



Cala Homes (South Home Counties) Limited

West End Nursery, Roundstone Lane, Angmering BN16 4AX

Remedial Strategy

Project no. 27621-R03 (00)

SEPTEMBER 2015

RSK

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1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Cala Homes (South Home Counties) Limited to prepare a Remedial Strategy for West End Nursery, Roundstone Lane, Angmering, BN16 4AX hereafter referred to as 'the site'.

The site is currently occupied by two commercial greenhouses, associated warehouse, offices, car parking, infrastructure and a boiler house.

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

1.1 Contaminated Land Process

It is understood that the site is being considered for redevelopment with 244 residential plots comprising a mixture of housing and flats, with private and communal gardens and some areas of communal soft landscaping.

The project was commissioned in order to allow safe redevelopment 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 Remedial 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 Remedial Strategy combines the first two phases, including a summary of the finding of the risk assessment. The remedial 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.

1.2 Objective

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

1.3 Scope

The scope of the investigation and layout of this report has been designed with consideration of CLR11 (Environment Agency, 2014) BS 10175: 2011 (BSI, 2013) and guidance on land contamination reports issued by the Environment Agency (EA) (2010a). A summary of the contaminated land legislation and policy is given in Appendix B.

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 verification works including reporting.

1.4 Existing reports

RSK has produced the following reports pertaining to the site:

- RSK Environment Limited, Geo-environmental site assessment, Ref: 27621-R01 (01), February 2015; and
- RSK Environment Limited, Additional geo-environmental site assessment, Ref: 27621-R02 (00), June 2015.

This report should be read in conjunction with the previous reports, however the pertinent environmental information from the previous phase of works has been summarised in Section 3.

1.5 Definitions

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

Client	Cala Homes (South Home Counties)
Groundworks Contractor	TBC
Demolition Contractor	TBC
Local Authority	Arun District Council
Pollution Control and Waste Regulatory Authority	Environment Agency
Environmental Consultant	RSK Environment Ltd
Principal Designer	OSP Architecture

1.6 Limitations

The Remedial Strategy 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. 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 may vary from those reported due to seasonal, or other, effects.

The Remediation Strategy 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 of West End Nursery is located at National Grid reference 507640, 103520 as shown on Figure 1. The current site layout is presented on Figure 2.

The site setting comprises a mix of residential, commercial and agricultural land as detailed in Table 1.

Table 1: Site setting

To the north:	Worthing Rugby Football Club is present. It is understood redevelopment is being considered for this area.
To the east:	Immediately adjacent to the site boundary is a footpath and drainage channel with the A280 and agricultural land beyond.
To the south:	Haskins Garden Centre (formerly Roundstone Nursery and Garden Centre) is present, in addition residential properties are located immediately to the southwest of the site and beyond the garden centre.
To the west:	Mix of residential and commercial properties located beyond Roundabout Lane.

The site covers approximately 11Ha at an elevation of approximately 11m above Ordnance Datum (AOD) although, along some boundaries, there are bunds which rise up above general site levels by approximately 0.75 to 2.25m.

2.2 Proposed development

The proposed layout of the site is shown on Figure 3.

3 SUMMARY OF EXISTING REPORTS

Pertinent information from RSK's geo-environmental site assessment and additional geo-environmental site assessment reports for West End Nursery (Report Refs: 27621-R01 (01) and 27621-R02 (00) dated February 2015 and June 2015) is contained in the following sections:

3.1 Findings of the RSK site investigations

The exploratory holes revealed that the site is underlain by made ground proven from 0.1m to 3m thick in 25 of the 28 locations advanced during the initial investigation underlain by River Terrace Deposits. Chalk of the Lewes Nodular Chalk Formation was encountered in one location only but is anticipated to underlie the River Terrace Deposits.

For the purpose of discussion, the ground conditions are summarised in **Table 2** and the strata discussed in subsequent subsections.

Table 2: General succession of strata

Strata	Exploratory holes encountered	Depth to top of stratum m bgl	Thickness (m)
Top soil	TP6, TP7, TP8	Ground level	0.0m to 0.4m bgl
Made Ground	33 of 43 locations	Ground level	0.0m to 3.0m*
River Terrace Deposits	28 of 43 locations	Ground level to 3.0m	>0.2 (TP4) to >3.3m bgl (BH12)
Lewes Nodular Chalk Formation	BH8 only	2.6	>0.4
Notes: *Location terminated in made ground: HA4, HA6, HA7, HA10, HA12, HA13, HA17, HA18, HA18A, TP3 and TP5 to TP9			

3.1.1 Topsoil

Top soil was encountered in 3 trial pits TP6 (to 0.4m bgl), TP7 (to 0.1m bgl) and TP8 (to 0.1m bgl) located in the south of the north-west bund, south-west bund A and south of the south-west bund respectively.

3.1.2 Made ground

Made ground was encountered within all the trial pit locations excavated within the bunds across the site. The materials encountered predominantly comprised of friable brown to dark brown blackish greyish sandy silty gravelly clay with frequent suspected

cement bonded asbestos containing materials (ACM), plastic sacking, metal, bricks, glass, plastic, charcoal, wood, and concrete. Some reworked clay was also identified.

In addition, made ground was encountered within all the machine drilled borehole locations and within 11 out of the 19 hand augured boreholes located within the greenhouses. The materials encountered in boreholes BH1-BH15 generally comprised clayey sandy gravels compacted limestone gravel overlying sandy gravelly clay, with brick, wood, charcoal, plastics, metal wire, clinker, ash and suspected ACM (in boreholes in BH1 to BH5, BH10 and BH12 to BH15). The made ground materials encountered in the hand auger locations generally comprised gravelly clay with varying quantities of sand and silt and occasional concrete, mortar, glass, polystyrene, and charcoal fragments present.

3.1.3 River Terrace Deposits

This stratum was encountered beneath the made ground or directly from the ground surface as detailed in Table 2. The River Terrace Deposits generally comprised silty clays and sandy gravelly clays with occasional fine to coarse gravel layers. The thickness of the River Terrace Deposits was only proven in BH8 at 2.5m thick.

3.1.4 Lewes Nodular Chalk Formation

Beneath the River Terrace Deposits, the Lewes Nodular Chalk was encountered in BH8 from a depth of 2.6m bgl to the full depth of boring of 3mbgl. The stratum comprised off white cream very gravelly clayey comminuted chalk (weathered chalk).

3.1.5 Groundwater

Groundwater was not encountered during the intrusive investigation works or the first gas monitoring visit (with exception to BH5), however, during the subsequent second and third gas monitoring visits, groundwater was encountered at depths ranging between 1.79m (BH5 24/02/14) and 3.4m bgl (BH1 24/02/15) in boreholes BH1, BH5, BH11 and BH14A. It is noted that a large difference was observed in the groundwater level within BH1 between the second and third visit at 1.4m. It should also be noted that groundwater levels might fluctuate for a number of reasons including seasonal and tidal variations.

Based on the thickness of the water columns encountered within the monitoring wells during the three gas monitoring visits, it was considered that insufficient quantities of groundwater were present in order that representative samples could be collected. Therefore, no groundwater samples have been collected from the site to date. Based on review of the above estimated groundwater elevations groundwater flow beneath the site is inferred in a southerly direction.

3.1.6 Ground gas

Three gas monitoring visits were carried out at the site on 30 January 2015, 13 February 2015 and 24 February 2015. The results of the three ground gas monitoring visits carried out are summarised below:

- Methane – maximum concentration of 0.1%v/v;
- Carbon dioxide – Maximum concentration 13.4%v/v; and
- Flow – Maximum positive steady rate 0.1l/hr.

Based on the above concentrations, GSV's may be calculated as follows:

- $GSV_{\text{METHANE}} = (0.1 / 100) * 0.1 = 0.0001 \text{ l/hr; and}$
- $GSV_{\text{CARBON DIOXIDE}} = (13.4 / 100) * 0.1 = 0.0134 \text{ l/hr.}$

Monitoring results from the three visits conducted at the site to date would characterise the site as being Characteristic Situation 'Amber 1' for traditional low-rise houses, based on the concentrations of carbon dioxide consistently in excess of 5%v/v in BH1. On this basis, low level ground gas protection measures would be considered necessary at the site. Low-level gas protection measures would involve an appropriate membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into the buildings.

It is considered that the ground gas data collected is reasonably representative of likely worse case conditions at the site, given the low pressure recorded during monitoring visit 1 of 982mbars.

3.1.7 Visual/olfactory evidence of soil and groundwater contamination

Suspected cement bonded ACM were encountered in all the investigation locations undertaken during the additional site investigation works (undertaken on the bund materials except for TP7) and within BH1, BH4, BH12 and BH15 during the initial phase of works. Across both phases of intrusive works made ground was encountered in all except two exploratory hole locations. Charcoal and ash fragments were encountered in 16 of the initial exploratory investigation locations however was only detected in TP6 during the additional intrusive works. No other visual/olfactory evidence for gross soil or groundwater contamination was encountered during either phase of intrusive works.

3.1.8 Identified pollutant linkages

The results of the initial GQRA, report reference 27621-R01, February 2015, indicated that a risk exists for human health via direct contact pathways from measured concentrations of pesticides in soil due to an exceedance of p,p-DDE in one of the four samples analysed and the presence o,p-DDT for which no readily available screening value is available. Furthermore, comparison of chemical laboratory test results to RSK GACs has demonstrated that a potential pollutant linkage exists in relation to measured

concentrations of zinc in soil associated with phytotoxic effects and to standard plastic water supply pipes in relation to measured concentrations of hydrocarbons in soil.

In addition to the above, additional GQRA, report reference 27621-R02, June 2015, indicated that measured concentrations of hydrocarbons and metals within the bund materials pose a risk to human health from direct contact pathways. Furthermore, in addition, zinc, copper and nickel were identified within the bund material at concentrations that may result in phytotoxic effects.

Previously, report 27621-R01, February 2015, identified asbestos containing materials of cement and loose insulation in six of the 27 soil samples submitted for chemical analysis and comprised chrysotile and amosite. In addition the five samples of suspected asbestos containing materials were all confirmed to be asbestos cement comprising chrysotile. The detections of asbestos were identified as posing potentially unacceptable risk to the health of construction workers and future residents via inhalation and dermal contact pathways.

The results of the additional testing in the bunds reaffirm this conclusion, with asbestos detected in 15 out of 22 soil samples analysed and ACM confirmed in seven out of nine suspected samples submitted. Quantified asbestos analysis conducted reported results between <0.001% and 7.214%.

Given the frequency of asbestos detected and magnitude of the quantified asbestos results within the bund materials, a remedial options appraisal was conducted for the bund materials as detailed in report reference 27621-R02, June 2015, to inform the client of the economic cost associated with the remedial options. Six options for remediation of the bund materials were identified which included:

1. Do nothing other than maintain existing grass vegetation
2. Off-site disposal to a hazardous waste facility
3. Segregation of visual asbestos from the soil, dispose of the visual asbestos to a hazardous waste facility and re-use remaining soil at the site
4. Re-use of material at depth
5. Provide a cover system to the existing bunds
6. Combination of the above

Based on the remedial options appraisal, RSK suggested that a combination approach was likely to be the most suitable.

3.1.9 Uncertainty

Although every effort has been made to identify all potential sources of contamination and investigate areas of potential risk, the nature of site investigations is such that there may be areas of undiscovered contamination which have not been encountered, particularly directly beneath the CHP building, nitric acid store, substations and ASTs. The uncertainty associated with the CHP building and the ASTs includes potential risks posed to the underlying aquifer which are yet to be quantified due to the limited presence of groundwater encountered during the monitoring visits to date.

