Development Plot on Southgate Street, Long Melford	SUBADRA Environmental - Geotechnical - Laboratory - Foundations 13 Triangle Business Park, Stoke Mandeville, HP22 5BL Tel: 01296 739400 Email: consultants@subadra.com

GROUNWATER MONITORING REPORT AND RISK ASSESSMENT UPDATE

Report Prepared By:	Report Reviewed By:
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Client: Willowwalk (Thaxted) Developments Ltd	Subadra Consulting Ltd. Registered in England No. 4586038 Registered Office 13 Triangle Business Park, Stoke Mandeville, HP22 5BL	Report	FI03088 CL 024
		Date	October 2023
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1 Introduction

1.1 Purpose of Works

The site is located on Southgate Street, in Long Melford and comprises a cleared development plot. We understand that Willowwalk (Thaxted) Developments Ltd (Willowwalk) proposes to redevelop the site with residential housing, as detailed in a planning application references B/12/00875 and DC/23/00659 conditionally approved by Babergh District Council.

In July 2023 our Validation Monitoring Report and Updated Remedial Strategy was submitted to the Council to assist in the discharge of planning conditions 8-11 (planning Ref. DC/23/03362). As a consultees to the Local Planing Authority, the Environment Agency requested that two additional rounds of groundwater monitoring be carried to to provide additional confidence in the results presented in the submitted report.

We have been commissioned by Willowwalk to carry out the additional groundwater monitoring and also carry out monitoring for the presence of potentially hazardous ground gases in shallow soils. Our works are intended to assist in the discharge of Conditions 8-11.

This report provides the results of our additional environmental works and recommendations for further works (if required).

Your attention is drawn to the Notice to Interested Parties included as Attachment One.

1.2 Scope of Works

We have completed the following:

- Two site visits to carry out groundwater monitoring and obtain representative groundwater samples from the monitoring wells previously installed at the site;
- Screening of hazardous ground gases and hydrocarbon vapours using GA5000 series landfill gas monitor during both visits;
- Chemical analysis of representative groundwater water samples;
- Provision of this report, which details the results of our sampling visit, our assessment groundwater quality and ground-gas monitoring data, and provides recommendations for further works (if necessary).

All the activities comprising this assessment were carried out in accordance with the procedures set out in our Quality Manual.

1.3 Previous Reports Relating to the Site

We have produced the following reports on behalf of Willowwalk over the course of the last five years.

Our Ref.	Report Title	Date of Issue	Report Reference
Ref. 1	Remediation Strategy Report	December 2018	FI03088 CL 015
Ref. 2	Updated Detailed Quantitative Risk Assessment	February 2019	FI03088 CL 016
Ref. 3	Groundwater Monitoring Results	November 2019	FI03088 CL 019
Ref. 4	Update on Site Remediation	November 2020	FI03088 CL 020
Ref. 5	Investigation and Monitoring Report	October 2022	FI03088 CL 022
Ref. 6	Validation Monitoring Report and Updated Remediation Strategy	June 2023	FI03088 CL 023

We have used information from these documents, where relevant, in other sections of this report.

Table One: Previous Environmental Reports Relating to the Site

2 Groundwater Monitoring Data

2.1 Groundwater Monitoring

We competed the following works as part of our monitoring of groundwater quality at the site:

Visit Details	We attended site on two occasions to complete groundwater monitoring and sampling (21st/22nd August and 2nd/3rd October 2023).
Groundwater Monitoring	We recorded the depth to groundwater, where present, in all groundwater monitoring wells on-site using a water dip metre.
Groundwater Sampling	We purged all groundwater monitoring wells a minimum of three well volumes prior to sampling. We collected groundwater samples from the shallow wells (BH101 to BH105 and MW1), using low flow techniques, comprised of a peristaltic pump incorporating a flow through dedicated tubing into a multi-parameter cell which allows for collection of the following field measurements: pH, conductivity, temperature, redox potential, and dissolved oxygen. Samples were collected from the deep wells (BH1 to BH3) using tubing and an inertia pump.
Sample Preservation	Sub-samples were preserved in glass bottles and stored in cool boxes during transportation to the laboratory for subsequent analysis.

Table Two: Groundwater Monitoring and Sampling Methodologies

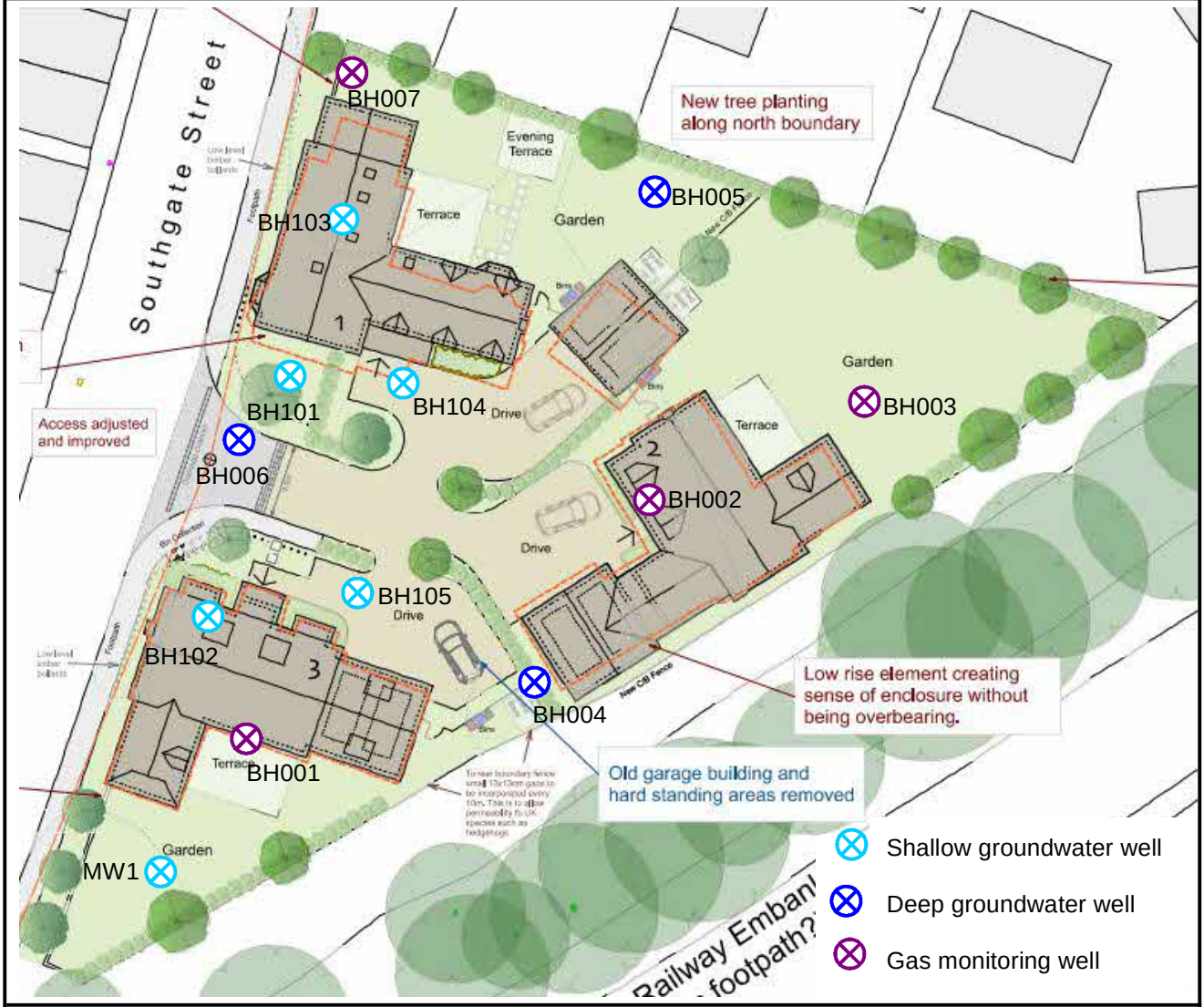


Figure One: Monitoring Well Locations

2.2 Groundwater Monitoring Data

Groundwater monitoring data is summarised in the following table.

