

**South Bersted Garage,
Bognor Regis**

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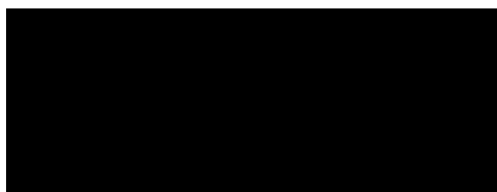
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13 Triangle Business Park, Stoke Mandeville, HP22 5BL

REVISED DETAILED QUANTITATIVE RISK ASSESSMENT REPORT

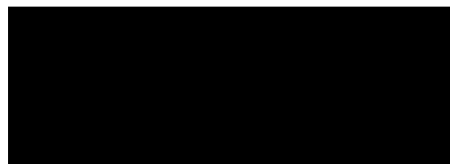


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Client: Enterprise Rent-a-Car Ltd	Subadra Consulting Ltd. Registered in England No. 4586038 Registered Office 13 Triangle Business Park, Stoke Mandeville, HP22 5BL	Report	In17597 CL 004
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Summary

We have been commissioned by Enterprise Rent-a-Car Ltd to complete a revised Detailed Quantitative Risk Assessment for South Bersted Garage in Bognor Regis, following the completion of additional verification groundwater monitoring at the site. Our assessment has generated remedial targets protective of human health and controlled waters for assessment of groundwater quality.

We have calculated site-specific target levels for the site using risk assessment models following current best practice and adhering to current statutory guidance. These target levels are the levels above which the identified contamination would pose an unacceptable risk to identified controlled water or human health receptors.

The results of our risk assessment indicate that hydrocarbon concentrations recorded in groundwater do not pose a significant risk to human health receptors but do pose a potential long-term risk to identified controlled water receptors.

The results of our risk assessment are summarised below.

Contaminant	Groundwater		Critical Pollutant Linkages
	Target Level (µg/litre)	Pass/Fail	
Benzene	174	Pass	-
Benzo(a)pyrene	0.00289	Pass	-
Ethylbenzene	6,020	Pass	-
Naphthalene	39.1	Fail	Lateral migration to surface and groundwater
Toluene	5,560	Pass	-
TPH Aliphatic C ₈₋₁₀	Sol	Pass	-
TPH Aliphatic C ₁₀₋₁₂	Sol	Pass	-
TPH Aliphatic C ₁₂₋₁₆	Sol	Pass	-
TPH Aliphatic C ₁₆₋₃₅	Sol	Pass	-
TPH Aromatic C ₈₋₁₀	5,570	Fail	Lateral migration to surface and groundwater
TPH Aromatic C ₁₀₋₁₂	1,760	Pass	-
TPH Aromatic C ₁₂₋₁₆	1,850	Pass	-
TPH Aromatic C ₁₆₋₂₁	Sol	Pass	-
TPH Aromatic C ₂₁₋₃₅	Sol	Pass	-
Xylenes	557	Fail	Lateral migration to surface and groundwater

Notes: Sol –target is greater than solubility limit; target is removal of free-phase, if present.

Site-Specific Targets for Groundwater

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We recommend that a review of potential remedial strategies be completed for the site in order to assess potential remediation options available to reduce concentrations of dissolved phase hydrocarbons in underlying groundwater to acceptable levels.

Our risk assessment conclusions are subject to a number of limitations:

- These target levels are appropriate for the assessment of groundwater quality in connection with the site's current use and any proposed redevelopment detailed in this report. They may not be appropriate for other uses or redevelopment schemes. Should any work on site encounter conditions varying to those used in our assessment, target levels should be reviewed and, if necessary, revised.
- The basis of our risk assessment, together with our assumptions and input values, has not been agreed with the relevant regulatory authorities. The target levels presented in this report should be discussed and agreed with the relevant regulatory authorities prior to their use. Our models are reliant on data from limited investigations of the site and from literature-sourced values. Other conditions may exist in areas of the site that have not been fully investigated and which may invalidate the target values we have calculated. In this case, the target levels should be reviewed and, if necessary, revised.

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

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List of Attachments

Attachment One: Notice to Interested Parties
Attachment Two: Properties of Contaminants of Concern
Attachment Three: RTM Model Input Parameters
Attachment Four: RISC Model Input Parameters
Attachment Five: Chemical Analysis Certificates

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1 Introduction

1.1 The Purpose of This Assessment

We were commissioned by Enterprise Rent-a-Car Ltd (Enterprise) to complete an intrusive investigation and detailed quantitative risk assessment for South Bersted Garage, in Bognor Regis, in early 2018.

Following these works we recommended that we carry out an additional round of groundwater monitoring, and use the results to complete a revision of the conceptual model and detailed quantitative risk assessment modelling. This report details the additional works completed.

This assessment has generated site-specific target levels (target levels) following current best practice and adhering to current statutory guidance. The target levels correspond to the concentration of each contaminant below which poses no significant risk to controlled water receptors such as aquifers and/or nearby rivers and streams or identified human health receptors. Unless stated in this report, our target levels have not been agreed with any regulatory authority and have not been derived to assist in satisfying any planning conditions relating to the site.

All the activities comprising this assessment were carried out in accordance with the procedures set out in our Quality Manual. Your attention is drawn to the Notice to Interested Parties included as Attachment One.

1.2 The Scope of This Assessment

Our assessment included:

- A round of groundwater verification monitoring including collection and analysis of groundwater samples;
- A review of all the available site data and any conceptual site model;
- Derivation of site-specific target levels for relevant contaminants in groundwater.

Our assessment only addresses contaminants of concern associated with the site's use as stated in this report.

1.3 Previous Reports Relating to the Site

As part of our environmental assessment we have reviewed the reports listed in the following table.

Our Ref.	Report Title	Prepared By	Prepared on Behalf of	Date of Issue	Report Reference
Ref.1	Phase I Environmental Desk Study Report	Subadra Consulting Ltd	Enterprise Rent-a-Car Ltd	November 2017	In17597 CL 001
Ref.2	Environmental Investigation Report			February 2018	In17597 CL 002
Ref.3	Detailed Quantitative Risk Assessment Report			March 2018	In17597 CL 003

Our review of these documents is provided in Table Two below. We have used information from these documents, where relevant, in other sections of this report.

Table One: Previous Environmental Reports Relating to the Site

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Our Ref.		Summary of Results and Conclusions of Previous Works
Ref.1		<u>Phase I Environmental Desk Study Report, November 2017</u> This report comprised a desk based Phase I environmental assessment of the site, reviewing the environmental sensitivity of the location and site history . Relevant information is included in other sections of this report.
Ref.2		<u>Environmental Investigation Report, February 2018</u> This report details an intrusive environmental investigation that we subsequently completed at the site in January 2018. The investigation comprised the construction of five boreholes to a maximum depth of 5.1m below ground level, all of which were completed as groundwater monitoring wells. The investigation proved underlying geology to comprise Made Ground to a maximum depth of 0.9m. This was underlain in the north-western corner by a shallow layer of River Terrace Deposits. The Made Ground and/or drift deposits were underlain by the chalk of the Lewes Nodular Chalk Formation. We recorded hydrocarbon staining and/or odours in soil from BH001, BH004 and BH005 in the north-western part of the site, in the vicinity of the former forecourt and tank farm. We also noted staining in soils from BH003, located towards the southern end of the forecourt. Chemical analysis confirmed the presence of hydrocarbons, generally consistent with petrol, in soil samples from BH001, BH003 and BH004 and low concentrations of PAHs in shallow soils from BH001 and BH004. We recorded dissolved-phase TPH, BTEX and PAHs in groundwater samples from BH004 and BH005, with lower concentrations recorded in BH001. Hydrocarbons were again consistent with petrol. The results of our Generic Quantitative Risk Assessment indicated that concentrations of hydrocarbons recorded in soil and groundwater did not pose a significant risk to future commercial site users, but concentrations in groundwater posed a potential risk to controlled water receptors.
Ref.3		<u>Detailed Quantitative Risk Assessment Report, March 2018</u> This report presents the detailed quantitative risk assessment we completed for the site. We identified the source to be dissolved-phase petroleum hydrocarbons, recorded in three boreholes in the centre and north-east of the site. We identified the following viable source-pathway-receptor linkages: ➤ Impact of groundwater in the Lewes Nodular Chalk Formation under the site. This unit is classified as a Principal Aquifer, although BGS data indicates there is likely to be a high degree of saline intrusion in this location and the aquifer is therefore not usable as a drinking water resource. ➤ Lateral migration of impacted groundwater to nearby surface water features: The Aldingbourne Rife, ~160m north, and a drainage ditch ~250m north-west. ➤ Volatilisation of hydrocarbons, migration into indoor air and inhalation of vapours by on site workers. Our generic quantitative risk assessment (Ref. 2) indicated that this pathway did not pose a risk to on site workers, however we included an assessment of the risk to on site workers to provide additional confidence in the generic assessment.
Continued overleaf		

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Our Ref.	Summary of Results and Conclusions of Previous Works
Ref.3	The results of our detailed quantitative risk assessment indicated that dissolved-phase hydrocarbon concentrations recorded on site did not pose a significant risk to on-site workers. However concentrations of some compounds exceed the calculated remedial targets for controlled water receptors. Due to the site setting, and the underlying chalk aquifer at the site location not being viable for potential groundwater abstraction due to saline intrusion, we proposed remedial targets calculated for a compliance point at 150m (the distance to the closest surface water feature) to be the most suitable for use. We recommended that an additional round of groundwater monitoring be completed to confirm the results of previous monitoring, followed by revision of the conceptual site model and detailed quantitative risk assessment. We recommended that a review of potential remedial strategies be completed for the site.

