St James Group Limited

Former Royal Mail Depot, London Road, Twickenham - Metropolitan Open Land (MOL)

Remediation Method Statement

25024-07 (01)

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RSK GENERAL NOTES

Project No.: 25024-07 (01)

Title: Remediation Method Statement (RMS) – Former Royal Mail Depot, London Road, Twickenham – Metropolitan Open Land (MOL)

Client: St James Group Limited

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Limited.

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1 INTRODUCTION

1.1 Introduction

RSK Environment Limited (RSK) was commissioned by St James Ltd to prepare a Remediation Method Statement (RMS) for Twickenham Sorting Office, Metropolitan Open Land (MOL).

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

1.2 Contaminated Land Process

It is understood that the site has been acquired and that it is intended to construct a footpath across the site and conduct minor landscaping works along the flanks of the footpath. The project was commissioned in order to allow the safe redevelopment of the site and to mitigate any potential long-term environmental impact associated with past operations at the site.

The assessment and development of “brownfield” sites follows a phased approach to managing the risks associated with land contamination. The following stages are defined in Model Procedures for the Management of Land Contamination (CLR11) published by the Environment Agency in 2004:

Risk Assessment:

Comprises three tiers: a preliminary risk assessment (desk study and desk based research); generic quantitative risk assessment (based on staged investigations); and detailed quantitative risk assessment. The risk assessment tiers identify potential sources of contamination, potential pathways for migration and potential receptors of concern, and then estimates or quantifies the risks associated with the identified pollutant linkages to determine if there are unacceptable risks requiring further action.

Options Appraisal:

The options appraisal also involves a staged approach, which commences with the identification of feasible remediation options for each relevant pollutant linkage. A detailed evaluation is then made of feasible remediation options to identify the most appropriate option for any particular linkage. Finally, a remediation strategy is developed that addresses all relevant pollutant linkages, where appropriate by combining remediation options.

Implementation of the Remediation Strategy:

There are three main stages in the implementation process: the preparation of the implementation plan; the design, implementation and verification of remediation; and (if required) long-term monitoring and maintenance.

This Remediation Method Statement combines the later two phases, including a summary of the finding of the risk assessment. The remediation strategy defines the remedial measures required to break the pollutant linkages identified by the risk assessment process and conceptual model for the site, and the procedures to be adopted to enable verification of the correct implementation of those remedial measures.

1.3 Background

The site, which is located in Twickenham, currently comprises an area of sensibly level, heavily vegetated open space extending over an area of approximately 2.8 hectares.

During a recent site reconnaissance survey, the presence of brick and concrete rubble was evident in several locations (where access was available) together with a 2.0m high bund measuring approximately 3.0m wide by 10.0m long in southern central areas. In two locations, discarded sleepers and track sections were noted to be present in the undergrowth.

It is understood that the MOL is due to undergo localised clearance works to facilitate the construction of a footpath running around the perimeter of the site linking in to the ongoing development on the east and open land to the west of the site.

The footpath will comprise a 3.0m wide gravel path with a 1.0m wide maintained grass strip along either side of the path with a fence beyond. Beyond this 1.0m wide buffer strip, it is proposed to leave the remainder of the MOL untouched and therefore in its current overgrown condition.

RSK has previously undertaken site investigation works across the adjoining Royal Mail Depot site, which included limited intrusive investigation works within eastern areas of the MOL. Subsequent to this, additional works have been conducted across the remainder of the MOL in order to assess the potential for contamination of groundwater and near surface soils, with a view to assessing pollutant linkages relating to the development proposals.

1.4 Objective

The objective of this report is to summarise the Geo-environmental issues identified in RSK's preceding investigation reports and detail the remedial works to be undertaken to address these issues.

1.5 Scope

This report has been designed with consideration of CLR11 (Environment Agency, 2004a), BS 10175: 2011 (BSI, 2011+A1 2013), National Panning Policy Framework and guidance on land contamination reports issued by the Environment Agency (EA) (2010).

The scope of this report includes:

- A summary of the existing reports pertaining to the site;
- Identification of the complete pollutant linkages to be addressed by the remedial works;
- A summary of the remedial technique(s) to be implemented; and
- Details of the validation and verification works including reporting.

1.6 Existing reports

RSK has either produced the following reports pertaining to the site:

- Geoenvironmental Site Investigation, Former Royal Mail Depot, London Road, Twickenham. RSK Environment Ltd (Ref: 25024 R01) dated April 2014; and
- Supplementary Geoenvironmental Site Investigation: Former Royal Mail Depot, London Road, Twickenham – Metropolitan Open Land (MOL) RSK Environment Ltd (Ref: 25024 R06) dated February 2015.

Relevant content from this report is summarised in **Section 3.**

1.7 Definitions

The following parties have direct interest or involvement in the works described herein.

Land owner / Client	St James Limited
Groundworks Contractor	TBC
Demolition Contractor	N/A
Local Authority	London Borough Richmond Upon Thames
Pollution Control and Waste Regulatory Authority	Environment Agency
Environmental Consultant	RSK Environment Ltd

1.8 Limitations

The Remediation Method Statement is based upon previous investigations designed generally to meet the objectives of a main investigation, as defined by BS 10175:2011 +A1 2013 “Code of Practice for the Investigation of Potentially Contaminated Sites”. The remediation strategy is therefore based on the ground conditions encountered during these investigations, the results of field and laboratory testing and interpretation between exploratory holes. The material encountered and samples obtained represent a proportion of the materials present on-site, and therefore other conditions may be encountered during the remediation and ground works, which have not been revealed by these investigations.

The Remediation Method Statement 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 Principal 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 verification of the works by a representative from RSK, or if suspect materials are not notified to RSK.

2 THE SITE

2.1 Site location and description

The site is located in Twickenham in West London at National Grid Reference 515701E, 173548N, as shown in **Figure 1**.

The area around the site comprises mixed residential and commercial as detailed in **Table 1**.

Table 1: Site setting

To the north:	River Crane, with residential housing and open land beyond
To the east:	Active residential construction site with the London Road and Twickenham railway station beyond
To the south:	Railway lines and sidings with occasional residential properties and unidentified commercial properties beyond
To the west:	Allotment gardens and open land

The site covers an area of approximately 2.8 hectares and comprises an area of sensibly level, heavily vegetated open space.

A summary of the current site setting is included in **Table 2** utilising information obtained during the site reconnaissance survey (conducted in February 2015).

Table 2: Site description

Feature	Description
Physical characteristics	
Area of site	Approximately 2.8 hectares.
Ground levels	The site is sensibly level.
Depressions in the ground surface	None observed.
Waterlogged or marshy ground	None observed.
Surface water	The canalised River Crane runs along the northern boundary of the site.
Trees and hedges	The site contains mature deciduous trees together with impenetrable shrubs and brambles extending to a height of approximately 2.0m.
Existing buildings on site	None.
Basements on site	No evidence of existing or infilled basements was observed.

Feature	Description
External hardstanding	None observed.
Retaining walls and adjacent buildings on or close to site boundary	None observed.
Made ground, earthworks and quarrying	Made ground is anticipated to be present across much of the site. The presence of brick and concrete rubble was evident in several locations together with a 2m high bund measuring approximately 3.0m wide by 10.0m long in southern central areas.
Potentially unstable slopes on or close to site	None observed.
Buried services present	None observed.
Environmental characteristics	
Tank storage and dispensing facilities	None observed.
Potentially hazardous materials storage and use	None observed.
Asbestos-containing materials	None observed.
Waste storage	None observed.
Electricity sub-stations	None observed on or close to site.
Evidence of possible land contamination	Discarded sleepers and track sections were noted in the undergrowth.

2.2 Proposed development

It is understood that the MOL is due to undergo localised clearance works to facilitate the construction of a footpath running around the perimeter of the site linking in to the ongoing development on the east and open land to the west of the site.

The footpath will comprise a 3.0m wide gravel path with a 1.0m wide maintained grass strip along either side of the path. Beyond this 1.0m wide buffer strip, it is proposed to leave the remainder of the MOL untouched and therefore in its current overgrown condition.

A copy of the proposed footpath layout is included as **Figure 3**.

3 SUMMARY OF EXISTING REPORTS

Pertinent information from RSK's Supplementary Geo-environmental Site Investigation: Former Royal Mail Depot, London Road, Twickenham – Metropolitan Open Land (MOL) (Report Ref: 25024-06) dated February 2015 (which has appraised any preceding investigation work pertaining to the MOL area) is contained in the following sections:

3.1 Findings of the RSK site investigations

The exploratory holes revealed that the site is underlain by a variable thickness of made ground and/or imported topsoil overlying the Kempton Park Gravel Formation and the London Clay Formation at depth. Alluvial deposits were also encountered in northern areas of the site.

For the purpose of discussion, the ground conditions encountered during the supplementary investigation are summarised in **Table 3** below.

Table 3: General succession of strata

Strata	Exploratory holes encountered	Depth to top of stratum m bgl	Thickness (m)
Made ground	All exploratory holes	Ground level	0.3m to 1.3m
Alluvium	WS202-WS206, WS208, WS217	0.4mbgl to 1.0mbgl	0.8m to 1.3m
Kempton Park Gravels	All exploratory holes apart from WS2013	0.3mbgl to 1.9mbgl	0.5m confirmed to 2.4m
London Clay Formation	WS201-WS203, WS205, WS208, WS211 and WS217	2.7mbgl to 3.6mbgl	Confirmed to 5.0mbgl

3.1.1 Made ground

Made ground was encountered in all exploratory holes extending from ground level to depths ranging between 0.80m and 1.80m with the maximum depth encountered in WS201, advanced in the east of the site.