		BH004	BH005	BH006	MW1	BH101
Borehole Elevation (mASD)		100.040	100.354	99.873	99.919	99.821
Response Zone (m bgl)		8.9 to 11.8	9.8 to 12.3	9.5 to 12.4	1.2 to 3.4	0.5 to 5.2
Groundwater Strike (m bgl)		-	-	-	-	N/R
Groundwater Rest Level 21/08/2023	m bgl	1.976	2.272	1.789	1.861	1.725
	m ASD	98.064	98.082	98.084	98.058	98.096
Groundwater Rest Level 2/10/2023	m bgl	1.973	2.270	1.787	1.866	1.726
	m ASD	98.067	98.084	98.086	98.053	98.095

		BH102	BH103	BH104	BH105	
Borehole Elevation (mASD)		99.912	100.094	100.003	99.901	
Response Zone (m bgl)		0.7 to 6.6	0.7 to 6.1	0.8 to 6.3	0.6 to 3.1	
Groundwater Strike (m bgl)		2.2	N/R	N/R	1.8	
Groundwater Rest Level 21/08/2023	m bgl	1.827	2.001	1.912	1.807	-
	m ASD	98.085	98.093	98.091	98.094	
Groundwater Rest Level 2/10/2023	m bgl	1.826	2.001	1.911	1.806	
	m ASD	98.086	98.093	98.092	98.095	
Groundwater Flow Direction		Piezometric plots, presented below, are consistent with previous data and indicate the following groundwater flow directions: Cretaceous Upper Chalk: To the east or south-east. River Terrace Deposits: Overall direction to the south, but some distortion in the north-western corner of the site.				
Notes		Groundwater elevations are ~0.7m lower than levels recorded in March and May 2023.				

Note: m bgl denotes metres below ground level, mASD denotes metres above arbitrary site datum. N/R - not recorded / not clear.

Table Three: Groundwater Monitoring Data

	August 2023					
	BH101	BH102	BH103	BH104	BH105	MW1
pH	7.1	6.8	7.1	7.0	7.6	6.7
DO (mg/litre)	4.3	0.41	1.1	4.9	0.1	0.23
ORP (mV)	-17.9	43.6	-23.8	24.7	-3.56	-268
Conductivity (mS/cm)	838	1280	787	814	1130	1650

	October 2023					
	BH101	BH102	BH103	BH104	BH105	MW1
pH	7.1	6.7	7.0	7.0	7.7	6.6
DO (mg/litre)	4.0	0.75	1.2	4.6	8.4	0.74
ORP (mV)	36.4	-118	-62.3	79.0	-243	-174
Conductivity (mS/cm)	878	1280	680	841	NR	1860

Note: N/R - not recorded / not clear.

Table Four: Low Flow Data, August and October 2023

2.3 Visual and Olfactory Signs of Hydrocarbon Contamination

BH004	BH005	BH006	MW1
None noted	None noted	None noted	Hydrocarbon odour. No sheen

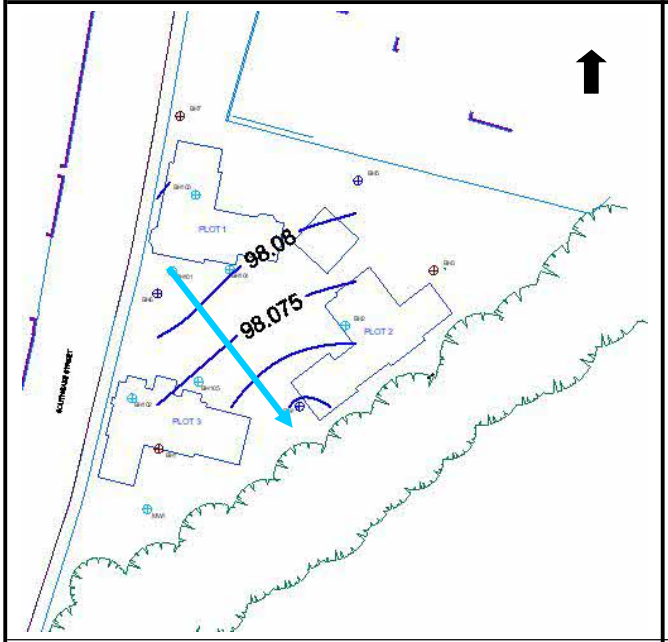
BH101	BH102	BH103	BH104	BH105
Hydrocarbon odour. No sheen	Hydrocarbon odour. No sheen	None noted	Faint hydrocarbon odour. No sheen	Hydrocarbon odour. No sheen

Table Five: Visual and Olfactory Signs of Hydrocarbon Contamination, 21st-22nd August 2023

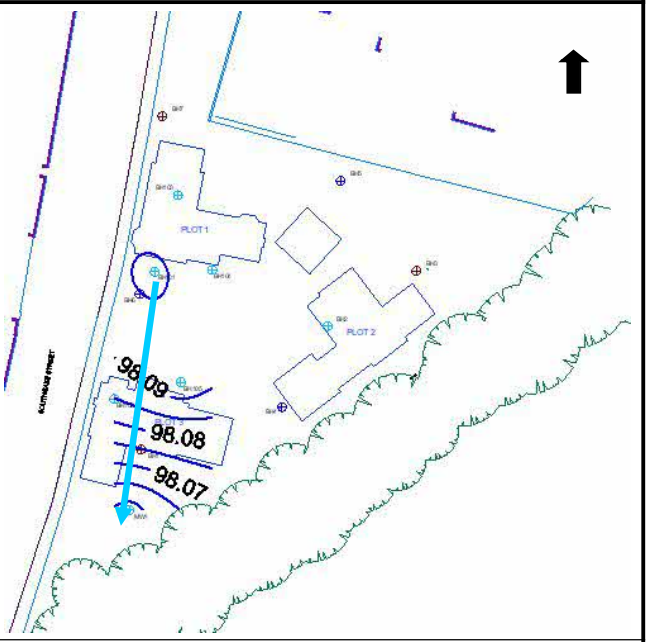
BH004	BH005	BH006	MW1
None noted	None noted	None noted	Faint hydrocarbon odour. No sheen

BH101	BH102	BH103	BH104	BH105
None noted	None noted	None noted	None noted	None noted

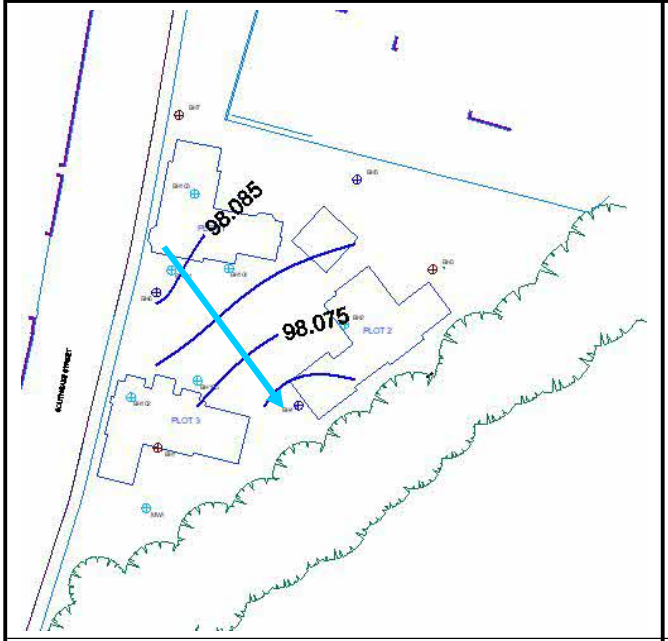
Table Six: Visual and Olfactory Signs of Hydrocarbon Contamination, 2nd - 3rd October 2023



