the auger rotates, spoil will travel upwards, keeping the flights of the auger full of spoil at all times. Once the auger has reached the founding depth, sand-cement or concrete is pumped down the stem at a controlled rate as the auger is steadily withdrawn, thus closing any pathway that may be created at this point. Standard reinforcement details are used where appropriate, which comprise either single centrally positioned reinforcing bars or reinforcement cages to suit horizontal/bending moments. Specially made reinforced cages can be manufactured to suit specific loading situations if needed.

The Environment Agency guidance on piling on land affected by contamination states that...."Provided the pile is formed or placed in intimate contact with the surrounding soil, there should be no formation of preferential pathways..."No permanent preferential pathways are created as a result of CFA pile construction. Furthermore, the method of construction of the pile minimises the risk of cross-contamination from upper groundwater to the lower Secondary A Aquifer.

The piling technique will generate arisings, which will almost certainly include contaminated materials. As the Made Ground soils at the site have been found to have elevated concentrations of asbestos, there will need to be in place a site based system which will set out the main risks for groundworkers during piling works and the appropriate mitigation measures required.

RISK TO UNDERLYING AQUIFER USING CFA PILES - Negligible

RISK TO CONSTRUCTION WORKERS USING CFA PILES - Moderate (pile arisings at surface which contain asbestos)

RISK TO PERCHED WATER/SHALLOW GROUNDWATER USING CFA PILES - Negligible

RISK TO END-USERS FROM GROUND GAS BY USING CFA PILES - Negligible

7.5. Floors

With regard to the design and construction of normal ground bearing floor slabs, it must be noted at the outset, that due to the thickness of Made Ground, unless appropriate measures are taken there will be a risk of significant total and differential settlements, the extent of which will be a matter of chance rather than being assessable by calculation.

To obviate any significant damaging settlements we would recommend using a suspended floor slab with intermediate support designed on the same basis as the main foundations where the spans are too large for economical single suspended slab design.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 35 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

If it is necessary to take the piles below the base of the boreholes, the piling contractor should undertake testing to confirm that strata of equal or greater strength are present below.

Ground bearing floor slabs may be suitable subject to a turnover, proof rolling and confirmatory testing of the Made Ground.

7.6. Earthworks

Based on visual inspection of the Made Ground, the materials are likely to be suitable for reuse. 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. It should be noted that the geophysics survey has recorded obstructions that may lie beneath this depth. 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.

The Made Ground PFA silt materials generally recorded high SPT N values of between $N=19$ and $N>50$, indicating this may be a suitable material for reuse. However careful management of the material will be required, particularly during inclement weather. Possible cement stabilisation of the material may be required should it start to degrade.

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. However, the following factors should be considered.

It is understood that the existing Made Ground at the site is to be excavated to a depth of 2.00m bgl and re-engineered to remove buried obstructions. Excavated materials will be processed and re-engineered as an Engineered Fill. The new Design CBR should be assumed to be equivalent to 2.5%, however values of between 10% and 20% should be achievable given the material present at the site.

During construction, the in situ CBR value must be checked against the Design CBR value, to confirm design requirements are being met.

7.7. Retaining Structures

Several retaining structures are present across the site, most notably a brick retaining wall of up to 1.00m height at the northern boundary with College Road (which lies at a higher level than the site at points along the northern boundary), and a concrete retaining wall at the south of the car park, with the banks of the River Roch lying between approximately 0.50m and 1.00m bgl lower than the car park level. Evidence of cracks and possible former repairs within this southern retaining wall were observed.

The footings of these retaining walls were exposed within HDP101, HDP102 and HDP104. Foundation Inspection drawings detailing the size, materials and backfill placed around the footings are included within Appendix A.

It is recommended that a structural survey is undertaken for any retaining features that are to remain on site.

7.8. 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.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 36 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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 0.86m and 4.35m were encountered in the boreholes, with possible sub artesian groundwater conditions noted during the intrusive investigation and groundwater monitoring undertaken to date. Should groundwater seepages occur, and water accumulate in shallow excavations it should be able to be removed by pumping from a filtered sump. However, groundwater control by more robust means, such as well pointing, may be required locally.

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

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

It should be noted that all excavations and groundworks within the Made Ground will need to be undertaken in accordance with the Control of Asbestos Regulations (CAR:2012) due to the presence of asbestos.

7.9. Pavements and Highways

The results of the DCP testing area included within Appendix E. CBR values derived from DCPs have been presented for preliminary purposes only and should not be relied on for final design purposes. We would recommend that confirmatory CBRs derived from full Plate Bearing Tests are conducted once the final formation levels have been achieved.

Once the design layout is known and demolition/remediation is complete, then *in situ* testing should be carried out to confirm CBR values.

The design of pavements, highways, embankments and retaining structures (if required) should be discussed with the relevant local authority if highways are to be subject to Section 38 agreement.

The results indicate a range of values reported between 0.52% to >25%. Of the 49 results, 41 No. CBR values were reported >5%, 1 No. was reported between 2.5 and 5% and 7 No. were reported <2.5%.

7.10. Infiltration Testing

The results of the soakaway and falling head tests are included within Appendix H.

Sue to the significant depth of Made Ground and the poor infiltration test results, soakaways are not likely to be a viable form of surface water drainage.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 37 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

8. HUMAN HEALTH RISK ASSESSMENT

The results of chemical analysis are presented in full in Appendix C and Appendix D.

8.1. Data Interpretation Approach

The analytical data obtained were reviewed for completeness and consistency. The data for each sample type was then compiled, screened against the Generic Assessment Criteria (GACs) for a commercial 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.

8.2. Selection of Generic Assessment Criteria (GAC)

In short, for the majority of the contaminants of concern, LQM/CIEH Suitable 4 Use Levels (S4ULs) published in 2015 have been adopted as GACs for a commercial 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 J.

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 2.5% has been selected based on the reported Total Organic Carbon (TOC) concentrations (which have been converted to SOM by dividing by a conversion



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 38 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

factor of 0.58). It should be noted; however, that for any soil samples where the TOC may be artificially driven by the presence of petroleum hydrocarbons, that these TOC results have been removed from the data set when determining an appropriate characteristic SOM. For this purpose, Tier Environmental have notionally considered that any TOC results from soil samples where the measured total TPH concentration exceeds 500mg/kg should be removed.

8.3. Human Health Risk Assessment

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

However, given the proposed soft landscaping area within the east of the site, further sensitivity analysis has been undertaken using Public Open Space (POS) Park GACs. When comparing the results to these more sensitive GACs, there is 1no. exceedance recorded reported in excess of the respective GACs, as reported in the table overleaf:



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 39 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Table 8.1 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	WS113B	0.35	MG4 (clay)	mg/kg	13.24	12	Minor exceedance within the same order of magnitude as the GAC for POS Park. Note that this is not elevated when compared to the GAC for commercial end use.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 40 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Measured Potential Contaminant of Concern Concentrations without Publicly Available GACs

Table 8.2 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.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 41 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 8.2 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						
Chloromethane	WS103A	0.40	MG5	mg/kg	0.06	These measured concentrations represent chlorinated hydrocarbons and so risks to chlorinated VOCs has been assessed via comparison of measured results against those chlorinated VOCs for which GACs are available. Overall, it is not considered that the risk assessment demonstrated a significant risk from chlorinated VOCs.
Dichloromethane (DCM)	WS105	0.60	MG2	mg/kg	0.087	
	WS112	1.20	MG5	mg/kg	0.013	
	WS113B	0.35	MG4	mg/kg	0.051	
	WS117	0.40	MG2	mg/kg	0.019	
	WS114	0.50	MG2	mg/kg	0.01	
Chlorobenzene	WS105	0.60	MG2	mg/kg	0.005	
4-Methylphenol	WS113B	0.35	MG4	mg/kg	0.166	Risk from phenols has been conducted via comparison of the total phenols concentrations and phenol concentrations to the phenol GAC.
2-Methylnaphthalene	WS103A	0.40	MG5	mg/kg	0.097	2-Methylnaphthalene is PAH based. PAHs have been assessed in against the EPA16 GACs, for which there is a GAC for naphthalene. No measured concentrations of naphthalene were recorded for these locations or elsewhere across the site, and therefore it is considered that the risk from 2-Methylnaphthalene has been adequately considered within the assessment of PAHs in general above.
	WS105	0.60	MG2	mg/kg	0.174	
	WS110	0.61	MG2	mg/kg	0.027	
	WS113B	0.35	MG4	mg/kg	0.525	
	WS117	0.40	MG2	mg/kg	0.105	
	WS116	1.90	MG3	mg/kg	0.182	
	WS114	0.50	MG2	mg/kg	0.322	
Bis(2-ethylhexyl) phthalate	WS117	0.40	MG2	mg/kg	0.3	Bis(2-ethylhexyl) phthalate has low volatility and strong sorption to soil particles, meaning it is not readily released as vapour and is unlikely to migrate significantly via groundwater. This reduces the primary exposure pathways for on-site commercial workers to incidental ingestion of or direct dermal contact with soil particles. The main concern for DEHP is often chronic exposure through ingestion of food or consumer products, rather than incidental contact with soil.
	WS111	0.80	MG3	mg/kg	1.274	
	WS116	1.90	MG3	mg/kg	1.201	
	WS114	0.50	MG2	mg/kg	0.245	



