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

01962 673 330
soilslimited.co.uk

Foreman Homes Limited
F.A.O. Laura Harvell
Our Ref: 16020/SGRA
11th December 2017

Dear Laura,

RE: Soil-Gas Risk Assessment at Land at Romsey Avenue, Portchester, Hampshire PO16 9TA

Foreman Homes Limited commissioned Soils Limited to undertake a Soil Gas Risk Assessment at the site known as Romsey Avenue, Portchester, Hampshire PO16 9TA.

Background
The Phase I Desk Study (Report ref: 15939/DS, dated December 2016) identified a low risk of soil gas associated with a Historic Landfill located within 250m of the site.

The preliminary investigation (Report ref: 16020/GIR, dated March 2017) at the site comprised the installation of five monitoring wells (WS1 – WS5) and subsequent monitoring on six occasions.

Six gas monitoring visits were undertaken over a period of five months to assess the risk posed to the site from the identified sources. This letter report provides a final assessment, based on the 6No. visits undertaken to date.

The following reports must be read in conjunction with this report:

- Soils Limited Phase I Desk Study (Report ref: 15939/DS, dated December 2016);
- Soils Limited Phase II Ground Investigation Report (Report ref: 16020/GIR, dated March 2017).

This letter report documents the findings of the soil gas monitoring and makes recommendations for gas protection measures, where required.

Sources of Soil Gas at the Site
The following potential sources of soil-gas presented in Table 1 were identified by the Desk Study, prepared by Soils Limited.

Table 1 Potential Sources of Soil-gas

Sources	Distance (m)	Direction	Risk
BGS Recorded/Historic Landfill	199	W	Low
Historic Landfill Site	205	SW	Low

Geology of the Site

The 1:50,000 BGS map showed the site to be located upon the bedrock of the Lewes Nodular Chalk Formation, with the River Terrace Deposits overlying.

Works Undertaken

On 31st January 2017 five windowless sampler boreholes (WS1 – WS5) were drilled, using a Premier Compact 110 windowless sampler rig, to depths of between 4.00 and 5.00m below ground level (bgl) at locations selected by Soils Limited using a development plan provided by the client.
A standpipe was installed within all of the windowless sampler boreholes to allow for continued monitoring of both soils gas and groundwater, where present.

The ground conditions encountered during the site works are presented in the table below.

Table 2 Ground Conditions Encountered

Strata	Age	Depth Encountered (m bgl)		Typical Thickness (m)	Typical Description
		Top	Bottom		
TS	Holocene	G.L.	0.20 – 0.60	0.35	Light brown silty CLAY with flint gravel.
RTD	Quaternary	0.20 – 0.60	1.10 – 3.80	1.80	Firm light orangish brown silty gravelly CLAY.
LNCF	Cretaceous	1.10 – 3.80	>7.00	Not Proven[1]	Off-white to white weathered CHALK recovered as fine to coarse gravel sized chalk and flint fragments within a comminuted clay/silt matrix.

Note: [1] Base of strata not encountered

The monitoring well installations comprised 25mm ID HPDE pipework installed in boreholes WS1 – WS5 to depths ranging between 4.00 and 5.00m bgl. The response zone comprised a slotted pipe with non-calcareous gravel pack surround with a bentonite seal above.

The headworks comprised a single gas tap fitted into an end cap and placed on the end of the pipework just below ground level within a metal stopcock cover set in concrete.

Soil Gas Monitoring Records

Monitoring was undertaken on six separate occasions over a total period of approximately five months. These included targeting periods of low and falling pressure where possible. Readings were taken of the concentrations of Oxygen, Methane, Carbon Dioxide, Carbon Monoxide, Hydrogen Sulphide, and flow rates, atmospheric pressure and groundwater levels were taken. Photo-Ionisation Detector (PID) was undertaken in each well to check for any volatile organic compounds (VOC).

The results of the monitoring are provided within Table 3.