The stratum comprised a localised upper horizon of imported topsoil (encountered in WS201, WS203, WS205, WS207, WS208, WS211, WS213 and WS215 to WS217, typically overlying a dark brown clayey sand with inclusions of gravel and anthropogenic materials.

Where present, the imported topsoil typically comprised a friable blackish brown sandy clay/sandy silt with occasional to frequent rootlets. The stratum typically extended to depths in the order of 0.2m to 0.4m with a maximum depth of 1.0m recorded WS201.

The underlying made ground was predominantly granular in nature comprising of a clayey sand albeit with subordinate pockets of sandy clay. Anthropogenic materials including glass, mortar, concrete, ash, brick, clinker, chalk, slate, metal and ceramic tile were encountered throughout the stratum.

In several locations, notably WS206, WS208 and WS215, the presence of concrete slabs, typically 0.2-0.3m thick, were encountered at or just beneath the existing ground surface.

With the exception of the identified anthropogenic materials, no visual or olfactory evidence of contamination was encountered on site.

3.1.2 Alluvium

Alluvium was encountered beneath the made ground in WS202 to WS206, WS208 and WS217, generally located along the northern edge of the site in close proximity to the existing or former course of the River Crane.

The stratum, which generally comprised firm to stiff (locally soft) brown mottled orange silty clay with occasional inclusions of sand and flint gravel extended to depths ranging between 1.60mbgl and 1.80mbgl.

No visual or olfactory evidence of contamination was encountered within the stratum.

3.1.3 Kempton Park Gravels

The Kempton Park Gravel Formation was encountered within all exploratory holes except WS213, which terminated within deep made ground deposits.

The stratum was typically encountered at depths ranging between 0.30mbgl and 1.90mbgl (beneath either made ground or Alluvium) extending to depths ranging between 1.0mbgl and 3.60mbgl.

The stratum was predominantly granular in nature, and generally comprised of an orange/brown/grey sandy gravel with varied inclusions of clay and silt or gravelly sand.

Subordinate cohesive strata were encountered in PH4 to PH10, WS203, WS207, WS209 to WS212, and WS214 to WS16, inter-bedded with the granular portion of the stratum. These cohesive strata generally comprised firm to stiff (locally soft) light greyish brown mottled orange/brown sandy gravelly clay.

No visual or olfactory evidence of contamination was encountered within the stratum.

3.1.4 London Clay Formation

The London Clay Formation was encountered directly beneath the Kempton Park Gravels (within all boreholes that fully penetrated the overlying gravels) at depths ranging between 2.70mbgl and 3.60mbgl. The stratum extended to the full depth of the investigation at 5.0mbgl.

The London Clay Formation generally comprised a firm to stiff fissured greyish brown (locally blue/gray) silty clay.

3.1.5 Groundwater

Groundwater was encountered within WS201, WS202, WS203 and WS205 at depths ranging between 1.80mbgl and 2.0mbgl.

Subsequent monitoring visits encountered groundwater between 2.10mbgl and 4.90mbgl and therefore predominantly within the Kempton Park Gravel Formation.

3.1.6 Ground gas

The development proposals do not include for the placement of any structures or deep excavations or similar, with the potential create of a feasible scenario under which sensitive receptors would be exposed to ground gases. As such, an assessment of the potential for ground gases to accumulate has not been completed.

3.1.7 Identified pollutant linkages

Investigation works have identified the presence of marginally elevated concentrations of Lead, Benzo(a)pyrene and Benzo(a)anthracene within the general made ground and Lead within the imported topsoil by comparison to RSK's GAC for a residential end use. Subsequent statistical assessment of the general made ground data-set and comparison to C4SL's has revealed that the concentrations of Benzo(a)anthracene, Benzo(a)pyrene and Lead are unlikely to pose a significant risk to end users of the site.

Statistical assessment of testing results relating to the imported topsoil horizons were not possible owing to the small number of samples from this stratum. By means of a direct comparison against the corresponding GAC's, the recorded concentrations of Lead may pose a risk to end users of the site. As such, remedial measures were recommended to break the identified pollutant linkage.

Laboratory screening identified the presence of asbestos containing materials in two of the made ground samples at concentrations of <0.001% and 0.169% weight/weight, the former was identified as Chrysotile fibres and the latter as Chrysotile board.

Given the presence of asbestos containing materials within shallow soils, albeit at low levels, remedial measures were recommended to break the identified pollutant linkage with respect to end users of the site and groundworkers and/or members of the public during the earthworks.

The assessment of potential phytotoxic effects has indicated that a relevant pollutant linkage may exist given the presence of elevated concentrations of lead, mercury and Zinc. However, given the development proposals, with minimal surface disruption outside of the footpath footprint, and the relatively healthy nature of the existing vegetation, the risks associated with plant phytotoxicity are unlikely to be realised unless additional planting of sensitive vegetation (i.e. grass or shrubs) is proposed.

The assessment of leaching of contaminants to groundwater in the underlying Principal Aquifer, and subsequent migration to surface watercourse, has indicated that a relevant pollutant linkage may exist given the presence of leachable concentrations of Lead, Copper and Zinc. However, given the aggressive nature of the leachability testing, and depth of the unsaturated zone, the recorded concentrations of these compounds are not considered to pose an unacceptable risk to controlled waters.

Assessment of surface water quality within the neighbouring River Crane has revealed a number of marginally elevated concentrations of several inorganic compounds, together with Ammoniacal Nitrogen, in a sample analysed from an upstream stretch of the River. Within the down-gradient sample, marginal exceedances were only recorded for two compounds, namely Chrysene and Ammoniacal Nitrogen. With the recorded concentration of Chrysene having reduced markedly from that recorded upstream of the site. As such, the site is not considered to have a detrimental impact upon surface water quality within the adjacent River Crane.

Analytical testing of groundwater samples identified a marginally elevated concentration of Mercury in WS201. No other determinants were identified in excess of the relevant GAC. Given the absence of elevated concentrations of Mercury within the near surface soils (and associated leachability testing) together with groundwater samples and adjacent surface water samples, the recorded concentration of Mercury was not considered to give cause for concern. As such, pollutant linkages relating to contaminants in the dissolved phase were considered to be absent.

4 REMEDIAL STRATEGY

4.1 Introduction

This Remediation Method Statement has been designed to break or remove the potential pollutant linkages identified on site from preceding investigation works. Essentially these comprise:

- Risks to end users of the site attributable to the presence of localised asbestos containing materials and elevated concentrations of Lead; and
- Risk to groundworkers and adjacent site users during redevelopment works.

4.2 Remedial objectives

The objectives of the remediation are to produce a site that is suitable for its intended purposes whilst providing a safe working environment with respect to site workers and adjacent users. This will involve the following measures:

- Targeted excavation of impacted soils (identified contamination hotspots) for disposal off-site at an appropriate licensed facility;
- The placement of a 150mm of clean topsoil along the 1.0m wide landscaped strip to be created along the flanks of the footpath; and
- Adoption of safe working procedures with respect to the identified presence of asbestos containing materials.

4.3 Implementation plan

4.3.1 Introduction

The overall remediation strategy for the site may be divided into the enabling phase, i.e. those works required to produce a suitable development platform, and the subsequent construction phase. The sequence of works required under both phases is outlined in the following sections.

4.3.2 Enabling phase

4.3.2.1 Removal of identified Asbestos impacted soils

Localised excavation of soils identified to contain asbestos containing materials should be conducted before further disturbance of the ground. This will require localised excavation in the vicinity of WS214 and WS215. In each instance excavation works should cover a plan area of 3m by 3m extending at least 0.2m beyond the depth at which asbestos containing materials were confirmed (0.60mbgl and 0.50mbgl respectively).

Excavation works should be conducted under the supervision of a suitably accredited asbestos surveyor or similar. Soils to be excavated should be suitably damped down before being disturbed, and ideally removed off site without delay or temporary stockpiling which, depending upon the weather and soil moisture, may require covering if temporary stockpiling is necessary. The full control measures to be implemented during these works should be detailed within the contractors working method statements.

Where these works are conducted during dry weather, air monitoring should be undertaken for the duration of the excavation works with an appropriate number of monitoring points targeting the works face and site boundaries. Copies of the monitoring records should be made available for inclusions within the site verification report.

Whilst these excavation works will effectively remove soils proven to contain asbestos containing materials, similar occurrence may and are likely to occur in the surrounding materials and therefore adjacent excavation works should be conducted under a careful watching brief.

Following excavation of the soils, the exposed sides and base of the excavation should be validated by means of analytical testing to confirm the removal of all impacted soils. A minimum of five soil samples should be analysed for comparison against the validation criteria contained in **Table 4**.

Where validation testing confirms the extent of the excavation works to be appropriate, backfilling of the resultant void should be conducted using certified clean soils complying with the validation criteria contained in **Table 4**.

4.3.2.2 Removal of identified Lead impacted soils

Localised excavation of soils identified to contain elevated concentrations of Lead should be conducted before further disturbance of the ground. This will require localised excavation in the vicinity of WS216 at a depth of 0.2m. In this area, excavation works should cover a plan area of 3m by 3m extending at least 0.2m beyond the depth at which contamination was encountered.

Soils to be excavated should ideally be removed off site without delay or temporary stockpiling which, depending upon the weather and soil moisture, may require covering if temporary stockpiling is necessary. The full control measures to be implemented during these works should be detailed within the contractors working method statements.