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 42 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Contaminant of Concern	Exploratory Hole Location	Depth (m bgl)	Soil Population	Units	Measured Concentration	Comments
4-Nitroaniline	WS110	0.61	MG2	mg/kg	0.023	4-nitroaniline exhibits relatively low volatility (i.e., low vapour pressure), so the potential for inhalation of vapours is low. The reported concentration is not indicative of any widespread concern and as it has been reported at a depth of 0.61m bgl, the risks from dermal contact / ingestion are not likely to be viable.
Carbazole	WS103A	0.40	MG5	mg/kg	0.022	Carbazole and dibenzofuran both exhibit limited volatility, which means minimal potential for inhalation, and under typical commercial use. Publicly available commercial GAC were not available for carbazole and dibenzofuran. An international literature search including the following sources was undertaken to provide a risk based context for these analytes: - RIVM (2001). Maximum Permissible Values - USEPA (2014). Regional Screening Levels - CCME (2014). Soil Quality Guidelines. These sources are not supported by the UK Contaminated Land Framework. However, if concentrations reported are several orders of magnitude below the international assessment values then the potential for exceeding a UK specific number is considered to be very low. The maximum concentration of dibenzofuran (0.516 mg/kg) is three orders of magnitude below the USEPA (2014) Regional Screening Level of 100 mg/kg. The potential human health risk from these chemicals is considered to be low. An international literature search did not reveal a commercial soil GAC for carbazole. The Henry's Law Constant for carbazole is 5.11×10^{-7} atm m³ / mol. Carbazole is not considered to be volatile as the UK based contaminated land exposure assessment (CLEA) model only considers volatility if the Henry's Law Constant exceeds 1×10^{-5} atm m³ / mol. Due to the lack of commercial GAC, it is considered that risks from carbazole should be considered in the context of the broader VOC/SVOC assessment carried out for this site which does not indicate that the reported concentrations of VOCs/SVOCs represent a risk to the proposed end-users.
	WS105	0.60	MG2	mg/kg	0.014	
	WS113B	0.35	MG4	mg/kg	0.427	
	WS117	0.40	MG2	mg/kg	0.155	
	WS116	1.90	MG3	mg/kg	0.299	
	WS114	0.50	MG2	mg/kg	0.182	
Dibenzofuran	WS103A	0.40	MG5	mg/kg	0.059	
	WS105	0.60	MG2	mg/kg	0.044	
	WS110	0.61	MG2	mg/kg	0.012	
	WS113B	0.35	MG4	mg/kg	0.431	
	WS117	0.40	MG2	mg/kg	0.206	
	WS116	1.90	MG3	mg/kg	0.516	
	WS114	0.50	MG2	mg/kg	0.241	



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 43 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Contaminant of Concern	Exploratory Hole Location	Depth (m bgl)	Soil Population	Units	Measured Concentration	Comments
Nitrobenzene	WS110	0.61	MG2	mg/kg	0.028	Nitrobenzene is an aromatic hydrocarbon. Hydrocarbons have been assessed in accordance with the GACs for TPHCWG, of which benzene is included. No fractions were recorded to be elevated, and therefore it is considered that the risk from nitrobenzene has been adequately considered within the assessment of TPH above.
OTHERS						
pH	WS105	0.60	MG2 (gravel)	pH	10.93	Alkali conditions in line with what would be expected for materials containing concrete. However likely due to be due to gravel comprising crushed brick and concrete, and therefore given that these materials are relatively inert, it is not considered to pose a significant risk to human health
	WS117	0.40	MG2 (gravel)	pH	10.24	Alkali conditions in line with what would be expected for materials containing concrete. However likely due to be due to gravel comprising brick, concrete, sandstone, limestone, and therefore given that these materials are relatively inert, it is not considered to pose a significant risk to human health.
	WS108	0.70	MG2 (gravel)	pH	10.40	Alkali conditions in line with what would be expected for materials containing concrete. However likely due to be due to gravel comprising brick, sandstone, rare plastic and metal, and therefore given that these materials are relatively inert, it is not considered to pose a significant risk to human health



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 44 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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.

It should be noted that widespread asbestos was recorded to be present across the site during a previous third party ground investigation, up to a maximum concentration of 0.003% w/w. However it is understood that Wilmott Dixon has no reliance on this data.

Of the 18 No. Made Ground samples submitted for asbestos screening by Tier Environmental, 10 No. were reported to contain asbestos. Those positive identifications are summarised in Table 8.3, below.

Table 8.3 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 (Tier Environmental, 2024)					
WS103A	0.40	Northwest (proposed car park with soft landscaping)	MG5 (gravelly sand)	Chrysotile and amosite fibre bundles	<0.001
WS105	0.60	Centre (beneath proposed building footprint)	MG2 (gravel)	Chrysotile fibre bundles and bitumen products	0.019
WS106	1.00	North (north of proposed building footprint)	MG2 (gravel)	Chrysotile and amosite fibre bundles	0.03
WS108	0.70	Centre east (beneath proposed building footprint)	MG2 (gravel)	Chrysotile and amosite fibre bundles and ACM debris	0.017
WS113B	0.35	Northeast (proposed car park with soft landscaping)	MG4 (clay)	Chrysotile and amosite fibre bundles	<0.001
WS114	0.50	East (east of proposed building footprint)	MG2 (gravel)	Chrysotile and amosite fibre bundles and ACM debris	0.021
WS115B	0.90	Northeast (proposed soft landscaped area)	MG3 (silt)	Chrysotile and amosite fibre bundles	0.002
WS116	1.90	Southeast (east of proposed building footprint)	MG3 (silt)	Chrysotile fibre bundles	<0.001
WS117	2.20	East (southeastern current soft landscaped area not to change)	MG2 (gravel)	Amosite fibre bundles	<0.001
WS117	2.40	East (southeastern current soft landscaped area not to change)	MG5 (gravelly sand)	Chrysotile and amosite fibre bundles	<0.001

The reported asbestos concentrations are also shown on Drawing Ref TE1880-TE-00-XX-DR-GE-013-V01, included within Appendix A. It is considered that further detailed assessment would be required, in accordance with CIRIA C733 in order to further assess the risks from these reported concentrations.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 45 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Groundwater

The groundwater results have been compared to the SOBRA general assessment criteria for commercial land use detailed in Tables 6, 7, 8, 9 and 10 of the 'Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater'.

The GACs given in the above guidance assume that the groundwater is at a depth of 0.65m bgl. Recorded groundwater levels on site range between 0.10m bgl and 4.14m bgl, and as such these GACs are considered likely to be over cautious for groundwater deeper than 0.65m bgl.

None of the recorded contaminants exceed the GAC for commercial land use.

8.4. Utilities

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

8.5. Construction and Maintenance Workers

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

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

- Localised elevated benzo(a)pyrene – Minor exceedance (13.24mg/kg) within the same order of magnitude as the GAC for POS Park (12mg/kg). Note that this is not elevated when compared to the GAC for commercial end use (35mg/kg).
- Asbestos within the Made Ground – chrysotile and amosite fibre bundles, bitumen products and ACM debris at a maximum concentration of 0.03% w/w.

As asbestos has been reported at concentrations above 0.001% w/w (i.e. above 'trace' levels), the Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is provided in Appendix O.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 46 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

9. CONTROLLED WATERS RISK ASSESSMENT

9.1. Introduction

In order to assess whether there is a potentially unacceptable risk of pollution of controlled waters, samples of soil leachate, groundwater and surface water have been submitted for laboratory chemical analysis as per the summary presented in Table 5.4 within this report. Analytical data from soil leachate, groundwater and surface water 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 K.

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.

For those potential contaminants of concern for which the WQS values are dependent on hardness (e.g. cadmium EQS values), a hardness of 50-100mg CaCO₃/l has been selected based on the reported values in the groundwater beneath the site.

9.2. Controlled Waters Environment Conceptual Site Model Summary

From a conceptual site model perspective, both the Alluvium and Glaciofluvial deposits are Secondary A Aquifers, with the Pennine Lower Coal Measures also classed as a Secondary A Aquifer. There are no Source Protection Zones, potable, non-potable or surface water abstractions recorded within 250m of the site. The nearest surface water feature is the River Roch located beyond the southern site boundary, with the River Spodden also located 209m southwest of the site. No further surface water features are located within 250m of the site. There are no saltwater bodies beneath or near to the site. Groundwater flow is anticipated to be towards the southwest based on surrounding topography and the presence of the River Roch. There is understood to be limited surface water drainage in the form of ACO drains at the main car park perimeters, with an interceptor located in the northeast of the car park. The site is located within an area of significant historical commercial and industrial heritage, meaning it is less likely the underlying aquifer systems may be used as a future water resource in the future.

On the basis of the above, the sensitivity of the controlled waters environment is considered to be moderate.

9.3. Soil Leachate Testing

Table 9.1 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 9.1 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
Arsenic	µg/l	2.5	50	166.8	1 of 5	WS107	0.65	MG3 (silt)



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 47 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Potential Contaminant of Concern	Units	LoD*	WQS	Maximum concentration	No. samples >WQS	Exploratory Hole Location	Depth (m bgl)	Soil Population
Chromium	µg/l	1.5	4.7	10.5	2 of 5	WS105, WS110	0.60, 0.61	MG2 (gravel), MG2 (gravel)
Copper	µg/l	7	1	11	1 of 5	WS105	0.60	MG2 (gravel)
Anthracene	µg/l	0.005	0.1	0.102	1 of 5	WS105	0.60	MG2 (gravel)
Fluoranthene	µg/l	0.005	0.12	0.826	4 of 5	WS105, WS110, WS113B, WS118	0.60, 0.61, 0.35, 0.30	MG2 (gravel), MG2 (gravel), MG4 (clay), MG1 (topsoil)
Benzo(a)pyrene	µg/l	0.005	0.27	0.606	4 of 5	WS105, WS113B	0.60, 0.35	MG2 (gravel), MG4 (clay)

* LOD= Laboratory Method Limit of Detection

Measured leachable concentrations of arsenic, chromium, copper, anthracene, fluoranthene and benzo(a)pyrene have been reported only *marginally* in excess of the WQS protective of the controlled waters environment by up to one order of magnitude. Given the following, these marginal exceedances are not considered to pose a significant risk to the controlled waters environment.

