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Gas Monitoring Addendum Report

LOCATION	Proposed Residential Development, Land at Main Road, Gainford, Darlington DL2 3BQ
ISSUE DATE	November 2018
FOR	Kebbell Homes
CLIENT REF.	
OUR REF.	G18214gas

Prepared by

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Table of Contents

Contents

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1.Final Gas Monitoring Results

Six (6) gas monitoring visits to three monitoring installations at the above site were carried out by Geoinvestigate as part of the phase 2 site investigation (G18214).

The initial results of gas monitoring in the shallow boreholes at the site are presented in Table 1 below.

Table 1 Summary of Initial Gas Monitoring Data

Job Number	G18214
Client	Kebbell Homes
Site	Main Road, Gainford, Darlington DL2 3BQ

	CH_4 (%)	CO_2 (%)	O_2 (%)
Minimum	0.00	0.30	18.1
Maximum	0.00	2.40	20.40

Borehole	Number of Visits	CH_4 (%)		CO_2 (%)		O_2 (%)		Flow Rate (l/hr)	Atmospheric Pressure (mb)
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum		
BH4	6	0	0	0.3	0.7	19.8	20.4	<0.1	976
BH10		0	0	0.6	2.4	18.1	20	<0.1- 0.9	to
BH14		0	0	0.7	1.8	19.4	20.1	<0.1- 0.6	1021

The results of gas levels recorded at the site at pressures of between 976mb and 1021mb returned levels of O_2 between 18.1% and 20.4%, with a CO_2 content between 0.30% and 2.40% and CH_4 content recorded below detectable levels (%). Gas flow rates were generally below detectable limits (<0.01lt/hr) on each monitoring occasion with the exception of a single occasion where flow was recorded in BH10 and BH14.

On the basis of the of the above gas results, the sections below will review the potential risk to site and ground conditions encountered. This information will be utilised with CL:AIRE Research Bulletin 17 to provide an comprehensive overview of the gas risk and associated classification for the site.

2.Review of sources and ground conditions encountered.

2.1 Review of sources

It was considered that the most likely source of hazardous gas to the site would be as a result of the development and demolition of the main buildings at the north of the site, residential development, nearby sewage works and ground workings on site.

The extract of the 1:50,000 Solid & Drift geological map (BGS Sheet 32 – Barnard Castle) indicates the site to be underlain by superficial deposits of River Terrace Deposits (gravel, sand and silt) with a bedrock geology of Stainmore Formation (mudstone, siltstone and sandstone).

BGS borehole record on site shows below 0.60m of topsoil is clayey, sandy gravel to 5.00m then coarse sand with occasional gravel to 7.50m. This is underlain by sandy silt to 11.00m followed by gravel to 13.80m then coarse sand to termination at 15.00m.

The area is considered within a coal mining reporting area but not in a high risk development area. The site is not within close proximity (100m) to landfills or other gas generating industry. No peat or alluvium soils are considered to underlie the site.

2.2 Review of ground conditions encountered

<u>Made ground</u>

Generally, the made ground at the site showed no obvious evidence of potential contamination or contaminative materials and mostly comprised sandstone and brick gravel with occasional concrete, pot, dolomitic limestone etc. However, the fill material in several locations was noted to contain ash and

occasionally slag, wood, asphalt, metal and plastic fragments; soils containing ash and/or slag were deemed to be the most likely materials to contain elevated levels of potential contaminants and representative samples were duly recovered and submitted for laboratory analysis (specifically BH6 and TPE). Other more general made ground, inferred to mostly comprise demolition rubble, was assumed to have some risk of non-visible asbestos contamination as well as other more general potential contaminants but this risk was thought to be lower due to a lack of visual/olfactory evidence of potential contamination.

It has been assumed that the raised areas of the site will subsequently be removed from site prior to its future residential development to create a relatively level development site. As such, the remainder of this report will assume that this mass of made ground will be removed prior to development and the future ground level is hitherto assumed to be that of the surrounding ground levels.

