

Michael Lucas
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11A West Street
Reigate
RH2 9BL

Our Ref: P9864J1122/ps
21 December 2017

Dear Michael,

1 – 3 CASTLE CRESCENT, READING, RG1 6AQ - GAS MONITORING RISK ASSESSMENT

Background

Jomas Associates have previously undertaken a Geo- Environmental Assessment (Ground Investigation) Report (Ref: P9864J1122 rev. Final 2.0 dated 22nd September 2017) for the above site. This report reviews a Desk Study report has been produced for the site and issued separately (Listers Geotechnical Consultants, August 2015).

The desk study identifies the “ground gases from unrecorded landfilling of nearby chalk pits” as a potential source of hazardous ground gases.

The ground investigation was undertaken on 21st July 2017 and comprised of 6No window sample boreholes with combined gas and groundwater monitoring wells installed in 3No of them.

The ground conditions on site were found to comprise brown sandy gravelly clay with brick and concrete (Made Ground) to a maximum depth of 1.20mbgl, overlying medium dense to dense orange and brown sandy fine to coarse flint gravel to terminal depth in WS2-WS6, and to a maximum depth of 2.80mbgl in WS1, overlying orange and yellow mottled silty clay to the base of the borehole at 3.50mbgl. It is known that underlying the clay are chalk deposits.

The chalk deposits are known to have been historically mined and subsequently treated / remediated by grouting.

Proposed Development

It is understood that the existing central building is to be redeveloped, to provide residential apartments. The outbuildings are to be demolished and 8No residential dwellings along the eastern boundary of the site are to be constructed.

In the assessment of risks posed by hazardous ground gases and selection of appropriate mitigation measures, BS8485 (2015) identifies four types of development, termed Type A to Type D. Type A has been adopted as the relevant category for the proposed development as Type A buildings are defined as:

“private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.”

Gas Monitoring

Following the ground investigation four return monitoring visits were undertaken from 1st August 2017 to 25th August 2017, with a fifth visit undertaken on 14th December 2017 to monitor wells installed within boreholes at the site for soil gas concentrations and groundwater levels. During these visit atmospheric pressures varied between 984mb and 1018mb, and barometric pressures trends were steady and falling.

The results of the monitoring undertaken are summarised in the table below, with the full monitoring records appended to this letter.

Table 1: Summary of Gas Monitoring Data

Hole No.	CH ₄ (%)	CO ₂ (%)	O ₂ (%)	H ₂ S (ppm)	VOCs (ppm)	Peak Flow Rate (l/hr)	Depth to water (m bgl)	Depth of installation (m bgl)
WS1	0.0-0.1	5.4-5.6	13.8-14.4	0	24	+0.1- +0.5	2.69-2.73	3.03
WS4	0.0-0.1	5.0-8.0	11.9-15.7	0	11	+0.2- +0.4	DRY	1.24
WS6	0.0-0.1	3.9-8.1	13.0-15.7	0	9	+0.2- +0.4	DRY	1.36

Screening of Results

As shown in Table 1, methane has been reported to a maximum concentration of 0.1%. Carbon dioxide has been reported to a maximum concentration of 8.1% v/v. Volatile organic compounds (VOCs) were detected at a maximum concentration of 24ppm by means of a photo-ionisation detector. The maximum flow rate detected was +0.5 l/hr.

Gas Assessment

The soil gas assessment method is based on that proposed by Wilson & Card (1999), which was a development of a method proposed in CIRIA publication R149 (CIRIA, 1995). The method uses both gas concentrations and borehole flow rates to define a characteristic situation based on the limiting borehole gas volume flow for methane and carbon dioxide. In both these methods, the limiting borehole gas volume flow is renamed as the Gas Screening Value (GSV).

The Gas Screening Value (litres of gas per hour) is calculated by using the following equation

$$\text{GSV} = (\text{Concentration}/100) \times \text{Flow rate}$$

Where concentration is measured in percent (%) and flow rate is measured in litres per hour (l/hr).

The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

To accord with C665, worst case conditions are used in the calculation of GSVs for the site.

A worst case flow rate of 0.5l/hr (maximum reported) will be used in the calculation of GSVs for the site. The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

To accord with C665, worst case conditions are used in the calculation of GSVs for the site. These have been summarised in the table below

Summary of Gas Monitoring Data

Gas	Concentration (v/v %)	Peak Flow Rate (l/hr)	GSV (l/hr)	Characteristic Situation (after CIRIA C665)
CO ₂	8.1	+0.5	0.0405	1
CH ₄	0.1	+0.5	0.0005	1

The methodology set out in BS 8485 (2015) has been used for determining the required gas protection measures.

