Remediation Strategy

Main Avenue, Kirklees

Client:	Strata Homes & Thirteen Group
Document Type:	Report
Document No.:	1152-ACE-GEO-RS-003
Revision:	002
Date:	2025/03/18

Registered in England and Wales. Company no. 07661675

Version History

This report has been prepared by Apex Consulting Engineers with reasonable skill, care and diligence, within the best practice and guidance current at the time of issue, within the scope of works which have been agreed with the client.

This report is confidential to the client and Apex Consulting Engineers accepts no responsibility whatsoever to third parties to whom this report, or any part thereof is presented, unless this is formally agreed in writing by a Director of Apex Consulting Engineers before any reliance is made. Any such party relies upon the information at their own risk. Apex Consulting Engineers disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

The report is written in the context of the development proposals submitted to Apex by the Client as part of the appointment. Any changes to the development proposals may necessitate significant revisions to this report.

The report (including appendices) should be read in its entirety. Apex cannot be held responsible for any sections of this report being taken out of context. This includes information submitted separately via download link (i.e. full copies of environmental search data from Envirocheck) which are not included as part of the main PDF due to their file size.

Intrusive investigation only allows observation and assessment of ground across a small portion of the total site area. Therefore, it is possible that significant features may not have been encountered during the investigation, despite appropriate design and planning. Apex cannot accept for conditions not revealed by the exploratory holes. Any interpretation of strata between or below exploratory holes is for guidance only and Apex hold no responsibility as to its accuracy.

It should be noted that groundwater levels are susceptible to seasonal and other variations; this should be borne in mind when considering observations/measurements associated with groundwater contained in this Report.

Apex reserve the right to amend this Report in the light of further information that may become available.

Revision	Date	Notes	Prepared by	Checked by	Approved by
000	2024/09/09	First Issue	M Thompson	W Ballance	M Thompson
001	2024/11/11	Updated Section 4.14	M Thompson	-	M Thompson
002	2025/03/18	Updated to include findings off additional trial pitting	M Thompson	-	M Thompson

Contents

1. INTRODUCTION

1.1 Background & context

This remediation strategy has been prepared for Strata Home and Thirteen Group for the proposed development at Main Avenue, Kirklees.

1.2 Previous reports

Apex have been provided with copies of the following reports relating to this site:

- *Phase I Geo-Environmental Risk Assessment, Land to the East of Main Avenue, Cowlersley, Huddersfield* (ref. 220322.2) issued to Thirteen Group in May 2022 by Roberts Environmental Limited (REL).

- *Phase II Geo-Environmental Site Investigation and Risk Assessment, Land to the East of Main Avenue, Cowlersley, Huddersfield* (ref. 22022.1) issued to Thirteen Group in May 2022 by Roberts Environmental Limited (REL).

In addition, Apex have already issued the following reports in relation to this site:

- *Ground Appraisal Report – Main Ave, Kirklees* (ref. 1152-ACE-GEO-GAR-001 revision 002 dated March 2025).
- *Earthworks Specification – Main Ave, Kirklees* (ref. 1152-ACE-GEO-ES-002 dated September 2024).

It is understood that Strata & Thirteen Group have reliance on the previous third-party reports and Apex's Ground Appraisal Report was designed to supplement the existing data.

Contractors involved in the remediation works should familiarise themselves with previous reports.

This report is an updated version of Remediation Strategy (ref. 1152-ACE-GEO-RS-003 Rev. 001). Report 1152-ACE-GEO-RS-003 Rev. 001 is now superseded.

1.3 Development proposals

It is understood that proposals include development of residential housing. A Viability Layout (drawing ref. 22-CL1-SEGA-MAK-01-VL, dated 20th July 2022) has been provided by Strata and is included in Appendix B. It shows 45no. traditional low-rise semi-detached/detached houses with gardens, POS, adoptable roads and sewers.