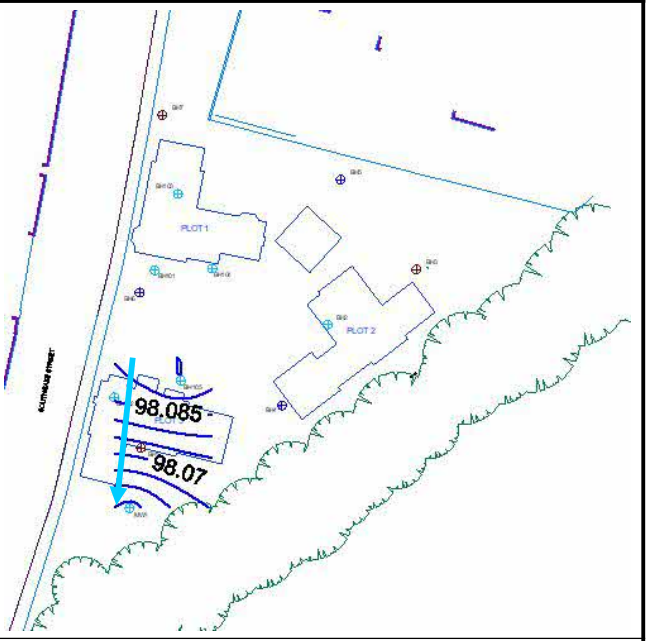
21/8/2023: Deep Boreholes (BH004, BH005 and BH006). Groundwater flow to the South-east



21/8/2023: Shallow Boreholes (MW1, BH101 to BH105). Overall groundwater flow to the South



2/10/2023: Deep Boreholes (BH004, BH005 and BH006). Groundwater flow to the South-east



2/10/2023: Shallow Boreholes (MW1, BH101 to BH105). Overall groundwater flow to the South

Figure Two: Piezometric Plots

3 Chemical Analysis Results

3.1 Chemical Analysis Rationale

Analysis	Rationale	No. Samples Analysed	
		August	October
Total Petroleum Hydrocarbons (TPHCWG) reported by carbon range and with aromatic and aliphatic speciation	Representative of compounds present in petrol, diesel and lube oils but with additional information regarding composition of contaminant source	9	9
Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)	Representative of compounds present in petrol	9	9
Polycyclic Aromatic Hydrocarbons	Representative of compounds present in diesel and lube oil	9	9

The results of our analysis are summarised in the following tables. Certificates for all chemical analysis are included in Attachment Three.

Table Seven: Schedule of Analysis

3.2 Groundwater Analysis, 21st-22nd August 2023

Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
C_{6-8} Aliphatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{8-10}$ Aliphatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{10-12}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{12-16}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{16-21}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{21-35}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
C_{6-8} Aromatic TPH	<10	<10	<10	<10	<10	<10	<10	**27.2**	<10
$>C_{8-10}$ Aromatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{10-12}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{12-16}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{16-21}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{21-35}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table Eight: Speciated TPH Analysis Results - Groundwater, 22nd August 2023

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Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
MTBE	<25	<25	<25	<25	<25	<25	<25	**42.1**	<25
Benzene	<5	<5	<5	<5	<5	<5	<5	**26**	<5
Toluene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
p+m Xylene	<10	<10	<10	<10	<10	<10	<10	<10	<10
o Xylene	<5	<5	<5	<5	<5	<5	<5	<5	<5

Table Nine: BTEX Analysis Results - Groundwater, 22nd August 2023

Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
Naphthalene	<0.01	<0.01	<0.01	<0.01	**0.11**	<0.01	<0.01	**0.50**	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.07**	**0.02**
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.05**	**0.02**
Phenanthrene	**0.05**	<0.01	<0.01	<0.01	<0.01	<0.01	**0.03**	**0.05**	**0.10**
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	**0.19**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	**0.17**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	**0.04**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	**0.05**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	**0.03**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	**0.02**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	**0.03**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi)perylene	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Total PAHs (EPA16)	**0.58**	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	**0.67**	<0.16

Table Ten: PAHs Analysis Results - Groundwater, 22nd August 2023

3.3 Groundwater Analysis, 2nd-3rd October 2023

Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
C_{6-8} Aliphatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{8-10}$ Aliphatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{10-12}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{12-16}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{16-21}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{21-35}$ Aliphatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
C_{6-8} Aromatic TPH	<10	<10	<10	<10	<10	<10	<10	**18.2**	<10
$>C_{8-10}$ Aromatic TPH	<10	<10	<10	<10	<10	<10	<10	<10	<10
$>C_{10-12}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{12-16}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{16-21}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50
$>C_{21-35}$ Aromatic TPH	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table Eleven: Speciated TPH Analysis Results - Groundwater, 2nd - 3rd October 2023

Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
MTBE	<25	<25	<25	<25	<25	<25	<25	<25	<25
Benzene	<5	<5	<5	<5	<5	<5	<5	**18.2**	<5
Toluene	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
p+m Xylene	<10	<10	<10	<10	<10	<10	<10	<10	<10
o Xylene	<5	<5	<5	<5	<5	<5	<5	<5	<5

Table Twelve: BTEX Analysis Results - Groundwater, 2nd - 3rd October 2023

Analyte	Sample Details and Results (µg/l)								
	BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
Naphthalene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.22**	**0.01**
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.03**	**0.02**
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.02**	**0.01**
Phenanthrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.02**	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.01**	< 0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi)perylene	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Total PAHs (EPA16)	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	**0.3**	<0.16

Table Thirteen: PAHs Analysis Results - Groundwater, 2nd-3rd October 2023

3.4 Summary of Analysis Results

3.4.1 Chalk Aquifer

We did not encounter detectable concentrations of TPH or BTEX compounds in samples from the three monitoring wells installed into the chalk aquifer on either of our most recent monitoring rounds. This is consistent with previous results.

We recorded low concentrations of PAHs in the sample obtained from in BH004 in August 2023. PAH concentrations returned to below detection limits in the October 2023 samples. Three previous monitoring rounds, one in July 2022 and two in March 2023, recorded no detectable concentrations of PAH in any of the deep monitoring wells. We consider the results from August 2023 to be anomalous (perhaps resulting from cross contamination during sampling etc) and not fully representative of groundwater quality in this borehole.

3.4.2 Drift Deposits

In the latest two monitoring rounds we recorded low concentrations of TPH, benzene and MTBE in BH105 and low concentrations of PAHs in BH102, BH104 and MW1

We recorded a rapid decline in recorded concentrations in the period following borehole installation (Ref.6). The latest two rounds of monitoring confirm that dissolved concentrations have remained low, indicating that groundwater has equilibrated and only limited dissolved concentrations of hydrocarbons remain. The following table presents the highest recorded concentrations of selected contaminants of concern.

Contaminant of Concern	Maximum Concentration Recorded in Shallow Groundwater (µg/litre)					
	November 2018	March 2023 (early)	March 2023 (mid)	May 2023	August 2023	October 2023
Benzene	1,960 (MW4)	11.1 (BH105)	18.0 (BH105)	37.7 (BH105)	26 (BH105)	18.2 (BH105)
Toluene	15,600 (MW4)	6.6 (BH103)	<5	<5	<5	<5
Ethylbenzene	7,300 (MW4)	<5	<5	<5	<5	<5
Xylenes	42,000 (MW4)	2,570 (BH103)	<15	<15	<15	<15
MTBE	2,840 (MW4)	<10	<10	59.3 (BH105)	42.1 (BH105)	<25
TPH Aromatic C_{6-8}	22,400 (MW3)	712 (BH103)	56.4 (BH103)	39.8 (BH105)	27.3 (BH105)	18.2 (BH105)
TPH Aromatic C_{8-10}	40,300 (MW3)	9,310 (BH103)	2,120 (BH103)	<10	<10	<10
TPH Aromatic C_{10-12}	18,400 (MW3)	905 (BH103)	331 (BH103)	<50	<50	<50
TPH Aromatic C_{12-16}	12,500 (MW3)	50.2 (BH105)	<50	<50	<50	<50
TPH Aromatic C_{16-21}	567 (MW2)	<50	<50	<50	<50	<50
TPH Aromatic C_{21-35}	Not Detected	217 (BH105)	<50	<50	<50	<50

Table Fourteen: Comparison of Contaminant Concentrations Over Time (Shallow Drift Deposits)