In accordance with BS8485, although the site can be considered CS1 in terms of the GSV, the concentrations of carbon dioxide recorded (>5%) mean that consideration must be given to increasing this to CS2.

As part of this assessment reference was made to guidance published within CL:AIRE RB17 (2012). It is stated within this document that carbon dioxide production by natural soils such as chalk (present at depth beneath this site) can often be recorded up to 15%, but this does not pose a risk to development. It also states (Table A1, Appendix A) that where natural soils are the source of gas (including chalk) that no gas protection is required.

It was considered that due to the ground profile identified on site comprising clay based Made Ground, overlying granular material, that ground gas from the diffuse chalk source would preferentially enter the monitoring well from the granular material as a “path of least resistance”, concentrating the ground gas within the well and resulting in artificially elevated carbon dioxide levels when monitoring.

The desk study undertaken by Listers identified potential sources of ground gas comprising:

- Potential for deep Made Ground associate with historical chalk mining on site
- Migrating ground gases from unrecorded landfilling of nearby chalk pits

It is noted that a significant thickness of made ground at surface was not encountered during the site investigations by Jomas, and therefore such a source is not considered to be present.

The Listers desk study also records that former chalk mines in the vicinity of the site have been remediated by grouting, which would significantly restrict the potential for gas generation.

Given the above assessments, it is therefore considered that on the basis of the Site Conceptual Model, there is no justification for increasing the Characteristic Situation above CS1 on the basis of the carbon dioxide levels being detected above 5%.

Characteristic Situation 1 sites require no formal gas protection measures.

Gas Calculations

In accordance with CIRIA C665 gas calculations have been undertaken.

The porosity of the soils is used to calculate the potential amount of Carbon Dioxide present beneath the site. This has been taken at 30%, this is in the middle of the normally accepted range for granular

materials (20% to 40%) but is likely to be on high side as the materials are noted to be “dense” and “very dense”. It will therefore give a conservative approach.

The highest recorded carbon dioxide concentration during the gas monitoring period is 8.1% and the highest atmospheric pressure is 1018mb. The model assumes a lowest atmospheric pressure of 1000mb. Consequently, a worst case pressure drop of 18mb over a three hour period has been adopted.

To carry out the calculations, a footprint to the building is normally used. However given the size and shape of the structure, the fact that gas will migrate along the path of least resistance and the fact that granular materials beneath the floor slab will act as a pressure relief layer a maximum collection area of ground gas of 55m² has been used. This equates to a square whose sides are the width of the building.

The area of smallest room on the ground floor (toilet) of 2.19m² (taken from Barton Willmore drawing APT 10). This room is assumed to be significant as they tend to have reduced natural ventilation (i.e. small or no windows). It is also assumed that the ceiling is at 3m. This is again considered to be typical and represent the largest area likely to collate gas and the smallest proposed room.

The values used and calculations are summarised in the table below:

Table 2: Gas Calculation for Pressure Drop as Section A5.3.3 (CIRIA C665) Overview

Parameter	Value
Max CO ₂ (% v/v)	8.1
Depth of Unsaturated Soil	2.7
Porosity of Soils (%)	30
Gas collection area (m ²)	55
Area of Smallest Room (m ²)	2.19
Ceiling Height (m)	3
Volume of CO ₂ Below collection area (V1 m ³)	3.61
Assume Worse Case Pressure Drop (mb)	18
Volume of CO ₂ Following Pressure Drop (V2 m ³)	3.67
Volume of Gas Emitted Following Pressure Drop (V3 m ³) = V2-V1	0.06
Volume of Smallest Room (m ³)	6.57
Assuming all gas enters smallest room. Increase volume of CO ₂ in Smallest Room (m ³)	0.005
Percentage increase CO ₂ in Smallest Room (%)	0.0003

Following the pressure drop as outlined above and assuming all of the ground gas entering the structure would collect in the above described room an increase in carbon dioxide concentration

above standard atmospheric concentrations of 0.0003% is predicted. This is calculated to be the immediate increase following a worst-case pressure drop of 18mb in a 3 hour period.

This is negligible and is equivalent to an adult sitting quietly in the room for approximately 7min. It should be noted that the CO₂ risk is considered negligible even given the extreme worst case outlined above.

In addition, a calculation has been undertaken using the Penkson (1986) method. There is some debate in C665 as to the appropriateness of using 10m² to represent the area a borehole installation “drains” of gas. This method assumes that the worst-case flows detected are constant for the period of time specified within the model for which gas collection can occur within a sealed room, which Jomas have specified as three (relevant to a weekend) or 14 days (relevant to a potential holiday). The calculation above assumes the largest foot print of likely gas collection and the smallest room across all of the plots.