Table 3 – Soil Gas Results

Date (Baro Trend)	BH	CH_4 (%v/v)	CO_2 (%v/v)	O_2 (%v/v)	H_2S (ppm)	CO (ppm)	LEL (%)	aP (mb)	Flow (l/h)	Dp	H_2O (m bgl)	Well Depth (m bgl)	VOC (ppm)
24/02/2017 (High – rising)	Atmos	0.0	0.1	20.5	0.0	0.0	0.0	1022	0.0	0.0	N/A	N/A	0.0
	WS1	0.0	0.4	20.9	0.0	0.0	0.0	1021	0.0	0.0	Dry	5.00	0.0
	WS2	0.0	0.0	21.2	0.0	0.0	0.0	1021	0.0	0.0	Dry	4.00	0.0
	WS3	0.0	0.3	21.0	0.0	0.0	0.0	1021	0.0	0.0	Dry	4.00	0.0
	WS4	0.0	2.5	20.6	0.0	0.0	0.0	1022	0.0	0.0	Dry	5.00	0.0
	WS5	0.0	2.5	18.1	0.0	0.0	0.0	1022	0.0	0.0	4.30	5.00	0.0
28/03/2017 (High – steady)	Atmos	0.0	0.0	20.8	0.0	0.0	0.0	1019	0.0	0.0	N/A	N/A	0.0
	WS1	0.0	1.6	17.8	0.0	0.0	0.0	1018	0.0	0.0	Dry	4.93	0.0
	WS2	0.0	1.0	19.5	0.0	0.0	0	1018	0.0	0.0	Dry	3.80	0.0
	WS3	0.0	0.9	18.8	0.0	0.0	0	1018	0.0	0.0	Dry	3.77	0.0
	WS4	0.0	0.7	20.2	0.0	0.0	0	1019	0.0	0.0	Dry	5.06	0.0
	WS5	0.0	1.0	19.2	0.0	0.0	0	1019	0.0	0.0	4.04	4.84	0.1
13/04/2017 (High – steady)	Atmos	0.0	0.0	21.3	0.0	0.0	0	1016	0.0	0.0	N/A	N/A	0.0
	WS1	0.0	2.0	17.3	0.0	0.0	0	1015	0.0	0.0	Dry	4.90	0.3
	WS2	0.0	1.1	19.6	0.0	0.0	0	1016	0.0	0.0	Dry	3.80	0.0
	WS3	0.0	1.1	19.9	0.0	0.0	0	1016	0.0	0.0	Dry	3.80	0.3
	WS4	0.0	2.0	18.0	0.0	0.0	0	1014	0.0	0.0	Dry	4.90	0.1
	WS5	0.0	1.7	18.3	0.0	0.0	0	1015	0.0	0.0	4.28	4.82	0.4
25/04/2017 (High – steady)	Atmos	0.0	0.0	21.1	0.0	0.0	0	1009	0.0	0.0	N/A	N/A	0.0
	WS1	0.0	0.0	21.3	0.0	0.0	0	1012	0.0	0.0	Dry	5.00	0.0
	WS2	0.0	1.3	19.7	0.0	0.0	0	1012	0.0	0.0	Dry	3.88	0.5
	WS3	0.0	1.0	20.3	0.0	0.0	0	1012	0.0	0.0	Dry	3.87	0.8
	WS4	0.0	1.6	20.1	0.0	0.0	0	1012	0.0	0.0	Dry	4.95	0.5
	WS5	0.0	1.7	19.4	0.0	0.0	0	1009	0.0	0.0	4.65	4.92	0.4
18/05/2017 (Low – steady)	Atmos	0.0	0.0	21.1	0.0	0.0	0	1010	0.0	0.0	N/A	N/A	
	WS1	0.0	2.0	25.9	0.0	0.0	0	1010	0.0	0.0	Dry	5.00	
	WS2	0.0	1.6	23.7	0.0	0.0	0	1010	0.0	0.0	Dry	3.88	
	WS3	0.0	1.5	22.6	0.0	0.0	0	1010	0.0	0.0	Dry	3.87	
	WS4	0.0	2.1	20.1	0.0	0.0	0	1010	0.0	0.0	Dry	4.95	
	WS5	0.0	1.5	23.3	0.0	0.0	0	1010	0.0	0.0	4.70	4.92	
01/06/2017 (High – steady)	Atmos	Data corrupted											
	WS1	0.0	2.0	23.5	0.0	0.0	0	1022	0.0	0.0	Dry	5.00	0.0
	WS2	0.0	1.4	22.4	0.0	0.0	0	1022	0.0	0.0	Dry	4.00	0.0
	WS3	0.0	1.5	22.6	0.0	0.0	0	1022	0.0	0.0	Dry	4.00	0.0
	WS4	0.0	2.2	25.6	0.0	0.0	0	1022	0.0	0.0	Dry	5.00	0.0
	WS5	0.0	1.9	23.6	0.0	0.0	0	1022	0.0	0.0	4.80	5.00	0.0
Minimum		*0.0*	*0.0*	*17.3*	0.0	0.0	0.0	*1009*	*0.0*	0.0			*0.0*
Average		*0.0*	*1.1*	*20.3*	0.0	0.0	0.0	*1015*	*0.0*	0.0			*0.1*
Maximum		*0.0*	*2.5*	*25.9*	0.0	0.0	0.0	*1022*	*0.0*	0.0			*0.8*

The trend in barometric pressure over the week of the above dates is presented below, respectively.

Figure 1: Weekly Barometric Trend for Week commencing 20th Feb. 2017

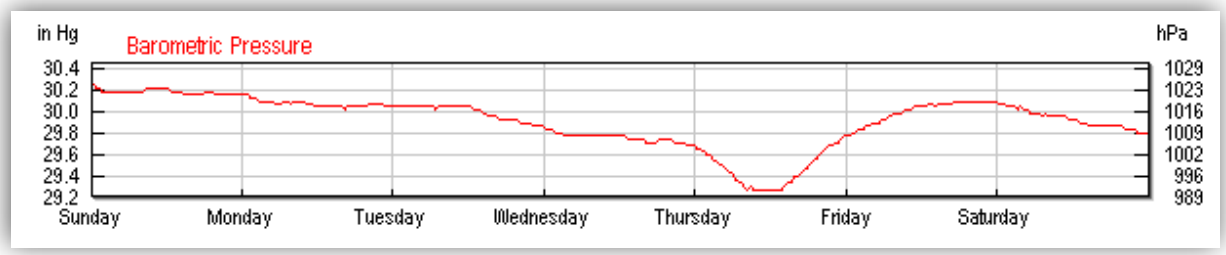


Figure 2: Weekly Barometric Trend for Week commencing 27th Feb. 2017

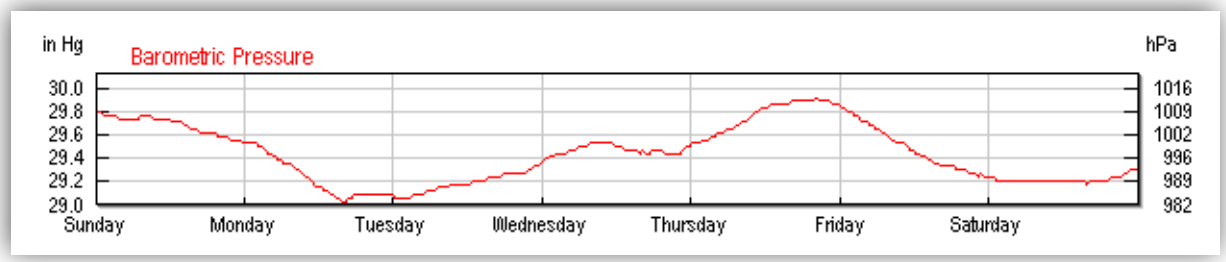


Figure 3: Weekly Barometric Trend for Week commencing 10th April 2017

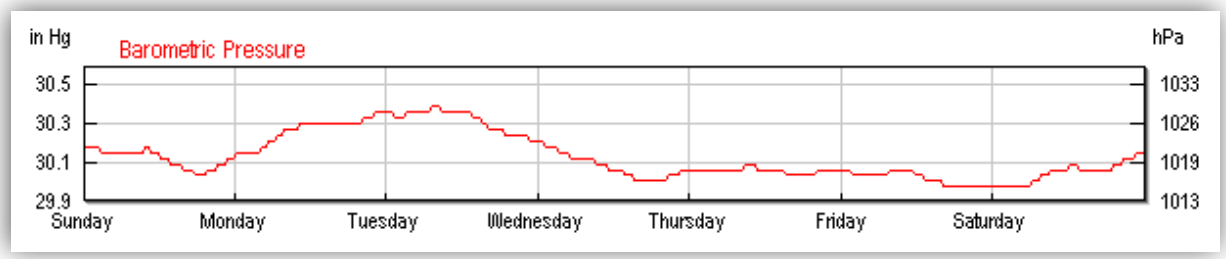


Figure 4: Weekly Barometric Trend for Week Commencing 24th April 2017

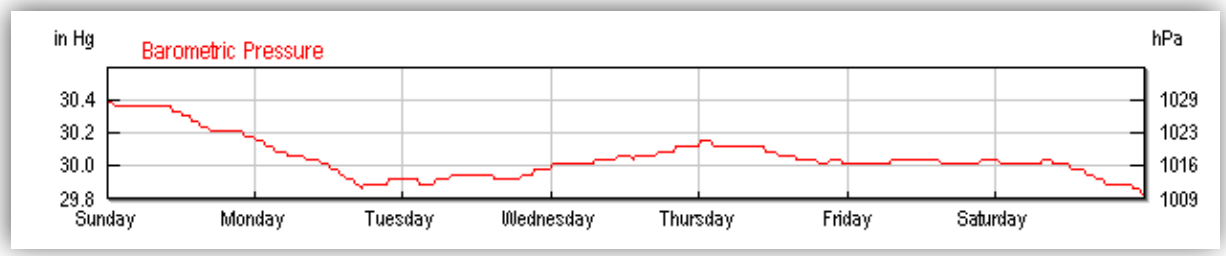


Figure 5: Weekly Barometric Trend for Week Commencing 15th May 2017

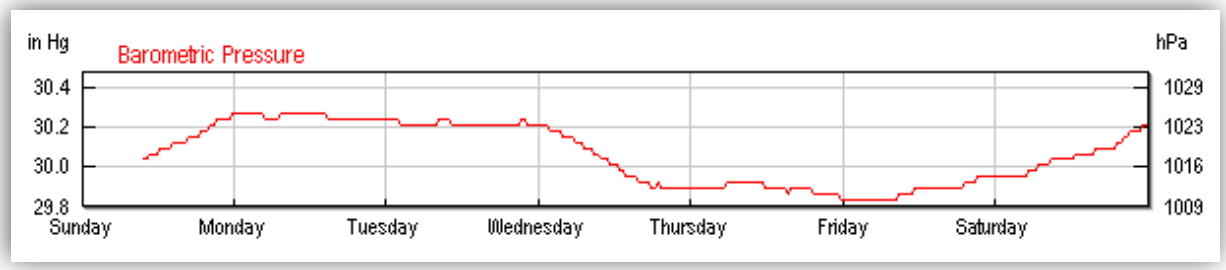
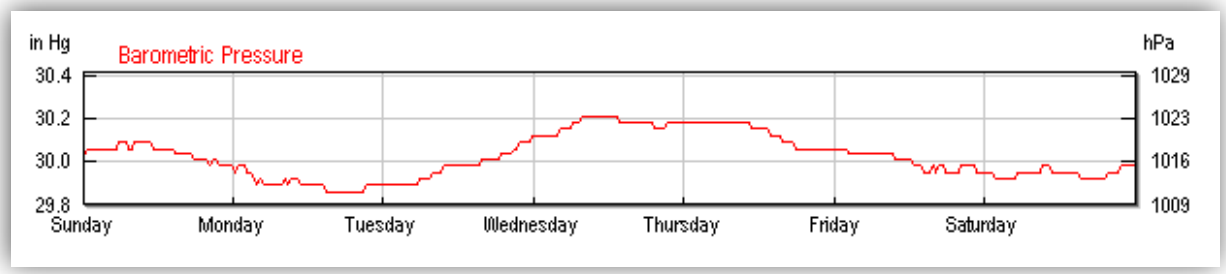


Figure 6: Weekly Barometric Trend for Week Commencing 29th May 2017



No concentration of methane (CH_4) was recorded above the instrument detection limit on any of the gas monitoring visits.

The **highest concentration of carbon dioxide (CO_2) was recorded at 2.5% by volume** in WS4 and WS5 on 24th February 2017.

The **lowest concentration of oxygen (O_2) was recorded at 17.3% by volume** in WS1 on 13th April 2017.

A concentration of 1ppm of carbon monoxide (CO) was recorded in WS3 on 25th April 2017.

No concentration of hydrogen sulphide (H_2S) was recorded above the instrument detection limit on any of the gas monitoring visits.

No flow rates were recorded during the monitoring period.

Concentrations of Volatile Organic Compounds (VOCs) within the monitoring wells were measured using a Photo-Ionisation Detector (PID). The highest concentration recorded was 0.8ppm, which was not considered hazardous.

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 from Desk Study and logged trial holes was good.	CIRA 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 six occasions over five-month period. Monitoring has been undertaken over a range of seasons and weather conditions including falling-rising and low and high atmospheric pressures.	CIRIA 665 recommends approximately 3-month monitoring over a range of weather conditions.
Gas data sets	Borehole flow velocity has been measured on each monitoring occasion.	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.

Data quality was characterised as **good**, covering a range of atmospheric pressure trends. Geological and hydrogeological conditions have been investigated and fully understood.

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 hazardous gas flow rate (Q_{hg}) was calculated using Equation 1:

$$\mathbf{Q_{hg} = (C_{hg}/100) * q} \qquad \textit{Equation 1}$$

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.

If gas borehole flow was not detectable, it was assumed to be at the detection limit of the equipment used which was 0.1l/hr.

The Q_{hg} for **carbon dioxide** was calculated using Equation 2a.

$$\mathbf{Q_{hg}\ (l/hr) = gas\ concentration * borehole\ flow\ rate\ (l/hr)} \qquad \textit{Equation 2a}$$

$$\mathbf{= 2.5/100 * 0.1 =} \ \mathbf{0.0025\ l/h}$$

The maximum carbon dioxide concentration was taken as the gas concentration and maximum gas flow across all boreholes and visits was taken to be the minimum detection limit of the equipment used.

Based on a *Site Characteristic hazardous gas flow rates (Q_{hg})* of 0.0025 l/hr the site fell into a Characteristic Gas Situation 1 (CS1), very low risk. This does not require gas protection in accordance with BS 8485:2015, Table 3 and modified Wilson and Card, Table 8.5 of CIRIA 665.

BS 8485:2015 defines four building types, which have been summarised in Table 5.

Table 5 – Summary of Building Types

Type	Summary	Examples
A	Private ownership with no building management controls on alterations.	Private housing and some retail premises.
B	Private or commercial property with central building management control of any alterations. Multiple occupancy.	Managed apartments, multiple occupancy offices, some retail premises and pars of some public buildings and parts of hotels, hospitals.
C	Commercial building with central building management control of any alterations. Single occupancy of ground floor and basement areas.	Offices, some retail premises, and parts of some public buildings i.e. schools, hospitals, leisure centres, parts of hotels.
D	Industrial style building have large volume internal space(s) that are well ventilated.	Retail park sales buildings, factory shop floor areas, warehouses.

At the time of reporting, the proposed development was for a residential end-use.

Following the relevant guidance of BS 8484:2015 and based on the Characteristic Gas Situation and the type of building derived, the minimum gas protection score ranging between 0 and 7.5 should be determined in accordance with Table 6.

Table 6 – Gas Protection Score by CS and Type of Building

CS	Minimum gas protection score (points)			
	High risk (A, B)		Medium risk (C)	Low risk (D)
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5	5.5	4.5	3.5
5	-	6.5	5.5	4.5
6	-	-	7.5	6.5

Notes: 1 Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations. 2 The gas hazard is too high for this empirical method to be used to define the gas protection measures.

Based on the readings, and with reference to Table 6 for a CS1 and for a building Type A, as proposed on this site, a gas protection score of 0 must be achieved.

No gas protection measures are required to achieve the required score. A summary of the scores for each protection type, as outlined in BS 8485:2015 are presented in Table 7. These tables are given for information and the designer must refer to the full document in preparing the detailed design.

Table 7 – Gas Protection Scores for Structural Barrier

Floor and substructure design	Score [1]
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 [2]

Floor and substructure design	Score [1]
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing [3]	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing [3]	2.5

Notes: [1]Scores are conditional on breaches of floor slabs, etc., being effectively sealed. [2]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. [3]The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product.

When comparing the gas screening value for Carbon Dioxide to the NHBC traffic light criteria, the site would fall into the Green characterisation. Based on the value of 2.5%v/v for Carbon Dioxide it is considered that the Green characterisation is appropriate.

Table 8. Summary of Soil Gas Risk Assessment For CO_2

Range	CO_2 (%)	Flow (l/h)	Screening Value (Qhgs)	Characteristic Situation	
				(CIRIA 149)	Traffic Lights
Min	0.0	0.0	0.0	1	Green
Mean	1.1	0.1	0.0011	1	Green
Max	2.5	0.1	0.0025	1	Green

Summary of Findings

An assessment of the soil gas risk at the site has been undertaken based on the monitoring carried out, which comprises six visits. In accordance with BS8485:2015, a very low risk was identified, which does not require gas protection measures.

In accordance with BS845:2015 and with reference to Table 4 a score of 0 is required for the proposed development. No protection measures are required to achieve the required score, as detailed in Table 7.

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

Yours Sincerely

L. Philip BEng. FGS
Graduate Geotechnical Engineer

For and on behalf of Soils Limited

The following appendices complete the letter report

Figure 1 Proposed layout
Figure 2 Trial hole location Plan

Figure number
1

Project
Land at Romsey Road, Portchester, Hampshire PO16 9TA

Client
Foreman Homes Ltd

Title
Proposed Layout

Date
December 2017

Job Number
16020

Figure number
2

Project
Land at Romsey Road, Portchester, Hampshire PO16 9TA

Client
Foreman Homes Ltd

Title
Trial Hole Location Map

Date
December 2017

Job Number
16020