Also, the risk associated with DDE,DDT, hydrocarbons and metals to the aquifer is presently unknown since water sampling has not taken place. Although, it is noted that based on the low magnitude of the measured concentrations of determinands encountered in soil to date and the low solubility of the pesticides detected above LOD, it is considered unlikely that these would result in significant impacts within the underlying aquifers.

In light of the uncertainty regarding potential risks posed to the underlying aquifer the drilling and installation of five deep light cable percussive (LCP) boreholes has been recommended at the site: In order that soil samples (including for leachate analysis) and groundwater samples can be collected to assess the groundwater quality beneath the site and determine whether groundwater remediation is required. These additional works are yet to be undertaken.

In light of the above, this report has been prepared assuming that the results of the additional monitoring works demonstrate that there is not a significant risk posed to the underlying groundwater, and that movement of the bund materials and placement at depth will not create a significant risk to the underlying groundwater. In the event that significant contamination is identified and/or the results indicate that the movement of the bund materials and placement at depth poses a potentially significant risk to the underlying groundwater: Any changes to the remedial requirements detailed within, will result in this report requiring revision, or production of an addendum.

In addition, with specific reference to asbestos, although every effort has been made to identify and delineate the presence of asbestos across the site, asbestos is often distributed discretely and as such there is the potential for asbestos fibres and ACM to be present in un-investigated areas of the site or different forms of ACM and asbestos type to be encountered.

4 REMEDIAL STRATEGY

4.1 Introduction

This Remedial Strategy has been designed to break or remove the potential pollutant linkages identified on site from preceding investigation works. These comprise inhibiting:

- future end-uses coming into contact with measured concentrations of pesticides and hydrocarbons in excess of human health screening values in soil;
- future end-users and buildings from the accumulation of ground gases;
- future end-users and surrounding users from the presence of asbestos fibres and ACM (in the bund materials) and ACM (cement and loose insulation) within made ground across other areas of the site;
- construction workers from asbestos fibres associated with the potential disturbance of the asbestos containing materials;
- healthy vegetation growth in relation to phytotoxic effects from measured concentrations of nickel, copper and zinc in soil; and,
- the permeation of future water supply pipes.

As noted in Section 3.1.9, the remedial strategy presently excludes mitigation measures that may be necessary to protect controlled waters. This requirement can only be confirmed post additional intrusive investigation.

4.2 Remedial objectives

The objective of the remediation is to produce a site that is suitable for its intended purposes (residential (housing and flats) end use with private gardens and communal soft landscaping) whilst providing a safe working environment with respect to site workers and adjacent users. This will involve the following measures:

- The placement of a 450mm clean cover layer within any private gardens and 300mm in proposed communal soft landscaped areas, locally deepened (to the requirements of the Landscape Architect) in the proximity of any proposed deep root-balled shrubs and/or trees. It is noted that tree pits could alternatively be constructed in raised planting beds (set upon areas of hardstanding) in order to break potential contamination pathways with respect to the underlying made ground;
- Following decommissioning and demolition of the CHP building, nitric acid store, substations and ASTs, it is recommended that, in the event that any visually impacted materials are observed, an Environmental Engineer be contacted so that appropriate sampling can be implemented to determine any additional remedial and validation requirements;
- Regrading of the bund materials (where required), in accordance with the development plan and to facilitate placement of sufficient thickness of 'clean' cover layer can be achieved across the bund materials. Followed by reuse of any excess materials resulting from the reggrading works in suitable areas, for example beneath

the 'clean' cover and hardstanding areas, with record keeping in accordance with the materials management plan (yet to be developed).

- Incorporation of gas protection measures within the proposed buildings: structural barrier comprising suspended or ground bearing floor slab with appropriate ventilation and a minimum thickness of gas resistant membrane of 2000 gauge, sealed at all joints and penetrations. Detailed design of the gas measures will be required once foundation solutions have been finalised and an implementation report prepared for gas alone against which future verification can be undertaken; and
- Compliance with CAR 2012, through the adoption of safe working procedures with respect to the potential presence of ACM.

4.3 Implementation plan

4.3.1 Introduction

The overall remediation strategy may be divided into the enabling and demolition 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 relating to the proposed demolition sequence and the subsequent construction works.

4.3.2 Enabling and demolition phase

4.3.2.1 Demolition and site clearance

Before commencing demolition works, an asbestos clearance survey should be undertaken to confirm the presence or absence of asbestos containing materials within all structures. Where asbestos containing materials are encountered removal works should be undertaken by an appropriately licensed contractor before commencing demolition works.

Copies of the relevant survey and clearance documents, including disposal records, should be made available for inclusion within the site verification report.

4.3.2.2 Removal of existing building floor slabs

In the event that the asbestos clearance survey identifies the presence of asbestos in the buildings at the site, following the demolition the associated ground slabs should be removed under the supervision of a suitably accredited asbestos surveyor given the increased likelihood of ACM lagging materials to be present along service ducts beneath the slab.

As a part of this process, licensed asbestos removal contractors may need to be in attendance to remove lagging materials identified within service ducts beneath the slab.

The removal of any licensed materials will need to be conducted following the submission of an ASB5 notification to the HSE, with an appropriate method statement having been prepared and approved in advance of the works commencing. The contractor's method statement will need to outline all appropriate control measures to be implemented including the requirement for air testing, damping down of all exposed soils and the provision for decontamination measures to demonstrate compliance with the Control of Asbestos Regulations 2012.

Copies of the relevant survey and clearance documents, including records of air monitoring and disposal records should be made available for inclusion within the site verification report (in the event that asbestos is identified in the clearance survey).

4.3.2.3 *Empty / make safe and removal of above ground storage tanks (ASTs) and substations*

Live services to these features will need to be isolated/disconnected before removal. In addition the contents of any ASTs and associated pipework should be purged of their liquid contents. The liquid shall be tankered off-site for appropriate disposal by a licensed waste disposal contractor.

The existing ASTs, substations and associated pipework, underlying concrete and brick, should be removed under the supervision of a suitably geo-environmental engineer and disposed off-site. Validation of the soils underlying these features, in relation to potential contamination, should be completed at the discretion of the geo-environmental engineer. Validation of the underlying soils is likely to include some or all of the following:

- logging of the underlying materials to BS5930 (2015);
- in-situ screening by a photo-ionisation device;
- and materials suspected to be contaminated based on visual/olfactory observations and/or in-situ screening should be stockpiled in areas of impermeable surfacing (hard-standing/on impermeable geo-membrane material. Soil sample(s) should be collected from the stockpiled material and submitted for laboratory analysis to verify its suitability for re-use on-site or off-site disposal.

Any remaining drains or service ducts associated with these features, which have the potential to provide a pathway for contaminant migration should be removed or sealed.

4.3.2.4 *Regrading/movement of the bund materials*

In order for the northern access road onto the site to be constructed (refer to Figures 2 and 3), a small section of the NW bund, total approximately 694m³, will need to be excavated. Furthermore, in order for a suitable capping layer to be placed on the bund materials, sections of the bunds will need to be regraded, including removal of the top 1m (approximately). Subject to proposed levels, the excavated materials can be re-used beneath the 'clean' cap in other agreed areas of the site.

The distribution of asbestos impacts identified across the site to date, are presented on Figure 4. The areas anticipated to require regrading are presented on Figure 5 and summarised below:

- NW bund – 1,031m³
- SW bund A – 570m³
- SW bund B – 94m³
- Southern section NE bund – 490m³
- Total regrading – 2,185m³

The total amount of soil required to be re-used at depth or disposed off-site following regrading and excavation works associated with the bund materials equates to approximately 2,879m³.

The central landscape area proposed in the centre of the site is considered to be the most appropriate location for the re-use of these soils at depth. The central landscaped area is approximately 1645m². Once natural ground is reached (assuming that natural soils in this area are suitable for use as capping material), materials down to approximately 2.0m are suggested to be excavated to provide sufficient capping material (sub-soil only) for use on the regarded bund materials, and to ensure that the entirety of the regraded and excavated bund materials can be reused within the central area and capped with 300mm of clean topsoil/subsoil. Given the concentration of asbestos locally, it is recommended that a geo-marker layer is placed between the re-used materials and the 'clean' topsoil/subsoil layer to provide a visual guide in the event that the capping layer is penetrated in future. Documentation containing the quality of the soil should also be retained in the CDM file for future management of soft landscaping areas.

Whilst underground services could be constructed through the central landscaped area, avoidance of service placement in this area would ease in order to avoid disturbance of the asbestos impacted materials once re-used. Furthermore, re-use of the materials will be subject to the proposed additional site investigation works being conducted (including leachate testing of soils and groundwater monitoring), to demonstrate that the hydrocarbon, DDE, DDT and metal compounds detected within the bund materials would not pose a significant risk to the underlying Secondary A and Principal aquifers.

The regrading, bund excavation and re-use at depth works outlined above will need to be undertaken following preparation and approval of an appropriate contractor method statement in advance of the works commencing. The contractor's method statement will need to outline all appropriate control measures to be implemented during the works including the requirement for air testing, damping down of all exposed soils and the provision for decontamination measures to demonstrate compliance with the Control of Asbestos Regulations 2012. Owing to the asbestos type and quantity, the works may well be licensable. This will be confirmed during development of the contractors method statement and as a result may require additional monitoring and procedures to be in place over and above those documented in this report.

4.3.2.5 *Capping of the bund materials*

The void created in the central communal landscaped area (created in order to provide potentially clean material suitable for use as the subsoil component of the clean capping

material and provide a suitable location for re-use of the excess regraded materials to aid landscaping and restoration of the remaining bund materials) is anticipated to result in approximately 2680m³ of natural soils. In order to achieve the required capping depth (300mm) across the bunds and central soft landscaped areas approximately 2050m³ of material will be required, half of which potential may be provided by the resultant natural soils. Certified clean topsoil would need to be imported for the top 150mm of the capping layer in these areas.

It is recommended that a geo-marker layer is placed between the materials re-used at depth/the bund materials remaining in-situ and the 'clean' topsoil/subsoil layer to provide a visual guide in the event that the capping layer is penetrated in future.

4.3.2.6 *Foundations (spread/ pile)*

During the construction of spread foundations or piles particularly in areas where asbestos has been found such as the southwest and southeastern parts of the site, consideration will need to be given to locations of individual foundations with respect to the presence of ACM. Where foundations are to be advanced in areas where ACM have previously been encountered, the contractor's method statement will need to adequately demonstrate compliance with CAR 2012, for example by damping down of soil during the disturbance and subsequent removal of the made ground.

In all areas, piling works should take place under a watching brief and be conducted by ground workers that have completed appropriate asbestos awareness training. In addition, owing to the asbestos type and quantity, the works may well be licensable. This will be confirmed during development of the contractors method statement and as a result may require additional monitoring and procedures to be in place over and above those documented in this report.

4.3.3 **Construction phase**

The principal objectives of the remedial strategy for the construction phase is to break pollutant linkages to future residents associated with elevated pesticides and hydrocarbons encountered within the shallow made ground as well as the identified ACM and asbestos fibres across the site and ACM within the bund materials.

In addition, the strategy aims to provide a suitable growing medium in areas of soft landscaping across the site.

