



ENVIRONMENTAL ASSESSMENT

MONCKTON COKE &
CHEMICALS LIMITED,
ROYSTON, SOUTH YORKSHIRE

REPORT NO: 16492-R1 (01)

HARGREAVES SERVICES PLC

MAY 2011

CONFIDENTIAL



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Risk Assessment Methodology

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: Preliminary, Generic Quantitative and Detailed Quantitative. An outline Conceptual Model should be formed at the preliminary risk assessment stage that collates all the existing information pertaining to a site in text, tabular or diagrammatic form. The outline conceptual model identifies potentially complete (termed possible) pollutant linkages (source–pathway–receptor) and is used as the basis for design of the site investigation. The outline Conceptual Model is updated as further information becomes available, for example as a result of the site investigation.

Production of a Conceptual Model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk. RSK has adopted guidance provided in CIRIA C552 for use in the production of conceptual models.

The likelihood of an event can be classified on a four-point system using the following terms and definitions based on CIRIA C552:

- Highly likely: the event appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution;
- Likely: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term;
- Low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term; and
- Unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- Severe: short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- Medium: chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);

- Mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment; and
- Minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the likelihood of an event occurring and its severity have been classified, a risk category can be assigned the table below.

		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

Definitions of these risk categories are as follows together with an assessment of the further work that might be required:

- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability and urgent investigation and remediation are likely to be required;
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability and urgent investigation is required and remedial works may be necessary in the short term and are likely over the long term;
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term;
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild; and
- Very Low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.

APPENDIX D

Borehole Logs

APPENDIX E

Ground Gas Monitoring Data

APPENDIX F

Laboratory Certificates for Soil Analysis

APPENDIX G

Laboratory Certificates for Groundwater Analysis

APPENDIX H

Geotechnical Laboratory Certificates

APPENDIX I

Human Health Generic Assessment Criteria

APPENDIX J

Generic Assessment Criteria for Controlled Waters

GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

This appendix presents the generic assessment criteria (GAC) that RSK considers are suitable for assessing risks to controlled waters.

CONTROLLED WATERS

The GAC for controlled waters are presented in Table A3. In line with the Environment Agency's Remedial Targets Methodology dated December 2006, the GAC for controlled waters are termed 'target concentrations'.

The target concentration can be derived by several means with consideration to:

- Whether the substance is classified as hazardous or non-hazardous by the EU under the the Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC) implemented through the Environmental Permitting Regulations 2010;
- Background concentrations in the aquifer; and
- Published guidance such as Environmental Quality Standards that are protective of ecology or The Water Supply (Water Quality) Regulations 2001 that are protective of drinking water.

A list of target concentrations considered suitable to assess risks to principal aquifers and secondary aquifers are presented in Table A3. Those for a principal aquifer are taken from the UK Water Supply (Water Quality) Standards where possible owing to the possibility of a drinking water supply being within an influencing distance from the site or the possibility of one being installed. The target concentrations for a secondary aquifer are generally taken as the freshwater Environmental Quality Standards where available owing to groundwater in secondary aquifers commonly providing base flow to surface watercourses.

Table A3: Target Concentrations for Controlled Waters

Determinant	Target Concentrations (mg/l)	
	Principal Aquifer/Source Protection Zone	Secondary Aquifer/Surface Watercourse
Metals		
Arsenic	0.01 ⁽¹⁾	0.05 ⁽⁶⁾
Cadmium	0.005 ⁽¹⁾	0.005 ⁽⁶⁾
Chromium (total)	0.05 ⁽¹⁾	Salmonid: 0.150, 0.175, 0.2, 0.2, 0.25, 0.25 ⁽⁷⁾ Cyprinid: 0.005, 0.01, 0.02, 0.02, 0.05, 0.05 ⁽⁸⁾
Copper	2.0 ⁽¹⁾	All fish life: 0.001, 0.006, 0.01, 0.01, 0.01 0.028 ⁽⁹⁾
Lead	0.025 ⁽¹⁾	Salmonid: 0.004, 0.01, 0.01, 0.02, 0.02, 0.02 ⁽⁷⁾ Cyprinid: 0.05, 0.125, 0.125, 0.25, 0.25, 0.25 ⁽⁸⁾
Mercury	0.001 ⁽¹⁾	0.001 ⁽⁶⁾
Selenium	0.01 ⁽¹⁾	0.01 ^(1,13)
Nickel	0.02 ⁽¹⁾	0.05, 0.1, 0.15, 0.15, 0.2, 0.2 ⁽⁹⁾
Zinc	5 ⁽²⁾	Salmonid: 0.008, 0.05, 0.075, 0.075, 0.075, 0.125 ⁽⁷⁾ Cyprinid: 0.075, 0.175, 0.25, 0.25, 0.25, 0.5 ⁽⁸⁾
Chlorinated Solvents		
Trichloroethene	0.01 ⁽¹⁾	0.01 ⁽⁶⁾
Tetrachloroethene		0.01 ⁽⁶⁾
1,1,1-Trichloroethane	0.0001 ⁽³⁾	0.1 ⁽⁶⁾
1,1,2-Trichloroethane	0.0001 ⁽³⁾	0.4 ⁽⁶⁾
Carbon Tetrachloride	0.003 ⁽¹⁾	0.012 ⁽⁶⁾
1,2-Dichloroethane	0.003 ⁽¹⁾	0.01 ⁽⁶⁾
Vinyl Chloride	0.0005 ⁽¹⁾	0.0005 ^(1,13)
Trihalomethanes	0.1 ⁽⁴⁾	0.1 ^(4,13)
Chloroform (one of the trihalomethanes included above)	-	0.012 ⁽⁶⁾
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	0.0058 ^(8,14)	0.0058 ⁽¹⁰⁾
Acenaphthylene	0.0058 ^(8,14)	0.0058 ⁽¹⁰⁾
Anthracene	0.000012 ^(8,14)	0.000012 ⁽¹⁰⁾
Benzo(a)anthracene	0.000018 ^(8,14)	0.000018 ⁽¹⁰⁾
Benzo(b)fluoranthene	0.0001 ⁽¹⁾	0.000014 ⁽¹⁰⁾
Benzo(k)fluoranthene		0.000014 ⁽¹⁰⁾
Benzo(g,h,i)perylene		0.00002 ⁽¹⁰⁾

Determinant	Target Concentrations (mg/l)	
	Principal Aquifer/Source Protection Zone	Secondary Aquifer/Surface Watercourse
Indeno(1,2,3-cd)pyrene		No data ⁽¹⁰⁾
Chrysene	0.00001 ^(8,14)	0.00001 ⁽¹⁰⁾
Dibenzo(a,h)anthracene	0.00001 ^(8,14)	0.00001 ⁽¹⁰⁾
Fluoranthene	0.00001 ^(8,14)	0.00001 ⁽¹⁰⁾
Fluorene	0.0021 ^(8,14)	0.0021 ⁽¹⁰⁾
Phenanthrene	0.003 ^(8,14)	0.003 ⁽¹⁰⁾
Pyrene	0.00004 ^(8,14)	0.00004 ⁽¹⁰⁾
Benzo(a)pyrene	0.00001 ⁽¹⁾	0.000015 ⁽¹⁰⁾
Naphthalene	0.01 ^(8,14)	0.01 ⁽⁶⁾
Petroleum Hydrocarbons		
Total Petroleum Hydrocarbons	0.01 ⁽²⁾	0.01 ^(2,11)
Benzene	0.001 ⁽¹⁾	0.03 ⁽⁶⁾
Toluene	0.004 ⁽³⁾	0.05 ⁽⁶⁾
Ethylbenzene	0.02 ^(7,12)	0.02 ⁽⁷⁾
Xylene	0.003 ⁽³⁾	0.03 ⁽⁶⁾
Styrene	0.05 ⁽¹⁴⁾	0.05 ⁽⁶⁾
Methyl t-Butyl ether	0.015 ⁽⁵⁾	0.015 ^(5,13)
Pesticides and Herbicides		
Aldrin	0.00003 ⁽¹⁾	0.00001 ⁽⁶⁾
Dieldrin	0.00003 ⁽¹⁾	0.00003 ^(1,34)
Heptachlor	0.00003 ⁽¹⁾	0.00003 ^(1,13)
Heptachlor epoxide	0.00003 ⁽¹⁾	0.00003 ^(1,13)
Other pesticides	0.0001 ⁽¹⁾	0.0001 ^(1,13)
Total pesticides	0.0005 ⁽¹⁾	0.0005 ^(1,13)
Endrin	0.000005 ^(6,14)	0.000005 ⁽⁶⁾
Total DDT	0.000025 ^(6,14)	0.000025 ⁽⁶⁾
Azinphos - methyl	0.00001 ^(6,14)	0.00001 ⁽⁶⁾
Cyfluthrin	0.000001 ^(8,14)	0.000001 ⁽⁶⁾
Demeton	0.0005 ^(6,14)	0.0005 ⁽⁶⁾
Dichlorvos	0.000001 ^(6,14)	0.000001 ⁽⁶⁾
Dimethoate	0.001 ^(6,14)	0.001 ⁽⁶⁾
Endosulphan	0.000003 ^(6,14)	0.000003 ⁽⁶⁾
Fenitrothion	0.000001 ^(6,14)	0.000001 ⁽⁶⁾
Fluocifuron	0.001 ^(6,14)	0.001 ⁽⁶⁾
Malathion	0.00001 ^(8,14)	0.00001 ⁽⁶⁾
Mevinphos	0.00002 ^(8,14)	0.00002 ⁽⁶⁾
Omethoate	0.00001 ^(6,14)	0.00001 ⁽⁶⁾
PCSDs	0.00005 ^(6,14)	0.00005 ⁽⁶⁾
Permethrin	0.00001 ^(6,14)	0.00001 ⁽⁶⁾
Sulcofuron	0.025 ^(6,14)	0.025 ⁽⁶⁾