Following excavation of the soils, the exposed sides and base of the excavation should be validated by means of analytical testing to confirm the removal of all impacted soils. A minimum of five soil samples should be analysed for comparison against the validation criteria contained in **Table 4**.

Where validation testing confirms the extent of the excavation works to be appropriate, backfilling of the resultant void should be conducted using certified clean soils complying with the validation criteria contained in **Tables 4** and **5**.

4.3.3 Construction phase

The principal objectives of the remedial strategy for the construction phase is to break pathways via which end users of the site may be exposed to contaminants within the shallow made ground deposits identified on site.

In addition, the strategy aims to provide a suitable growing medium in areas of soft landscaping to be created along the flanks of the proposed footpath.

4.3.3.1 Placement of clean cover soils

Where it is proposed to create a 1.0m wide maintained grass strip along either side of the proposed footpath (with a fence beyond preventing access to the adjoining areas) it will be necessary to place 150mm of clean cover soils to break potential pollutant linkages.

Where ground levels are to remain unaltered, construction of the clean cover horizon will generally require made ground deposits to be removed to the corresponding depths (i.e. 150mm) and replaced with suitably clean and certified soils. As a minimum, the cover layer should include for at least 150mm of certified clean topsoil.

Made ground excavated during the construction of the clean cover horizon should be removed off-site to a suitably licensed or exempt facility.

4.3.4 Validation of clean cover soils

The requirements for the validation of cover systems are outlined in NHBC Standards Chapter 4.1 'Land Quality – Managing Ground Conditions'. The two main aspects to consider when validating cover systems are:

a) Confirmation that the designed thickness of the material has been placed
b) Confirmation that the materials comprising the cover system are themselves not contaminated, i.e. suitable for residential use

To assess the thickness of the cover layer, it will be necessary to dig through the cover layer at selected locations to verify the required thickness of topsoil and subsoil.

In addition, the topsoil and subsoil (whether imported or site derived during earthworks or the subsequent construction phase) will be chemically validated by the collection and analysis of representative soil samples. The frequency of testing for any site-derived or imported materials stockpiled for re-use should be a minimum of one sample for every $50m^3$ for the following parameters:

- Metals: arsenic, cadmium, chromium, copper, nickel, lead, mercury, selenium and zinc and pH;
- Speciated TPH CWG (split into aliphatic and aromatic carbon bands) with BTEX compounds;
- Speciated 16 No. PAH; and
- Asbestos in soil with ID.

It is acceptable to test stockpiled topsoil/subsoil intended for use in gardens and soft landscaped areas before placement, however the cover layer thickness will still require validation at a later date.

The groundworks contractor shall provide details of the provenance of any imported soil and evidence of compliance (i.e. chemical testing certificates representative of the type and volume of material) to the Environmental Consultant whose written approval will be required **before** importation and use of the material.

4.3.5 Validation assessment criteria (VAC)

To assess human health risks via the soil ingestion, dermal contact and inhalation, results of validation sampling will be compared directly with the validation criteria detailed in **Table 4** below. The validation criteria are a combination of RSK derived GAC's suitable for a communal soft landscaping end land use, and recently published DEFRA C4SL. Assessment criteria suitable for 6% soil organic matter (SOM) have been selected since topsoil and subsoil are likely to be high in organic content. Should lower SOM be present, the RSK GAC appendix within **Appendix B** provides alternative criteria for 1% and 2% SOM.

The Category 4 Screening Levels (C4SLs) have recently been issued by DEFRA in March 2014 and are intended for use as a technical tool for defining which land is suitable for use and is definitely not contaminated land and therefore requires no further assessment with respect to Part 2a. C4SLs provide a more pragmatic approach than SGVs/GACs, yet are still strongly precautionary, and have been developed using the CLEA model, which is the same framework used for the development of the SGVs/GACs.

C4SL's have been derived using a newly termed 'Low Level of Toxicological Concern (LLTC)' which represents an intake of low concern that remains suitably protective of health, instead of the minimal risk Health Criteria Values (HCV) which have been used in the development of the SGV/GACs. The C4SLs also take into account a number of updated exposure parameters which have been selected following several stakeholder engagement workshops.

There is some debate within industry as to the applicability of C4SL's within the planning scenario, however RSK is of the opinion that they provide very pragmatic yet still strongly precautionary targets which demonstrate the site is suitable for use, therefore it is considered appropriate to use them, where available, as validation criteria.

The RSK GAC appendix which details the generation of the GAC's is presented as **Appendix B**. The proposed screening criteria for the site are shown in the following table.

Table 4: Validation Assessment Criteria

Compound	Validation Assessment Criteria (VAC) 6% SOM (mg/kg)	Justification
Metals		
Arsenic	**37**	C4SL
Cadmium	**26**	C4SL
Chromium (III) - oxide	3,000	RSK GAC
Chromium (VI)	**21**	C4SL
Copper	6,200	RSK GAC
Lead	**310**	C4SL
Elemental Mercury (Hg0)	1.0	RSK GAC
Inorganic Mercury (Hg2+)	240	RSK GAC
Methyl Mercury (Hg4+)	14	RSK GAC

Compound	Validation Assessment Criteria (VAC) 6% SOM (mg/kg)	Justification
Nickel	130	RSK GAC
Selenium	600	RSK GAC
Zinc	41,000	RSK GAC
BTEX Compounds		
Benzene	**0.87**	C4SL
Toluene	2,700	RSK GAC
Ethylbenzene	840	RSK GAC
Xylene - m	300	RSK GAC
Xylene - o	320	RSK GAC
Xylene - p	290	RSK GAC
Total xylene	300	RSK GAC
Semi-volatile organic compounds (Polycyclic Aromatic Hydrocarbons)		
Acenaphthene	3,900	RSK GAC
Acenaphthylene	3,900	RSK GAC
Anthracene	23,000	RSK GAC
Benzo(a)anthracene	6.2	RSK GAC
Benzo(b)fluoranthene	7.4	RSK GAC
Benzo(g,h,i)perylene	48	RSK GAC
Benzo(k)fluoranthene	10	RSK GAC
Chrysene	10	RSK GAC
Dibenzo(a,h)anthracene	0.93	RSK GAC
Fluoranthene	1,000	RSK GAC
Fluorene	2,900	RSK GAC
Indeno(1,2,3-cd)pyrene	4.4	RSK GAC
Phenanthrene	970	RSK GAC
Pyrene	2,400	RSK GAC
Benzo(a)pyrene	**5.3**	C4SL
Naphthalene	9.2	RSK GAC
Total Petroleum Hydrocarbons		
Aliphatic hydrocarbons EC_5–EC_6	110	RSK GAC
Aliphatic hydrocarbons >EC_6–EC_8	370	RSK GAC
Aliphatic hydrocarbons >EC_8–EC_{10}	110	RSK GAC
Aliphatic hydrocarbons >EC_{10}–EC_{12}	540	RSK GAC
Aliphatic hydrocarbons >EC_{12}–EC_{16}	3,000	RSK GAC
Aliphatic hydrocarbons >EC_{16}–EC_{35}	77,000	RSK GAC
Aromatic hydrocarbons >EC_8–EC_9	1,400	RSK GAC
Aromatic hydrocarbons >EC_9–EC_{10}	190	RSK GAC
Aromatic hydrocarbons >EC_{10}–EC_{12}	870	RSK GAC
Aromatic hydrocarbons >EC_{12}–EC_{16}	1,700	RSK GAC

Compound	Validation Assessment Criteria (VAC) 6% SOM (mg/kg)	Justification
Aromatic hydrocarbons $>EC_{16}–EC_{21}$	1,300	RSK GAC
Aromatic hydrocarbons $>EC_{21}–EC_{35}$	1,300	RSK GAC
Other		
Asbestos	Not observed in asbestos in soil with ID analysis	Laboratory analysis LOD
Highlighted cells indicate where C4SL values are being used for validation.		

In addition, where deeper tree/shrub pits are dug, the following validation criteria protective of phytotoxic risks presented within **Table 5** should be used as a supplement to the VAC above.

Table 5: Phytotoxic Validation Assessment Criteria

Determinant	Generic assessment criteria (mg/kg)			
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0
Zinc	200	200	200	300
Copper	80	100	135	200
Nickel	50	60	75	110
Note: Only compounds within BS3882:2007 and BS8601:2013 for topsoil and subsoil specification have been included. There are additional criteria regarding the suitability of a subsoil and topsoil which should be referred to in these documents.				

4.3.6 Inspection and testing

Responsibility for the correct implementation of the remediation strategy lies with the Principal Contractor (PC). However, the remedial works shall be monitored, inspected and validated by the Environmental Consultant's experienced Geoenvironmental Engineers with part time attendance on-site dependent on the operations being undertaken.

During periods of part time supervision, it will be the PC's responsibility to provide adequate notice (at least three days) of any key activities that will require the attendance of the Environmental Consultant.

Validation testing shall be conducted as specified in the relevant sections. Laboratory analysis shall be carried out at an MCERTS and UKAS-accredited laboratory.

4.3.7 Discovery strategy

Whilst the investigations undertaken to date have been thorough, it remains possible that previously unexpected soil conditions may be encountered during the enabling and construction process (e.g. the presence of discrete/visually identifiable asbestos, soils exhibiting strong odours, former structures of brickwork).

Where unexpected ground conditions or potentially suspect materials are encountered, the following course of action should be adhered to:

- The contractor shall immediately inform the Environmental Consultant who shall then carry out an inspection as soon as is reasonably practical;
- Following the inspection, the Environmental Consultant shall advise the Client of any requirements for additional investigations or possible modifications to the remediation works; and
- The Regulatory Authorities shall be consulted if any substantially different conditions are encountered or modifications to the remedial works are required.