4.3.3.1 *Placement of clean cover soils*

In order to break the identified pollutant linkages, within proposed areas of private gardens and communal soft landscaping the placement of a 450mm and 300mm clean cover horizon respectively, will be required, locally deepened (to the requirements of the Landscape Architect) in the proximity of any deep root-balled shrubs and/or trees proposed. This thickness may be reduced if natural soils are encountered at shallower depths. It is noted that tree pits could be constructed in raised planting beds (set upon

areas of hardstanding) in order to break potential contamination pathways with respect to the underlying made ground.

Construction of the clean cover horizon will generally require made ground deposits to be removed to 450mm and replaced with suitably 'clean' and certified soils finished with 150mm topsoil. The cover layer should also include a geo-membrane marker layer.

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

4.3.3.2 *Installation of gas protection membranes*

A detailed gas membrane installation design and implementation plan will need to be completed in accordance with the recent updates in UK guidance (BS8485). It is anticipated that a gas resistant membrane with a minimum gauge thickness of 2000 will need to be installed in accordance with the manufacturer's specifications beneath the entire footprint of the proposed buildings, including sealing of all joints and penetrations.

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; and
- b) Confirmation that the materials comprising the cover system are themselves not contaminated, i.e. suitable for residential (with gardens) end-use.

To verify 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, subsoil and presence of the marker layer.

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 50m³, with a minimum of 3 samples, for the following parameters:

- Arsenic, cadmium, chromium, copper, nickel, lead, mercury, selenium and zinc and pH;
- Speciated total petroleum hydrocarbons criteria working group (TPH CWG) (split into aliphatic and aromatic carbon bands with benzene, toluene, ethylbenzene and xylene (BTEX) compounds);
- Speciated 16 No. PAH; and
- Asbestos in soil with ID.

It is acceptable to test stockpiled topsoil/subsoil intended for use in 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 soil ingestion, dermal contact and inhalation, results of validation sampling will be compared directly with the validation criteria detailed in Table 3 and 4 below. The validation criteria are RSK derived GAC's suitable for a residential with plant uptake end-use for 6% soil organic matter (SOM) which 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 RSK GAC appendix which details the generation of the VAC's is presented as Appendix C. The proposed screening criteria are shown in the following table.

Table 3: Validation assessment criteria

Compound	Generic Assessment Criteria (GAC) 6% SOM (mg/kg)
Metals	
Arsenic	37
Cadmium	30
Chromium (III) - oxide	910
Chromium (VI)	21
Copper	2,500
Lead	200
Elemental Mercury (Hg0)	1.2
Inorganic Mercury (Hg2+)	39
Methyl Mercury (Hg4+)	10
Nickel	180
Selenium	258
Zinc	3,900
BTEX Compounds	
Benzene	0.87
Toluene	680
Ethylbenzene	260
Xylene - m	327

Compound	Generic Assessment Criteria (GAC) 6% SOM (mg/kg)
Xylene - o	332
Xylene - p	310
Total xylene	310
Semi-volatile organic compounds (Polycyclic Aromatic Hydrocarbons)	
Acenaphthene	1,170
Acenaphthylene	970
Anthracene	10,900
Benzo(a)anthracene	13
Benzo(b)fluoranthene	3.7
Benzo(g,h,i)perylene	350
Benzo(k)fluoranthene	100
Chrysene	27
Dibenzo(a,h)anthracene	0.30
Fluoranthene	900
Fluorene	880
Indeno(1,2,3-cd)pyrene	41
Phenanthrene	440
Pyrene	2,040
Benzo(a)pyrene	5
Naphthalene	71
Total Petroleum Hydrocarbons	
Aliphatic hydrocarbons EC ₅ –EC ₆	160
Aliphatic hydrocarbons >EC ₆ –EC ₈	530
Aliphatic hydrocarbons >EC ₈ –EC ₁₀	154
Aliphatic hydrocarbons >EC ₁₀ –EC ₁₂	7,50
Aliphatic hydrocarbons >EC ₁₂ –EC ₁₆	3,500
Aliphatic hydrocarbons >EC ₁₆ –EC ₃₅	79,000
Aromatic hydrocarbons >EC ₈ –EC ₉	56
Aromatic hydrocarbons >EC ₉ –EC ₁₀	189
Aromatic hydrocarbons >EC ₁₀ –EC ₁₂	367
Aromatic hydrocarbons >EC ₁₂ –EC ₁₆	600
Aromatic hydrocarbons >EC ₁₆ –EC ₂₁	800
Aromatic hydrocarbons >EC ₂₁ –EC ₃₅	1,200
Other	
Asbestos	Not observed in asbestos in soil with ID analysis

In addition, where deeper tree/shrub pits are dug, the following validation criteria protective of phytotoxic risks presented within **Table 4** should be used as a supplement to the GAC's outlined above.

Table 4: Phytotoxic generic 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
Lead	300	300	300	300
Cadmium	3	3	3	3
Mercury	1	1	1	1

Note: Only compounds with assessment criteria documented within the Directive 86/278/EEC have been included, although criteria for 5 additional compounds have been presented within the 2006 CoP.

4.3.6 Validation of gas protection membranes

As a minimum, validation certificates should be provided for the gas membrane installation along with supporting photographs, demonstrating that the membranes cover the entire building footprint and that all joints and penetrations have been suitably sealed in accordance with the manufacturer's guidelines. Additionally, validation such as 3rd party inspections may be required depending on the outcome of the detailed gas mitigation measures design and implementation plan.

4.3.7 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 Geo-environmental 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.

4.3.8 Management of unforeseen contamination

Whilst the investigations undertaken to date have been thorough, the nature of site investigations is such that there may be areas of undiscovered contamination which have not been encountered, particularly directly beneath the CHP building, nitric acid store, substations and ASTs. The uncertainty associated with the CHP building and the ASTs includes potential risks posed to the underlying aquifer which are yet to be quantified due to the limited presence of groundwater encountered during the monitoring visits to date. In order to reduce the likelihood of undiscovered contamination, as already mentioned in section 3.1.9 further investigation works are planned.

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 dampened down and covered over with plastic sheeting and advice be sought from a suitably accredited asbestos surveyor or similar.

4.3.9 Regulatory approval

This report will need to be forwarded to the Local Authority and Environment Agency before commencement of enabling and demolition works.

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, Principal Designer and, if appropriate, with the Environmental Health Officer. Also, notification to the HSE in line with the Control of Asbestos Regulations 2012 may be required.

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 with a P3 filter, footwear, eye protection and gloves. These should not be removed from site, and advice should be given on when and how they are to be used.

Care should be taken to minimise the amount of dust and mud generated on-site.

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.

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".

In the event that additional measures are required with respect to the presence of ACM, these should be documented within the licenced and Principal contractors' working method statements and approved before the works being undertaken.

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, including asbestos boundary and personnel monitoring, to be implemented during the bund regrading exercise.

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 tankered off-site 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, these 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; or
- Be disposed of to the foul sewer 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.

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 the remedial strategy 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; gas membrane installation certificates and supporting 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.

In the event that the additional site investigation works planned result in further remediation requirements and validation works to ensure safe development, the contents of the verification report may vary to that listed above.

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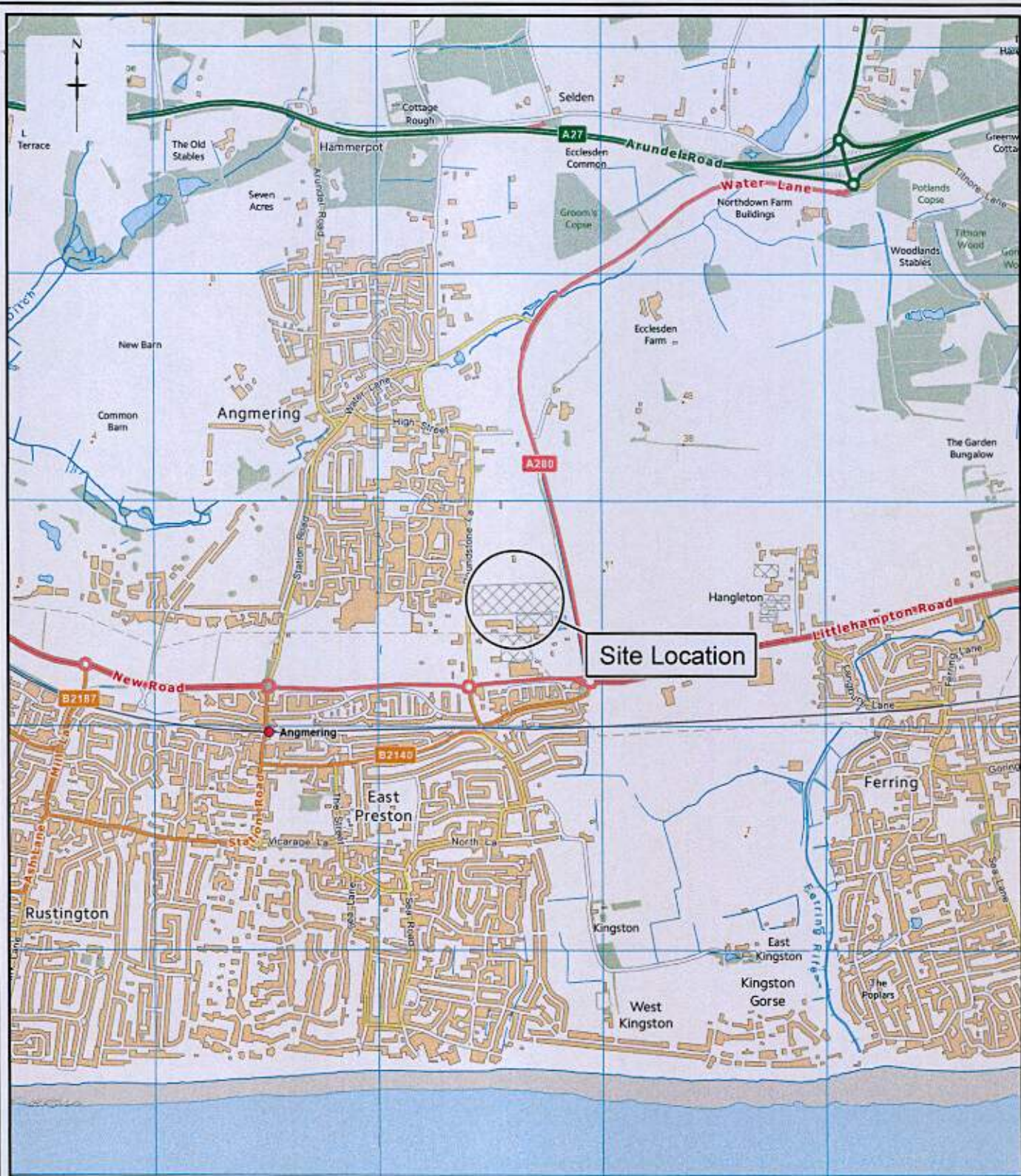
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FIGURES