Determinant	Target Concentrations (mg/l)	
	Principal Aquifer/Source Protection Zone	Secondary Aquifer/Surface Watercourse
Triazaphos	0.000005 ^(6,14)	0.000005 ⁽⁶⁾
Atrazine & Simazine	0.002 ^(6,14)	0.002 ⁽⁶⁾
Bentazone	0.5 ^(6,14)	0.5 ⁽⁶⁾
Linuron	0.002 ^(6,14)	0.002 ⁽⁶⁾
Mecoprop	0.02 ^(6,14)	0.02 ⁽⁶⁾
Trifluralin	0.0001 ^(6,14)	0.0001 ⁽⁶⁾
Miscellaneous		
Cyanide	0.05 ⁽¹⁾	0.05 ^(1,134)
Phenol	0.0005 ⁽²⁾	0.03 ⁽⁶⁾
Sodium	200 ⁽¹⁾	170 ⁽⁶⁾
Chloride	250 ⁽¹⁾	250 ⁽⁶⁾
Ammonium (as NH ₄ ⁺)	0.5 ⁽¹⁾	0.5 ^(1,13)
Ammonia (NH ₃ as N)	0.015 ^(6,14)	0.015 ⁽⁶⁾
Sulphate	250 ⁽¹⁾	400 ⁽⁶⁾
Iron	0.20 ⁽¹⁾	1 ⁽⁷⁾
Manganese	0.05 ⁽¹⁾	0.05 ^(1,13)
Aluminium	0.2 ⁽¹⁾	0.2 ^(1,13)
Nitrate (as NO ₃)	50 ⁽¹⁾	50 ^(1,13)
Nitrite (as NO ₂)	0.5 ⁽¹⁾	0.5 ^(1,13)

Notes

1. Statutory Instrument 2000 No 3184. The Water Supply (Water Quality) Regulations.
2. Statutory Instrument 1991 No 2790. Private Water Supplies Regulations.
3. Environment Agency. Minimum Reporting Values listed in Appendix 7 of Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels. LFTGN01. Note target concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
4. Statutory Instrument 1989 No 3184. The Water Supply (Water Quality) Regulations, 2000 – sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
5. Environment Agency MTBE Guidance.
6. Freshwater Environmental Quality Standards.
7. Freshwater Environmental Quality Standards for salmonid (coarse) fish and dependent upon hardness range. Hardness ranges are: 0-50mg/l CaCO₃, 50-100 mg/l CaCO₃, 100-150 mg/l CaCO₃, 150-200 mg/l CaCO₃, 200-250 mg/l CaCO₃ and >250 mg/l CaCO₃. The target concentrations included in Table 3 are listed in order of increasing calcium carbonate concentrations.
8. Freshwater Environmental Quality Standards for cyprinid (game) fish and dependent upon hardness range. Hardness ranges are: 0-50mg/l CaCO₃, 50-100 mg/l CaCO₃, 100-150 mg/l CaCO₃, 150-200 mg/l CaCO₃, 200-250 mg/l CaCO₃ and >250 mg/l CaCO₃. The target concentrations included in Table 3 are listed in order of increasing calcium carbonate concentrations.

9. Freshwater Environmental Quality Standards for all fish life and dependent upon hardness range. Hardness ranges are: 0-50mg/l CaCO_3 , 50-100 mg/l CaCO_3 , 100-150 mg/l CaCO_3 , 150-200 mg/l CaCO_3 , 200-250 mg/l CaCO_3 and >250 mg/l CaCO_3 . The target concentrations included in Table 3 are listed in order of increasing calcium carbonate concentrations.
10. Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development, WRc Plc, R&D Technical Report P45. 2002. Where Predicted No-Effect Concentration is below the laboratory method detection limit (LMDL) for chrysene, dibenzo(ah)anthracene and fluoranthene, the target concentration has been set at the LMDL of 0.00001mg/l.
11. Owing to hydrocarbons being hazardous substances, 0.01mg/l (DWS) should be used in the first instance against the total of the hydrocarbon bands. However, if the hydrocarbon concentrations measured in groundwater exceed this value, an alternative value of 0.05mg/l could be used providing it is justified based on the type of aquifer and distance to secondary receptors such as a stream. The value is taken as the lowest concentration in Statutory Instrument 1996 No. 3001 titled The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations, 1996.
12. Value for ethylbenzene taken from R&D Technical Report P2-115/TR4 – Proposed Environmental Quality Standards for Ethylbenzene in Water.
13. Where a published target concentration considered suitable for use with a secondary aquifer could not be found for certain substances such as selenium, the target concentration used for the principal aquifer has been adopted.
14. Where a published target concentration considered suitable for use with a principal aquifer could not be found for certain substances such as ethylbenzene, the target concentration used for the secondary aquifer has been adopted.

^{4.1} A target concentration for chloroform for a principal aquifer is absent since it is one of the trihalomethane compounds. See note 4 above.

APPENDIX K

Topographical Survey

EXECUTIVE SUMMARY

RSK STATS Geoconsult Limited (RSK) was commissioned by Hargreaves Services plc to carry out an environmental assessment of Monckton Coke & Chemicals Limited, Lund Hill Lane, Royston. The site is currently in use for the manufacture of coke from coal, and this use is expected to continue for the foreseeable future.

The review of information and the construction of the outline conceptual site model (CSM) highlight potential pollutant linkages. Potentially, contaminated soils at the site pose a risk to site workers from direct contact, and surface waters and groundwater in the underlying bedrock are also at risk as a result of mobilisation of contamination and migration of groundwater. To investigate these potential risks to receptors further, an intrusive site investigation should be carried out.

Five deep boreholes were drilled by rotary means, and, monitoring wells for groundwater were installed in these boreholes. Additional ground gas and groundwater monitoring wells were installed in most of the twelve windowless-sampling boreholes.

The intrusive investigation has confirmed the presence of contamination within the subsurface, both in the shallow made ground, and at greater depth within the underlying bedrock. The investigation has proved the presence of made ground at all locations, and in the central part of the site this was directly underlain by bedrock from depths of less than 1.0m bgl.

Results of analyses of soil samples have been compared against the human health Generic Acceptance Criteria (GAC) for a commercial end use, and compounds that have been found to exceed the GAC in soil include naphthalene, benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene.

Analysis of groundwater samples have recorded concentrations of contaminants in excess of the GACs for human health. These GACs are all related to the inhalation of vapours from groundwater that have migrated to indoor air, but are mostly set at the solubility limit in water of the compound in question. The GAC are considered to be highly conservative, so there is unlikely to be a pathway for the migration of vapour between these and indoor air at the surface.

Given the elevated concentrations of contaminants that have been detected in samples of groundwater from the site, it is likely that soil-borne contamination has and is being mobilised by fluctuating groundwater and percolation of surface waters. As the site surface is largely permeable, percolation of surface waters is likely to be significant.

Comparison between the concentrations of contaminants detected in groundwater at the site and RSK derived GAC values indicate a number of exceedences, and therefore a

potential risk to surface waters. Concentrations of TPH, benzene and phenanthrene have all been recorded at concentrations that exceed the GAC by three orders of magnitude.

The results of the gas monitoring have been compared with the Revised Wilson and Card Classification presented within the CIRIA Report, and the site is designated as Characteristic Situation 1 (CS1) for methane (GSV is <0.07) and CS2 for carbon dioxide (GSV is >0.07 and <0.7). The Gas Screening Value for carbon dioxide indicates a low risk from ground gases at the site, and were a new development to be constructed, it would be expected to be fitted with basic gas ingress preventative measures.

Although the refined CSM has not identified any high or very high risks significant levels of contamination are present. In order to confirm that conditions are not deteriorating it is recommended that regular ongoing water sampling be carried out.

If changes in conditions, such as changes to on site or surrounding land uses take place then the CSM should be revised to assess such changes. If any changes or new development are proposed on site work detailed appraisals of these areas should also be completed.

1. INTRODUCTION

RSK STATS Geoconsult Limited (RSK) was commissioned by Hargreaves Services plc to carry out an environmental assessment of Monckton Coke & Chemicals Limited, Lund Hill Lane, Royston. This assessment was carried out with the understanding that the site is to continue in its current use for the foreseeable future. It should be noted that Hargreaves Services plc currently own Monckton Coke & Chemicals Limited.

RSK STATS Environment Health & Safety Limited (a sister company of RSK STATS Geoconsult Limited) have previously undertaken a Due Diligence Environmental Site Assessment of the site.

1.1 Objectives

The objectives of this assessment are as follows:

- To investigate the contamination status of soils and groundwater beneath the site; and
- To identify existing or future liabilities and risks resulting from any contamination of soils and groundwater that is attributable to the operations on site.

1.2 Scope

The scope of the investigation and layout of this report has been designed with CLR11 ⁽¹⁾ (NB all references indicated by superscripts are listed in full in Section 7) in mind and guidance issued by the Environment Agency in July 2005 for land contamination reports ⁽²⁾. A summary of relevant legislation and government policies applicable to land development is included in Appendix B.

The risk management process comprises up to three stages of risk assessment: preliminary, generic quantitative and detailed quantitative (PRA, GQRA and DQRA). The basis for the risk assessment is a conceptual model that is produced as part of the PRA and is updated throughout the risk management process.

The scope of works for the environmental assessment includes:

- A PRA involving the review of existing reports, utility location information, geological, hydrogeological and hydrological information, a commercially available database, historical plans, correspondence with appropriate regulatory authorities and site walkover. The findings from the previous Due Diligence Environmental Site Assessment, undertaken by RSK, has been reviewed and updated for this report. The information has been used to construct an outline conceptual model and consider any possible pollutant linkages (where a

receptor may be connected to a source by a viable pathway) that may be present and design appropriate intrusive investigation of such linkages;

- Evaluation of possible pollutant linkages by intrusive investigation and laboratory analysis. This information is used to refine the conceptual model; and
- GQRA to assess possible pollutant linkages identified in the PRA and enable outline conceptual model to be refined.