- The marginal nature of these exceedances;
- The localised nature of those soil leachate concentrations in excess of the WQS and the absence of any reported widespread leachable concentrations (with the exception of fluoranthene that was recorded to exceed the WQS in 4 of 5 locations, discussed further below);
- There are no source protection zones, potable or non-potable groundwater or surface water abstractions located within 500m of the site;
- The historical commercial / industrial heritage of the wider area surrounding the site;
- The fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils.

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 urban setting of the site.

Subsequent sensitivity analysis has demonstrated that measured soil leachate concentrations of fluoranthene and benzo(a)pyrene have been reported only *marginally* in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters 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 factors listed 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; however, further assessment has been given in groundwater testing section below.

9.4. Groundwater Testing

Table 9.2 below summarises the measured concentrations of contaminants of concern from groundwater samples at the site that have been reported in excess of the respective WQS values. In addition to selected Tier Environmental monitoring locations, CP4 from the previous Geotechnics ground investigation was sampled due to its downgradient location on site.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 48 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 9.2 Summary of Measured Concentrations of Dissolved Phase Groundwater and Surface Water Potential Contaminants of Concern in Excess of WQS Values

Potential Contaminant of Concern	Units	LoD*	WQS	Maximum Concentration	No. samples >WQS	Monitoring Well Location	Surface Water Location
Copper	µg/l	1	1	3	6 of 9	CP01, CP02, CP03	Upstream (WS02UP), Midstream (WS03MID), Downstream (WS01DS)
Nickel	µg/l	0.2	4	17.7	1 of 9	CP01	-
Zinc	µg/l	1.5	10.9	12.9	3 of 9	CP103	Upstream (WS02UP), Midstream (WS03MID)
Fluoranthene	µg/l	0.005	0.12	0.007	2 of 9	CP4, WS112	-
Bis(2-ethylhexyl) phthalate	µg/l	5	1.3	12	1 of 9	CP4	-
Total Ammonia	mg/l	0.03	0.3	0.5	4 of 9	CP103, CP4, RH102, WS112	-

* LOD= Laboratory Method Limit of Detection

Measured groundwater concentrations of copper, nickel, zinc, bis(2-ethylhexyl) phthalate and total ammonia have been reported in excess of the WQS protective of the controlled waters environment by either the same order of magnitude or one order of magnitude. Given the marginal nature of these exceedances, Given the following, these marginal exceedances are not considered to pose a significant risk to the controlled waters environment.

- The marginal nature of these exceedances;
- The localised nature of those groundwater concentrations in excess of the WQS and the absence of any reported concentrations
- Elevated concentrations of copper and zinc were recorded in the upstream, midstream and in the case of copper downstream samples as well as within groundwater samples from monitoring locations on site. This suggests that there is elevated background concentrations of copper and zinc;
- There are no source protection zones, potable or non-potable groundwater or surface water abstractions located within 500m of the site;
- The historical commercial / industrial heritage of the wider area surrounding the site;
- The fact that the site will incorporate buildings / hardstanding and a dedicated drainage system that shall reduce infiltration rates through the soils.

Measured dissolved phase groundwater concentrations of fluoranthene have been reported in excess of the respective WQS protective of the controlled waters environment by 2 No. orders of magnitude. Further qualitative assessment of these reported concentrations has been undertaken.

The EQS values for fluoranthene is 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 urban setting of the site.

Subsequent sensitivity analysis has demonstrated that measured groundwater concentrations of fluoranthene have been reported only *marginally* in excess of the respective Maximum Allowable Concentrations (MAC) EQS values for Inland Surface Waters 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 factors listed above, it is therefore considered that the reported groundwater concentrations of fluoranthene are unlikely to present a potential risk to the controlled waters environment.

Glycols have been recorded above the laboratory detection limit within CP101 and RH102 within the centre of the site, for which there are no assessment criteria available. However, given the fact that these have been recorded within the centre of the site only, and that concentrations above



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 49 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

the limit of detection have not been recorded downgradient, these recorded concentrations are considered to be localised and are not considered to pose a significant risk to the controlled waters environment.

It should be noted that the results of the surface water testing demonstrate that water quality improved by the point that the water has flowed past the site.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 50 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

10. GROUND GAS RISK ASSESSMENT

10.1. Introduction

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

- BS 8485:2015+A1:2019;
- CIRIA C665, 2007;
- Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide Are Present, NHBC, 2007 (note that this is being withdrawn on 1st July 2025);
- A Pragmatic Approach to Ground Gas Risk Assessment RB17. CL:AIRE, 2012; and,
- Ground Gas Monitoring and 'Worst-Case' Conditions TB17, CL:AIRE, 2018

In addition, due to the findings of the ground investigation, due consideration has been made with respect to coal mine gas risk in line with the CL:AIRE Good Practice for Risk Assessment for Coal Mine Gas Emissions (dated October 2021).

The ground gas risk assessment has been conducted with full consideration of the viable sources, pathways and receptors discussed in detail in Section 3 and included within the Preliminary Conceptual Site Model presented in Section 3.

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

10.2. Groundwater Conditions

BS 8576:2013 states *"Where practical and reasonable, the response zone for permanent gas monitoring wells should be located in an unsaturated zone. (Such a zone might exist below perched water tables and could form a migration pathway.) This is subject to intercepting all potential gas sources. For example, peat layers in alluvium might be below the groundwater table but pockets of gas can be trapped within the peat. In this case, it would be desirable for the well to penetrate below the groundwater. If there is doubt, it is useful to install wells with response zones above and below the water table."*

Tier Environmental observed during the ground investigation works that groundwater levels were ostensibly shallow beneath the site. To date, groundwater levels have been monitored at depths between 0.10m and 4.14m bgl and artesian water was observed during monitoring of RH103C and groundwater was reported at ground level at RH101; however in both instances this is representative of a deep confined water body within the Pennine Lower Coal Measures. As such, gas monitoring has been conducted within a combination of gas monitoring wells with shallow response zones designed to target the unsaturated zone (e.g. WS104, WS107, WS108, WS109, WS111 and WS116), some designed to target deep coal bearing strata within the Pennine Lower Coal Measures (e.g. RH101 and RH103C), RH102 was designed to target the shallower Pennine Lower Coal Measures and other wells included slotted response zones within the deeper Made Ground and superficial deposits. On this basis, it is considered that the ground gas monitoring well design is sufficient to adequately characterise the ground gas regime beneath the site by virtue of intercepting all viable ground gas sources and geological pathways.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 51 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

10.3. Gas Monitoring Data Quality

The calibration certificate for the Geotech GA5000 unit used on site for the reported gas monitoring results in Appendix F, is also provided in Appendix F. Field checks were conducted to ensure accuracy during the monitoring events. The locations for the monitoring wells are considered adequate to assess the current ground gas regime.

Flow rates and gas concentrations were allowed to fully stabilise during the monitoring.

10.4. Ground Gas Monitoring Results

The full ground gas monitoring results from the installations are presented in Appendix F and summarised below:



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 52 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 10.1 Ground Gas Monitoring Results Summary –6 No. Visits of Proposed Monitoring Programme of 6 No. Visits

Strata targeted by response zone	Monitoring well reference	Maximum peak CH ₄ (%v/v)	Maximum steady state CH ₄ (%v/v)	Maximum peak CO ₂ (%v/v)	Maximum steady state CO ₂ (%v/v)	Lowest O ₂ recorded (%v/v)	Maximum peak gas flow rate (l/h)	Maximum steady state gas flow (l/h)
Deep PCM (inc. coal)	RH101	0.6	0.6	0.3	0.2	20.4	0.3	0.3
Shallow PCM	RH102	0.7	0.7	1.1	1.1	12.3	1.0	-0.1
Deep PCM (inc. coal)	RH103C	0.6	0.6	0.7	0.7	15.4	24.0	<0.1
MG / GT / PCM	CP101	0.6	0.6	2.9	2.9	12.3	0.2	0.2
MG / PCM	CP102	0.6	0.6	3.0	3.0	13.4	1.0	<0.1
MG	CP103	0.7	0.7	1.9	1.9	18.1	0.2	0.2
MG / PCM	CP105	0.6	0.6	0.4	0.1	10.2	0.1	<0.1
MG	WS104	0.7	0.7	0.3	0.1	17.0	0.1	0.1
MG	WS107	0.7	0.6	2.6	0.3	13.4	0.4	0.4
MG	WS108	0.6	0.6	0.3	0.2	18.6	0.1	0.1
MG	WS109	0.7	0.7	0.2	0.2	14.0	4.3	-0.1
MG / GFD	WS112	0.6	0.6	4.2	4.2	0.5	0.2	0.2
MG	WS116	0.6	0.6	0.5	0.2	18.6	-0.1	-0.1
MG	WS111	0.6	0.6	1.8	0.1	12.1	0.2	0.2

Bold = maximum value reported across all visits.

For information: gas analyser instrument limits of detection are as follows: Methane 0.1% v/v, Carbon Dioxide 0.1% v/v, Oxygen 0.1% v/v, Hydrogen Sulphide 1ppm, Carbon Monoxide 1ppm and flow rate 0.1 l/hr



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 53 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

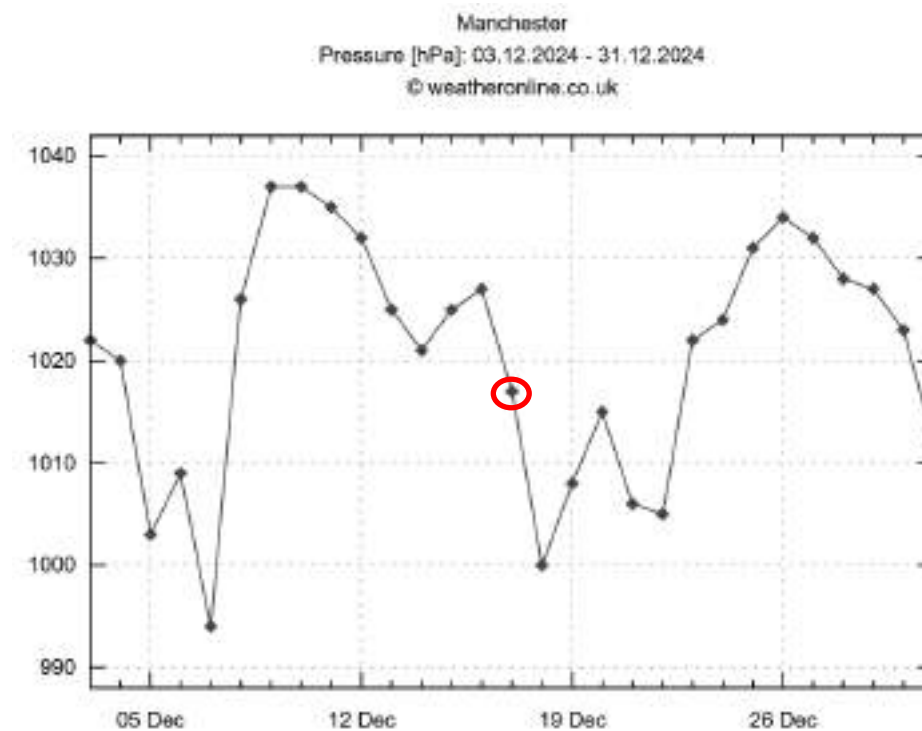
10.5. Ground Gas Risk Assessment

Section 6 of the separate PRA report demonstrates how, in accordance with CIRIA C665, the periods and frequency of monitoring have been selected for the site.

The total atmospheric pressure range of the ground gas monitoring data included in this report was between 963mbar and 1020mbar. This range covers low (<1000 mbar), moderate (1000 mbar to 1015mbar) and high (>1015 mbar) atmospheric pressures. Monitoring events included periods of stable, rising and falling pressure trends.

The pressure graphs information is from the *nearest* available weather station (relative to the site) and therefore indicative of *regional* pressure trends. The below does not represent direct atmospheric pressure conditions on the site.

Visit 1 – 17.12.24





GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

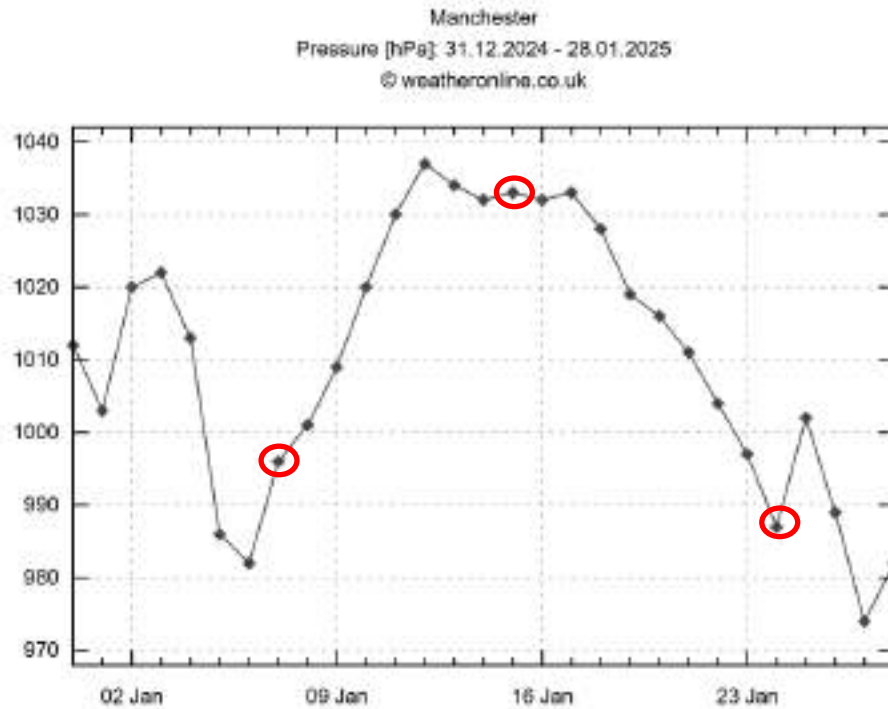
Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 54 of 81

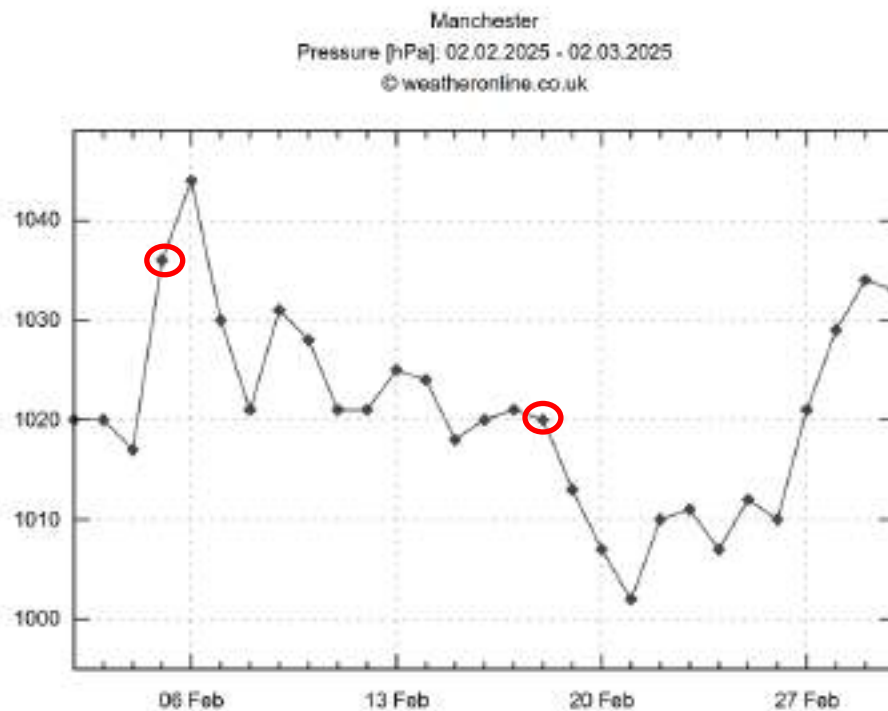
Engineer: Stefani Ellis

Date: 03/03/2025

Visits 2, 3 & 4 – 07.01.25, 15.01.25 and 24.01.25



Visits 5 & 6 – 05.02.25 and 18.02.25





GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 55 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

BS8576:2013 states that gas monitoring does not necessarily need to be carried out under worst case conditions. It does not necessarily need to be at low or falling atmospheric pressure, but rather should be continued until it is unlikely that additional data will change the interpretation of the data, the outcome of the risk assessment and proposed remedial actions. One of the main considerations is to assess whether gas flow rates or concentrations could possibly increase and thereby affect the risk assessment and hence the choice of protective measures. On the basis of the above results and conceptual site model understanding of the site, Tier Environmental does not consider that additional data is necessary.

Consideration of Groundwater Effects

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

The results of gas monitoring have indicated the following instances where groundwater pumping is likely to have influenced the measured ground gas flow rates such that they may be reasonably discounted from the Gas Screening Value (GSV) calculation:

- Groundwater levels at RH101, RH102, RH103C and WS109 have all been reported at depths within the plain section of the monitoring well pipe. Therefore elevated peak flow rates can be reasonably discounted from these locations (particularly, the maximum peak flow rate of 24.0 l/hr that was reported at RH103C and a peak flow rate of 4.3 l/hr reported at WS109 during the first ground gas monitoring visit);

In addition to the above, consideration has been made as to whether waterlogged ground or frozen ground conditions may have led to gas becoming trapped and then emitted into the monitoring wells causing a rapid gas release. There is no evidence of this from the monitoring works to date with respect to carbon dioxide or methane.

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

Ground Gas Risk Assessment

Methodology

In accordance with Section 6.3.1 in BS 8485:2015 +A1:2019, the development of the GSV for the site or the zone follows a process in which:

1. borehole hazardous gas flow rates are calculated for each borehole standpipe for each monitoring event and included in a database;
2. the reliability of the measured gas flow rates and concentrations is assessed taking into account borehole construction, etc;
3. decisions are made as to whether to use peak gas flow rates or steady-state rates in each calculation;
4. decisions are made about how to deal with any temporal or spatial shortages in the data;
5. a decision is made about whether the site might be zoned or not; and
6. judgements are made about what GSV to use for design purposes taking all relevant information into account.

Subsequently to the above, the calculated borehole hazardous gas flow rates are considered to determine a Gas Screening Value (GSV) either for the site as a whole, or for site zones, if applicable.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 56 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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

Consideration of Peak Gas Flow Rates

In accordance with BS 8485:2015 +A1:2019 it may be appropriate to robustly discount *“peak instantaneous flows and negative flows that have been judged to be unrepresentative of a possible worst case”*. In addition, it is stated that *“peak flow measurements might result in a disproportionately high gas hazard prediction, and assignment of an over-precautionary CS”*.

Tier Environmental has conducted a review of the peak flow rates reported at the site. A maximum peak gas flow rate of 24 l/hr was reported at RH103C on the first gas monitoring visit. This, alongside other peak instantaneous peak flow rates attributable to groundwater pumping have been discounted for the purposes of borehole hazardous gas flow rate assessment.

Consideration of Peak Ground Gas Concentrations

An assessment has been made as to whether peak flow rates or steady flow rates should be applied for the purposes of calculating the borehole hazardous gas flow rates.

Overall, based on the conceptual site model understanding of the site and with due consideration of the flow rates and reported TOC concentrations, it is not considered that there is evidence of significant gas generation from the Made Ground.

Similarly, for superficial deposits peak concentrations and flow rates are not representative of sustained gas flow that would cause elevated emissions from the ground. Finally, no significantly elevated flows, carbon dioxide or methane has been reported from the wells targeting coal seams within the Coal Measures.

On this basis, it is considered appropriate to discount peak gas concentrations from the borehole hazardous gas flow rate calculations.

Borehole Hazardous Gas Flow Rates

Calculated borehole hazardous gas flow rates have been determined and are presented in Appendix F. In light of the above conclusions regarding whether peak or steady flow rates and peak or steady gas concentrations should be included within the borehole hazardous gas flow rate calculations, it shows that across the whole site in all deposit types the Borehole Hazardous Gas Flow Rates are below the limit for Characteristic Situation CS1.

‘Worst-Case’ GSV Check Calculation – Carbon Dioxide and Methane

In accordance with BS8485, Tier Environmental has conducted a ‘worst-case’ check by calculating the Gas Screening Value (GSV) for the site:

“Irrespective of the apparent comprehensiveness of the dataset, the plausible worst case condition should be calculated for each hazardous gas by multiplying the maximum recorded flow in any standpipe in that strata (and zone) with the maximum gas concentration in any other standpipe in that strata (and zone), but discounting any peak instantaneous flows and negative flows that have been judged to be unrepresentative of a possible worst case.”

Therefore, the following process has been followed:

- the maximum reported methane or carbon dioxide concentration (whichever is highest) from any monitoring well and during any ground gas monitoring visit; and,



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 57 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

- the remaining maximum peak positive flow rate (after any negative flow rates or 'artificially' high flow rates have been discounted as described above) from any monitoring well and during any ground gas monitoring visit.

Table 10.2 Worst-Case GSV Check Calculation

Ground Gas	Maximum Reported Peak Concentration (% v/v)	}	Selected Concentration used in GSV Calculation (% v/v)	X	Maximum Appropriately Selected Gas Flow Rate (l/hr)	=	'Worst case' GSV (l/hr)
Methane (CH ₄)	0.7		4.2		0.4		0.0168
Carbon dioxide (CO ₂)	4.2						

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

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

In this instance, as the site is due to be developed as new proposed college building in the north, a water tank and small ancillary building in the centre, and a substation in the northwest of the site., it shall be regarded as a Situation A scenario for the purposes of the ground gas risk assessment.

Table 10.2 demonstrates that the site is placed in a Characteristic Situation 1 – Very Low Risk scenario on the basis of the 'worst case' GSV alone calculated for the data set obtained from 6 No. of the proposed total of 6 No. gas monitoring visits.

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

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

Carbon Monoxide and Hydrogen Sulphide

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

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



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 58 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

A maximum steady carbon monoxide concentration of 12 ppm has been reported which is below the workplace long term exposure limit (30ppm) and the workplace short term exposure limit (200ppm) published by the Health and Safety Executive (EH40/2005 Workplace Exposure Limits) but above the WHO long term (24 hours) indoor exposure guideline value (5.68 ppm). Nevertheless, it is not considered that the measured concentrations are sufficient to warrant any variation in the ground gas recommendations for the site.

Coal Mine Gas Risk Assessment Considerations

Tier Environmental has encountered potential evidence of shallow coal mine workings and recommendations are to be made with respect to remedial grouting works, prior to construction of the new building development. Tier Environmental has therefore further considered coal mine gas risks in line with the CL:AIRE Good Practice for Risk Assessment for Coal Mine Gas Emissions (dated October 2021).

It is evident from the coal mine risk assessment works conducted to date (including desk-based research) that any shallow workings beneath the site are dated from prior to 1808. The CL:AIRE Guidance states that Abandoned mine methane (AMM) emissions are characterised by a high rate of release immediately following closure, then falling to much lower rates of emission over a period of 8 to 10 years. In one study, emissions completely stopped after 15 to 20 years although the majority of methane currently vented by the Coal Authority surpasses this timescale (Duda and Krzemien, 2018). As such, it is considered that the gas generation potential from the extremely old workings beneath the site is therefore very low in line with terminology used in BS 8576:2013 and The Local Authority Guide to Ground Gas, CIEH (2008), if it can be proven that they are permanently flooded.

Other extracts from the CL:AIRE Guidance further suggest lower risk concern associated with flooded coal mine workings:

- From Page 15: "Abandoned mines can continue to release methane until the workings are completely flooded.....";
- From Page 16: "Static flooded workings will limit the supply of oxygen and subsequent transport of gas";
- From Page 18: "Once a mine becomes flooded desorption of methane reduces significantly and when the water pressure is greater than the desorption pressure it stops completely. A study of abandoned mine sites in the USA has observed that if a mine floods after closure, methane emissions are negligible while if no flooding occurs, emissions are likely to occur (Kirchessner et al., 2000);
- From Page 25: "If workings are above the natural groundwater levels then rising groundwater is not likely to push gas out of them. However, the interconnection with deeper workings that could become flooded should be considered and is known to have caused issues on some sites.", and "Partially flooded workings where the groundwater level can vary above and below some workings present a high risk situation in relation to mine gas."
- From Page 28: "There will be a requirement to undertake more detailed assessment where there are credible potential sources of mine gas emissions (**unflooded working less than 150m** or there is <50m to a mine entry).
- From Page 42: "Once a mine becomes completely flooded, the risk of gas emissions reduces significantly".

Consideration has been given to the distance from the nearest off-site recorded mine shaft (which may act as a preferential pathway for mine gas if located in close proximity to the building footprint). It should be noted that there are no mine shafts located within 50m of the site (the closest is Circa 300m from the site).

Tier Environmental has prepared the table below to assess the reported groundwater levels at the site relative to potential evidence of mine workings beneath the Site.

The table below demonstrates that the groundwater levels monitored in wells to date by Tier Environmental are consistently more elevated than the worst-case shallowest probable mine workings identified beneath the site. Seasonal variations in shallow groundwater are captured by the late summer water monitoring conducted by Geotechnics which reported groundwater levels ranging between 118.23m AOD and 115.51m AOD again demonstrating that the shallow mine workings are evidently permanently flooded.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 59 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Further consideration has been made with regards to coal mine gas risk in line with Figure 13.1 from the Good Practice for Risk Assessment for Coal Mine Gas Emissions (CL:AIRE, 2021)

- Workings are shallow but permanently flooded;
- Mine entries are >50m from the site boundary according to the Coal Authority information for the shaft;
- Additional lines of evidence include
 - o The significant age of the mine workings (pre 1808);
 - o No reports of any historical ground related issues in nearby adjacent college building structures developed pre-1977 (at which time gas protection measures were not a standard practice in UK building practices);
 - o The absence of any significant ground gases or flow rates monitored at the site and determination of the site based on available data as a Characteristic Situation 1 – Very Low Risk scenario.
- The ternary plot produced for the steady gas concentrations (see below) does not indicate the presence of thermogenic methane (mine gas) in any wells monitored (either in saturated or unsaturated zone)
- The shallow flooded mine workings are to be grouted as part of the development works thereby significantly reducing ground gas risks even further by sealing potential migration pathways, reducing void space, and mitigating the risk of any gas displacement.

On this basis, it is considered that the site is likely to be regarded as being a Low Risk Zone in accordance with the guidance for which mitigation is not required.

It should be noted that the above may be re-evaluated in the event that any unrecorded mine shafts are encountered during development works.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 60 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 10.3 Groundwater Depth Summary (after and Anticipated Depth to Possible Mine Workings)

Monitoring Well Reference	Well Elevation	Minimum Groundwater Level (mbgl)	Maximum Groundwater Level (mbgl)	Minimum Groundwater Level (mAOD)	Maximum Groundwater Level (mAOD)	Elevations of Probable Workings
RH101	119.52	ND	0.32	119.20	119.52	Shallowest elevation reported of probable mine workings would be: RH101 – 113m to 111m AOD; RH102 – 110m AOD RH103 (RH103, RH103A, RH103B and RH103C) – 113m to 112m AOD The deepest measured groundwater reported beneath the building footprint is 115.74m AOD which means that the shallowest recorded probable mine workings are a full 2.74m below the saturated zone beneath the building footprint. Third party monitoring data from summer months demonstrates that seasonal fluctuations do not significantly affect the groundwater levels and the workings remain permanently flooded.
RH102	119.64	1.89	2.10	117.54	117.75	
RH103C	119.53	ND	0.85	118.68	119.53	
CP101	119.53	3.01	3.11	116.42	116.52	
CP102	119.51	3.43	3.77	115.74	116.08	
CP103	119.43	3.77	4.14	115.29	115.66	
CP105	119.50	1.28	2.19	117.31	118.22	
WS104	119.69	ND	ND	ND	ND	
WS107	119.51	ND	ND	ND	ND	
WS108	119.61	0.58	0.67	118.94	119.03	
WS109	119.56	0.10	0.35	119.21	119.46	
WS112	118.86	3.44	3.76	115.10	115.42	
WS116	119.14	ND	ND	ND	ND	
WS111	119.74	0.64	0.71	119.03	119.10	

N.D. Green highlighted locations are beneath (or in close proximity to) the proposed building footprint.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

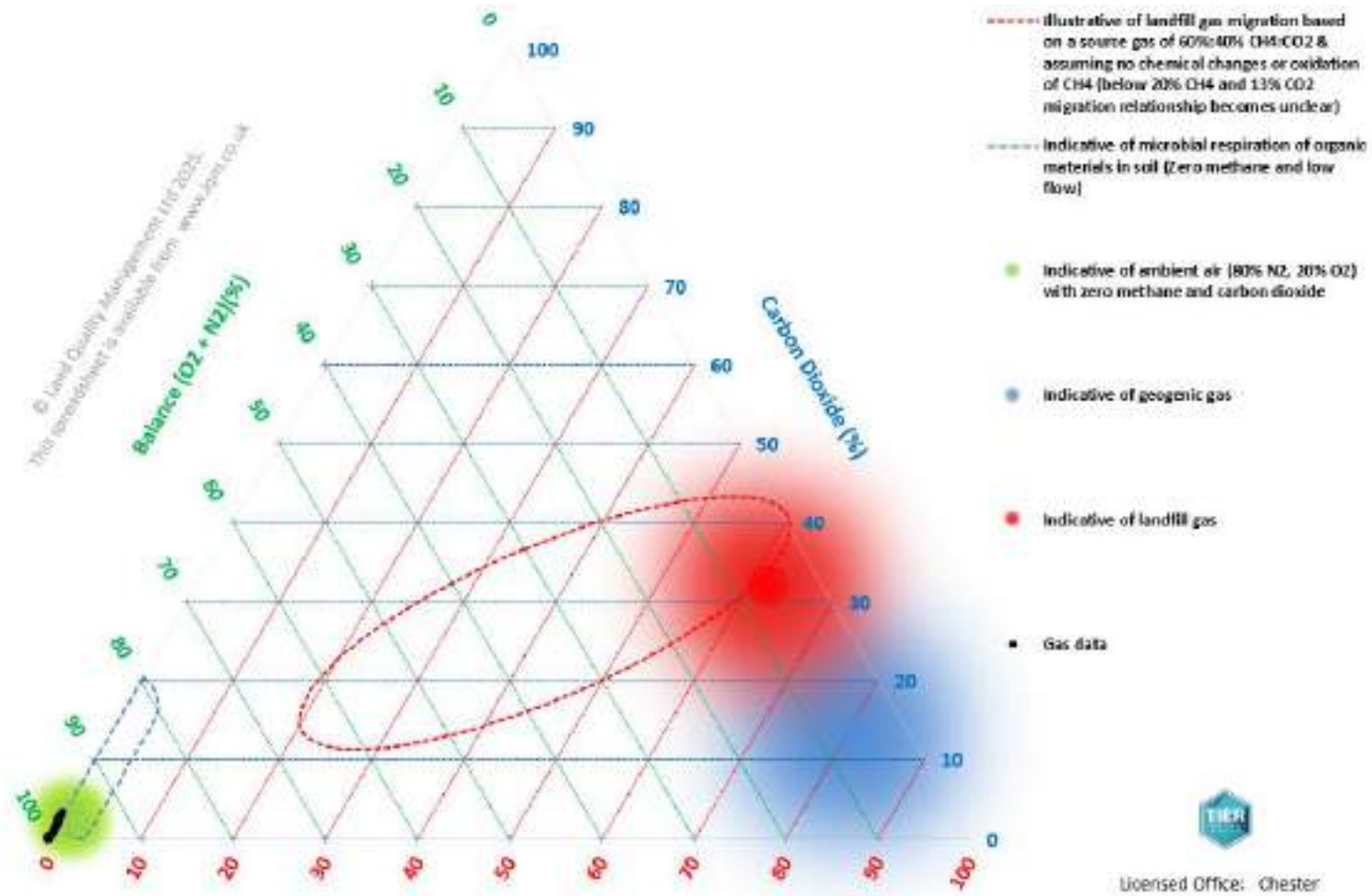
Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 61 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Figure 10.1 Ternary Plots for Ground Gases





GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 62 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Consideration of Foundation Types and Floor Slab Design

BS 8485 states that deeper foundations can influence or change ground gas pathways and gas generation rates. This might be due to the creation or alteration of flow paths for existing ground gases or be the result of the introduction of oxygen at depth (e.g. in peaty soils) promoting the generation of ground gas. The guidance states that the foundations adopted for a building can influence the generation of gas and/or the pathways through which the gas might move and thus impact on the gas protection measures required. This could be a result of changing the permeability of the underlying strata, possible changes to the groundwater regime and the creation of preferential pathways due to the proposed foundation solution.

The guidance also states that assumptions made during initial gas risk assessments, including gas flow rates, are re-evaluated during the design of the foundations for the building.

Tier Environmental has considered the proposed foundation types within the ground gas risk assessment, which are proposed at this stage to comprise Continuous Flight Auger (CFA) piles socketed into the solid bedrock. CFA piles are cast in place with a continuous concrete column, which effectively seals the borehole, thereby minimizing vertical and lateral gas migration pathways. Therefore the proposed CFA piles represent a preferred piling solution, particularly when compared with alternatives such as Vibro Stone Columns which, due to their permeable nature, allows gases to migrate vertically and laterally.

Tier Environmental considers that it would be possible, via multiple lines of evidence provided above, and consideration of the CSM, to determine that the site be regarded as a Characteristic Situation 1 – Very Low risk scenario, for which no ground gas protection measures would be required and the proposed foundation design will not alter the gas regime in such a way that increased gas generation or preferential pathways will be formed in such a way that it affects the 'baseline' assumption that diffusive flow is the principle gas migration mechanism beneath the site.

With regards to the inherent design of the floor slab, it is assumed that the slab may be formed from a suspended cast in situ floor slab which would, in isolation achieve a point score as a structural barrier (point score of 1.0, or possibly 1.5 points if well reinforced to control cracking with minimal penetrations) in accordance with Table 5 in BS 8485 thereby providing additional confidence in the conclusions. In the event that a ground bearing floor slab be implemented, then again it is considered that such a structure may also attract 0.5 or 1.0 points in accordance with BS 8485 and again provide confidence in the conclusions.

Considerations for Construction and Maintenance Workers

During engineering and construction activities, the ground gas data indicate that the following aspects are to be considered during the preparation of relevant site H&S plans, method statements and related documents, and appropriate working methods adopted:

Carbon dioxide concentrations in ground gas: The measured CO₂ concentrations in ground gas reported are slightly elevated relative to background levels and could present an asphyxiation risk in excavations and other confined spaces. The Health & Safety Executive has published information defining safe occupational exposure levels for CO₂ and the latest guidance must be consulted to determine whether the ground gas regime necessitates specific precautions during site works.

Methane concentrations in ground gas: The measured methane concentrations in ground gas reported are slightly elevated relative to background levels and could give rise to explosive mixtures in confined spaces. Safe working methods should be adopted to mitigate this risk.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 63 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

Radon Gas

The site lies within an area where less than 1% of properties above the Action Level. As stated within BR 211, 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, it is understood that no 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.

Radon protection measures are not required.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 64 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

11. 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 3, has been revised in light of the ground investigation and the chemical analysis results presented above in Table 11.1, below.

The revised conceptual site model is presented in schematic form in Appendix A, Drawing No. TE1880-TE-00-XX-DR-GE-015-V01.

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.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 65 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 11.1 Revised Assessment of Potential Pollutant Linkages (Continued on Next Page).

Justification / Comments
- An asphalt surfacing over concrete (possible former floor slab) was recorded across the main car park area, underlain by further Made Ground generally comprising silt (suspected PFA former ground improvement layer) and further generally granular Made Ground. Made Ground was encountered to depths of between 3.40m and 6.50m bgl (and recorded to 6.80m bgl within the previous third party report). This was recorded to be underlain by a thin band of Alluvium in the north and Glaciofluvial Deposits in the southeast, over mudstone with interbedded sandstone and siltstone of the Pennine Lower Coal Measures. - Groundwater strikes were recorded at depths of between 0.86m and 4.35m were encountered in the exploratory locations, with possible sub artesian groundwater conditions noted during the intrusive investigation and groundwater monitoring undertaken to date. Perched groundwater within the Made Ground and a deeper groundwater body have been identified. - Benzo(a)pyrene has been recorded to be elevated above POS park GAC but not commercial GAC within the proposed soft landscaping area in the northeast of the site. It is not considered that there is any risk to end-users in the proposed car parking / hardstanding / building areas or peripheral proposed soft landscaping associated with commercial land use. However, it is recommended that post-demolition, further soil sampling is conducted in the vicinity of the proposed contoured landscaped area in the east. It is also understood that no soft landscaping will be used for horticultural or vegetable growing purposes; however, should this change then the risk assessment will need to be updated accordingly. - Asbestos was recorded widespread across the site, at concentrations of up to 0.03% w/w. This includes chrysotile and amosite fibre bundles and ACM debris. No visible ACMs were observed during the ground investigation. Further detailed risk assessment is required in accordance with CIRIA C733 to further define the potential risk associated with these reported concentrations. - Measured soil leachate and groundwater concentrations are unlikely to present a potential risk to the controlled waters environment. No free phase product was encountered. - The results of the ground gas monitoring undertaken to date conclude that the site lies within Characteristic Situation 1 – Very Low Risk alongside multiple lines of evidence considered with respect to coal mine gas risk which have identified a low risk from coal mine gases.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 66 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Localised concentrations of benzo(a)pyrene within the northeast of the site which exceeds Public Open Space (Park) land use (NOT commercial land use) GAC.	benzo(a)pyrene	Direct contact, dust inhalation and ingestion	Future site users (educational)	Medium	Low Likelihood	Moderate / Low Risk
			Adjacent site users (residential and commercial)	Medium	Unlikely	Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Unlikely	Low Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (residential and commercial)	Medium	Unlikely	Low Risk
Widespread asbestos within the Made Ground, up to 0.03% w/w	Asbestos	(Dust migration and) dust inhalation	Future site users (educational)	Medium	Likely	Moderate Risk
			Adjacent site users (residential and commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk

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



12. PRELIMINARY WASTE MATERIALS CLASSIFICATION AND WASTE DISPOSAL ROUTE DETERMINATION

12.1. 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



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 68 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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.

12.2. 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 been obtained during the investigation.

The results of basic waste characterisation are summarised in the table below. It is likely that any natural soils (that are not impacted by any known contamination from shallow Made Ground, or unexpected contamination or that are organic rich and therefore likely to have a TOC >3%) 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.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 69 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 12.1 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
WS114	0.50m	MADE GROUND: Greyish brown, slightly sandy, clayey GRAVEL with medium cobble content. Sand is fine to medium, gravel is fine to coarse, subangular to angular of brick, sandstone, slate and limestone of slag. Cobbles are angular of brick and concrete	Potentially Hazardous Waste	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	Chrysotile and Amosite fibre bundles and ACM debris - 0.002% w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS108	0.70m	MADE GROUND: Dark greyish black, slightly clayey, sandy GRAVEL of fine to coarse, angular to subangular of mixed lithologies including brick, sandstone, rare plastic and metal	Non-hazardous	N/A	N/A	Chrysotile and Amosite fibre bundles and ACM debris - 0.017% w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS109	0.40-0.60m	MADE GROUND: Very stiff, light grey, slightly gravelly SILT. Gravel is fine to medium, angular of brick. (possible PFA)	Non-hazardous	N/A	N/A	Not analysed.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS111	0.80m	MADE GROUND: Very stiff, light grey, slightly sandy, slightly gravelly SILT. Gravel is medium to coarse, angular to subangular of brick. Refusal of core barrel at 0.80m bgl. (possible PFA) MADE GROUND	Potentially Hazardous Waste	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	No asbestos detected.	Yes	Materials should be disposed to a non-hazardous waste facility due to elevated selenium and arsenic in excess of the inert waste landfill WAC threshold.
WS116	1.90m	MADE GROUND: Firm, dark grey, gravelly CLAY/SILT. Gravel is fine to coarse, angular to subangular of brick. (possible PFA)	Potentially Hazardous Waste	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	Chrysotile fibre bundles <0.001 w/w	Yes	Materials should be disposed to a non-hazardous waste facility due to elevated TOC and sulphate as SO4 in excess of the inert waste landfill WAC threshold.
WS116	3.40m	Loose, brownish grey silty SAND. Wet material between 3.30m and 3.50m bgl.	Non-hazardous	N/A	N/A	No asbestos detected.	No	Natural soils =, likely to be suitable for disposal to an inert waste landfill.
WS103A-	0.40m	MADE GROUND: Greyish brown, clayey, gravelly SAND. Gravel is fine to coarse, angular to subangular of brick, sandstone, occasional concrete, timber and rare glass.	Potentially Hazardous	Yes. Driven by 'HP 3(iv): Flammable "flammable gaseous waste"' (hazard statement: Flam. Gas. 1; H220 "Extremely flammable gas.>"). However, Tier Environmental consider that such a hazard property does not apply to soils and as no flammable properties were observed during the ground investigation (i.e. during sampling) it is considered that the materials above may be regarded as being non-hazardous.	N/A	Chrysotile and amosite fibre bundles <0.001 w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS105	0.60m	MADE GROUND: Reddish brown, sandy GRAVEL of fine to coarse, angular to subangular crushed brick and rare concrete.	Hazardous	N/A	TPH (C6 to C40) petroleum group (conc.: 0.137%), toluene (conc.: 2.32e-06%), xylene (conc.: 6.02e-07%) & chlorobenzene (conc.: 4.3e-07%)	Chrysotile fibre bundles and bitumen products 0.019% w/w	Yes	Materials are suitable for being disposed of as hazardous waste to a Stable Non-Reactive Hazardous Waste facility.
WS105	0.75m	MADE GROUND: Dense, very compacted, light grey, sandy SILT with occasional fine brick fragments. (possible PFA)	Non Hazardous	N/A	N/A	No asbestos detected.	Yes	Materials should be disposed to a non-hazardous waste facility due to elevated TOC and arsenic in excess of the inert waste landfill WAC threshold.
WS107	0.40m	MADE GROUND: Reddish brown, fine to coarse, angular GRAVEL of crushed brick.	Non Hazardous	N/A	N/A	No asbestos detected.	No	Non-hazardous waste landfill, based on WAC results from other samples.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 70 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

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
WS107	0.65m	MADE GROUND: Light grey, friable SILT/SAND (possible PFA)	Non Hazardous	N/A	N/A	Not analysed.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS110	0.61m	Greyish brown, sandy, fine to coarse, angular to subangular GRAVEL of brick, limestone and sandstone.	Potentially Hazardous	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	Not analysed.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS112	1.20m	MADE GROUND: Medium dense, light grey, friable, silty, slightly gravelly SAND. Gravel is fine to medium, angular of brick. Cobble of brick at 1.50m to 1.60m bgl and 1.90 to 1.92m bgl. (possible PFA)	Potentially Hazardous	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	No asbestos detected.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS112	3.35m	POSSIBLE MADE GROUND: Very loose, grey, mottled dark grey, clayey, silty SAND	Non Hazardous	N/A	N/A	Not analysed.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS113B	0.35m	MADE GROUND: Dark brown, sandy, gravelly CLAY. Gravel is fine to coarse, angular to subangular of brick, concrete, sandstone. Occasional cobbles of brick and sandstone. Cobble content increasing from 0.50m bgl.	Potentially Hazardous	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	Chrysotile and amosite fibre bundles <0.001 w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS115	0.10m	TOPSOIL: Grass over dark brown, slightly silty, sandy LOAM with occasional rootlets. Cobbles of sandstone and brick.	Non Hazardous	N/A	N/A	No asbestos detected.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS115B	0.90m	MADE GROUND: Grey, stiff, gravelly SILT. Gravel is fine to medium, angular to subangular of brick, occasional concrete. Gravel content increasing around 1.05m bgl. (possible PFA)	Non Hazardous	N/A	N/A	Chrysotile and amosite fibre bundles 0.002 w/w	Yes	Materials should be disposed to a non-hazardous waste facility due to elevated TOC in excess of the inert waste landfill WAC threshold. Fluoride has also been reported at the inert waste landfill threshold.
WS117	1.10m	MADE GROUND: Firm, light grey, sandy SILT. (possible PFA)	Non Hazardous	N/A	N/A	Not analysed.	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS117	0.40m	MADE GROUND: Dark brown, slightly clayey, sandy GRAVEL of fine to coarse, angular to subangular of brick, concrete, sandstone, limestone and occasional clinker.	Hazardous	N/A	TPH (C6 to C40) petroleum group (conc.: 0.16%)	No asbestos detected.	No	Maybe suitable for disposal to a stable non-reactive hazardous waste facility based on site-wide WAC results.
WS117	2.40m	MADE GROUND: Dense, dark grey, slightly clayey, gravelly SAND. Gravel is fine to coarse, angular to subangular of brick, occasional concrete, limestone and sandstone. MADE GROUND	Non Hazardous	N/A	N/A	Chrysotile and amosite fibre bundles <0.001 w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS117-	2.20m	Red crushed BRICK	Non Hazardous	N/A	N/A	Amosite fibre bundles <0.001 w/w	No	Non-hazardous waste landfill, based on WAC results from other samples.
WS118	0.20m	TOPSOIL: Grass over, dark brown, slightly silty, sandy LOAM with occasional rootlets	Non Hazardous	N/A	N/A	No asbestos detected.	No	Non-hazardous waste landfill, based on WAC results from other samples.



GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 71 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

Table 12.2 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
RH101	0.05	Yes	0.3	<10	µg/kg	No	Yes	Despite the coal tar concentration being at or greater than 0.1%, as BaP is <0.005% of the coal tar concentrations, 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.
WS105	0.05	Yes	0.2	497	µg/kg	No	No	As the coal tar concentration is at or exceeds 0.1% and the concentration of BaP is >0.005% of the coal tar concentration, the asphalt would be classed as HAZARDOUS WASTE in accordance with WM3. The hazardous EWC code 17 03 01* bituminous mixtures containing coal tar, therefore applies.
WS112	0.05	Yes	0.3	533	µg/kg	No	No	As the coal tar concentration is at or exceeds 0.1% and the concentration of BaP is >0.005% of the coal tar concentration, the asphalt would be classed as HAZARDOUS WASTE in accordance with WM3. The hazardous EWC code 17 03 01* bituminous mixtures containing coal tar, therefore applies.
WS116	0.05	Yes	0.3	309	µg/kg	No	No	As the coal tar concentration is at or exceeds 0.1% and the concentration of BaP is >0.005% of the coal tar concentration, the asphalt would be classed as HAZARDOUS WASTE in accordance with WM3. The hazardous EWC code 17 03 01* bituminous mixtures containing coal tar, therefore applies.
RH103	0.05	Yes	0.2	48	µg/kg	No	Yes	Despite the coal tar concentration being at or greater than 0.1%, as BaP is <0.005% of the coal tar concentrations, 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.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 72 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

12.3. 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)."*



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 73 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

13.CONCLUSIONS AND RECOMMENDATIONS

13.1. Conclusions

- Some areas of the site were not accessible due to pre-existing site activities, buildings or safe access. Nevertheless, it is considered that the ground investigation works have provided good coverage of the site so as to characterise the ground conditions in key areas which are due to be redeveloped.
- Hardstanding comprising asphalt was encountered in the car park, access road, and footpaths across the site to depths between 0.05m and 0.35m bgl. A concrete slab was encountered across the footprint of the former building which occupied the present-day car park, comprising thicknesses between 0.21m and 0.47m. Made Ground has been reported to a maximum depth of 6.50m bgl and was found to be thickest towards the southwest and central west of the site within the former infilled watercourse. Made Ground was found to comprise both granular and cohesive deposits, with a layer of suspected Pulverised Fuel Ash (PFA) identified across the site, thickest beneath the former building footprint within the present-day car park area. Other anthropogenic materials encountered within the Made Ground include brick, concrete, sandstone, limestone, clinker/slag, plastic, metal, glass, timber, and occasional rebar.
- The Made Ground was found to be underlain by superficial deposits in some instances, comprising Alluvium (clay) and Glaciofluvial Deposits (silty sand). The Made Ground and superficial deposits were found to be underlain at depths between 3.30m and 6.50m bgl by bedrock of the Pennine Lower Coal Measures, found to comprise mudstone with interbedded sandstone and siltstone Coal
- Coal was reported at depths between 6m and 40m bgl within rotary boreholes, with evidence of probable workings within the Arley Mine seam.
- Shallow groundwater has been monitored across the site at depths between 0.10m and 3.97m bgl and a separate deeper confined, locally artesian, groundwater body has been reported within the deep sandstone bands at RH101 and RH103C (sandstone bands present from depths of 28.50m bgl and 32.00m bgl). The head of water reported during one groundwater monitoring visit at RH103C was reported as 0.04m.
- It is understood that a CFA piled solution will be implemented at the site with preliminary consideration of socketing Circa 5m into the bedrock; however, the final design of the piles will be subject to a specialist piling contractor and due consideration will need to be made with respect to the probable shallow coal mining workings encountered.
 - To obviate any significant damaging settlements we would recommend using a suspended floor slab with intermediate support designed on the same basis as the main foundations where the spans are too large for economical single suspended slab design. Ground bearing floor slabs may be suitable subject to a turnover, proof rolling and confirmatory testing of the Made Ground.
- CBR values derived from DCPs have been presented for preliminary purposes only and should not be relied on for final design purposes. The results indicate a range of values reported between 0.52% to >25%. Of the 49 results, 41 No. CBR values were reported >5%, 1 No. was reported between 2.5 and 5% and 7 No. were reported <2.5%.
- It is considered that a Design Sulphate Class of DS-2 and ACEC Class AC-2 is appropriate for buried concrete at the site.
- Justification has been provided for screening measured soil concentrations of potential contaminants of concern against commercial / industrial GACs. No measured concentrations of potential contaminants of concern have been reported in excess of these GACs. Sensitivity analysis via comparison against POS Park GACs has reported a single measured concentration of benzo(a)pyrene in Made Ground in the northeast of the site. Overall, it is not considered that the site presents a risk from potential chemical contaminants of concern for the proposed areas of hardstanding, buildings or peripheral soft landscaping; however, it is recommended that additional, post-demolition, soil sampling and risk assessment is conducted in the vicinity of the proposed contoured landscaped area in the east of the site.
- Asbestos has been reported in the Made Ground across the site (in 56% of those samples analysed) at concentrations between <0.001% and 0.03% w/w (amosite and chrysotile - fibre bundles, ACM debris and locally, bitumen products). Further detailed risk assessment is recommended for asbestos at the site in accordance with CIRIA C733.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 74 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

- Results from controlled waters risk assessment has demonstrated that measured groundwater concentrations of cadmium, copper, nickel, zinc, fluoranthene, and ammonia reported in excess of relevant Water Quality Standards and localised measured concentrations of glycols do not present a significant risk to the controlled waters environment when factors including the hydraulic upgradient and downgradient concentrations, aquifer sensitivity, wider commercial and industrial use of the surrounding land and surface water sample results are taken into account.
- Due consideration of the conceptual site model (including ground gas generation potential of possible sources) has been considered alongside the results from ground gas monitoring works conducted. Based on the information obtained, it is considered that the site may be regarded as a Characteristic Situation 1 – Very Low Risk scenario for which no basic ground gas protection measures are required.
 - In addition, separate consideration has been made for potential coal mine gas risk. Multiple lines of evidence have demonstrated a low risk for which no protection measures are required.
- Less than 1% of properties are recorded to be above the Action Level for Radon, therefore no radon protection measures are required.
- The results of soakaway testing (failed test) and prevalence of deep Made Ground across the site indicates that soakaways are not suitable for the site.
- Tier Environmental considers that further discussions are held with the structural engineers regarding the interaction between the former floor slab and the river-side retaining wall. Tier Environmental has studied photographs taken during the former building demolition works and these suggest that the slab is not tied into the retaining wall. Tier Environmental also has noticed some evidence of resin repairs to the river-side retaining wall and so further discussion and consideration of this should be made by the structural engineer.
- Basic waste characterisation has determined that Made Ground soils are non-hazardous with the following exceptions:
 - Made Ground at WS105 (0.60m bgl) due to elevated TPH;
 - Made Ground at WS117 (0.40m bgl) due to elevated TPH.
- The results of WAC testing demonstrate that the localised hazardous soils are suitable for disposal as **hazardous waste to a Stable Non-Reactive Hazardous Waste Cell in a Non-Hazardous Landfill**.
- For the non-hazardous Made Ground and Topsoil, WAC testing has demonstrated that these materials are not suitable for disposal to an inert waste landfill and therefore should be disposed to a **non-hazardous landfill**.
- Natural soils (other than any organic rich materials with TOC >3%) are suitable for disposal to an inert waste landfill.
- The results from asphalt testing have indicated coal tar concentrations consistently >0.1% w/w/ indicating that these materials would be hazardous waste. However, further assessment has demonstrated that in some (but not all) cases that the concentration of benzo(a)pyrene is low such that the classification may be downgraded to non-hazardous. It is recommended that further detailed consideration of asphalt is conducted to determine potential re-use opportunities and further refine the waste classification. In the meantime, it is recommended that all asphalt is considered to be coal-tar containing until such additional works are carried out.

13.2. Recommendations

The following further work is recommended (at a time when the car park is no longer in use):

- It is recommended that further works are conducted to confirm that the former concrete slab associated with the building is not tied into the river-side retaining wall.
- It is recommended that further soil sampling and human health risk assessment is conducted post-demolition in the vicinity of the proposed contoured landscaped area in the east of the site.
- It is recommended that an asbestos Detailed Quantitative Risk Assessment is carried out for the asbestos concentrations reported at the site. If this is not carried out or if a potential risk is identified following any future risk assessment, then a remediation strategy will be required for a clean cover system at the site.
- It is recommended that an Asbestos Management Plan is prepared for the site.



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 75 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

- Treatment / grouting works will be required associated with probably shallow coal mine workings identified beneath the site. Please see the separate Coal Mining Risk Assessment report for more details.
- An earthworks specification is recommended that taken into consideration any proposed re-use / earthworks of the PFA materials which may degrade in inclement weather.
- It is recommended that further detailed consideration of asphalt is conducted to determine potential re-use opportunities and further refine the waste classification.
- Any further intrusive works, groundworks and earthworks will need to be undertaken in accordance with the Control Of Asbestos Regulations (CAR2012) due to the recorded presence of asbestos.
- Presently no ground gas protection measures are considered necessary for the site, subject to reappraisal in the event of identification during earthworks of any unrecorded mine shaft, adit or associated coal mining features that may present a preferential pathways.
- An asbestos DQRA is recommended in accordance with CIRIA C733; however, in the event that an unacceptable risk is identified then a clean cover system will likely be required for the soft landscaped areas. If the results of the risk assessment demonstrate a minimal risk from asbestos , then a clean cover system will not be required.
- Tier consider that due to the moderate / high risk posed by the potential shallow mineworkings and the shallow position of the Arley Mine Coal Seam underlying the site there is a risk of unacceptable differential settlements that could affect the developme nt. Due to this the building footprint, drainage/attenuation and service corridors will require stabilisation via proof grouting. The full extent of these works will be detailed within a specification to be produced by Tier in due course.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 76 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

14.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.



GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 77 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 78 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02
Page No : 79 of 81
Engineer: Stefani Ellis
Date: 03/03/2025

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GROUND INVESTIGATION REPORT HOPWOOD HALL COLLEGE, ROCHDALE

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 80 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

16.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



**GROUND INVESTIGATION REPORT HOPWOOD
HALL COLLEGE, ROCHDALE**

Report No : TE1880-TE-00-XX-RP-GE-002-V02

Page No : 81 of 81

Engineer: Stefani Ellis

Date: 03/03/2025

SPT	Standard Penetration Test
SPZ	Source Protection Zone (see Appendix K)
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