

Crayfern Homes

F.A.O. Kevin Wawman

By email only: [REDACTED]

1 August 2018

Our ref.: 16671/LR/CS/JSH

Thomas Telford House
Sun Valley Business Park
Winnall Close
Winchester SO23 0LS

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Dear Kevin,

**Re: Soil-Gas Risk Assessment at Orchard Business Park, North End Road, Yapton,
West Sussex BN18 0GA**

We are writing regarding the soil-gas monitoring that was undertaken at the above-named site.

Introduction

Soils Limited were instructed to carry out a soil-gas risk assessment following the findings presented in the conceptual site model of the Phase I Desk Study prepared by Soils Limited (report ref. 16671/DS, dated January 2018) and the Phase II Site Investigation undertaken by Soils Limited (report ref. 16671/GIR, dated February 2018). The Phase I Desk Study identified a very low to low risk of soil-gas associated with potential deposits of Made Ground onsite, former onsite activities, as well as a nursery and a farm in proximity to the site.

This letter report has been produced following six soil-gas monitoring visits to the site over a period of four months. The monitoring was undertaken to assess soil-gas risks present at the development site and to recommend suitable gas protection measures by which that risk can be mitigated, if necessary.

This letter report must be read in conjunction with the following documents:

- Soils Limited Phase I Desk Study (Report ref: 16671/DS, dated January 2018);
- Soils Limited Phase II Environmental Report (Report ref: 16671/GIR, dated February 2018).

Site Location

The site was located at Orchard Business Park, North End Road, Yapton, West Sussex BN18 0GA and had an approximate O.S Land Ranger Grid Reference of SU 979 037.

Proposed Development

At the time of reporting, the proposed development of the site was to comprise 2No. two-bed, 7No. three-bed and 1No. 4-bed terraced two-storey houses with private gardens, garages and associate car parking spaces. The development also included hard



landscaping such as access roads driveways and pavements and amenity soft landscaping.

A site location plan is presented in Figure 1.

Site Works

On 14th December 2017, four windowless sampler boreholes (WS1 – WS4) were drilled, using an Archway Competitor, to depths ranging between 3.00m (WS3) and 5.00m below ground level (bgl) (WS2 and WS4).

Dual purpose groundwater/gas monitoring wells were installed within three of the windowless sampler boreholes (WS1, WS2 and WS3), reaching to depths of up to 2.90m bgl within WS1, 4.75m bgl within WS2 and 4.80m bgl within WS3, and fitted with a gas tap.

The response zone of the wells was constructed using slotted plastic pipe from approximately 1.00m bgl depth. Plastic plain pipe was used from the end of the response zone to the ground level. The response zone was backfilled with gravel while bentonite was used for the rest of the hole to the surface. In the absence of a well installation, windowless sampler borehole WS4 was backfilled with pea shingle upon completion.

A total of six site visits were undertaken between 30th January 2018 and 30th June 2018.

A trial hole location plan has been included as Figure 2.

Site Geology

The 1:50,000 BGS Geology map showed the site to be underlain by the Lewes Nodular Chalk Formation bedrock, with overlying superficial deposits of River Terrace Deposits. It should be noted that chalk of this nature can be a natural source of carbon dioxide as it weathers or degrades.

Ground Conditions

A summary of the ground conditions encountered during the site works are presented in

Table 1.

Made Ground/Topsoil (MG/TS)
River Terrace Deposits (RTD)
Lewes Nodular Chalk Formation (LPCK)

Table I - Ground Conditions Encountered

Strata	Period	Depth Encountered (m bgl)		Typical Thickness (m)	Typical Description
		Top	Bottom		
MG/TS	Anthropocene	G.L.	0.20-1.70	0.85	MG: Turf over soft dark brown very silty CLAY to clayey gravelly SILT becoming gravelly fine to coarse SAND becoming silty sandy fine to boulder sized GRAVEL with depth. TS: Turf over dark brown gravelly sandy clayey SILT to soft dark brown silty CLAY.
RTD	Quaternary	0.20-1.70	2.00 ¹ -3.80	2.00	Firm dark orangish brown CLAY to clayey SILT to grey and red very gravelly fine to coarse SAND becoming clayey gravelly SAND to firm sandy gravelly CLAY to clayey sandy gravelly SILT with depth.
LPCK	Campanian	2.20-3.80	5.00-6.00 ¹	Not proven ²	Moderately weak, light brown weathered structureless CHALK composed of silty sub-angular to sub-rounded mainly fine and medium GRAVEL. Gravel was weak to hard low to high density, light brown. Bedding fractures medium-spaced; Matrix was light brown silty. Occasional soft spots were noted. Occasional angular flint gravel (Grade Dm to Grade Dc with depth).