1.3 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater and ground gas levels may vary from those reported due to seasonal, or other, effects.

This report is subject to the RSK STATS Geoconsult Limited service constraints given in Appendix A.

1.4 Previous Work

RSK STATS Environment Health & Safety Limited has previously undertaken a due diligence assessment of the site, and the results of this are presented in the following report:

Due Diligence Environmental Site Assessment of Monckton Coke & Chemicals Limited at Royston, South Yorkshire. Revision: 00, Final Draft, 15 June 2010.

The following reports relating to the site prepared by third parties have also been reviewed:

- ABB Eutech, 2001 Phase 1a Site Report;
- ABB Eutech, 2002 Phase 1b/2 Site Report;
- WSP Environmental UK, 2005 Environmental Due Diligence Report; and
- WSP Environmental UK, 2008 Application Site Report.

2. SITE DETAILS

Details of the site setting are presented below.

2.1 Site Location

The site is located on Lund Hill Lane, Royston, north east of Barnsley, South Yorkshire. The main operational site covers approximately 14 hectares, and is accessed via two gated entrances off the B6428 road (Lund Hill Lane). This road forms the southern and eastern site boundaries, with a railway in a cutting and a disused railway forming the western and northern boundaries, respectively. A further parcel of land to the south west of the main site, on the other side (to the west) of the railway is also part of the site, though is no longer in use.

Figure 1 shows a location map for the site in relation to the surrounding area.

2.2 Site Description

The site comprises a coke manufacturing plant with associated by-product manufacture and electricity generation. As such, areas of the site include a coal and coke stockpile yard area to the north, coke and by products production area close to the site centre, a CHP plant to the south, and office building and messing facilities to the east. Site features are discussed in more detail in Section 3.9, below.

Ground levels at the site are generally highest to the south of the site centre (between the CHP plant and the by products area) from where they fall gently to the north and steeply to the south. The main entrance to the north east of the site is used for deliveries and access to the main process areas. The second entrance is at the south east corner of the site and leads to the office car park and through gates to operational areas such as the CHP plant and the effluent treatment plant. Apart from access roadways around the coke and by-products areas, the majority of the site is surfaced with soft-standing, although it is understood that a concrete slab is present over much of the coal/coke yard area.

Figure 2 shows a layout plan for the site.

2.3 Surrounding Area

Adjacent properties and land use include a disused area to the north (formerly the site of Monckton Colliery coal yard), a pallet recycling company to the east with a large area that was used by the colliery as a landfill beyond. To the west is a railway line, waste

ground and the Barnsley canal. To the south lies farmland, and the town of Royston is present to the south west.

3. PRELIMINARY RISK ASSESSMENT

Review of available data for the site has been used to undertake a PRA and develop an outline conceptual model. Much of the data is presented in the report previously prepared by RSK STATS Environment Health & Safety Limited, which included the information from an environmental database report. Pertinent information is presented and discussed below.

3.1 Geology

The geology ⁽³⁾ of the area consists of sandstone (i.e. Mexborough Rock) from the Bolsovian (Westphalian) geological age, overlying mudstone, siltstone and sandstone (i.e. Pennine Middle Coal Measures Formation from the Bolsovian to Duckmantian (Westphalian) ages). There is little overlying superficial geology in the area with the exception of made ground, which is shown to cover the majority of the site.

A Coal Authority Report was obtained for the previous Due Diligence Environmental Site Assessment report, and indicates the following:

- Past mining activities involved 10 seams of coal at 70m to 510m depths that were last worked in 1978.
- Ground movement from past mining activities that should by now have stopped.
- The subject property is not in an area likely to be influenced by present underground coal workings.
- Four mine entries exist. Three are on the subject property within the area where coke and coal is stockpiled and have been filled and capped. The fourth is off site to the west between the canal and railway.

Information in the environmental database report confirms that the subject property is in a radon affected area and an area where radon protection measures are required.

Previous intrusive investigations undertaken at the site by a third party (ABB Eutech) appear to have confirmed the presence of made ground across the site comprising coal, coke, clinker, sandstone, brick, concrete, ash, sand and clay. This generally overlay bedrock of mudstone, siltstone and sandstone, which was often weathered in the upper surfaces, and was usually encountered at depths from between 1.0m and 3.0m below ground level (bgl).

3.2 Hydrogeology

The underlying bedrock is designated by the Environment Agency ⁽⁴⁾ as a Secondary A aquifer (capable of supporting water supplies at a local rather than strategic scale, and

in some cases forming an important source of base flow to rivers). Due to the absence of overlying superficial deposits, there is no aquifer designation for them.

Groundwater vulnerability mapping indicates overlying soils to have a high (unknown) leaching potential.

The site is not in or near an area classified by the Environment Agency as a ground water source protection zone. There are no groundwater abstractions listed in the environmental database report within 1km of the site.

3.3 Hydrology

There are a number of surface water features indicated in the environmental database report in the vicinity of the site. A disconnected linear surface water feature is indicated alongside the western site boundary (adjacent to the railway line), and other disconnected features are shown in the area. It is likely that many of these water features ultimately connect to Poois Dike, 500m south of the site, which flows to the south. In addition, the disused Barnsley Canal runs in a north south direction to the south and west of the site, on the other side of the railway cutting.

Monckton Coke & Chemicals Company Limited are licensed to abstract water from the Barnsley Canal for industrial use.

3.4 Sensitive Land Uses

Information in the environmental database report confirms that the subject property and surrounding area are not subject to sensitive land use designations such as SSSI (Sites of Special Scientific Interest). Areas of adopted green belt exist in the surrounding area and the area in general is in a nitrate vulnerable zone.

3.5 Site History Review

A review of the site history has been carried out through the study of Ordnance Survey maps dating from the late 1800s, and is presented in Table 1. The review is designed to identify potential historic sources of contamination that may have impacted soil or groundwater quality beneath the site and to identify any potentially contaminative land uses in the area that may have impacted the site.

Table 1: Review of Historical Mapping

Map Dates	Description
1854	The site and surrounding area is shown as undeveloped agricultural land. The railway to the west of the site is shown, as is the Barnsley Canal.
1893	The site is developed as Monckton Main Colliery over the northern part. A network of railways is shown connecting the colliery to the nearby main railway lines. The site has numerous railway sidings, coke ovens located slightly to the north of the position of the existing ovens, a gas works located to the west of these, and two 'powder magazines' close to the site centre. The south end of the site is clear of colliery buildings and appears to be open land with terrace houses and a Methodist church at the southern most corner. At the south eastern side of the site, adjacent to Lund Hill Lane, a quarry is shown. The area of land between the canal and the railway off-site to the west is shown as a spoil area for the colliery.
1906	Generally as above, but with additional buildings and plant in the site centre, in the location of the existing by-products area. A single gasholder is shown on the parcel of land west of the railway near the road and railway bridge.
1917	The coke ovens are now indicated to be in a position consistent with their current location, and a number of the features in the existing by-products area are annotated as tanks. A railway track crossing the north western part of the site is indicated to be within a tunnel.
1933	Spoil heaps apparently emanating from the colliery on site are shown extending off-site to the north and east. The town of Royston is indicated to have expanded considerably with residential areas developed to the west side of the canal. The gas works on the parcel of land west of the railway is increased in size and indicates two gasholders.
1981	The terraced houses on the southern part of the site are no longer present, much of the railway on the site is gone, and the railway adjacent the northern site boundary is shown as dismantled.
1990	Generally as above, but with further reduction in railway tracks and a reduction in the size of the colliery particularly to the north of the site.
2000	Generally as today, with most of the railways and sidings removed and the spoil area to the south east of the site labelled as Tip (disused). Buildings on the site appear to be as they are today with the CHP plant and office block added.
2006 and 2010	As above and generally as today, but with the disused tip area shown to be planted with conifers and the gas works and gas holders to the west of the railway removed.

3.6 Landfill Sites and Waste Management

There are many landfill sites in the area listed in the environmental database report, with the majority clustered off site to the west on the land adjacent to the canal and railway line, including the area formerly used by the on-site colliery for dumping spoil from the mines. Others are further from the site and are clustered to the south east. They also include another area formerly used by the colliery for dumping spoil from the mines. A number of waste types are listed for the various landfill sites, including, domestic, industrial and liquid wastes.

A Registered Waste Treatment or Disposal Site entry is listed, for a location off-site to the south west, that relates to a licence held by Monckton Coke & Chemicals Company Limited for materials generated through the desulphurisation and purification of coke oven gas.

3.7 Database and Regulatory Information

The following information is provided in the environmental database report:

Three pollution incidents to controlled waters are recorded within 1,000m of the subject property. The nearest occurred approximately 500m west of the site, and all of the incidents were classed as category 3 – minor incidents.

Five substantiated pollution incidents are listed within 1km of the site. Three relate to incidents on site and are classed as significant incidents for air impact, and minor or no impact for land.

3.8 Anecdotal Information

The CHP plant was built in 1998 making the gas purification plant on the parcel of land to the west of the railway, near the road and railway bridge, redundant. Site representatives stated that the area on which the gas purification plant stood has since been remediated and is now left as fenced-off open land. This area is not accessible directly from the main site and is not included in this assessment report.

Site representatives indicated that a practice historically undertaken at the site was the disposal of used process water by pumping it onto mounds of colliery spoil located off-site to the east, on the other side of Lund Hill Lane.

3.9 Current Site Activities

The activities taking place on site are discussed in the Due Diligence Environmental Site Assessment report previously prepared by RSK. A summary of these activities is provided below.