Should disturbance of the made ground result in the identification of suspected asbestos containing materials, any exposed materials/soils should be damped down and covered over with plastic sheeting and advice be sought from a suitably accredited asbestos surveyor or similar.

5 WORKING PRACTICE AND VERIFICATION

5.1 Securing the site against unauthorised access

Suitable fencing shall be erected around the site and shall be maintained to prevent members of the public and any other unauthorised personnel from entering the site. On the site, individual remedial excavations shall also be fenced off when being left unattended.

5.2 Health and safety of site personnel

It is the responsibility of the PC and any appointed sub-contractors to enforce an appropriate health and safety regime for all site personnel. Full details regarding the proposed working practices in connection with the remediation works shall be agreed in advance of the commencement of the works with the Planning Supervisor and, if appropriate, with the Environmental Health Officer.

Measures will be necessary to protect the health and safety of site workers during the site works. The following measures are suggested to provide a minimum level of protection. All ground workers on-site should be issued with protective clothing, dust masks, footwear and gloves. These should not be removed from site, and advice should be given on when and how they are to be used.

Great care should be taken to minimise the amount of dust and mud generated on-site, especially given the requirement to excavate and remove asbestos impacted soils.

Reference should also be made to CIRIA C733: Asbestos in soil and made ground: a guide to understanding and managing risks and the Health and Safety Executive (HSE) document “Protection of Workers and the General Public during the Development of Contaminated Land”.

Where additional measures are required with respect to the presence of asbestos containing materials, these should be documented within the contractors working method statements and approved prior to the works being undertaken.

Good practices relating to personal hygiene should be adhered to on-site, i.e. food and drink should only be consumed within designated areas on the site and smoking should be prohibited in all working areas.

5.3 Prevention of pollution

5.3.1 General

The targets perceived to be potentially most at risk from pollution during the remediation of the site are the workers on-site together with nearby residents.

All contractors on-site shall adhere to environmental good practice as set out in CIRIA publication C650 (2005) and in particular those issues identified below.

5.3.2 Airborne pollution (dust and asbestos)

Care shall be taken by the contractor to minimise the amount of dust generated on-site during excavation, backfilling and trafficking. In the event that dry weather leads to excessive dust generation, exposed soils shall be damped down, but not flooded, with clean water.

The Contractor's method statement shall include a detailed dust control plan together with air monitoring procedures to be implemented during the removal of soils identified to contain asbestos fibres.

5.3.3 Surface runoff

The PC shall implement appropriate procedures to prevent surface run-off, including forming bunds around any temporary stockpiles of contaminated soils.

5.3.4 Vehicles

Wheel cleaning/washing facilities shall be provided on-site if operations are likely to result in vehicles leaving site with potentially contaminated soil/mud clinging to them. Contaminated water on-site, including water and other liquid collected from vehicle washing facilities, shall be disposed of off-site in an approved manner with full regard to current legislation and good practice.

All vehicles leaving the site shall be clear of contaminated materials other than that contained within the load container, which shall be sheeted to prevent the loss of dust and other materials.

5.3.5 Re-contamination

The programme of works and any subsequent modifications shall be designed to avoid the potential re-contamination of areas already worked, e.g. site traffic shall be routed to avoid passing from contaminated to clean areas and contaminated soils shall not be stockpiled on clean areas.

5.3.6 Discharge of pumped water

Any potentially contaminated perched groundwater, groundwater or surface water runoff encountered on site shall be contained or either treated onsite to permit disposal to the public sewer, subject to the approval of the sewerage authority, or tinkered offsite for appropriate disposal as dictated by the results of the chemical testing.

5.3.7 Migration pathways

During construction of the site, redundant services may be exposed. To prevent these acting as conduits for the movement of contamination, where encountered, they features should be sealed.

5.4 Waste disposal

All contaminated materials removed off-site shall:

- Be transported to an approved licensed waste management facility for treatment or final disposal; and
- Or be disposed of to the foul sewers under an appropriate discharge consent.

The contractor shall provide a full documentary record of this operation in accordance with the Duty of Care. This should, where appropriate, include waste transfer notes, discharge consents, laboratory results and details of the receiving site. Copies of the relevant documents shall be provided to the Environmental Consultant for inclusion in the verification report.

It should be noted that the Site Waste Management Plans Regulations 2008, require the preparation of a Site Waste Management Plan (SWMP) for all construction projects in England with a value of more than £300,000 and a more detailed plan for projects with a value of more than £500,000. The purpose of the SWMPs is to encourage better resource utilisation and waste management practices in construction, improve environmental performance, minimise the landfilling of wastes, and reduce instances of fly-tipping.

A SWMP is therefore likely to be required for the development and will need to consider all potential construction waste streams, including soils.

Classification of any material to be disposed of to landfill shall be agreed in advance with the landfill operator(s), as appropriate. Any waste classified as Hazardous shall be disposed of in accordance with the Hazardous Waste Regulations 2005.

5.5 Documentation

All contaminated materials removed off-site shall be transported to an approved licensed landfill for final disposal. The PC shall provide a full documentary record of this operation in accordance with the Duty of Care. Copies of the landfill documents shall be provided to the Environmental Consultant for inclusion in the verification report.

5.6 Verification of remediation

On the completion of the remediation works, the Environmental Consultant shall produce a verification report for the site to demonstrate the works were undertaken in accordance with this method statement or highlighting where they differed, if appropriate. The report will include:

- The extent of works that have actually been carried out;
- The results of all monitoring and testing carried out during the works;
- Approvals, if appropriate, for imported materials, including test results and thickness of cover; and
- Collation of all other relevant documents, including records of on-site soil movements and off-site waste movements; and a photographic record of the works.

A copy of the report shall be forwarded to the Local Authority and Environment Agency (if appropriate) for approval of the proposed remediation works and to obtain discharge of relevant planning conditions.

FIGURES

Reproduced from the 2006 Ordnance Survey 1:50,000 Scale Landranger Map 176, OSGR - TQ159736

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Client
ST JAMES GROUP

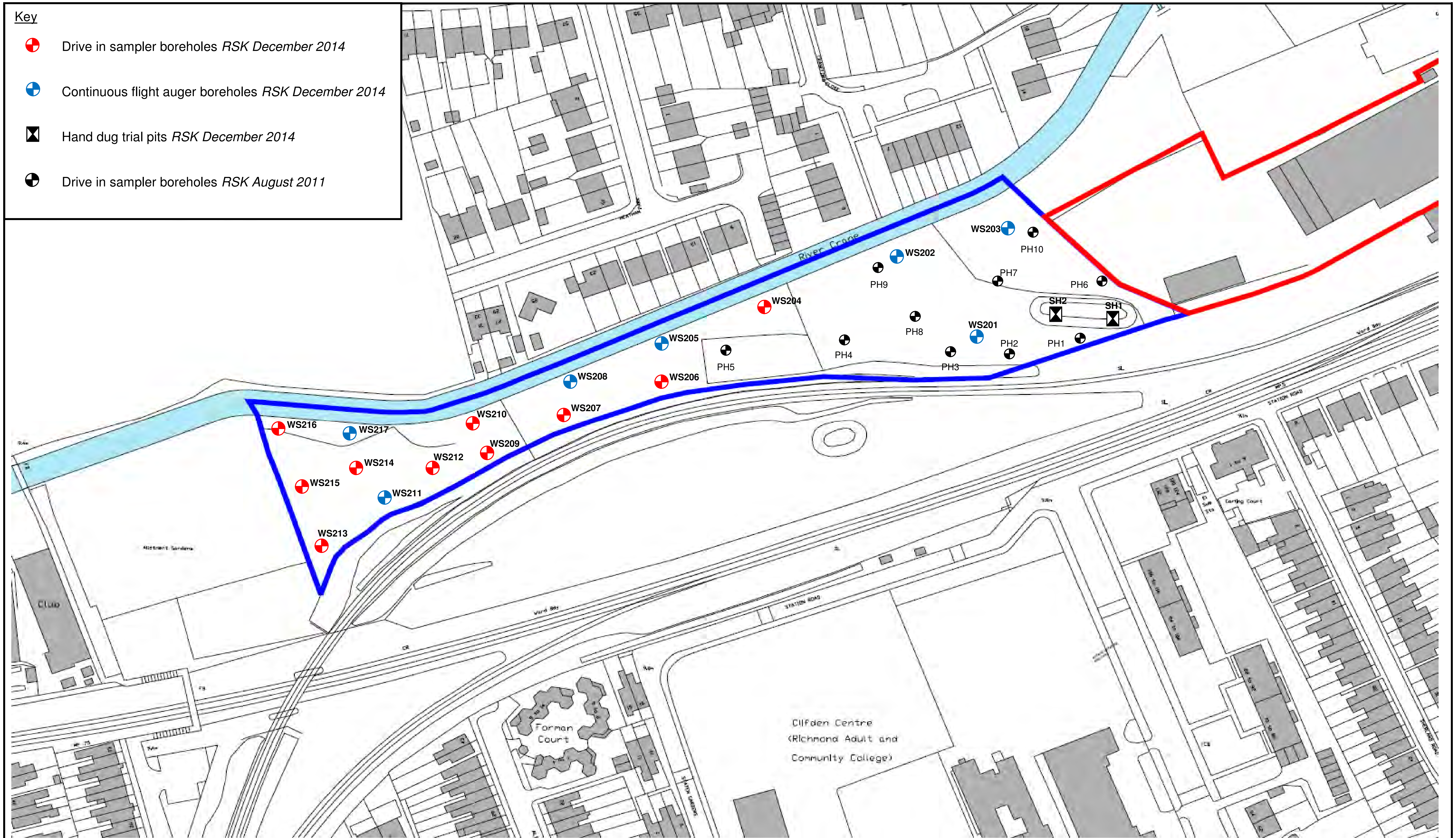
Project Title
FORMER ROYAL MAIL DEPOT
TWICKENHAM

Drawing Title
SITE LOCATION MAP

Rev	Drawn	Date	Checked	Date	Approved	Date
P1	RS	12.09.11	CJL	12.09.11	CJL	12.09.11

Dimensions	Scale	Original Size
m	1:50,000	A4

Project Number	Drawing File	Drawing Number
25024-1 (00)	25024 - Fig 1 SLP.dwg	FIGURE 1



RSK	Exploratory Hole Location Plan	Client:	St James	Figure No:	2
		Site:	Twickenham Sorting Office - MOL	Job No:	25024-06
		Scale:	-	Source:	-

RSK	**Proposed Development Plan**	Client:	St James	Figure No:	3
		Site:	Twickenham Sorting Office - MOL	Job No:	25024-06
		Scale:	-	Source:	-

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for St James Limited (the "client") in accordance with the terms of a contract between RSK and the "client", dated 20th March 2014. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. 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.