Table Two: Review of Previous Environmental Works at the Site

1.4 Proposed Development Plans

Proposed Developments	Enterprise propose to redevelop the site for future use as a car rental depot. The redevelopment scheme comprises the demolition of existing workshop buildings and construction of a small modular office building and covered wash bay in the centre of the site. The existing overhead canopy is to be retained, with new signs and cladding, and the remainder of the site will be covered with hard standing to be used for car parking. Conditional planning permission for the proposed works has been granted by Arun District Council (Planning ref. BR18/18/PL).
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Table Three: Proposed Development Plans

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2 Review of Site Data

2.1 Site Description, Location and Setting

Site Description	The site comprises a former retail filling station, currently used for vehicle hire and repair. There is forecourt area, off Shripney Road, with an overhead canopy. The main building comprises offices and an MOT workshop on the ground floor, with offices and residential flat above.		
Grid Reference	393030 89630	Location	The site is located off Shripney Road, to the immediate south of the A29 (also called Shripney Road), toward the north eastern outskirts of Bognor Regis.
Elevation	~3m AOD		
Size (approx)	~0.25ha		

Table Four: Site Location and Setting

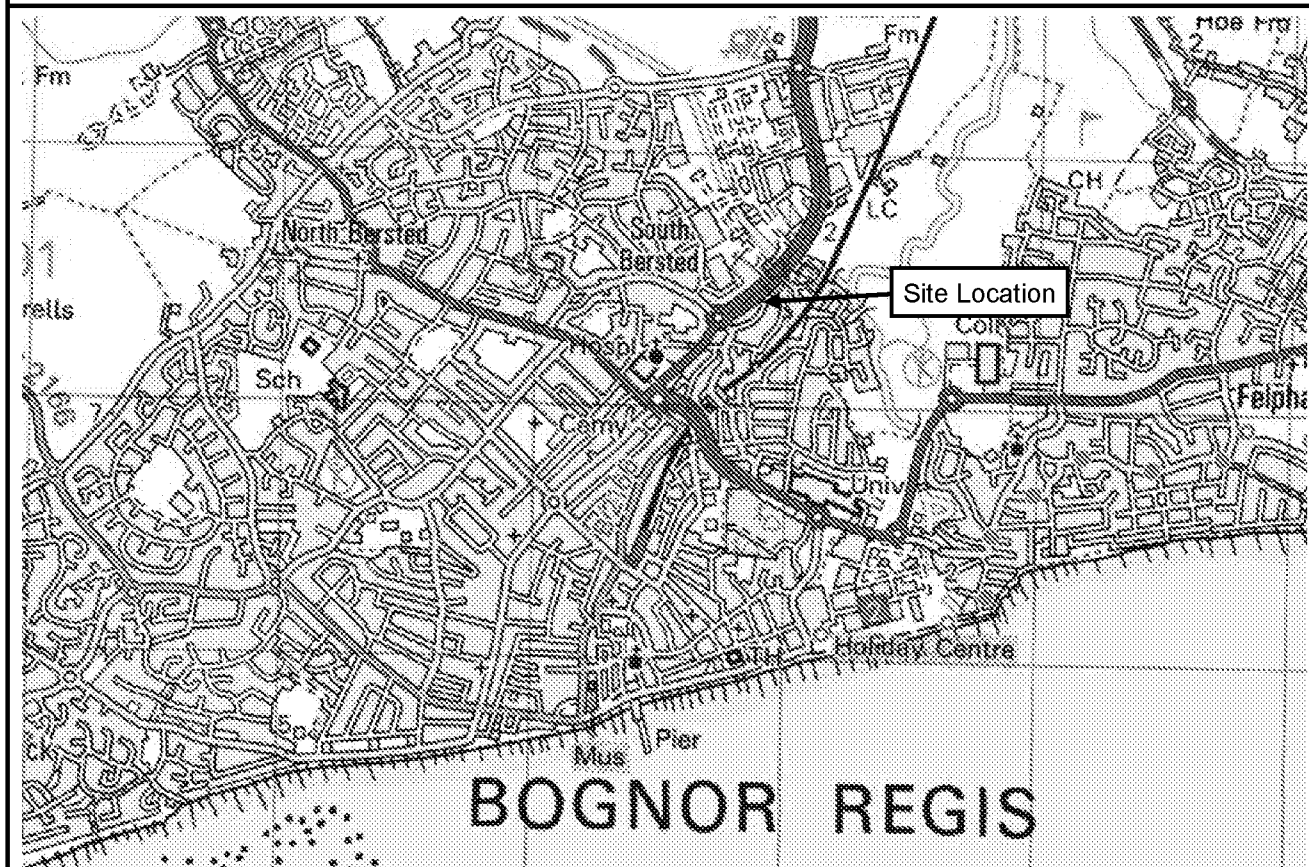


Figure One: Site Location Map

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Figure Two: Aerial; Photograph Showing Site Layout

Direction	Details
North	Tesco supermarket with associated retail filling station beyond the A29 (>50m). Offices to the immediate north west (~20m), with A29 beyond. Car dealership and industrial estate to the north east (>25m).
East	Residential properties to the immediate east and south east (>10m). Industrial estate to the north east (>25m).
South	Residential properties to the immediate south (>5m). Public house beyond (~50m), then further residential properties.
West	Office building (possible former workshop) to the west/north west (~20m) and residential properties to the west/south west (>20m). A29 and industrial areas beyond (>50m).

Table Five: Surrounding Land Use

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2.2 Geology, Hydrogeology and Hydrology

	Geological Unit	Description	Estimated Thickness	Data Source
Drift Geology	River Terrace Deposits	Generally comprises layers of sand or gravel, with occasional sandy clays	~5m	British Geological Survey
Solid Geology	Lewes Nodular Chalk Formation	Creamy white chalk with flints	>25m	
Previous Investigation Data	BGS borehole Ref. SU90SW18, ~40m north west of the site, encountered silty clay with flints to ~2m, overlying putty chalk to termination depth of 4m. BGS borehole Ref. SU90SW78, ~50 north east of the site, encountered layers of sandy silt and sand to ~13.5m depths, overlying chalk to termination depth of ~30m.			BGS
	We recorded gravel or clay made ground to a maximum depth of 0.9m, underlain in three boreholes by a layer of clay, sand or gravel to a maximum depth of 2.8m. The chalk aquifer was present as structureless slightly sandy chalk with occasional flint gravels, become more intact with depth, from depths of 0.5m to 2.8m to the base of all boreholes.			Ref.2

Table Six: Regional Geology

	Geological Unit	Environment Agency Aquifer Classification	Data Source
Drift Geology	River Terrace Deposits	Secondary Aquifer (Class A)	Environment Agency
Solid Geology	Lewes Nodular Chalk Formation	Principal Aquifer	
Previous Investigation Data	BGS borehole Ref. SU90SW18, ~40m north west of the site, recorded groundwater at ~1m depth. BGS borehole Ref. SU90SW78, ~50 north east of the site, recorded groundwater at ~13m in the underlying chalk. BGS borehole SU90SW21, ~700m north-north-east, known as the Shripney borehole, has 'a high degree of saline intrusion' (as reported in BGS document 'The Chalk Aquifer of the South Downs'): This is likely to apply to groundwater under the site which is located between the Shripney borehole and the English Channel.		BGS
	We recorded groundwater strike at depths of between 1.4m and 2.0m below ground level. Piezometric data indicates groundwater flow to the west/north-west (see Figure Three below). We recorded rapid recharge in all boreholes on site, indicating high permeability in the underlying soils.		Ref.2

Table Seven: Regional Hydrogeology

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	Description	Distance and Direction	Data Source
Surface Water Features	Aldingbourne Rife (stream) flowing south-east [River Quality E/River Quality Biology Grade C (Fairly Good)]	~160m North East	OS mapping/ Envirocheck report/ gov.uk website
	A drainage ditch is shown on older mapping as terminating ~100m from the site. However, our historical map review shows this section of the ditch was removed between 1985 and 1989 when the Tesco superstore was constructed to the immediate east of the ditch.. The ditch now terminates ~250m north-west of the site and flows north-west before turning east and flowing into the Aldingbourne Rife.	~250m North West	

Table Eight: Regional Hydrology

Abstraction	Surface Water			Groundwater
	Distance	Direction	Purpose	
Nearest	807m	North	Spray irrigation	None identified within 1km
Nearest Public Water Supply	None identified within 1km			None identified within 1km
Source Protection Zone	No			No
Notes	The identified abstraction is not considered to be at risk from the site as it is located to the north, beyond the Aldingbourne Rife. Regional groundwater flow is to the south.			