Table 3: Surface Emission Gas Calculation after Penkson (1986)

Parameter	Value
Assume WS Represents Area (m ²)	10
Assume Area of Gas Collection (m ²)	55
Max CO ₂ (%)	8.1
Max Flow from BH (l/hr)	0.5
Max Flow from BH (m ³ /hr)	0.0005
CO ₂ Flow From BH (m ³ /hr)	0.0000405
CO ₂ Flow Into area (m ³ /hr)	0.00023
Assume All Flow Into the Smallest Room of Volume (m ³)	6.57
Increase in CO ₂ in the smallest room if it is sealed for:	
3 Days (m ³ CO ₂)	0.016
3 Days (% CO ₂)	0.24
14 Days (m ³ CO ₂)	0.075
14 Days (% CO ₂)	1.14

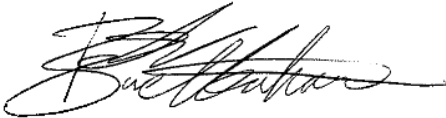
The results indicate that, under the conditions modelled, carbon dioxide concentrations could increase by 0.24% over 3 days, and 1.14% over 14 days, above standard atmospheric concentrations. Given that standard atmospheric concentrations of CO₂ are 0.037% by volume, and short and long term workplace exposure limits of CO₂ are 1.5% and 0.5% respectively, the modelled increases on CO₂ concentrations are not considered to be a cause for concern.

It should be noted that both of the above calculations assume no gas protection measures have been installed. In effect, the floor of the room being the bare ground. As floor slabs will be present within the proposed development, with a minimum of a damp proof membrane the levels calculated above will be further reduced.

Simple window and door vents would further reduce this result as the smallest room would no longer be sealed and would prevent the build up of gas within the room.

It is therefore considered that the calculations undertaken confirm that characterisation of the ground gas regime underlying the site as CS1 is appropriate.

Yours sincerely



Peter Swettenham BSc (Hons) MSc PgCert CEnv MoIES
Principal Geotechnical Engineer

Enc:

Ground Gas Monitoring Results.

GAS AND GROUNDWATER MONITORING BOREHOLE RECORD SHEET					
Site: Castle Crescent	Operative(s): JWT	Date: 01/08/17	Time: 12:00	Round: 1	Page: 1
MONITORING EQUIPMENT					
Instrument Type	Instrument Make	Serial No.	Date Last Calibrated		
Analox	GA5000		19/06/2017		
PID	Phocheck tiger		20/05/2016		
Dip Meter	GeoTech				
MONITORING CONDITIONS					
Weather Conditions: Sunny		Ground Conditions: Dry		Temperature: 19 °C	
Barometric Pressure (mbar): 1008		Barometric Pressure Trend (24hr): Steady		Ambient Concentration: 0.0%CH ₄ , 0.1%CO ₂ , 20.8%O ₂	

MONITORING RESULTS													
Monitoring Point Location	Flow		Atmospheric Pressure (mbar)	Methane %	Methane % LEL	Carbon Dioxide %	Oxygen %	VOC (ppm)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Depth to water (mbgl)	Depth to Base of well (mbgl)
	Peak	Average						Peak	Average				
WS1	+0.1	+0.1	1008	0.0	-	5.4	14.4	0	0	0	0	2.69	3.03
WS4	+0.2	+0.2	1008	0.0	-	5.6	14.5	0	0	0	0	DRY	1.24
WS6	+0.2	+0.2	1008	0.0	-	3.9	15.7	0	0	0	0	DRY	1.36

GAS AND GROUNDWATER MONITORING BOREHOLE RECORD SHEET					
Site: Castle Crescent	Operative(s): JWT	Date: 10/08/17	Time: 12:20	Round: 2	Page: 1
MONITORING EQUIPMENT					
Instrument Type	Instrument Make	Serial No.	Date Last Calibrated		
Analox	GA5000		19/06/2017		
PID	Phocheck tiger		20/05/2016		
Dip Meter	GeoTech				
MONITORING CONDITIONS					
Weather Conditions: Sunny		Ground Conditions: Dry		Temperature: 17 °C	
Barometric Pressure (mbar): 1017		Barometric Pressure Trend (24hr): Steady		Ambient Concentration: 0.0%CH ₄ , 0.1%CO ₂ , 20.8%O ₂	

MONITORING RESULTS													
Monitoring Point Location	Flow		Atmospheric Pressure (mbar)	Methane %	Methane % LEL	Carbon Dioxide %	Oxygen %	VOC (ppm)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Depth to water (mbgl)	Depth to Base of well (mbgl)
	Peak	Average						Peak	Average				
WS1	+0.3	+0.3	1018	0.0	-	5.5	14.1	0	0	0	0	2.71	3.03
WS4	+0.2	+0.2	1017	0.0	-	5.0	15.7	0	0	0	0	DRY	1.24
WS6	+0.2	+0.2	1018	0.0	-	5.9	14.1	0	0	0	0	DRY	1.36