The site is currently in use for the manufacture of coke from coal, and this use is expected to continue for the foreseeable future. Coke and coal is stored over the northern part of the site, and the coke ovens are located in a battery close to the site centre. After being discharged from the oven, the hot coke is taken to quencher tower, where process water is poured over to cool it. Flue gases from the coke ovens are piped to the by-products plant area where they undergo a series of production processes that produce the following:

- Tar;
- Benzole;
- Ammonia; and
- Residual coke oven gas.

The gas was formerly purified at the parcel of land to the west of the railway, before being sold off-site. Now the gas is used by the site's combined heat and power (CHP) plant to generate electricity and steam.

There are two workshops on site. The main engineering workshop is located at the north east corner of the site and includes the site stores and a nearby area for waste collection. The second workshop is for servicing mobile plant and is located adjacent to the coke stockpile area.

The CHP plant is located on the southern part of the site, it is relatively modern and in good condition. Ground staining was observed near to the north west corner of the building where operatives clean boiler components. Bunding around hydrochloric acid and caustic soda tanks near the south west corner of the building was constructed in blockwork and there was evidence of staining due to spills on the outside surfaces of the bund and within the bunded area.

The two main workshops on site are located centrally on the northern part of the site and in the north eastern corner. Various oil containers are stored in both, sometimes not on drip trays, and the floor is heavily stained. There is a designated oil storage building in the north eastern corner that contained new drums of oil of various sizes.

The main by-product production areas are south of the site centre and consist of various tanks, pumps, vessels and interconnecting pipework. Combustion gases from the ovens are fed into the production area, which is generally divided into tar, benzole and ammonia production areas. Remaining gas after these processes is used as fuel for the

CHP plant towards the south of the site. The ground surface in the production area was observed to be heavily stained, with indications of recent diffuse and point releases. The condition of some plant in the area is poor with, for example, leaking pipework, leaking valves and pumps, leaking tanks and indications of severe corrosion. Surface water gullies in the area collect liquors that had escaped from the equipment, and in some cases appeared to be blocked and overflowing. The ammonia production area was noted as being in particularly poor state of repair with vessels with exposed lagging and corroded interconnecting pipework. There was evidence of spillages having occurred in the vicinity of a number of the loading/unloading points and damage to the infrastructure (e.g. pipework supports, etc.) in several places. Concrete hardstanding flooring in the area was damaged in many places (e.g. uneven, cracked, etc.). Many bunded areas contained significant quantities of coloured liquids at the time of the site visits.

3.10 Previous Intrusive Environmental Assessment

Information from two known phases of site investigation work undertaken at the site in relation to soil and groundwater contamination is summarised below:

3.10.1 ABB Eutech, 2001 Phase 1a Site Report

This Phase 1a investigation was commissioned in 2001 and the report is dated 22 August 2001. According to the introduction the report was prepared to support Monckton Coke & Chemical Limited PPC application.

The following points of interest are presented in the report:

- A gas exploration borehole was recently drilled on the southern part of the site to a depth in excess of 500m, though no further information is available.
- An area to the south of the by products area was historically used for the disposal of tar and associated liquids.
- There is evidence that the former quarry on the south eastern part of the site (shown on mapping of 1883) was partially infilled with waste material.
- Corrosion of the concrete floor has occurred as a result of leaks from the concentrated ammoniacal liquor (CAL) plant.
- Leaks from the CAL and benzole plants could overflow drainage channels and flow off-site to the west to the railway cutting.
- Leaks of the final effluent from the biological effluent treatment plant that was destined for the public sewer regularly impacted the railway embankment to the west of the site.
- A leak of 600 litres of oil to Cudworth Dike occurred from the CHP plant, and frequent spillages of concentrated sulphuric acid occurred from the 'salt house and acid tanks'.

The report concludes that there is the potential for contamination to be present in the ground under specific areas of the site. Potential contamination could have resulted from loss of containment in process or storage areas, waste disposal and leakage or failure of drains and pipelines. As a result, a number of significant contaminant linkages to receptors are considered to be potentially present. An intrusive investigation was recommended.

3.10.2 ABB Eutech, 2002 Phase 1b/2 Site Report

The text of the report was made available to RSK for review, but none of the appendices were available (including borehole/trial pit logs and laboratory analytical data), and the site plan figure, which indicated the borehole and trial pit locations, was illegible.

The purpose of this report, which is dated 19 April 2002, was to establish the baseline site conditions for the purpose of the PPC Permit (note: now the environmental permit).

Intrusive investigations comprised the excavation of 33 trial pits and the drilling of six boreholes over the site. Trial pits were made to a maximum depth of approximately 3.5m below ground level (bgl) using a mechanical backhoe excavator. Boreholes were drilled to a maximum depth of approximately 37m bgl using rotary open hole methods with air flush. Monitoring wells were installed in boreholes to facilitate subsequent groundwater monitoring.

Samples of soils were recovered for chemical analysis, as were groundwater samples, surface water samples from the Lineside Dyke (in the railway cutting to the west of the site) and samples of leachate from the side of the adjacent railway cutting. Field measurements of volatile organics in soil headspace were made using a portable photo-ionisation detector (PID).

Ground conditions encountered comprised between 0.3m to 3.0m of made ground, including clay, sand, gravel, coke, concrete and bricks. Made ground was underlain by Coal Measures, outcropping as sandstone (Mexborough Rock) and undifferentiated mudstones. The upper surface of the Coal Measures was weathered in places to form sand and gravel to a maximum thickness of 1.1m. Groundwater was reportedly encountered during the drilling of boreholes BH1, BH2 and BH3 at depths of 8.5m, 14.1m and 20.6m bgl respectively.

Visual and olfactory evidence of contamination was encountered during the site works. Tarry products, hydrocarbon sheens and odours were recorded in several trial pits, particularly in the central portion of the site. The text of the report indicates that floating product was encountered at water strike in borehole BH5, and black tarry product was encountered at water strike in the second sandstone unit encountered in borehole BH6.

Chemical analysis identified elevated levels of inorganic and organic contaminants in some soil and groundwater samples. The maximum concentrations of contaminants in soil were generally encountered in trial pits in the by-products area. The maximum concentrations in groundwater were generally encountered in monitoring well MW5, apparently situated in the western portion of the by-products area, close to the western boundary of the site. Analytical results include the following, maximum recorded values:

Soils:

- TPH (total petroleum hydrocarbons): 47,525mg/kg;
- BTEX (benzene, toluene, ethyl benzene and xylenes): 0.436mg/kg;
- PAH: 16,200mg/kg;
- Phenol Index: 21.5mg/kg; and
- Sulphate: 17,100mg/kg

Groundwater:

- PAH: 1.35mg/l;
- BTEX: total 0.246mg/l;
- SVOC (semi-volatile organic compounds): 0.437mg/l;
- TPH: 26mg/l; and
- Cyanide: 3.3mg/l.

Elevated concentrations of contaminants were also identified in the sample of leachate taken from the railway cutting.

The intrusive work identified considerable soil and groundwater contamination, likely to be concentrated under the by-products area. The levels of contamination encountered were well in excess of current environmental quality standards for groundwaters. Without having the laboratory test results and legible site layout plan, which would have been included in the full report, it is not possible to make a more thorough evaluation.

3.11 Summary of Potentially Contaminative Land Uses

The historic use of the site, dating from the late 1800s, as a colliery with associated coke production has the potential to have resulted in contamination of the underlying soil and groundwater. A number of potential sources of subsurface contamination have been present, particularly the by-products from the coke production process, but also including a range of chemicals and oils that would have been and still are used on site. The current by-products area is located to in the centre of the site, and this appears to have been present in part in this area since 1906. Before then, the available mapping does not show an obvious area where by-products were handled, except for a gasworks close to the western site boundary. A number of tanks and pipelines in the existing by-products area have been observed to be in poor condition, with leaks and staining of the ground observed in places. Furthermore, anecdotal information indicates that some

waste disposal took place to the south of the site centre, and such practices are likely on a site of this age. As a result, underlying soils are likely to have been contaminated with materials including coal tar, benzole and ammoniacal liquors. The purification of the coal gas was carried out on the area of land to the west of the railway.

It is unlikely that off-site sources of soil and groundwater contamination will have a significant effect on the contamination status of the site, although this cannot be ruled out.

3.12 Potential Sources

Across the central part of the site, leaks and spillage of various by-products from the manufacture of coke represent historic and current sources of sub-surface contamination. In addition, other oil and chemical storage and use takes place around the site, although much of this is also located close to the central area. Anecdotal information indicates that waste materials may have previously been deposited on site.

Chemicals which may be present in soil and groundwater as a result of the above sources include petroleum hydrocarbons (including BTEX), PAH compounds, phenols, sulphates (and other sulphur-containing compounds), ammonia compounds, cyanide and other heavy metals, and volatile and semi-volatile organic compounds (VOCs and SVOCs).

Although the materials and products stored and handled at the site may be considered to be the source element of the source-pathway-receptor linkage, the conceptual site model (CSM) considers contamination within the sub-surface (by the materials and products) to be the source.

The following sources are identified on the site:

- S1: Soil contamination as a result of historic and current operations on site;
- S2: Groundwater contamination as a result of historic and current operations on site; and
- S3: Hazardous ground gases generated from made ground materials.

3.13 Sensitive Receptors

Potential receptors identified for the site are:

- R1: Controlled waters – groundwater in the permeable horizons of the underlying bedrock;
- R2: Controlled waters – surface waters in the area, including a number of drainage ditches;
- R3: Workers on site; and
- R4: Users/occupants of surrounding land/properties.

Buildings, structures and infrastructure in contact with the ground may also be at risk of damage as a result of the ground conditions present. However, as no new buildings are planned for the site (as far as RSK are aware), except for an area to the north where a rail terminal is proposed, this potential receptor is not considered further.