Data sourced from Environment Agency

Table Nine: Nearest Surface and Groundwater Abstractions

3 Additional Groundwater Verification Monitoring - June 2018

3.1 Works Completed

We attended site on 18th June 2018 to carry out an additional round of groundwater verification monitoring, following the resolution of site access issues with the former site tenant.

Groundwater rest levels were recorded in all boreholes prior to sampling using low-flow techniques. Groundwater samples were analysed for TPH, BTEX, PAHs and a suite of natural attenuation indicators. The results of our monitoring and groundwater analysis are summarised in the following tables.

3.2 Groundwater Monitoring Results

The results of our groundwater monitoring are summarised in the following table.

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	BH001	BH002	BH003	BH004	BH005
Borehole Elevation (mASD)	100.184	100.271	100.544	100.211	100.112
Depth to Groundwater	m bgl	1.512	1.613	1.877	1.557
	m ASD	98.672	98.658	98.667	98.654
DO (mg/litre)	0.08	0.95	1.44	1.0	0.09
pH	7.1	7.5	6.8	6.7	7.7
Conductivity (mS/cm)	385	416	480	567	469
ORP (mV)	374	382	86.1	105	249
Visual and Olfactory Evidence of Hydrocarbons	Slight odour	Odour	None	Odour	Odour
Groundwater flow direction	North				

Table Ten: Groundwater Monitoring Results, 18th June 2018

3.3 Groundwater Analysis Results

The results of our groundwater analysis are summarised in the following tables. Chemical analysis certificates are included in Attachment Five.

Analyte	Unit	Sample Details				
		BH001	BH002	BH003	BH004	BH005
C ₆₋₈ Aliphatic TPH	ug/l	754	61	72.6	1,540	414
>C ₈₋₁₀ Aliphatic TPH	ug/l	<50	<50	<50	321	<50
>C ₁₀₋₁₂ Aliphatic TPH	ug/l	<50	<50	<50	<50	<50
>C ₁₂₋₁₆ Aliphatic TPH	ug/l	<50	<50	<50	<50	<50
>C ₁₆₋₂₁ Aliphatic TPH	ug/l	<50	<50	<50	<50	<50
>C ₂₁₋₃₅ Aliphatic TPH	ug/l	<50	<50	<50	<50	<50
C ₆₋₈ Aromatic TPH	ug/l	79.5	<50	<50	1,240	<50
>C ₈₋₁₀ Aromatic TPH	ug/l	1,060	<50	<50	12,700	1,270
>C ₁₀₋₁₂ Aromatic TPH	ug/l	105	<50	<50	596	178
>C ₁₂₋₁₆ Aromatic TPH	ug/l	<50	<50	<50	56.8	<50
>C ₁₆₋₂₁ Aromatic TPH	ug/l	<50	<50	<50	<50	<50
>C ₂₁₋₃₅ Aromatic TPH	ug/l	<50	<50	<50	<50	<50

Table Eleven: TPH CWG Analysis Results - Groundwater, 18th July 2018

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Analyte	Unit	Sample Details				
		BH001	BH002	BH003	BH004	BH005
MTBE	µg/l	285	<50	<50	168	100
Benzene	µg/l	<10	<10	<10	97.1	<10
Toluene	µg/l	86.2	<10	<10	1,250	43.9
Ethylbenzene	µg/l	63.7	<10	<10	1,250	210
p+m Xylene	µg/l	401	<10	<10	5,900	278
o Xylene	µg/l	144	<10	<10	2,170	57
C6-C8	µg/l	963	70.4	83.8	3,210	524
>C8-C10	µg/l	1,260	<50	<50	14,900	1,490
>C10-C12	µg/l	405	<50	<50	2,850	861

Table Twelve: VOC Analysis Results - Groundwater, 18th July 2018

Analyte	Unit	Sample Details				
		BH001	BH002	BH003	BH004	BH005
Naphthalene	ug/l	18	< 0.01	< 0.01	136	26.2
Acenaphthylene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	0.15
Acenaphthene	ug/l	0.65	< 0.01	< 0.01	0.33	5.08
Fluorene	ug/l	0.79	< 0.01	< 0.01	0.68	4.02
Phenanthrene	ug/l	1.33	< 0.01	< 0.01	0.93	3.09
Anthracene	ug/l	0.26	< 0.01	< 0.01	< 0.01	0.46
Fluoranthene	ug/l	0.77	< 0.01	< 0.01	< 0.01	0.38
Pyrene	ug/l	0.6	< 0.01	< 0.01	< 0.01	0.17
Benzo(a)anthracene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenzo(ah)anthracene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

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Analyte	Unit	Sample Details				
		BH001	BH002	BH003	BH004	BH005
Benzo(ghi)perylene	ug/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total PAHs (EPA16)	ug/l	22.4	< 0.16	< 0.16	138	39.5

Table Thirteen: PAH Analysis Results – Groundwater, 18th July 2018

Analyte	Unit	Sample Details				
		BH001	BH002	BH003	BH004	BH005
pH	-	6.7	6.5	6.5	6.4	7.2
Ammonium as NH3	mg/l	0.328	4.43	0.064	1.28	1.87
Nitrate as NO3-N	mg/l	<0.45	0.642	3.54	<0.45	<0.45
Nitrite as NO2-N	mg/l	<0.02	0.022	<0.02	0.036	0.02
Sulphate	mg/l	<60	<60	<60	<60	<60
Sulphide	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chloride	mg/l	21.3	33.1	22.4	32.7	24.4
Manganese (II)	mg/l	0.151	0.186	0.304	0.517	0.282
Manganese(IV)	mg/l	0.028	0.039	0.019	0.085	0.148
Iron(II)	mg/l	<0.2	<0.2	<0.2	0.349	0.443
Iron(III)	mg/l	<0.2	<0.2	<0.2	0.296	0.247

Table Fourteen: MNA Suite Analysis Results – Groundwater, 18th July 2018

3.4 Discussion

The results of our additional groundwater monitoring broadly confirmed the results of previous works.

3.4.1 Piezometric Data

Piezometric data indicates that groundwater flow is to the north (see Figure Three below). Our previous set of data indicates flow towards the north-west. We recorded a shallow gradient of ~0.0007 on this visit. The groundwater level in BH001, on both monitoring rounds, appears to be anomalous and slightly distorts the plot, data has therefore been plotted with and without data from BH001.

Groundwater analysis confirmed the presence of petrol-range hydrocarbons in boreholes in the north-western part of the site. The highest concentrations were again recorded in BH004, although concentrations of the majority of analytes, particularly TPH, had reduced significantly.

Concentrations of TPH in BH005 have reduced, although BTEX concentrations are similar to those previously recorded. Concentrations of TPH and BTEX in BH01 have increased resulting in similar concentrations to those in BH001.

We recorded trace concentrations of TPH in the range C6-C8 in BH002 and BH003.

