

MCFC North Stand

Gas Risk Assessment

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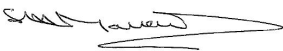
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date **27.02.2014**

approved **Hugh Mallett**

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Contents

1	Introduction	4
1.1	Background and commission	4
1.2	Objectives and scope	4
1.3	Information sources and limitations	5
1.4	Competence	5
2	Site setting	6
2.1	Location	6
2.2	Geology and hydrogeology	6
2.3	Hydrogeology	8
2.4	History	8
3	Previous investigations and assessments	10
3.1	Buro Happold desk study	10
3.2	Buro Happold Generic Quantitative Risk Assessment (GQRA)	10
4	Ground gas and mining gas risk assessment	13
4.1	Introduction and methodology	13
4.2	Ground gas assessment criteria	13
4.3	Ground gas results	14
4.4	Assessment of ground gas regime	14
4.5	Comment on likelihood of mine gas impacting the proposed development	16
5	Summary and conclusion	17
6	References	18

1 Introduction

1.1 Background and commission

This report presents a ground gas risk assessment based on the results previous studies undertaken for Project North Stand Manchester. It was prepared by Buro Happold on behalf of Manchester City Football Club. A series of historic reports relating to ground conditions have been produced to support the proposed development, a summary of which is presented in Section 3. The most recent report, a Generic Quantitative Risk Assessment (GQRA) was produced in 2023 by Buro Happold (ref NSE-BHE-XX-XX-RP-CG-000003, April 2023 [1]) and submitted to the local authority to support the relevant planning condition. The following response was received:

The ground gas monitoring undertaken to date falls short of the typical/idealised period and frequency as stated in CIRIA C665. They have undertaken up to 5 rounds of monitoring in one month, none of which were during the worst case of low and falling pressure. Whilst I had no concerns with the enabling/remediation works commencing under 135764/FO/2022 [SIW], I commented that further gas monitoring should be undertaken prior to the construction works commencing for application 136763/FO/2023. Due to the history of mining in this part of Manchester there is a risk of mine gas being present and as such I would class the site as at least a moderate risk (and not very low/low as the monitoring to date would suggest). This is why I have asked for further gas monitoring to be undertaken with a focus beneath the proposed building footprints once the enabling/mine shaft grouting works have been completed.

If they do not think this is necessary then I would expect a detailed ground gas risk assessment to be provided based on a lines of evidence approach using the conceptual site model. I have seen that a risk assessment has been provided and mine gas does not appear to have been detected ruling out this source. The NHBC has recently published some updated ground gas guidance which includes the use of ternary plots to determine the potential source of any ground gas.

A subsequent call between Buro Happold (G Perrett) and the relevant Contaminated Land Officer (L Miller) confirmed that a more detailed assessment was required to determine the site specific risk from gas. This purpose of this report is to address the comments from the Contaminated Land Officer and update the gas risk assessment. The responses to the questions are presented in the final sections of this report.

1.2 Objectives and scope

The objectives of this report are to establish the environmental and geological conditions at the Site and assesses the potential ground gas risks for the proposed development in accordance with current guidance (CIRIA report C665 [2] (although superseded by BS 8485 [3]), National Housing Building Council (NHBC) [4] and CL:AIRE guidance [5]).

Based on the above, the scope of works is:

- Review existing data in relation to the ground model, ground investigation data and ground gas data;
- Review the conceptual site model of the site;
- Produce an assessment of risk to people and the environment (natural and built) associated with ground gas; and
- To provide recommendations and outline scope, if necessary, for further works such as intrusive ground investigation and / or remedial action or design.

1.3 Information sources and limitations

The principal sources of information were taken from the Desk Study [6], GQRA [1] and the Coal Mining Risk Assessment [7]. Other previous reports (including historical ground investigations) are summarised within these reports. This current report is therefore based upon information obtained from these third-party sources, together with data obtained from the ground investigation undertaken between December 2022 and February 2023. The third-party data has been accepted at face value and has not been independently verified. Buro Happold can therefore give no warranty, representation or assurance as to the accuracy or completeness of such information.

No investigation, however comprehensive, can be expected to determine absolutely the nature and variation of all the geology or contamination which could be present on any site. There will always be an element of uncertainty about the ground conditions including contamination. This potential for currently undetected contamination or variations in geology, together with the gaps in the investigation set out above, must therefore be taken into account not only in the risk assessment presented here but also in consideration of future development activities, for example, health and safety planning, financial planning and risk management and in the implementation of the below ground works during construction.

1.4 Competence

The work reported here was carried out by an appropriately qualified chartered geoenvironmental engineer with over 15 years of experience in contaminated land and C.WEM. The work has been overseen by a Technical Director with experience in the assessment of land affected by contamination who is a Chartered Geologist and a registered SiLC (Specialist in Land Contamination) and SQP (Suitably Qualified Person).