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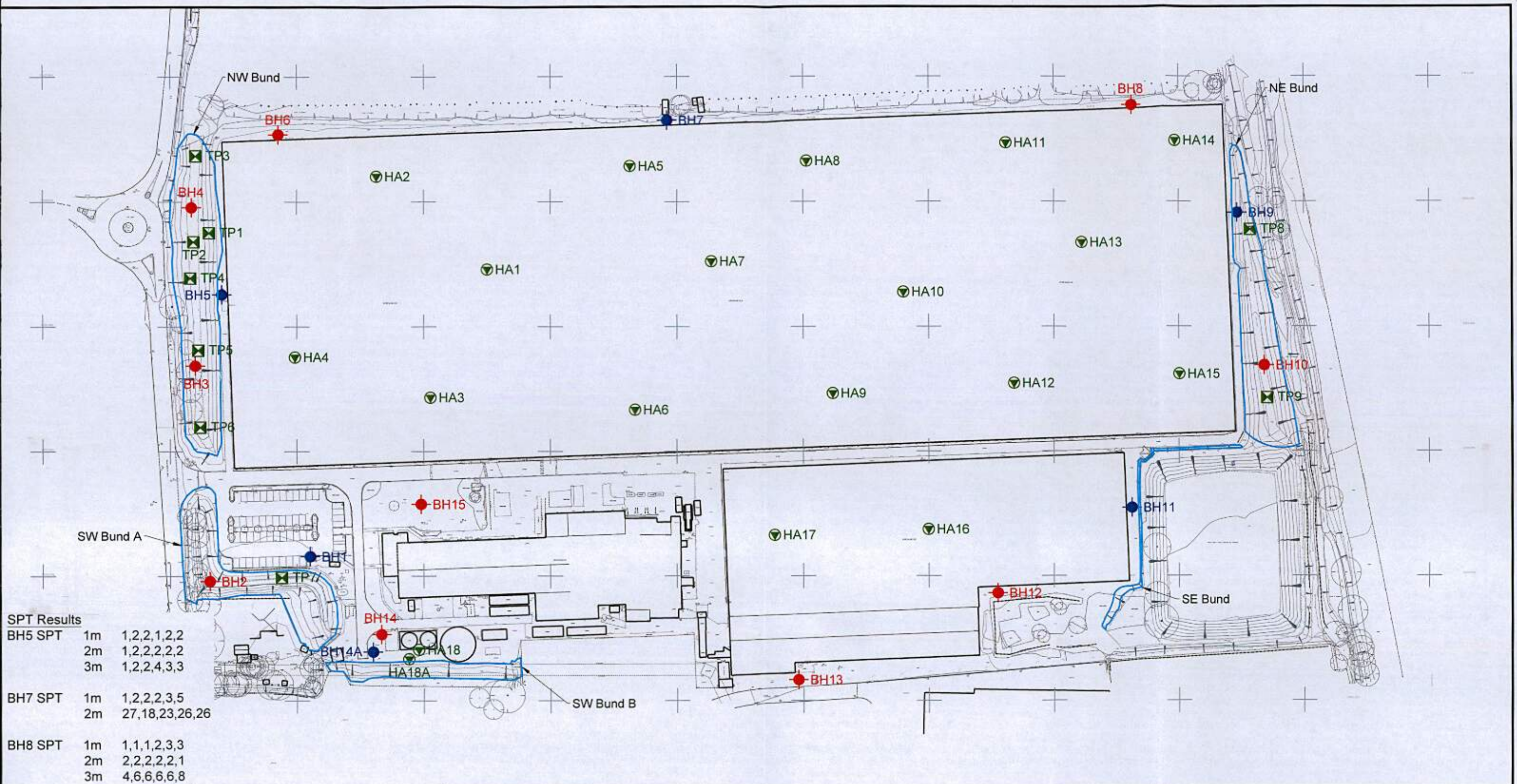
Client
CALA HOMES (SOUTH HOME COUNTIES) LTD

Project Title
WEST END NURSERY,
ANGMERING

Drawing Title
SITE LOCATION MAP

Rev	Drawn	Date	Checked	Date	Approved	Date
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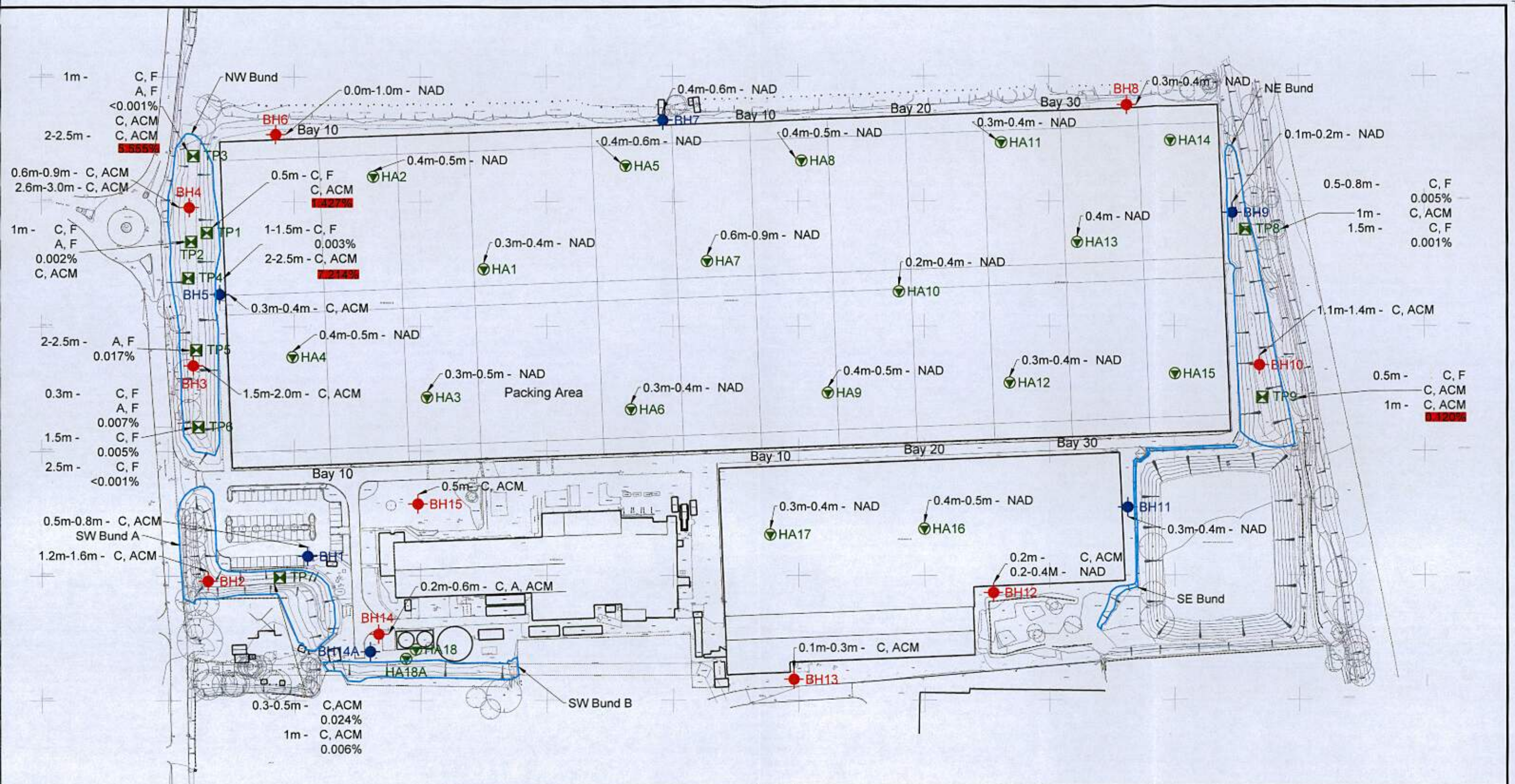
Project Number	Drawing File	Drawing Number
27621-03 (00)	27621 - SLP.dwg	FIGURE 1



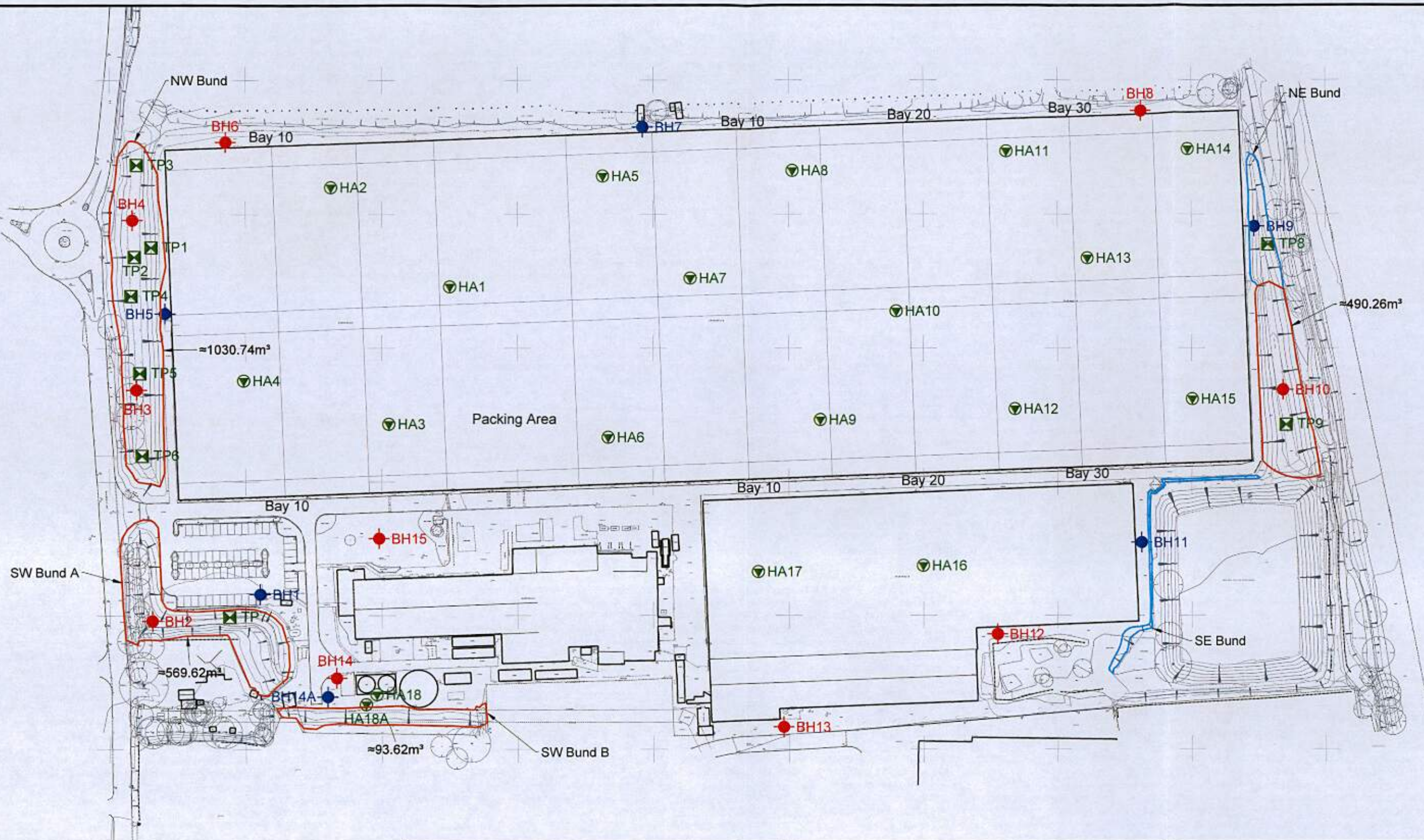
LEGEND Borehole Location - Jan 2015 Hand Auger Location - Jan 2015 Borehole Location with installation - Jan 2015 Trial Pit Location - May 2015 N						RSK 18 Frogmore Road Hemel Hempstead Hertfordshire HP3 9RT United Kingdom Tel: +44 (0) 1442 437500 Fax: +44 (0) 1442 437550 Email: info@rsk.co.uk Web: www.rsk.co.uk						Client CALA HOMES (SOUTH HOME COUNTIES) LTD											
												Project Title WEST END NURSERY, ANGMERING											
												Drawing Title EXPLORATORY HOLE LOCATION PLAN											
												Drawn ASC		Date 07.09.15		Checked CL		Date 07.09.15		Approved LT		Date 07.09.15	
Rev.		Date		Amendment		Drawn		Chkd.		Appd.		Scale 1:1500		Orig Size A3		Dimensions m		Drawing No. FIGURE 2				Rev.. P1	