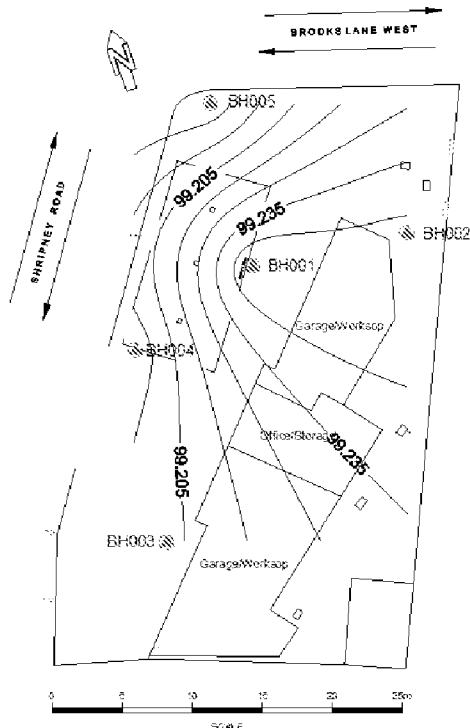
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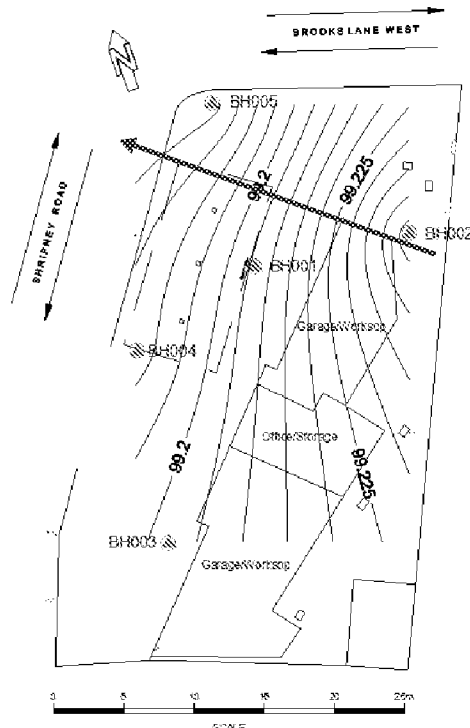
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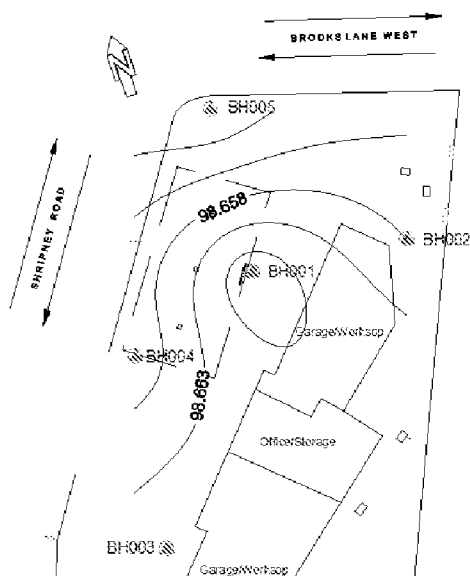
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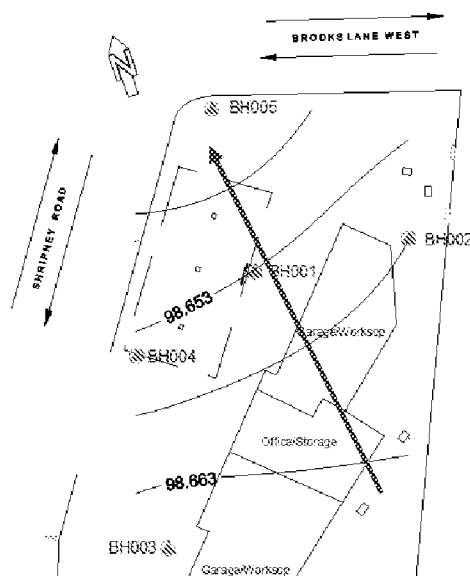
16/1/2018 all boreholes



16/1/2018 excluding BH001



18/6/2018 all boreholes



18/6/2018 excluding BH001

Figure Three: Piezometric Plots

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3.4.2 Natural Attenuation Indicators

Dissolved oxygen concentrations were at or below 1mg/litre in all boreholes, indicating suitable conditions for anaerobic degradation to be taking place. The oxygen redox potential ranged from 86mV to 382mV, with concentrations reducing from east to west, not showing a particular correlation with the plume location on site.

Nitrate concentrations show depletion in impacted boreholes with significantly higher concentrations in the remaining two boreholes, indicating natural attenuation may be taking place.

Chloride concentrations did not show a clear pattern across the site.

Nitrite, sulphate and sulphite concentrations were all at or close to method detection limits. Manganese IV and II were present in all boreholes at concentrations below 0.6mg/litre. Iron II and iron II were both present at low concentrations in BH004 and BH005, but both absent in the remaining three wells. None of these results provide useful information on the potential occurrence of natural attenuation under the site.

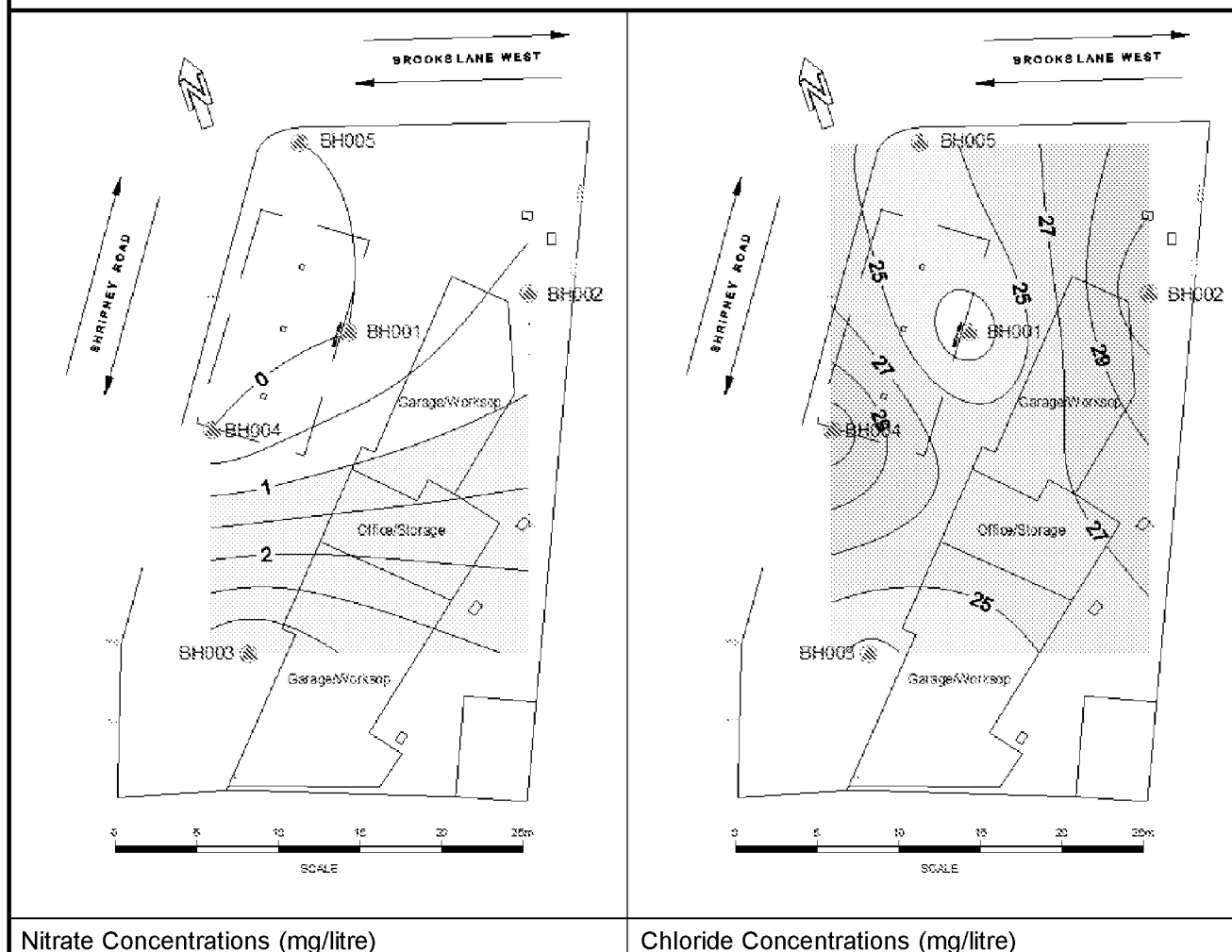


Figure Four: Nitrate and Chloride Concentration Plots

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4 Conceptual Site Model

4.1 Potential Sources of Hydrocarbons

We have identified the following potential sources of hydrocarbon impact at the site.

Dates	Source	Contaminant
1932-1961	Possible use as a garage	Petrol, diesel, oils, solvents
1961 onward	Petroleum filling station. Underground storage tanks, fuel lines and interceptor possible sources	Petrol, diesel, oils
Present day	Car repair and MOT workshop	Petrol, diesel oils, solvents

Table Fifteen: Potential Sources of Hydrocarbons

4.2 Source - Contaminants of Concern

Source Contaminant	Petrol	Diesel
Compounds Encountered	BTEX compounds (Benzene, Toluene, Ethylbenzene and Xylenes) and MTBE	PAHs including Naphthalene and Benzo(a)pyrene
Compound Groups Encountered	Total petroleum hydrocarbons (TPH) in the range C ₈ to C ₃₅ . We have not assessed TPH groups lighter than C ₈ as the BTEX compounds are representative of these	
Comments	Hydrocarbon concentrations generally consistent with the the presence of petrol. BTEX ratios indicate a highly weathered source.	

Table Sixteen: Contaminants of Concern

4.3 Source Delineation

We have recorded dissolved-phase hydrocarbons in groundwater samples from three boreholes on the north-western part of the site, in the vicinity of the former fuel installation. The highest concentrations were recorded in BH004 on the western site boundary, on both monitoring rounds. Concentrations generally an order of magnitude lower were recorded in BH005 to its north and BH001 in front of the site building.

Both sets of groundwater elevation data indicate that groundwater flow under the site is to the north or north-west, towards the drainage ditch. We note that the site lies within the flood zone of the Aldingbourne Rife, to the north-east and regional groundwater flow is expected to be in a southerly direction, towards the English Channel.

