



Ground Gas Addendum Report
Belle Vue

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GROUND GAS ADDENDUM REPORT

Belle Vue
Manchester

Prepared for:



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Table of Contents

1. INTRODUCTION	3
1.1. Background.....	3
1.2. Proposed Development	3
1.3. Objectives	3
1.4. Limitations.....	4
1.5. Confidentiality	4
2. INVESTIGATION RATIONALE	5
2.1. Monitoring Methodology	5
3. GROUND GAS RISK ASSESSMENT	12
3.1. Ground Gas Risk Assessment Methodology	12
3.1.1. Sources of Ground Gas	13
3.1.2. Groundwater.....	13
3.1.3. Gas Flow	14
3.1.4. Gas Concentrations	14
3.1.5. Gas Assessment	14
3.2. Residential Building Gas Risk Mitigation	15
APPENDIX I LIMITATIONS	19
APPENDIX II GLOSSARY	21
APPENDIX III DRAWINGS.....	24



1. INTRODUCTION

1.1. BACKGROUND

E3P has previously completed a ground investigation on the site known as Belle Vue Greyhound Race track, Manchester. The findings of the ground investigation are presented within the E3P report entitled Phase I & II, Geoenvironmental Site Assessment (report ref: 12-123-r1 Rev 2).

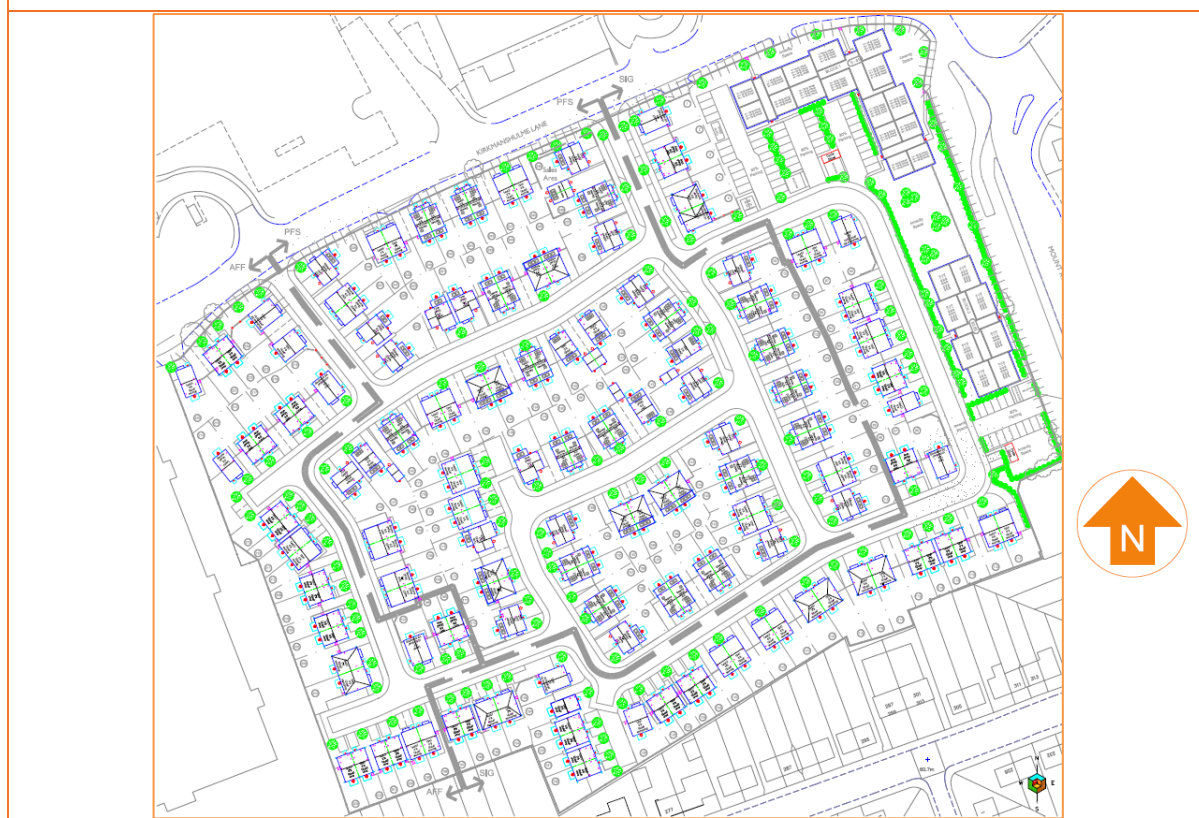
During the investigation E3P installed ground gas monitoring wells, which were to be monitored over a period of six months after installation. The data collected from the gas monitoring wells are summarised in this report and this comprises the completed ground gas assessment.

1.2. PROPOSED DEVELOPMENT

Countryside Properties intends to construct a low rise residential development comprising residential dwellings with associated gardens, estate roads and infrastructure.

A snapshot of the proposed development layout is indicated in Figure 1.1.

FIGURE 1.1 SNAPSHOT OF PROPOSED DEVELOPMENT



1.3. OBJECTIVES

The objectives of the ground gas addendum report are to provide a detailed assessment of ground gas risk based on all available data from the E3P ground investigation works.



1.4. LIMITATIONS

The limitations of this report are presented in Appendix I.

1.5. CONFIDENTIALITY

E3P has prepared this report solely for the use of the client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from E3P; a charge may be levied against such approval.



2. INVESTIGATION RATIONALE

The Initial Conceptual Site Model has identified that the underlying Made Ground, may represent a potential source of ground gas generation. Ground conditions are discussed in more detail in Section 3. Based on the identification of these sources, E3P has determined that the site represents a low ground gas source generation potential.

Within the context of the proposed residential end use and ground gas generation potential, the gas assessment requires that 9 visits are required over 6 months, with at least two sets of readings at low or falling atmospheric pressure as set out within CIRIA 665 Tables 5.5a and 5.5b.

The spacing requirements for monitoring wells are detailed within CIRIA 665 Table 4.2, which indicates that for low gas hazard sites (Made Ground with limited degradable material, organic clay of limited thickness) and a high sensitivity development, nominal well spacing should be between 25 m and 50 m.