Although hazardous ground gases do pose a theoretical risk to buildings on site, the risks posed to human health are considerably more significant. As such, the risks to buildings are not considered further.

3.14 Plausible Pathways

The routes by which potential sources of contamination could come into contact with the sensitive receptors are:

- P1: Direct contact/ingestion;
- P2: Gas/vapour migration;
- P3: Diffusion through drinking water pipes;
- P4: Mobilisation of soil-borne contamination; and
- P5: Groundwater migration (lateral and vertical).

Run-off of surface waters and trade effluents from the site to surface water receptors in the area is not included in the above list of plausible pathways, as this is not considered to be a sub-surface contamination issue, and is not considered further.

3.15 Data Gaps and Uncertainties

As discussed above, much of the data from the previous intrusive work (circa 2002) is no longer available. Given this and the age of the data new investigation works are necessary to assess the site.

3.16 Outline Conceptual Model

The information presented in Sections 2 and 3 has been used to compile an outline conceptual model. The identified potential contaminants and receptors have been considered with any possible pathways that may link them. The resulting pollutant linkages are considered in Table 2, and a graphical representation is given as Figure 3. The risk classification has been estimated in accordance with information in Appendix C.

Table 2: Risk Estimation for Potential Pollutant Linkages in Outline Conceptual Model

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
S1: Soil contamination as a result of historic and existing operations on site	R4: Users/occupants of surrounding land/properties	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Unlikely (distance to adjacent buildings)	Medium	Low
	R3: Workers on site	P1: Direct contact/ingestion	Highly likely (much of site un-surfaced)	Medium	High
		P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood (emission from process equipment probably more significant)	Medium	Moderate/low
		P3: Diffusion through drinking water pipes	Low likelihood	Medium	Moderate/low
	R2: Surface waters in vicinity of site	P4: Mobilisation of soil-borne contamination	Highly likely	Mild (surface waters not likely to be particularly sensitive)	Moderate
	R1: Groundwater in underlying bedrock	P4: Mobilisation of soil-borne contamination	Highly likely	Mild (Secondary A aquifer)	Moderate
S2: Groundwater contamination as a result of historic and existing operations on site	R4: Users/occupants of surrounding land/properties	P5: Groundwater migration	Unlikely (distance to adjacent buildings)	Medium	Low
	R3: Workers on site	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood (emission from process equipment more significant)	Medium	Moderate/low
		P3: Diffusion through drinking water pipes	Unlikely	Medium	Low

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
	R2: Surface waters in vicinity of site	P5: Groundwater migration	Highly likely	Mild (surface waters not likely to be particularly sensitive)	Moderate
	R1: Groundwater in underlying bedrock	P5: Groundwater migration	Highly likely	Mild (Secondary A aquifer)	Moderate
S3: Hazardous ground gases generated from made ground materials	R3: Workers on site	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood	Severe	Moderate

The conceptual model identifies the following potential pollutant linkages with a high or moderate risk:

- Direct contact between site workers and contaminated soils;
- Mobilisation of soil-borne contaminants to impact surface waters or groundwater in the underlying bedrock;
- Migration of contaminated groundwater to impact surface waters or groundwater in the underlying bedrock; and
- Ground gas migration from made ground materials posing a risk to site workers in buildings/confined spaces.

3.17 Preliminary Risk Assessment Conclusions and Recommendations

The review of information and the construction of the outline conceptual model highlight potential pollutant linkages. Contaminated soils at the site pose a risk to site workers from direct contact, and surface waters and groundwater in the underlying bedrock are also at risk as a result of mobilisation of contamination and migration of groundwater. There is a risk to site workers in buildings and confined spaces from hazardous ground gases.

To investigate these risks to receptors further, an intrusive site investigation is recommended. Details of this are presented in Section 4. The scope of works for the intrusive investigation were agreed with Hargreaves Services plc in advance of the works.

4. ENVIRONMENTAL SITE INVESTIGATION

RSK carried out intrusive investigation works and subsequent ground gas and groundwater monitoring from 14 February to 11 March 2011 to assess the potential pollutant linkages identified in the outline conceptual model and to provide additional coverage of ground conditions across the site.

Following these intrusive works, a topographical survey was undertaken to provide coordinates and elevations of the investigation locations. A table containing this information is presented as Appendix K.

4.1 Sampling Strategy and Methodology

Five deep boreholes were drilled by rotary means to penetrate the underlying bedrock and enable investigation of the groundwater it contains. Re-circulated water flush drilling methods were used due to the possibility of hydrocarbon vapours within the subsurface.

Prior to drilling, concrete coring was undertaken in some of the borehole locations to penetrate the surface hardstanding. All borehole locations were vacuum excavated or hand-dug to 1.2m bgl reduce the risk of damage to services. At four of the windowless-sampling borehole locations, ground conditions prevented the completion of the inspection pit, so the location was not subsequently drilled.

Twelve windowless-sample boreholes were attempted to achieve widespread coverage of the site and investigate the made ground and shallow superficial deposits.

Monitoring wells for groundwater were installed in the rotary boreholes, and ground gas and groundwater monitoring wells were installed in most of the windowless-sampling boreholes. The monitoring wells were constructed using 50mm diameter PVC well pipe, with filter gravel installed in the annulus around the response zone, and bentonite pellets in the annulus around the plain sections of pipe. To facilitate the sampling of shallow groundwater that was encountered in the inspection pit of borehole BH204, a short piece (0.7m long) of slotted well pipe was installed with a filter gravel annulus at shallow depth, in addition to the deeper monitoring well that was installed in the borehole. However, during the subsequent water sampling, this shallow well was found not to contain sufficient water to obtain a sample.

In addition to the contamination assessment that forms the principal purpose of this report, a limited amount of geotechnical testing was undertaken on soil samples recovered from the northern part of the site, where the development of a rail terminal is proposed. Plasticity Index analysis was undertaken on one sample of natural clay soil, and particle size distribution (PSD) analysis was undertaken on granular made ground materials. Results of these analyses are presented in the geotechnical laboratory

certificates in Appendix H. A sample each of the made ground and natural soils from this area were tested to investigate aggressive ground conditions for buried concrete, and the results of these analyses are included with the laboratory certificates for soil analyses in Appendix F. (Another sample of made ground material from the western part of the site was also subject to PSD analysis, to provide data on the permeability of this horizon, if required for the risk assessment. This is also presented in the laboratory certificates in Appendix H).

4.1.1 Investigation Locations

The location of the intrusive investigations are shown in Figure 2. Investigation locations were selected to provide a general coverage of the site, but with a focus on the areas where potential sources of contamination were identified. As such, most of the shallow, windowless-sample boreholes were located in and around the by-products area in the site centre.

The depths of the exploratory holes, descriptions of strata encountered, comments on groundwater conditions, samples obtained and installation details are included on the borehole records in Appendix D.

4.1.2 Soil Sampling

At least one sample of soil was recovered from each stratum encountered. Samples were collected and stored in accordance with the RSK quality procedures encountered to maintain sample integrity and preservation and to minimise the chance of cross contamination. The samples taken are recorded, together with their depths, on the borehole logs in Appendix D. The samples were transported to the laboratory in chilled cool boxes.

4.1.3 Groundwater Monitoring and Levelling

Depths to groundwater were recorded using an oil/water interface probe on 11 March 2011. The monitoring results are given with the gas monitoring records in Appendix E.

The groundwater monitoring and levelling data are used to provide the information on the hydrogeological regime at the site presented in Section 4.2.3, below.

4.1.4 Groundwater Sampling

Groundwater sampling was undertaken on all of the wells installed within the deep, rotary boreholes, as well as on one of the shallow window-less sampling boreholes. Following the installation the wells were developed using disposable bailers by removal

of three well volumes of water. Following development, wells were allowed to equilibrate for three weeks prior to sampling.

Sampling was then undertaken using a disposable bailer dedicated to the monitoring location to avoid the risk of cross contamination.

In addition to the above, and during the intrusive phase of the investigation, a sample of the groundwater was collected from the inspection pit of borehole BH204, before the borehole was drilled, by direct filling of the sample containers. This sample was subsequently analysed for a reduced suite of determinants, after the shallow monitoring well installed in the inspection pit of BH204 failed to yield a groundwater sample.

The groundwater samples were collected in glass bottles and vials, as appropriate to the anticipated suite of testing. The containers were filled to capacity and placed in a cool box to minimise volatilisation. Samples were transported to the testing laboratory in a cool box under Chain of Custody documentation.

4.1.5 *Ground Gas Monitoring*

Ground gas monitoring was carried out on one occasion. An infrared gas meter was used to measure concentrations of carbon dioxide (CO₂), methane (CH₄) and oxygen (O₂) in percentage by volume, whilst hydrogen sulphide (H₂S) and carbon monoxide (CO) were recorded in parts per million. Concentrations were recorded every 15 seconds for the first minute and then every 30 seconds for a minimum of three minutes. A separate flow meter was used to measure borehole flow rate in litres per hour (l/hr).

In addition, the atmospheric pressure before and during monitoring together with the weather conditions was recorded.

All monitoring results together with the temporal conditions are contained within Appendix E and discussed in Section 4.2.4.

4.2 **Ground Conditions**

The results of the onsite observations are detailed below.

4.2.1 *Soil Stratigraphy*

The borehole records are presented in Appendix D and include records of the soil samples taken, comments on any visual or olfactory evidence of contamination and details of the borehole completion, i.e. installation of monitoring wells or reinstatement.

Concrete hardstanding was present at the surface at four locations. Made ground was encountered across the site in all locations, to depths of between 0.2m bgl in the site centre and 2.9m bgl on the northern part of the site. Made ground materials generally comprised a dark brown, grey or black silty gravelly sand, the gravel comprising of clinker, ash, coal and brick fragments. At one location close to the western boundary, a borehole refused on a hard obstruction at a depth of 2.0m bgl, without having proved the base of made ground materials.