Note: ¹ Final depth of trial hole. ² Base of strata not encountered

Soil-Gas Monitoring Results

A total of six soil gas monitoring visits were undertaken using an LMS Gas monitor and Tiger LT PID, over a period of roughly 4 months (on 30th January, 2nd February and 15th February, 6th March 26th March 2018 and 11th May 2018), as agreed with the Client, to provide a preliminary assessment of the risk posed to the site from the identified sources.

Readings of the concentrations of oxygen, methane (total and LEL), carbon dioxide, carbon monoxide, hydrogen sulphide, flow rates, atmospheric pressure and groundwater levels were taken (where possible) following installation of the wells. In addition, monitoring with a Photo-Ionisation Detector (PID) was undertaken in each well to check for the presence of volatile organic compounds (VOCs).

The results of the soil-gas monitoring are summarised and presented in Table 2.

Table 2 - Summary of Soil-Gas Conditions

Date (Baro Trend)	Trial Hole	CH ₄ (%v/v)	CO ₂ (%v/v)	O ₂ (%v/v)	H ₂ S (ppm)	CO (ppm)	LEL (%)	aP (mb)	Flow (l/h)	Dp	H ₂ O (m bgl)	VOC (ppm)
30/01/2018 (Falling)	ATM	0.0	0.0	20.5	0.0	0.0	0.0	1030	0.7	3.0	-	0.0
	WS1	0.0	8.5	8.3	0.0	0.0	0.0	1029	0.5	2.0	2.61	1.0
	WS2	0.0	2.6	11.3	0.0	0.0	0.0	1028	0.6	2.0	3.92	0.0
	WS3	0.0	1.7	15.9	0.0	0.0	0.0	1029	0.5	2.0	4.45	1.0
07/02/2018 (Falling)	ATM	0.0	0.0	20.3	0.0	0.0	0.0	1022	1.5	7.0	-	0.0
	WS1	0.0	9.5	6.0	0.0	0.0	0.0	1022	1.6	7.0	2.83	0.0
	WS2	0.0	3.1	10.1	0.0	0.0	0.0	1022	1.2	6.0	4.78	0.0
	WS3	0.0	2.0	16.2	0.0	0.0	0.0	1020	1.2	6.0	4.50	0.0
15/02/2018 (Rising)	ATM	0.0	0.0	20.8	0.0	0.0	0.0	1015	0.0	0.0	-	0.0
	WS1	0.0	12.0	2.4	0.0	0.0	0.0	1015	0.0	0.0	2.72	0.0
	WS2	0.0	3.9	5.4	0.0	0.0	0.0	1015	0.0	0.0	4.02	0.0
	WS3	0.0	2.3	14.5	0.0	0.0	0.0	1015	0.0	0.0	4.31	0.0
06/03/2018 (Rising)	ATM	0.0	0.0	20.4	0.0	0.0	0.0	989	0.0	0	-	-
	WS1	0.0	7.8	6.4	0.0	0.0	0.0	989	0.0	0	DRY	0.1
	WS2	0.0	2.3	10	0.0	0.0	0.0	989	0.0	0	4.22	0.3
	WS3	0.0	2.3	15.7	0.0	0.0	0.0	989	0.0	0	DRY	0.5
26/03/2018 (Rising)	ATM	0.0	0.0	20.4	0.0	0.0	0.0	1015	0.0	0.0	-	0.0
	WS1	0.0	13.0	1.7	0.0	2.0	0.0	1015	0.0	0.0	2.73	0.0
	WS2	0.0	3.9	4.3	0.0	0.0	0.0	1015	0.0	0.0	4.26	0.0
	WS3	0.0	2.1	12.4	0.0	0.0	0.0	1015	0.0	0.0	DRY	0.0
11/05/2018 (Rising)	ATM	0.0	0.0	20.1	0.0	0.0	0.0	1017	1.2	4.0	DRY	0.0
	WS1	0.0	1.1	18.1	0.0	0.0	0.0	1017	0.4	1.0	2.44	0.2
	WS2	0.0	1.4	14.3	0.0	0.0	0.0	1017	0.7	2.0	3.84	0.2
	WS3	0.0	0.2	19.8	0.0	0.0	0.0	1017	1.2	4.0	4.66	0.1
Minimum		0.0	0.2	0.3	0.0	0.0	0.0	989	0.0	0.0	-	0.1
Average		0.0	4.3	14.7	0.0	0.0	0.0	1018	0.7	1.77	-	0.2
Maximum		0.0	13	21.2	0.0	2.0	0.0	1030	1.6	7	-	1.0

Note: Zero reading = below the equipment detection limit. Published barometric pressure trend data were obtained for each monitoring visit (data from Tadley weather station). >>> denotes value exceeds equipment detection limit.