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.

3. Unless otherwise agreed 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 otherwise 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 environmental consultant and/or lawyer.

4. It is RSK's understanding 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 RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. 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. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. 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 contract 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 the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and 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. 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 contract between the client and RSK.

8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the 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 soil and groundwater conditions, together with the position of any current structures and underground 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 contract 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 are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

APPENDIX B
RSK GENERIC ASSESSMENT CRITERIA (GAC'S)

Generic assessment criteria (GAC) for human health: residential scenario – communal soft landscaping

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]. Where available, the published soil guideline values (SGV)[1] were used as the GAC. 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, after attendance at the SOBRA summer workshop June 2011, RSK has revised its GAC and is currently undertaking a review of recent toxicological developments that will be used to refine this GAC further in the coming months. In the meantime, RSK has undertaken sensitivity analysis using the Society of Environmental Geochemistry and Health (SEGH) equation and the CLEA model to produce an interim GAC value. The results are summarised below:

- Using CLEA with the former provisional tolerable weekly intake (PTWI) (25 µg/kg bw), assuming 100% lead is bioavailable, produces a GAC of 212 mg/kg
- Using CLEA with the former PTWI, assuming 50% lead is bioavailable, produces a GAC of 478 mg/kg
- Using the SEGH equation amended for a blood target concentration of 5.6 µg/dl (equal to the LOAEL for IQ defects) gives a negative GAC number unless other factors such as child background blood concentration or delta are amended. Without undertaking further research into these numbers, RSK can present sensitivity analysis to demonstrate the sensitivity of these input parameters but cannot justify one parameter over another. The results are:
    - GAC between 39mg/kg and 99mg/kg if the value of delta (the slope or response of blood Pb versus soil and dust Pb relationship) only is amended from 5 to 2µg/dl/1000µg/g. The value of 2 was chosen as it is within the reasonable range quoted in the former SGV report
    - GAC between 244mg/kg and 610mg/kg if the geometric mean of blood lead concentration in young children is reduced from 3.4µg/dl to 2µg/dl. This decrease has been simulated on the basis that blood concentrations are likely to decrease over time across the UK owing to a ban on lead in petrol, lead within paint used internally and water pipe replacement. This decrease is considered reasonable as the site is a new development so lead-based paints will not be used internally and lead water supply pipelines will be absent.

Therefore, given the results above RSK proposes to use a GAC of **300mg/kg** for a residential end use. This value is broadly in the middle of the range of sensitivity modelling results quoted above when background mean blood lead concentrations in children are reduced to reflect a new development. The value is also broadly in the middle of the range of sensitivity modelling results for a range of bioavailability of lead between 50% and 100%. This number is considered reasonably protective of human health while being practical for use.

GAC derivation for other metals and organic compounds

Model selection

Soil assessment criteria (SAC) were calculated using CLEA v1.06 and the supporting UK 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.

Conceptual model

In accordance with EA Science Report SC050021/SR3[3], the residential with communal soft landscaping scenario considers risks to a female child between the ages of 0 and 6 years old. In accordance with Box 3.1, SR3, the pathways considered for production of the SAC in the residential with communal soft landscaping scenario are:

- direct soil and dust ingestion
- dermal contact with soil and indoor dust
- inhalation of indoor and outdoor dust and vapours.

Figure 1 is a conceptual model illustrating these linkages.

The pathway considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by residents 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 CLEA 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 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 not to be practical in many cases because of the subsequent 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 limits given in brackets. Therefore, when using the SAC to screen laboratory analysis the assessor should take note if a given SAC has a corresponding solubility or vapour saturation limit (in brackets) and subsequently incorporate this 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 total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH), toxicological and specific chemical 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 as 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 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:

- amendments to the MDI using Table 3.4 of SR2[2]
- a child weighing 13.3kg (average of 0–6 year old female in accordance with Table 4.6 of SR3[3]) and breathing 11.85m^3 (average daily inhalation rate for a 0–6-year old female in accordance with Table 4.14 of SR3[3]
- The 50% rule (for petroleum hydrocarbons, trimethylbenzenes and MTBE)[2] where MDI data is not available but background exposure is considered important in the overall exposure.

Physical parameters

For the residential with communal soft landscaping scenario, the CLEA default building is a small two-storey terrace house with concrete ground-bearing slab. SR3[3] notes this residential building type to be the most conservative in terms of protection from vapour intrusion. 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 to 3 and the GrAC using the input parameters in Table 4. The GAC by pathway are presented in Table 5 and the combined GAC presented in Table 6.

Figure 1: Conceptual model for CLEA residential scenario – with communal soft landscaping

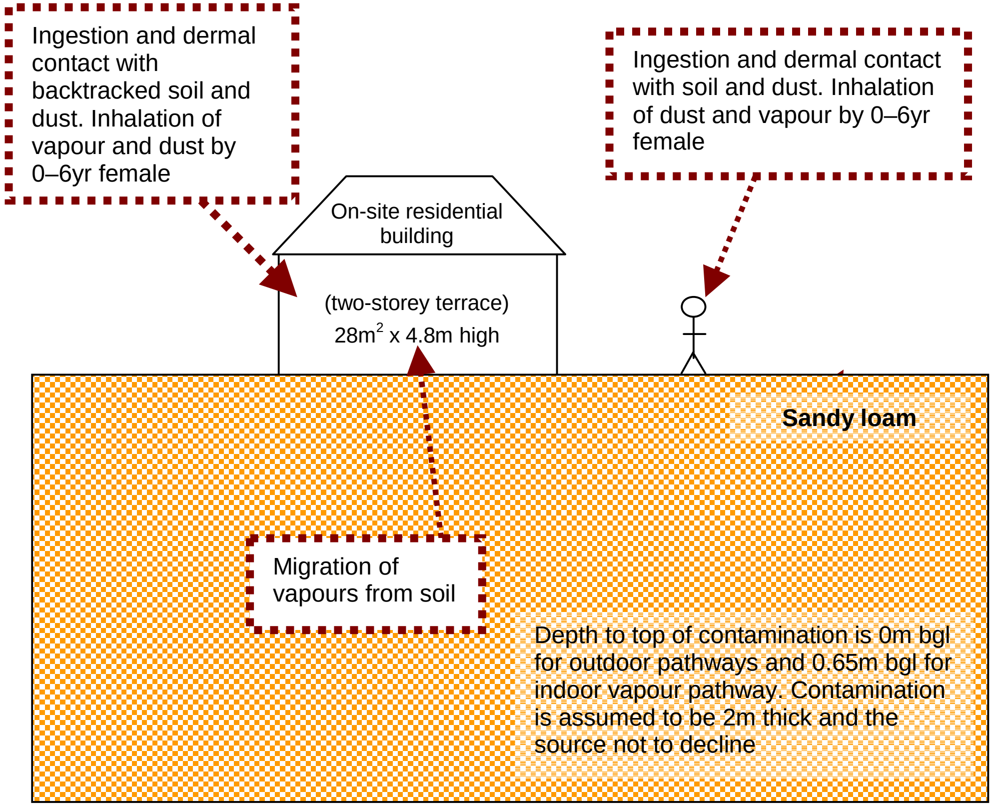


Table 1: Exposure assessment parameters for residential scenario – with communal soft landscaping – inputs for CLEA model

Parameter	Value	Justification
Land use	Residential without homegrown produce	Chosen land use
Receptor	Female Child	Taken as female child exposed over 6 years from 0 to 6 years, Box 3.1, SR3(3)
Building	Small terraced house	Key generic assumption given in Box 3.1, SR3(3). Two-storey small terraced house chosen, as the most conservative residential building type in terms of protection from vapour intrusion (Section 3.2.6, report SC050021/SR3(3)). Table 3 presents building-specific input data
Soil type	Sandy loam	Most common UK soil type (Section 4.3.1, Table 4.4, SR3(3)). Table 4 presents soil-specific input data
Start age class (AC)	1	Range of AC corresponding to key generic assumption that the critical receptor is a young female child aged 0–6 years. From Box 3.1, SR3(3). Data specific to the receptor is presented in Table 2
End AC	6	
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: Residential with communal soft landscaping – land use and receptor data for CLEA model