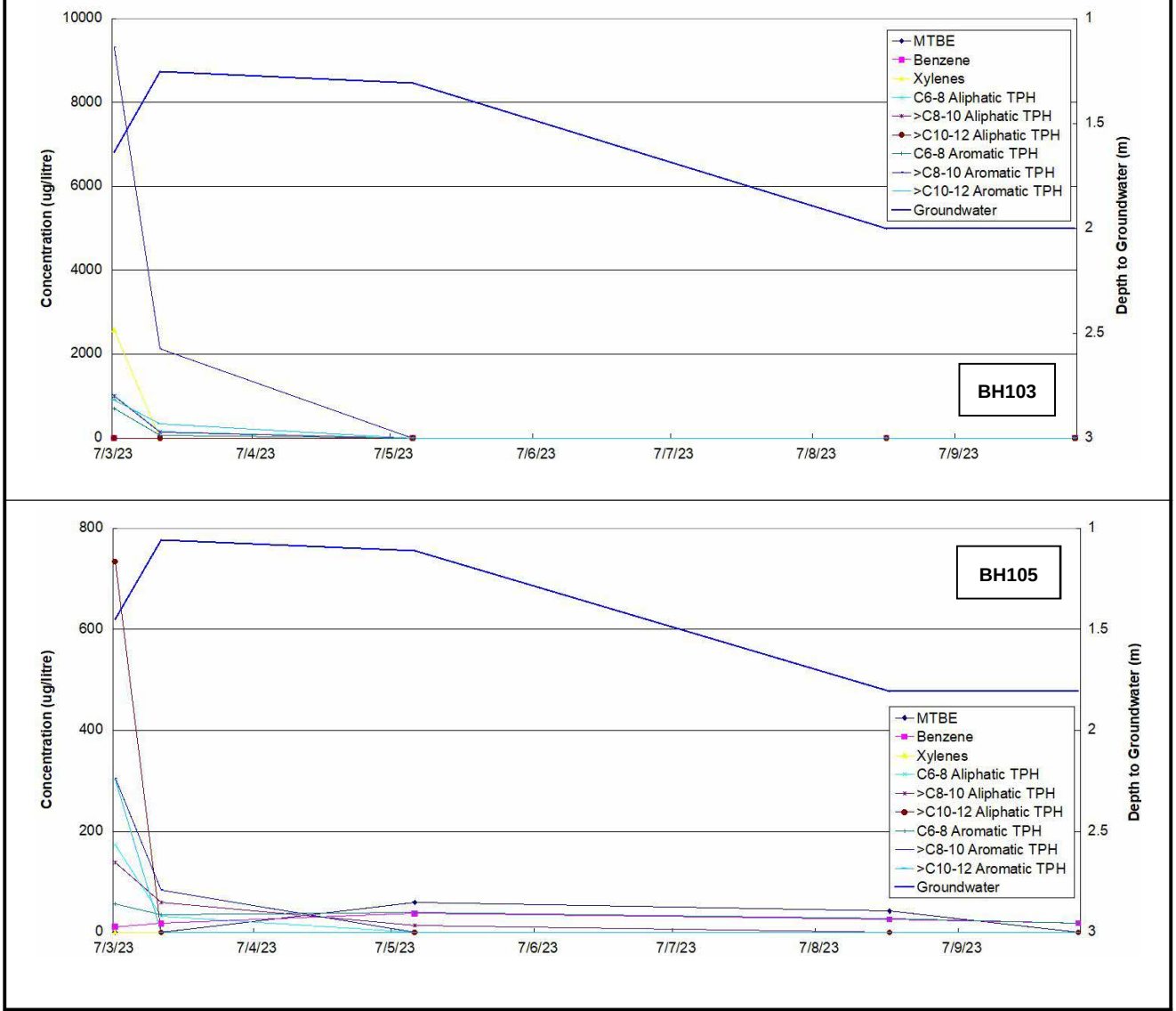

Figure Three: Contamination Concentrations and Groundwater Levels

We have plotted dissolved contaminant concentrations against depth to groundwater for BH103 and BH105, presented in Figure Three above. The results indicate that the most significant drop in concentrations in both wells occurred between 7th and 17th March 2023, within the first month following monitoring well construction. Over this period groundwater level rose by ~0.4m.

In BH103 a further decrease to non-detect concentrations was recorded between 17th March and 11th May, when there was a slight decrease in groundwater elevation. No detectable concentrations of hydrocarbons were recorded in the following two monitoring rounds when groundwater levels were ~0.7m lower than peak (recorded) groundwater levels.

In BH105 concentrations have remained low, albeit fluctuating during the monitoring period.

These results demonstrate dissolved concentrations of contaminants remained low during both high (May 2023) and low (August and October 2023) groundwater levels. This suggests that the initial high concentrations recorded in March 2023 were due to disturbance of the ground during monitoring well construction and that the more recent monitoring rounds are representative of groundwater quality under the site. Given concentrations remain relatively consistent at low and high water levels, there appears to be no significant seasonal change in contaminant concentrations (as is often observed at such sites).

4 Updated Detailed Quantitative Risk Assessment for Controlled Water

We have updated our risk assessment for controlled water to used screening criteria as presented in the following table, and revised source data.

4.1 Conceptual Site Model

4.1.1 Source

Over the last three monitoring rounds (May, August and October 2023) following equilibration of the monitoring wells, we have recorded benzene, MTBE, aromatic TPH C6-8 and PAHs, in BH105. We have also recorded low concentrations of PAHs in BH102, BH104 and MW1. We have carried out an initial screening exercise to determine whether these concentrations exceed the relevant water quality targets.

Contaminant of Concern	Maximum Concentration Recorded (µg/litre)	Location, Date	Water Quality Target *	Water Quality Target Exceeded?
Benzene	37.7	BH105, May 2023	10	Yes
Toluene	<5	-	74	No
Ethylbenzene	<5	-	300	No
Xylenes	<15	-	30	No
MTBE	59.3	BH105, May 2023	15	Yes
Naphthalene	0.50	BH105, August 2023	2.0	No
TPH Aliphatic C_{6-8}	<50	-	15,000	No
TPH Aliphatic C_{8-10}	13.7	BH105, May 2023	300	No
TPH Aliphatic C_{10-12}	<50	-	300	No
TPH Aliphatic C_{12-16}	<50	-	300	No
TPH Aliphatic C_{16-35}	<50	-	-	-

Table continued on following page

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Contaminant of Concern	Maximum Concentration Recorded (μg/litre)	Location, Date	Water Quality Target *	Water Quality Target Exceeded?
TPH Aromatic C_{6-8}	39.8	BH105, May 2023	700	No
TPH Aromatic C_{8-10}	<50	-	300	No
TPH Aromatic C_{10-12}	<50	-	90	No
TPH Aromatic C_{12-16}	<50	-	90	No
TPH Aromatic C_{16-21}	<50	-	90	No
TPH Aromatic C_{21-35}	<50	-	90	No

Note: * CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies CL:AIRE, London. Sources provided in Attachment Three.

Table Fifteen: Generic Risk Assessment Screening

The results, presented in the table below, indicate that concentrations of benzene and MTBE, recorded in BH105 exceed the theoretical screening criteria. For completeness, we have carried out a detailed quantitative risk assessment for all contaminants included in our previous risk assessment: BTEX compounds, MTBE and TPH aromatic fractions, based on a source in BH105.

4.1.2 Pathways and Receptors

We have not recorded hydrocarbon impact in the chalk aquifer (excluding anomalous PAH results) and we have therefore carried out no further assessment of this receptor.

The primary pollutant linkage has been identified as lateral migration of hydrocarbons within the River Terrace Deposits (Secondary (A) Aquifer) to the wider aquifer and to the River Stour ~220m west of site and a tributary/drain leading to the river ~50m west of the site.

Site data indicates that groundwater flow in the drift deposits is to the south, parallel to the direction of flow of the River Stour, rather than directly towards the river, however the plot is distorted around the northern end of the site and flow gradient cannot be determined with any degree of certainty.

4.2 Methodology

We have evaluated the risk to controlled water receptors using the Environment Agency's 'Remedial Targets Methodology Hydrogeological Risk Assessment for Land Contamination' (RTM). We have used RTM to determine site specific assessment criteria for the site that will be protective of groundwater. To do this we use a fate-transport model to calculate the likely impact on groundwater quality in a hypothetical compliance well located 50m and 100m from the contaminant source.