<u>Natural Underlying Strata</u>

Competent generally sandy gravel soils have been encountered across the site at relatively shallow depth or directly below the made ground (where present) with the exception of BH6 where slightly less competent ground exists to 2.60m BGL. In the southeast of the site (BH10-BH15) these deposits are noted to have a clay content at shallow depth (generally up to ca. 1m-2m).

3.CL:AIRE Research Bulletin 17

A research bulletin posted by Contaminated Land – Applications in Real Environments (CL:AIRE) has reviewed and presented potential scope for sites that can be considered low risk and therefore require no to limited gas testing.

It considers that many sites, including sites in Radon risk areas, are likely to have Radon measures or air tight construction has led to measures that are likely to provide good measures against ground gas ingress. This is specific to sites that may have no sources, assumptions can be made about protection measures or small volumes of ground gas present in soil pores.

Assumptions are made for sites that have less need for monitoring include sites with high carbonate natural soils, organic soils with potential methane content that may be slow to be released (eg peat and alluvium), made ground with low organic content, and mine workings flooded or abandoned in the early 20th century.

The report does make mention that made ground values exceeding 6% Total Organic Carbon and sites where shallow mine workings exist at the surface or where the site is within 20m of a shaft or adit would need monitoring. The bulletin provides the table to indicate requirements for gas testing based on common scenarios. The scenario most likely to fit with the current site is highlighted:

Table A1: Application of approach to common scenarios

Scenario and source of ground gas	Gas monitoring	Gas protection
Natural soils with no Made Ground eg London Clay, Mercia Mudstone, Lias Clay, Chalk, Gault Clay or Glacial Till.	✗	✗
Natural soils with no Made Ground. In an area where radon protection is required.	✗	✓ Gas/radon measures required
Natural soils with low organic content. Less than 1m of Made ground that comprises general infill and car park construction materials eg Made ground over London Clay, Mercia Mudstone, Lias, Clay, Chalk, Gault Clay or Glacial Till.	✗	✗
Natural soils with high organic content. Less than 1m of Made ground that comprises general infill and car park construction materials eg Alluvium, Peat over natural soils such as London Clay, Mercia Mudstone, Lias, Clay, Chalk, Gault Clay or Glacial Till.	✗	✓ CS3 Gas measures required
Natural Soils with low organic content and 1m to 5m of Made Ground (average <3m) that compromises general infill and car park construction materials. TOC is less than 6% eg Made Ground over London Clay, Mercia Mudstone, Lias Clay, Chalk , Gault Clay or Glacial Till.	✗	? Determine gas protection using TOC of Made Ground and Table 2
Old landfill with 6m of older refuse material. Identified as old on historical maps.	✓ Determine TOC content and use gas generation modelling to assist with the interpretation of results	? To be determined from gas monitoring data
Old Mine workings that were abandoned before the early 20th century.	? To be determined based on preliminary conceptual model using desk study data	?
Glacial drift deposits over Coal Measures strata with no former mine workings.	✗	✗

4. Gas Risk Conclusions

Small amounts of positive flow (flow out from the borehole) were measured at boreholes BH10 and BH14 on the second monitoring visit. The reason for this is unclear but on occasion wind can affect the sensitive monitoring equipment and this may have been the case in this instance. No obvious cause for gas flow can be identified from the ground conditions at these boreholes (or generally throughout the site) and it may be that this phenomenon is not observed again during the continuing gas monitoring exercise. The subsequent monitoring visits will confirm or deny this possibility but for now it will be assumed for the sake of prudency that this is the constant condition at this part of the site. Gas flow rates were otherwise consistently <0.1 l/hr and below detectable limits.