TABLE 1.1 GROUND GAS MONITORING LOCATION RATIONALE

LOCATION	GROUND GAS SOURCE	DEPTH OF MONITORING WELL (m)
WS101	Made Ground	1.00-2.00
WS103	Made Ground	1.00-2.00
WS104	Made Ground	1.00-2.00
WS106	Made Ground	1.50-4.00
WS107	Made Ground	0.50-1.50
WS109	Made Ground	1.00-4.00
WS111	Made Ground	1.00-5.00
WS112	Made Ground	1.00-4.00
WS113	Made Ground	1.00-5.00
WS114	Made Ground	1.00-3.50
WS117	Made Ground	1.00-2.50
WS118	Made Ground	1.00-3.00
WS101	Made Ground	1.00-2.00
WS103	Made Ground	1.00-2.00
WS104	Made Ground	1.00-2.00
WS106	Made Ground	1.50-4.00

2.1. MONITORING METHODOLOGY

Concentrations of methane (CH₄), carbon dioxide (CO₂) and oxygen (O₂) were measured using a calibrated infra-red gas analyser (GFM435) with gas flow rates measured using an integrated flow meter.

Gas measurements were recorded for a minimum of 60 seconds at each location, at which point the maximum concentration of CH₄ and CO₂, together with the lowest concentration of O₂ were recorded. The results of the ground gas monitoring are presented in Table 1.2.



TABLE 1.2 SUMMARY OF GROUND GAS MONITORING RESULTS

WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIA L %V/V	CO ₂ STEA DY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mb)	ATMOS. DYNAMI C	FLOW (l/hr)	RESPONS E ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)	
WS101	26/3/18	0.1	0.1	-0.00133	0.6	0.6	-0.00798	17.9	1007	Falling	-1.33	0.5-2.0	2.1	0.82	
	5/4/18	0.1	0.1	-0.00089	0.5	0.5	-0.00445	18.0	1002	Rising	-0.89		2.1	0.80	
	26/4/18	0.1	0.1	-0.00052	0.4	0.4	-0.00208	18.6	1001	Steady	-0.52		2.1	0.90	
	7/5/18	0.1	0.1	-0.0013	0.6	0.6	-0.0078	18.2	1015	Falling	-1.3		2.09	0.88	
	17/5/18	0.1	0.1	-0.00074	0.7	0.7	-0.00518	17.8	1020	Falling	-0.74		2.08	0.90	
	31/5/18	0.1	0.1	-0.00174	0.9	0.9	-0.01566	17.2	1009	Rising	-1.74		2.06	0.90	
	11/6/18	0.1	0.1	-0.00098	0.8	0.8	-0.00784	17.6	1011	Steady	-0.98		2.07	0.95	
	21/6/18	0.1	0.1	-0.00126	0.6	0.6	-0.00756	17.9	1008	Rising	-1.26		2.06	0.94	
	2/7/18	0.5	0.5	0.00905	1.2	1.2	0.02172	17.4	1010	Rising	1.81		2.06	0.90	
	12/8/19	2.5	2.5	0.12325	4.8	4.8	0.23664	4.2	1007	Rising	4.93		2.02	0.82	
	3/10/19	0.9	0.9	0.01782	2.7	2.7	0.05346	9.5	1007	Falling	1.98		2.03	0.8	
	28/11/19	0.1	0.1	0.00186	1.6	1.6	0.02976	11.5	990	Rising	1.86		2.03	0.83	
WS103	26/3/18	0.4	0.4	-0.01088	4.8	4.8	-0.13056	10.1	1007	Falling	-2.72	1.0-2.0	1.84	1.04	
	5/4/18	0.2	0.2	-0.0036	4.1	4.1	-0.0738	11.2	1002	Rising	-1.8		1.85	1.06	
	26/4/18	0.1	0.1	-0.0021	4.2	4.2	-0.0882	11	1001	Steady	-2.1		1.85	1.10	
	7/5/18	0.1	0.1	-0.0014	3.8	3.8	-0.0532	12.9	1015	Falling	-1.4		1.84	1.09	
	17/5/18	0.1	0.1	-0.00052	4.0	4.0	-0.0208	12.1	1020	Falling	-0.52		1.83	1.12	
	31/5/18	0.1	0.1	0.0001	3.9	3.9	0.0039	13.3	1009	Rising	0.1		1.83	1.14	
	11/6/18	0.1	0.1	-0.00013	4.1	4.1	-0.00533	12.9	1011	Steady	-0.13		1.84	1.16	
	21/6/18	0.1	0.1	-0.00026	3.8	3.9	-0.00988	12.1	1008	Rising	-0.26		1.82	1.17	
	2/7/18	0.1	0.1	-0.00322	13.5	13.5	-0.4347	2.7	1010	Rising	-3.22		1.83	1.21	
	12/8/19	Destroyed											N/A	N/A	
	3/10/19	Destroyed											N/A	N/A	
	28/11/19	Destroyed											N/A	N/A	



WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIA L %V/V	CO ₂ STEADY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mb)	ATMOS. DYNAMI C	FLOW (l/hr)	RESPONSE ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)	
WS118	26/3/18	0.1	0.1	-0.00121	0.4	0.4	-0.00484	19.6	1007	Falling	-1.21	1.0-3.0	3.00	0.41	
	5/4/18	0.1	0.1	-0.00079	0.3	0.3	-0.00237	19.7	1002	Rising	-0.79		3.00	0.45	
	26/4/18	0.1	0.1	-0.00052	0.4	0.4	-0.00208	19.5	1001	Steady	-0.52		3.00	0.50	
	7/5/18	0.1	0.1	-0.00089	0.3	0.3	-0.00267	20.1	1015	Falling	-0.89		3.00	0.41	
	17/5/18	0.1	0.1	0.0013	0.3	0.3	0.0039	20.5	1020	Falling	1.30		3.00	0.35	
	31/5/18	0.1	0.1	0.00316	0.4	0.4	0.01264	20.8	1009	Rising	3.16		3.00	0.20	
	11/6/18	0.1	0.1	0.0029	0.3	0.3	0.0087	20.9	1011	Steady	2.90		3.00	0.25	
	21/6/18	0.1	0.1	0.0019	0.4	0.4	0.0076	20.5	1008	Rising	1.90		3.00	0.29	
	2/7/18	0.1	0.1	0.0015	0.5	0.5	0.0075	20.1	1010	Rising	1.50		3.00	0.35	
	12/8/19	0.1	0.1	-0.0113	0.4	0.4	-0.0452	19.3	1007	Rising	-11.3		2.98	0.28	
	3/10/19	Flooded											3.00	GL	
	28/11/19	Flooded											3.00	GL	
WS106	26/3/18	0.1	0.1	-0.00112	0.8	0.8	-0.00896	19.4	1007	Falling	-1.12	1.5-4.0	3.75	2.34	
	5/4/18	0.1	0.1	-0.00176	0.7	0.7	-0.01232	19.3	1002	Rising	-1.76		3.75	2.4	
	26/4/18	0.1	0.1	-0.00089	0.6	0.6	-0.00534	19.2	1001	Steady	-0.89		3.75	2.45	
	7/5/18	0.1	0.1	-0.0012	1.4	1.4	-0.0168	18.3	1015	Falling	-1.20		Damaged bung stuck in monitoring well.		
	17/5/18	0.1	0.1	0.00092	2.1	2.1	0.01932	17.5	1020	Falling	0.92				
	31/5/18	0.1	0.1	0.00133	3.2	3.2	0.04256	16.6	1009	Rising	1.33				
	11/6/18	0.1	0.1	0.00098	2.9	2.9	0.02842	17.3	1011	Steady	0.98				
	21/6/18	0.1	0.1	0.00102	3.0	3.0	0.0306	16.9	1008	Rising	1.02				
	2/7/18	0.1	0.1	-0.00259	4.9	4.9	-0.12691	14.7	1010	Rising	-2.59				
	12/8/19	0.1	0.1	0.00052	0.1	0.1	0.00052	20.6	1007	Rising	0.52				
	3/10/19	0.1	0.1	0.00026	0.1	0.1	0.00026	20.4	1007	Falling	0.26				
	28/11/19	0.1	0.1	-0.0003	2.2	2.2	-0.0058	18.3	990	Rising	-0.26				



WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIA L %V/V	CO ₂ STEA DY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mb)	ATMOS. DYNA MI C	FLOW (l/hr)	RESPONS E ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)	
WS117	26/3/18	0.1	0.1	-0.00112	0.4	0.4	-0.00448	19.7	1007	Falling	-1.12	1.0-2.5	2.14	1.6	
	5/4/18	0.1	0.1	-0.00052	0.5	0.5	-0.0026	19.5	1002	Rising	-0.52		2.15	1.58	
	26/4/18	0.1	0.1	-0.00026	0.3	0.3	-0.00078	19.9	1001	Steady	-0.26		2.15	1.65	
	7/5/18	0.1	0.1	-0.00013	0.6	0.6	-0.00078	18.9	1015	Falling	-0.13		2.14	1.68	
	17/5/18	0.1	0.1	0.0011	0.5	0.5	0.0005	19.1	1020	Falling	0.10		2.13	1.70	
	31/5/18	0.1	0.1	0.0001	0.8	0.8	0.0006	18.6	1009	Rising	0.10		2.13	1.76	
	11/6/18	0.1	0.1	0.0001	0.6	0.6	0.0008	19	1011	Steady	0.10		2.13	1.80	
	21/6/18	0.1	0.1	0.00013	0.7	0.7	0.00091	18.8	1008	Rising	0.13		2.13	1.82	
	2/7/18	0.1	0.1	0.00026	0.9	0.9	0.00234	18.4	1010	Rising	0.26		2.13	1.90	
	12/8/19	Destroyed											N/A	N/A	
	3/10/10	Destroyed											N/A	N/A	
	28/11/19	Destroyed											N/A	N/A	
WS107	26/3/18	0.1	0.1	0.00374	1.7	1.7	0.06358	18.2	1007	Falling	3.74	0.5-1.5	1.58	0.65	
	5/4/18	0.1	0.1	0.00196	1.5	1.5	0.0294	18.4	1002	Rising	1.96		1.59	0.63	
	26/4/18	0.1	0.1	0.0024	1.2	1.2	0.0288	19.2	1001	Steady	2.40		1.58	0.69	
	Destroyed											N/A		N/A	N/A
WS114	26/3/18	0.1	0.1	-0.00112	3.2	3.2	-0.03584	19.6	1007	Falling	-1.12	1.0-3.5	2.58	1.57	
	5/4/18	0.1	0.1	-0.00089	2.8	2.8	-0.02492	19.8	1002	Rising	-0.89		2.59	1.60	
	26/4/18	0.1	0.1	-0.00059	2.5	2.5	-0.01475	19.6	1001	Steady	-0.59		2.60	1.62	
	7/5/18	0.1	0.1	-0.00052	3.8	3.8	-0.01976	18.2	1015	Falling	-0.52		2.60	1.60	
	17/5/18	0.1	0.1	-0.00026	4.0	4.0	-0.0104	16.8	1020	Falling	-0.26		2.58	1.59	
	31/5/18	0.1	0.1	0.0001	5.4	5.4	0.0054	15.4	1009	Rising	0.10		2.57	1.60	
	11/6/18	0.1	0.1	0.0001	4.9	4.9	0.0049	16.1	1011	Steady	0.10		2.58	1.62	
	21/6/18	0.1	0.1	0.00013	5.2	5.2	0.00676	15.8	1008	Rising	0.13		2.58	1.65	
	2/7/18	0.1	0.1	0.00026	6.2	6.2	0.01612	14.9	1010	Rising	0.26		2.58	1.70	
	12/8/19	0.1	0.1	0.0017	0.6	0.6	0.0102	19.9	1007	Rising	1.70		2.57	1.39	
	3/10/19	0.1	0.1	0.00088	0.7	0.7	0.00616	19.7	1007	Falling	0.88		2.58	1.41	



WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIAL %V/V	CO ₂ STEADY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mb)	ATMOS. DYNAMIC	FLOW (l/hr)	RESPONSE ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)	
WS114	28/11/19	0.1	0.1	0.00121	6.5	6.5	0.07865	12	990	Rising	1.21	1.0-3.5	2.56	1.44	
WS113	26/3/18	0.1	0.1	-0.00188	0.4	0.4	-0.00752	19.7	1007	Falling	-1.88	1.0-5.0	4.48	0.30	
	5/4/18	0.1	0.1	-0.00085	0.4	0.4	-0.0034	19.6	1002	Rising	-0.85		4.47	0.38	
	26/4/18	0.1	0.1	-0.00052	0.3	0.3	-0.00156	19.9	1001	Steady	-0.52		4.48	0.40	
	7/5/18	0.1	0.1	-0.00013	0.4	0.4	-0.00052	20	1015	Falling	-0.13		4.47	0.45	
	17/5/18	0.1	0.1	-0.00068	0.5	0.5	-0.0034	19.9	1020	Falling	-0.68		4.45	0.47	
	31/5/18	0.1	0.1	-0.00102	0.6	0.6	-0.00612	19.8	1009	Rising	-1.02		4.44	0.50	
	11/6/18	0.1	0.1	-0.00098	0.4	0.4	-0.00392	19.9	1011	Steady	-0.98		4.45	0.52	
	21/6/18	0.1	0.1	-0.00052	0.5	0.5	-0.0026	19.7	1008	Rising	-0.52		4.45	0.58	
	2/7/18	0.1	0.1	-0.00013	0.6	0.6	-0.00078	19.4	1010	Rising	-0.13		4.45	0.62	
	12/8/19	Destroyed												N/A	N/A
	3/10/10	Destroyed												N/A	N/A
	28/11/19	Destroyed												N/A	N/A
WS109	26/3/18	0.1	0.1	-0.0113	5.3	5.3	-0.5989	14.2	1007	Falling	-11.3	1.0-4.0	4.17	0.70	
	5/4/18	0.1	0.1	-0.0089	4.9	4.9	-0.4361	15.6	1002	Rising	-8.9		4.18	0.78	
	26/4/18	0.1	0.1	-0.0075	4.7	4.7	-0.3525	15.9	1001	Steady	-7.5		4.16	0.82	
	7/5/18	0.1	0.1	-0.0087	5.6	5.6	-0.4872	14.3	1015	Falling	-8.7		4.16	0.78	
	17/5/18	0.1	0.1	-0.0059	5.9	5.9	-0.3481	13.9	1020	Falling	-5.9		4.17	0.72	
	31/5/18	0.1	0.1	-0.01036	6.4	6.4	-0.66304	12.2	1009	Rising	-10.3		4.16	0.67	
	11/6/18	0.1	0.1	-0.0094	5.9	5.9	-0.5546	13.5	1011	Steady	-9.4		4.16	0.7	
	21/6/18	0.1	0.1	-0.0073	6.2	6.2	-0.4526	12.6	1008	Rising	-7.3		4.16	0.75	
	2/7/18	0.1	0.1	-0.0068	6.8	6.8	-0.4624	12.1	1010	Rising	-6.8		4.16	0.86	
	12/8/19	0.1	0.1	-0.01039	5.7	5.7	-0.59223	5.2	1007	Rising	-10.3		4.12	0.41	
	3/10/19	0.1	0.1	-0.00855	10.1	10.1	-0.86355	8.2	1007	Falling	-8.55		4.18	0.40	
28/11/19	Flooded										N/A		N/A	N/A	



WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIA L %V/V	CO ₂ STEADY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mb)	ATMOS. DYNAMI C	FLOW (l/hr)	RESPONSE ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)
WS112	26/3/18	0.1	0.1	-0.00112	2.7	2.7	-0.03024	18.7	1007	Falling	-1.12	1.0-4.0	4.02	0.62
	5/4/18	0.1	0.1	-0.0016	2.4	2.4	-0.0384	19	1002	Rising	-1.6		4.01	0.69
	26/4/18	0.1	0.1	-0.0021	2.5	2.5	-0.0525	18.8	1001	Steady	-2.1		4.02	0.75
	7/5/18	0.1	0.1	-0.00174	2.4	2.4	-0.04176	18.9	1015	Falling	-1.74		4.02	0.74
	17/5/18	0.1	0.1	-0.00078	2.1	2.11	-0.01638	19.1	1020	Falling	-0.78		4.01	0.72
	31/5/18	0.1	0.1	0.0026	1.7	1.7	0.0442	19.2	1009	Rising	2.6		4.01	0.7
	11/6/18	0.1	0.1	0.0019	1.9	1.9	0.0361	19.6	1011	Steady	1.9		4.02	0.76
	21/6/18	0.1	0.1	0.00185	1.6	1.6	0.0296	19.1	1008	Rising	1.85		4.00	0.72
	2/7/18	0.1	0.1	0.00098	2.2	2.2	0.02156	18.5	1010	Rising	0.98		4.01	0.82
	12/8/19	0.1	0.1	0.01136	5.3	5.3	0.60208	4.7	1007	Rising	11.3		4.06	0.72
	3/10/19	0.1	0.1	0.01026	5.9	5.9	0.60534	3.8	1007	Falling	10.2		4.05	0.64
	28/11/19	0.1	0.1	0.00996	6.4	6.4	0.63744	6.5	990	Rising	9.96		4.03	0.72
WS111	26/3/18	0.1	0.1	0.00271	0.7	0.7	0.01897	19.9	1007	Falling	2.71	1.0-5.0	3.95	0.40
	5/4/18	0.1	0.1	0.00167	0.5	0.5	0.00835	19.8	1002	Rising	1.67		3.95	0.47
	26/4/18	0.1	0.1	0.0012	0.6	0.6	0.0072	19.6	1001	Steady	1.2		3.95	0.53
	7/5/18	0.2	0.1	-0.0056	1.4	1.4	-0.0392	18.4	1015	Falling	-2.8		3.94	0.49
	17/5/18	0.4	0.3	-0.0312	1.6	1.6	-0.1248	17.2	1020	Falling	-7.8		3.95	0.47
	31/5/18	1.3	1.3	-0.13403	4.0	4.0	-0.4124	15.4	1009	Rising	-10.3		3.93	0.43
	11/6/18	0.1	0.1	-0.0075	3.5	3.5	-0.2625	16.1	1011	Steady	-7.5		3.94	0.49
	21/6/18	0.1	0.1	-0.0083	3.8	3.8	-0.3154	15.8	1008	Rising	-8.3		3.93	0.52
	2/7/18	0.2	0.2	-0.0152	4.8	4.8	-0.3648	15.1	1010	Rising	-7.6		3.94	0.69
	12/8/19	4.5	4.5	-0.4563	7.2	7.2	-0.73008	8.3	1007	Rising	-10.1		3.93	0.10
	3/10/19	2.7	2.7	0.30672	11.3	11.1	1.28368	6.7	1007	Falling	11.3		3.95	0.18
	28/11/19	Flooded												