Parameter	Unit	Age class					
		1	2	3	4	5	6
Exposure frequency (EF) (soil and dust ingestion)	day yr^{-1}	180	365	365	365	365	365
EF (skin contact, indoor)	day yr^{-1}	180	365	365	365	365	365
EF (skin contact, outdoor)	day yr^{-1}	180	365	365	365	365	365
EF (inhalation of dust and vapour, indoor)	day yr^{-1}	365	365	365	365	365	365
EF (inhalation of dust and vapour, outdoor)	day yr^{-1}	365	365	365	365	365	365
Justification		Table 3.1, SR3[(3)]					
Occupancy period (indoor)	hr day^{-1}	23	23	23	23	19	19
Occupancy period (outdoor)	hr day^{-1}	1	1	1	1	1	1
Justification		Table 3.2, SR3[(3)]					
Soil ingestion rate	g/day	0.1	0.1	0.1	0.1	0.1	0.1
Justification		Table 6.2, SR3[(3)]					
Soil to skin adherence factor – (indoor)	mg soil/cm^2 skin	0.06	0.06	0.06	0.06	0.06	0.06
Soil to skin adherence factor – (outdoor)	mg soil/cm^2 skin	1	1	1	1	1	1
Justification		Table 8.1, SR3[(3)]					
Body weight	kg	5.6	9.8	12.7	15.1	16.9	19.7
Body height	m	0.7	0.8	0.9	0.9	1	1.1
Justification		Table 4.6, SR3[(3)]					
Inhalation Rate	m^3 day^{-1}	8.5	13.3	12.7	12.2	12.2	12.2
Justification		Table 4.14, SR3[(3)]					
Max exposed skin fraction (indoor)	m^2 m^{-2}	0.32	0.33	0.32	0.35	0.35	0.33
Max exposed skin fraction (outdoor)	m^2 m^{-2}	0.26	0.26	0.25	0.28	0.28	0.26
Justification		Table 4.8, SR3[(3)]					

Note: for **cadmium**, the exposure assessment for a residential land use is based on estimates representative of lifetime exposure AC1–18. This is because the TDI_{oral} and TDI_{inh} are based on considerations of the kidney burden accumulated over 50 years. It is therefore reasonable to consider exposure not only in childhood but averaged over a longer time period. See the Environment Agency Science report SC050021 / TOX 3[(1)] and Science Report SC050021/Cadmium SGV[(1)] for the full AC1-18 Land use Data suite.

Table 3: Residential with communal soft landscaping – soil, air and building specific 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	$m\ s^{-1}$	7.2	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 0.8m	$g\ m^{-2}\ s^{-1}$ per $kg\ m^{-3}$	2400	From Table 9.1, SR3[(3)]. Values for a 0.01ha site, appropriate to a residential land use in Newcastle (representative city for UK, section 9.2.1, SR3[(3)])
Fraction of site with hard or vegetative cover	$m^2\ m^{-2}$	0.75	Section 3.2.6, SR3[(3)] for residential land use
Building properties for house with ground-bearing floor slab			
Building footprint	m^2	28	From Table 3.3 and 4.21, SR3[(3)]
Living space air exchange rate	hr^{-1}	0.50	
Living space height (above ground)	m	4.8	
Living space height (below ground)	m	0.0	Assumed no basement
Pressure difference (soil to enclosed space)	Pa	3.1	From Table 3.3 and 4.21, SR3[(3)]
Foundation thickness	m	0.15	

Parameter	Unit	Value	Justification
Floor crack area	cm^2	423	
Dust loading factor	$\mu g\ m^{-3}$	50	Default value for a residential site taken from Section 9.3, SR3[(3)]
Vapour model			
Default soil gas ingress rate	$cm^3\ s^{-1}$	25	Generic flow rate, Section 10.3, SR3[(3)]
Depth to top of source (beneath building for indoor exposure)	cm	50	Section 3.2.6, 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	6	Time period of a 0–6 year old, 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 residential with communal soft landscaping scenario

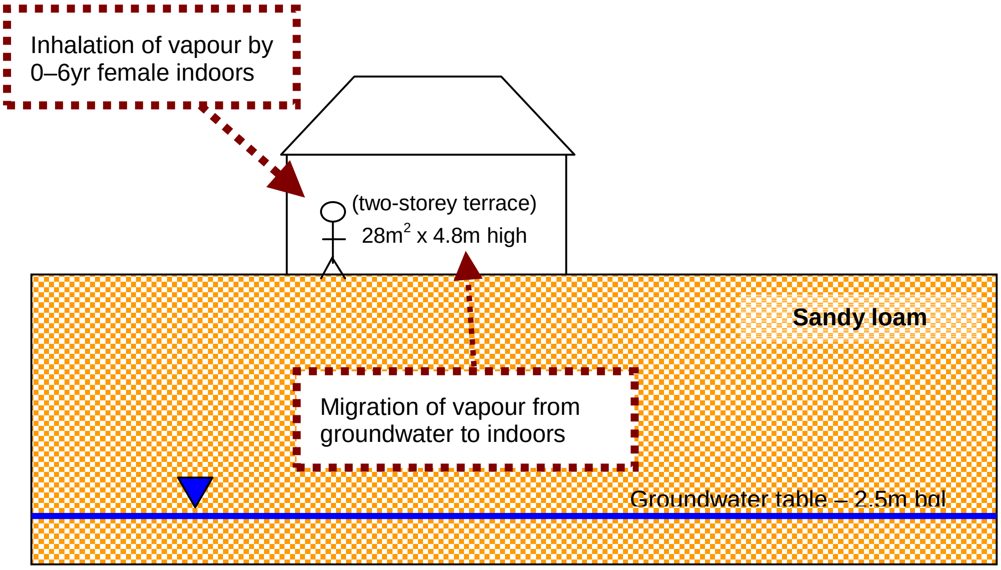


Table 4: Residential with communal soft landscaping – RBCA inputs

Parameter	Unit	Value	Justification
Receptor			
Averaging time	Years	6	From Box 3.1, SR3[(3)]
Receptor weight	kg	13.3	Average of CLEA 0-6 year old female data, Table 4.6, SR3[(3)]
Exposure duration	Years	6	From Box 3.1, report , SR3[(3)]
Exposure frequency	Days/yr	350	Weighted using occupancy period of 23 hours per day for 365 days of the year
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)

Parameter	Unit	Value	Justification
Capillary zone thickness	m	0.1	Professional judgement
Building			
Building volume/ area ratio	m	4.8	Table 3.3, SR3(3)
Foundation area	m^2	28	
Foundation perimeter	m	22	Calculated assuming building measures 7m x 4m to give $28m^2$ foundation area
Building air exchange rate	d^{-1}	12	Table 3.3, SR3(3)
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	
Foundation crack fraction	-	0.0151	Calculated from floor crack area of 423 cm^2 and building footprint of $28m^2$ in Table 4.21, SR3(3)
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	3.1	From Table 3.3, SR3(3)

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.

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH COMMUNAL SOFT LANDSCAPING

Table 5

Human Health Generic Assessment Criteria by Pathway for Residential Scenario With Communal Soft Lanscaping