1.4 Limitations

This strategy sets out the remediation objectives to be achieved; however, the following matters are outside the scope of this report and relevant specialists/designers should be consulted as necessary:

- Ecological investigation and protection

- Archaeological investigation and protection
- Advice on the presence, removal or eradication of invasive species such as Japanese Knotweed
- Obtaining approvals for previous reports
- Obtaining any necessary consents, licences or approvals for the work
- Design of permanent or temporary works
- Unexploded ordnance (UXO) mitigation

The Foreword to this report and the appended guidance notes on Apex's procedures and definitions (Appendix A of the Ground Appraisal Report) should be read in conjunction with the main text.

2. SITE BACKGROUND & CONTEXT

2.1 Site location & description

A location plan is included as Drawing 001 in Appendix B. The site is situated on the land north-east of Main Avenue, Cowlersley in Kirklees.

Photographs of the site and a more detailed site description are included in the Ground Appraisal Report.

Site details are summarised in the table below:

CATEGORY	DETAILS
Location	Land to the East of Main Avenue, Cowersley.
NGR	Easting: 411039 Northing: 415158
Nearest postcode	HD4 5US
Area and shape	The site is an irregular shape and 2.28 hectares in size.
Current use	Much of the site is vacant land. Lots of the land is heavily overgrown with footpaths crisscrossing the site.
Surrounding land	**North, East & West –** Continued residential housing. Primary school directly to the north. **South –** An ascending slope.
Known constraints	The site slopes downwards towards the northeastern corner.

2.2 Site history

The site is predominantly greenfield, with the exception of:

- Former buildings (Jubilee property) in the north-east corner from before the 1890s until 1960s.
- A well is shown on the 1938 OS plan associated with the above property.
- Replacement of Jubilee with smaller structures (likely garages) in the 1960s.

In addition, a former large area of quarrying (Crosland Hill Quarry) was identified as close as 170m south-east.

A more detailed assessment of the site's history is presented in the Ground Appraisal Report.

2.3 Environmental setting

The site is mapped by BGS as being underlain by Millstone Grit (sandstone, mudstone and siltstone) with no overlying superficial deposits mapped.

The Millstone Grit is classed as a Secondary A Aquifer. The site is not within a Source Protection Zone.

Two historical landfills are mapped within potential influencing distance of the site:

- 220m west – The Folly, inert, commercial, household and liquid sludge waste deposit.
- 242m east – Quarry Road; no further information known.

The north of the site lies within an area where 3-5% of properties are above the action level for radon and therefore plots within this zone require **basic radon protection** measures.

The site lies in Flood Zone 1.

3. GROUND INVESTIGATION & CONCEPTUAL SITE MODEL

3.1 Ground investigation findings

A summary of the ground investigation carried out by Apex is given below:

Dates	Technique	Depths	Remarks/justification
16th May 2024	12No. Mechanically excavated trial pits	Up to 3m.	Provide a detailed view of shallow strata. Enable sampling for contamination & geotechnical testing.
	3no. soakaway tests	To between 1.0m and 1.8m.	Within TPs 104 ,108 and 112
	6No. Rotary open-hole boreholes & installation of monitoring wells	Advanced to c. 6m.	Completed to allow the installation of gas & groundwater monitoring wells to c. 6m.
21st February 2025	5 No. Mechanically excavated trial pits	Up to 1.5m.	Additional trial pitting in the north-east following vegetation clearance and removal of some garages.

Made ground

Made ground was encountered in the north-east and the far west and generally comprised the following strata:

- **MADE GROUND TOPSOIL:** Encountered in TPs 101, 106, 113 and 117 to between 0.2m and 0.4m in the north-east comprising topsoil with anthropogenic materials including glass, pottery, clay piping, brick, crisp packets, clinker. One fragment of suspected asbestos cement sheeting was found in TP101 and was sampled for analysis.
- **REWORKED SANDSTONE:** Encountered in TP101 to 1.2m above a foul drainage run (not shown on utility survey). Also encountered in TPs 113, 114 and 116 to between 0.9m and 1.4m. Material comprised sandy GRAVEL AND COBBLE, predominantly of sandstone in a random orientation.
- **HARDCORE SURFACING:** Encountered in TP112 in the car park in the far west to 0.2m as black sandy angular fine to medium GRAVEL of clinker and mixed lithologies AND COBBLE of suspected limestone.