Given there was no likelihood of highly organic soils at site, gas generating industry, and landfills, it is likely that there is a reduced potential risk from hazardous gas to exist at site. It was considered that if hazardous gas could potentially be generated from made ground located at site to depths upto 3.80m. It was also concluded that this made ground may be removed in order to make the site level prior to its development. It is therefore likely that if this material was to be removed, the gas risk as site would be further reduced.

Subsequently six (6) gas monitoring visits were carried out as site and based on this gas data and information as provided by CL:AIRE, the site could be classed as "Characteristic Situation 1" of the Modified Wilson and Card classification or "Green" of the NHBC Traffic Light System for low rise housing with a ventilated under-floor void (min 150mm) (CIRIA C665.)

Consequently, on the basis of these results, NO gas measures according to the above classifications should be incorporated into the construction of the new buildings at the site. Please see illustrative tables/descriptions of common measures below for classification and associated measures for the above characterisation schemes. Please note that these tables are illustrative and further information can be found in BRE 414 and BS8485:2015.

5. Gas Risk considerations

New guidance as provided by BS8485: 2015 has indicated a new system of design and implementation of gas measures suitable for a site. The new guidance works to highlight a risk to site through both the sensitivity of the receptors and risk associated with potential sources of hazardous ground gas. In this instance, it is likely considered that the site would be considered as a Type A as shown in table 3 below.

Table 2: Building types for site classification as per BS 8485:2015

	High Risk		Medium Risk	Low Risk
	Type A Building	**Type B Building**	**Type C Building**	**Type D Building**
Ownership	Private	Private or commercial/public, possible multiple	Commercial/public	Commercial/public
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full
Room sizes	Small	Small/medium	Small to large	Large industrial/retail park style

Using the classification as per buildings types above (table 2), BS8485:2015 has incorporated a scoring system dependent on type in order to select the appropriate measures for hazardous gas implementation measures. This scoring system works by selecting different measures including structural barriers, ventilation measures and gas resistant membranes which are graded separately within the points system. In order to ensure sufficient measures are in place; one measure is normally selected from each category (see tables for gas protection) and should be equal to or more then the points required as per its building type and CS value (see table 3 below).

Table 3: Gas protection scoring by CS level and building type

CS	Minimum gas protection score (points)			
	High Risk		Medium Risk	Low Risk
	Type A Building	Type B Building	Type C Building	Type D Building
CS1	0	0	0	0
CS2	3.5	3.5	2.5	1.5
CS3	4.5	4	3	2.5
CS4	6.5	5.5	4.5	3.5
CS5	-	6.5	5.5	4.5
CS6	-	-	7.5	6.5

Table A gas protection scores for ventilation protection measures

Protection element/system	Score	Comments
(a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	0.5	Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is zero.
(b) Passive sub floor dispersal layer: Very good performance: Good performance: Media used to provide the dispersal layer are: • Clear void • Polystyrene void former blanket • Geocomposite void former blanket • No-fines gravel layer with gas drains • No-fines gravel layer	 2.5 1.5	Performance criteria for methane and carbon dioxide are shown in Figure B.6 and Figure B.7, respectively. The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B. Passive ventilation should be designed to meet at least "good performance", see Annex B
(c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance", as described in Annex B.
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to *Buildings Regulations 2000, Approved Document F* [9].

Table B gas protection scores for the structural barrier

Floor and substructure design (see Annex A)	Score
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations 1 or 1.5	1 or 1.5
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing C)	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing C)	2.5
A) The scores are conditional on breaches of floor slabs, etc., being effectively sealed. B) To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see **A.2.2.2**). C) The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product (see **C.3**, Note 4).	

Table C gas protection score for the gas resistant membrane

Protection element/system	Score	Comments
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and verified in accordance with CIRIA C735 [N1]	2	The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. For example, a minimum 0.4 mm thickness (equivalent to 370 g/m2 for polyethelene) reinforced membrane (virgin polymer) meets the performance criteria in Table 7 (see **C.3**). If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.