LEGEND Central Landscaped area. (Area ≈ 1341.62m²) Area of bund in vicinity of access road. (Area ≈ 693m³)	N	RSK 18 Frogmore Road Hemel Hempstead Hertfordshire HP3 9RT United Kingdom Tel: +44 (0) 1442 437500 Fax: +44 (0) 1442 437550 Email: info@rsk.co.uk Web: www.rsk.co.uk	Client CALA HOMES (SOUTH HOME COUNTIES) LTD							
			Project Title WEST END NURSERY, ANGMERING							
			Drawing Title PROPOSED DEVELOPMENT PLAN							
			Project No. 27621 - R03 (00)	Drawing File 27621 (R03-00).dwg						
Rev.	Date	Amendment	Drawn	Chkd.	Appd.	Scale 1:1500	Orig Size A3	Dimensions m	Drawing No. FIGURE 3	Rev. P1



LEGEND Approximate area of bunds Borehole Location - Jan 2015 Hand Auger Location - Jan 2015 Borehole Location with installation - Jan 2015 Trial Pit Location - May 2015 C Chrysotile ACM Asbestos Containing Material F Asbestos Fibres Present A Amosite 0.01% Percentage composition of asbestos 10.00% Percentage >0.1% (Hazardous waste threshold) NAD No Asbestos Detected	N	RSK 18 Frogmore Road Hemel Hempstead Hertfordshire HP3 8RT United Kingdom Tel: +44 (0) 1442 437500 Fax: +44 (0) 1442 437550 Email: info@rsk.co.uk Web: www.rsk.co.uk	Client CALA HOMES (SOUTH HOME COUNTIES) LTD						
			Project Title WEST END NURSERY, ANGMERING						
			Drawing Title ASBESTOS DISTRIBUTION PLAN						
			Project No. 27621 - R03 (00)	Drawing File 27621 (R03-00).dwg					
			Drawing No. FIGURE 4	Rev. P1					
Drawn ASC	Date 07.09.15	Checked CL	Date 07.09.15	Approved LT	Date 07.09.15	Scale 1:1500		Orig Size A3	Dimensions m
Rev.	Date	Amendment	Drawn	Chkd.	Appd.				



- LEGEND**
- Approximate area of bunds
 - Borehole Location - Jan 2015
 - Hand Auger Location - Jan 2015
 - Borehole Location with installation - Jan 2015
 - ⊠ Trial Pit Location - May 2015
 - Regrading proposed in this area

 18 Frogmore Road Hemel Hempstead Hertfordshire HP3 9RT United Kingdom Tel: +44 (0) 1442 437500 Fax: +44 (0) 1442 437550 Email: info@rsk.co.uk Web: www.rsk.co.uk						Client CALA HOMES (SOUTH HOME COUNTIES) LTD	
						Project Title WEST END NURSERY, ANGMERING	
						Drawing Title PROPOSED REGRADING AREAS	
						Project No. 27621 - R03 (00)	Drawing File 27621 (R03-00).dwg
						Drawing No. FIGURE 5	Rev. P1
Drawn ASC	Date 07.09.15	Checked CL	Date 07.09.15	Approved LT	Date 07.09.15		
Scale 1:1500		Orig Size A3		Dimensions m			
Rev.	Date	Amendment	Drawn	Chkd.	Appd.		

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 Cala Homes (South Home Counties) Ltd (the "client") in accordance with the terms of a contract between RSK and the "client". 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 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 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 of this report, 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 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. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B

SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990 (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA of the EPA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2010 provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2010 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use.

PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF).

The new framework has only limited guidance on contaminated land, as follows:

- *"planning policies and decisions should also ensure that:*
 - *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
 - *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
 - *adequate site investigation information, prepared by a competent person, is presented".*



APPENDIX C

RSK GENERIC ASSESSMENT CRITERIA

Generic assessment criteria for human health: residential scenario with home-grown produce

Background

RSK's generic assessment criteria (GAC) were initially prepared following the publication by the Environment Agency (EA) of soil guideline value (SGV) and toxicological (TOX) reports, and associated publications in 2009⁽¹⁾. RSK GAC were updated following the publication of GAC by LQM/CIEH in 2009⁽²⁾. RSK GAC are periodically revised when updated information on toxicological, land use or receptor parameters is published.

Updates to the RSK GAC: 2015

In 2014, the publication of Category 4 Screening Levels (C4SL)^(3,4), as part of the Defra-funded research project SP1010, included modifications to certain exposure assumptions documented within EA Science Report SC050221/SR3 (herein after referred to as SR3)⁽⁵⁾ used in the generation of SGVs.

C4SL were published for six substances (cadmium, arsenic, benzene, benzo(a)pyrene, chromium VI and lead) for a sandy loam soil type with 6% soil organic matter, based on a low level of toxicological concern (LLTC; see Section 2.3 of research project report SP1010⁽³⁾). Where a C4SL has been published, the RSK GAC duplicates the C4SL published values using all input parameters within the SP1010 final project report⁽³⁾ and associated appendices⁽⁶⁾, and adopts them as GAC for these six substances.

For all other substances the C4SL exposure modifications, with the exception of the "top two" produce type approach taken in the C4SL, have been applied to the current RSK GAC. These include alterations to daily inhalation rates for residential and commercial scenarios, reducing soil adherence factors in children (age classes 1 to 12 only) for residential land use, reducing exposure frequency for dermal contact outdoors for residential land use, and updated produce type consumption rates (90th percentile) based on recent data from the National Diet and Nutrition Survey.

The RSK GAC have also been revised with updated toxicology published by LQM/CIEH in 2015⁽⁷⁾, where a C4SL has not been published.

RSK GAC derivation for metals and organic compounds

Model selection

Soil assessment criteria (SAC) were calculated using the Contaminated Land Exposure Assessment (CLEA) tool v1.06, supporting EA guidance^(5,8,9) and revised exposure scenarios published for the C4SL⁽³⁾. 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 EA guidance^(1,5,8,9). The SAC and GrAC collectively are termed GAC.

Conceptual model

In accordance with SR3⁽⁵⁾, the residential with home-grown produce scenario considers risks to a female child between the ages of 0 and 6 years old as the highest risk scenario. In accordance

with Box 3.1 of SR3⁽⁵⁾, the pathways considered for production of the SAC in the residential with home-grown produce scenario are

- direct soil and dust ingestion
- consumption of home-grown produce
- consumption of soil attached to home-grown produce
- dermal contact with soil and indoor dust
- inhalation of indoor and outdoor dust and vapours.

Figure 1 is a conceptual model illustrating these linkages.

In line with guidance in the EA SGV report for cadmium⁽¹⁾, the RSK GAC for cadmium has been derived based on estimates representative of lifetime exposure. Although young children are generally more likely to have higher exposures to soil contaminants, the renal toxicity of cadmium, and the derivation of the TDI_{oral} and TDI_{inh} , are based on considerations of the kidney burden accumulated over 50 years or so. It is therefore reasonable to consider exposure not just in childhood but averaged over a longer period.

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 chemical 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.

With respect to volatilisation, the CLEA model assumes a simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase⁽⁹⁾. The upper boundaries of this partitioning are represented by the maximum aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA model estimates saturated soil concentrations where these limits are reached⁽⁹⁾. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous- or vapour-based soil saturation limits. Model output cells are flagged red where the saturated soil concentration has been exceeded and the contribution of the indoor and outdoor vapour pathway to total exposure is greater than 10%. In this case, further consideration of the following is required⁽⁹⁾:

- Free phase contamination may be present.
- Exposure from the vapour pathways will be over-predicted by the model, as in reality the vapour phase concentration will not increase at concentrations above saturation limits
- Where the vapour pathway contribution is greater than 90%, it is unlikely the relevant health criteria value (HCV) will be exceeded at soil concentrations at least a factor of ten higher than the relevant HCV.

Where the vapour pathway is the predominant pathway (contributes greater than 90% of exposure) or the only exposure route considered and the cell is highlighted red (SAC exceeds saturation limit), the risk based on the assumed conceptual model is likely to be negligible as the vapour risk is assumed to be tolerable at maximum possible soil concentrations. In such circumstances, the vapour pathway exposure should be considered based on the presence of free phase or non-aqueous phase liquid sources and the measured concentrations of volatile organic compounds (VOC) in the vapour phase. Screening could be considered based on setting

the SAC as the modelled soil saturation limits. However, as stated within the CLEA handbook⁽⁹⁾, this is likely to not be practical in many cases because of the very low saturation limits and, in any case, is highly conservative.

It should also be noted that for mixtures of compounds, free phase may be present where soil (or groundwater) concentrations are well below saturation limits for individual compounds.

Where the vapour pathway is only one of the exposure pathways considered, an additional approach can then be utilised as detailed within Section 4.12 of the CLEA model handbook⁽⁹⁾, which explains how to calculate an effective assessment criterion manually.

SR3⁽⁵⁾ states that, as a general rule of thumb, it is recognised that estimating vapour phase concentrations from dissolved and sorbed phase contamination by petroleum hydrocarbons are at least a factor of ten higher than those likely to be measured on-site. RSK has therefore applied an empirical subsurface to indoor air correction factor of 10 into the CLEA model chemical database for all petroleum hydrocarbon fractions (including BTEX, trimethylbenzenes and the polycyclic aromatic hydrocarbons (PAH) naphthalene, acenaphthene and acenaphthylene) to reduce this conservatism.

Input selection

The most up-to-date published chemical and toxicological data was obtained from EA Report SC050021/SR7⁽¹⁰⁾, the EA TOX⁽¹¹⁾ reports, the C4SL SP1010 project report and associated appendices^(3,6) or the 2015 LQM/CIEH report⁽⁷⁾. Where a C4SL has been published, the RSK GAC have duplicated the C4SL published values using all input parameters within the SP1010 final project report⁽³⁾ and associated appendices⁽⁶⁾, and has adopted them as GAC for these six substances. Toxicological and specific chemical parameters for aromatic hydrocarbon C₈–C₉ (styrene), 1,2,4-trimethylbenzene and methyl tertiary-butyl ether (MTBE) were obtained from the CL:AIRE Soil Generic Assessment Criteria report⁽¹¹⁾.

For TPH, aromatic hydrocarbons C₅–C₈ were not modelled, as this range comprises benzene and toluene, which are modelled separately. The aromatic C₈–C₉ hydrocarbon fraction comprises ethylbenzene, xylene and styrene. As ethylbenzene and xylene are being modelled separately, the physical, chemical and toxicological data for aromatic C₈–C₉ have been taken from styrene.