Compound	Notes	GrAC	SAC Appropriate to Pathway SOM 1% (mg/kg)			Soil Saturation	SAC Appropriate to Pathway SOM 2.5% (mg/kg)			Soil Saturation	SAC Appropriate to Pathway SOM 6% (mg/kg)			Soil Saturation
		(mg/l)	Oral	Inhalation	Combined	Limit (mg/kg)	Oral	Inhalation	Combined	Limit (mg/kg)	Oral	Inhalation	Combined	Limit (mg/kg)
Metals														
Arsenic	(c)	-	3.50E+01	8.50E+01	-	NR	3.50E+01	8.50E+01	-	NR	3.50E+01	8.50E+01	-	NR
Cadmium		-	1.21E+02	1.85E+02	8.49E+01	NR	1.21E+02	1.85E+02	8.49E+01	NR	1.21E+02	1.85E+02	8.49E+01	NR
Chromium (III) -oxide		-	1.98E+04	3.55E+03	3.01E+03	NR	1.98E+04	3.55E+03	3.01E+03	NR	1.98E+04	3.55E+03	3.01E+03	NR
Chromium (VI) - hexavalent		-	8.40E+01	4.25E+00	4.12E+00	NR	8.40E+01	4.25E+00	4.12E+00	NR	8.40E+01	4.25E+00	4.12E+00	NR
Copper		-	1.08E+04	1.04E+04	6.20E+03	NR	1.08E+04	1.04E+04	6.20E+03	NR	1.08E+04	1.04E+04	6.20E+03	NR
Lead	(a)	-	3.00E+02	-	-	NR	3.00E+02	-	-		3.00E+02	-	-	NR
Elemental Mercury (Hg^0)	(d)	9.40E-03	-	1.70E-01	-	4.31E+00	-	4.24E-01	-	1.07E+01	-	1.02E+00	-	2.58E+01
Inorganic Mercury (Hg^{2+})		-	2.62E+02	2.55E+03	2.38E+02	NR	2.62E+02	2.55E+03	2.38E+02	NR	2.62E+02	2.55E+03	2.38E+02	NR
Methyl Mercury (Hg^{4+})		2.00E+01	1.80E+01	1.59E+01	8.43E+00	7.33E+01	1.80E+01	1.59E+01	1.13E+01	1.42E+02	1.80E+01	6.53E+01	1.41E+01	3.04E+02
Nickel	(d)	-	7.86E+02	1.27E+02	-	NR	7.86E+02	1.27E+02	-	NR	7.86E+02	1.27E+02	-	NR
Selenium	(c)	-	5.95E+02	-	-	NR	5.95E+02	-	-	NR	5.95E+02	-	-	NR
Zinc	(c)	-	4.05E+04	2.55E+07	-	NR	4.05E+04	2.55E+07	-	NR	4.05E+04	2.55E+07	-	NR
Cyanide		-	7.69E+02	1.15E+02	1.06E+02	NR	7.69E+02	1.15E+02	1.06E+02	NR	7.69E+02	1.15E+02	1.06E+02	NR
Volatile Organic Compounds														
Benzene		7.00E+00	2.58E+01	2.69E-01	2.66E-01	1.22E+03	2.58E+01	4.99E-01	4.90E-01	2.26E+03	2.58E+01	1.04E+00	9.98E-01	4.71E+03
Toluene		1.90E+03	1.98E+04	6.26E+02	6.07E+02	8.69E+02	1.98E+04	1.38E+03	1.29E+03	1.92E+03	1.98E+04	3.14E+03	2.71E+03	4.36E+03
Ethylbenzene		2.60E+02	8.88E+03	1.70E+02	1.67E+02	5.18E+02	8.88E+03	3.98E+02	3.81E+02	1.22E+03	8.88E+03	9.32E+02	8.43E+02	2.84E+03
Xylene - m		8.40E+01	1.60E+04	5.56E+01	5.54E+01	6.25E+02	1.60E+04	1.31E+02	1.30E+02	1.47E+03	1.60E+04	3.07E+02	3.02E+02	3.46E+03
Xylene - o		1.00E+02	1.60E+04	5.98E+01	5.95E+01	4.78E+02	1.60E+04	1.40E+02	1.39E+02	1.12E+03	1.60E+04	3.27E+02	3.21E+02	2.62E+03
Xylene - p		8.70E+01	1.60E+04	5.34E+01	5.33E+01	5.76E+02	1.60E+04	1.26E+02	1.25E+02	1.35E+03	1.60E+04	2.94E+02	2.88E+02	3.17E+03
Total xylene		8.40E+01	1.60E+04	5.56E+01	5.54E+01	6.25E+02	1.60E+04	1.31E+02	1.30E+02	1.47E+03	1.60E+04	3.07E+02	3.02E+02	3.46E+03
Methyl tertiary butyl ether (MTBE)		2.20E+03	4.45E+02	1.84E+02	1.61E+02	1.66E+04	4.45E+02	2.40E+02	2.00E+02	2.16E+04	4.45E+02	3.70E+02	2.68E+02	3.34E+04
Trichloroethene		1.80E+00	4.63E+02	1.10E-01	1.10E-01	1.54E+03	4.63E+02	2.30E-01	2.30E-01	3.22E+03	4.63E+02	5.11E-01	5.11E-01	7.14E+03
Tetrachloroethene		3.60E+00	1.20E+03	1.03E+00	1.03E+00	4.24E+02	1.20E+03	2.30E+00	2.30E+00	9.51E+02	1.20E+03	5.28E+00	5.26E+00	2.18E+03
1,1,1-Trichloroethane		2.60E+01	5.34E+04	6.33E+00	6.33E+00	1.43E+03	5.34E+04	1.29E+01	1.29E+01	2.92E+03	5.34E+04	2.84E+01	2.84E+01	6.39E+03
1,1,1,2-Tetrachloroethane		1.40E+01	5.07E+02	1.08E+00	1.08E+00	2.60E+03	5.07E+02	2.50E+00	2.49E+00	6.02E+03	5.07E+02	5.83E+00	5.76E+00	1.40E+04
1,1,2,2-Tetrachloroethane		1.40E+01	5.07E+02	2.76E+00	2.74E+00	2.67E+03	5.07E+02	5.65E+00	5.58E+00	5.46E+03	5.07E+02	1.24E+01	1.21E+01	1.20E+04
Carbon tetrachloride		5.50E-02	1.25E+02	1.81E-02	1.81E-02	1.52E+03	1.25E+02	3.97E-02	3.96E-02	3.32E+03	1.25E+02	8.99E-02	8.99E-02	7.54E+03
1,2-Dichloroethane		3.00E-01	1.07E+01	6.46E-03	6.46E-03	3.41E+03	1.07E+01	9.32E-03	9.31E-03	4.91E+03	1.07E+01	1.60E-02	1.60E-02	8.43E+03
Vinyl chloride		1.90E-02	1.25E+00	5.43E-04	5.43E-04	1.36E+03	1.25E+00	7.02E-04	7.02E-04	1.76E+03	1.25E+00	1.07E-03	1.07E-03	2.69E+03
1,2,4-Trimethylbenzene		7.50E-02	-	4.08E-01	-	5.57E+02	-	9.91E-01	-	1.36E+03	-	2.33E+00	-	3.25E+03
1,3,5-Trimethylbenzene		4.70E-02	1.28E+03	4.60E-01	4.60E-01	9.47E+01	1.28E+03	1.10E+00	1.10E+00	2.26E+02	1.28E+03	2.59E+00	2.58E+00	5.33E+02
Semi-Volatile Organic Compounds														
Acenaphthene		3.20E+00	4.85E+03	3.46E+03	2.02E+03	5.70E+01	4.85E+03	8.54E+03	3.09E+03	1.41E+02	4.85E+03	2.30E+04	3.91E+03	3.36E+02
Acenaphthylene		4.20E+00	4.85E+03	3.27E+03	1.95E+03	8.61E+01	4.85E+03	8.03E+03	3.02E+03	2.12E+02	4.85E+03	1.91E+04	3.87E+03	5.06E+02
Anthracene		2.10E-02	2.43E+04	1.08E+05	1.98E+04	1.17E+00	2.43E+04	2.65E+05	2.22E+04	2.91E+00	2.43E+04	6.15E+05	2.33E+04	6.96E+00
Benzo(a)anthracene		3.80E-03	1.12E+01	5.55E+00	3.71E+00	1.71E+00	1.12E+01	9.83E+00	5.23E+00	4.28E+00	1.12E+01	1.41E+01	6.22E+00	1.03E+01
Benzo(b)fluoranthene		2.00E-03	1.15E+00	1.79E+01	6.99E+00	1.22E+00	1.15E+01	1.97E+01	7.25E+00	3.04E+00	1.15E+01	2.05E+01	7.36E+00	7.29E+00
Benzo(g,h,i)perylene		2.60E-04	7.35E+01	1.27E+02	4.66E+01	1.54E-02	7.35E+01	1.32E+02	4.72E+01	3.85E-02	7.35E+01	1.34E+02	4.75E+01	9.23E-02
Benzo(k)fluoranthene		8.00E-04	1.62E+01	2.66E+01	1.01E+01	6.87E-01	1.62E+01	2.83E+01	1.03E+01	1.72E+00	1.62E+01	2.91E+01	1.04E+01	4.12E+00
Chrysene		2.00E-03	1.62E+01	1.95E+01	8.84E+00	4.40E-01	1.62E+01	2.45E+01	9.74E+00	1.10E+00	1.62E+01	2.72E+01	1.01E+01	2.64E+00
Dibenzo(a,h)anthracene		6.00E-04	1.46E+00	2.13E+00	8.65E-01	3.93E-03	1.46E+00	2.42E+00	9.09E-01	9.82E-03	1.46E+00	2.56E+00	9.28E-01	2.36E-02
Fluoranthene		2.30E-01	1.01E+03	2.69E+04	9.72E+02	1.89E+01	1.01E+03	6.23E+04	9.93E+02	4.73E+01	1.01E+03	1.28E+05	1.00E+03	1.13E+02
Fluorene		1.90E+00	3.23E+03	4.35E+03	1.85E+03	3.09E+01	3.23E+03	1.07E+04	2.48E+03	7.65E+01	3.23E+03	2.54E+04	2.87E+03	1.83E+02
Indeno(1,2,3-cd)pyrene		2.00E-04	6.95E+00	1.04E+01	4.17E+00	6.13E-02	6.95E+00	1.17E+01	4.35E+00	1.53E-01	6.95E+00	1.22E+01	4.43E+00	3.68E-01
Phenanthrene		5.30E-01	1.00E+03	5.04E+03	8.37E+02	3.60E+01	1.00E+03	1.23E+04	9.28E+02	8.96E+01	1.00E+03	2.86E+04	9.70E+02	2.14E+02
Pyrene		1.30E-01	2.42E+03	6.18E+04	2.33E+03	2.20E+00	2.42E+03	1.44E+05	2.38E+03	5.49E+00	2.42E+03	2.97E+05	2.40E+03	1.32E+01
Benzo(a)pyrene		3.80E-03	1.62E+00	2.62E+00	1.00E+00	9.11E-01	1.62E+00	2.81E+00	1.03E+00	2.28E+00	1.62E+00	2.90E+00	1.04E+00	5.46E+00
Naphthalene		1.90E+01	1.58E+03	1.64E+00	1.64E+00	7.64E+01	1.58E+03	3.93E+00	3.92E+00	1.83E+02	1.58E+03	9.27E+00	9.22E+00	4.32E+02
Phenol		-	9.17E+04	3.11E+02	3.10E+02	4.16E+04	9.17E+04	4.20E+02	4.18E+02	8.15E+04	9.17E+04	5.21E+02	5.19E+02	1.74E+05

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH COMMUNAL SOFT LANDSCAPING

Table 5

Human Health Generic Assessment Criteria by Pathway for Residential Scenario With Communal Soft Lanscaping