2 Site setting

2.1 Location

The Site covers some 3.58 ha and is located north of Manchester City Football Club Stadium. It is centred on National Grid Reference SJ 86784 98665 within the remit of Manchester City Council. The Stadium, City Shop and surrounding infrastructure currently occupy the Site. To the north are Ashton Canal and Joe Mercer Way, with the new Co-op Live arena to the east and the Manchester Tennis and Football Centre to the west. Beyond these is Sportcity Way. To the south is the Manchester City Football Club Stadium.

2.2 Geology and hydrogeology

The 1:50,000 and 1:10,000 geological maps [8] and [9] together with borehole logs available from several Site historical investigations indicate the geology to be the Carboniferous Pennine Upper Coal Measures, overlain by superficial deposits namely, Glacial Till.

Owing to the significant industrial past of the Site area (including Bradford Ironworks and Bradford Road Gas Works) and the nature of redevelopments, Made Ground will be present.

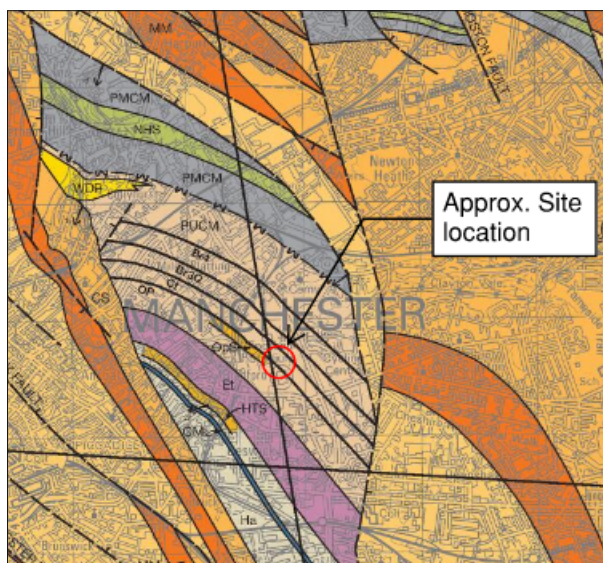


Figure 2-1 Extract of 1:50,000 BGS map (Sheet 85)



Figure 2-2 Extract of 1:10,000 BGS map (SJ89NE)

The Coal Measures have been thrown up by faulting and are surrounded by Permo-Triassic rocks. The Bradford Fault forms the eastern boundary of the Coal Measures, this has a total throw of about 1000m to the east. The Ardwick Fault system forms the western boundary of the workings. The BGS geological maps indicate two coal seams underlie the Site, the Openshaw and the Charlotte. Further northeast are the Bradford Three Quarter and the Bradford Four Foot seams, owing to the dip direction of the seam (SW) there is a potential that these seams contain workings within / under the Site area. The maps indicate that the strata dips between 20° and 25° southwest.

During previous ground investigations (ESG, May Gurney, Norwest Holst) rockhead has generally been found between 15m and 21m depth (+47.0 to +41.3mOD). The Coal Measures at rockhead are highly weathered and were typically

recorded as very stiff clay, often fissures. In some boreholes rockhead was recorded as weak to moderately weak sandstone or siltstone which was moderately to highly weathered.

The 2022/2023 ground investigation confirmed the above sequence with the ground conditions presented in **Table 2-1**.

Table 2-1 Encountered geological conditions

Strata	Description	Top of Strata		Thickness (average) m
		m BGL	m OD	
Made Ground	Tarmac across the majority of the Site (with the exception of those locations in the east).	0.0	+60.55 to +62.4	0.1
	Light grey concrete and limestone GRAVEL (Type 1 material). Occasionally a geotextile identified separating this material from the underlying Made Ground (generally recorded between 0.3 – 0.5m bgl).	0.1		0.15 – 0.4 (0.2)
	Brown to dark grey silty sandy GRAVEL or sandy gravelly CLAY. Gravel is fine to coarse, subangular to subrounded, brick, concrete, sandstone, limestone, quartzite, clinker, rare glass and metal. Occasional concrete and brick obstructions. Occasional hydrocarbon odours. Material was frequently hard to excavate due to lime stabilisation from previous remedial activities.	0.3-0.5		3.0 – 8.0 (4.8)
Glacial Till	Soft to firm light grey mottled light brown slightly sandy silty CLAY. Stiff becoming very stiff brown to grey slightly sandy slightly gravelly CLAY.	3.0 – 8.0	+53.05 to +57.75	9.7 – 12.6 (11.4)
Coal Measures	Extremely weak to weak light grey to dark grey MUDSTONE. Bedding fractures are sub-horizontal to 20° and sub-vertical to 80°. Mudstone becomes carbonaceous and occasionally tends to black pyritic COAL. Moderately weak grey SILTSTONE, locally with thin interlaminated mudstone. Moderately weak light grey fine to medium SANDSTONE with extremely closely to closely spaced thinly and thickly interlaminated mudstone and siltstone.	15.0 – 17.7	+45.7 to +43.1	Not proven

2.3 Hydrogeology

Groundwater monitoring was carried out as part of the ground investigation. Monitoring began upon completion of the installation and then continued as part of a six-week monitoring programme. Groundwater levels within the Coal Measures ranged between +37.7mOD and +42.0mOD (some 20m below ground level). The direction of groundwater flow is considered to be west / southwest generally consistent with the direction of the River Medlock. Data obtained from the ground investigation does not present any obvious groundwater flow direction though slightly lower levels in the groundwater monitoring were recorded to the east of the Site.