For the GrAC, owing to the lack of UK-specific data, default information in the RBCA model was used to evaluate 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⁽⁸⁾
- a child weighing 13.3kg (average of 0–6 year old female in accordance with Table 4.6 of SR3⁽⁵⁾) and breathing 11.85m³ (average daily inhalation rate for a 0–6-year old female in accordance with Table 4.14 of SR3⁽⁵⁾). Inhalation rates used in the derivation of the GrAC have not been updated in line with the 2011 USEPA published values⁽¹²⁾; these will be updated in subsequent revisions of the RSK GAC. The lower inhalation rates presented by the USEPA in 2011 for ages classes 1 to 11 (values are higher for age classes 12 to 18) are not considered to make a significant difference.
- the 50% rule (for petroleum hydrocarbons, trimethylbenzenes and MTBE)^(8,9) where MDI data is not available but background exposure is considered important in the overall exposure.

Physical parameters

For the residential with home-grown produce scenario, the CLEA default building is a small, two-storey terrace house with a concrete ground-bearing slab. The house is assumed to have a 100m² private garden consisting of lawn and flowerbeds, incorporating a 20m² plot for growing fruit and vegetables consumed by the residents. SR3⁽⁵⁾ notes this residential building type to be the most conservative in terms of potential for vapour intrusion. The building parameters used in the production of the RSK GACs are the default CLEA v1.06 inputs presented in Table 3.3 of SR3⁽³⁾, with a dust loading factor detailed in Section 9.3 of SR3⁽⁵⁾. The parameters for a sandy loam soil type were used in line with Table 4.4 of SR3⁽⁵⁾. 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 SOM, RSK has produced an additional set of GAC for SOM of 1% and 2.5% for all substances using the CLEA tool.

For the GrAC, the depth to groundwater was taken as 2.5m based on RSK's experience of assessing the volatilisation pathway from groundwater. The GrAC were produced using the input parameters in Table 4.

Summary of modifications to the default CLEA 1.06/SR3⁽⁵⁾ input parameters for residential with home-grown produce land-use scenario

In summary, the RSK GAC were produced using the default input parameters for soil properties, the air dispersion model, building properties and the vapour model detailed in SR3⁽⁵⁾. Modifications to the default SR3⁽⁵⁾ exposure scenarios based on the C4SL exposure scenarios⁽³⁾ are presented in Tables 2 and 3 below.

The final selected GAC are presented by pathway in Table 5 and the combined GAC in Table 6.

Figure 1: Conceptual model for residential scenario with home-grown produce

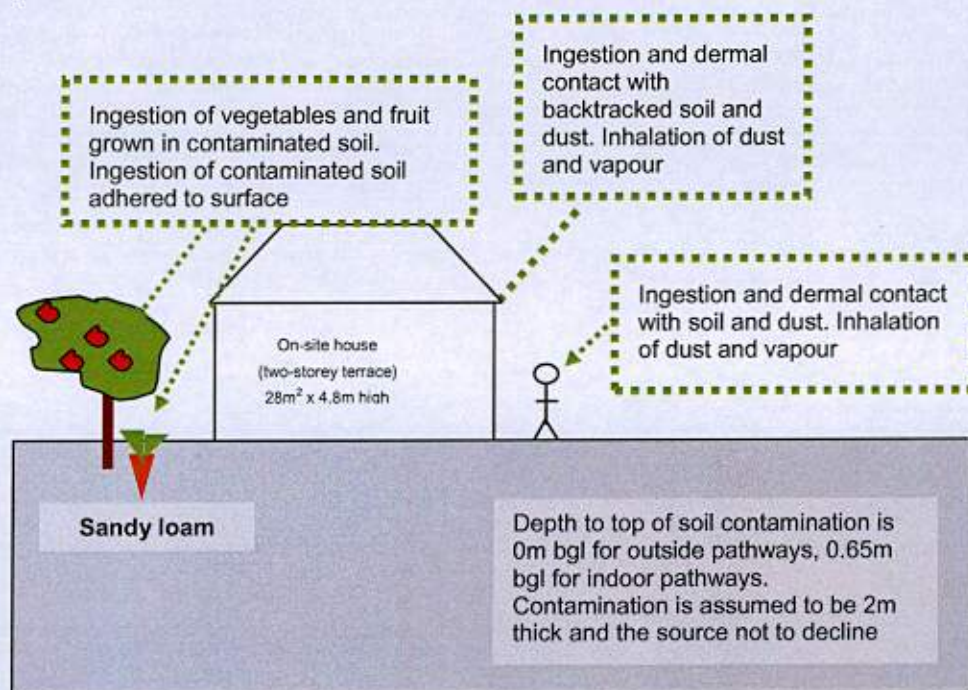


Table 1: Exposure assessment parameters for residential scenario with home-grown produce – inputs for CLEA model

Parameter	Value	Justification
Land use	Residential with homegrown produce	Chosen land use
Receptor	Female child age 1 to 6	Key generic assumption given in Box 3.1, SR3 ⁽⁵⁾
Building	Small terraced house	Key generic assumption given in Box 3.1, SR3. Small, two-storey terraced house chosen, as it is the most conservative residential building type in terms of protection from vapor intrusion (Section 3.4.6, SR3) ⁽⁵⁾
Soil type	Sandy Loam	Most common UK soil type (Section 4.3.1, from Table 3.1, SR3) ⁽⁵⁾
Start AC (age class)	1	Range of age classes corresponding to key generic assumption that the critical receptor is a young female child aged 0–6. From Box 3.1, SR3 ⁽⁵⁾
End AC (age class)	6	
SOM (%)	6	Representative of sandy loamy soil according to EA guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents' ⁽¹³⁾
	1	To provide SAC for sites where SOM <6% as often observed by RSK
	2.5	
pH	7	Model default

Table 2: Residential with home-grown produce – modified home-grown produce data

Name	Consumption rate 90 th percentile (g FW kg ⁻¹ BW day ⁻¹) by age class						Dry weight conversion factor (g DW g ⁻¹ FW)	Home-grown fraction (average)	Home-grown fraction (high end)	Soil loading factor (g g ⁻¹ DW)	Preparation correction factor
	1	2	3	4	5	6					
Green vegetables	7.12	5.87	5.87	5.87	4.53	4.53	0.096	0.05	0.33	1.00E-03	2.00E-01
Root vegetables	10.7	2.83	2.83	2.83	2.14	2.14	0.103	0.06	0.4	1.00E-03	1.00E+00
Tuber vegetables	16	6.6	6.6	6.6	4.95	4.95	0.21	0.02	0.13	1.00E-03	1.00E+00
Herbaceous fruit	1.83	3.39	3.39	3.39	2.24	2.24	0.058	0.06	0.4	1.00E-03	6.00E-01
Shrub fruit	2.23	0.46	0.46	0.46	0.19	0.19	0.166	0.09	0.6	1.00E-03	6.00E-01
Tree fruit	3.82	10.3	10.3	10.3	5.16	5.16	0.157	0.04	0.27	1.00E-03	6.00E-01
Justification	Table 3.4, SP1010 ⁽³⁾						Table 6.3, SR3 ⁽⁵⁾	Table 4.19, SR3 ⁽⁵⁾		Table 6.3, SR3 ⁽⁵⁾	

Table 3: Residential with home-grown produce – modified and use and receptor data

Parameter	Unit	Age class					
		1	2	3	4	5	6
EF (soil and dust ingestion)	day yr ⁻¹	180	365	365	365	365	365
EF (consumption of home-grown produce)	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	170	170	170	170	170	170
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 3.5, SP1010 ⁽³⁾ ; Table 3.1, SR3 ⁽⁵⁾					
Soil to skin adherence factor (outdoor)	mg cm ⁻² day ⁻¹	0.1	0.1	0.1	0.1	0.1	0.1
Justification		Table 3.5, SP1010 ⁽³⁾					
Inhalation rate	m ³ day ⁻¹	5.4	8.0	8.9	10.1	10.1	10.1
Justification		Mean value USEPA, 2011 ⁽¹²⁾ ; Table 3.2, SP1010 ⁽³⁾					
Notes: 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 just in childhood but averaged over a longer period. See the Environment Agency Science Report SC05002/ TOX 3 ⁽¹⁾ , Science Report SC050021/Cadmium SGV ⁽¹⁾ and the project report SP1010 ⁽³⁾ for more information.							

Figure 2: GrAC conceptual model for RBCA residential with home-grown produce scenario

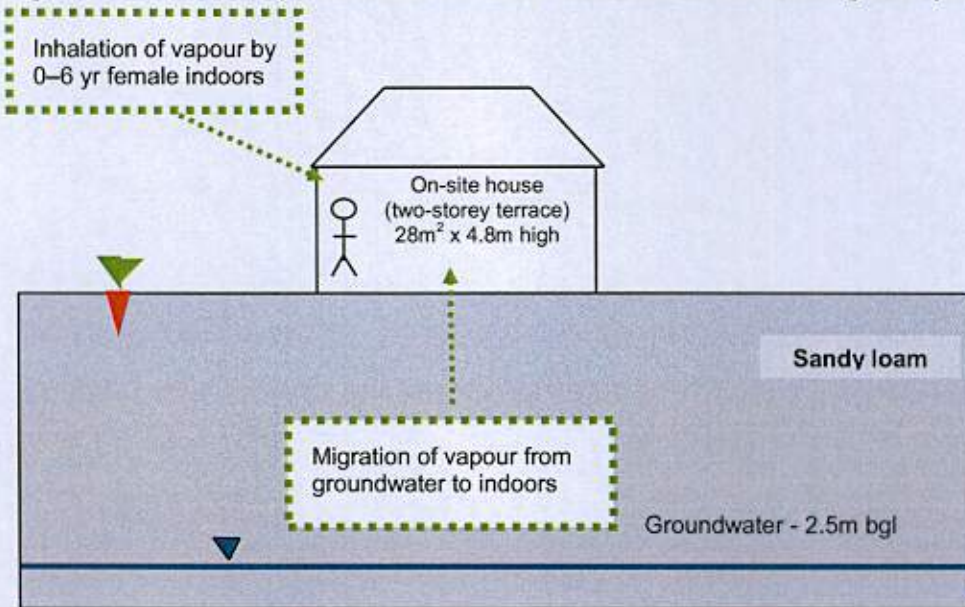


Table 4: Residential with home-grown produce – RBCA inputs

Parameter	Unit	Value	Justification
Receptor			
Averaging time	Years	6	From Box 3.1, SR3 ⁽⁵⁾
Receptor weight	kg	13.3	Average of CLEA 0–6 year old female data, Table 4.6, SR3 ⁽⁵⁾
Exposure duration	Years	6	From Box 3.1, report, SR3 ⁽⁵⁾
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 ⁽⁵⁾
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 ⁽⁵⁾
Vapour permeability	m ²	3.05E-12	Calculated for sandy loam using equations in Appendix 1, SR3 ⁽⁵⁾
Capillary zone thickness	m	0.1	Professional judgement
Fraction organic carbon	%	0.0348	Representative of sandy loam according to EA guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents' ⁽¹³⁾
Building			
Building volume/area ratio	m	4.8	Table 3.3, SR3 ⁽⁵⁾
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 ⁽⁵⁾
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 ⁽⁵⁾
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 ⁽⁵⁾
Volumetric air content of cracks	-	0.2	
Indoor/outdoor differential pressure	Pa	3.1	From Table 3.3, SR3 ⁽⁵⁾

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GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH HOME-GROWN PRODUCE



Table 5

Human Health Generic Assessment Criteria by Pathway for Residential With Home-Grown Produce 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	(a,b)	-	3.71E+01	5.26E+02	NR	NR	3.71E+01	5.26E+02	NR	NR	3.71E+01	5.26E+02	NR	NR
Cadmium	(a)	-	NR	NR	2.60E+01	NR	NR	NR	2.60E+01	NR	NR	NR	2.60E+01	NR
Chromium (III) - trivalent	(c)	-	1.84E+04	3.07E+02	8.80E+02	NR	1.84E+04	3.07E+02	8.80E+02	NR	1.84E+04	3.07E+02	8.80E+02	NR
Chromium (VI) - hexavalent	(a,d)	-	2.92E+01	2.06E+01	NR	NR	2.92E+01	2.06E+01	NR	NR	2.92E+01	2.06E+01	NR	NR
Copper	-	-	2.72E+03	1.41E+04	2.47E+03	NR	2.72E+03	1.41E+04	2.47E+03	NR	2.72E+03	1.41E+04	2.47E+03	NR
Lead	(a)	-	2.01E+02	NR	NR	NR	2.01E+02	NR	NR	NR	2.01E+02	NR	NR	NR
Elemental Mercury (Hg ⁰)	(d)	8.40E-03	NR	2.35E-01	NR	4.31E+00	NR	5.60E-01	NR	1.07E+01	NR	1.22E+00	NR	2.58E+01
Inorganic Mercury (Hg ²⁺)	-	-	3.95E+01	3.69E+03	3.91E+01	NR	3.95E+01	3.69E+03	3.91E+01	NR	3.95E+01	3.69E+03	3.91E+01	NR
Methyl Mercury (Hg ⁺)	-	2.00E+01	1.26E+01	1.87E+01	7.32E+00	7.33E+01	1.26E+01	1.87E+01	8.34E+00	1.42E+02	1.26E+01	1.87E+01	1.09E+01	3.04E+02
Nickel	(d)	-	1.27E+02	1.81E+02	NR	NR	1.27E+02	1.81E+02	NR	NR	1.27E+02	1.81E+02	NR	NR
Selenium	(b)	-	2.58E+02	NR	NR	NR	2.58E+02	NR	NR	NR	2.58E+02	NR	NR	NR
Zinc	(b)	-	3.66E+03	3.63E+07	NR	NR	3.66E+03	3.63E+07	NR	NR	3.66E+03	3.63E+07	NR	NR
Cyanide	-	-	2.74E+01	4.09E+00	3.78E+00	NR	2.74E+01	4.09E+00	3.78E+00	NR	2.74E+01	4.09E+00	3.78E+00	NR
Volatile Organic Compounds														
Benzene	(a)	7.20E+00	2.62E-01	8.01E-01	2.03E-01	1.22E+03	5.30E-01	1.88E+00	4.08E-01	2.26E+03	1.16E+00	3.48E+00	8.72E-01	4.71E+03
Toluene	-	5.90E+02	1.53E+02	9.08E+02	1.31E+02	8.68E+02	3.49E+02	2.00E+03	2.92E+02	1.92E+03	7.95E+02	4.55E+03	6.73E+02	4.38E+03
Ethylbenzene	-	1.80E+02	1.10E+02	8.34E+01	4.74E+01	5.18E+02	2.65E+02	1.90E+02	1.12E+02	1.22E+03	6.00E+02	4.54E+02	2.60E+02	2.84E+03
Xylene - m	-	8.40E+01	2.10E+02	8.25E+01	5.92E+01	6.25E+02	5.01E+02	1.95E+02	1.40E+02	1.47E+03	1.15E+03	4.34E+02	3.27E+02	3.46E+03
Xylene - o	-	1.00E+02	1.02E+02	5.87E+01	6.67E+01	4.78E+02	4.59E+02	2.68E+02	1.43E+02	1.12E+03	1.01E+03	4.26E+02	3.30E+02	2.62E+03
Xylene - p	-	8.70E+01	1.98E+02	7.03E+01	5.69E+01	5.76E+02	4.70E+02	1.86E+02	1.30E+02	1.35E+03	1.09E+03	4.36E+02	3.10E+02	3.17E+03
Total xylene	-	8.40E+01	1.97E+02	7.03E+01	5.69E+01	6.25E+02	4.59E+02	1.86E+02	1.30E+02	1.47E+03	1.09E+03	4.36E+02	3.10E+02	3.46E+03
Methyl tertiary-Butyl ether (MTBE)	-	2.20E+03	1.54E+02	1.04E+03	1.34E+02	2.04E+04	2.97E+02	1.89E+03	2.03E+02	3.31E+04	6.00E+02	3.21E+03	5.09E+02	6.27E+04
Trichloroethene	-	1.80E+00	2.83E-01	1.72E-02	1.67E-02	1.54E+03	6.25E-01	3.58E-02	3.40E-02	3.22E+03	1.41E+00	2.98E-02	7.55E-02	7.14E+03
Tetrachloroethene	-	3.60E+00	4.44E+00	1.70E-01	1.70E-01	4.24E+02	1.04E+01	4.92E-01	3.04E-01	9.51E+02	2.38E+00	8.21E-01	8.04E-01	2.18E+03
1,1,1-Trichloroethane	-	2.80E+01	2.30E+02	9.01E+00	8.77E+00	1.43E+03	7.34E+02	1.84E+01	1.89E+01	2.92E+03	1.62E+03	8.04E+01	7.94E+01	6.39E+03
1,1,1,2-Tetrachloroethane	-	1.40E+01	5.38E+00	1.54E+00	1.20E+00	2.60E+03	1.27E+01	3.56E+00	2.78E+00	6.02E+03	2.93E+01	8.29E+00	6.46E+00	1.40E+04
1,1,2,2-Tetrachloroethane	-	1.40E+01	2.81E+00	3.92E+00	1.64E+00	2.67E+03	8.09E+00	8.04E+00	3.47E+00	5.46E+03	1.76E+01	7.65E+00	7.67E+00	1.20E+04
Carbon Tetrachloride	-	5.50E+02	3.18E+00	2.58E+02	2.57E+02	1.52E+03	3.11E+00	3.85E+02	5.62E+02	3.32E+03	1.62E+03	1.78E+01	1.22E+01	7.54E+03
1,2-Dichloroethane	-	3.00E+01	3.47E+02	9.20E+03	7.13E+03	3.41E+03	5.73E+02	1.33E+02	1.94E+02	4.91E+03	1.99E+01	2.28E+02	1.99E+02	8.43E+03
Vinyl Chloride	-	1.90E+02	3.10E+03	7.73E+04	6.43E+04	1.36E+03	8.37E+03	1.00E+03	8.25E+04	1.76E+03	1.25E+02	1.23E+02	1.38E+03	2.89E+03
1,2,4-Trimethylbenzene	-	7.50E+02	NR	1.26E+00	NR	4.74E+02	NR	4.38E+00	NR	1.16E+03	NR	9.72E+00	NR	2.76E+03
1,3,5-Trimethylbenzene	(a)	4.70E+02	NR	NR	NR	2.30E+02	NR	NR	NR	5.52E+02	NR	NR	NR	1.30E+03
Semi-Volatile Organic Compounds														
Acenaphthene	-	3.20E+00	2.27E+03	4.88E+04	2.26E+02	5.70E+01	5.41E+02	1.18E+05	5.38E+02	1.41E+02	1.18E+03	2.89E+05	1.17E+03	3.36E+02
Acenaphthylene	-	4.20E+00	1.85E+02	4.59E+04	1.84E+02	8.61E+01	4.42E+02	1.11E+05	4.40E+02	2.12E+02	8.78E+02	2.53E+05	9.74E+02	5.06E+02
Anthracene	-	2.10E+02	2.45E+03	1.53E+05	2.38E+03	1.17E+00	5.53E+03	3.77E+05	5.45E+03	2.91E+00	1.10E+04	8.76E+05	1.08E+04	6.96E+00
Benzo[a]anthracene	-	3.80E+03	1.01E+01	2.47E+01	7.18E+00	1.71E+00	1.42E+01	4.37E+01	1.07E+01	4.28E+00	1.89E+01	6.26E+01	1.33E+01	1.03E+01
Benzo[b]fluoranthene	-	2.00E+03	2.86E+00	1.93E+01	2.65E+00	1.22E+00	3.89E+00	2.13E+01	3.94E+00	3.04E+00	4.43E+00	2.22E+01	3.89E+00	7.29E+00
Benzo[g,h,i]perylene	-	2.60E+04	3.77E+02	1.87E+03	3.14E+02	1.64E+02	4.09E+02	1.94E+03	2.58E+02	3.85E+02	4.23E+02	1.27E+03	5.48E+02	9.23E+02
Benzo[k]fluoranthene	-	8.00E+04	8.02E+01	5.41E+02	7.88E+01	6.87E+01	1.10E+02	5.76E+02	9.22E+01	1.72E+00	1.21E+02	5.91E+02	1.03E+02	4.12E+00
Chrysene	-	2.00E+03	1.66E+01	1.19E+02	1.48E+01	4.40E+01	2.54E+01	1.49E+02	2.17E+01	1.10E+00	3.18E+01	1.66E+02	2.67E+01	2.84E+00
Dibenz[a,h]anthracene	-	6.00E+04	2.30E+01	1.48E+00	2.41E+01	3.93E+03	3.43E+01	1.64E+05	2.84E+01	9.82E+03	3.69E+01	1.74E+00	3.04E+01	2.36E+02
Fluoranthene	-	2.30E+01	2.87E+02	3.83E+04	2.85E+02	1.89E+01	5.63E+02	8.87E+04	5.60E+02	4.73E+01	8.00E+02	1.83E+05	8.89E+02	1.12E+02
Pyrene	-	1.90E+00	1.77E+02	6.20E+03	3.09E+01	3.09E+01	4.19E+02	1.83E+04	4.07E+02	7.65E+01	8.38E+02	3.62E+04	8.79E+02	1.83E+02
Indeno[1,2,3-cd]pyrene	-	2.00E+04	3.09E+01	2.12E+02	2.73E+01	6.13E+02	4.22E+01	2.38E+02	3.58E+01	1.53E+01	4.32E+01	2.50E+02	4.11E+01	3.68E+01
Phenanthrene	-	5.30E+01	8.85E+01	7.17E+03	9.72E+01	3.60E+01	2.24E+02	1.76E+04	2.22E+02	8.90E+01	4.46E+02	4.67E+04	4.43E+02	2.14E+02
Pyrene	-	1.30E+01	6.25E+02	8.79E+04	8.20E+02	2.20E+00	1.25E+03	2.04E+05	1.24E+03	5.49E+00	2.09E+03	4.23E+05	2.04E+03	1.32E+01
Benzo[a]pyrene	(a)	3.80E+03	4.51E+00	3.51E+01	4.30E+00	9.11E+01	4.81E+00	3.77E+01	4.34E+00	2.28E+00	4.81E+00	3.89E+01	4.39E+00	5.46E+00
Naphthalene	-	1.80E+01	2.79E+01	2.39E+01	1.27E+01	7.64E+01	6.68E+01	5.58E+01	3.04E+01	1.83E+02	1.53E+02	1.31E+02	7.66E+01	4.32E+02
Phenol	-	-	1.60E+02	4.88E+02	1.20E+02	2.42E+04	2.56E+02	6.90E+02	2.09E+02	3.81E+04	5.88E+02	1.98E+03	5.93E+02	7.03E+04