The area of groundwater impacted by hydrocarbons are presented in Figure Four on the following page.

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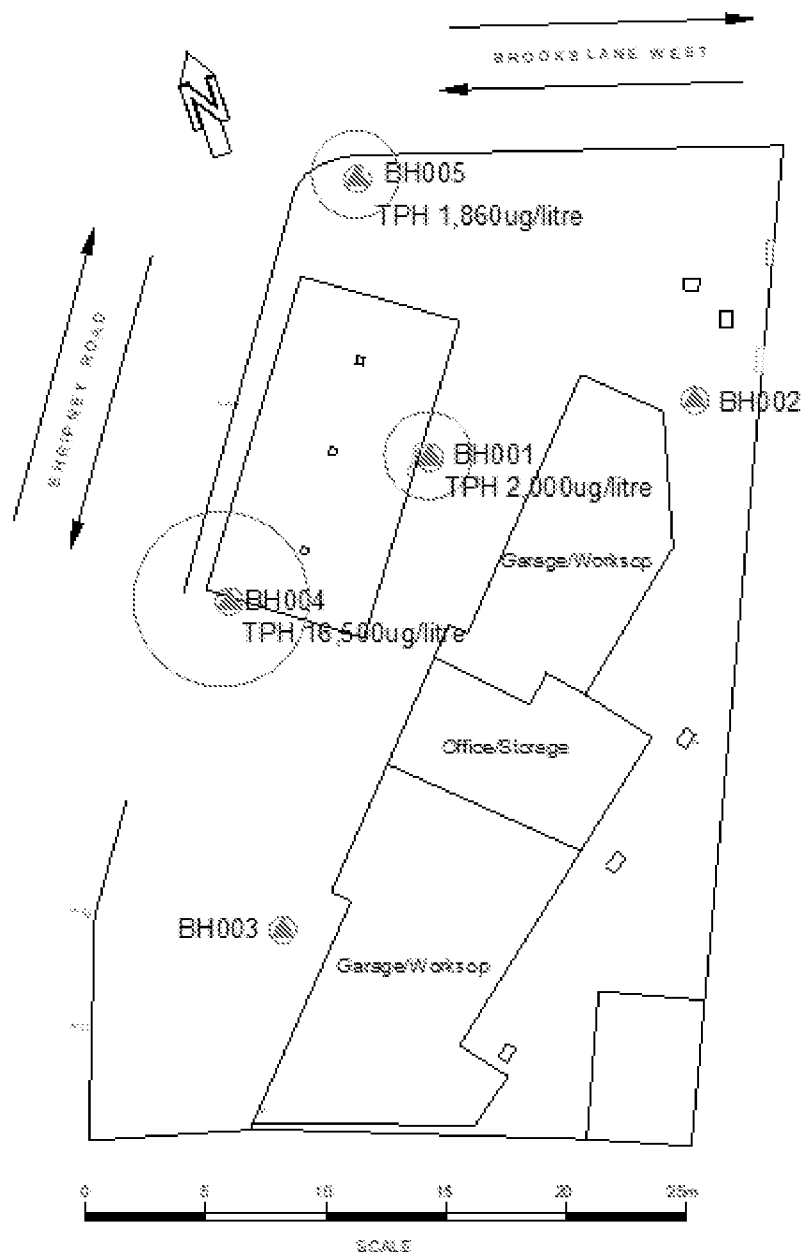


Figure Five: Estimated Area of Hydrocarbon Impact

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4.4 Source Concentrations

We have used the following maximum concentrations recorded during our most recent groundwater monitoring round as source concentrations for the risk assessment.

Contaminant of Concern	Maximum Concentration in Groundwater (µg/litre)	Sample Location
Benzene	97.1	BH004
Benzo(a)pyrene	<0.01	
Ethylbenzene	1,250	
MTBE	285	BH001
Naphthalene	136	
Toluene	1,250	BH004
TPH Aliphatic C ₈₋₁₀	321	
TPH Aliphatic C ₁₀₋₁₂	<50	
TPH Aliphatic C ₁₂₋₁₆	<50	
TPH Aliphatic C ₁₆₋₃₅	<100	
TPH Aromatic C ₈₋₁₀	12,700	
TPH Aromatic C ₁₀₋₁₂	596	
TPH Aromatic C ₁₂₋₁₆	56.8	
TPH Aromatic C ₁₆₋₂₁	<50	
TPH Aromatic C ₂₁₋₃₅	<50	
Xylenes	8,070	BH004

Table Seventeen: Concentrations of Contaminants of Concern

Note that the target levels we have derived are independent of their initial source concentrations. These have been included here for information only.

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4.5 Potential Source - Pathway - Receptor Linkages

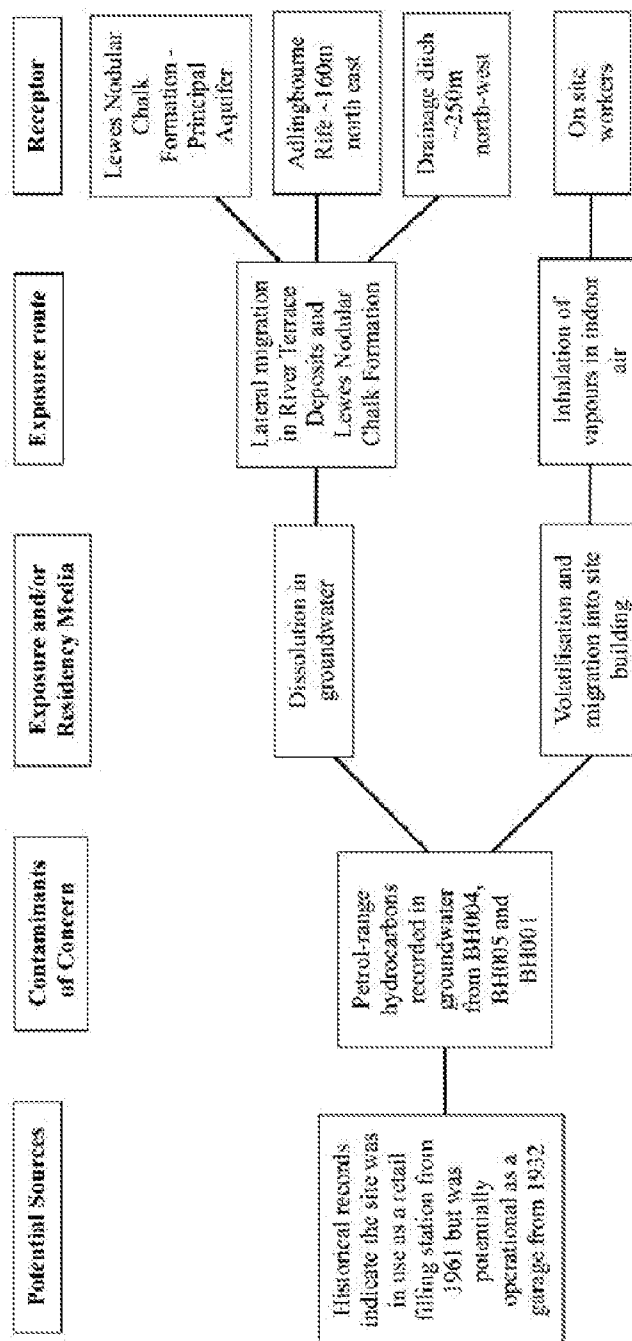


Figure Six: Potential Source-Pathway-Receptor Linkages

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1. Potential source - old fuel infrastructure
2. Pathway - Inhalation of hydrocarbon vapours in indoor air
3. Pathway - Lateral migration of hydrocarbon impacted groundwater