WELL	DATE	CH ₄ INITIAL %V/V	CH ₄ STEADY %V/V	CH ₄ GSV l/hr	CO ₂ INITIAL %V/V	CO ₂ STEADY %V/V	CO ₂ GSV l/hr	O ₂ %V/V	ATMOS(mB)	ATMOS. DYNAMI C	FLOW (l/hr)	RESPONS E ZONE / STRATUM (mbgl)	DEPTH TO BASE (mbgl)	DEPTH TO WATER (mbgl)
WS104	26/3/18	0.1	0.1	-0.00112	0.6	0.6	-0.00672	19.8	1007	Falling	-1.12	1.0-2.0	2.10	0.40
	5/4/18	0.1	0.1	-0.00089	0.5	0.5	-0.00445	19.9	1002	Rising	-0.89		2.10	0.43
	26/4/18	0.1	0.1	-0.00074	0.6	0.6	-0.00444	20	1001	Steady	-0.74		2.10	0.49
	7/5/18	0.1	0.1	-0.00171	0.5	0.4	-0.00855	19.9	1015	Falling	-1.71		2.10	0.78
	17/5/18	0.1	0.1	-0.00052	0.6	0.6	-0.00312	19.8	1020	Falling	-0.52		2.09	0.90
	31/5/18	0.1	0.1	-0.00181	0.7	0.7	-0.01267	19.8	1009	Rising	-1.81		2.08	1.37
	11/6/18	0.1	0.1	-0.00056	0.5	0.5	-0.0028	19.7	1011	Steady	-0.56		2.09	1.45
	21/6/18	0.1	0.1	-0.00079	0.6	0.6	-0.00474	19.6	1008	Rising	-0.79		2.08	1.46
	2/7/18	0.1	0.1	-0.00052	0.7	0.7	-0.00364	19.2	1010	Rising	-0.52		2.08	1.63
	12/8/19	0.1	0.1	0.00026	1.2	1.2	0.00312	19.1	1007	Rising	0.26		2.10	1.4
	3/10/19	0.1	0.1	0.00052	1.4	1.4	0.00728	18.9	1007	Falling	0.52		2.10	1.33
	28/11/19	0.1	0.1	0.00052	0.6	0.6	0.00312	19.8	990	Rising	0.52		2.07	1.3



3. GROUND GAS RISK ASSESSMENT

3.1. GROUND GAS RISK ASSESSMENT METHODOLOGY

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in CIRIA Report 665 – *Assessing risks posed by hazardous ground gases to buildings* (2007). However, it is recommended that the full ground gas assessment and recommended protection measures are agreed with the local authority prior to their adoption on site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

CIRIA C665 and NHBC Report No 10627-R01 provide assessments for carbon dioxide and methane based upon gas screening values (GSVs) utilising flow rates and concentrations. The site-based GSVs for steady state methane and carbon dioxide are based upon the following equation:

$$GSV = \frac{\text{concentration (by vol)}}{100} \times \text{flowrate (l / hr)}$$

The GSVs within CIRIA C665 are based upon all buildings other than standard residential houses. The NHBC GSVs are based upon standard residential houses with precast concrete floors (block and beam). The CIRIA 665 report author (Steve Wilson) since provided further clarification regarding which guidance should be adopted for residential houses that have suspended cast in-situ concrete floor slab: for the avoidance of doubt, it was confirmed that the GSVs within the CIRIA 665 guidance should be adopted.

For this development the NHBC thresholds have been adopted due to the use of a subfloor void.

The thresholds for GSVs based upon NHBC guidance are provided within Table 3.1

TABLE 3.1 RESIDENTIAL THRESHOLDS FOR GAS SCREENING VALUES (GSV) IN ACCORDANCE WITH NHBC REPORT NO 10627-R01 – RESIDENTIAL END USE

NHBC – SUBFLOOR VOID				
CLASSIFICATION	Methane ¹		Carbon Dioxide ¹	
	TYPICAL MAXIMUM CONCENTRATION ³ (%V/V)	GAS SCREENING VALUE ^{2,4} (l/hr)	TYPICAL MAXIMUM CONCENTRATION ³ (%V/V)	Gas Screening Value ^{2,4} (l/hr)
Green	< 1	< 0.16	< 5	< 0.78
Amber 1	< 5	< 0.63	< 10	< 1.56
Amber 2	< 5	< 1.56	< 30	< 3.10
Red	> 20	> 1.56	> 30	> 3.10

Notes

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worstcase temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;
2. Gas Screening Value is the Borehole Gas Volume Flow Rate, in litres per hour, as defined in Wilson and Card (1999), which is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.



3.1.1. SOURCES OF GROUND GAS

The Phase I report and subsequent Ground Investigation has identified the following potential sources of ground gas:

-  Made Ground deposits
-  Infilled boating lake
-  Former marsh

The ground gas risk was classified as Low with the proposed end use deemed to be low to medium Risk in accordance with the assessment methodology proposed by CIRIA 665.

The ground conditions encountered are summarised below:

Made Ground

Made Ground was encountered within all exploratory hole locations to a maximum depth of 4.00 m, however the Made Ground is typically 0.5 m to 1.50 m bgl.

Made Ground deposits across the site are generally granular and comprise brown gravelly sand over a gravel sub-base to 0.20 m bgl. This was then underlain by a black ashy gravel containing mainly building materials to circa 1.50 m. However, porcelain tiles, timber and glass are present in a minority of the holes toward the south east of the site.

Black sandy silty clay with cobbles of brick and mudstone is present in thin layers at shallow depths 0.10 m to 1.50 m in isolated areas across the site.