We have then determined the maximum concentration of each contaminant that will not give rise to a concentration in the compliance well that exceeds pre-determined criteria. In this assessment the compliance criteria comprise Environmental Quality Standards.

Full details of the model's input parameters are included as Attachment Three.

4.3 Results

The results of our assessment of groundwater quality are presented in the following table.

Compound	Maximum Concentration Recorded on Site (µg/l)	Screening Criteria	Site-Specific Target(µg/litre)		Pass/Fail	
			50m	100m	50m	100m
Benzene	26 (BH105)	10	80.7	669	Pass	Pass
Toluene	Not detected	74	1,200	16,100	Pass	Pass
Ethylbenzene	Not detected	300	4,850	65,100	Pass	Pass
Xylenes	Not detected	30	485	6,510	Pass	Pass
MTBE	42.1 (BH105)	15	61.7	299	Pass	Pass
TPH Aromatic C_{6-8}	39.8 (BH105)	700	Solubility	Solubility	Pass	Pass
TPH Aromatic C_{8-10}	Not detected	300	6.520	Solubility	Pass	Pass
TPH Aromatic C_{10-12}	Not detected	90	853	7,950	Pass	Pass
TPH Aromatic C_{12-16}	Not detected	90	1,410	Solubility	Pass	Pass
TPH Aromatic C_{16-21}	Not detected	90	322	Solubility	Pass	Pass
TPH Aromatic C_{21-35}	Not detected	90	Solubility	Solubility	Pass	Pass

Note: Solubility– target is greater than solubility limit.: target is removal of free-phase, if present.

Table Sixteen: Groundwater Targets - Protective of Controlled Water Receptors

The results of our updated risk assessment for controlled water indicates that none of the concentrations recorded in the drift deposits over the last three monitoring rounds exceed the generated Site Specific Assessment Criteria, indicating they do not pose a significant risk to identified controlled water receptors.

5 Hazardous Ground Gas Assessment

5.1 Monitoring Details

Visit Details	We attended site to complete hazardous ground as monitoring on 22nd August and 2nd October 2023.
Screening for Hazardous Ground Gases	During both site visits we carried out screening for hazardous ground gases in the dedicated ground-gas monitoring wells (BH001-BH003 and BH007) and in other monitoring wells on site (BH101-BH105 and MW1). Monitoring was completed using a GA5000 series landfill gas monitor, designed to record concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and oxygen (and flow readings).
Hydrocarbon Vapours	During the August visit we carried out semi-quantitative screening for hydrocarbon vapours using a photo-ionisation detector (PID) calibrated with isobutylene gas.

Note: m bgl denotes metres below ground level, mASD denotes metres above arbitrary site datum

Table Seventeen: Gas Screening Completed

5.2 Previous Data

We have carried out three previous rounds of ground gas monitoring: 14th July 2022, 7th March 2023 and 17th March 2023. The results of these monitoring rounds indicated significant concentrations of ground-gases were not present, with the site being classified as Characteristic Situation One and NHBC Traffic Light Classification Green. Based on the results of our preliminary assessment, we noted gas protection measures were not required, subject to the completion of further monitoring (in accordance with relevant guidance).

5.3 Hazardous Ground Gas Monitoring Data

The result of our monitoring for hazardous ground gases are provided in the following table.

		BH 001	BH 002	BH 003	BH 007	BH 101	BH 102	BH 103	BH 104	BH 105	MW1
Groundwater Rest Level (m bgl)		1.538	Dry	Dry	1.365	1.725	1.827	2.001	1.912	1.807	1.861
PID reading (ppm)	Peak	0	0	0	0	0	0	0	0	0	0
	Stable	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide (%)	Peak	0	0	0	0	0	0	0	18	0	0
	Stable	0	0	0	0	0	0	0	18	0	0
Hydrogen Sulphide (%)	Peak	0	0	0	0	0	0	0	0	0	0
	Stable	0	0	0	0	0	0	0	0	0	0

Table continued on following page

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		BH 001	BH 002	BH 003	BH 007	BH 101	BH 102	BH 103	BH 104	BH 105	MW1
Methane (%)	Peak	0.1	0.1	0.1	0	0	0.1	0	0.2	0.1	0.1
	Stable	0	0	0	0	0	0	0	0.1	0	0.1
Carbon Dioxide (%)	Peak	7.7	4.6	0.5	1.3	8.8	8.6	1.1	2.6	7.4	6.2
	Stable	5.8	4.6	0.4	1.1	7.9	8.6	1.1	1.3	7.4	6.2
Oxygen (%)	Min	10.9	16.9	19.7	20.0	12.2	10.8	20.2	17.3	14.6	13.4
	Stable	14.0	16.9	20.7	20.1	13.2	10.8	20.2	19.2	14.8	13.4
Flow (L/hr)	Peak	0.1	0.1	0.1	0.1	0	0.1	0	0.1	0.1	0
	Stable	0.1	0.1	0.1	0.1	0	0.1	0	0.1	0	0
Time to Stabilise (mins)		5	5	5	5	5	5	5	5	5	5
Weather		Sunny with no precipitation.									
Barometric Pressure		1012 to 1019hPa rising									

Table Eighteen: Ground Gas Monitoring Data, 22nd August 2023

		BH001	BH002	BH003	BH007	BH101	BH102	BH103	BH104	BH105	MW1
Groundwater Rest Level (m bgl)		1.513	Dry	Dry	1.364	1.726	1.826	2.001	1.911	1.806	1.866
Methane (%)	Peak	0.1	0	0.1	0	0.1	0	0	0.2	0	0
	Stable	0	0	0	0	0	0	0	0.2	0	0.1
Carbon Dioxide (%)	Peak	7.8	3.1	1.8	2.2	10.7	8.4	3.4	3.0	0.9	8.6
	Stable	7.2	3.1	0.6	2.2	10.7	8.4	3.4	2.9	0.9	5.6
Oxygen (%)	Min	8.6	17.5	19.8	18.4	6.2	10.8	14.8	16.8	19.6	14.8
	Stable	9.6	17.5	20.8	18.6	6.2	10.8	15.0	17.1	19.6	14.8
Flow (L/hr)	Peak	0	0.1	0.1	0	0	0	0	0	0	0
	Stable	0	0.1	0	0	0	0	0	0	-0.1	0
Time to Stabilise (mins)		5	5	5	5	5	5	5	5	5	5
Weather		Overcast with no precipitation.									
Barometric Pressure		1017 to 1015hPa falling									

Table Nineteen: Ground Gas Monitoring Data, 2nd October 2023

5.4 Preliminary Gas Screening Assessment

To establish whether the concentrations of methane and carbon dioxide are present at potentially hazardous concentrations in shallow soils in the vicinity of the shop building, we have calculated Gas Screening Values (GSV) using our monitoring data. These were calculated using gas concentrations and flow rates, in accordance with the methodologies and guidance presented within BS8485 (2015).

In order to assure conservatism within our assessment we have used maximum gas concentrations and flow rates recorded at each location when calculating GSVs.

		BH1	BH2	BH3	BH7	BH 101	BH 102	BH 103	BH 104	BH10 5	MW1
Gas Screening Value (l/hr)	CH_4	<0.07									
	CO_2	<0.07									
Risk Classification (CIRIA C665)		Very Low Risk									
Characteristic Situation (CIRIA 149)		CS2 Although all of the calculated Gas Screening Values are <0.07l/hr, generally classified as CS1/Very low risk, we have recorded concentrations of CO_2 >5% in five monitoring wells in August and in four monitoring wells in October 2023.									
NHBC Traffic Light Classification		Amber 1									

Table Twenty: Gas Screening Value for CO_2 and Methane

The low Gas Screening Values calculated are consistent with the previous two rounds of monitoring, however we recorded higher concentrations of carbon dioxide in the recent monitoring rounds indicating a higher Risk Classification than previously recorded.

In addition we recorded a high concentration of carbon monoxide in one monitoring well (BH104).