2.4 History

From the 1840s the Site was shown as fields with several tracks passing through, these all led to a structure in the central-east. Southwest of the Site (adjacent) was occupied by Manchester and Salford Water Works Reservoir. To the south was Bradford Colliery and associated coal pits. To the east the Colliery Arm (an extension of the canal) and Bradford Mill. To the north was Ashton Canal. By the 1890s, significant industrial development took place to the Site (and area), including Bradford Iron Works and associated infrastructure (rail lines), Albion Works and various other mills and rail land. By 1905 the gas works was developed to the north. Between the 1930s and 1940s there were no significant changes to the Site. By the 1950s some of the residential buildings were no longer present (namely those between Middlewood Street, Eldon Street, Beswick Street, Woolton Street and Thornbury Street).

By the 1970s the north of the Site was entirely redeveloped from residential to industrial (works). Complete redevelopment of the Site took place in the 1980s. Clearance of the Site took place in the 1990s followed by the construction of the Stadium for the Commonwealth Games in the early 2000s. The areas surrounding the Stadium have been subject to some remediation over more recent years (2000 and 2010), including lime stabilisation in the eastern part.

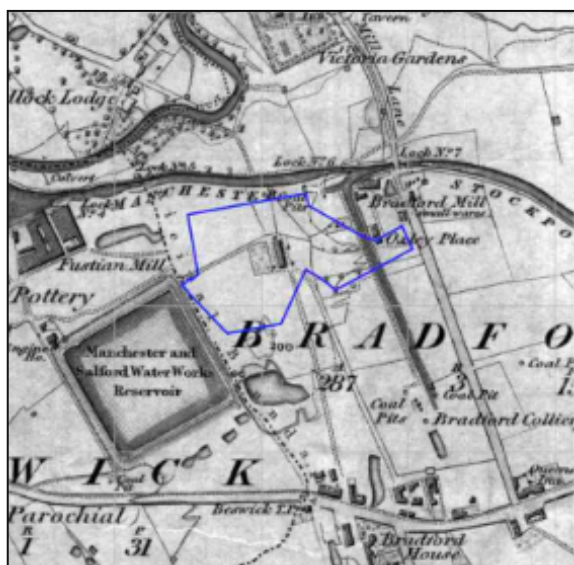


Figure 2-3 – Extract of 1848 map from the Groundsure report.

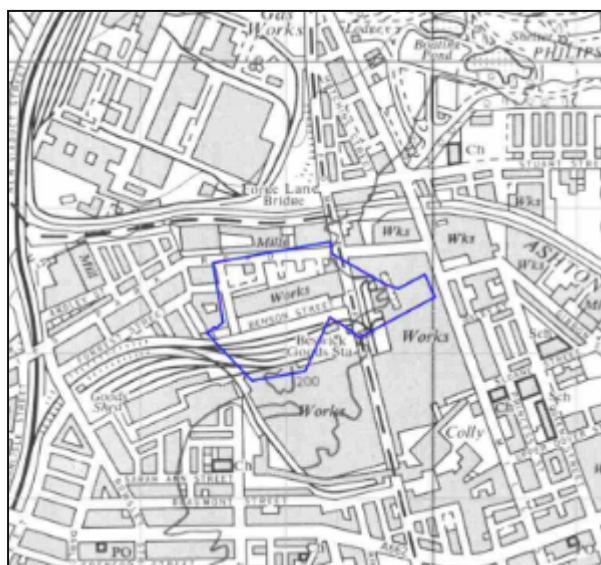


Figure 2-4 – Extract of 1968 map from the Groundsure report.

2.4.1 Mining history

The Site is located within the Central Manchester Coalfield (CMC) and has a long history of coal mining. Early mine workings date as far back as the 1590s, where shallow coal was extracted from thin seams via a method known as 'bell pits'. This methodology requires a shaft to be sunk to the seam and coal extracted by miners, a winch was used to carry coal to the surface. As coal extraction proceeded the bottom of the shaft was enlarged and a sloping roof created, resembling a bell shape. When these pits were considered too dangerous to work, they were abandoned and a second shaft sunk nearby. Between the 1700s and 1800s it was likely the coal within the top 100m of the ground surface was mined using 'pillar and stall' techniques.