GAS AND GROUNDWATER MONITORING BOREHOLE RECORD SHEET					
Site: Castle Crescent	Operative(s): JWT	Date: 17/08/17	Time: 11:00	Round: 3	Page: 1
MONITORING EQUIPMENT					
Instrument Type	Instrument Make	Serial No.	Date Last Calibrated		
Analox	GA5000		19/06/2017		
PID	Phocheck tiger		20/05/2016		
Dip Meter	GeoTech				
MONITORING CONDITIONS					
Weather Conditions: Intermittent sun		Ground Conditions: Dry		Temperature: 18°C	
Barometric Pressure (mbar): 1004		Barometric Pressure Trend (24hr): Steady		Ambient Concentration: 0.0%CH ₄ , 0.1%CO ₂ , 20.5%O ₂	

MONITORING RESULTS													
Monitoring Point Location	Flow		Atmospheric Pressure (mbar)	Methane %	Methane % LEL	Carbon Dioxide %	Oxygen %	VOC (ppm)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Depth to water (mbgl)	Depth to Base of well (mbgl)
	Peak	Average						Peak	Average				
WS1	+0.5	+0.5	1004	0.1	-	5.6	13.9	0	0	0	0	2.73	3.03
WS4	+0.4	+0.4	1005	0.0	-	7.6	12.7	0	0	0	0	DRY	1.24
WS6	+0.4	+0.4	1005	0.0	-	7.1	13.2	0	0	0	0	DRY	1.36

Water sample obtained from WS1.

GAS AND GROUNDWATER MONITORING BOREHOLE RECORD SHEET					
Site: Castle Crescent	Operative(s): JWT	Date: 25/08/17	Time: 11:15	Round: 4	Page: 1
MONITORING EQUIPMENT					
Instrument Type	Instrument Make	Serial No.	Date Last Calibrated		
Analox	GA5000		19/06/2017		
PID	Phocheck tiger		20/05/2016		
Dip Meter	GeoTech				
MONITORING CONDITIONS					
Weather Conditions: Sunny		Ground Conditions: Dry		Temperature: 18°C	
Barometric Pressure (mbar): 1011		Barometric Pressure Trend (24hr): Steady		Ambient Concentration: 0.1%CH ₄ , 0.1%CO ₂ , 20.9%O ₂	

MONITORING RESULTS													
Monitoring Point Location	Flow		Atmospheric Pressure (mbar)	Methane %	Methane % LEL	Carbon Dioxide %	Oxygen %	VOC (ppm)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Depth to water (mbgl)	Depth to Base of well (mbgl)
	Peak	Average						Peak	Average				
WS1	+0.1	-	1011	0.1	-	5.6	13.8	24	24	0	0	2.72	3.03
WS4	+0.3	-	1011	0.1	-	8.0	11.9	11	8	0	0	DRY	1.24
WS6	+0.4	-	1011	0.1	-	8.1	13.0	9	7	0	0	DRY	1.36

GAS AND GROUNDWATER MONITORING BOREHOLE RECORD SHEET					
Site: Castle Crescent	Operative(s): JWT	Date: 14/12/17	Time: 15:00	Round: 5	Page: 1
MONITORING EQUIPMENT					
Instrument Type	Instrument Make	Serial No.	Date Last Calibrated		
Analox	GA5000		19/06/2017		
PID	Phocheck tiger		20/05/2016		
Dip Meter	GeoTech				
MONITORING CONDITIONS					
Weather Conditions: Sunny		Ground Conditions: Dry		Temperature: 4°C	
Barometric Pressure (mbar): 984		Barometric Pressure Trend (24hr): Falling		Ambient Concentration: 0.1%CH ₄ , 0.2%CO ₂ , 21.0%O ₂	

MONITORING RESULTS													
Monitoring Point Location	Flow		Atmospheric Pressure (mbar)	Methane %	Methane % LEL	Carbon Dioxide %	Oxygen %	VOC (ppm)		Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Depth to water (mbgl)	Depth to Base of well (mbgl)
	Peak	Average						Peak	Average				
WS1*	+0.1	+0.1	984	0.1	/	0.1	21.1	1	1	0	0	Dry	2.88
WS4**	-	-	-	-	-	-	-	-	-	-	-	-	-
WS6	+0.4	+0.4	986	0.1	/	6.0	15.3	1	1	0	0	Dry	1.36

*On arrival WS1 cap was found destroyed and covered with a brick, no rubber bung/tap was leftover. Replacement tap was added prior to test.

**WS4 has been destroyed by use of bulldozer on site.