The results of our latest screening indicate ground-gases recorded in wells on the western part of the site are likely to be classified as Characteristic Situation Two and NHBC Traffic Light Classification Amber 1 (see Figure Four). This indicates that, to protect future residents from ground gases, low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings.

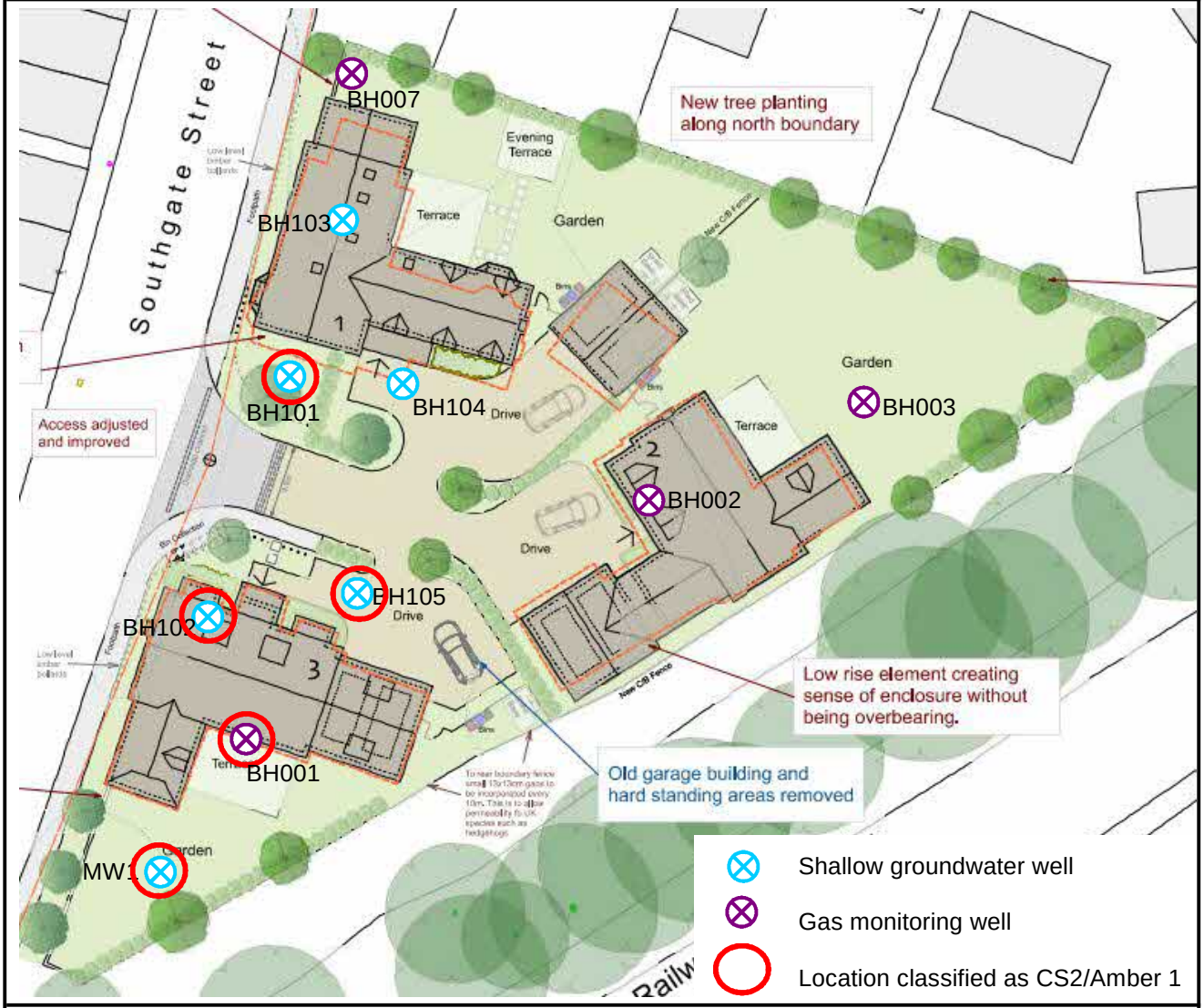

Figure Four: Gas Monitoring Well Locations

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6 Conclusions

6.1 Groundwater Quality

We completed two rounds of groundwater monitoring to confirm the results of our previous monitoring rounds. We did not encounter detectable concentrations of TPH or BTEX compounds in samples from the chalk aquifer on either of these monitoring rounds. This is consistent with previous results, indicating no significant impact of the chalk aquifer. Low concentrations of PAHs recorded in one well in August 2023 were inconsistent with the non-detect values recorded in the other four monitoring rounds completed in 2023 and are therefore considered anomalous and not representative of groundwater quality at the site.

We recorded low concentrations of TPH, benzene and MTBE in BH105 and low concentrations of PAHs in three other wells, installed within the drift deposits. This is consistent with monitoring results from May 2023. These results indicate that the initial higher concentrations, recorded in March 2023, were most likely due to disturbance of the ground during monitoring well construction and that the more recent monitoring rounds are representative of groundwater quality under the site, which are consistent at low and high water levels.

We have updated our risk assessment for controlled water to use recommended screening criteria and revised source data. The results indicate that the hydrocarbon concentrations recorded in drift deposits over the last three monitoring rounds do not pose a significant risk to identified controlled water receptors.

6.2 Ground-gas

We have carried out four rounds of ground-gas monitoring in shallow wells at the site.

The results of our latest screening indicate ground-gases are likely to be classified as Characteristic Situation Two and NHBC Traffic Light Classification Amber 1. This indicates that, to protect future residents from ground gases, low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings.

Your attention is drawn to the Notice to Interested Parties included as Attachment One.

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ATTACHMENT ONE:
NOTICE TO INTERESTED PARTIES

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NOTICE TO INTERESTED PARTIES

The purpose of our work Is to provide general information on the environmental And/Or geotechnical conditions existing at the site And related to soil And/Or groundwater. The Client Or others specified the scope of the investigation And the validity of our conclusions Is limited by the scope of work specified. We are Not responsible for any such limitations Or omissions.

Where stated in this report, we have used information supplied by third parties. While we have evaluated As far As possible the validity Of this information, we cannot guarantee its accuracy In any way whatsoever.

No investigation technique Is capable Of completely identifying all Of the contaminants that might be present In the soil Or groundwater under a site. Where specified In our report, we have examined the ground by constructing a number Of boreholes And/Or trial pits. We recovered samples Of soil And/Or groundwater from available exposures.

The depth And spacing Of our Sampling locations were selected To ensure With a reasonable probability that they would be representative Of the actual conditions across the whole site. However, safety considerations relating To existing site infrastructure may have restricted our ability To investigate all potential contaminant sources. Specifically, we were unable To investigate the soil And groundwater condition immediately adjacent To the underground structures And/Or buried services. These limitations must be borne In mind When considering the conclusions reached In this report.

Soil Is intrinsically variable And the spread Of contaminants within the soil Is therefore subject To a degree Of non-uniformity. For these reasons no sampling technique can completely eliminate the possibility Of obtaining samples that are Not representative Of the actual conditions. Our sampling techniques are intended To reduce the possibility To an acceptable level, within the limits imposed by the scope of the investigation.

Groundwater levels And soil vapour levels that we report were accurate at the time of the investigation. Groundwater And soil vapour levels are variable. Long term monitoring may be required to ensure that the levels recorded during our investigation are representative of long term And possible 'worst case' conditions. In accepting our recommendations and/or conclusions the Client acknowledges that further, more detailed investigation would allow a more accurate assessment of site conditions to be made and that this would reduce any consequential risk to the Client.

Our investigation was carried out to assess the significance of contamination resulting from use of the site as identified in this report. Unless we have indicated otherwise, no assessment of the potential impact of any other previous uses has been made. No investigation was carried out to determine whether or not any deleterious or hazardous materials (such as asbestos) have been used in the construction of the buildings present on the site. Unless otherwise stated no investigation or assessment has been made of the presence or otherwise of invasive plant species including but not limited to Japanese Knotweed.

Unless specifically stated otherwise, we have not assessed the effect of any proposed future construction activities on existing structures on or near to the site. Nor, unless stated otherwise, have we assessed the likely effect of trees on existing or proposed structures on or near the site.