Methane above the detection level of the instrument (as total or LEL) was not recorded during any of the monitoring visits.

The highest concentration of carbon dioxide was recorded at 13%v/v on 26th March 2018, in WS1. Carbon dioxide was recorded consistently at elevated concentrations within WS1 between 1.1% v/v and 13% v/v. Concentrations within WS2 and WS3 ranged between 0.2% v/v and 3.9% v/v. The average concentration of carbon dioxide was 4.3%v/v across all boreholes across all monitoring visits.

The lowest concentration of oxygen was recorded at 1.7%v/v on 26th March 2018, in WS1, which corresponds with the highest carbon dioxide concentrations.

Hydrogen sulphide was not recorded above instrument detection limit.

The highest concentration of carbon monoxide was recorded at 2.0ppm on 26th March 2018, in WS1. With the exception of this isolated reading, carbon monoxide was not recorded during any other monitoring visit.

VOCs were recorded between 0.1 and 1 ppm during the monitoring.

A summary of the elevated soil-gas concentrations is presented in Table 3.

Table 3 - Summary of Elevated Soil-Gas Concentrations

Soil-Gas	Concentration Range % v/v	Maximum Concentration	Additional Notes
Methane	None	None	None are recorded during the monitoring period
Carbon Dioxide	0.2 - 13	13%v/v	Maximum value recorded on 26 th March 2018 in WSI
Carbon Monoxide	0 - 2	2.0ppm	Maximum value recorded on 20 th February 2018 in WS3
Note: A maximum flow rate of 2.2 l/hr was recorded during monitoring			

Data Quality

A review was made of the quality of the available data for the site, which can be viewed in Table 4. CIRIA 665 (2007) and BS 8485:2015 stress the need for risk assessments to be based on good quality data and give guidance as to best practice in this respect.

Table 4 - Review of Data Quality

Data Type	Current Situation	UK Practice
Geological and hydro-geological conditions	With regard to soil-gas risk assessment, the data quality from the Desk Study and logged trial holes was considered good.	CIRIA 665, Wilson and Card (2007) and BS 8485:2015 recommend that geology and hydrogeology be fully understood.
Monitoring period	The monitoring has been undertaken on a total of 6 occasions over a 4-month period. Monitoring has been undertaken over a range of weather conditions and included both falling and rising pressure trends. The data quality is considered good.	CIRIA 665 Table 5.5 recommends 6 readings and approximately 4-month monitoring period over a range of weather and pressure conditions.
Gas data sets	Borehole flow velocity has been measured on each monitoring occasion and the data quality is considered good.	Borehole flow velocity and borehole gas volume required to define characteristic gas saturation. Modified Wilson and Card, Table 8.5 of CIRIA 665 (2006)/Table 2 of BS 8485:2015.

In accordance with BS8485:2015 and CIRIA 665 (2007), the overall data quality is therefore considered good and reasonable, with no additional monitoring being recommended to further quantify the gas regime.

Quantitative Risk Assessment

Based on the documentation presented in the “BS 8485:2015, Code of practice for the characterisation and remediation from soil-gas in affected developments” the worst case hazardous gas flow rate (Q_{hg}) was calculated using Equation 1:

$$Q_{hg} = (C_{hg}/100) * q \quad \text{Equation 1}$$

Where:

C_{hg} is the measured hazardous gas concentration (in percentage volume-by-volume).

q is the flow rate in litres per hour of combined gases found by direct measurement.

The worst case Q_{hg} for carbon dioxide at this site was calculated using Equation 2.

$$Q_{hg} \text{ (l/hr)} = \text{gas concentration} * \text{borehole flow rate (l/hr)}$$

Equation 2

$$= 21.3/100 * 2.2 = 0.47 \text{ l/h}$$

As part of the overall assessment to quantify the general gas regime, the Hazardous gas flow rate (Q_{hg}) has been calculated for the highest, average, lowest and worst-case readings using Equation 1 for carbon dioxide (methane being absent at this site) using the highest associated flow rate. Where the flow rate is below the detection limit of the gas analyser, a flow rate of 0.01 l/hr (the detection limit of the analyser) has been used. The results of the calculations are presented below in Table 5 to Table 7.

Table 5: Trial Hole WS1

Gas	Range	Concentration C _{hg}	Adopted Flow (l/hr)	Q _{hg}
Carbon dioxide	Highest	13	1.6 ¹	0.208
	Average	8.6	1.6 ¹	0.13
	Lowest	1.1	1.6 ¹	0.017
	Worst Case	13	1.6 ²	0.208
Notes: ¹ The highest flow rate from within the monitoring well has been adopted. ² Worst case flow recorded across all the monitoring wells				

Table 6: Trial Hole WS2

Gas	Range	Concentration C _{hg}	Adopted Flow (l/hr)	Q _{hg}
Carbon dioxide	Highest	3.9	1.2 ¹	0.0468
	Average	2.8	1.2 ¹	0.0344
	Lowest	1.4	1.2 ¹	0.0168
	Worst Case	3.9	1.6 ²	0.0624
Notes: ¹ The highest flow rate from within the monitoring well has been adopted. ² Worst case flow recorded across all the monitoring wells				

Table 7: Trial Hole WS3

Gas	Range	Concentration C _{hg}	Adopted Flow (l/hr)	Q _{hg}
Carbon dioxide	Highest	2.3	1.2 ¹	0.044
	Average	1.76	1.2 ¹	0.024
	Lowest	0.2	1.2 ¹	0.0132
	Worst Case	2.3	1.6 ²	0.0368
Notes: ¹ The highest flow rate from within the monitoring well has been adopted. ² Worst case flow recorded across all the monitoring wells				

Hazardous gas flow rates of between 0.0132 and 0.208 l/hr have been calculated for carbon dioxide. The adoption of these results as a Gas Screening Value (GSV) would designate the site as being somewhere between Characteristic Situation 1 and Characteristic Situation 2.

It should be noted that, with the exception of trial hole WS1, WS2 and WS3 recorded Hazardous gas flow rates that (if adopted) would designate the site as Characteristic Situation 1 (CS1).

In addition to the Hazardous flow rates derived for each monitoring well, a 'worst case condition' has been derived adopting the maximum soil gas concentration for carbon dioxide (13% v/v in WS1) using the highest recorded flow rate (1.6l/h in WS1) taken from the monitoring wells across all of the six monitoring visits. From these adopted values, a worst case hazardous flow rate of 0.208 l/hr for carbon dioxide has been calculated.

The worst-case condition hazardous flow rate for carbon dioxide (0.208l/h) exceeds the GSV of 0.07 l/h which, if accepted as the GSV for the overall site, would define the site as Characteristic Situation 2 (CS2).

However, following a review of the overall dataset, it is considered that the Hazardous gas flow rate (Q_{hg}) calculated for the 'worst-case' is significantly higher, by a factor of ten, than those values calculated for WS2 and WS3 and could be an outlier or artefact of the investigation process. It is considered that based on the data to date, the 'worst-case' is not representative of the overall soil gas regime and therefore should not be adopted as the overall site GSV in this case.

CIRIA C665 and BS8485:2015 both state that where concentrations of carbon dioxide are recorded over 5% v/v, consideration should be given to increasing the Characteristic Situation from 1 to 2. After reviewing the dataset over all of the 18 individual soil gas readings, a total of only 5 readings recorded carbon dioxide at concentrations greater than 5% v/v. As the number of readings over 5% v/v is less than a third of the total number of readings taken, it is considered that these readings are probably not characteristic of the overall site gas regime or present a significant risk.

In addition, the results (lacking any significant methane, sulphur dioxide, carbon monoxide or other evidence of combustion products or activity) probably relate to and reflect the presence of and degradation of the underlying chalk. This may have been extenuated by the process of investigation, drilling and installation leading to the creation of artefact results, again not indicative of the overall gas regime under normal conditions. On this basis, the level of protection should not be upgraded to Characteristic Situation 2 (CS2) in this case, as we consider that this would not be reflective of the actual levels of ground gas risk at this site, given the intended use as currently understood.

It is therefore considered appropriate and reasonable, based on the results of the monitoring to date, to designate the site as being within Characteristic Situation 1 (CS1), where no soil gas protection is required within the proposed development and risk is considered low to negligible to the identified receptors.

Conclusions

Soil-gas monitoring was undertaken on six occasions in total across a period of approximately four months which on analysis have characterised the site as

Characteristic Situation 1 (CS1), where no gas protection measures are considered necessary and risk is considered low to negligible.

Should you have any further questions please do not hesitate to contact the undersigned.

The following figures and appendices complete the letter report.

Figure 1. Site Location

Figure 2. Trial Hole Location Plan

Yours sincerely



James Hucklesby MSci FGS MEnvSc
Senior Geo Environmental Engineer

For and on behalf of Soils Limited

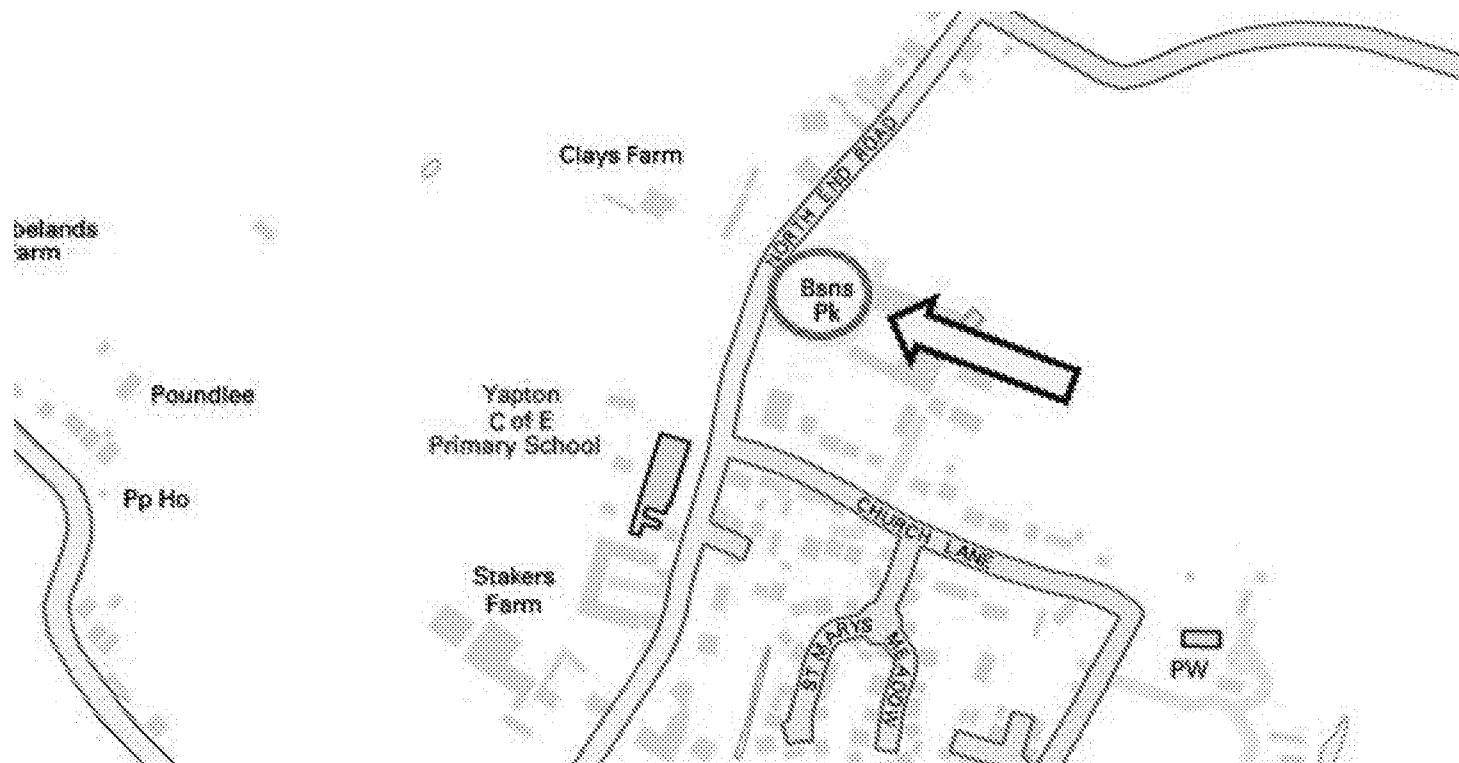


Figure number

1

Project

Orchard Business Park, North End
Road, Yaptan

Client

Crayfern Homes

Title

Site Location

Date

April 2018

Job Number

16671



Figure number

2

Project

Orchard Business Park, North End
Road, Yapton

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Trial Hole Location Plan

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