Table D: Gas protection measures for low-rise housing development based upon NHBC Traffic Light system

Traffic Light Classification	Protection measures required
Green	Negligible gas regime identified and gas protection measures are not considered necessary.
Amber 1	Low to intermediate gas regime identified, which requires low – level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be prescribed as per BRE Report 414. Ventilation of sub – floor void should facilitate a minimum of one complete volume change per 24 hours.
Amber 2	Intermediate to high gas regime identified, which requires high – level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be prescribed as per BRE Report 414. Gas membranes should always be fitted by a specialist contractor. As with Amber 1, Ventilation of sub – floor void should facilitate a minimum of one complete volume change per 24 hours. Certification that these measures have been installed correctly should be provided.
Red	High gas regime identified. It is considered that standard residential housing would not be normally acceptable without a further gas irsk assessment and/or possible remedial mitigation measures to reduce and/or remove the source of gas.

*Table is for illustration only; please see BRE 414 for more information on designing appropriate measures. (BRE 414 - Protective measures for housing on gas-contaminated land)

END OF REPORT

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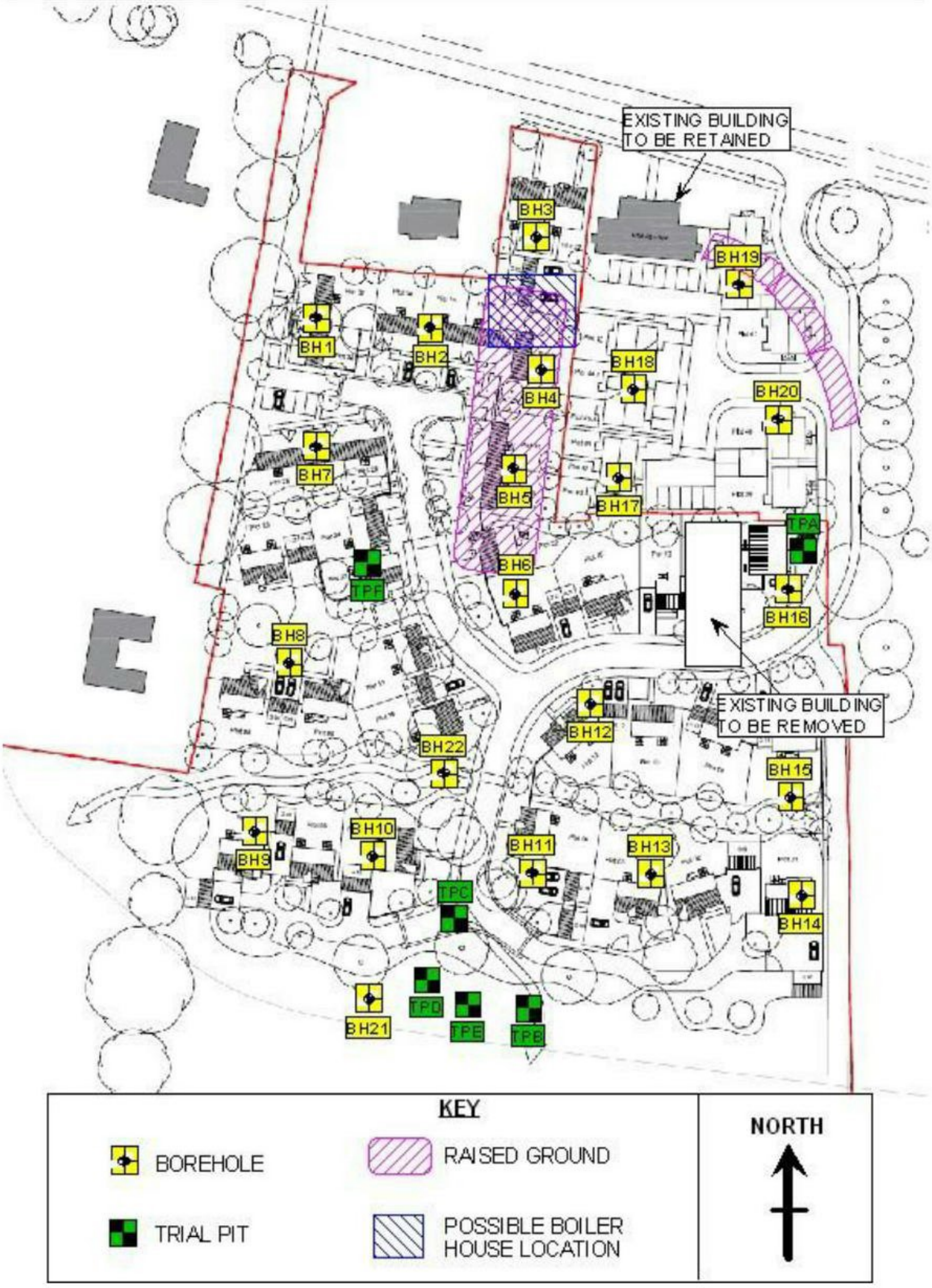
APPENDIX 1