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH HOME-GROWN PRODUCE



Table 5

Human Health Generic Assessment Criteria by Pathway for Residential With Home-Grown Produce 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 ₁₇ -EC ₂₈		1.00E+01	4.96E+03	4.24E+01	4.23E+01	3.04E+02	1.12E+04	7.79E+01	7.79E+01	5.58E+02	2.41E+04	1.81E+02	1.80E+02	1.15E+03
Aliphatic hydrocarbons >EC ₁₇ -EC ₂₈		5.40E+03	1.46E+04	1.04E+02	1.03E+02	1.44E+02	3.27E+04	2.31E+02	2.31E+02	3.22E+02	6.47E+04	5.29E+02	5.29E+02	7.36E+02
Aliphatic hydrocarbons >EC ₂₉ -EC ₃₂		2.30E+01	1.45E+03	2.88E+01	2.87E+01	7.77E+01	2.42E+03	6.55E+01	6.55E+01	1.90E+02	3.29E+03	1.58E+02	1.54E+02	4.51E+02
Aliphatic hydrocarbons >EC ₃₃ -EC ₃₆		3.40E+02	3.47E+03	1.33E+02	1.32E+02	4.75E+01	3.80E+03	3.31E+02	3.24E+02	1.18E+02	4.23E+03	7.83E+02	7.52E+02	2.83E+02
Aliphatic hydrocarbons >EC ₃₇ -EC ₄₀		7.60E+04	4.36E+03	1.11E+03	1.03E+03	2.37E+01	4.40E+03	2.78E+03	2.22E+03	5.91E+01	4.41E+03	6.67E+03	3.47E+03	1.42E+02
Aliphatic hydrocarbons >EC ₄₁ -EC ₄₄	(b)	-	5.28E+04	NR	NR	8.48E+00	6.95E+04	NR	NR	2.12E+01	7.94E+04	NR	NR	5.09E+01
Aliphatic hydrocarbons >EC ₄₅ -EC ₄₈	(b)	-	5.28E+04	NR	NR	8.48E+00	6.95E+04	NR	NR	2.12E+01	7.94E+04	NR	NR	5.09E+01
Aromatic hydrocarbons >EC ₄₉ -EC ₅₂ (styrene)		7.40E+03	1.07E+01	5.20E+02	1.95E+01	6.26E+02	2.31E+03	1.20E+03	2.46E+03	1.44E+03	5.72E+03	2.79E+03	5.69E+03	3.35E+03
Aromatic hydrocarbons >EC ₅₃ -EC ₅₆		7.40E+03	5.71E+01	4.74E+01	3.44E+01	6.13E+02	1.35E+02	1.10E+02	8.29E+01	1.50E+03	2.91E+02	2.77E+02	1.89E+02	3.58E+02
Aromatic hydrocarbons >EC ₅₇ -EC ₆₀		2.50E+01	8.17E+01	2.58E+02	7.42E+01	3.64E+02	1.30E+02	6.08E+02	1.74E+02	8.99E+02	3.90E+02	1.82E+03	3.67E+03	2.15E+03
Aromatic hydrocarbons >EC ₆₁ -EC ₆₄		5.80E+03	1.43E+02	2.85E+03	1.41E+02	1.69E+02	3.18E+02	7.07E+03	3.14E+02	4.19E+02	6.93E+02	1.68E+04	6.03E+02	1.00E+03
Aromatic hydrocarbons >EC ₆₅ -EC ₆₈	(b)	-	2.48E+02	NR	NR	5.37E+01	4.84E+02	NR	NR	1.34E+02	7.68E+02	NR	NR	3.21E+02
Aromatic hydrocarbons >EC ₆₉ -EC ₇₂	(b)	-	6.72E+02	NR	NR	4.83E+00	1.10E+03	NR	NR	1.21E+01	1.22E+03	NR	NR	2.90E+01
Aromatic hydrocarbons >EC ₇₃ -EC ₇₆	(b)	-	6.72E+02	NR	NR	4.83E+00	1.10E+03	NR	NR	1.21E+01	1.22E+03	NR	NR	2.90E+01

Notes:

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 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.

Calculated SAC exceeds soil saturation limit but will not effect the SSV significantly since 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 cells 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 Powell 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) SAC for arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead are derived using the C4SL toxicology data.

(b) SAC for selenium should not include the inhalation pathway as no expert group HCV has been derived; aliphatic and aromatic hydrocarbons >EC16 should not include inhalation pathway due to their non-volatile nature and inhalation exposure being minimal (oral, dermal and inhalation exposure is compared to the oral HCV); arsenic should only be based on oral contribution (rather than combined) owing to the relative small contribution from inhalation in accordance with the SGV report. The Oral SAC should be adopted for zinc and benzo(a)pyrene.

(c) SAC for CrIII should be based on the lower of the oral and inhalation SAC (see LQM/CIEH 2015 Section 6.8)

(d) SAC for elemental mercury, chromium VI and nickel should be based on the inhalation pathway only.

(e) SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data, SAC for 1,2,4-trimethylbenzene may be used.

Table 6
Human Health Generic Assessment Criteria for Residential with home-grown produce

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	-	37	37	37
Cadmium	-	30	30	30
Chromium (III) - trivalent	-	910	910	910
Chromium (VI) - hexavalent	-	21	21	21
Copper	-	2,500	2,500	2,500
Lead	-	200	200	200
Elemental Mercury (Hg ⁰)	0.0094	0.2	0.6	1.2
Inorganic Mercury (Hg ²⁺)	-	39	39	39
Methyl Mercury (Hg ⁺)	20	10	10	10
Nickel	-	130	130	130
Selenium	-	258	258	258
Zinc	-	3,900	3,900	3,900
Cyanide	-	3.8	3.8	3.8
Volatile Organic Compounds				
Benzene	7.2	0.20	0.41	0.87
Toluene	590	130	300	680
Ethylbenzene	180	50	110	260
Xylene - m	84	59	140	327
Xylene - o	100	61	143	332
Xylene - p	87	57	133	310
Total xylene	84	57	133	310
Methyl tertiary-Butyl ether (MTBE)	2200	130	250	510
Trichloroethene	1.8	0.02	0.03	0.08
Tetrachloroethene	3.6	0.2	0.4	0.9
1,1,1-Trichloroethane	26	9	18	39
1,1,1,2-Tetrachloroethane	14	1.2	2.8	6.5
1,1,2,2-Tetrachloroethane	14	1.6	3.5	7.7
Carbon Tetrachloride	0.055	0.026	0.056	0.127
1,2-Dichloroethane	0.3	0.007	0.011	0.019
Vinyl Chloride	0.019	0.0006	0.0009	0.0014
1,2,4-Trimethylbenzene	0.075	1.8	4.3	9.7
1,3,5-Trimethylbenzene	0.047	NR	NR	NR
Semi-Volatile Organic Compounds				
Acenaphthene	3.2	230	540	1,170
Acenaphthylene	4.2	180	440	970
Anthracene	0.021	2,400	5,500	10,900
Benzo(a)anthracene	0.0038	7	11	13
Benzo(b)fluoranthene	0.002	2.6	3.3	3.7
Benzo(g,h,i)perylene	0.00026	310	340	350
Benzo(k)fluoranthene	0.0008	77	92	100
Chrysene	0.002	15	22	27
Dibenzo(a,h)anthracene	0.0006	0.24	0.28	0.30
Fluoranthene	0.23	280	560	900
Fluorene	1.9	170	410	880
Indeno(1,2,3-cd)pyrene	0.0002	27	36	41
Phenanthrene	0.53	100	220	440
Pyrene	0.13	620	1,240	2,040
Benzo(a)pyrene	0.0038	5	5	5
Naphthalene	19	13	30	71
Phenol	-	120	210	390
Total Petroleum Hydrocarbons				
Aliphatic hydrocarbons EC ₅ -EC ₉	10	42	78	160
Aliphatic hydrocarbons >EC ₉ -EC ₁₃	5.4	100	230	530
Aliphatic hydrocarbons >EC ₁₃ -EC ₁₉	0.23	27	65	154
Aliphatic hydrocarbons >EC ₁₉ -EC ₂₅	0.034	130 (48)	320 (118)	750 (283)
Aliphatic hydrocarbons >EC ₂₅ -EC ₃₅	0.00076	1,000 (24)	2,200 (59)	3,500 (142)
Aliphatic hydrocarbons >EC ₃₅ -EC ₄₄	-	53,000 (6)	70,000 (21)	79,000
Aromatic hydrocarbons >EC ₅ -EC ₉ (styrene)	7.4	11	25	56
Aromatic hydrocarbons >EC ₉ -EC ₁₀	7.4	34	83	189
Aromatic hydrocarbons >EC ₁₀ -EC ₁₂	25	74	174	367
Aromatic hydrocarbons >EC ₁₂ -EC ₁₆	5.8	100	300	600
Aromatic hydrocarbons >EC ₁₆ -EC ₂₁	-	200	500	800
Aromatic hydrocarbons >EC ₂₁ -EC ₃₅	-	900	1,100	1,200
Aromatic hydrocarbons >EC ₃₅ -EC ₄₄	-	900	1,100	1,200

Minerals

Asbestos - No asbestos detected with ID or <0.001% dry weight¹

Notes:

^{1/} Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data.

NR - SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data. SAC for 1,2,4-trimethylbenzene may be used.

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

¹ LOD for weight of asbestos per unit weight of soil calculated on a dry weight basis using PLM, handpicking and gravimetry.

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.

(VALUE IN BRACKETS) The SAC has been set as the model calculated SAC with the saturation limit shown in brackets.

RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIH 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.

(VALUE IN BRACKETS) For consistency where the GrAC exceeds the solubility limit, GrAC has been set at the solubility limit. The GrAC is conservative since 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.

GENERIC ASSESSMENT CRITERIA FOR PHYTOTOXIC EFFECTS

Several compounds can inhibit plant growth; hence it is important to have generic assessment criteria (GAC) to promote healthy plant growth. In the absence of other published GAC, the GAC have been obtained from legislation (UK and European) and guidance related to the use of sewage sludge on agricultural fields.

The Council of European Communities Sewage Sludge Directive (86/278/EEC) dated 1986, has been transposed into UK law by Statutory Instrument No. 1263, The Sludge (use in Agriculture) Regulations 1989 (Public Health England, Wales and Scotland), as ammended in 1990 and The Sludge (use in Agriculture) Regulations (Northern Ireland) SR No, 245, 1990. In addition the Department of Environment (DoE) produced a Code of Practice (CoP) (Updated 2nd Edition) in 2006 which provided guidance on the application of sewage sludge on agricultural land (however the status of this document is unclear as it is on the archive section of the Defra website).

The directive seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to "**prevent harmful effects on soil, vegetation, animals and man**". To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone "biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use". To provide protection against potential health risks from residual pathogens, sludge must not be applied to soil in which fruit and vegetable crops are growing, or less than ten months before fruit and vegetable crops are to be harvested. Grazing animals must not be allowed access to grassland or forage land less than three weeks after the application of sludge.

The specified limits of concentrations of selected elements in soil are presented in Table 4 of the updated 2nd Edition of the DoE Code of Practice and are designed to protect plant growth. It is noted that these values are more stringent than the values set in current UK regulations. However since they were ammended following recommendations from the Independent Scientific Committee in 1993. (MAFF/DOE 1993). The GAC are presented in Table 1.

Table 1: Generic 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
Lead	300	300	300	300
Cadmium	3	3	3	3
Mercury	1	1	1	1
Note: Only compounds with assessment criteria documented within the Directive 86/278/EEC have been included, although criteria for 5 additional compounds have been presented within the 2006 CoP.				