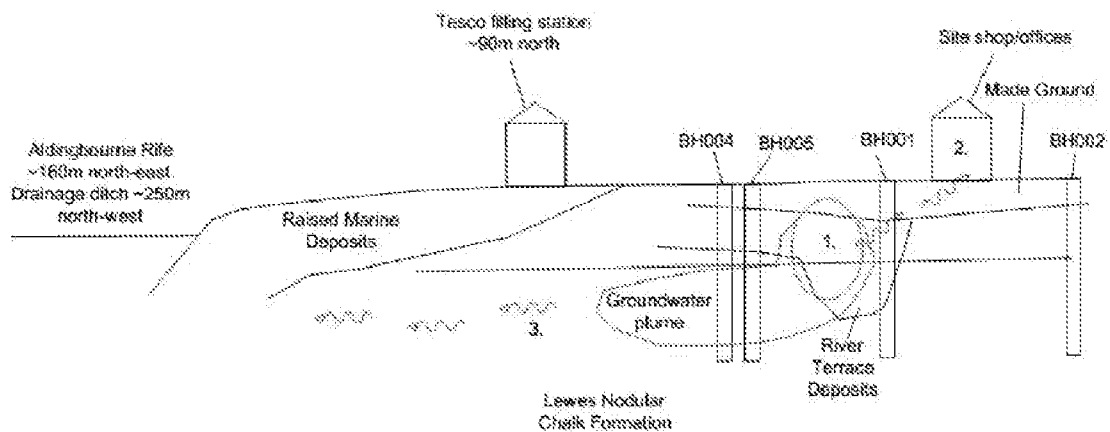
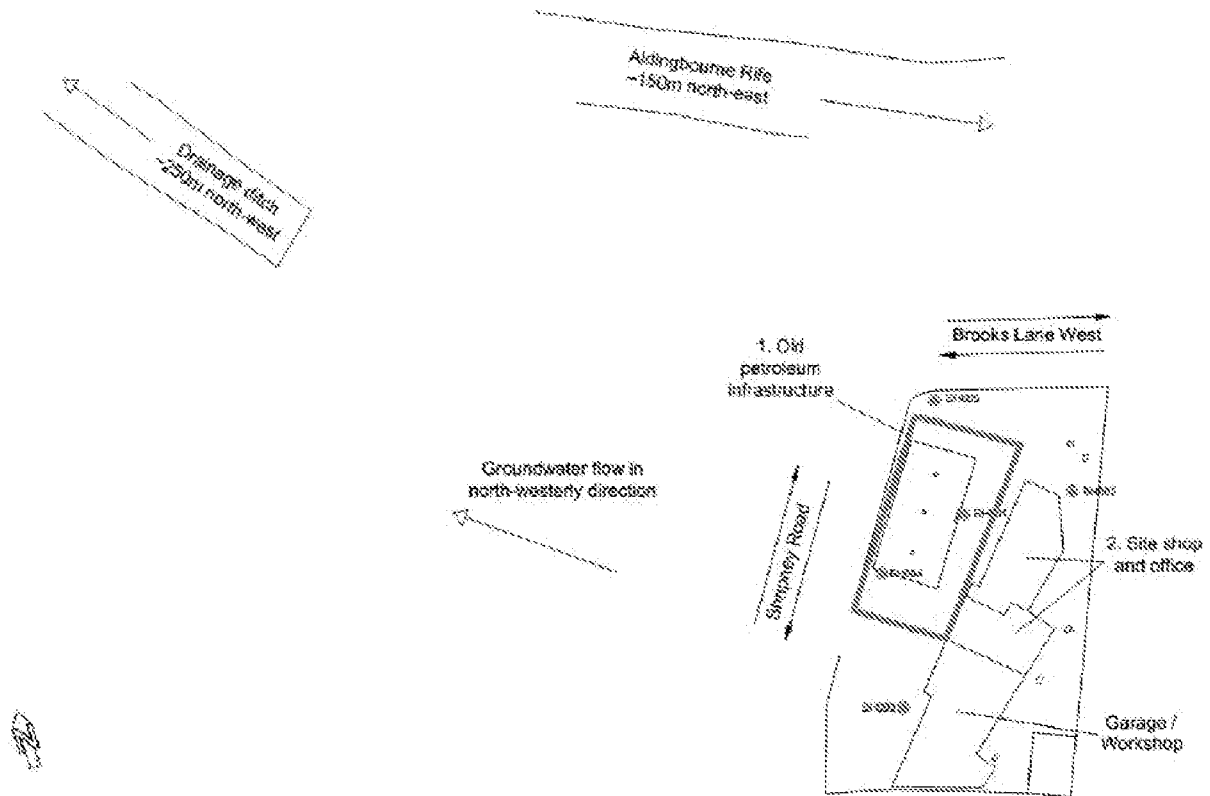


Figure Seven: Conceptual Site Model

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The results of our Generic Quantitative Risk Assessment (Ref.2) indicated that hydrocarbon concentrations recorded on site did not pose a significant risk to on site workers. We have, however, included an assessment of the risk to on site workers to provide additional confidence in the generic assessment.

The Lewes Nodular Chalk Beds underlying the site is classified as a principal aquifer. However, BGS research indicates that groundwater as far as and beyond the Shripney borehole has a high degree of saline intrusion and therefore is not usable as a drinking water resource.

5 Detailed Quantitative Risk Assessment

5.1 Methodology – Risk to Controlled Waters

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 targets for the site that will be protective of groundwater and the nearby surface water features. To do this we use a fate-transport model to calculate the likely impact on groundwater quality in a hypothetical compliance well located various distances 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.

5.2 Methodology – Risk to Human Health

We have evaluated the risk to human receptors using the Risk-Integrated Software for Clean-ups (RISC) based on ASTM 1739. However, we have incorporated principles and input parameter values from The Environment Agency's Contaminated Land Exposure Assessment Model (CLEA), most notably by amending the software to include an index dose assessment for non-threshold compounds and by inputting CLEA parameters wherever available. Therefore, our assessment is consistent with CLEA, but allows for a broader assessment of sources, compounds and pathways.

Since the site will be used for commercial purposes in the future, we have assessed the effect on a female worker at the site. Full details of the model's input parameters are included as Attachment Four.

5.3 Results

Compound	Solubility Limit (µg/l)	Site-Specific Target (µg/litre)			
		Compliance Point at 50m	Compliance Point at 100m	Compliance Point at 150m	Compliance Point at 250m
Benzene	1,780,000	30.7	83.2	174	478
Benzo(a)pyrene	3.8	0.000518	0.00139	0.00289	0.00784
Ethylbenzene	180,000	966	2,750	6,020	18,200
Naphthalene	19,000	6.39	18.0	39.1	116
Toluene	590,000	388	1,710	5,560	34,200

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Compound	Solubility Limit (µg/l)	Site-Specific Target (µg/litre)			
		Compliance Point at 50m	Compliance Point at 100m	Compliance Point at 150m	Compliance Point at 250m
TPH Aliphatic C ₈₋₁₀	430	Sol	Sol	Sol	Sol
TPH Aliphatic C ₁₀₋₁₂	34	Sol	Sol	Sol	Sol
TPH Aliphatic C ₁₂₋₁₆	0.76	Sol	Sol	Sol	Sol
TPH Aliphatic C ₁₆₋₃₅	0.0013	Sol	Sol	Sol	Sol
TPH Aromatic C ₈₋₁₀	65,000	941	2,610	5,570	16,000
TPH Aromatic C ₁₀₋₁₂	25,000	288	812	1,760	5,240
TPH Aromatic C ₁₂₋₁₆	5,800	292	839	1,850	5,670
TPH Aromatic C ₁₆₋₂₁	510	273	Sol	Sol	Sol
TPH Aromatic C ₂₁₋₃₅	6.6	Sol	Sol	Sol	Sol
Xylenes	191,000	94.1	261	557	1,600

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

Table Eighteen: Groundwater Targets - Protective of Controlled Water Receptors

Compound	Site-Specific Target for Groundwater(µg/litre)
Benzene	33,100
Benzo(a)pyrene	Sol
Ethylbenzene	Sol
Naphthalene	Sol
Toluene	Sol
TPH Aliphatic C ₈₋₁₀	Sol
TPH Aliphatic C ₁₀₋₁₂	Sol
TPH Aliphatic C ₁₂₋₁₆	Sol
TPH Aliphatic C ₁₆₋₃₅	Sol
TPH Aromatic C ₈₋₁₀	Sol
TPH Aromatic C ₁₀₋₁₂	Sol
TPH Aromatic C ₁₂₋₁₆	Sol
TPH Aromatic C ₁₆₋₂₁	Sol

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Compound	Site-Specific Target for Groundwater(µg/litre)
TPH Aromatic C ₂₁₋₃₅	Sol
Xylenes	Sol

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

Table Nineteen: Vapour Targets - Protective of Human Health

6 Discussion

6.1 Conclusions

The results of our groundwater sampling and fate-transport modelling confirm that dissolved-phase hydrocarbon concentrations recorded on site do not pose a significant risk to on-site workers. However concentrations of some compounds exceed the calculated remedial targets for controlled water receptors.

Given the site setting, and due to the underlying chalk aquifer at the site location not being viable for potential groundwater abstraction due to saline intrusion, we would propose the remedial targets calculated for a compliance point at 150m (the distance to the closest surface water feature) to be the most suitable for use.

This assessment has generated site-specific target levels following current best practice and adhering to current statutory guidance. These have been calculated to ensure that contaminant concentrations in groundwater below the target levels do not pose a significant risk to the health of site occupants or to controlled water receptors such as aquifers and/or nearby rivers and streams. These are summarised in the table below.