The cluster of productive seams that sub-crop across the wider Sportcity area include: Openshaw Mine, Charlotte Mine, Three Quarters Mine and Bradford Four-foot Mine. The seams in this group were separated by bands of shale and fireclay. Situated at a depth of about 509 yards (465m) the Bradford Four-foot Mine is the deepest and thickest of these seams (depth assumed to be from Bradford Colliery, seam sub-crops to the north and east of the Site). Below the Bradford Group are the Parker Mine, Crombouke Mine and Roger Mine. The insets to the Parker and Roger Mines are at depths of about 543 yards (496m) and 946 yards (865m) respectively. The Crombouke Mine is 26 yards (24m) above the Roger Mine.

Clayton Colliery was located on the south side of Ashton New Road, and it was served by Clayton Branch of the Ashton Canal. Clayton Colliery is understood to have opened in 1798, owing to its close proximity to Bradford Colliery (southeast of the Site) these were merged around the 1870s. Coal was worked by deep mining from Bradford Colliery in the Roger, Crombouke, Parker and Four-foot seams from these deep shafts. These deep workings are present beneath the Site.

In 1948, Bradford Colliery became the first pit in Britain to adopt 'longwall' mining techniques. However, there were many reports of subsidence in the overlying and surrounding areas including the tilting of the gas holder north of the Canal. Consequently, the National Coal Board decided they had to close Bradford Colliery down in 1968.

2.4.2 Mine shafts

There are a number of mine shafts located in the surrounding areas, although none specifically identified on Site. This said, unrecorded mine shafts cannot be discounted.

The nearest shafts located in the vicinity of the site are about 25m north of the Site boundary, the closest referred to as Shaft F, was 2.4m in diameter. The Coal Authority record states that this shaft was pressure grouted to a depth of 40m with 25.5tonnes of grout by contractors on behalf of Amec Capitol Projects Ltd. The shaft was grouted as part of Metrolink Advance Works Contract. Grout injected under pressure until constant pressure was maintained indicating limit of grout take, process repeated until casing was at 20m and grout at the surface. Total grout take was 23 tonnes. No cap constructed.

Four shafts were sunk at Bradford Colliery over the years, the Colliery is located some 200m southeast of the Site. The two earliest were Forge Pit and Little Pit, the latter being an air shaft to ventilate the workings. The first modern shaft was Deep Pit (No. 1) [later referred to as Shaft U by Arup and Buckingham], this was sunk in 1854 and had a diameter of 18 feet (5.5m). The second modern shaft was the Parker Shaft (No. 2) [later referred to as Shaft T by Arup and Buckingham], which was sunk in 1902. See Coal Mining Risk Assessment [7] for more detail.

3 Previous investigations and assessments

This section provides a brief summary of relevant information from two earlier reports issued by Buro Happold. For more information the original reports should be referred to. An assessment of the data is then presented in the subsequent sections.

3.1 Buro Happold desk study

The desk study [6] identified the site history and geology (summarised in Section 2) and provided a preliminary conceptual site model following the “source-pathway-receptor” approach in accordance with Land Contamination Risk Management [10].

The desk study considered the risk from coal measures, specifically unknown coal mining entrances (shafts / adits) located within the Site creating preferential pathways for ground gas. The preliminary conceptual site model concluded that although the consequence to future site users or construction workers was severe, the probability was unlikely resulting in a moderate to low risk.

The desk study recommended that a site investigation should be undertaken to understand the ground gas regime of the site.

3.2 Buro Happold Generic Quantitative Risk Assessment (GQRA)

The GQRA [1] reported on the ground investigation undertaken in 2022 and 2023. The scope of the ground investigation was designed to meet the aims and objectives set out in the Desk Study. The investigation was designed and supervised (part-time) by Buro Happold with contractor services provided by Geotechnical Engineering Limited (GEL). The ground investigation scope, relating to understanding the gas regime was:

- 8 No. boreholes to depths between 45m and 65m bgl, constructed by cable percussion with rotary follow on;
- 3 No. windowless sample holes through the Made Ground (initially trial pits but owing to Site constraints altered to windowless sample holes);
- 5 No. machine excavated trial pits to depths between 3m and 4m bgl, through the Made Ground;
- Standpipe installations within all borehole and window sample locations;
- Geoenvironmental laboratory testing; and
- Ground gas monitoring (it was proposed that a six-round post fieldwork monitoring programme be undertaken however only five visits were undertaken between the 3rd and 30th January 2023 in a total of 9 locations).
- Ground gas sampling

The ground conditions encountered during the investigation were broadly as predicted in the desk study (Section 2.2), comprising Made Ground overlying Glacial Till (predominantly a clay). The Coal Measures were present below the Glacial Till from about 15m below ground level (bgl) or +45.7m Ordnance Datum (OD).