A 2 m high bund is located in the eastern and western sectors of the site, however E3P did not excavate into these due to the knotweed present at the surface.

Drift

The drift deposits are encountered within all exploratory holes where the full depth of Made Ground was penetrated and generally comprise a firm low strength silty CLAY with an organic odour to circa 1.3 m which is underlain by a firm to stiff medium to high strength slightly gravelly CLAY. The gravel is medium coarse, sub-angular to sub-rounded of mudstone. This strata was encountered to bedrock at circa 15 m bgl.

Fibrous PEAT was encountered in isolated in TP101 between 1.30 m and 1.70 m bgl. It must be noted a large portion of the central sector could not be investigated and the historical maps show this sector to be former marsh. Therefore, it is anticipated that further organic soils could be encountered within this area of the site.

Solid

The cable percussive boreholes encountered weathered red SANDSTONE at 15.10 m bgl in BH101 and 16.60 m bgl in BH102.

3.1.2. GROUNDWATER

Groundwater levels were observed to fluctuate over the monitoring period with levels generally falling over the monitoring period. The greatest groundwater change occurred within WS104 where levels decreased by 0.9 m over the monitoring period. WS104 was set within a low permeability clay stratum and groundwater may be a result of a reduction in rainfall over the monitoring period.



3.1.3. GAS FLOW

During the monitoring a positive flow was noted in WS101, WS118, WS106, WS117, WS107, WS114, WS112, WS111, WS104 and WS109. The measure of positive flow is likely due to the varying air pressure throughout the monitoring period.

Negative flows are indicative of back pressure from wind being greater than the active flow from the wells and falling groundwater levels. Negative flows were recorded in all monitoring wells at some point during the monitoring period.

3.1.4. GAS CONCENTRATIONS

Methane has been recorded within monitoring wells at concentrations in excess of 1% within WS101 (2.5%v/v) and WS111 (4.5 v/v). No elevated concentrations were recorded within any of the remaining monitoring wells. WS101 was located within Made Ground whilst WS111 was within natural material.

Carbon dioxide concentrations were recorded within all the monitoring wells at concentrations ranging from 0.1% v/v to 13.5% v/v (WS103). The maximum carbon dioxide were also associated within low oxygen concentrations and appear to be associated with Made Ground which were identified in WS103.

WS103 and WS114 were installed within unnatural soils the with Made Ground exceeding 5.00m in WS103. WS114 was located within Made Ground containing silt which could have been the source of the CO₂,

WS109, WS112, WS111 are installed in close proximity within natural materials aware from any significant historical features, however elevated hydrocarbons were identified within soil samples taken from WS111 which is likely causing these elevated ground gas readings.

3.1.5. GAS ASSESSMENT

In accordance with the methodology outlined with the CIRIA publication C665, E3P have utilised the results of the ground gas monitoring surveys to calculate a tentative gas screening value (GSV). The GSVs for the monitoring positions are summarised in Table 3.2.

TABLE 3.2 GAS RISK PROFILE AND LOCATION

LOCATION	MAX CO ₂ (% v/v)	GSV (l/hr)	MAX CH ₄ (% v/v)	GSV (l/hr)	CLASSIFICATION
WS101	4.8	0.23664	2.5	0.12325	Amber 1
WS103	13.5	0.4347	0.4	0.01088	Amber 1
WS118	0.4	0.01264	0.1	0.00316	Green
WS106	4.9	0.04256	0.1	0.00259	Green
WS117	0.9	0.00234	0.1	0.00026	Green
WS107	1.7	0.0635	0.1	0.00374	Green
WS114	6.5	0.07865	0.1	0.00121	Amber 1
WS113	0.6	0.00612	0.1	0.0068	Green
WS109	10.1	-0.86355	0.1	0.094	Amber 1
WS112	6.4	0.63744	0.1	0.01136	Amber 1
WS111	11.3	1.28368	4.5	0.30572	Amber 1
WS104	1.4	0.00728	0.1	0.00052	Green



The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

Ground gas monitoring suggests that the site can be predominantly classified as Green and in these areas it is considered that gas protection measures will not be required. However, localised areas of the site have been assessed as being Amber 1 and properties within this area will likely require specialist protection measures as detailed below.

3.2. RESIDENTIAL BUILDING GAS RISK MITIGATION

British Standard BS8485 (2015)+A1(2019) provides two types of residential property that require assessment. These building types are:

- ✳ **Type A Building** – 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 are present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
- ✳ **Type B Building** – Private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small- to medium-sized rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels.

Based on the ground gas risk assessment and the proposed Type A Building, it is envisaged that a point score of 3.5 will be required for affected properties, as summarised in Table 3.3.

TABLE 3.3 BS8485 (2015)+A1(2019) POINTS REQUIRED FOR TYPE A AND TYPE B BUILDINGS

CHARACTERISTIC SITUATION	NHBC TRAFFIC LIGHT SYSTEM	MINIMUM GAS PROTECTION SCORE (POINTS)	
		HIGH SENSITIVITY	
		TYPE A BUILDING	TYPE B BUILDING
1	Green	0	0
2	Amber 1	3.5	3.5
3	Amber 2	4.5	4
4	Red	6.5 ^{A)}	5.5 ^{A)}
5	N/A	— ^{B)}	6
6	N/A	— ^{B)}	— ^{B)}

BS8485 (2015)+A1(2019) Notes

A) 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.

B) The gas hazard is too high for this empirical method to be used to define the gas protection measures.



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, for example, high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system such as in institutional and/or fully serviced contractual situations.

The requisite 3.5 points must be achieved by installation of a suitable combination of measures detailed in Table 3.4.

TABLE 3.4 SUMMARY OF GROUND GAS MITIGATION MEASURES – BS8485 (2015)+A1(2019)

GAS PROTECTION SCORES FOR THE STRUCTURAL BARRIER		SCORE ^A
Floor and Substructure Design		
Precast Suspended Segmental Subfloor (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 ^B
Basement Floor and Walls Conforming to BS 8102:2009, Grade 2 Waterproofing^{C D}		2
Basement Floor and Walls Conforming to BS 8102:2009, Grade 3 Waterproofing^{C D}		2.5
Notes 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 being provided by a suitable structural barrier with the design and detailing of the walls and floor meeting the requirements for Type B protection. The score cannot be assigned for Type A (waterproof membrane) or Type C (drained cavity wall). D) If a membrane is installed beneath and around the basement to provide Type A waterproofing (BS 8102:2009), it can be assigned a gas protection score in accordance with Table 7, if it meets all the criteria for a gas-resistant membrane in that table. When practical, utilities should enter the building above floor level with any conduit or meter housing being properly vented outside of the building.		
PROTECTION ELEMENT SYSTEM	SCORE	COMMENTS
Gas protection scores for ventilation protection measures		
(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 0.
(b) Passive Subfloor Dispersal Layer – 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; and ☛ No-fines gravel layer.	Very good performance	2.5
	Good performance	1.5
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 of BS 8485 (2015). Passive ventilation should be designed to meet at least “good performance”.		



(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”.
PROTECTION ELEMENT SYSTEM	SCORE	COMMENTS
(d) Active Positive Pressurisation – Provided 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].
Gas Protection Score for the Gas-Resistant Membrane		
Gas-resistant membrane meeting all of the following criteria: ✳ Sufficiently impervious to the gases with a methane gas transmission rate < 40 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); ✳ Capable, after installation, of providing a complete barrier to the entry of the relevant gas; and ✳ Verified in accordance with CIRIA C735.	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. If a membrane is installed that does not meet all the criteria opposite then the score is zero.
A) Membrane with a methane gas transmission rate < 40.0 ml/day/m²/atm (average) for sheets and joints (tested in accordance with BS ISO 15105-1:2007 manometric method) is regarded as sufficiently impervious. B) For example, reinforced LDPE (virgin polymer) membranes having a minimum mass per unit area of 370 g/m² and not significantly less than 0.4 mm thickness between the reinforcement scrim (tested in accordance with Procedure D (2 mm diameter tip) of BS EN ISO 9863-1:2016) installed above floor slabs are considered sufficiently strong to meet the performance criteria (see also C.3). Thicker and more robust membranes or an additional membrane protection layer should be installed directly beneath cast-in-situ floor slabs.		



END OF REPORT



APPENDIX I

LIMITATIONS

1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between E3P and the client as indicated in Section 1.3.
2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.
3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.
4. During the site walkover, reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover, no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not been made known or accessible.
5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.
6. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.
7. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials, this is for indicative purposes only and do not constitute or replace full and proper surveys.
8. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.
9. E3P cannot be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by E3P is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by E3P in this connection without their explicit written agreement there to by E3P.
10. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.



APPENDIX II

GLOSSARY

TERMS

ACM	Asbestos-containing material	MMP	Materials management plan
ADS	Acoustic design statement	ND	Not detected
AST	Above-ground storage tank	NDP	Nuclear density probe
BGS	British Geological Survey	NMP	Noise management plan
BSI	British Standards Institute	NPSE	Noise policy statement for England
BTEX	Benzene, toluene, ethylbenzene, xylenes	NR	Not recorded
CA	Coal Authority	PAH	Polycyclic aromatic hydrocarbon
CBR	California bearing ratio	PCB	Polychlorinated biphenyl
CIEH	Chartered Institute of Environmental Health	PI	Plasticity index
CIRIA	Construction Industry Research Association	PID	Photo ionisation detector
CLEA	Contaminated land exposure assessment	POS	Public open space
CML	Council of Mortgage Lenders	PPE	Personnel protective equipment
CoC	Contaminants of concern	ProPG	Professional practice guidance
CSM	Conceptual site model	QA	Quality assurance
DNAPL	Dense non-aqueous phase liquid (chlorinated solvents, PCB)	SGV	Soil guideline value
DWS	Drinking water standard	SPH	Separate-phase hydrocarbon
EA	Environment Agency	SPT	Standard penetration test
EQS	Environmental quality standard	SVOC	Semi-volatile organic compound
FFL	Finished floor level	TPH	Total and speciated petroleum hydrocarbon
GAC	General assessment criteria	TPH CWG	Total Petroleum Hydrocarbon (Criteria Working Group)
GL	Ground level	UKWIR	United Kingdom Water Infrastructure Risk
GSV	Gas screening value	UST	Underground storage tank
HCV	Health criteria value	VCC	Vibro-concrete column
ICSM	Initial conceptual site model	VOC	Volatile organic compound
LEL	Lower explosive limit	VRSC	Vibro-replacement stone columns
LMRL	Lower method reporting limit	VSC	Vibro-stone columns
LNAPL	Light non-aqueous phase liquid (petrol, diesel, kerosene)	WHO	World Health Organisation
MCV	Moisture condition value	WRAP	Waste and Resources Action Programme

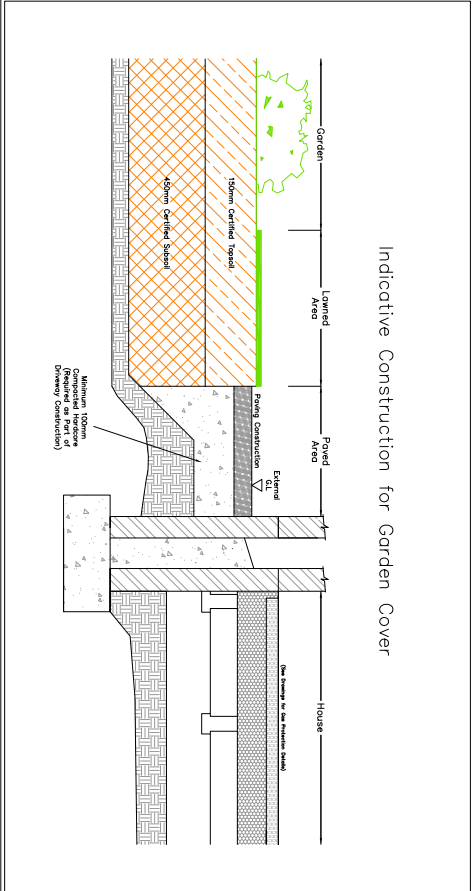
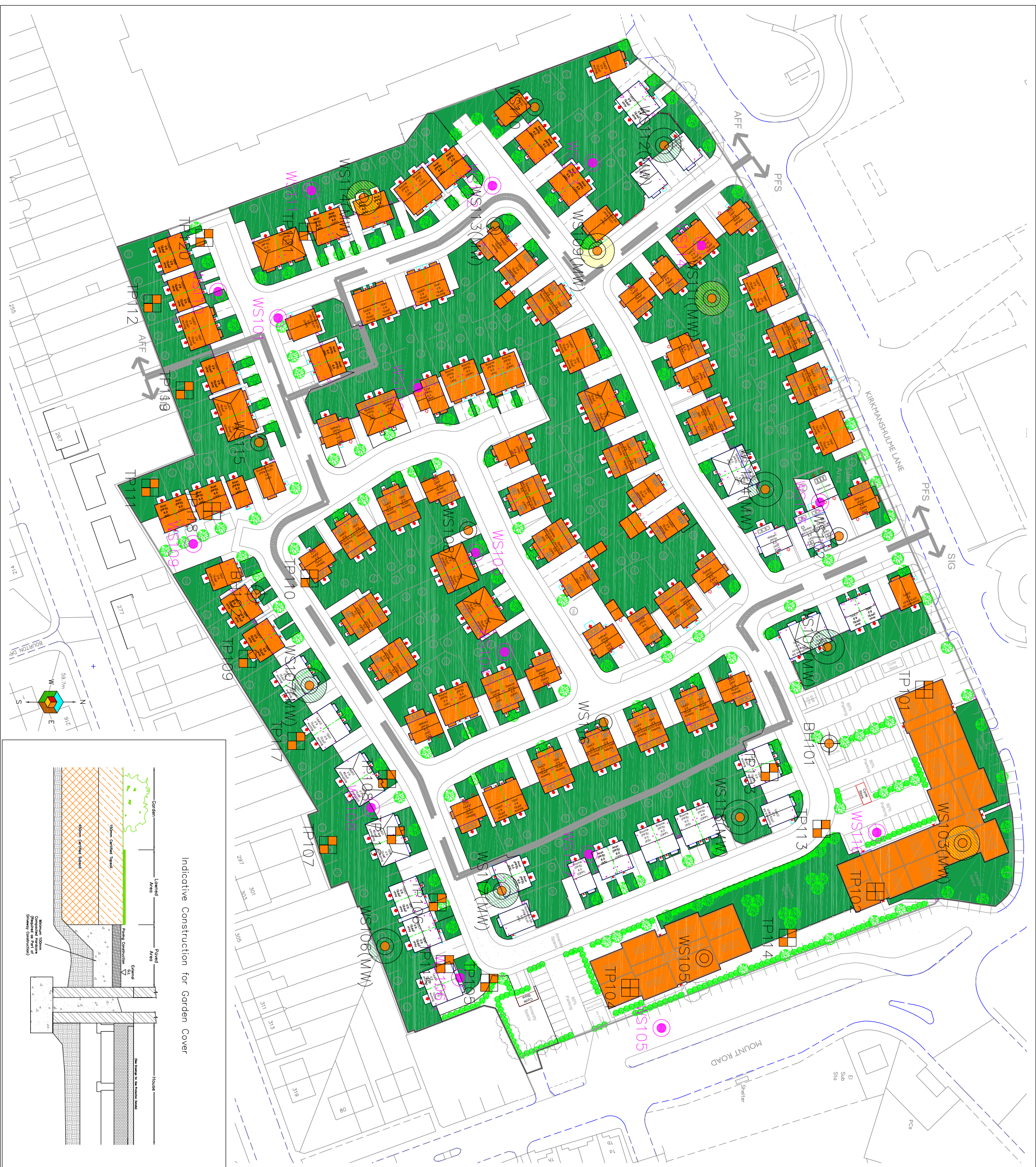


MIBK	Methyl isobutyl ketone	WTE	Water table elevation
m	Metres	ppm	Parts per million
km	Kilometres	mg/m³	Milligram per metre cubed
% v/v	Percent volume in air	m bgl bgl	Metres below ground level
mb	Millibars (atmospheric pressure)	m bcl	Metre below cover level
l/hr	Litres per hour	mAOD	Metres above ordnance datum (sea level)
µg/l	Micrograms per litre (parts per billion)	kN/m²	Kilonewtons per metre squared
ppb	Parts per billion	µm	Micrometre
mg/kg	Milligrams per kilogram (parts per million)	SSRT	Site Specific Remediation Target
PSD	Particle Size Distribution	DD	Dry Density
CL:AIRE	Contaminated Land: Applications in Real Environments	Mc	Moisture Content
ρ	Bulk Density	GPR	Ground Penetrating Radar
NDP	Nuclear Density Probe	FFL	Finished Floor Level
LEL	Lower Explosive Limit	UKWIR	UK Water Industry Research
CIRIA	Construction Industry Research and Information Association	LOD	Limit of Detection



APPENDIX III

DRAWINGS



Key:

Location Symbols

- WS101 Approximate Window Sample Probehole Location
- WS101(WW) Approximate Window Sample Probehole Location with Install
- TP101 Approximate Trial Pit Location
- BH101 Approximate Cable Percussive Borehole Location
- WS107 Approximate DB Window Sample Probehole Location

Remediation Treatment

- CS2/Amber 1 Private garden requiring 600mm certified cover comprising 150mm sub-soil and 450mm topsoil. Garden to be individually validated.
- Elevated Ground Gas
- No Ground Gas

Notes

N.B: All areas of identified contamination impact to soil and groundwater are estimated using best endeavors from historic and current intrusive investigation. However, the contractor must satisfy themselves of the potential extent of remediation works. The identified impact must be spatially delineated in accordance with the E3P Remediation strategy. The entire development site will require a 600mm chemically suitable cover system comprising of 150mm topsoil & 450mm subsoil with underlying orange 'no dig' geotextile membrane installed in all proposed garden areas to mitigate the elevated contaminant concentrations.

P1		-	26.02.2019	DRAFT	HM	SE
Phase		Revision	Date	Issue	Drawn	Authorised
Client:		Countrywide Properties		Job No:	12-123	Date: 26.02.2019
Job Title:		Belle Vue Stadium		Drawing Title:	Build Phase Mitigation Plan	Scale: NTS



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