Contaminant	Groundwater		Critical Pollutant Linkages
	Target Level (µg/litre)	Pass/Fail	
Benzene	174	Pass	-
Benzo(a)pyrene	0.00289	Pass	-
Ethylbenzene	6,020	Pass	-
Naphthalene	39.1	Fail	Lateral migration to surface and groundwater
Toluene	5,560	Pass	-
TPH Aliphatic C ₈₋₁₀	Sol	Pass	-
TPH Aliphatic C ₁₀₋₁₂	Sol	Pass	-
TPH Aliphatic C ₁₂₋₁₆	Sol	Pass	-
TPH Aliphatic C ₁₆₋₃₅	Sol	Pass	-
TPH Aromatic C ₈₋₁₀	5,570	Fail	Lateral migration to surface and groundwater

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Contaminant	Groundwater		Critical Pollutant Linkages
	Target Level (µg/litre)	Pass/Fail	
TPH Aromatic C ₁₀₋₁₂	1,760	Pass	-
TPH Aromatic C ₁₂₋₁₆	1,850	Pass	-
TPH Aromatic C ₁₆₋₂₁	Sol	Pass	-
TPH Aromatic C ₂₁₋₃₅	Sol	Pass	-
Xylenes	557	Fail	Lateral migration to surface and groundwater

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

Table Twenty: Calculated Site Specific Target Levels

6.2 Recommendations

We recommend that a review of potential remedial strategies be completed for the site in order to assess potential remediation options available to reduce concentrations of dissolved phase hydrocarbons in underlying groundwater to acceptable levels.

6.3 Limitations and Uncertainties

These target levels are appropriate for the assessment of groundwater quality in connection with the site's current use and any proposed redevelopment detailed in this report. They may not be appropriate for other uses or redevelopment schemes. Should any work on site encounter conditions varying to those used in our assessment, then the target levels should be reviewed and, if necessary, revised.

The basis of our risk assessment, together with our assumptions and input values, has not been agreed with the relevant regulatory authorities. The target levels presented in this report should be discussed and agreed with the relevant regulatory authorities prior to their use. Our models are reliant on data from limited investigations of the site and from literature-sourced values. Other conditions may exist in areas of the site that have not been fully investigated and which may invalidate the target values we have calculated. In this case, the target levels should be reviewed and, if necessary, revised.

7 Additional References

BP Oil International (2001). 'Risk-Integrated Software for Clean-ups, Users Manual Version 4.0', BP, Middlesex.

Environment Agency (April 2003). 'Fact Sheet for RISC', Fact Sheet FS-04.

Environment Agency (2006). 'Remedial Targets Methodology. Hydrogeological Risk Assessment for Land Contamination' Environment Agency, Bristol.

Environment Agency (November 2008). 'Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values' Science Report SC050021/SR7.

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Environment Agency (January 2009). 'Updated Technical Background to the CLEA Model' Science Report SC050021/SR3

Environment Agency (November 2012). 'Groundwater protection: Principles and practice (GP3)' Version 1. Environment Agency, Bristol.

Gustafson et al. (July 1997). 'Selection of Representative TPH Fractions Based on Fate and Transport Considerations' Total Petroleum Hydrocarbon Criteria Working Group Series Volume 3.

Jones, HK, and Robins, NS (editors) (1999). 'The Chalk aquifer of the South Downs'. Hydrogeological Report Series of the British Geological Survey.

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**ATTACHMENT ONE:
NOTICE TO INTERESTED PARTIES**

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NOTICE TO INTERESTED PARTIES

The purpose of our target levels is to determine site-specific concentrations of soil and/or groundwater that will not pose a toxicological risk to identified on-site and off-site receptors.

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.

When examining the voracity of the base data used in our assessment, we would make the following comments. 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.

Soil is, however, 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 have simply reduced the possibility to an acceptable level.

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.

This 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 have been used in the construction of the buildings present on 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 we carry out any remedial works we deem necessary.

This report has been prepared for Enterprise Rent-a-Car Ltd. Use of, and reliance on, this report by other third parties will be at such third parties own risk, and we are unable to accept any liability or responsibility to third parties.

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.

This report and its contents, together with any supporting correspondence or other documentation, remain the property of Subadra Consulting Limited until paid for in full.

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**ATTACHMENT TWO:
PROPERTIES OF CONTAMINANTS OF CONCERN**

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Compound	Henry's Law Constant	K _{oc} (cm ³ /g)	Information Source
Benzene	0.116	67.6	Environment Agency Report SC050021/SR7.
Benzo(a)pyrene	1.76x10 ⁻⁶	129,000	
Ethylbenzene	0.139	447	
Naphthalene	6.62x10 ⁻³	646	Environment Agency Report SC050021/SR7. Average value for m, p and o xylenes.
Toluene	0.115	204	
Xylenes	0.104	453	
TPH: Aliphatic C ₈ -C ₁₀	48.6	30,200	Environment Agency Report SC050021/SR7 recommends using values provided by Total Petroleum Hydrocarbons Working Group. Values taken from RISC Chemical Database, based on TPH CWG. (Henry's Law constant value converted to 10°C)
TPH: Aliphatic C ₁₀ -C ₁₂	71.8	240,000	
TPH: Aliphatic C ₁₂ -C ₁₆	254	5,370,000	
TPH: Aliphatic C ₁₆ -C ₃₅	2410	575,000,000	
TPH: Aromatic C ₈ -C ₁₀	0.290	1,580	
TPH: Aromatic C ₁₀ -C ₁₂	0.0774	2,510	
TPH: Aromatic C ₁₂ -C ₁₆	0.0254	5,010	
TPH: Aromatic C ₁₆ -C ₂₁	0.00489	14,100	
TPH: Aromatic C ₂₁ -C ₃₅	0.000144	126,000	

Table 2.1: Chemical Properties of Contaminants of Concern

Compound	Half-Life in Groundwater (days)	Information Source
Benzene	720	High-end value from Howard, Handbook of Environmental Degradation Rates, Lewis Publishers, 1989.
Benzo(a)pyrene	1,060	
Ethylbenzene	228	
Naphthalene	258	
Toluene	28	
Xylenes	360	

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Compound	Half-Life in Groundwater (days)	Information Source
TPH: Aliphatic C ₈ -C ₁₀	360	Values for TPH fractions calculated from individual compounds (see below)
TPH: Aliphatic C ₁₀ -C ₁₂	258	
TPH: Aliphatic C ₁₂ -C ₁₆	204	
TPH: Aliphatic C ₁₆ -C ₃₅	1660	
TPH: Aromatic C ₈ -C ₁₀	360	
TPH: Aromatic C ₁₀ -C ₁₂	258	
TPH: Aromatic C ₁₂ -C ₁₆	204	
TPH: Aromatic C ₁₆ -C ₂₁	1560	
TPH: Aromatic C ₂₁ -C ₃₅	1750	

Table 2.2: Half-Life data for Contaminants of Concern

We have assigned half-lives to TPH groups based upon the criteria listed below.

- For the lower-range TPH values (C₆ to C₁₆) where we have data for only a few compounds, we have used the highest individual half-life in the TPH range to ensure a conservative assessment of risk.
- For the higher-range TPH values (C₁₆ to C₃₅), where we have data for a greater number of compounds, we have used the average half-life in the TPH range as more appropriate for the overall behaviour of all the compounds within the range.

TPH Range	Individual Compounds Used in Calculations	Equivalent Carbon Number	Half-life in Groundwater (days)	Average Value of Half-life (days)
TPH >C ₈ -C ₁₀	Ethylbenzene	8.5	228	360
	Xylenes	8.6	360	
	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	—	258
	Naphthalene	11.7	258	

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TPH Range	Individual Compounds Used in Calculations	Equivalent Carbon Number	Half-life in Groundwater (days)	Average Value of Half-life (days)
TPH >C ₁₂ -C ₁₆	Acenaphthalene	15.5	204	204
	Biphenyl	14.26	14	
TPH >C ₁₆ -C ₂₁	Fluorene	16.5	120	1,560
	Benzo(ghi)perylene	18	1,300	
	Phenanthrene	19.36	400	
	Anthracene	19.43	920	
	Pyrene	20.8	3,800	
	3-Methylchloanthrene	21	2,800	
TPH >C ₂₁ -C ₃₅	Fluoranthene	21.85	880	1,750
	Benz(a)anthracene	26.37	1,360	
	Chrysene	27	2,000	
	Benzo(b)fluoranthene	30.14	1,220	
	Benzo(k)fluoranthene	30.14	4,280	
	Benzo(a)pyrene	31	1,060	
	Indeno(1,2,3-cd)pyrene	35.01	1,460	

Table 2.3: Properties of Individual Compounds Used to Determine Half-lives values For TPH

Compound	Toxicity Parameter Type	Oral (µg kg ⁻¹ bw day ⁻¹)	Inhalation (µg kg ⁻¹ bw day ⁻¹)	Source
Benzene	Index Dose ¹	0.29	1.4	SC050021
Benzo(a)pyrene	Index Dose ¹	0.02	0.07x10 ⁻³	R&D Tox Pub 2
Ethylbenzene	TDI ²	100	220	SC050021
Naphthalene	TDI ²	20	0.82 – adult 0.79 - child	R&D Tox Pub 20
Toluene	TDI ²	223	1,400	SC050021
Xylenes	TDI ²	180	58 – adult 55 - child	SC050021