SITE PLAN

OUR REF: G18214b	YOUR REF:	SITE PLAN (NOT TO SCALE)
DATE: July 2018	LOCATION: Proposed Dvelopment, Main Road, Gainford, Darlington, DL2 3BQ	



APPENDIX 2

COMPLETE GAS MONITORING RESULTS

Job Number	G18214
Client	Kebbell Homes
Site	Main Road, Gainford, Darlington DL2 3BQ
Instrument	GFM 406 + 410

Key	
WL	Water logged
BDL	Below detectable levels
NB	No Bung
WD/I	Well destroyed/inaccessible

Monitoring personal	MB	Date	15/11/2018	Weather	Cloudy		Temperature	13		Starting pressure	991	
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	990	0	0	0.7	19.8				0	0	0
BH10	<0.1	990	0	0	2	19.4				0	0	0
BH14	<0.1	991	0	0	0.9	20				0	0	0

Monitoring personal	MB	Date	07/11/2018	Weather	Rain		Temperature	12		Starting pressure	976	
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	975	0	0	0.4	20				0	0	0
BH10	<0.1	976	0	0	0.6	20				0	0	0
BH14	<0.1	976	0	0	1.8	19.7				0	0	0

Monitoring personal	MB	Date	26/10/2018	Weather	Sunny		Temperature	8		Starting pressure	1000	
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	1000	0	0	0.4	20.2				0	0	0
BH10	<0.1	999	0	0	2.1	19.3				0	0	0
BH14	<0.1	999	0	0	1.3	19.9				0	0	0

Monitoring personal	MB	Date	25/09/2018	Weather	Cloudy		Temperature		14	Starting pressure		1021
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	1020	0	0	0.3	20.4				0	0	0
BH10	<0.1	1020	0	0	2.1	19.1				0	0	0
BH14	<0.1	1021	0	0	0.7	20.1				0	0	0

Monitoring personal	MB	Date	22/08/2018	Weather	Overcast		Temperature		14	Starting pressure		1000
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	1000	0	0	0.5	20.2				0	0	0
BH10	<0.1	1000	0	0	2.4	18.1				0	0	0
BH14	<0.1	999	0	0	1.5	19.4				0	0	0

Monitoring personal	MB	Date	11/07/2018	Weather	Sunny		Temperature		19	Starting pressure		1003
Monitoring point	Flow range (l/hr)	Atmospheric pressure	Methane % (v/v)	Methane % LEL	Carbon dioxide % (v/v)	Oxygen % (v/v)	Water level (mbgl)	Depth of well (m)	Volume of gas in well (m3)	Differential Pressure (pa)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)
BH4	<0.1	1003	0	0	0.4	20.2				0	0	0
BH10	0.9	1003	0	0	2.1	18.9				4	0	0
BH14	0.6	1001	0	0	1.5	19.8				1	0	0