Natural ground

Natural ground typically comprised the following sequence:

- **TOPSOIL:** Encountered in all TPs except TPs 101, 106 and 112 noted above. Varied between a clayey SAND and sandy CLAY with rootlets, often with gravel of sandstone. In a number of locations, the upper section of soil just below the turf was noted to be black and peaty. Depths ranged from 0.2m to 0.35m.
- **COHESIVE RESIDUAL SOILS:** Encountered in the majority of locations beneath the topsoil comprising firm (medium strength) to stiff (high strength) CLAY with varying proportion of gravel and cobble. Towards the south, minor constituents (gravel and cobble) were typically mudstone/mudstone lithorelicts, and in the north, they were typically sandstone. Locally soft in TP103. Depth to base ranged from 0.55m and 2.0m.
- **GRANULAR RESIDUAL SOILS:** Typically encountered beneath Cohsive Residual Soils or immediately beneath the topsoil, this material comprised sandy GRAVEL/COBBLE and was often clayey. Lithology varied from predominantly mudstone in the south and sandstone in the north as per the Cohesive Residual Soils. Depth to base ranged from 0.9m and 2.7m.
- **SANDSTONE BEDROCK:** Encountered in TPs 102, 104, 110 112 at respective depths of 1.4m, 1.5m 2.4m and 1.8m as moderately strong thinly bedded SANDSTONE. Unable to excavate with a JCB.
- **SILSTONE BEDROCK:** Encountered in TP 111 at 1.5m at 1.5m as very week thinly bedded SILSTONE. Unable to excavate with a JCB.
- **COAL:** An unnamed coal seam was encountered from 2.7m in TP107 to >3.0m.

Groundwater

Monitoring of groundwater levels suggests water is present at between c. 1m and 5m, generally shallower in lower-lying areas of the site towards the north, becoming deeper further south (uphill).

During trial pitting, strikes were encountered at between 0.9m and 1.9m, mainly in lower-lying site areas.

3.2 Conclusions

Contamination

Topsoil and Made Ground Topsoil within the car park area (far west) was found to contain elevated concentrations of PAHs; careful stripping and segregation of this material was recommended; further testing could be considered in this zone to provide more data and able further assessment of suitability for re-use.

One fragment of asbestos-containing cement was encountered in the area of garages/former Jubilee Property (identified in TP101); additional trial pitting suggests asbestos contamination is not widespread and no loose fibres are present. Material in this area is suitable for re-use on site. Hand-picking of asbestos-containing materials is required where found. Should significant quantities be found, further advice should be sought from Apex.

Hardcore surfacing in the former car park (far west) contains elevated concentrations of PAHs and should be isolated beneath proposed areas of hardstanding.

Elsewhere, no significant made ground was encountered and the Topsoil is considered chemically suitable for re-use.

Drawing 006 in Appendix B shows the extent of the areas noted above.

In addition, REL noted a “solvent odour” in TP07, possibly associated with a broken drainage pipe. Apex did not identify any such olfactory evidence of contamination within the vicinity. Nonethless, a watching brief is recommended when excavating in this area, together with delineation of any contamination identified via visual observation, use of a PID and soil sampling to form part of the Verification Report (see Section 4.9).

Hazardous gas

Gas monitoring concluded that the site should be classed a Characteristic Situation 2 – low hazard potential; gas protection measures are likely to include use of a ventilated sub-floor void and installation of a gas membrane.

Such measures would be sufficient to mitigate risks of radon in the areas where basic protection measures are required.

Foundations

At this stage, foundations for the proposed plots are likely to comprise traditional strip/trench fill footings cast within competent weathered Millstone Grit/Millstone Grit bedrock. Design should be finalised once final development levels are known.

3.3 Summary of Conceptual Site Model

A revised Conceptual Site Model was generated following completion of Apex’s ground investigation; a copy is included in Appendix B as Drawing 005.

The objective of remediation is to protect human health and the environment by either: removal of the contamination source; or breakage of contamination pathways.

In summary, the following remediation was recommended; reference should also be made to Drawings 005 and 006:

Material	Contaminant	Receptor	Remediation options
Topsoil/ Made Ground Topsoil (Car Park Area)	PAHs	Human health	Careful stripping and segregation of material is required. Further sampling of topsoil could be undertaken of the material in this zone to assess suitability for re-use.
Topsoil/ Made Ground Topsoil (former Jubilee Property & garages)	Asbestos & anthropogenic materials	Human health	Material is considered suitable for re-use; however, screening of undesirable materials (anthropogenic materials) is required prior to re-use. In addition, a single fragment of ACM was noted in this area, but no loose fibres are present. Any such material requires hand-picking and removal from site. Should significant quantities be identified, further advice should be sought from Apex.
Topsoil (main site)	Localised PAHs	Human health	After review of data, this material is considered suitable for re-use in gardens and POS.
Hardcore Surfacing	PAHs	Human health	Careful stripping and segregation of material, then placement beneath areas of proposed hardstanding.
Off-site quarries	Hazardous gas	Human health, buildings	See Section 12.

** Where new water mains are to be laid, UKWIR testing will be required in order to confirm pipe construction materials, as detailed in UKWIR report 10/WM/03/21[1].*

4. REMEDIATION REQUIREMENTS

4.1 Overview

On this site, the main remediation objectives are:

- Monitoring for unforeseen conditions
- Management of Topsoil & Made Ground Topsoil to ensure re-usable material is placed correctly.
- Supervision of excavations/earthworks within the vicinity of REL's TP07.
- Decommissioning of existing monitoring wells.
- Decommissioning of the "well" shown on historical plans (if located).
- Isolation of Hardcore Surfacing beneath areas of hardstanding.
- Installation of gas protection measures.

[1] Guidance for the selection of water supply pipes to be used in brownfield sites – UK Water Industry Research (2011)

- Provision of barrier pipe for water supply water supply pipes where in contact with made ground (if required following UKWIR testing).

4.2 Definitions

During the following sections, the follow definitions apply:

- Contractor: party responsible for implementation of this Remediation Strategy
- Engineer: suitably qualified Geo-environmental Engineer acting on behalf of Strata and Thirteen Group to ensure the requirements of this strategy are met

4.3 Contractor requirements

Prior to start of site works, the Contractor shall provide a Remediation Method Statement detailing how the objectives of this Strategy will be achieved, along with all appropriate health & safety documentation, including (but not limited to):

- Method statements and risk assessments for all planned activities
- UXO mitigation measures
- Plans to manage asbestos in soils and asbestos discovery
- Measures to mitigate risks to the public and the environment (including details on working hours and control measures for fuel spillages, noise, odour, dust and silt)
- Measures to mitigate risks to underground services
- Details of segregation along established site boundaries
- Details of any necessary tree and ecological protection measures

The Contractor should prepare a Materials Management Plan (MMP) which should detail:

- Quantities and types of materials, how they will be used and against what criteria they will be assessed to ensure suitability for use
- Storage arrangements for material types and tracking measures
- Parties involved
- Verification plan which relates back to remediation requirements

The MMP will require review and Declaration by a Qualified Person.

4.4 Monitoring for unforeseen conditions

In the event that unforeseen contamination or unusual/unanticipated ground conditions are encountered the Engineer shall be informed in writing immediately. An investigation and risk assessment of the unforeseen condition may then be necessary to revise the strategy and obtain the approval of the Local Authority.

4.5 Decommissioning existing monitoring wells

Monitoring wells installed by Apex shall be located and decommissioned prior to remediation works commencing. The methodology used to decommission the boreholes should be in accordance with EA document: 'Decommissioning Redundant Boreholes and Wells' and approved by the Engineer who should be present during the decommissioning works.

4.6 Water and silt management

A Silt Management Plan shall be prepared by the Contractor detailing how surface run-off will be intercepted and prevented from impacting off-site receptors.

Any groundwater encountered with evidence of organic contamination (eg oily sheens, odours etc) should be collected and stored awaiting sampling and further advice from the Engineer.

4.7 Obstruction removal

Old slabs and foundations associated with the Jubilee Property/garages are to be chased out and grubbed-up to remove potential obstructions to new foundations and infrastructure. Where significantly deep obstructions are found (considered unlikely) and cannot be removed by conventional means, they are to be cut at a depth to be agreed with the Supervising Engineer. The positions of all obstructions remaining in the ground shall be accurately recorded by survey. The survey shall be provided to the Supervising Engineer for inclusion in the validation report.

4.8 Asbestos

The Contractor should implement an asbestos discovery and management plan. All works should be undertaken in accordance with CAR 2012, with a watching brief by suitably trained personnel during any excavation works.

If asbestos is encountered during excavations, works should stop in this area and the area cordoned off to prevent access. A suitably qualified consultant should be contacted, and additional testing and risk assessment works may be required to determine suitability for re-use or disposal of the surrounding excavated materials.

If fragments of suspected ACMs are encountered during remediation works, they should be hand-picked by trained staff with appropriate PPE, placed in double-sealed bags and put into designated sealed skip awaiting off-site disposal.

The Contractor will need to submit a method statement and risk assessment regarding mitigation of asbestos risks. As a minimum, this should ensure that soils are kept damp during site works and that all personnel have appropriate PPE.

4.9 Grossly contaminated soils

Elevated concentrations of PAHs were encountered within REL's TP07 which could be indicative of a former fuel source in the vicinity. A watching brief should be in place when carrying out excavations/earthworks in this area.

During earthworks, should any areas of grossly contaminated soils be encountered, work should cease immediately, and further advice be sought from the Engineer.

Any excavations to remove contaminated materials from hotspots should have their extents accurately recorded by survey. In order to validate removal of contaminated material, samples shall be taken from the base and 4 side walls of the excavation. For larger excavations, sampling of the base and side walls shall continue every 10m until all grossly contaminated material has been 'chased out'. A PID instrument should be used to assist in delineating the contamination, via headspace analysis of samples taken, using <10ppm isobutylene as a target value.

Where grossly contaminated soils are excavated, they should be placed within a designated stockpile. The stockpile should be underlain by protective material (eg Visqueen), covered, and bunded to prevent leaching of contamination into soils below.

Contaminated materials from different site areas may be impacted by different sources and so should not be placed together; separate stockpiles are required for different areas of hydrocarbon-impacted soils.

At least 6 samples should be taken from each stockpile and be scheduled for chemical analysis by the Engineer. On receipt of results, the fate of the material shall be determined (i.e. either treatment or off-site disposal). Where treatment is proposed, appropriate permits/exemptions should be requested from the Environment Agency.

Any hydrocarbon-impacted material should be taken off-site should be removed as quickly as possible in order to minimise nuisance to surrounding land users.

4.10 Placement and validation of fill

As noted in the Ground Appraisal Report, the site's topography will necessitate significant earthworks to create level development platforms.

Placement of fill by the Contractor shall be done in accordance with Apex's Earthworks Specification (ref. 1152-ACE-GEO-ES-002), dated September 2024.

4.11 Water supply pipes

Given the site's history, use of standard water mains is likely to be acceptable. However, this should be verified by the service provider (Yorkshire Water) and may necessitate UKWIR testing along the route of proposed mains in areas where made ground is present.

4.12 Hazardous Gas

Ground Gas

In accordance with BS 84585-2015+A1:2019, assuming a gas characterisation of CS2 and a Type B building a gas protection score of 3.5 should be achieved using a combination of two or more of the following:

- Structural barrier of the floor slab or basement slab and walls
- Ventilation measures
- Gas resistant membrane

Floor slab

It is likely that most/all plots will utilise a suspended floor slab, thus not achieving any “points” in relation to gas protection.

Ventilation

Most plots are likely to employ a suspended floor slab, likely pre-cast block and beam where which a sub-floor void of at least 250mm is required.

In accordance with BS 8485-2015+A1:2019, a score of 1.5 with a passive sub floor dispersal layer where a clear void with air bricks placed along the building edges allow for natural dispersion.

Membrane

It is recommended that a gas membrane is combined with the floor slab to meet the required gas protection score.

In accordance with BS 8485-2015+A1:2019, a score of 2.0 can be assumed for the membrane providing the membrane is:

- Sufficiently impervious in material and in sealing sheets & around penetrations
- Sufficiently durable to remain serviceable for the life of the building and the duration of gas emissions
- Sufficiently strong to withstand installation process; damage during construction; in-service stresses (eg settlement if placed beneath floor slab)
- Capable of providing a complete barrier to entry of hazardous gas following installation
- Verified in accordance with YALPAG Guidance[2] and CIRIA Gudiance[3] a copy of the YALPAG Guidance is included as Appendix D.

[2] Verification Requirements for Gas Protection Systems – YALPAG (December 2016)
[3] Good practice on the testing and verification of protection systems for buildings against hazardous ground gases – CIRIA (2014)

The developer should send a copy of this gas risk assessment to the membrane supplier, installer, and verifier to ensure the conditions of this assessment are met.

Radon

Basic radon protection measures are required for plots in the north.

BRE guidance[4] states that basic radon protection measures comprise the following:

- Membrane within floor construction (minimum 1,200 gauge)
- Link of membrane into the DPC in the building walls
- Cavity trays to be used within walls to link the DPC to the radon membrane
- Joints within the membrane and service penetrations are to be sealed

BRE guidance also recommends installation be carried out by a competent installer accredited National Occupational Standard (NOS), Construction Skills Certification Scheme (CSCS) or similar gas barrier scheme.

Given the need for CS2 measures outlined above, the radon risk will be mitigated with the placement of an appropriate membrane as recommended, subject to the conditions above being met.

Inspection of the membrane should also be carried out during installation to ensure the above requirements are met.

Gas Verification Requirements are presented in Section 5.4.

4.13 Imported materials

Import of suitable aggregate is likely to be required for highway construction; only natural products (i.e. quarried aggregate) or inert recycled material are considered suitable.

Where natural aggregates are used (products) evidence of the source of material shall be provided to the Engineer for use in the Validation Report.

Where recycled aggregates are used, evidence that the material is compliant with WRAP Quality Protocol[5] shall be provided to the Engineer for use in the Validation Report.

[4] Guidance on protective measures for new buildings - BR211 Radon (2015)
[5] Aggregates from inert waste – end of waste criteria for the production of aggregates from inert waste – Environment Agency

Proposed End Use	Testing criteria/material type	Additional Requirements
Materials placed within natural ground at base of excavation (eg, for blinding/bedding of floor slab)	Clean, naturally occurring aggregate to be used. Evidence of source to be provided.	Geotechnical suitability (see Apex's Earthworks Specification).
	Recycled materials, produced in accordance with WRAP Quality Protocol[6]. Evidence of compliance with WRAP protocol to be provided.	
Imported soil for landscaping (see section 4.13 below)	No set screening values, but soils must be clean naturally occurring only, with background concentrations at or below those on the development site.	No geotechnical criteria for landscaped soils. Topsoil should comply with BS 3882 Specification for Topsoil requirements. No groundwater constraints for imported natural soils.

4.14 Provision of cover to soft landscaping

As per the findings of the Ground Appraisal Report, Topsoil/Made Ground Topsoil has been Zoned with respect to suitability for re-use into 3 areas:

Area	Suitability
Main site	Topsoil from the Main Area is clean naturally occurring and can be reused in garden areas and areas of POS. Surplus topsoil from the main area could be reused on another development, moved via direct transfer under the Definition of Waste Code of Practice (DoW:CoP).
Car park	Topsoil from the Car Park zone must be stockpiled separately and resampled prior to consideration of reuse.
Former Jubilee Property & garages	Topsoil/Made Ground Topsoil from Jubilee Garage zone is suitable for reuse on site subject to screening prior to use and hand-picking of any isolated fragments of ACMs.