No evidence of widespread and/ or gross contamination was encountered during the ground investigation. However, "hydrocarbon odours" were recorded in some locations at relatively shallow depth, specifically BH22/01, BH22/07, CPT22/01 and CPT22/04. The maximum depth of these odours was noted in BH22/01 at 4.1m bgl, although most were typically <2m bgl.

The geochemical samples, taken predominantly from the Made Ground, identified a maximum concentration of 5.4% soil organic matter (average 2.2%) with low concentrations of other mobile or degradable hydrocarbons, with many short chain organic determinands below the laboratory limits of detection. The main contaminant noted within the soil samples was various PAHs (although these were still below commercial screening thresholds). The PAH ratios indicated that these were typical of a combustion product or coal.

Up to five rounds of gas monitoring were undertaken at the Site between the 3rd and 30th January 2023. Monitoring was undertaken on a total of 9 locations, which all contained unsaturated / partially unsaturated response zones. The installations capable of providing reliable ground gas monitoring data are summarised below (Table 3-1).

Table 3-1 Ground gas monitoring data

Borehole	No. Readings	Response zone	Depth to water	Response Zone flooded?	Strata	Max flow rate l/hr*	Peak methane %*	Peak carbon dioxide %*	Min oxygen %*	Peak carbon monoxide	Peak hydrogen sulphide	VOC readings ppm
BH22/01	5	1-4	2-2.4	Partially	Made Ground	-0.4	<0.05	<0.05	11.8 [20.1, 20.0, 20.1, 19.9]	0.2	<0.05	1.2 [1, 0.6, <0.05]
BH22/02	5	1-3	DRY	No, dry		<0.05	<0.05	<0.05	19.7	<0.05	<0.05	5.7 [5.4, 4.9, 5.7, <0.05]
BH22/03	5	1-3	1.9-2.1	Partially		<0.05	<0.05	0.6	6.8 [19.8, 20.0, 19.8, 19.3]	<0.05	<0.05	6.5 [4.5, 4.5, 4.3, 0.5]
BH22/04	5	1-5	0.7-2.0	Mostly		0.4	<0.05	<0.05	19.9	<0.05	<0.05	9.9 [0.3, 0.4, 0.2, <0.05]
BH22/05	5	1-3	DRY	No, dry		<0.05	<0.05	2.7 [<0.05, <0.05, <0.05, <0.05]	10.4 [20.2, 20.2, 19.7, 20.1]	<0.05	<0.05	7.8 [7.5, 5.6, 2.9, 2.9]
BH22/06A	5	1-4	2.1-2.3	Partially		<0.05	<0.05	<0.05	11.1 [19.8, 19.8, 19.9, 19.9]	<0.05	<0.05	14 [11.9, 11.5, 9.3, 0.6]
BH22/07	5	1-4	1.9-2.3	Partially		<0.05	<0.05	<0.05	13.2 [19.9, 20.0, 19.9, 20.1]	<0.05	<0.05	34.3 [28.5, 28, 24.1, 0.2]
BH22/08	5	1-8	1.8-3.3	Partially to mostly		0.1	<0.05	<0.05	8.3 [19.9, 20.0, 20.0, 20.4]	<0.05	<0.05	3.6 [2.9, 2, 2.3, 0.2, 0.5]
(WS) TP22/01	5	1-2.6	DRY	No, dry		0.1	0.2	0.4	7.7 [19.9, 20.2, 19.9, 17.9]	<0.05	<0.05	15.4 [0.8, 0.2, 0.7, <0.05]
Worst case example	-	-	-	-	-	0.4	0.2	2.7	6.8	0.2	0.05	34.3

*Where 0.0%, 0.0l/hr or 0.0ppm recorded within results, limit of detection used (0.05%, 0.05l/hr or 0.05ppm) as worst case scenario

Atmospheric pressures were recorded by the field instrument and weather data obtained from the meteorological office. The maximum atmospheric pressure recorded on the days of monitoring was 1035mb and the minimum was 979mb. The results indicate the following:

Return visit 1	3 rd January 2023: 1018-1008-1000mb (falling)
Return visit 2	9 th January 2023: 989-1003-1008mb (rising)
Return visit 3	17 th January 2023: 987-979-981mb (steady)
Return visit 4	23 rd – 24 th January 2023: 1033-1038-1033mb (rising then falling)
Return visit 5	30 th January 2023: 1025-1019-1025mb (falling then rising)

In addition to the gas monitoring, three ground gas samples were obtained (BH22/05, BH22/06A and BH22/07) on 23rd January 2023. The majority of all determinands tested were below the limit of detection. Between the three samples the concentrations of carbon dioxide ranged between 44000ppm (4.4%) and 710ppm (0.07%). Methane concentrations ranged between 4400ppm (0.4%) and 43ppm (0.004%). Oxygen concentrations ranged between 6% and 9.7%. For carbon dioxide and methane the readings were below the guideline thresholds of 5% and 1% respectively. However depleted concentrations of oxygen were consistently below the guideline threshold of 16%. Very small concentrations of propane and ethane were recorded within one sample (7.5ppm and 13ppm respectively).