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		1.00E+01	2.23E+05	2.98E+01	2.98E+01	3.04E+02	2.23E+05	5.47E+01	5.47E+01	5.58E+02	2.23E+05	1.13E+02	1.13E+02	1.15E+03
Aliphatic hydrocarbons >EC_6-EC_8		5.40E+00	2.23E+05	7.27E+01	7.27E+01	1.44E+02	2.23E+05	1.62E+02	1.62E+02	3.22E+02	2.23E+05	3.72E+02	3.71E+02	7.36E+02
Aliphatic hydrocarbons >EC_8-EC_{10}		2.30E-01	4.45E+03	1.89E+01	1.88E+01	7.77E+01	4.45E+03	4.60E+01	4.59E+01	1.90E+02	4.45E+03	1.09E+02	1.09E+02	4.51E+02
Aliphatic hydrocarbons >EC_{10}-EC_{12}		3.00E-02	4.45E+03	9.34E+01	9.29E+01	4.75E+01	4.45E+03	2.32E+02	2.29E+02	1.18E+02	4.45E+03	5.57E+02	5.38E+02	2.83E+02
Aliphatic hydrocarbons >EC_{12}-EC_{16}		8.00E-04	4.45E+03	7.82E+02	7.45E+02	2.37E+01	4.45E+03	1.95E+03	1.69E+03	5.91E+01	4.45E+03	4.68E+03	3.04E+03	1.42E+02
Aliphatic hydrocarbons >EC_{16}-EC_{35}	(c)	-	4.53E+04	-	-	8.48E+00	6.41E+04	-	-	2.12E+01	7.66E+04	-	-	5.09E+01
Aliphatic hydrocarbons >EC_{35}-EC_{44}	(c)	-	4.53E+04	-	-	8.48E+00	6.41E+04	-	-	2.12E+01	7.66E+04	-	-	5.09E+01
Aromatic hydrocarbons >EC_5-EC_7		-	1.98E+04	2.66E+02	2.63E+02	1.22E+03	1.98E+04	4.95E+02	4.83E+02	2.26E+03	1.98E+04	1.03E+03	9.78E+02	4.71E+03
Aromatic hydrocarbons >EC_7-EC_8		-	1.98E+04	6.26E+02	6.07E+02	8.69E+02	1.98E+04	1.38E+03	1.29E+03	1.92E+03	1.98E+04	3.14E+03	2.71E+03	4.36E+03
Aromatic hydrocarbons >EC_8-EC_9 (styrene)		7.40E+00	5.34E+03	2.65E+02	2.61E+02	6.20E+02	5.34E+03	6.47E+02	6.27E+02	1.52E+03	5.34E+03	1.54E+03	1.41E+03	3.61E+03
Aromatic hydrocarbons >EC_9-EC_{10}		7.40E+00	1.78E+03	3.33E+01	3.32E+01	6.13E+02	1.78E+03	8.16E+01	8.07E+01	1.50E+03	1.78E+03	1.94E+02	1.89E+02	3.58E+03
Aromatic hydrocarbons >EC_{10}-EC_{12}		2.50E+01	1.78E+03	1.82E+02	1.77E+02	3.64E+02	1.78E+03	4.48E+02	4.17E+02	8.99E+02	1.78E+03	1.07E+03	8.66E+02	2.15E+03
Aromatic hydrocarbons >EC_{12}-EC_{16}		5.80E+00	1.78E+03	2.00E+03	1.25E+03	1.69E+02	1.78E+03	4.96E+03	1.59E+03	4.19E+02	1.78E+03	1.18E+04	1.71E+03	1.00E+03
Aromatic hydrocarbons >EC_{16}-EC_{21}	(c)	-	1.29E+03	-	-	5.37E+01	1.31E+03	-	-	1.34E+02	1.32E+03	-	-	3.21E+02
Aromatic hydrocarbons >EC_{21}-EC_{35}	(c)	-	1.33E+03	-	-	4.83E+00	1.33E+03	-	-	1.21E+01	1.33E+03	-	-	2.90E+01
Aromatic hydrocarbons >EC_{35}-EC_{44}	(c)	-	1.33E+03	-	-	4.83E+00	1.33E+03	-	-	1.21E+01	1.33E+03	-	-	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.

(red hatched)	Calculated SAC exceeds soil saturation limit and may significantly effect the interpretation of any exceedances since 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.
(yellow)	Calculated SAC exceeds soil saturation limit but will not effect the SAC significantly since the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.
(green)	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.

The SAC for organic compounds are dependant 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) Sensitivity analysis undertaken on SEGH equation and CLEA model, considered reasonable in absence of UK specific data

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

(c) SAC for selenium, aliphatic and aromatic hydrocarbons >EC16 do 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 are based on the inhalation pathway only owing to an absence of toxicity for elemental mercury, in accordance with the SGV report for nickel and LQM report for chromium VI.

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH COMMUNAL SOFT LANDSCAPING

Table 6

Human health generic assessment criteria for residential with communal soft landscaping

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	-	35	35	35
Cadmium	-	85	85	85
Chromium (III) - oxide	-	3,000	3,000	3,000
Chromium (VI) - hexavalent	-	4.3	4.3	4.3
Copper	-	6,200	6,200	6,200
Lead	-	300	300	300
Elemental Mercury (Hg0)	0.0094	0.17	0.42	1.0
Inorganic Mercury (Hg2+)	-	240	240	240
Methyl Mercury (Hg4+)	20	8.4	11	14
Nickel	-	130	130	130
Selenium	-	600	600	600
Zinc	-	41,000	41,000	41,000
Cyanide	-	110	110	110
Volatile organic compounds				
Benzene	7	0.27	0.49	1.0
Toluene	1,900	610	1,289	2,700
Ethylbenzene	260	170	381	840
Xylene - m	84	55	130	300
Xylene - o	100	60	139	320
Xylene - p	87	53	125	290
Total xylene	84	55	130	300
Methyl tertiary butyl ether (MTBE)	2,200	160	199.55	270
Trichloroethene	1.8	0.11	0.2	0.51
Tetrachloroethene	3.6	1.0	2.3	5.3
1,1,1-Trichloroethane	26	6.3	12.9	28
1,1,1,2-Tetrachloroethane	14	1.1	2.5	5.8
1,1,2,2-Tetrachloroethane	14	2.7	5.58	12
Carbon tetrachloride	0.055	0.02	0.040	0.09
1,2-Dichloroethane	0.30	0.006	0.0093	0.02
Vinyl chloride	0.019	0.0005	0.0007	0.001
1,2,4-Trimethylbenzene	0.075	0.4	0.99	2.3
1,3,5-Trimethylbenzene	0.047	0.5	1.10	2.6
Semi-volatile organic compounds				
Acenaphthene	3.2	2,000 (57)	3,100 (141)	3,900 (340)
Acenaphthylene	4.2	2,000 (86)	3,000 (212)	3,900 (510)
Anthracene	0.021	20,000 (1.2)	22,000	23,000
Benzo(a)anthracene	0.004	3.7	5.2	6.2
Benzo(b)fluoranthene	0.002	7.0	7.3	7.4
Benzo(g,h,i)perylene	0.0003	47	47	48
Benzo(k)fluoranthene	0.0008	10	10	10
Chrysene	0.002	8.8	9.7	10
Dibenzo(a,h)anthracene	0.0006	0.87	0.91	0.93
Fluoranthene	0.23	970	993	1,000
Fluorene	1.9	1,900 (31)	2,500 (77)	2,900 (180)
Indeno(1,2,3-cd)pyrene	0.0002	4.2	4.4	4.4
Phenanthrene	0.53	840 (36)	930	970
Pyrene	0.13	2,300	2,400	2,400
Benzo(a)pyrene	0.004	1.0	1.0	1.0
Naphthalene	19	1.6	3.9	9.2
Phenol	-	310	420	520
Total petroleum hydrocarbons				
Aliphatic hydrocarbons EC_5–EC_6	10	30	55	110
Aliphatic hydrocarbons >EC_6–EC_8	5.4	73	160	370
Aliphatic hydrocarbons >EC_8–EC_{10}	0.23	19	46	110
Aliphatic hydrocarbons >EC_{10}–EC_{12}	0.03	93 (48)	230 (118)	540 (280)
Aliphatic hydrocarbons >EC_{12}–EC_{16}	0.0008	746 (24)	1,700 (59)	3,000 (140)
Aliphatic hydrocarbons >EC_{16}–EC_{35}	-	45,000	64,000 (21)	77,000
Aliphatic hydrocarbons >EC_{35}–EC_{44}	-	45,000	64,000 (21)	77,000
Aromatic hydrocarbons >EC_8–EC_9 (styrene)	7.4	260	627	1,400
Aromatic hydrocarbons >EC_9–EC_{10}	7.4	33	81	190
Aromatic hydrocarbons >EC_{10}–EC_{12}	25	180	417	870
Aromatic hydrocarbons >EC_{12}–EC_{16}	5.8	1,300 (170)	1,600 (419)	1,700
Aromatic hydrocarbons >EC_{16}–EC_{21}	-	1,300	1,300	1,300
Aromatic hydrocarbons >EC_{21}–EC_{35}	-	1,300	1,300	1,300
Aromatic hydrocarbons >EC_{35}–EC_{44}	-	1,300	1,300	1,300

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.

[Shaded cell key:] The SAC has been set as the model calculated SAC with the saturation limit shown in brackets.
For consistency where the GrAC exceeds the solubility limit, GrSV 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.

APPENDIX C
SITE INVESTIGATION REPORTS (ON CD)