We do not accept any responsibility for the cost of remedial works or other costs incurred in whatever way whatsoever as a result of any omissions, errors or other shortcomings in this report unless we have been given reasonable opportunity to verify ourselves that such faults exist and we have been given a reasonable opportunity to carry out works to remedy such faults ourselves using the most practicable means available to us. We do not accept liability for any consequential losses incurred by you while either we or others carry out any remedial works we deem necessary.

This report has been prepared for the Client, as specified on the cover page of this report. In accepting our recommendations and/or conclusions the Client accepts that the terms of our appointment were as detailed in the Proposal, or Proposals, that we provided to the Client before being appointed and that these terms supersede any other terms and/or conditions set out in any contracts agreed between ourselves and the Client, regardless of when such terms and/or conditions were agreed to by us and/or signed by us.

Use of, and reliance on, this report by other third parties will be at such third parties own risk, and we do not accept any liability or responsibility to them.

Neither the whole nor any part of this report, or any reference to it, may be included in any published document circular or statement or published in any way without our prior written approval.

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ATTACHMENT TWO:
CHEMICAL ANALYSIS CERTIFICATES

Report No 13346

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Project	FI03088 Southgate Service Station	Sampled	22nd August 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - TPH CWG - 22nd August 2023

Analyte	Unit	Method Detection Limit	Sample Details									
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1	
			1.98m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.86m	
C6-8 Aliphatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C8-10 Aliphatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C10-12 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C12-16 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C16-21 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C21-35 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
C6-8 Aromatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	27.2	<10	
>C8-10 Aromatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C10-12 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C12-16 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C16-21 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C21-35 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	

Method: C6 to C10 bands: Determined by headspace GC-FID (E6.3 and E7.1). C10 to C40 bands: Determination of hexane extractable hydrocarbons by GCxGC-FID (E6.5 and E7.2). Samples unfiltered.

The results included within the report relate only to the sample(s) submitted for testing.
Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25617	Analysed	WS 25/08/23
Received	WS 24/08/23	Reported	KC 01/09/23
Prepared	WS 24/08/23	Page	One of One

Report No 13317

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Project	FI03088 Southgate Service Station	Sampled	22nd August 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - BTEX and MTBE - 22nd August 2023

Analyte	Unit	Method Detection Limit	Sample Details								
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
			1.98m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.86m
MTBE [2]	ug/l	25	<25	<25	<25	<25	<25	<25	<25	42.1	<25
Benzene [2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	26	<5
Toluene [2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene [2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
p+m Xylene [2]	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10
o Xylene [2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Method: Determined by headspace GC-FID(Methods E6.3 and E7.1). Analysed as unfiltered sample.

2. UKAS ISO17025
The results included within the report relate only to the sample(s) submitted for testing.
Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25615	Analysed	WS 25/08/23
Received	WS 24/08/23	Reported	KC 30/08/23
Prepared	WS 24/08/23	Page	One of One

Report No 13345

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Project	FI03088 Southgate Service Station	Sampled	22nd August 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - PAHs (EPA16) - 22nd August 2023

Analyte	Unit	Method Detection Limit	Sample Details								
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1
			1.98m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.86m
Naphthalene [3]	ug/l	0.01	<0.01	<0.01	<0.01	< 0.01	0.11	< 0.01	<0.01	0.50	<0.01
Acenaphthylene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthene [3]	ug/l	0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01	< 0.01	0.07	0.02
Fluorene [3]	ug/l	0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.02
Phenanthrene [3]	ug/l	0.01	0.05	< 0.01	<0.01	<0.01	<0.01	< 0.01	0.03	0.05	0.10
Anthracene [3]	ug/l	0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoranthene [3]	ug/l	0.01	0.19	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01	< 0.01
Pyrene [3]	ug/l	0.01	0.17	<0.01	<0.01	< 0.01	< 0.01	< 0.01	<0.01	<0.01	< 0.01
Benzo(a)anthracene [3]	ug/l	0.01	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene [3]	ug/l	0.01	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene [3]	ug/l	0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene [3]	ug/l	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene [3]	ug/l	0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenzo(ah)anthracene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene [3]	ug/l	0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Total PAHs (EPA16) [3]	ug/l	0.16	0.58	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	0.67	<0.16

Method: Determined by concentration through SPE cartridge, collection in DCM followed by GC-MS (Filtered)

3. Subcontracted

The results included within the report relate only to the sample(s) submitted for testing.
Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25616	Analysed	
Received	WS 24/08/23	Reported	KC 01/09/23
Prepared		Page	One of One

Report No 13449

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Project	FI03088 Southgate Service Station	Sampled	2nd October 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - TPH CWG - 2nd October 2023

Analyte	Unit	Method Detection Limit	Sample Details									
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1	
			1.97m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.87m	
C6-8 Aliphatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C8-10 Aliphatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C10-12 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C12-16 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C16-21 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C21-35 Aliphatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
C6-8 Aromatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	18.2	<10	
>C8-10 Aromatic TPH	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
>C10-12 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C12-16 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C16-21 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	
>C21-35 Aromatic TPH	ug/l	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	

Method: BTEX and C6-10 Bands: Determined by headspace GC-FID, Methods E6.3 and E7.1 (Unfiltered).; Determination of hexane extractable hydrocarbons by Methods GCxGC-FID E6.5 and E7.2 (Unfiltered).

The results included within the report relate only to the sample(s) submitted for testing.
Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25714	Analysed	WS 04/10/23
Received	BO 04/10/23	Reported	KC 09/10/23
Prepared	BO 04/10/23	Page	One of One

Report No 13441

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13 Triangle Business Park, Stoke Mandeville, HP22 5BL

Project	FI03088 Southgate Service Station	Sampled	2nd October 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - BTEX and MTBE - 2nd October 2023

Analyte	Unit	Method Detection Limit	Sample Details									
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1	
			1.97m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.87m	
MTBE[2]	ug/l	25	<25	<25	<25	<25	<25	<25	<25	<25	<25	
Benzene[2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	18.2	<5	
Toluene[2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Ethylbenzene[2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
p+m Xylene[2]	ug/l	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
o Xylene[2]	ug/l	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	

UKAS TESTING 2628

Method: Determined by headspace GC-FID, Methods E6.3 and E7.1 (Unfiltered)

2. UKAS 17025
The results included within the report relate only to the sample(s) submitted for testing.
Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25712	Analysed	WS 04/10/23
Received	BO 04/10/23	Reported	WS 06/10/23
Prepared	BO 04/10/23	Page	One of One

Report No 13451

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Project	FI03088 Southgate Service Station	Sampled	2nd October 2023
Client	Subadra Consulting Ltd/James May	Report Approved By	[redacted] Duty Reporting Manager
Sample Type	Water		

Water - PAHs (EPA16) - 2nd October 2023

Analyte	Unit	Method Detection Limit	Sample Details									
			BH004	BH005	BH006	BH101	BH102	BH103	BH104	BH105	MW1	
			1.97m	2.27m	1.79m	1.73m	1.83m	2.00m	1.91m	1.81m	1.87m	
Naphthalene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.22	0.01	
Acenaphthylene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Acenaphthene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.02	
Fluorene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.01	
Phenanthrene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	
Anthracene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Fluoranthene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	
Pyrene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Benzo(a)anthracene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Chrysene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Benzo(b)fluoranthene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Benzo(k)fluoranthene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Benzo(a)pyrene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Indeno(1,2,3-cd)pyrene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Dibenzo(ah)anthracene [3]	ug/l	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Benzo(ghi)perylene [3]	ug/l	0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	
Total PAHs (EPA16) [3]	ug/l	0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	0.30	< 0.16	

Method: Determined by concentration through SPE cartridge, collection in DCM followed by GC-MS (Filtered)

3. Subcontracted

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Dates of laboratory activities for each tested analyte are available upon request.
Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation.