In the majority of locations, sandstone bedrock was encountered directly beneath the made ground, and this was mostly weathered to a gravelly sand at its upper surface. At its shallowest, the (weathered) sandstone bedrock was recorded from 0.2m bgl, at a location in the centre of the site.

In locations over the northern part of the site, superficial deposits of sandy gravelly clay or silt were found to lie beneath the made ground, and these were reported to a maximum depth of 4.0m bgl.

In two of the five deep boreholes, grey mudstone bedrock was encountered beneath the sandstone.

Shallow, perched, groundwater was encountered in the inspection pits of three of the boreholes, all located in the by-products area. Due to the use of water flush during the rotary drilling, groundwater strikes within the underlying bedrock could not be recorded.

4.2.2 Observed Contamination

Whilst drilling through the made ground, contamination was observed in boreholes PH102 and PH111 from ground level to 1.2m and 0.6m bgl, respectively, consisting of a hydrocarbon sheen and tar odour. In borehole PH108, strong petrol odours were noted from 0.3m to 1.3m bgl, and in PH106, a slight chemical odour was noted from 0.2m to the base of drilling (1.2m bgl).

Drilling returns from the bedrock were noted to have a strong hydrocarbon odour and dark staining in boreholes PH105, BH203, BH204 and BH205. Depth to the contamination varied from 1.2m in BH203 to 1.9m in BH205. The contamination was generally found within the sandstone bedrock with the exception of BH203 where it extended into the underlying mudstone. It was noted during subsequent developing and sampling of these wells that the groundwater also had a hydrocarbon odour, as well as a slight sheen.

In addition to the above, ash and clinker was noted in made ground materials at the majority of locations across the site.

4.2.3 Groundwater Regime

The results of the groundwater monitoring and well surveying exercise are given in Table 3. The data indicate groundwater flow within the underlying bedrock may be towards the north. (NB. It should be noted that due to the spacing between boreholes groundwater activity is unlikely). Shallow perched groundwater is not a continuous water body, so no flow direction has been derived.

Table 3: Groundwater Monitoring Data (11 March 2011)

Monitoring Well	TOC Level (m AOD)	Depth to Product (mb TOC)	Depth to Water (mb TOC)	Water Level (m AOD)
PH101	60.865	N/A	2.782	58.083
PH102	62.181	N/A	Dry	-
PH103	64.106	N/A	Dry	-
PH104	63.429	N/A	Dry	-
PH105	65.742	N/A	2.335	63.407
PH106	67.807	N/A	Dry	-
PH108	71.281	N/A	0.784	70.497
PH109A	69.917	N/A	Dry	-
PH110	72.475	N/A	Dry	-
PH111	69.805	N/A	Dry	-
BH201	60.850	N/A	6.127	54.723
BH202	66.724	N/A	11.418	55.306
BH203	65.400	N/A	9.66	55.740
BH204D	67.628	N/A	8.925	58.703
BH204S	67.599	N/A	Dry	-
BH205	71.871	N/A	8.171	63.700

mb TOC Metres below top of casing of installation

m AOD Metres Above Ordnance Datum

TOC Top of Casing of Installation

It should be noted that the TOC elevations provided above are different to ground levels in the vicinity of the monitoring well. Ground levels are generally 0.1m to 0.3m lower than the TOC elevation.

4.2.4 Ground Gas Regime

The results of the ground gas monitoring (visit on 9 March 2011) are given in Appendix E. Results are summarised in Table 4, where calculated gas screening values (GSVs) are also provided. GSVs have been calculated from the product of the highest gas concentrations and the highest gas flow recorded from all of the boreholes

during the monitoring visit, and therefore provide a worst-case indication of the flow of the particular gas in question out of the ground. In many cases, during monitoring of borehole flow rates a higher initial flow is recorded immediately after opening the gas tap, as a build up of gas in the borehole is released. This tends to drop off quickly until a stable (steady state) flow rate is recorded. In calculating the GSVs only the steady state flow rate is used, as this is considered to be a more realistic representation of the ground gas conditions.

Table 4: Summary of Ground Gas Monitoring Data

Date	Methane (% v/v)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Flow rate (l/hr)	GSV	
	Min	Max	Min	Max	Min	Max	Max	CH ₄	CO ₂
9 March 2011	0.1	0.5	0.1	10.1	0.1	20.5	3.0	0.02	0.3

In relation to the above data, Table 5 provides information on the weather conditions at the time of the monitoring visit. The atmospheric pressures (in mBar) are given for the three days preceding the visit, as well as for the day of the visit. This pressure data is taken from a publicly available weather history internet site, and relates to regional data from a monitoring station in the general area of the site, rather than to the site itself.

Table 5: Weather Conditions Preceding Gas Monitoring

Date	Atmospheric pressure during the preceding three days			Temporal conditions during the monitoring round		
	3	2	1	Atmospheric Pressure	Rainfall	Other
Monitoring round 1 9 March 2011	1032	1030	1016	1011	Intermittent	Warm sunny with broken clouds, windy

4.3 Analytical Strategy and Methodology

Soil and groundwater samples were tested for a selection of the analytes listed below:

- Metals: arsenic, cadmium, chromium (with chromium VI dependant on result), copper, mercury, nickel, lead, selenium and zinc;
- Speciated total petroleum hydrocarbons (includes BTEX);
- Polycyclic aromatic hydrocarbons (PAHs);
- Speciated phenols by HPLC;
- Semi-volatile organic compounds (SVOCs) (testing includes PAHs and speciated phenols);
- Volatile organic compounds (VOCs) (testing includes BTEX);

- Polychlorinated biphenyls (PCBs);
- Water soluble sulphate, sulphide, and free/elemental sulphur;
- Ammoniacal nitrogen;
- Chloride;
- Free cyanide, total cyanide, and thiocyanate;
- Alkalinity;
- pH value; and
- Fraction organic carbon.

A number of soil samples were also screened for the presence of asbestos-containing materials.

The analytical schedule was based on the previous use of the site identified in Section 3 and the ground conditions encountered which are discussed in Section 4.2. All analysis was undertaken by UKAS and MCERTS certified laboratories. The details of the laboratory certification are included on the laboratory reports in Appendices F and G.

It should be noted that some individual determinants are included in more than one of the analytical suites scheduled, and as such there may be two results for an analyte for a particular sample. Where this is the case, it is the highest concentration of the two that is discussed below and used to inform the risk assessment.

5. GENERIC QUANTITATIVE RISK ASSESSMENT

In line with CLR11 ⁽¹⁾, there are two stages of quantitative risk assessment, generic and detailed. The GQRA comprises the comparison of soil, groundwater and ground gas results with generic assessment criteria (GAC) that is appropriate to the linkage being assessed. The GAC used in this assessment are included in Appendix I for human health (together with details of their derivation) and in Appendix J for the assessment of risks to controlled waters.

The site investigation work and subsequent refinement of the conceptual model indicates that there are relevant pollutant linkages at the site, which require further consideration. A graphical **representation** of the refined conceptual site model is presented as Figure 4.

5.1 Comparison of Soil and Groundwater Results with GACs

Samples where laboratory analysis has recorded concentrations of contaminants in soil and groundwater that exceed the relevant GAC are detailed in Tables 6 to 9 below. These are discussed in greater detail with reference to the individual potential pathways in Section 5.3.

Although UK guidance (CLR7 and 11) requires statistical analysis to be undertaken prior to comparison of the laboratory data with the GAC, samples were obtained on a targeted basis. Therefore, statistics are not appropriate and the laboratory analytical data have been compared directly with the GAC.

5.1.1 Human Health

Results of analyses of soil samples have been compared against the human health GACs for a commercial end use, as appropriate for the existing and proposed future use of the site. Table 6, below, details all of the soil samples that exceed the GACs for the various determinands.

Table 6: Summary of Soil Human Health GAC Exceedences

Analyte	Sample				
	GAC	PH108 0.80m	PH111 0.30m	PH104 1.10m	PH102 0.50m
Benzo(a)anthracene	90		653	167	93.7
Benzo(a)pyrene	14		360	83.4	49.8
Benzo(b)fluoranthene	100		385	108	
Benzo(k)fluoranthene	140		168		
Chrysene	140		340		
Dibenzo(ah)anthracene	13		45		
Indeno(1,2,3-cd)pyrene	60		155		
Naphthalene	200	2940	3570	1290	2710
1,2,4-Trimethylbenzene	42	150	86		
1,3,5-Trimethylbenzene	47	50			
Benzene	28		295		

All values in mg/kg

Results of analyses of groundwater samples have been compared against RSK's GAC values for human health in a commercial scenario, as appropriate given the existing and proposed future use of the site. Table 7, below, details all of the groundwater samples that exceed the GACs for the various determinands.

Table 7: Summary of Groundwater Human Health GAC Exceedences

Analyte	Sample				
	GAC	BH203	BH204D	BH205	PH108
Ali >C10-C12	0.034			0.184	
Ali >C12-C16	0.00076	0.132		0.106	0.071
Aro >C12-C16	5.8		6.623	7.882	6.441
Anthracene	0.021			0.20864	0.04287
Benzo(a)anthracene	0.0038	0.00411			
Benzo(ghi)perylene	0.00026	0.0523			
Benzo(k)fluoranthene	0.0008	0.00369			
Benzo(b)fluoranthene	0.002	0.0683			
Benzo(a)pyrene	0.0038	0.0879			
Chrysene	0.002	0.0579			
Indeno(123-cd)pyrene	0.0002	0.0798			
Naphthalene	1.9		182	183	285
Phenanthrene	0.53			1.18683	0.83403

All values in mg/l

5.1.2 Controlled Waters

Results of analyses of groundwater samples have been compared against RSK's GAC values for surface waters and Secondary A aquifers. Table 8 shows the exceedences of the GAC values, which are the EA Environmental Quality Standards (EQS), at the site.

Table 8: Summary Controlled Waters GAC Exceedences

Analyte	Sample							
	GAC	BH201	BH202	BH203	BH204D	BH205	BH108	BH204
Chloride (w)	250	604	819	510	851	302		392
Arsenic (dissolved)	0.05				0.108			
Copper (dissolved)	0.001		0.002					
Chromium (dissolved)	0.005		0.007		0.011		0.006	
Nickel (dissolved)	0.05			0.072				
Zinc (dissolved)	0.008	0.409	0.047	0.013		0.028		
TPH (Ali & Aro) (w)	0.01			1.848	25.139	58.52	12.716	
BTEX - Benzene (w)	0.03			0.071	6.38	22.8		
BTEX - Ethyl Benzene (w)	0.02				0.033	0.169		
BTEX - Toluene (w)	0.05				0.414	7.1		
BTEX - m & p Xylene (w)	0.03				0.554	2.4		
BTEX - o Xylene (w)	0.03				0.253	0.856		
Acenaphthene (w)	0.0058			0.8553	0.28053	0.10027		
Acenaphthylene (w)	0.0058			0.02655	0.08811		0.02462	
Anthracene (w)	0.000012			0.00184	0.01361	0.20864	0.04287	
Benzo(a)anthracene (w)	0.000018			0.00411	0.00071	0.00021	0.0011	
Benzo(a)pyrene (w)	0.000015			0.00232	0.00015	0.00004		
Benzo(b)fluoranthene (w)	0.000014			0.00175	0.00014	0.00005	0.00021	
Benzo(ghi)perylene (w)	0.00002			0.00196	0.00008	0.00003	0.0001	
Benzo(k)fluoranthene (w)	0.000014			0.00369	0.00039	0.00008	0.00034	
Chrysene (w)	0.00001			0.00335	0.00075	0.00016	0.0011	
Dibenzo(ah)anthracene (w)	0.00001			0.0005	0.00002		0.00002	
Fluoranthene (w)	0.00001	0.00009		0.01738	0.00556	0.05368	0.12438	
Fluorene (w)	0.0021			0.00421	0.0658	0.02589	0.02289	
Indeno(123-cd)pyrene (w)	0.00001			0.00174	0.00005	0.00003	0.00007	
Naphthalene (w)	0.01				0.04458	0.12481	0.01094	
Phenanthrene (w)	0.003				0.06407	1.18683	0.83403	
Pyrene (w)	0.00004	0.00009		0.01165	0.00359	0.03137	0.08387	
Phenol	0.03				0.15			38.8
Sulphate	400	640	575	455	1030	794		439

All values in mg/l

5.1.3 Water Supply Pipes

Guidance on the assessment of brownfield land for installation of water supply pipes has recently been published by WRc ⁽⁶⁾. Comprehensive laboratory testing to comply with this guidance is beyond the scope of this report and is not warranted as the laying of new water pipes is not anticipated. However, the available laboratory soil contamination testing results have been compared, where appropriate, to the 'data supported threshold values' provided in the WRc guidance.

Table 9 shows the target values provided in the WRc guidance for the three chemical groups in that report that can be compared against soil laboratory data available for the site. These target values are compared against the maximum recorded concentrations of a selection of the compounds or groups of compounds that would fall within the WRc chemical group. Different target values for polyethelene (PE) and poly-vinyl chloride (PVC) pipes are provided. Target values for metal pipes are not discussed, as these are based on corrosion parameters, which have not been investigated at the site.

Table 9: Summary of Soil Pipeline Target Value Exceedences

WRc Chemical Group	Target Value (different pipe materials)		Compound / group of compounds comparable to Target Value	Maximum concentration
	PE	PVC		
Group 1: VOCs including TICs	0.125	0.125	Benzene	295
Group 2: SVOCs including TICs	0.02	1.4	Total PAH (sum of individual USEPA 16 PAH compounds)	17,400
Group 3: Mineral Oils C10 – C40	10	No effect	TPH (sum of carbon-banded aromatic and aliphatic hydrocarbons)	42,200

All values in mg/kg

5.2 Relevant Linkages for Assessment

The relevant pollutant linkages which are considered further in this assessment are shown in Table 10 below.

Table 10: Relevant Linkages for GQRA Assessment

Sources	Pathway (Description)	Receptors
S1 and S2	P1: Direct contact/ingestion	R3
S1 to S3	P2: Gas/vapour migration	R3 and R4
S1	P3: Diffusion through drinking water pipes	R3
S1	P4: Mobilisation of soil-borne contamination	R1, R2 and R4
S1 and S2	P5: Groundwater migration (lateral and vertical)	R1, R2 and R4

5.3 Methodology and Results

The methodology and results of the generic quantitative risk assessment are presented below for each relevant pollutant linkage in turn, following the sequence of pathways listed in Table 10.

5.3.1 *P1: Direct contact/ingestion*

Comparison of soil laboratory results with human health GAC values indicate the presence of a number of contaminants at concentrations in excess of the GACs, particularly PAH compounds.

Exposure via the direct contact/ingestion pathway will generally only be significant where the exceedences of the GACs are recorded in soils at or near to ground level, as any other surface covering or shallower soils will prevent exposure to the contaminated material.

Samples PH111 0.3m and PH102 0.5m were both characteristic of the material present at the ground surface in their respective locations. These samples are from the by-products area, and from the northern part of the coal yard. Given the largely unsurfaced nature of the site, site operatives will be in contact with these impacted soils. Samples PH108 0.8m and PH104 1.1m are from greater depth and, as such, site operatives are not likely to come into contact with them. Whilst any site construction workers in excavations may be at greater risk of exposure via these pathways, this would be expected to be mitigated against through the use of standard PPE (gloves, overalls etc.) and good site working practices.

Despite the exceedences of the RSK GACs for the direct contact/ingestion pathway recorded in shallow soils at the site, the probability of the pollutant linkage being complete has been reduced to 'Likely' in the revised CSM for the following reasons:

- Only two samples of the shallow (surface) soils were found to contain concentrations of contaminants that exceed the GAC; and
- Neither of the locations where the exceedences were identified are in locations where site personnel appear to work on a regular basis. In fact, most of the site

operatives appear to work largely inside buildings or within vehicles, or only visit specific parts of the site periodically.

5.3.2 P2: Gas/vapour Migration

Ground Gas

Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site, and are presented in Table 4 above. CIRIA document C659 ⁽⁵⁾ provides guidance on assessing the risks from hazardous ground gases, and the GSVs have been compared with the Revised Wilson and Card Classification presented in that report, as appropriate given the commercial use of the site.

Calculated GSVs for methane and carbon dioxide are 0.02 and 0.3, respectively. Using the Wilson and Card Classification, the site is designated as Characteristic Situation 1 (CS1) for methane (GSV is <0.07) and CS2 for carbon dioxide (GSV is >0.07 and <0.7). The GSV for carbon dioxide indicates a low risk from ground gases at the site, and that were a new development to be constructed, it would be expected to be fitted with basic gas ingress preventative measures. The highest borehole flow rates were recorded only on the northern part of the site, and it is possible, if a full programme of gas monitoring were to be undertaken (comprising several monitoring visits), to zone the site into higher and lower risk areas.

Only a preliminary assessment of the ground gas regime at the site has been undertaken, and this has identified slightly elevated borehole flow rates and concentrations of carbon dioxide, typical of many brownfield sites. The risk of the potential linkage in the refined CSM remains as moderate, due to its severity. However, it is assumed that buildings on site are generally well ventilated, due to the greater potential risk of build up of process gases. Despite the presence of areas of former landfill areas off-site, RSK considers that these are unlikely to be significant sources of ground gas migrating on site. This is based on the results of the gas monitoring undertaken being consistent with the ground conditions encountered.

Vapours

Comparison of soil laboratory results with human health GAC values (as shown in Table 6) indicate the presence of a number of contaminants at concentrations in excess of the GACs, which, for the more volatile organic compounds, are largely based on the vapour inhalation pathway. Such compounds that have been found to exceed the GAC in soil are naphthalene, benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene.

Table 7 shows the samples of groundwater from the site that were found to contain concentrations of contaminants in excess of the GACs for human health. These GACs are all related to the inhalation of vapours from groundwater that have migrated to

indoor air, but are mostly set at the solubility limit in water of the compound in question. The GAC are considered to be highly conservative, and only the sample from PH108 was of shallow perched groundwater (as little such groundwater was encountered at the site). The other samples were of deep groundwater, so there is unlikely to be a pathway for the migration of vapour between groundwater and indoor air at the surface.

The results of the analyses of soil samples in particular indicate the presence of contaminants at concentrations that may pose a threat to human health through the migration of vapours into buildings and confined spaces. However, the risk estimation in the revised CSM has not been changed, as it is still considered likely that emissions of such vapours from the process equipment in the by-products area will be a much more significant factor in the exposure of site operatives. Given the depths to any continuous groundwater body and the distance to any off-site buildings (particularly from the by-products area of the site), linkages to off-site receptors are still considered unlikely.

5.3.3 P3: Diffusion Through Drinking Water Pipes

Although a full assessment of the potential for attack of buried water supply pipes is beyond the scope of this report, a preliminary screen of the available soil analytical data against the available WRc target values has been undertaken. As shown in Table 9 above, concentrations in soil of compounds within the chemical groups to which they relate exceed the target values for both PE and PVC pipelines. This indicates that there is a risk of permeation of any plastic water supply pipes by organic contaminants, potentially resulting in exposure to users of the water supply. RSK is not aware of the routes or construction material of any water supply pipes that feed the buildings on site.

The overall risk from this linkage remains as moderate/low in the refined CSM. It is assumed that water supply pipes enter the site from Lund Hill Lane and that potable water is generally only consumed in the offices and mess area adjacent to that road. As such, the supply will only cross the site for a short distance, and will not pass through the more heavily contaminated process area.

5.3.4 P4: Mobilisation of soil-borne contamination

Given the elevated concentrations of contaminants that have been detected in samples of groundwater from the site, it is likely that soil-borne contamination has and is being mobilised by fluctuating groundwater and percolation of surface waters. As the site surface is largely permeable, percolation of surface waters is likely to be significant. This mobilisation does not constitute a pathway to a sensitive receptor in isolation, but it is important in causing groundwater contamination that then links to sensitive receptors via pathways P2 and P5.

5.3.5 P5: Groundwater Migration (lateral and vertical)

Comparison between the concentrations of contaminants detected in groundwater at the site and RSK derived GAC values indicate a number of exceedences, and therefore a potential risk to surface waters. Groundwater samples from wells installed in and around the by-products area of the site have been reported to contain the highest contaminant concentrations, with fewer GAC exceedences reported for two wells located over the northern site area. Concentrations of TPH, benzene and phenanthrene have all been recorded at concentrations that exceed the GAC by three orders of magnitude. A number of other organic contaminants (mostly PAH and BTEX compounds) in groundwater samples from beneath the by-products area are also reported to exceed the GACs. Chloride and metals including chromium and zinc are also present in most of the samples in excess of the GAC, including the samples from the northern part of the site.

Discrete pockets of shallow, perched, groundwater were encountered within the made ground in three locations around the by-products area. At these locations the saturated horizon was found to directly overlie the sandstone bedrock, with no impermeable horizon in between. Given the general permeability of the surface covering and the underlying soils, it is likely that surface waters and perched groundwaters will infiltrate vertically into the sandstone bedrock and impact the groundwater contained within. Indeed, contamination of the deeper groundwater detected during this investigation indicates that vertical migration has, and is, occurring. The results of the well surveying and groundwater monitoring (presented in Table 3 of the deep wells installed within the bedrock indicate a likely groundwater flow direction to the north, if a single, continuous water body is assumed. However, it is unlikely that the water bodies intercepted by the monitoring wells are entirely continuous.

The lateral and vertical extent of the contaminated groundwater plume beneath the site is unknown. If the direction of flow in this water body is to the north, as possibly shown by this investigation, the considerably reduced contaminant concentration encountered in the two boreholes on the northern part of the site would indicate that the contaminant plume is localised. However, if – as is considered likely – the groundwater flow direction has not been established, and is in fact in any other direction than north, the extent of the plume cannot be estimated. Groundwaters may discharge into surface waters in the vicinity of the site. During the previous investigation undertaken at the site (by ABB), samples of groundwater discharging from the bedrock at the railway cutting to the west of the site were found to contain elevated concentrations of contaminants.

The pollutant linkages to controlled water receptors (surface waters and groundwaters) remain as moderate in the refined CSM, as neither are considered to be particularly sensitive.

5.4 Refinement of Outline CSM following GQRA

RSK has refined the conceptual model following the site investigation and GQRA. The refined pollutant linkage table (Table 11 below) shows the risk classification for the pollutant linkages which the site investigation and GQRA has indicated are potentially complete.

The likelihood of only one of these pollutant linkages has changed from that shown in the Outline CSM (Table 2), and it is underlined and made bold in Table 11.

Although the Refined Conceptual Model is little changed from the Outline presented in advance of the main site works it is important to note that the Environmental Assessment work completed has confirmed the actual presence of the contaminant sources and pathways, which were only assumed possible in the Outline Model.

Table 11: Risk Estimation for Potential Pollutant Linkages in Refined Conceptual Model

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
S1: Soil contamination as a result of historic and existing operations on site	R4: Users/occupants of surrounding land/properties	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Unlikely (distance to adjacent buildings and depth to groundwater)	Medium	Low
	R3: Workers on site	P1: Direct contact/ingestion	<u>Likely (exposure generally limited)</u>	<u>Medium</u>	<u>Moderate</u>
		P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood (emission from process equipment probably more significant)	Medium	Moderate/low
		P3: Diffusion through drinking water pipes	Low likelihood	Medium	Moderate/low
	R2: Surface waters in vicinity of site	P4: Mobilisation of soil-borne contamination	Highly likely (confirmed by groundwater analyses)	Mild (surface waters not likely to be particularly sensitive)	Moderate
	R1: Groundwater in underlying bedrock	P4: Mobilisation of soil-borne contamination	Highly likely (confirmed by groundwater analyses)	Mild (Secondary A aquifer)	Moderate
S2: Groundwater contamination as a result of historic and existing operations on site	R4: Users/occupants of surrounding land/properties	P5: Groundwater migration	Unlikely (distance to adjacent buildings)	Medium	Low
	R3: Workers on site	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood (emission from process equipment more significant)	Medium	Moderate/low
		P3: Diffusion through drinking water pipes	Unlikely	Medium	Low

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
	R2: Surface waters in vicinity of site	P5: Groundwater migration	Highly likely	Mild (surface waters not likely to be particularly sensitive)	Moderate
	R1: Groundwater in underlying bedrock	P5: Groundwater migration	Highly likely	Mild (Secondary A aquifer)	Moderate
S3: Hazardous ground gases generated from made ground materials	R3: Workers on site	P2: Gas/vapour migration (and accumulation in buildings/confined spaces)	Low likelihood	Severe	Moderate

6. CONCLUSIONS AND RECOMMENDATIONS

The intrusive investigation and refinement of the CSM has confirmed a number of complete pollutant linkages that have been assigned a moderate risk. For human health receptors, these are migration and accumulation of hazardous ground gases in buildings and confined spaces, and direct contact with contaminated soils. Only people on the site itself on a regular basis – site personnel – are considered to be at risk from these linkages.

As discussed in Section 5.3.1, contact between site operatives and soils at the site does not appear to be extensive, with few personnel regularly in the outdoor and unsurfaced areas of the site. The risks from contact with contaminated soils can be reduced by encouraging good personal hygiene and providing a designated clean messing area. Hardstanding or a capping layer of clean stone would prevent contact with soils in any areas of the site where personnel work for a prolonged period.

Only a preliminary assessment of the ground gas regime has been carried out at the site. As discussed in Section 5.3.2, there is little evidence to suggest that ground gases pose an immediate risk to site operatives. However, if new buildings or groundworks are to be completed, additional monitoring will be necessary.

Risks to controlled waters (surface waters and groundwater in the underlying bedrock) have been assigned a moderate risk from contaminated soils and groundwater at the site. Concentrations of contaminants have been recorded in samples of groundwater at orders of magnitude above GAC values, though there are no known groundwater abstractions in the vicinity of the site, and the surface waters are not considered to be particularly sensitive.

Any future change in use of the site for which planning permission is necessary would be likely to result in a requirement to demonstrate that the site does not pose a risk of contamination of sensitive receptors. In particular shallow soils and controlled waters are impacted and would require remediation before any redevelopment could commence.

The regulatory authorities (principally the Environment Agency) can exercise powers to require the investigation and remediation of land that may be causing harm to receptors. Although the investigation has confirmed the site has caused contamination to shallow soils and groundwater the refined CSM has not identified any high or very high risks. Under these conditions it is considered unlikely that any enforcement would be exercised by the regulators. However, it will be necessary to continue monitoring on site to ensure that conditions do not deteriorate and also to assess any potential changes in receptors, due for example to changes in surrounding land use. It is recommended that

a regular programme of groundwater monitoring is implemented on the recently constructed borehole monitoring wells. Initially this should include four quarterly visits to assess seasonal variations and thereafter, on the basis that no more elevated concentrations are recorded, the frequency may be reduced to annual visits.

7. REFERENCES

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5. Wilson, S, et al. (2006) "CIRIA Report C659: Assessing Risks Posed By Hazardous Ground Gases To Buildings", Construction Industry Research and Information Association.
6. UK WRc (2010), Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites, 10/WM/03/21; ISBN: 1 84057 5697.

FIGURES

APPENDIX A

Service Constraints

APPENDIX B

Summary of Legislation and Policy Relating to Contaminated Land

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Part IIA of the Environmental Protection Act (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, are the basis for the current regulatory framework and form the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered all groundwater, inland waters and estuaries. The intention of the EPA 1990 Part IIA is to deal with contaminated land issues that are considered to cause significant harm, on land that is not undergoing development, (see circular 2-2000 for definitions of what is significant harm, website link - <http://www.defra.gov.uk/environment/land/contaminated/circ2-2000/index.htm>).

The Water Framework Directive 2000/60/EC (WFD) legislation aims to deliver long-term protection of the water environment and to improve the quality of all water bodies, including rivers, wetlands, coasts, estuaries, lakes, man-made structures and groundwater. The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991 which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so. The Groundwater Regulations (England & Wales) 2009, requires the Agency to exercise its functions in relation to permits for implementing the WFD and Groundwater Daughter Directive 2006/118/EC. Part 3 of the Regulations, Regulation 13 state: 'it is an offence to cause or knowingly permit the discharge of any hazardous substance or non-hazardous pollutant in circumstances that might lead to an indirect input of that hazardous substance or non-hazardous pollutant into groundwater unless it is carried on under and in accordance with a permit granted by the Agency under this regulation'.

Contaminated land is often dealt with through planning because of land redevelopment. This approach is documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. The overall aim of the planning and pollution control policy is to promote the sustainable and beneficial use of land (in particular, encouraging reuse of previously developed land in preference to greenfield sites). Within this aim, polluting activities that are necessary for society and the economy should be so sited and planned, and subject to such planning conditions, that their adverse effects are minimised and contained to within acceptable limits.

APPENDIX C

Methodology of Risk Assessment