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Compound	Toxicity Parameter Type	Oral ($\mu\text{g kg}^{-1} \text{ bw day}^{-1}$)	Inhalation ($\mu\text{g kg}^{-1} \text{ bw day}^{-1}$)	Source
TPH: Aliphatic C ₅ -C ₆	Toxicity Dose ³	5,000	5,000	LQM/CIEH S4UL
TPH: Aliphatic C ₆ -C ₈	Toxicity Dose ³	5,000	5,000	
TPH: Aliphatic C ₈ -C ₁₀	Toxicity Dose ³	100	290	
TPH: Aliphatic C ₁₀ -C ₁₂	Toxicity Dose ³	100	290	
TPH: Aliphatic C ₁₂ -C ₁₆	Toxicity Dose ³	100	290	
TPH: Aliphatic C ₁₆ -C ₃₅	Toxicity Dose ³	2,000	-	
TPH: Aromatic C ₅ -C ₇	Toxicity Dose ³	223	1,400	
TPH: Aromatic C ₇ -C ₈	Toxicity Dose ³	223	1,400	
TPH: Aromatic C ₈ -C ₁₀	Toxicity Dose ³	40	60	
TPH: Aromatic C ₁₀ -C ₁₂	Toxicity Dose ³	40	60	
TPH: Aromatic C ₁₂ -C ₁₆	Toxicity Dose ³	40	60	
TPH: Aromatic C ₁₆ -C ₂₁	Toxicity Dose ³	30	-	
TPH: Aromatic C ₂₁ -C ₃₅	Toxicity Dose ³	30	-	

- Notes:
- 1 Index Dose – A level set for each non-threshold contaminant that represents a minimal risk level from possible soil exposures. Non-threshold substances are toxicants that do not have a threshold at which they pose no risk, i.e. there is always some risk at any level of exposure.
 - 2 TDSI – Tolerable Daily Intake. A finite dose set for each threshold toxicant below which adverse effects are not discernible.
 - 3 Toxicity Dose – A finite dose set for each TPH range, approximately equivalent to TDSI. Where no TDSI has been published, the Toxicity Dose published in P5-080/TR3 has been used. The inhalation values are reported in P5-080/TR3 as concentrations (mg/m³). These have been adjusted for the female child body weight and indoor air inhalation rate to produce the toxicity dose.

Table 2.4: Toxicity Parameters of Contaminants of Concern Used for Human Health

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**ATTACHMENT THREE:
RTM MODEL INPUT PARAMETERS**

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Compound	Compliance Criteria	
	(µg/litre)	Source
Benzene	10	EU Environmental Quality Standard
Benzo(a)pyrene	0.00017	
Ethylbenzene	300	Annual–Average Environmental Quality Standard (AA-EQS)
Naphthalene	2.0	Annual–Average Environmental Quality Standard (AA-EQS). Value for xylene is and Environment Agency 'operational' target only.
Toluene	74	
Xylenes	30	
TPH: Aliphatic C ₈ -C ₁₀	300	WHO guide values for TPH CWG fractions in drinking water
TPH: Aliphatic C ₁₀ -C ₁₂	300	
TPH: Aliphatic C ₁₂ -C ₁₆	300	
TPH: Aliphatic C ₁₆ -C ₃₅	300	
TPH Aromatic C ₅ -C ₆	10	
TPH Aromatic C ₆ -C ₈	700	
TPH: Aromatic C ₈ -C ₁₀	300	
TPH: Aromatic C ₁₀ -C ₁₂	90	
TPH: Aromatic C ₁₂ -C ₁₆	90	
TPH: Aromatic C ₁₆ -C ₂₁	90	
TPH: Aromatic C ₂₁ -C ₃₅	90	

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)	30	Estimated from site data
Plume thickness (m)	1	Assumed to be in the top of the aquifer
Saturated aquifer thickness (m)	25	Literature value
Soil bulk density (g/cm ³)	2.3	ConSim median value
Effective porosity	0.01	Porosity data from Wealthall GP et al

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Hydraulic gradient	0.0021	Site data
Hydraulic conductivity (m/day)	10	Literature value for chalk
Fraction of organic carbon (g oc/g soil)	0.001	Site data for chalk
Time since pollution entered groundwater (days)	9e ⁹⁹	Steady State
Distance to compliance point (m)	-	Various

Table 3.2: Input Parameters for Tier Three Groundwater

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**ATTACHMENT FOUR:
RISC MODEL INPUT PARAMETERS**

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Threshold Substances for Human Receptors – Hazard Index

Threshold substances are toxicants that have a finite dose below which adverse effects are not discernible. For threshold substances, we have modelled the exposure risk using the standard hazard index. This is defined as the ratio of exposure to toxicity for each compound and exposure pathway:

$$HI_{xy} = CADD_{xy}/TDSI_{xy}$$

where

HI_{xy} Hazard Index for chemical x and exposure pathway y;
 $CADD_{xy}$ Chronic daily intake for chemical x and exposure pathway y;
 $TDSI_{xy}$ Tolerable Daily Soil Intake for chemical x and exposure pathway y from CLEA publications.

When a CLEA-defined $TDSI_{xy}$ is unavailable, the RfD_{xy} identified by RISC will be utilised.

Non-Threshold Substances for Human Receptors – Index Dose Ratio

Non-threshold substances are toxicants that have no threshold, there is always some risk at any level of exposure. Under the CLEA approach these compounds are assessed in terms of a soil Index Dose, a level set for each toxicant that represents a minimal risk level from possible soil exposures. For non-threshold substances, we assess risk by evaluating the an index dose ratio to see if the chronic average daily intake exceeds the given pathway index dose:

$$IDR_{xy} = CADD_{xy}/ID_{xy}$$

where

IDR_{xy} Index Dose Ratio for chemical x and exposure pathway y;
 $CADD_{xy}$ Chronic average daily intake for chemical x and exposure pathway y;
 ID_{xy} Index Dose for chemical x and exposure pathway y based on CLEA publications.

Acceptable Risk Levels for Human Receptors

Where we are assessing a residence, we will assess the exposure to a child resident as children are more sensitive to contaminants than adults. We have defined the acceptable risks as follows:

Receptor	Acceptable Threshold Hazard Index		Acceptable Non-Threshold Index-Dose Ratio	
	Individual Pathways	Cumulative for all Pathways	Individual Pathways	Cumulative for all Pathways
Residents on site	1.0	1.0	<1.0	<1.0
Residents off site	1.0	1.0	<1.0	<1.0
Workers on site	1.0	1.0	<1.0	<1.0
Workers off site	1.0	1.0	<1.0	<1.0

Table 4.1: Acceptable Risk Levels for Human Health

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Run	Linkage
001	Groundwater – Inhalation of vapours in indoor air – On site worker

Table 4.2: Model Runs

Parameter	Worker	Source/Justification
Body weight (kg)	70.0	SC050021 SR4, Table 3.2
Exposure Duration (years)	49	SC050021 SR4, Table 1.1
Exposure frequency (events/year)	230	SC050021/SR3 Table 3.9
Time indoors (hours/day)	8.3	SC050021/SR3 Box 3.6
Inhalation rate for indoor air (m ³ /hour)	0.62	SC050021/SR3 Table 4.14
Lung retention factor (-)	1	Conservative assumption

Table 4.3: CLEA Defined Exposure Data for Human Receptors

Parameter	Value	Data Source
Enclosed space floor length (m)	9	Given on site plan
Enclosed space floor width (m)	5	Measured from site plan
Enclosed space height (m)	4.8	SC050021/SR3 Table 4.21 –living space height of two storey building
Indoor air exchange rate (1/hr)	1/0.5	CLEA recommended value for commercial/residential building SC050021/SR3 Table 4.21
Thickness of foundation walls (cm)	15	CLEA recommended value for foundation thickness SC050021/SR3 Table 4.21
Crack fraction	0.0012	Calculation (0.002 x perimeter/area)
Porosity in foundation crack	0.25	RISC default value
Water content in foundation cracks	0	RISC default value
Foundation depth below ground surface (m)	0.5	Estimate

Table 4.4: On-Site Building Parameters

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Parameter	Value	Data Source
Total Porosity (cm ³ /cm ³)	0.54	CLEA recommendation for sand soils
Water content (cm ³ /cm ³)	0.24	CLEA recommendation for sand soils
Soil bulk density (g/cm ³)	1.18	CLEA recommendation for sand soils
Fraction of organic carbon (g oc/g soil)	0.001	Site data
Thickness of capillary fringe (cm)	17	RISC recommended value for sand soil
Air content in capillary fringe (cm ³ /cm ³)	0.12	RISC recommended value for sand soil
Vertical distance to foundation from groundwater (m)	1.0	Calculated using assumed foundation depth (0.5m) and depth to groundwater (1.5m).

Table 4.5: Unsaturated Zone Parameters

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**ATTACHMENT FIVE:
CHEMICAL ANALYSIS CERTIFICATES**

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