The sample results were broadly representative of the monitoring undertaken on the same day, for example the maximum concentration of 4.4% recorded in the sample corresponded to BH22/5 which recorded 2.2% v/v of methane.

4 Ground gas and mining gas risk assessment

4.1 Introduction and methodology

4.1.1 Standards and guidance

The design of the investigation was broadly in accordance with BS8576 [11] and the ground gas risk assessment is based on the approach outlined in BS8485 [3] and supplementary assessment as outlined in NHBC guidance [4] and the CL:AIRE guidance for the risk assessment for coal mine gas emissions [5]. All of these Standards and good practice guidance reports require a phased approach including, a preliminary investigation (desk study), the development of a conceptual site model, ground investigation (including gas monitoring) and the subsequent refining of the conceptual site model and assessment of risk.

4.1.2 Site conditions

The site is located over Coal Measures strata, overlain by some 15m of Glacial Till. The initial conceptual site model and preliminary risk assessment presented in the Desk Study identified a low to moderate risk associated with the Site's hazardous ground gas regime.

Previous investigations were reviewed as part of the Desk Study, with the most relevant being a 2014 assessment by ESG. ESG reported six rounds of ground gas monitoring undertaken on seven installations within dynamic sample holes across the stadium development. In these locations, carbon dioxide and methane were recorded below the limits of detection (<0.1% v/v) with flow rates also typically below the limits of detection (<0.1l/hr). The ESG report concluded that Characteristic Situation 1 would be suitable for any new stand extensions.

The ground investigation identified a Soil Organic Matter of up to 5.4% (although an average of 2.2%), which is equivalent to 3.1% maximum Total Organic Carbon (average 1.3%).

In accordance with BS8576 gas monitoring up should be completed for up to two months with up to weekly visits (e.g. up to 8 or 9 visits undertaken). During the 2023 monitoring data was reviewed after each visit, it was apparent that the gas concentrations and flow rates were consistent with themselves (low variation), the geological model (low organic matter Made Ground overlying cohesive Glacial Till) and the previous data (concentrations below detection limits) and therefore five monitoring visits were deemed sufficient to characterise the gas regime.

4.2 Ground gas assessment criteria

Ground gas data obtained from the Site were used to assess the risks to the Site with reference to BS8485 [3], CIRIA report C665 [2] and the National Housing Building Council (NHBC) guidance [4]. Accordingly, consideration was given to both methane (CH₄) and carbon dioxide (CO₂) concentrations as well as flow rates. The borehole hazardous gas flow rate (Q_{hg}) was calculated (as the product of gas concentration multiplied by flow rate) for each monitoring location at each monitoring event.

BS8485 states that if the data set is considered comprehensive and representative and consistent with the conceptual site model, the site characteristic Gas Screening Value (GSV) will be the maximum Q_{hg}. If the data set is temporally or spatially limited, a plausible worst-case condition should be determined (based upon maximum concentration and maximum flow rate from relevant monitoring wells) and this worst case Q_{hg} will be adopted to determine the site characteristic GSV. [Note – BS8485 advises that this worst-case scenario should be adopted only if it is prudent and reasonable to do so and that it would not result in unnecessarily conservative assessment and recommendations]. The

site characteristic GSV for both methane and carbon dioxide is then used to determine the characteristic gas situation (CS). Further consideration of the appropriateness of this Characteristic Situation is then given by reference to additional factors (e.g. recorded maximum concentrations and flow rates). Once this check is complete, the Characteristic Situation (and hazard potential) is confirmed, in turn enabling the identification of the need for and scope of gas protection measures.

The NHBC guidance [4], although mainly for residential developments, is predominantly based on BS8485 to determine a Characteristic Situation, however it also refers to using ternary plots with zones on the plots indicating potential gas sources and risks. The CLaire guidance provides particular advice regarding the assessment of potential risks associated with coal mine gasses

4.3 Ground gas results

The results (presented in Table 3-1) summarise the 45 readings taken as part of the post fieldwork monitoring programme. A description of these data is provided below.

There were no elevated concentrations of methane above the guideline threshold of 1%. All boreholes on all occasions recorded concentrations of methane below the limit of detection (<0.05%) with the exception of one location on one occasion whereby a concentration of 0.2% was recorded.

Elevated concentrations of carbon dioxide above the guideline threshold of 5% were not recorded in any installations on any occasion. The maximum concentration (2.7%) was recorded within one location on one occasion all other readings within this location were recorded as below the limit of detection. The majority of all readings (93% of the dataset) recorded concentrations of carbon dioxide below the limit of detection.

Depleted concentration of oxygen, below 16%, were generally not recorded (84% of the dataset included concentrations above the 16% guideline threshold). Within seven installations, on one occasion, depleted concentrations were recorded. The minimum concentration was recorded as 6.8%.

Concentrations of carbon monoxide were recorded below the limit of detection (<0.05ppm) within all installations on all occasions with the exception of one borehole whereby a concentration of 0.2ppm was recorded on the fourth return visit. Concentrations of hydrogen sulphide were recorded below the limit of detection (<0.05ppm) on all occasions within all boreholes.

VOC readings (using photo-ionizing detector) were taken during the monitoring rounds. Readings were not elevated (generally recorded as <10ppm) although BH22/07 recorded concentrations >20ppm on four occasions with a maximum recorded concentration of 34.3ppm. This likely reflects the hydrocarbon odours encountered within this location (see Section 3.2).

The data is consistent with the previous investigation undertaken by EPH in 2014 and is also consistent with the geology (Made Ground overlying Glacial Till, with Coal Measures present from 15m bgl).

4.4 Assessment of ground gas regime

In accordance with all of this guidance, the reliability of the site data summarised above, and thus characterisation of the ground gas regime is influenced by several factors described below.

- The main source of ground gas that can impact the proposed development relates to the Made Ground (both its thickness and nature)

- The substantial thickness (15m) of low permeability Glacial Till above the Coal Measures which will inhibit / prevent the upward migration of any mine gas
- No mine shafts have been identified on site which could provide preferential migration pathways (including prior to the ground investigation, during the investigation or during the subsequent works). Although there are records of mine shafts in the surrounding area, these are well documented and have been grouted.
- There is a sufficient set of monitoring data from the recent ground investigation to enable an assessment of the ground gas regime. Five return monitoring visits were carried out within all nine exploratory holes, a total of 45 readings were obtained on all determinands.
- The monitoring data is generally consistent with the nature and extent of the source (Made Ground). The Made Ground is typically about 3-5m thick, but locally up to 8m. Occasional hydrocarbon odours, coal and clinker were recorded but there is no evidence of putrescible / potentially methanogenic material.
- The monitoring data is generally consistent with the previous investigations undertaken at the Site reported in the Desk Study.
- The response zones of all installations contained a suitable length of unsaturated element with allows the ingress of ground gas from the target strata. Three of the nine wells were continuously recorded as dry. The remaining five wells contained some shallow perched water, partially flooding the wells. One well, BH22/04 recorded perched water that entirely flooded the response zone on two occasions, the remaining three occasions recorded >0.7m of unsaturated element. The majority of other wells contained at least 1m of unsaturated element on all occasions.
- The monitoring has been carried out during steady to rising and falling atmospheric pressure conditions.
- There were no elevated concentrations of methane above the guideline threshold of 1%. All boreholes on all occasions recorded concentrations of methane below the limit of detection (<0.05%) with the exception of one location on one occasion whereby a concentration of 0.2% was recorded.
- Concentrations of carbon dioxide above 5% were not recorded in any installations on any occasion. The maximum concentration (2.7%) was recorded within one location on one occasion all other readings within this location were recorded as below the limit of detection. The majority of all readings (93% of the dataset) recorded concentrations of carbon dioxide below the limit of detection.
- The recorded gas flow rates were consistently low with the majority of occasions recording a flow rate below the limit of detection (<0.05l/hr). The maximum recorded flow (0.4l/hr) was recorded in one location on one occasion, on all other occasions recording a flow of <0.05l/hr or a negative flow reading (-0.2l/hr).
- The most elevated VOC reading was 34.3ppm, located within BH22/07. The majority of readings from this well were recorded as >20ppm. This likely reflects the hydrocarbon odours encountered within this location. Slightly elevated concentrations were also recorded within BH22/06A (>10ppm).
- A total of three ground gas samples were obtained from the Site on 23rd January 2023. The majority of all determinands tested were below the limit of detection. Between the three samples the concentrations of carbon dioxide ranged between 44000ppm (4.4%) and 710ppm (0.07%). Methane concentrations ranged between 4400ppm (0.4%) and 43ppm (0.004%). Oxygen concentrations ranged between 6% and 9.7%. These were similar to the spot readings undertaken on the same day at the same locations. For carbon dioxide and methane the readings were below the guideline thresholds of 5% and 1% respectively. However depleted concentrations

of oxygen were consistently below the guideline threshold of 16%. Very small concentrations of propane and ethane were recorded within one sample (7.5ppm and 13ppm respectively).

- The borehole hazardous gas flow rate (Qhg) values for all of the individual data were consistent with Characteristic Situation 1 (CS1).

The data described above are generally considered reliable for an initial assessment of the ground gas regime having been obtained on five occasions from nine installations with appropriate response zones and under varying atmospheric conditions. The data are consistent, both with the data set itself, the observed ground conditions and previous assessments completed in 2014.

The calculated worst case gas screening value (GSV) for CO₂ and CH₄ (max. concentration x max. flow rate) have been determined as both falling within Characteristic Situation 1.

On the basis of all of the above, the hazardous ground gas regime on Site is considered to fall within Characteristic Situation 1 (CS1).

The ternary plots referenced in the NHBC guidance, indicate the results (low methane and low carbon dioxide) are representative of gas generated from oxidation of organic material in the ground and is therefore a low risk of emissions from the ground.

4.5 Comment on likelihood of mine gas impacting the proposed development

The underlying coal measures are present from about 15m bgl. These are overlain by Glacial Till which is predominantly clay. The workable coal seams are present at depths in excess of 150m bgl and there aren't any plausible pathways that connect the site to the workings.

It is noted that some mine shafts are present about 25m from the northern boundary (and further from proposed buildings), however these have been grouted up and do not present a plausible preferential migration pathway between any mine gas present at depth and the site

Following the CL:AIRE guidance for the risk assessment for coal mines [5] (specifically Figure 13.1 within the document), the site would be within a negligible to low risk zone. The geology and depth of the workings indicate a negligible risk. However, the nearby mine shaft (this is not a mine entry and it has been grouted) may increase the risk to low. As such, no mitigation is required.

This assessment is also consistent with the gas monitoring undertaken on site which has not shown any evidence of mine gas migrating into the Made Ground / to the near surface..

5 Summary and conclusion

There is a significant thickness of Made Ground that is associated with the industrial history of the Site. The Site is underlain by Coal Measure strata overlain by a substantial thickness (about 15m) of Glacial Till. The area has been subject to underground mine workings. However these are noted to be at significant depth (>150m bgl). The nearest mine shafts are located off-site (from 25m north and about 200m south) which have been grouted. The ground gas data obtained from an appropriate programme of investigation and monitoring is consistent with itself, with the geological model and with previous investigations on the site. The recorded concentrations of methane and carbon dioxide are all low, with all values being below any threshold guidelines. Similarly, the recorded gas flow rates were consistently low. The calculated Qhg values, including worst case scenarios, are representative of Characteristic Situation 1.

The ground gas regime has been assessed as Characteristic Situation 1 in accordance with BS 8485, therefore it is not considered a source of contamination and therefore there is no need or value in any more detailed assessment of risk for this source. In addition, the low concentrations of methane and carbon dioxide are representative of biological degradation of organic matter within the Made Ground soils and pose a low risk of emissions from the ground in accordance with NHBC guidance. Consideration of the potential for mine gas emissions indicates negligible to low risks associated with such a source.

The response received from the Contaminated Land Officer presented in Section 1.1 and questions over the previous report have been tabulated and are addressed below.

Table 5-1. Summary of responses to CLO

Question / comment from Contaminated Land Officer	Response
They have undertaken up to 5 rounds of monitoring in one month, none of which were during the worst case of low and falling pressure	Measurements were taken during low and falling pressure, notably on the 3 rd January during falling pressure and the 17 th January during low pressure.
Due to the history of mining in this part of Manchester there is a risk of mine gas being present and as such would class the site as at least a moderate risk.	The coal measures are located below the Glacial Till, a cohesive low permeability stratum, from about 15m below ground level. The mine workings themselves are at a much lower depth meaning there is no plausible pathway and therefore a low risk with relation to mine gas
Further monitoring is required or an additional gas risk assessment based on lines of evidence approach and using NHBC guidance including the use of ternary plots.	The monitoring to date has not shown any evidence of significant ground gas generation or mine gas. The readings are consistent with themselves (little variation), consistent with previous monitoring data, consistent with the ground model and consistent with the ground chemistry. All the data (lines of evidence) demonstrate that any gas generation relates to biological degradation of organic material in the Made Ground and the risk from gas emissions are low.

The data described within this report are considered reliable for the assessment of the ground gas regime. The conceptual model noted Glacial Till underlain by Coal Measures and previous monitoring noted the site to be representative of Characteristic Situation 1. This has been further demonstrated by the recent monitoring data in 2023. The calculated worst case gas screening value (GSV) for CO₂ and CH₄ (max. concentration x max. flow rate) have been determined as both falling within Characteristic Situation 1 and therefore no further assessment or mitigation is required. In addition, consideration of the potential for mine gas emissions indicates negligible to low risks associated with such a source.

6 References

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- [4] National House Building Council (NHBC), "Hazardous Ground Gas - an essential guide for house builders. NF94," National House Building Council, 2023.
- [5] CL:AIRE, "Good Practice for Risk Assessment for Coal Mine Gas Emissions," 2021.
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- [10] Environment Agency, "Land Contamination Risk Management (LCRM)," Environment Agency, 2021.
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