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Chain of Custody	25713	Analysed	
Received	BO 04/10/23	Reported	KC 12/10/23
Prepared		Page	One of One

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ATTACHMENT THREE:
RTM INPUT PARAMETERS

Contaminant	Compliance Criteria(μg/litre)	Source
Benzene	10	AA-EQS
Toluene	74	
Ethylbenzene	300	WHO guideline value for drinking water, 2017
Xylenes	30	AA-EQS
MTBE	15	WHO taste and odour threshold
TPH Aromatic C_{7-8}	700	WHO (2008). Petroleum Products in Drinking-water. WO/SDE/WSH/05.08/123
TPH Aromatic C_{8-10}	300	
TPH Aromatic C_{10-12}	90	
TPH Aromatic C_{12-16}	90	
TPH Aromatic C_{16-21}	90	
TPH Aromatic C_{21-35}	90	

Note: Compliance criteria are as presented in CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. CL:AIRE, London.

Table 3.1: Compliance Criteria

Parameter	Value	Data Source
Solution method	Ogata Banks	
Approach for vertical dispersion	Simulate vertical dispersion in one direction	
Nature of decay rate	Apply degradation rate to dissolved pollutants only	
Derivation of partition co-efficient	Calculate for non-polar organic chemicals	
Dispersivity	Dispersivities 10%, 1%, 0.1% of pathway length	
Width of plume (m)	10	Estimated from site data
Plume thickness (m)	2.3	Provectus
Saturated aquifer thickness (m)	5.18	Provectus
Soil bulk density (g/cm^3)	1.81	Provectus
Effective porosity	0.3	Provectus
Hydraulic gradient	0.001	Provectus
Hydraulic conductivity (m/day)	25	Provectus
Fraction of organic carbon (g oc/g soil)	0.015	Provectus
Time since pollution entered groundwater (days)	$9e^{99}$	Steady State
Distance to compliance point (m)	50, 100	EA groundwater protection guidance

Table 3.2: Input Parameters for Tier Three Groundwater Assessment

Contaminants	Henry's Law Constant	K_{oc} (cm^3/g)	Half-Life in Groundwater (days)
Benzene	0.116 [a]	81.2 [b]	350 [c]
Toluene	0.115 [a]	234 [b]	200 [c]
Ethylbenzene	0.139 [a]	537 [b]	200 [c]
Xylenes	0.104 [a]	586 [b]	200 [c]
MTBE	0.016 [d]	33.9 [d]	1,000 [c]
TPH: Aromatic C_7-C_8	0.116 [f]	204 [f]	200 [g]
TPH: Aromatic C_8-C_{10}	0.253 [f]	1,580 [f]	167 [g]
TPH: Aromatic C_{10}-C_{12}	0.0722 [f]	2,510 [f]	300 [g]
TPH: Aromatic C_{12}-C_{16}	0.0126 [f]	5,010 [f]	204 [g]
TPH: Aromatic C_{16}-C_{21}	$6.95x10^{-4}$ [b]	14,100 [f]	1560 [g]
TPH: Aromatic C_{21}-C_{35}	$2.48x10^{-5}$ [b]	126,000 [f]	1750 [g]

Notes: a EA (2009). SC050021/SR7 (average value used for xylenes)

b TPHCWG (1989). Volume 3.

c EA (2002). R&D Technical Report P2-228/TR

d CL:AIRE/AGS/EIC (2010). Soil Generic Assessment Criteria for Human Health Risk Assessment.

e Howard, et al (1989). Handbook of Environmental Degradation Rates, Lewis Publishers.

f Nathanail et all (2015). The LQM/CIEH S4ULs for Human Health Risk Assessment.

g Values for TPH fractions calculated from individual compounds (see below)

Table 3.3: Chemical Properties of Contaminants of Concern

We have assigned half-lives to TPH groups (see Table 2.2 below) based upon the following criteria.

- For bands which have less than three individual compounds listed, we have used the highest individual half-life in the range to ensure a conservative assessment of risk.
- For bands where more than three individual compounds are listed we have used the average of the half-lives in the range as more as more appropriate for the overall behaviour of all the compounds within the range.

TPH Range	Compounds in Range	Equivalent Carbon Number	Half Life	
			Compound (days)	Aromatic TPH band
TPH: Aromatic C_5-C_7	Benzene	6.5	350	350
TPH: Aromatic C_7-C_8	Toluene	7.58	200	200
TPH >C_8-C_{10}	Ethylbenzene	8.5	200	167
	Xylenes	8.6	200	
	Styrene	8.83	210	
	1,2,4 Trimethylbenzene	9.8	56	
	1,3,5 Trimethylbenzene	9.6	–	
	n-Propylbenzene	9.5	–	
TPH >C_{10}-C_{12}	n-Butylbenzene	10.5	–	300
	Naphthalene	11.7	300	
TPH >C_{12}-C_{16}	Acenaphthalene	15.5	204	204
	Biphenyl	14.26	14	
TPH >C_{16}-C_{21}	Fluorene	16.5	120	1662
	Benzo(ghi)perylene	18	1,300	
	Phenanthrene	19.36	400	
	Anthracene	19.43	920	
	Pyrene	20.8	3,800	
	3-Methylchloranthrene	21	2,800	
TPH >C_{21}-C_{35}	Fluoranthene	21.85	880	
	Benz(a)anthracene	26.37	1,360	
	Chrysene	27	2,000	
	Benzo(b)fluoranthene	30.14	1,220	
	Benz(k)fluoranthene	30.14	4,280	
	Benzo(a)pyrene	31	1,060	
	Indeno(1,2,3-cd)pyrene	35.01	1,460	

Table 3.4: Properties of Individual Compounds Used to Determine Half-lives values For TPH

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Benzene		from Level 1
Target Concentration	C_T	1.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	3.77E-02	mg/l	*May 2023 - BH105*
Half life for degradation of contaminant in water	$t_{1/2}$	3.50E+02	days	*EA 2002. R&D Tech Report P2-228/TR*
Calculated decay rate	λ	1.98E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*Estimated from site data*
Plume thickness at source	Sy	2.30E+00	m	*Provectus*
Saturated aquifer thickness	da	5.18E+00	m	*Provectus*
Bulk density of aquifer materials	ρ	1.81E+00	g/cm^3	*Provectus*
Effective porosity of aquifer	n	3.00E-01	fraction	*Provectus*
Hydraulic gradient	i	1.00E-03	fraction	*Provectus*
Hydraulic conductivity of aquifer	K	2.50E+01	m/d	*Provectus*
Distance to compliance point	x	5.00E+01	m	*EA Recommended*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	9.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.22E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	8.33E-02	m/d
Retardation factor	Rf	8.35E+00	fraction
Decay rate used	λ	2.37E-04	d^{-1}
Rate of contaminant flow due to retardation	u	9.98E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	4.67E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**8.07E+00**	

Remedial Targets

Remedial Target		**8.07E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**4.67E-03**	**mg/l**	Ogata Banks
after		**9.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.50E-02	fraction
Organic carbon partition coefficient	Koc	8.12E+01	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.22E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		MTBE		from Level 1
Target Concentration	C_T	1.50E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	5.93E-02	mg/l	*May 2023 - BH105*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+03	days	*EA 2002. R&D Tech Report P2-228/TR*
Calculated decay rate	λ	6.93E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*Estimated from site data*
Plume thickness at source	Sy	2.30E+00	m	*Provectus*
Saturated aquifer thickness	da	5.18E+00	m	*Provectus*
Bulk density of aquifer materials	ρ	1.81E+00	g/cm^3	*Provectus*
Effective porosity of aquifer	n	3.00E-01	fraction	*Provectus*
Hydraulic gradient	i	1.00E-03	fraction	*Provectus*
Hydraulic conductivity of aquifer	K	2.50E+01	m/d	*Provectus*
Distance to compliance point	x	5.00E+01	m	*EA Recommended*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	9.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.09E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	8.33E-02	m/d
Retardation factor	Rf	4.07E+00	fraction
Decay rate used	λ	1.70E-04	d^{-1}
Rate of contaminant flow due to retardation	u	2.05E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.44E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.12E+00**	

Remedial Targets

Remedial Target		**6.17E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**1.44E-02**	**mg/l**	Ogata Banks
after		**9.0E+99**	**days**	

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.50E-02	fraction
Organic carbon partition coefficient	Koc	3.39E+01	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.09E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed