Shell UK Oil Products Limited

Shell Blackhorse fuel retail station, Richmond, Surrey

Environmental Strategy Plan - Amendment

1922964-R03 (01)

RSK GEOSCIENCES

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RSK GENERAL NOTES

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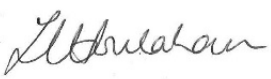
Signature		Signature	

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CONTENTS

1 INTRODUCTION 1
2 BACKGROUND 3
2.1 General 3
2.2 The site setting 3
2.3 Previous reports 3
2.4 Conclusions from RSK's investigations 3
3 ENVIRONMENTAL STRATEGY 5
3.1 Introduction 5
3.2 Site decommissioning and demolition 6
3.3 Monitoring wells 6
3.4 Potential additional trial pits 7
3.5 Re-development excavations 8
3.6 Validation of excavations 10
3.7 Backfilling of excavations 11
3.8 Ground and surface water during temporary works 12
3.9 Long term monitoring 12
3.10 Reporting 13
4 PROGRAMME OF WORKS 14
5 POTENTIAL ENVIRONMENTAL RISKS 15
REFERENCES 16

APPENDICES

APPENDIX A Service Constraints
APPENDIX B sampling methodology

TABLES

Table 1 Monitoring well designation
Table 2 Proposed programme of works

1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Shell UK Oil Products Limited (Shell) to prepare an environmental strategy plan (ESP) for the operational retail filling station at Blackhorse service station, Richmond, Surrey.

The work was carried out to support Shell with their site asset management. The following potential works are proposed at the site:

- proposed replacement of underground fuel storage tanks
- proposed replacement of fuel dispensing pumps
- proposed replacement of fuel lines and above ground offset fill points
- proposed replacement of canopy

This report is preceded by the following RSK reports:

- Phase 1 investigation: preliminary risk assessment: Blackhorse service station, Richmond, Surrey RSK reference 25986 R01, dated October 2012
- Phase 2 investigation: comprehensive environmental assessment report Blackhorse service station, Richmond, Surrey RSK reference 25986 R02, dated December 2012

This environmental strategy plan should be read in conjunction with the Phase 1 and Phase 2 reports which described development of the initial and refined conceptual models respectively, presented the results of risk assessment and on completion of this process, concluded with an assessment of the findings of these works relating to soil and groundwater.

The purpose of the ESP is to support the environmental aspects of the planning process related to soil and groundwater, and to include provisions for managing potential environmental liabilities associated with soil and groundwater at the site during the redevelopment.

At the date of issue the planning application has not been determined. It is intended that this document forms part of the planning submission.

At this site the Phase 1 and Phase 2 processes did not identify a requirement for specific remedial action (such as preparation of options appraisal, remedial strategy and implementation documents) as a result of the investigation findings, therefore this ESP sets out the approach to be adopted during re-development of the site to manage potential environmental risks associated with soil and groundwater which might arise and were not disclosed by the investigation for the reasons set out below.

It is understood by RSK that the proposed redevelopment works at this site involves excavation for the removal and replacement of existing USTs, and other sub-surface infrastructure. This work provides an opportunity during re-development to observe and record the presence (or not) of historical hydrocarbon impact related to the site's existing fuel infrastructure, and to undertake sampling and testing from locations precluded whilst the site was operational. It is feasible that during the re-development works, hydrocarbon impact may be encountered in the ground that was not identified or inferred at the Phase 2 investigation stage.

A major function of the ESP is to make provision for dealing with the eventualities described above.

This report is subject to the RSK service constraints given in **Appendix A**.

2 BACKGROUND

2.1 General

This section summarises the site's setting and existing information including a list of all known geo-environmental investigation reports. For detail, the relevant reports should be consulted. There are no known historical geo-environmental investigation reports which have been prepared by other organisations and made available to RSK.

2.2 The site setting

The site is an operational petrol filling station. Its surrounding environment and environmental setting is summarised below:

- the site is set in a predominantly residential area with residential properties with private gardens surrounding the site and a school beyond Sheen road to the south of the site
- the nearest surface water feature (120 m from the site) is an un-named stream associated with a reservoir/ pond. The River Thames is located 600 m south west of the site.
- the site is not located within a groundwater source protection zone
- local geology beneath the site was predominantly granular soils comprising sands with varying proportions of silt, and gravel (superficial deposits) overlying London Clay formation
- there are no licensed groundwater abstractions within 500 m of the site. The nearest groundwater abstraction is located >1000 m from the site

2.3 Previous reports

The following environmental reports relating to the condition of soil and groundwater beneath the site have been prepared by RSK, relating specifically to the proposed re-development works:

- Phase 1 investigation: preliminary risk assessment: Blackhorse service station, Richmond, Surrey RSK reference 25986 R01, dated October 2012
- Phase 2 investigation: comprehensive environmental assessment report Blackhorse service station, Richmond, Surrey RSK reference 25986 R02, dated December 2012

2.4 Conclusions from RSK's investigations

RSK has prepared Phase 1 preliminary risk assessment and Phase 2 intrusive investigation reports for this site which are required as part of the planning process for the proposed re-development. During this work, available existing information was consulted, and where relevant, this information was incorporated into the assessment of the condition of soil and groundwater beneath the site. Conclusions presented in the RSK Phase 2 report are summarised below.

The results of the Phase 2 assessment indicate that, based on evidence from the investigation, none of the identified potential linkages relating to human health and controlled waters are considered complete, except those described below which are not evaluated by the investigation. Groundwater was observed to be resting at 7.10 mbgl and flowing toward the Northwest

Potentially complete pollutant linkages relating to human health were identified that were not resolved by Phase 2 investigation, but will require control measures, typically established via construction phase health and safety plans and method statements. These comprise:

- potential risks to construction workers during redevelopment of the site
- potential risks arising because of construction activities – e.g. dust generation.

Following assessment of the data obtained during RSK's phase 1 and 2 investigations, it was concluded that specific remedial action, involving production of a remedial options appraisal, preparation of a remedial strategy report, and remedial implementation and remedial verification plans are not required for this site for the reasons summarised above and described in the RSK investigation reports. However, it is recognised that the limitations imposed on intrusive investigations on operational petrol filling stations precludes investigation and assessment of the condition of the ground and groundwater close to sub-surface infrastructure, in particular the ground around the existing USTs. Therefore, this ESP sets out a strategy to manage potential environmental risks arising from the condition of soil and groundwater undisclosed by investigations, as well as describing additional tasks during the re-development works, whose purpose is to manage potential environmental liabilities which might arise during re-development.

3 ENVIRONMENTAL STRATEGY

3.1 Introduction

The strategy described below presents a selection of tasks that are either planned to be carried out or serve as contingency in the event that circumstances at the site indicate they should be performed. Section 4 of this report presents the programme of intended works along with an anticipated timescale. Note that issues related to health and safety of workers during development, and/or potential health and safety issues arising from the re-development works are not dealt with in the ESP, these are covered by the health and safety plan of the main contractor undertaking the re-development works. Management of waste generated by the re-development works is the responsibility of the main contractor under the provisions of their site waste management plan (SWMP).

The ESP provides for the following tasks:

- review of existing wells at the site and evaluation of the need to decommission, or protect and maintain wells
- undertake decommissioning of the relevant wells
- establish protection to those wells to be maintained
- once the site is non-operational, there is contingency allowed to undertake additional sampling and chemical analyses via trial pits if considered appropriate to further delineate or assess hydrocarbon impact in soil
- undertake sampling and chemical analyses of soils from the limits of excavations carried out for re-development purposes (such as excavations to remove existing USTs)
- evaluation of the data obtained from re-development excavations by comparing analytical results against criteria protective of human health, typically generic assessment criteria in the first instance (GAC). The potential for residual hydrocarbons in the unsaturated zone to pose a risk to controlled waters will initially be undertaken qualitatively with consideration of source concentrations of the risk drivers, these being based on the guidance within the Environment Agency document *'Petroleum Hydrocarbons in Groundwater Supplementary Guidance for Hydrogeological Risk Assessment*, dated 2009.
- if necessary undertake further detailed risk assessment to evaluate the condition of soils remaining at the limits of re-development excavations in the event that existing GACs are not appropriate, or concentrations of constituents of potential concern (COPC) are found which require re-assessment
- preparation of a verification report which describe the relevant actions from the list above carried out at the site.

In the event that conditions are revealed during re-development which cannot be dealt with under the provisions of this ESP, it may be necessary to prepare a remedial strategy to deal with COPC in soil and/or groundwater.

On this basis, if previously unidentified contamination is discovered as part of redevelopment works, which cannot be dealt with by excavation or other methods during

the redevelopment, a remedial strategy will be required to be submitted and approved by the relevant planning authority prior to the commencement of further works, this may incur delays to the work programme.

3.2 Site decommissioning and demolition

The proposed re-development works comprise decommissioning of the fuel supply infrastructure (fuel lines and pumps) and relevant above ground infrastructure prior to the removal of 6No. existing USTs/compartments and installation of 4No. new USTs into a new tank farm excavation to the east of the site. In addition, new pumps and fuel lines are to be installed.

The work will be carried out as specified in the Design Access Statement prepared by the Shell Engineering Construction Project Management Consultant (PMC) (Artelia Group) on behalf of Shell.

3.3 Monitoring wells

Monitoring wells present at the site, installed by RSK, are identified in **Table 1** below. Where feasible, a number of existing wells are to be protected and maintained during the re-development works in the event that they are required during or after re-development of the site. Other wells have been selected for decommissioning in the event that there is any concern that these may act as preferential pathways during or on completion of the construction works.

Wells are allocated to one of the following groups that reflect their potential importance at the site, vulnerability to construction works, or potential to form a preferential pathway.

Protect: Wells designated as “protect” are significant installations at the site which are not in an area where they are at risk from excavation work and should be protected throughout the re-development works from physical damage and/or ingress of substances into the well from the surface. The re-development contractor will develop an approved method statement for protection of designated wells.

Keep: Wells designated as “keep”, are wells which may form part of ongoing future monitoring at the site, and as such should be maintained in a working condition wherever practicable during re-development. However these wells may be vulnerable to construction activities and it may not be feasible to maintain these wells throughout construction works. Consequently, RSK and the re-development contractor will liaise in respect of the condition of these wells, and should the contractor identify that these wells have the potential to be damaged by construction or re-development activities, then RSK will be informed in advance and measures will be put in place to decommission relevant wells.

Decommission: Wells designated as “decommission” will be rendered inoperable by methods appropriate to the ground conditions and well construction. The decommissioning methodology will be in accordance with Environment Agency guidance [(1)], to prevent the creation of preferential pathways on site. Given that the superficial deposits surrounding the well installations are granular soils except for where they penetrate into the London Clay, and given there is an appreciable thickness of bentonite

seal above the response zones to the groundwater monitoring wells, then it is concluded that, should wells need to be decommissioned at this site, this will be carried out by grouting below the water table into the well pipe so as to seal the well across the slotted section in the response zone and throughout the remainder of the well pipe.

Grouting works will be carried out by RSK employing a qualified site investigation contractor with experience of similar works.

Table 1 Monitoring well designation

Well ID	Action		
	Protect	Keep	Decommission
MW1/VW1	✓		
MW2/VW2	✓		
MW3/VW3	✓		
MW4	✓		

Note MW1/VW1 to MW3/VW3 comprised dual well installed within each borehole and were designed with a vapour well in the upper 1.2 m of borehole separated by a bentonite seal from a deeper response zone straddling the water table. As such vapour wells will be retained or decommissioned as appropriate along with the relevant groundwater monitoring well.

Groundwater monitoring wells are located outside the area of any proposed construction activities and therefore these wells should be protected from any damage. However changes to the construction works can occur and the wells may possibly be at risk. In this case, it is recommended that the monitoring wells are properly decommissioned as above. Note, where wells may be required for long term monitoring after redevelopment, those essential for this task which had to be decommissioned will be replaced.

3.4 Potential additional trial pits

Once the site is no longer operational and, following any preparatory decommissioning and clearance works, is made safe, there is contingency in the ESP to undertake excavation of trial pits to allow observations of the ground, and to obtain samples of soil for chemical testing if required. The trial pits may be carried out in advance of re-development excavation, where the findings of the phase 2 investigation suggests that further delineation of identified COPC is required or may be carried out in advance at the proposed limits of re-development excavations to provide information as to the condition of soils at these locations. Groundwater is not expected to be encountered during the redevelopment works.

Based on information to date, trial pits are not initially required and therefore, not included as an advance task; however the benefit of undertaking these will be reviewed during re-development, and if considered necessary, will be enacted. Trial pitting works will be technically managed by RSK, who will direct trial pitting and undertake sampling for chemical analyses.

A photo-ionisation detector (PID) will be used to identify the presence of volatile compounds, and together with visual and olfactory evidence, will assist in determining depths and locations of soils to undergo chemical testing to identify COPC.

It is envisaged that representative soil samples will be obtained from the unsaturated zone as groundwater is not expected to be encountered. The COPC which will typically be addressed are as follows:

- speciated total petroleum hydrocarbons (aliphatic and aromatic fractions)
- benzene, toluene, ethyl benzene and xylenes (BTEX compounds)
- methyl tertiary butyl ether (MTBE) and tertiary amyl methyl ether (TAME)
- polycyclic aromatic hydrocarbons (PAH compounds)

Information arising from the trial pits (if required) will be included within the verification report.

To prevent the vertical migration of surface water runoff in to any trial pit location, the trial pits will be covered with polythene sheeting during periods of rainfall. Once completed should there be a lengthy delay between undertaking trial pits and commencement of the redevelopment excavations, then the trial pits will be reinstated with concrete surface covering as a temporary measure until such time as the redevelopment excavations commence. However, it is considered unlikely that such a lengthy delay will occur between completion of trial pits and the larger excavations. In the event that re-development excavations will proceed shortly after completion of trial pits, temporary protection from surface runoff during periods of heavy rainfall, by use of polythene sheeting or similar as indicated in the contractor's method statements will be enacted.

3.5 Re-development excavations

Excavations for re-development purposes, such as to allow removal of existing USTs and/or other below ground infrastructure will be carried out according to methods and to a temporary works design provided by the re-development contractor. An appropriately qualified environmental consultant from RSK will observe all excavations, once opened, for the following purposes:

- observation of the condition of the soil exposed during excavation
- identification of soils that require removal from within the excavation that exhibit visual and/or olfactory evidence of hydrocarbons
- obtaining an appropriate number of samples for testing for COPC at the proposed limits of re-development excavations to provide evidence of the condition of soil which is to be left in situ
- where necessary, supervise the enlargement (as far as is practicable and safe to do so) of proposed re-development excavations to remove soils exhibiting hydrocarbon impact beyond the excavation's originally proposed limits
- provide information to the re-development contractor where required, in order that excavated soils are appropriately handled, stored, re-used (if suitable) and disposed of to an appropriately licensed authorised landfill.

The nominal frequency of validation testing at the limits of excavations is presented in **Appendix B**.

All excavations will be inspected by an RSK engineer, the contractor will contact RSK for attendance at site to inspect the findings and advise on how the excavations will be extended if required.

Should significant amounts of hydrocarbon impacted material be encountered that cannot be practicably excavated during the site works, then the Local Planning Authority will be informed and an assessment made of the extent and potential risks associated with the material and, if necessary, revisions made to this strategy including the possible development of a remedial strategy if considered necessary.

Waste Acceptance Criteria (WAC) testing will be undertaken, when appropriate, prior to the removal of potentially hydrocarbon impacted material from the site. This data will allow a decision to be taken as to which type of landfill can accept the waste.

Soils designated as waste and destined for off-site disposal fall within the provisions of the site waste management plan.

The old tank farm location overlaps the proposed new tank farm. When the new tank farm excavation is opened, then similar oversight of the excavation by RSK will be maintained to that of overseeing of the old tank farm excavation. Samples for chemical testing for COPC will be obtained at the limits of excavations as deemed necessary, this being dependant on the location of the excavation relative to sub surface infrastructure and other evidence obtained during the re-development works (such as from trial pits or already completed re-development excavations). Soil arisings from the new tank farm excavation will be sampled and chemically analysed to inform waste disposal options or, if suitable, re-use.

Excavated soils will be managed on site in accordance with the contractor's method statements and materials management plan. Soils will be stockpiled and covered on site prior to off-site disposal or re-use. Where there are significant restrictions on available space for the stockpiling of material, works will cease until laboratory analytical results are obtained and the designation of disposal or re-use is made.

Excavated soils will be segregated into different stockpiles reflecting:

- potential waste streams for further characterisation and eventual disposal
- soils with potential suitability for re-use, subject to confirmatory testing.

All stockpiled material on site will be covered to prevent dust generation and or runoff from rainfall. The covering of soil will be the responsibility of the contractor and detailed within their method statements which are supplied separately to this document.

Where practicable, excavations will be managed so as to limit the area of breakout of surface hardstanding, so as to minimise the area of soft underlying sub-surface soils which might allow significant infiltration during periods of heavy and/or prolonged rainfall. The hard surfacing across the site will remain in place except for localised excavation necessary to undertake the works until such time that major excavation works are complete.

During the works agreed measures will be put in place to minimise the potential for surface runoff to enter excavations during periods of heavy or prolonged rainfall. The contractor will work to their agreed method statements to cover these eventualities.

3.6 Validation of excavations

The nominal frequency of soil sampling at the limits of re-development excavations is set out in **Appendix B**. A nominal frequency of sampling is adopted based on the predicted size of the excavations; however this may be influenced by observations of the excavations made in the field (visual/olfactory or based on PID sample head space measurements).

Sampling will be undertaken where appropriate following removal of underground structures and the sides and base of the excavations will be visually inspected for hydrocarbon impact by RSK. Where works involve installation of temporary support to excavations which inhibit inspection of excavation faces, RSK and the contractor will devise a method of working to allow safe inspection and where appropriate, sampling. This work may invoke the provisions for undertaking additional trial pits.

A PID will be used to identify the presence of volatile compounds, and together with visual and olfactory evidence, will assist in determining depths and locations of soils to be removed and/or undergo chemical testing to identify COPC.

3.6.1 Soil analysis

Soil samples will be sent to a UKAS accredited laboratory for analytical chemical analysis. It is envisaged that representative soil samples will be obtained from the extent of the excavations and the COPC which will typically be assessed are as follows:

- speciated total petroleum hydrocarbons (aliphatic and aromatic fractions)
- benzene, toluene, ethyl benzene and xylenes (BTEX compounds)
- methyl tertiary butyl ether (MTBE) and tertiary amyl methyl ether (TAME)
- polycyclic aromatic hydrocarbons (PAH compounds)

3.6.2 Quantitative risk assessment

The soil laboratory results will be compared against relevant generic assessment criteria (GAC) suitable for the site continued oil end use. The GAC is presented in **Appendix B** along with the sampling methodology.

3.6.3 Detailed Quantitative Risk Assessment

The groundwater was recorded at an average depth of 7.1 m bgl. All the results of the groundwater sampling were predominantly below the LMDL and the nearest surface water receptor is located to the northeast of the site, in the opposite direction to the local groundwater flow assessed at Phase 2 stage. Therefore, based on the results of the Phase 2 site investigation, risks to groundwater and human health receptors were considered low and a detailed risk assessment was not necessary. Based on that groundwater sampling, at this stage it is not considered necessary to undertake detailed

risk assessment on concentrations of hydrocarbons found in the soil during the development works in relation to potential risks to controlled waters. However should laboratory results on soils at the limits of excavations exhibit significant concentrations of high risk hydrocarbon compounds, particularly if in excess of those recorded at Phase 2 and which cannot be dealt with by excavation, then the Environment Agency will be informed and the implications managed as per the programme set out in Section 4.

3.7 Backfilling of excavations

The replacement USTs are to be located to the middle of the site; therefore it is feasible that arisings from this excavation may be appropriate for use as backfill to the excavation undertaken to remove the old redundant tanks. Feasibility for re-use of such materials is dependent on the contractor's programme, method of working, as well as chemical and geotechnical suitability of the soils. Re-use of materials is subject to the provisions of a materials management plan.

Chemical suitability of soils excavated at the site for re-use is to be confirmed by chemical testing as follows:

- 1 test suite of analyses for COPC per 50 m^3 with a minimum of three tests on soil destined for re-use
- analytical results to be compared against the same risk based criteria used to assess the soils at the limits of excavations representing soils left in situ

Soils which fail the risk based criteria will be disallowed for re-use and will be disposed of from site under the provisions of the site materials management plan.

Determining geotechnical suitability of excavated soils for re-use is the responsibility of the re-development contractor.

Where re-use of excavated material is not feasible, then soils introduced to the excavation as backfill will be imported by the contractor from an approved source. No material will be placed in to any excavation prior to obtaining the laboratory analytical results. If necessary imported material may be stockpiled and covered on site prior to confirmation of use. Where materials for backfill are imported and which are not from a source of natural backfill, such as quarry stone then chemical suitability of soils is to be confirmed by chemical testing as follows:

- 1 test suite of analyses for COPC on imported backfill material at an approximate sampling frequency of 1 in 200 m^3 and a minimum of three tests per source
- analytical results to be compared against the same risk based criteria used to assess the soils at the limits of excavations representing soils left in situ

To minimise the potential for imported backfill material to be rejected at site, chemical testing of imported material may be demonstrated by provision of appropriate chemical testing certificates obtained from the source or may be confirmed by written statements as to the origin of the material and its suitability for use at the site, where this does not arise from a recycled source.

Confirmatory testing may be undertaken on soils at source prior to its import if there is any doubt relating to information provided by the contractor and/or the source of the imported material.

The earthworks sub-contractor will be required to keep a record of material transfer movements in accordance with their Duty of Care obligation and the material management plan.

Backfill material around the new tanks, pump islands and associated pipe work may comprise pea shingle (or similar as specified by the designer/contractor). It is not generally possible to undertake chemical testing of this granular material. However, all imported pea single (or similar) material will be derived from an approved stated source and will be visually inspected by the earthworks contractor and RSK prior to use on site.

3.8 Ground and surface water during temporary works

Based upon information obtained during the Phase 2 site investigation, it is considered unlikely that groundwater will be encountered during redevelopment works unless there is significant opportunity for groundwater level fluctuation in the area. However, perched water and/or phase separated hydrocarbons may be encountered within underground structures. The contractor will prepare method statements to deal with this possible eventuality.

It is envisaged that abstracted liquid will be dealt with by one of the methods described below:

- temporarily stored or removed directly from site by an appropriate and licensed organisation
- treated on site prior to removal from site by an appropriate and licensed organisation
- disposed of via the site's interceptor system, in accordance with any conditions in consents to discharge.

Phase separated hydrocarbon product, if encountered within excavations, will be removed and disposed of off-site.

Whilst open and not being actively worked on, excavations created to remove old underground infrastructure and excavations to facilitate the placement of new infrastructure will be covered to prevent the ingress of surface water and rainfall. Surface water will be directed away from excavations and dealt with as detailed above. Excavations will also be covered at the end of the working day.

The treatment and disposal of water (and NAPL if found) is the responsibility of the re-development earthworks subcontractor (including all related licensing).

3.9 Long term monitoring

It is intended that long term monitoring will be carried out at the site; comprising quarterly monitoring of groundwater monitoring wells retained on the site as a back up to the installed leak detection apparatus. This monitoring will comprise dipping of groundwater monitoring wells by interface probe to record the presence or not of LNAPL in those wells.

In the event of future technical developments relating to leak detection capabilities, then Shell would take the opportunity to review with the Environment Agency the need for these works to continue. It is Shell's intention to provide an annual statement each year that this monitoring continues, to provide notification of findings. In the event that a measurable thickness of LNAPL is recorded in wells, then this will be immediately reported.

Once post-redevelopment long term monitoring over a period of March 2018 to March 2024 has indicated no losses, together with no evidence of LNAPL recorded in monitoring wells, then it is proposed that monitoring will cease at the site. The results of the monitoring can be presented in a separate report for approval.

3.10 Reporting

A report which presents the tasks described in this ESP and the results of testing will be produced on completion of the works. The report will present the following information:

- details regarding decommissioning of wells at risk by construction activities
- the locations of any additional investigation work in the form of additional trial pits to delineate identified hydrocarbon impact if these are required
- the extents of excavations
- the results of analytical chemical testing at the limits of excavations (i.e. representative samples of soils left in situ)
- the results of chemical testing for waste classification and waste disposal purposes (if required)
- the results of chemical testing of soils used as backfill, either site won material suitable for re-use and/or imported soils
- records of waste disposal and import of materials for backfilling held by the contractor
- photographs of the site works
- an assessment of soils remaining in situ at the site against risk based criteria, if necessary
- if necessary, the results of a site specific risk assessment carried out to assess the condition of the site after re-development
- if required, details of the installation of new wells installed to replace those decommissioned during redevelopment (note these details may be submitted as an addendum to the report depending on timing).

If required, the report will be submitted to the Local Planning Authority in order to discharge relevant conditions put in place as part of the planning consent.

4 PROGRAMME OF WORKS

A summary of the likely programme of works is presented in **Table 2**.

Table 2 Proposed programme of works

Item	Scope	Point in Programme
Prior to closure	Decommission of relevant monitoring wells (at risk from construction works)	
Start of site redevelopment works	Closure of the site; set up welfare facilities, site office, secure fencing, etc	Week 1
Demolition	Above ground works	Week 2
Soil Verification Sampling	Collection of soil samples from excavations, following removal of tanks, fuel lines and pump lines. RSK to inspect all excavations.	Week 3 (tank excavation) & week 4 (pumps & line) Subject to progress
Await laboratory test results	Tank excavation is critical path in programme	Week 4
Initial Risk Assessment. Notification of findings to EA and Local Planning Authority	Review of analytical data and undertake Generic Quantitative Risk Assessment (GQRA). If no significant potential risk is identified, redevelopment works will continue as planned.	Week 5
Detailed Quantitative Risk Assessment. Notification of findings to EA and Local Planning Authority as required	If GQRA suggest potential risk to groundwater or human health, then DQRA. If no significant potential risk is identified, redevelopment works will continue as planned.	Weeks 5/6 - **Works will cease until the results of the DQRA are obtained (contingency item)**
Verification report	Assuming redevelopment works continue as planned and no remedial strategy is required then the verification report is targeted for issue approximately 4 weeks from completion of works to which it refers	Approximately Week 10
Notification of findings to EA / local planning authority Agreement on way forward	If the DQRA identifies that a potential risk to receptors is present then actions to be agreed with EA / local planning authority.	Week 7/8.
Instigate remedial action plan if required, based on risk based approach	Preparation of options appraisal, remedial strategy and implementation plan in the event that findings/risk assessment demonstrates hydrocarbons in ground are impacting on groundwater or human health. During this period, site redevelopment activities may be severely restricted as agreed with regulators Plans for completion of re-development and opening of site, to be agreed with regulators	**Contingency items.** **Potentially significant delay to redevelopment works programme**
Remediation, if required	Implementation of remediation. Remediation system may require to be designed to allow redevelopment and trading to continue subject to regulator agreement	
Remediation close out report	Report issue and content is subject to agreed scope of works.	

5 POTENTIAL ENVIRONMENTAL RISKS

This ESP has been prepared in order to provide information as to how potential environmental issues arising from the condition of soil and groundwater will be managed during the re-development works and reported thereafter. It has been produced for this site in place of a remedial options appraisal, remedial strategy and implementation and remedial verification plans as the findings of the investigations at this site prior to re-development have not indicated that a specific remedial action is required.

In the event that findings during the re-development works suggest that the provisions of this ESP are insufficient to manage potential environmental risks from soil or groundwater, then a remedial strategy along with the associated options appraisal, implementation and verification plans will be produced separately and agreed with the Local Planning Authority. Relevant stakeholders will be informed if this situation arises and delays to the redevelopment are considered likely and potentially extensive.

In the event that there are any queries with this document the author should be contacted in the first instance.

REFERENCES

Decommissioning redundant boreholes and wells, Environment Agency guidance booklet.

APPENDICES

APPENDIX A
SERVICE CONSTRAINTS

1. Service Constraints for all Reports

1.1. This Report (the “Report”) and any study, inspection, investigation, sampling, testing and or interpretation carried out in connection with the Report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) trading as Carbon Zero Consulting, Leap Environmental or RSK Geosciences, for the Client named in the first paragraph of the Report (the "Client") in accordance with the terms of an RSK Fee Proposal including RSK Environment Standard Terms and Conditions (the “Appointment”) between RSK and the Client, unless otherwise stated in the first paragraph of the Report. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by a geo-environmental consultant at the time the Services were performed. Nothing in this Report shall be construed as imposing any fitness for purpose obligation. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the Client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.

1.2 Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services. RSK shall not be liable in respect of any action or proceedings arising out of or in connection with this Report whether in contract, in tort, for breach of statutory duty or otherwise after the expiry of six (6) years from either (i) the date of the Report or (ii) such earlier date as prescribed by law, unless varied in the terms of the Appointment.

1.3 Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent, or condone any party, other than the Client relying upon the Services. Should this Report or any part of this Report, or details of the Services or any part of the Services, be made known to any such party, and such party relies thereon, that party does so wholly at its own and sole risk, and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent geo-environmental consultant and/or lawyer.

1.4 The Client shall not, without the prior written consent of RSK, assign, transfer, charge, mortgage, subcontract, or deal in any other manner with all or any of the benefits provided in this Report. Unless specified in the Appointment, RSK shall not be obliged to assign the benefit of the Report whether by collateral warranty, third party rights pursuant to the Contracts (Rights of Third Parties) Act 1999, letter of reliance or otherwise. If RSK agrees to any assignment of the benefit of this Report, in whatever form, benefits to third parties through collateral warranties, third party rights or letters of reliance shall not be provided unless a fee for each right, warranty or letter is agreed. The form of wording used in the warranty or letter shall be provided by RSK for agreement by the Client. Any reasonable changes to the form of wording will be implemented by mutual agreement, however the terms in the warranty or letter cannot offer the third party any greater benefit than the Appointment offered to the Client.

1.5 It is the understanding of RSK that this Report is to be used for the purpose described in the introduction to the Report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the Report is used, or the proposed use of the site change, this Report may no longer be valid and any further use of or reliance upon the Report in those circumstances by the Client without the review and advice of RSK shall be at the Client's sole and own risk. RSK shall not be liable for any use of this Report for any purpose other than that for which it was provided.

1.6 The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the Report inaccurate or unreliable. The information and conclusions contained in this Report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the Report in the future shall be at the Client's own and sole risk.

1.7 The observations and conclusions described in this Report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out, or required by the Appointment between the Client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this Report, RSK did not seek to evaluate the presence on or off site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas, fuel storage, persistent bio-accumulative or toxic chemicals (including PFAS and related compounds) or other radioactive or hazardous materials, unless specifically identified in the Services.

1.8 The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of desk based publicly available information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services and the limitations below:

a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.

b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.

c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the Client or third parties, including laboratories and information services, during the performance of the Services.

d. The Client has identified in writing to RSK, the information, reports, findings, surveys and preliminary works RSK may not rely upon when providing the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK, and including the doing of any independent investigation of the information provided to RSK, save as otherwise provided in the terms of the Appointment between the Client and RSK.

1.9 Any site drawing(s) provided in this Report is (are) not meant to be an accurate base plan for scale measurement but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for accurate setting out and should be considered indicative only.

1.10 Should RSK be requested to review the Report after the date of issue of this Report, RSK shall be entitled to additional payment at the existing rates, or such other terms as agreed between RSK and the Client.

2. Service Constraints where the Report provides an intrusive assessment of ground conditions:

2.1 The intrusive environmental ground investigation aspects of the Services are a limited sampling of soil from the site, at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this Report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together

with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope agreed between the Client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species (not tested) are not present.

2.2 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. The extent of the exploratory holes, laboratory testing and monitoring undertaken may have been restricted due to a number of factors including accessibility, the presence of buried or overhead services, current development, site usage, timescales or the Client's specification. The exploratory holes only assess a small proportion of the site area with respect to the site as a whole, and as such may only provide an indicative assessment of ground conditions on site. 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 levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised. The presence of hotspots of undisclosed contamination or exceptional and unforeseen ground conditions cannot be discounted.

2.3 Where the Services include Investigation of an exploratory nature or relating to physical ground works, any costings and prices provided in the Report are estimated and provided for guidance purposes only. The actual cost and time quantities shall be remeasured and shall be dependent upon the ground or other conditions, constraints present, and number and depth of the investigation locations, which shall influence the number of samples and tests required, and the quantities of soil being classified.

2.4 Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works. However, this Report does not constitute an asbestos survey. On this basis, the presence of asbestos on site cannot be discounted and a full asbestos survey should be undertaken.

2.5 Unless stated otherwise, only preliminary geotechnical recommendations are presented in this Report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed. Eurocode 7 gives guidance on the type of sampling, sample quality, number and spacing of intrusive investigations, and number of laboratory tests required. It is intended that the Geotechnical Information section of this Report will fulfil the general requirements of the Ground Investigation Report as set out in section 6 of Eurocode7, although this is subject to the restrictions imposed on the investigation, as listed above. For geotechnical design, Eurocode 7 requires the Geotechnical Design Report to address both the geotechnical and structural aspects of the geotechnical design for both the limit and serviceability states. The Geotechnical Appraisal section of this Report will not meet the requirements of a Geotechnical Design Report (GDR) and should therefore be used for preliminary guidance only.

3. Service Constraints where the Report relates to Surface Water Management:

3.1 The Surface Water Management Inspection (SWMI) Report, documents provided, observations, actions, and recommendations, with respect to the management of potential pollution issues to surface waters, made during the site Inspection visit, are those present at the time of the visit, and may not represent those recorded by others on the same day.

3.2 The comments given in this Report and the opinions expressed are based on the weather, ground and ground water 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 inspection and therefore could not be taken into account. In addition, groundwater levels and flows, may vary from those Reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.

3.3 RSK places a degree of dependence upon oral information provided by site representatives, which is not readily verifiable through visual inspection, or supported by any available written documentation. RSK shall not be held responsible for conditions or consequences arising from relevant facts that were not fully disclosed by facility or site representatives at the time this Report was prepared.

3.4 This Report is a live document, to be continually reviewed and updated as the development progresses or other changes occur on site. RSK can only maintain the currency of this Report through the Client requesting support with supplementary site visits or attendance at meetings ahead of key stages of the development in relation to surface water management. Our risk rating assesses a number of risk factors in line with the source-pathway- receptor model and is therefore subject to constant change.

3.5 Standard design drawings are indicative. Material types, dimensions and construction details will need to be adjusted by the Client to suit the specific conditions / flows on Site.

3.6 The full responsibly for implementing the site-specific protection and maintenance measures to protect the surface water system as stated in this Report, remains with the Client and their site management team. Additional control measures may be required to achieve the objectives set out in the Surface Water Management Plan to be implemented and financed by the Client.

4. Service Constraints where the Report relates to Waste Management:

4.1 In accordance with the definition provided in the Waste Framework Directive (WFD), materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Naturally occurring soils are not considered waste if re-used on the site of origin for the purposes of development. Soils such as made ground that are not of clean and natural origin (irrespective of whether they are contaminated or not) and other materials such as recycled aggregate, do not necessarily become waste until the criteria above are met. Excavation arisings from the development may therefore be classified as waste if surplus to requirements and/or unsuitable for re-use.

4.2 It is the duty of the waste producer, to ensure that all waste is accurately classified prior to waste disposal. Technical Guidance WM3 (EA, 2018) sets out in its Appendix D requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. Unless otherwise stated, the waste assessment presented in this Report should be considered as preliminary and further testing and assessment of the waste under the provisions of a Waste Sampling Plan may be required to obtain the necessary level of data required for basic characterisation of the waste in support of disposal.

4.3 Unless stated otherwise in the Report, information relating to historical operations at the site was not reviewed as part of the assessment by RSK. In addition, unless otherwise stated in the Services, RSK was not present during the collection of the samples nor had any input on the chemical testing suite. Therefore, the waste assessment and classification detailed in this Report are based solely on any information that were provided to RSK (e.g., laboratory chemical data, exploratory hole records) and were completed without prejudice for our Client.

4.4 RSK's assumes that any ground investigation data, chemical testing results etc., that were provided by the Client to inform the waste assessment and supporting review were carried out in accordance with current best practice and relevant guidance/ standards, where applicable. Thus, the comments given in this Report and the opinions expressed are based solely on the information provided by the Client. However, it is noted that there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account as part of the RSK assessment.

5. Service Constraints for Construction Environmental Management Plan Reports:

5.1 This Report should be considered in the light of any changes in legislation, statutory requirement or industry practices that may have occurred subsequent to the date of issue.

5.2 The measures and comments outlined in this Report and any opinions expressed are based on the plans provided at the time and discussions with relevant parties. However, there may be conditions pertaining to the site that have not been disclosed by investigations and therefore could not be taken into account.

5.3 This CEMP is a live document and is subject to change throughout the project, as and when necessary, to ensure management of environmental aspects remains relevant, and to ensure continued compliance with legislation and commitments as they may change. RSK understands that this CEMP will be reviewed by the Client every six months and updated as and when necessary.

5.4 It is the full responsibility of the Principal Contractor/ Client to ensure that their works do not contravene legal requirements, and adherence to this CEMP alone cannot be a full defence regarding legal action against the Principal Contractor.

6. Service Constraints where the Report relates to Ground Gas Membrane Verification:

6.1 This Report is limited to the verification of the gas resistant membrane/vapour membrane/ radon barrier after installation and no inspections were undertaken of the substrate (i.e. prepared ground). The Report therefore does not constitute as a full verification of ground gas protection system.

6.2 The comments given in this Report and the opinions expressed, are based on the condition of the ground gas membrane as encountered at the time of inspection by suitably qualified personnel. RSK cannot accept liability for any subsequent change to the status of the gas membrane by follow-on trades or other construction activity.

6.3 Where not designed by RSK, the verification of protection measures is carried out with reference to the gas protection design provided by the Client. RSK assume the scope of gas protection measures as determined by third parties to be correct and to have achieved any required approval from authorities.

6.4 The Ground Gas Design Report/Remediation Strategy and Verification Plan contains details of the procedures to be adopted for inspection and validation of the works. However, it should be noted that responsibility for the correct implementation of the strategy lies with the appointed contractor. RSK cannot be held responsible for any remedial works that are carried out without the agreed procedures involving either direct supervision by RSK, or inspection and validation of the works by a representative from RSK.

7. Service Constraints for Environmental Due Diligence (EDD)Reports:

7.1 The comments given in this Report and the opinions expressed are based on the information obtained and reviewed as part of the desk-based assessment. However, there may be conditions pertaining to the Site that have not been disclosed by the assessment and therefore could not be taken into account. Furthermore, no intrusive investigations, monitoring or sampling have been undertaken to confirm the environmental status of the site, therefore any comments relating to ground conditions and subsurface contamination are based solely on a review of desk-based information.

7.2 This Report describes the results of the EDD exercise. The scope of this EDD Report, where appropriate, covers legal or regulatory compliance with respect to UK or international regulations associated with environmental matters.

7.3 As with any EDD exercise, there is a certain degree of dependence upon information provided by the target company. The EDD does not include a site walkover / visit or liaison with site representatives unless identified in the Services. Therefore, the assessment is based on the available desk study information. Also, there is a certain degree of dependence upon oral information provided

by site representatives, which is not readily verifiable through visual inspection, or supported by any available written documentation. RSK shall not be held responsible for conditions or consequences arising from relevant facts that were not fully disclosed by facility or site representatives at the time this EDD exercise was performed.

7.4 This Report, including all supporting data and notes (collectively referred to hereinafter as "information"), was prepared or collected by RSK for the benefit of its Client.

7.5 The comments given in this Report and the opinions expressed are based on the information obtained and reviewed as part of the desk-based assessment and the site inspection visit. However, there may be conditions pertaining to the Site that have not been disclosed by the assessment and therefore could not be taken into account. Furthermore, no intrusive investigations, monitoring or sampling have been undertaken to confirm the environmental status of the Site therefore any comments relating to ground conditions and subsurface contamination are based solely on a review of desk-based information and observations collected during the site inspection visit.

8. Service Constraints for Ground source heat energy Reports:

8.1 It is understood that this is a desktop survey only and that there are no requirements for a site walkover, service utility survey, or provision of service plans. These services can be provided upon request if required.

8.2 At a later stage, it is possible that a thermal response test (TRT) will need to be completed, for which a test borehole will have to be drilled, and these would be costed at the time. RSK can provide all aspects of subsequent site work for a GSHP system if required.

9. Service Constraints for Water Abstraction Borehole Reports:

9.1 The Report aims principally to only identify and assess the suitability of the site for a water abstraction borehole. This Report should be considered in the light of any changes in legislation, statutory requirements, and industry practices, that have occurred subsequent to the date of the Report.

9.2 Unless stated in the Report, the opinions expressed in this Report including all comments and recommendations provided are on the basis of the information obtained from a desk-based assessment.

APPENDIX B
SAMPLING METHODOLOGY

Generic assessment criteria for human health: continued oil

The human health generic assessment criteria (GAC) have been developed during a period of regulatory review and updating of the Contaminated Land Exposure Assessment (CLEA) project. Therefore, the Environment Agency (EA) is in the process of publishing updated reports relating to the CLEA project and the GAC presented in this document may change to reflect these updates. This issue was prepared following the publication of soil guideline value (SGV) reports and associated publications[(1)] for mercury, selenium, benzene, toluene, ethylbenzene and xylene in March 2009, arsenic and nickel in May 2009, cadmium and phenol in June 2009, dioxins, furans and dioxin-like polychlorinated biphenyls (PCBs) in September 2009. It was also produced following publication of GAC by LQM[(6)]. The GAC for lead is discussed separately below owing to it not being derived using the same approach as other compounds.

Lead GAC derivation

The Environment Agency SGV and Tox reports for lead were withdrawn in 2009. In addition, the provisional tolerable weekly intake data published in the Netherlands were withdrawn in 2010 owing to concerns that they were not suitably protective of human health. The withdrawn SGVs were based on a target blood lead concentration of 10μg/dl. In the absence of current guidelines many consultants continue to use the withdrawn SGV. However, as this is not considered sufficiently protective of human health RSK has revised its GAC for lead and is currently undertaking a review of recent toxicological developments that will be used to refine this GAC further in the coming months.

Variable	Description of variable	Units	Value in SGV10	Revised value for RSK GAC
T	Health criteria value – reduced owing to concern that 10ug/dl may not be suitably protective of human health	ug/dl	10	5
G	Geometric standard deviation for B typically in range of 1.8 to 2.1	-	2.0	1.8
B	Geometric mean of blood lead concentration in adult women. The value used in SGV10 was based on UK data from 1995 from women in an urban area aged 16–44. Data in the US has shown decreases from between 1.7 and 2.2 to 1ug/dl between the late 1980s/early 1990s and late 1990s/early 2000s for adult females between 17 and 45 years old. Lead concentrations in blood are likely to be decreasing in the UK owing to a ban on lead in internal paint, a ban on lead in fuel and replacement of lead pipes for water supply	ug/dl	2.3	1.0
n	Selected on the basis of the degree of protection needed for a population at risk at the target concentration (T); the default value is 95%	-	1.645	1.645
$AT_{S,D}$	Averaging time assuming exposure over working lifetime. The value has been revised to reflect 49 years in accordance with CLEA commercial scenario outlined in SR3	days	15695	17885
BKSF	Biokinetic slope factor	ug/dl per ug/day	0.4	0.4
IR_S	Soil ingestion rate (including soil-derived indoor dust). This value has been revised to reflect the CLEA commercial scenario outlined in SR3	g/day	0.040	0.050
$AF_{S,D}$	Absorption fraction (same for soil and dust)	-	0.12	0.12
$EF_{S,D}$	Exposure frequency – based on CLEA commercial conceptual model	days/yr	230	230
ED	Exposure duration. This value has been revised to reflect CLEA commercial conceptual model outlined in SR3	years	43	49

The methodology utilised for the adult receptor is the Adult Lead Methodology used in the USA, which is a similar equation to that used in production of the UK SGV outlined in R&D publication SGV10. Parameters within the equation are presented below and have been updated to reflect:

- a revised and more health protective target blood level
- more recent US data pertaining to the geometric blood lead concentration, which indicates decreasing concentrations from 1988 to 2004
- more recent US data regarding the geometric standard deviation (the measure of inter-individual variability in blood lead concentrations within the adult population).

Although the update is based on US data, RSK considers that background blood levels in the UK will also be decreasing owing to lead pipes being replaced, lead no longer being used in fuel and lead paints being banned from internal use. Furthermore, RSK has run the equation with varying inputs to ascertain its sensitivity to certain parameters. Using the parameters outlined above RSK obtains a GAC of **600mg/kg** for an adult in a commercial setting. A similar value is obtained if all input parameters remain equal to those used in production of the former SGV but the soil ingestion rate is increased to reflect 50mg/day reported for the commercial scenario in SR3.

GAC derivation for other metals and organic compounds

Model selection

Soil assessment criteria (SAC) were calculated for all compounds being considered since soil guideline values have not been published for this land-use using CLEA v1.06 and the supporting guidance[1–6]. Groundwater assessment criteria (GrAC) protective of human health via the inhalation pathway were derived using the RBCA 1.3b model. RSK has updated the inputs within RBCA to reflect the UK guidance[1–5]. The SAC and GrAC collectively are termed GAC.

Pathway selection

In accordance with EA Science Report SC050221/SR3[3], the continued oil (petrol filling station) scenario is most similar to that of a commercial scenario. This end use considers risks to a female worker who works from 16–65 years. In accordance with Box 3.5, SR3[3], the pathways considered for production of the SAC in the commercial scenario (continued oil use) are:

- direct soil and dust ingestion
- dermal contact with soil both indoor and outdoors
- indoor air inhalation from soil and vapour and outdoor inhalation of soil and vapour.

Figure 1 is a conceptual model illustrating these linkages. It should be noted that the predominant pathway for the continued oil scenario is associated with vapour inhalation owing to hardstanding being present over the majority of petrol filling stations.

The pathway considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by workers while indoors. Figure 2 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air.

Within RBCA, the solubility limit of the determinant restricts the extent of volatilisation, which in turn drives the indoor air inhalation pathway. While the same restriction is not built into the CLEA model, the model output cells are flagged red where the soil saturation limit has been exceeded.

An assumption used in the CLEA model is that of simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase[4]. The upper boundaries of this partitioning are represented by the aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous-based or the vapour-based saturation limits. Where model output cells are flagged red the soil or vapour saturation limit has been exceeded and further consideration of the SAC to be used within the assessment is required. One approach that could be adopted is to use the 'modelled' solubility saturation limit or vapour saturation limit of the compound as the SAC. However, as stated within the CLEA handbook[4] this is likely to be impractical in many cases because of the very low solubility/vapour saturation limits and, in any case, is highly conservative. Unless free-phase product is present, concentrations of the chemical are unlikely to be present at sufficient concentration to result in an exceedance of the health criteria value (HCV).

RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIEH[6] whereby the concentration modelled for each petroleum hydrocarbon fraction has been tabulated as the SAC with the corresponding solubility or vapour saturation limit given in brackets. Therefore, when using the GAC to screen laboratory analysis the assessor should take note if a given GAC has a corresponding solubility or vapour saturation limit (in brackets) and subsequently incorporate this piece of information within the screening analytical discussion. If further assessment is required following this process then an additional approach can be utilised as detailed within Section 4.12 of the CLEA model handbook[4], which explains how to calculate an effective assessment criterion manually.

Input selection

Chemical data was obtained from EA Report SC050021/SR7[5] and the health criteria values (HCV) from the UK TOX[1] reports where available. For SAC for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH), toxicological and chemical-specific parameters were obtained from the LQM/CIEH report[6]. Similarly, toxicological and specific chemical parameters for the volatile organic compound 1,2,4-trimethylbenzene were obtained from EIC/AGS/CL:AIRE[7].

For TPH, aromatic hydrocarbons C_5–C_8 were not modelled since benzene and toluene are being modelled separately. The aromatic C_8–C_9 hydrocarbon fraction comprises ethylbenzene, xylene and styrene. As ethylbenzene and xylene are being modelled separately, the physical, chemical and toxicological data for this band have been taken from styrene.

Owing to the lack of UK-specific data, default information in the RBCA model was used to evaluate methyl tertiary butyl ether (MTBE). No published UK data was available for 1,3,5-trimethylbenzene, so information was obtained from the US EPA as in the RBCA model. RBCA

uses toxicity data for the inhalation pathway in different units to the CLEA model and cannot consider separately the mean daily intake (MDI), occupancy periods or breathing rates. Therefore, the HCV in RBCA was amended to take account of:

- an adult weighing 70kg and breathing 14.8m^3 air per day in accordance with the UK TOX reports[2] and SR3[3]
- the 50% rule (for petroleum hydrocarbons, trimethylbenzenes and MTBE)[2] where MDI data is not currently available but background exposure is considered important in the overall exposure.

Physical parameters

A typical kiosk on a petrol filling station is smaller than a CLEA office (24.5m x 24.5m x 9.6m) or warehouse (45m x 45m x 4.6m). Therefore, the SAC have been produced with a smaller building size considered more representative of a kiosk. The building size taken was 10m x 8m x 3m. No basement was assumed present in line with typical service stations. The building parameters are outlined in Table 3.

The parameters for a sandy loam soil type were used in line with SR3[3]. This includes a value of 6% for the percentage of soil organic matter (SOM) within the soil. In RSK's experience, this is rather high for many sites. To avoid undertaking site-specific risk assessments for this parameter, RSK has produced an additional set of SAC for an SOM of 1% and 2.5%.

For the GrAC, the depth to groundwater was taken as 2.5m based on RSK's experience of assessing the volatilisation pathway from groundwater.

GAC

The SAC were produced using the input parameters in Tables 1, 2 and 3, and the GrAC using the input parameters in Table 4. The pathway specific GAC are presented in Table 5 and the combined GAC are presented in Table 6.

Figure 1: Conceptual model for CLEA continued oil scenario

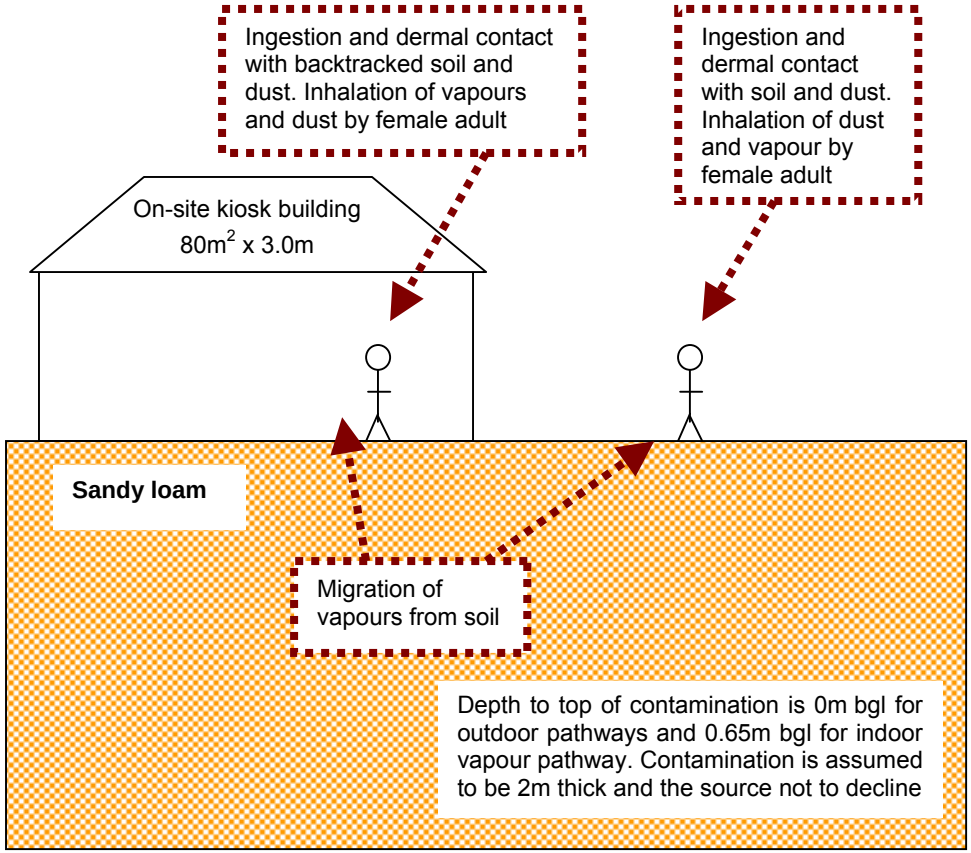

Table 1: Exposure assessment parameters for continued oil scenario – inputs for CLEA model

Parameter	Value	Justification
Land use	Commercial	Chosen land use
Receptor	Female worker	Taken as female adult exposed over 49 years from age 16 to 65 years, Box 3.5, SR3[3]
Building	Kiosk	Taken as a building measuring 8m x 10m, which is 3.0m high based on RSK experience of typical petrol filling stations
Soil type	Sandy loam	Most common UK soil type (Section 4.3.1, Table 4.4, SR3[3]). Table 4 presents soil-specific inputs
Start age class (AC)	17	AC corresponding to key generic assumption that the critical receptor is a working female adult exposed over a 49-year period from age 16 to 65 years. Assumption given in Box 3.5, SR3[3]. Data specific to AC exposure is presented in Table 2 and receptor specific in Table 3
End AC	17	
SOM (%)	6	Representative of sandy loam according to EA Guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents'[8]
	1	To provide SAC for sites where SOM < 6% as often observed by RSK
	2.5	
pH	7	Model default

Table 2: Continued oil – receptor inputs for CLEA model

Parameter	Unit	Value	Justification
Exposure frequency (EF) (soil and dust ingestion)	day yr^{-1}	230	From Table 3.9, SR3[3]. The working week is assumed 45 hours including a 1-hour lunch break each day. Indoor and outdoor exposure are weighted by the frequency of time spent indoors and outdoors (8.3 hours a day and 0.7 hours a day respectively)
EF (dermal contact with dust. indoor)	day yr^{-1}	230	
EF (dermal contact with soil, outdoor)	day yr^{-1}	170	
EF (inhalation of dust and vapour, indoor)	day yr^{-1}	230	
EF (inhalation of dust and vapour, outdoor)	day yr^{-1}	170	
Occupancy period (indoor)	hr day^{-1}	8.3	Box 3.6, SR3[3]. Weighted average based on a 9-hour day including 1-hour lunch being spent outside 75% of the year
Occupancy period (outdoor)	hr day^{-1}	0.7	
Soil to skin adherence factor (indoor and outdoor)	mg cm^{-2} day^{-1}	0.14	Table 8.1, SR3[3] for age class 17
Soil and dust ingestion rate	g day^{-1}	0.05	Table 6.2, SR3[3] for age class 17
Body weight	kg	70	Table 4.6, SR3[3] for female AC 17
Body height	m	1.6	Table 4.6, SR3[3] for female AC 17
Inhalation rate	m^3 day^{-1}	14.8	Table 4.14, SR3[3] for female AC 17
Max. exposed skin fraction (indoor and outdoors)	m^2 m^{-2}	0.08	Based on adult female assuming face and hands are exposed. Table 4.7, SR3[3]

Table 3: Continued oil – soil, air and building inputs for CLEA model

Parameter	Unit	Value	Justification
Soil properties for sandy loam			
Porosity, total	$cm^3\ cm^{-3}$	0.53	Default soil type is sandy loam, section 4.3.1, SR3[3]. Parameters for sandy loam from Table 4.4, SR3[3]
Porosity, air filled	$cm^3\ cm^{-3}$	0.20	
Porosity, water filled	$cm^3\ cm^{-3}$	0.33	
Residual soil water content	$cm^3\ cm^{-3}$	0.12	
Saturated hydraulic conductivity	$cm\ s^{-1}$	0.00356	
van Genuchten shape parameter (*m*)	-	0.3201	
Bulk density	$g\ cm^{-3}$	1.21	
Threshold value of wind speed at 10m	$m\ s^{-1}$	7.20	Default value taken from Section 9.2.2, SR3[3]
Empirical function (F_x) for dust model	-	1.22	Value taken from Section 9.2.2, SR3[3]
Ambient soil temperature	K	283	Annual average soil temperature of UK surface soils. Section 4.3.1, SR3[3]
Air dispersion model			
Mean annual wind speed (10m)	$m\ s^{-1}$	5.0	Default value taken from Section 9.2.2, SR3[3]
Air dispersion factor at height of 1.6m	$g\ m^{-2}\ s^{-1}$ per $kg\ m^{-3}$	120	From Table 9.1, SR3[3]. Values for a 2ha site, appropriate to a commercial land use in Newcastle (most representative city for UK, section 9.2.1, SR3[3])
Fraction of site with hard or vegetative cover	$m^2\ m^{-2}$	0.8	Section 3.4.6 and 9.2.2, SR3 for average office such as that used in the commercial scenario
Building properties for kiosk with ground-bearing floor slab			
Building footprint	m^2	80	Based on building measuring 8m x 10m that is based on RSK experience
Living space air exchange rate	hr^{-1}	1.0	From Table 3.10, SR3[3]
Living space height (above ground)	m	3.0	Height reduced from that in SR3[3] for an office or warehouse based on RSK observations of kiosks
Living space height (below ground)	m	0.0	Assumed no basement.

Parameter	Unit	Value	Justification
Pressure difference (soil to enclosed space)	Pa	3.2	Table 4.21, SR3 for a warehouse (considered more relevant to the warehouse scenario)
Foundation thickness	m	0.15	Table 4.21, SR3[3]
Floor crack area	cm^2	310.81	Floor crack area estimated by ratioing the building footprint and crack area for the pre-1970 commercial office and then applying this ratio to the building footprint for a kiosk
Dust loading factor	$\mu g\ m^{-3}$	100	Default value for a commercial site taken from Section 9.3, SR3[3]
Vapour model			
Default soil gas ingress rate	$cm^3\ s^{-1}$	150	Section 10.3, report SC050021/SR3[3]
Depth to top of source (beneath building for indoor exposure)	cm	50	Section 3.4.6, SR3[3] states source is 50cm below building or 65cm below ground surface
Depth to top of source (outdoors)	cm	0	Section 10.2, SR3[3] assumes impact from 0–1m for outdoor inhalation pathway
Thickness of contaminant layer	cm	200	Model default for indoor air, Section 4.9, SR4[4]
Time average period for surface emissions	years	49	Working lifetime from 16–65 years. Key generic assumption given in Box 3.5, SR3[3]
User-defined effective air permeability	cm^2	3.05E-08	Calculated for sandy loam using equations in Appendix 1, SR3[3]

Figure 2: GrAC conceptual model for RBCA continued oil scenario

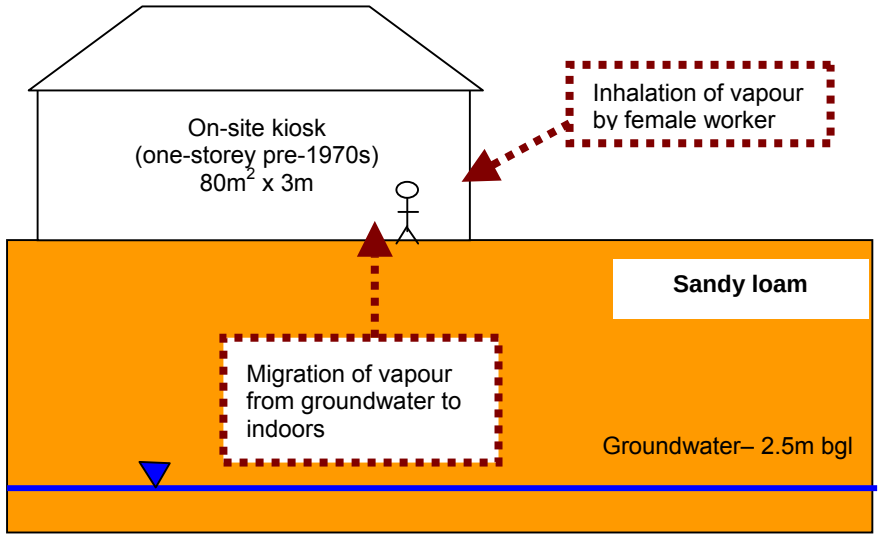

Table 4: Continued oil – RBCA inputs

Parameter	Unit	Value	Justification
Receptor			
Averaging time	Years	49	From Box 3.5, SR3[3]
Receptor weight	kg	70	Female adult, Table 4.6, SR3[3]
Exposure duration	Years	49	From Box 3.5, SR3[3]
Exposure frequency	Days/yr	86.25	Weighted using occupancy period of 9 hours per day for 230 days of the year ((9 hours x 230 days)/24 hours)
Soil type – sandy loam			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3[3]
Volumetric water content	-	0.33	
Volumetric air content	-	0.20	
Dry bulk density	g cm^{-3}	1.21	
Vertical hydraulic conductivity	cm s^{-1}	3.56E-3	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3[3]
Vapour permeability	m^2	3.05E-12	Calculated for sandy loam using equations in Appendix 1, SR3[3]
Capillary zone thickness	m	0.1	Professional judgement
Building			
Building volume/area ratio	m	3	Table 3.10, SR3[3]
Foundation area	m^2	80	Table 3.10, SR3[3]
Foundation perimeter	m	36	Based on square root of building area being 20.59m
Building air exchange rate	d^{-1}	24	Table 3.10, SR3[3]
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	

Parameter	Unit	Value	Justification
Foundation crack fraction	-	0.03	Calculated from floor crack area of 430cm^2 and building footprint of 80m^2
Volumetric water content of cracks	-	0.33	Assumed equal to underlying soil type in assumption that cracks become filled with soil over time. Parameters for sandy loam from Table 4.4, SR3[(3)]
Volumetric air content of cracks	-	0.2	
Indoor/outdoor differential pressure	Pa	3.2	From Table 3.10, SR3[(3)] for a warehouse (considered more representative of kiosk)

References

1. Environment Agency (2009), 'Science Report SC050021/benzene SGV, toluene SGV, ethylbenzene SGV, xylene SGV, mercury SGV, selenium SGV, nickel SGV, arsenic SGV, cadmium SGV, phenol SGV, dioxins, furans and dioxin like PCBs SGVs', 'Supplementary information for the derivation of SGV for: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin- like PCBs', and 'Contaminants in soil: updated collation of toxicological data and intake values for humans: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin- like PCBs', March 2009, May 2009 and September 2009.

2. Environment Agency (2009), *Human health toxicological assessment of contaminants in soil. Science Report – Final SC050021/SR2*, January (Bristol: Environment Agency).

3. Environment Agency (2009), *Science Report – SC050021/SR3. Updated technical background to the CLEA model* (Bristol: Environment Agency).

4. Environment Agency (2009), Contaminated Land Exposure Assessment (CLEA) software, version 1.06.

5. Environment Agency (2008), *Science Report SC050021/SR7. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values* (Bristol: Environment Agency).

6. Chartered Institute for Environmental Health and Land Quality Management (2009), 'The LQM/CIEH Generic Assessment Criteria for Human Health', second edition.

7. CL:AIRE (2009), *Soil Generic Assessment Criteria for Human Health Risk Assessment* (London: CL:AIRE).

8. Changes made to the CLEA framework documents after the three-month evaluation period in 2008, released January 2009 by the Environment Agency.

Table 5

Human health generic assessment criteria by pathway for continued oil scenario

Compound	Notes	GrAC (mg/l)	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Metals														
Arsenic	(c)	-	6.35E+02	6.95E+02	-	NR	6.35E+02	6.95E+02	-	NR	6.35E+02	6.95E+02	-	NR
Cadmium		-	3.99E+02	3.87E+02	2.30E+02	NR	3.99E+02	3.87E+02	2.30E+02	NR	3.99E+02	3.87E+02	2.30E+02	NR
Chromium (III) - oxide		-	3.31E+05	3.34E+04	3.04E+04	NR	3.31E+05	3.34E+04	3.04E+04	NR	3.31E+05	3.34E+04	3.04E+04	NR
Chromium (VI) - hexavalent		-	2.01E+03	3.48E+01	3.42E+01	NR	2.01E+03	3.48E+01	3.42E+01	NR	2.01E+03	3.48E+01	3.42E+01	NR
Copper		-	1.78E+05	9.60E+04	7.17E+04	NR	1.78E+05	9.60E+04	7.17E+04	NR	1.78E+05	9.60E+04	7.17E+04	NR
Lead	(a)	-	6.00E+02	-	-	NR	6.00E+02	-	-		6.00E+02	-	-	NR
Elemental mercury (Hg^0)	(d)	5.60E-02	-	3.99E+00	-	4.31E+00	-	9.94E+00	-	1.07E+01	-	2.38E+01	-	2.58E+01
Inorganic mercury (Hg^{2+})		-	4.41E+03	2.09E+04	3.64E+03	NR	4.41E+03	2.09E+04	3.64E+03	NR	4.41E+03	2.09E+04	3.64E+03	NR
Methyl mercury (Hg^{4+})		1.00E+02	4.25E+02	1.99E+02	1.35E+02	7.33E+01	4.25E+02	3.84E+02	2.02E+02	1.42E+02	4.25E+02	8.10E+02	2.79E+02	3.04E+02
Nickel	(d)	-	2.22E+04	1.79E+03	-	NR	2.22E+04	1.79E+03	-	NR	2.22E+04	1.79E+03	-	NR
Selenium	(c)	-	1.31E+04	-	-	NR	1.30E+04	-	-	NR	1.31E+04	-	-	NR
Zinc	(c)	-	6.67E+05	2.09E+08	-	NR	6.67E+05	2.09E+08	-	NR	6.67E+05	2.09E+08	-	NR
Cyanide		-	1.69E+04	1.95E+03	1.81E+03	NR	1.69E+04	1.95E+03	1.81E+03	NR	1.69E+04	1.95E+03	1.81E+03	NR
Volatile organic compounds														
Benzene		3.60E+01	5.53E+02	5.86E+00	5.80E+00	1.22E+03	5.53E+02	1.09E+01	1.07E+01	2.26E+03	5.53E+02	2.26E+01	2.18E+01	4.71E+03
Toluene		5.90E+02	4.25E+05	1.41E+04	1.36E+04	8.69E+02	4.25E+05	3.10E+04	2.89E+04	1.92E+03	4.25E+05	7.05E+04	6.04E+04	4.36E+03
Ethylbenzene		1.80E+02	1.91E+05	3.90E+03	3.82E+03	5.18E+02	1.91E+05	9.14E+03	8.72E+03	1.22E+03	1.91E+05	2.14E+04	1.92E+04	2.84E+03
Xylene - m		2.00E+02	3.43E+05	1.40E+03	1.39E+03	6.25E+02	3.43E+05	3.29E+03	3.26E+03	1.47E+03	3.43E+05	7.71E+03	7.54E+03	3.46E+03
Xylene - o		1.70E+02	3.43E+05	1.50E+03	1.50E+03	4.78E+02	3.43E+05	3.52E+03	3.48E+03	1.12E+03	3.43E+05	8.21E+03	8.02E+03	2.62E+03
Xylene - p		2.00E+02	3.43E+05	1.34E+03	1.34E+03	5.76E+02	3.43E+05	3.15E+03	3.12E+03	1.35E+03	3.43E+05	7.37E+03	7.21E+03	3.17E+03
Total xylene		2.00E+02	3.43E+05	1.40E+03	1.34E+03	5.76E+02	3.43E+05	3.29E+03	3.12E+03	1.35E+03	3.43E+05	7.71E+03	7.21E+03	3.17E+03
Methyl tertiary butyl ether (MTBE)		4.80E+04	9.53E+03	3.96E+03	3.47E+03	1.66E+04	9.53E+03	5.16E+03	4.28E+03	2.16E+04	9.53E+03	7.95E+03	5.76E+03	3.34E+03
Trichloroethene		9.20E+00	9.92E+03	2.43E+00	2.43E+00	1.54E+03	9.92E+03	5.09E+00	5.08E+00	3.22E+03	9.92E+03	1.13E+01	1.13E+01	7.14E+03
Tetrachloroethene		7.90E+01	2.65E+04	2.77E+01	2.76E+01	4.24E+02	2.65E+04	6.20E+01	6.19E+01	9.51E+02	2.65E+04	1.42E+02	1.41E+02	2.18E+03
1,1,1-Trichloroethane		5.60E+02	1.14E+06	1.44E+02	1.44E+02	1.43E+03	1.14E+06	2.94E+02	2.94E+02	2.92E+03	1.14E+06	6.45E+02	6.44E+02	6.39E+03
1,1,1,2 Tetrachloroethane		2.90E+02	1.10E+04	2.45E+01	2.45E+01	2.60E+03	1.10E+04	5.69E+01	5.66E+01	6.02E+03	1.10E+04	1.32E+02	1.31E+02	1.40E+04
1,1,2,2 Tetrachloroethane		2.90E+02	1.10E+04	6.24E+01	6.21E+01	2.67E+03	1.10E+04	1.28E+02	1.26E+02	5.46E+03	1.10E+04	2.80E+02	2.73E+02	1.20E+04
Carbon tetrachloride		1.50E+00	2.70E+03	6.26E-01	6.26E-01	1.52E+03	2.70E+03	1.37E+00	1.37E+00	3.32E+03	2.70E+03	3.11E+00	3.11E+00	7.54E+03
1,2-Dichloroethane		1.50E+00	2.29E+02	1.41E-01	1.41E-01	3.41E+03	2.29E+02	2.04E-01	2.03E-01	4.91E+03	2.29E+02	3.49E-01	3.49E-01	8.43E+03
Vinyl Chloride		9.70E-02	2.67E+01	1.15E-02	1.15E-02	1.36E+03	2.67E+01	1.49E-02	1.49E-02	1.76E+03	2.67E+01	2.28E-02	2.28E-02	2.69E+03
1,2,4-Trimethylbenzene		1.60E+01	-	9.18E+00	-	5.57E+02		2.23E+01		1.36E+03	-	5.23E+01	-	3.25E+03
1,3,5-Trimethylbenzene		1.00E+01	2.19E+04	1.04E+01	1.04E+01	9.47E+01	2.19E+04	2.48E+01	2.48E+01	2.26E+02	2.19E+04	5.85E+01	5.85E+01	5.33E+02
Semi-volatile organic compounds														
Acenaphthene		3.20E+00	1.10E+05	7.49E+04	4.45E+04	5.70E+01	1.10E+05	1.84E+05	6.87E+04	1.41E+02	1.10E+05	4.33E+05	8.75E+04	3.36E+02
Acenaphthylene		1.61E+01	1.10E+05	6.96E+04	4.26E+04	8.61E+01	1.10E+05	1.70E+05	6.67E+04	2.12E+02	1.10E+05	4.01E+05	8.62E+04	5.06E+02
Anthracene		2.10E-02	5.49E+05	2.09E+06	4.35E+05	1.17E+00	5.49E+05	5.03E+06	4.95E+05	2.91E+00	5.49E+05	1.12E+07	5.23E+05	6.96E+00
Benzo(a)anthracene		3.80E-03	2.52E+02	6.77E+01	5.34E+01	1.71E+00	2.52E+02	1.04E+02	7.37E+01	4.28E+00	2.52E+02	1.32E+02	8.68E+01	1.03E+01
Benzo(b)fluoranthene		2.00E-03	2.60E+02	1.48E+02	9.42E+01	1.22E+00	2.60E+02	1.60E+02	9.91E+01	3.04E+00	2.60E+02	1.66E+02	1.01E+02	7.29E+00
Benzo(g,h,i)perylene		2.60E-04	1.66E+03	1.04E+03	6.40E+02	1.54E-02	1.66E+03	1.07E+03	6.53E+02	3.85E-02	1.66E+03	1.09E+03	6.59E+02	9.23E-02
Benzo(k)fluoranthene		8.00E-04	3.66E+02	2.17E+02	1.36E+02	6.87E-01	3.66E+02	2.30E+02	1.41E+02	1.72E+00	3.66E+02	2.36E+02	1.43E+02	4.12E+00
Chrysene		2.00E-03	3.66E+02	1.72E+02	1.17E+02	4.40E+01	3.66E+02	2.05E+02	1.31E+02	1.10E+00	3.66E+02	2.23E+02	1.39E+02	2.64E+00
Dibenzo(a,h)anthracene		6.00E-04	3.29E+01	1.83E+01	1.17E+01	3.93E-03	3.29E+01	2.01E+01	1.25E+01	9.82E-03	3.29E+01	2.10E+01	1.28E+01	2.36E-02
Fluoranthene		2.30E-01	2.29E+04	4.33E+05	2.17E+04	1.89E+01	2.29E+04	9.32E+05	2.23E+04	4.73E+01	2.29E+04	1.70E+06	2.26E+04	1.13E+02
Fluorene		1.90E+00	7.31E+04	9.15E+04	4.07E+04	3.09E+01	7.31E+04	2.24E+05	5.51E+04	7.65E+01	7.31E+04	5.22E+05	6.42E+04	1.83E+02
Indeno(1,2,3-cd)pyrene		2.00E-04	1.57E+02	8.67E+01	5.59E+01	6.13E-02	1.57E+02	9.51E+01	5.93E+01	1.53E-01	1.57E+02	9.93E+01	6.09E+01	3.68E-01
Phenanthrene		5.30E-01	2.28E+04	9.53E+04	1.84E+04	3.60E+01	2.28E+04	2.29E+05	2.08E+04	8.96E+01	2.28E+04	5.07E+05	2.18E+04	2.14E+02
Pyrene		1.30E-01	5.49E+04	9.79E+05	5.20E+04	2.20E+00	5.49E+04	2.12E+06	5.35E+04	5.49E+00	5.49E+05	3.93E+06	5.41E+04	1.32E+01
Benzo(a)pyrene		3.80E-03	3.66E+01	2.14E+01	1.35E+01	9.11E-01	3.66E+01	2.28E+01	1.40E+01	2.28E+00	3.66E+01	2.35E+01	1.43E+01	5.46E+00
Naphthalene		1.90E+01	3.64E+04	4.35E+01	4.35E+01	7.64E+01	3.64E+04	1.04E+02	1.04E+02	1.83E+02	3.64E+04	2.46E+02	2.44E+02	4.32E+02
Phenol	(e)	-	1.54E+06	7.59E+03	7.56E+03	4.16E+04	1.54E+06	1.26E+04	1.25E+04	8.15E+04	1.54E+06	2.01E+04	1.98E+04	1.74E+05

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - CONTINUED OIL SCENARIO

Table 5

Human health generic assessment criteria by pathway for continued oil scenario

Compound	Notes	GrAC (mg/l)	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Total petroleum hydrocarbons														
Aliphatic hydrocarbons EC_5–EC_6		3.60E+01	4.77E+06	6.41E+02	6.41E+02	3.04E+02	4.77E+06	1.18E+03	1.18E+03	5.58E+02	4.77E+06	2.43E+03	2.43E+03	1.15E+03
Aliphatic hydrocarbons >EC_6–EC_8		5.40E+00	4.77E+06	1.56E+03	1.56E+03	1.44E+02	4.77E+06	3.49E+03	3.49E+03	3.22E+02	4.77E+06	7.99E+03	7.98E+03	7.36E+02
Aliphatic hydrocarbons >EC_8–EC_{10}		4.30E-01	9.53E+04	4.05E+02	4.05E+02	7.77E+01	9.53E+04	9.89E+02	9.86E+02	1.90E+02	9.53E+04	2.35E+03	2.34E+03	4.51E+02
Aliphatic hydrocarbons >EC_{10}–EC_{12}		3.00E-02	9.53E+04	2.01E+03	2.00E+03	4.75E+01	9.53E+04	4.99E+03	4.93E+03	1.18E+02	9.53E+04	1.19E+04	1.16E+04	2.83E+02
Aliphatic hydrocarbons >EC_{12}–EC_{16}		1.00E-03	9.53E+04	1.68E+04	1.60E+04	2.37E+01	9.53E+04	4.18E+04	3.63E+04	5.91E+01	9.53E+04	1.00E+05	6.51E+04	1.42E+02
Aliphatic hydrocarbons >EC_{16}–EC_{35}	(c)	-	9.65E+05	NR	NR	8.48E+00	1.37E+06	NR	NR	2.12E+01	1.63E+06	-	-	5.09E+01
Aliphatic hydrocarbons >EC_{35}–EC_{44}	(c)	-	9.65E+05	NR	NR	8.48E+00	1.37E+06	NR	NR	2.12E+01	1.63E+06	-	-	5.09E+01
Aromatic hydrocarbons >EC_8–EC_9 (styrene)		6.50E+01	1.14E+05	5.69E+03	5.62E+03	6.20E+02	1.14E+05	1.39E+04	1.34E+04	1.52E+03	1.14E+05	3.30E+04	3.03E+04	3.61E+03
Aromatic hydrocarbons >EC_9–EC_{10}		6.50E+01	3.81E+04	7.15E+02	7.12E+02	6.13E+02	3.81E+04	1.75E+03	1.73E+03	1.50E+03	3.81E+04	4.16E+03	4.04E+03	3.58E+03
Aromatic hydrocarbons >EC_{10}–EC_{12}		2.50E+01	3.81E+04	3.89E+03	3.79E+03	3.64E+02	3.81E+04	9.60E+03	8.92E+03	8.99E+02	3.81E+04	2.28E+04	1.85E+04	2.15E+03
Aromatic hydrocarbons >EC_{12}–EC_{16}		5.80E+00	3.81E+04	4.24E+04	2.67E+04	1.69E+02	3.81E+04	1.04E+05	3.40E+04	4.19E+02	3.81E+04	2.44E+05	3.65E+04	1.00E+03
Aromatic hydrocarbons >EC_{16}–EC_{21}	(c)	-	2.73E+04	-	-	5.37E+01	2.80E+04	-	-	1.34E+02	2.82E+04	-	-	3.21E+02
Aromatic hydrocarbons >EC_{21}–EC_{35}	(c)	-	2.84E+04	-	-	4.83E+00	2.84E+04	-	-	1.21E+01	2.84E+04	-	-	2.90E+01
Aromatic hydrocarbons >EC_{35}–EC_{44}	(c)	-	2.84E+04	-	-	4.83E+00	2.84E+04	-	-	1.21E+01	2.84E+04	-	-	2.90E+01

Notes:

'-' Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway or an absence of toxicological data.

NR - the compound is not volatile and therefore a soil saturation limit not calculated within CLEA

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

The CLEA model output is colour coded depending upon whether the soil saturation limit has been exceeded.

Calculated SAC exceeds soil saturation limit and may significantly affect the interpretation of any exceedances as the contribution of the indoor and outdoor vapour pathway to total exposure is >10%. This shading has also been used for the RBCA output where the theoretical solubility limit has been exceeded. The SAC has been set as the model calculated SAC with the saturation limits shown in brackets.

Calculated SAC exceeds soil saturation limit but the exceedance will not affect the SAC significantly as the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.

Calculated SAC does not exceed the soil saturation limit.

For consistency where the theoretical solubility limit within RBCA has been exceeded in production of the GrAC, these cellls have also been hatched red and the GrAC set as the solubility limit

The SAC for organic compounds are dependent upon soil organic matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58; 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, polycyclic aromatic hydrocarbons, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3

(a) RSK Lead GAC obtained following sensitivity analysis of blood lead concentrations.

(b) GAC taken from the Environment Agency SGV reports published 2009.

(c) SAC for selenium, aliphatic and aromatic hydrocarbons >EC16 does not include inhalation pathway owing to absence of toxicity data. SAC for arsenic is only based on oral contribution (rather than combined) owing to the relative small contribution from inhalation in accordance with the SGV report.

(d) SAC for elemental mercury, chromium VI and nickel is based on the inhalation pathway only owing to an absence of toxicity for elemental mercury, in accordance with the LQM report for chromium VI and in accordance with the SGV report for nickel.

(e) The GAC for phenol is based on a threshold that is protective of acute direct skin contact with phenol (the figure in brackets is based on health effects following long-term exposure and is provided for illustration only).

Table 6
Human health generic assessment criteria for continued oil scenario

Compound	GrAC for groundwater (mg/l)	SAC for soil SOM 1% (mg/kg)	SAC for soil SOM 2.5% (mg/kg)	SAC for soil SOM 6% (mg/kg)
Metals				
Arsenic	-	640	640	640
Cadmium	-	230	230	230
Chromium (III) - oxide	-	30,000	30,000	30,000
Chromium (VI) - hexavalent	-	35	35	35
Copper	-	72,000	72,000	72,000
Lead	-	600	600	600
Elemental mercury (Hg^0)	0.06	4.0	10	24
Inorganic mercury (Hg^{2+})	-	3,600	3,600	3,600
Methyl mercury (Hg^{4+})	100	140 (73)	200 (140)	280
Nickel	-	1,800	1,800	1,800
Selenium	-	13,000	13,000	13,000
Zinc	-	670,000	670,000	670,000
Cyanide	-	1,800	1,800	1,800
Volatile organic compounds				
Benzene	36	5.8	10.7	22
Toluene	590	14,000 (870)	29,000 (1,900)	60,000 (4,400)
Ethylbenzene	180	3,800 (520)	8,700 (1,200)	19,000 (2,800)
Xylene - m	200	1,400 (620)	3,300 (1,500)	7,500 (3,500)
Xylene - o	170	1,500 (480)	3,500 (1,100)	8,000 (2,600)
Xylene - p	200	1,300 (580)	3,100 (1,400)	7,200 (3,200)
Total xylene	200	1,300 (580)	3,100 (1,400)	7,200 (3,200)
Methyl tertiary butyl ether (MTBE)	48,000	3,500	4,300	5,800
Trichloroethene	9.2	2.4	5.1	11
Tetrachloroethene	79	28	62	140
1,1,1-Trichloroethane	560	140	290	640
1,1,1,2 Tetrachloroethane	290	24	57	130
1,1,2,2 Tetrachloroethane	290	62	130	270
Carbon tetrachloride	1.5	0.6	1.4	3.1
1,2-Dichloroethane	1.5	0.1	0.2	0.3
Vinyl chloride	0.097	0.01	0.01	0.02
1,2,4-Trimethylbenzene	16	9.2	22	52
1,3,5-Trimethylbenzene	10	10	25	58
Semi-volatile organic compounds				
Acenaphthene	3.2	45,000 (57)	69,000 (140)	88,000 (340)
Acenaphthylene	16	43,000 (86)	67,000 (210)	86,000 (510)
Anthracene	0.02	440,000 (1.2)	490,000	520,000
Benzo(a)anthracene	0.004	53	74	87
Benzo(b)fluoranthene	0.002	94	99	100
Benzo(g,h,i)perylene	0.0003	640	650	660
Benzo(k)fluoranthene	0.0008	140	140	140
Chrysene	0.002	120	130	140
Dibenzo(a,h)anthracene	0.0006	12	12	13
Fluoranthene	0.2	22,000	22,000	23,000
Fluorene	1.9	41,000 (31)	55,000 (77)	64,000 (180)
Indeno(1,2,3-cd)pyrene	0.0002	56	59	61
Phenanthrene	0.5	18,000 (36)	21,000	22,000
Pyrene	0.1	52,000	53,000	54,000
Benzo(a)pyrene	0.004	14	14	14
Naphthalene	19	44	100	240
Phenol	-	3200 * (7,600)	3200 * (13,000)	3200 * (20,000)
Total petroleum hydrocarbons				
Aliphatic hydrocarbons EC_5–EC_6	36	640 (304)	1,200 (558)	2,400 (1,150)
Aliphatic hydrocarbons >EC_6–EC_8	5.4	1,600 (144)	3,500 (322)	8,000 (736)
Aliphatic hydrocarbons >EC_8–EC_{10}	0.43	400 (78)	990 (190)	2,300 (451)
Aliphatic hydrocarbons >EC_{10}–EC_{12}	0.03	2,000 (48)	4,900 (118)	12,000 (283)
Aliphatic hydrocarbons >EC_{12}–EC_{16}	0.001	16,000 (24)	36,000 (59)	65,000 (142)
Aliphatic hydrocarbons >EC_{16}–EC_{35}	-	970,000 (8.5)	1,000,000 (21)	1,000,000
Aliphatic hydrocarbons >EC_{35}–EC_{44}	-	970,000 (8.5)	1,000,000 (21)	1,000,000
Aromatic hydrocarbons >EC_8–EC_9 (styrene)	65	5,600 (620)	13,000 (1,500)	30,000 (3,600)
Aromatic hydrocarbons >EC_9–EC_{10}	65	710 (610)	1,700 (1,500)	4,000 (3,600)
Aromatic hydrocarbons >EC_{10}–EC_{12}	25.0	3,800 (364)	8,900 (899)	19,000 (2,100)
Aromatic hydrocarbons >EC_{12}–EC_{16}	5.8	27,000 (169)	34,000 (419)	37,000
Aromatic hydrocarbons >EC_{16}–EC_{21}	-	27,000	28,000	28,000
Aromatic hydrocarbons >EC_{21}–EC_{35}	-	28,000	28,000	28,000
Aromatic hydrocarbons >EC_{35}–EC_{44}	-	28,000	28,000	28,000

Notes:

'-' Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway or an absence of toxicological data.

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

The SAC for organic compounds are dependent on soil organic matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58; 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, polycyclic aromatic hydrocarbons, MTBE, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3.

The SAC has been set as the model calculated SAC with the saturation limit shown in brackets. Where the GrAC exceeds the solubility limit, the GrAC has been set at the solubility limit. These are highly conservative as concentrations of the chemical are very unlikely to be at sufficient concentration to result in an exceedance of the health criteria value at the point of exposure (i.e. indoor air) provided free-phase product is absent.

SAMPLING METHODOLOGY

INTRODUCTION

This method statement describes RSK's procedures adopted during excavation works at Shell petroleum retail sites. It does not form a substitute for preparation of, separate site specific healthy and safety plans, job hazard analyses and safety risk assessments. Such aspects of the works are dealt with via RSK and Shell procedures and are not reproduced herein.

The method statement is applicable to attendance at a Shell owned petroleum retail site by a RSK environmental consultant engineer during excavation works for purposes such as removal of underground storage tanks (USTs), interceptors and other underground fuel infrastructure, which have the potential to act as primary sources of hydrocarbon release into the ground.

The objective of RSK's attendance is to provide an oversight of the works by a competent environmental professional at a time when ground conditions below the surface are revealed by excavations for redevelopment or civil engineering purposes, in particular at locations that could not safely be investigated during a phase 2 ground investigation whilst the site was operational.

The excavation work affords an opportunity to obtain information to supplement ground investigation data, including:

- geological information
- observations of groundwater
- information on the presence (or not) of hydrocarbons in the ground immediately surrounding sub surface fuel infrastructure
- the opportunity to obtain samples of soil at the limits of excavations, and for waste disposal purposes.

SAMPLING AND FIELD TESTS

Plant will be supplied by the contractor undertaking groundwork at the site, and for the purposes of soil sampling will be under the direct supervision of the RSK engineer.

Samples will be taken by the RSK engineer and headspace analyses will be screened on site with a photo ionisation detector (PID). The data will be used, along with visual and olfactory evidence to focus subsequent laboratory analytical testing on those samples apparently most representative of the soils exhibiting hydrocarbons at the limits of excavations or for waste disposal purposes.

Samples obtained at the limits of excavations (i.e. representing the condition of the ground left in situ) have depth and position recorded. Sample positions are recorded either by surveying or by triangulation from fixed features which can be related to site plans.

RSK's technical procedures govern sampling and the packaging and shipment of samples to the appointed analytical laboratory. The recovered soil samples are placed in containers suitable for the intended analyses and stored in a cool box with ice-packs to minimise temperature and volatilisation. Samples are forwarded to the laboratory as soon as practicable (but typically daily) to minimise holding times prior to analysis.

Each soil sample will be given a unique identifier and entered onto the chain of custody documentation. A copy of the chain of custody documentation accompanies the samples with a copy being retained by RSK.

Samples are not obtained by person entry to excavations under any circumstances, unless the groundwork contractor's methods involve temporary works to support excavations suitable for person entry. Under such circumstances the contractor will be required to demonstrate that temporary works are suitable and have been properly designed.

Under most circumstances, soil samples will be obtained by excavator operating from the surface. It is envisaged that the samples will be representative of the conditions of the soils at the limits of excavations after removal of hydrocarbon impacted material under the provisions in the main text of this document.

Measures to minimise cross contamination of soils destined for analyses are enacted in accordance with RSK's technical procedures, but as a minimum include cleaning of the engineer's sampling tools between sampling events. Samples obtained from the excavator bucket are obtained from material within that excavated (i.e., is not obtained from the outside of the material, such that it should not (as far as is reasonably practicable) include material which may have contacted the bucket itself.

Sampling frequency for different purposes is based on that set out in table 1. It should be noted that sampling will be targeted such that the most apparently impacted soils will be tested, and that there may be limitations on sampling due to safety, water ingress and access. The sampling frequency set out below is guidance as to the typical minimum quantity of samples, but site specific circumstances will dictate the actual numbers of samples obtained at a specific site.

Table 1

Task/Location	Nominal frequency of sampling at the limits of excavations
General Excavation	One per 25 m^2 of excavation wall and base area (1 per face and 1 per base minimum)
Aboveground Storage Tank Bunded Area	Two per tank & two per bund, or one per 25 m^2, whichever is greater
Underground Storage Tank Pit Floor	Two per tank, or one per 25 m^2, whichever is greater
Underground Storage Tank Pit Walls	One per pit wall, or one per 25 m^2, whichever is greater
Dispenser/Pump Area	One per dispenser/pump island (for natural soil; two where there is fill and natural soil)
Underground Fuel Pipeline	One per 7 metres of pipeline
Aboveground Fuel Pipeline	One per 15 metres of line
Waste Oil Underground Storage Tank	Two per tank, or one per 25 m^2, whichever is greater
Used Battery Storage Area	One per 25 m^2
Waste Disposal Area	One per 25 m^2
Interceptor and In-ground Hoist Pit	One per pit wall and one per pit floor, or one per 25 m^2, whichever is greater