Where material is found to be unsuitable, it will require either:

- Removal from site; or,
- Isolation beneath 600mm clean soil cover, including at least 150mm topsoil

Clean site-won natural ground (i.e. excavated during earthworks, when laying drainage etc) could be used as the clean soil cover, subject to this being covered in the MMP.

[6] Aggregates from inert waste – end of waste criteria for the production of aggregates from inert waste – Environment Agency

Any imported soils used as clean cover/topsoil should be subjected to quality checks by the Engineer, as per the requirements of YALPAG Guidance[7].

Testing requirements for imported materials are summarised in the table below:

Source	No. samples	Minimum testing
Virgin quarried material	Two	pH & metals
Crushed hardcore, stone, brick (excludes asphalt)	Minimum 3 and at least 1 per 500m^3	pH & metals, speciated PAH, asbestos, banded TPH*
Greenfield/manufactured soils	Minimum 3 and at least 1 per 250m^3*	pH & metals, speciated PAH, asbestos, banded TPH, TOC
Brownfield/screened soils	Minimum 6 and at least 1 per 100m^3	pH & metals, speciated PAH, asbestos, banded TPH, TOC*

* additional samples and testing may be required depending on history of the donor site/source of material.

In addition to the above, it is recommended that any soil used as a growing medium is also subject to Topsoil Quality testing in line with BS3882 requirements.

A full copy of the YALPAG Guidance is included as Appendix C.

Chemical analysis results shall be compared to screening values in order to check suitability for re-use. Screening values recommended are presented in Appendix A; land use to be assumed is “Residential with Home Produce - RwHP”.

Where soil cover is placed as a remediation requirement, the thickness and quality of clean cover shall be inspected by the Engineer. Where requested, the Contractor shall arrange for inspection pits to be excavated to the Engineer’s satisfaction. The Engineer will check to make sure the thickness of soil cover is in line with the requirements of the Remediation Strategy. The Engineer will also check to make sure the quality of materials has not been compromised during placement (i.e. mixing with construction wastes etc).

Photographs of the inspection pits shall be taken using a surveying staff to provide evidence of soil thickness; the locations of the inspection pits shall also be recorded; as per the requirements of YALPAG Guidance. This information will be used in the Validation Report.

4.15 Off-site disposal

Assessment of any material proposed for off-site disposal should be undertaken in accordance with WM3[8]. At the heart of this guidance is the need to accurately characterise sub-populations of waste via appropriate sampling (ideally when stockpiled). Waste classification should never be determined on the basis of individual sample test results. Consequently, landfills accepting waste from this site may require additional testing of stockpiles prior to disposal.

[7] Verification Requirement for Cover Systems – YALPAG (June 2021)
[8] Technical Guidance WM3 – Guidance on the classification and assessment of waste – Environment Agency (2015)

Waste Acceptance Criteria (WAC) testing should only be required where material is likely to be disposed of as 'hazardous' based on the WM3 assessment.

Where materials are taken off site, an auditable trail should be left including transfer note signed by all parties involved. This should include details of the nature and volume of waste, the waste haulier and the material's final destination.

Where excavations result in an excess of clean, naturally occurring soils, consideration should be given to a direct transfer to another site under the CL:AIRE Definition of Waste Code of Practice[9]. It is recommended that a detailed earthworks balance is completed prior to commencement on site to assess the likelihood and approximate volume of surplus clean naturally occurring arisings to ensure these are clearly identified in the material management plan; this will support sustainable reuse of soils.

Non-Hazardous Wastes

Non-hazardous wastes removed from site for disposal must:

- Be accompanied by waste transfer notes (each load)
- Comply with the permitting requirements of the receiving landfill
- Comply with the waste acceptance criteria of the receiving landfill
- Include a written description of any pre-treatments or processes that have been applied to the waste

Signed waste transfer notes and returns must be kept for a minimum of 2 years and be available for inspection by the Local Authority or the Environment Agency when asked.

Hazardous Wastes

Should waste soil arisings be assessed to be hazardous waste requiring treatment prior to disposal, the Contractor shall carry out pre-treatment of the waste soils either on-Site (under an appropriate Environmental Permit to a methodology that is agreed with the receiving landfill operator) or off-site at a Permitted facility.

For Hazardous Wastes removed from site, the following additional requirements apply:

- A Hazardous Waste Consignment Note must be completed with each load.
- The waste must be taken to the receiving landfill by a registered Hazardous Waste Carrier
- Copies of signed Consignment Notes and Consignee Returns must be kept for a minimum of 3 years at the premises that produced or stored the waste and be available for inspection by an enforcement officer from the Local Authority or Environment Agency when asked.

[9] The Definition of Waste: Code of Practice CL:AIRE (March 2011)

4.16 Management of materials

As mentioned in Section 4.3, a MMP should be prepared by the Contractor. The Contractor shall comply with the following hierarchy of waste management requirements:

- Prevention of waste generation;
- Reuse and/or recycle the materials for beneficial use on other projects; and
- Dispose of the materials at a suitably licensed Site.

During earthworks, good materials management is essential in order to maximise material re-use and minimise off-site disposal costs. Materials belonging to separate soil types should not be mixed.

The generation of stockpiles of excavated material shall be minimised as far as is reasonably practical. Any soils that are stockpiled shall be managed in a controlled manner, with different material types segregated and clearly labelled.

The Contractor shall employ a system to track the material and stockpiles; from the creation of the stockpile through to the final destination of the material. The Contractor shall maintain a log on site of the material/stockpile tracking system. The log shall incorporate reference to validation testing where required. Each stockpile shall be identified according to assumed or confirmed categorisation, source, type and deposition date, and details of any chemical analyses.

Stockpiles shall be physically separated to avoid cross contamination and temporary road access provided for placement and loading. Stockpiles shall be positioned on impervious surfaces to collect drainage and prevent loss of entrained water and leachate to ground, the Contractor shall ensure that runoff from stockpiles is minimised and controlled such that it cannot enter local drains or impact the vicinity of the stockpile. Mitigation measures should be employed to minimise wind whip from stockpiled materials.

The Contractor shall determine the methods for appropriate handling and storage of materials which may include damping down and covering of stockpiles where necessary. All excavation arisings shall either:

- be loaded directly into lorries for further sorting and segregation in other areas of the Site; moved directly to the required location; and/or,
- stockpiled in a methodical order for future reuse.

Each stockpile should be identified according to assumed or confirmed categorisation, source, type and deposition date, and details of any chemical analyses.

Full records of the quantities of disposed materials and the receiving facilities shall be kept during the works. In addition, consignment notes for the materials shall be collated. A summary of all material types, volumes removed from the Site, receiving facilities/sites and Duty of Care documentation shall be provided within the Validation Report.

There should be separate stockpiles of:

- Hardcore surfacing
- Topsoil/Made Ground Topsoil from the north-east (see Drawing 006)
- Topsoil/Made Ground Topsoil from the west (see Drawing 006)
- Topsoil from elsewhere on site
- Any grossly contaminated soils (see also comments in Section 4.12)
- Excess natural ground arisings

The reuse, movement and/or treatment of soils on or off-site shall be completed in accordance with a Materials Management Plan. Where secondary aggregates are brought onto Site these shall be produced in accordance with the WRAP Quality Protocol for the production of aggregates from inert waste.

The Contractor shall ensure that effective materials management and storage is practiced and that waste streams do not become mixed. All Site staff shall be made aware of the materials management strategy being employed during the works.

4.17 Environmental monitoring

The Contractor should comply with any environmental monitoring and mitigation requirements as agreed with the local authority, such as: -

- Noise
- Dust
- Odour
- Surface water runoff

4.18 Well

Monitoring wells installed as part of previous investigations shall be located and decommissioned prior to remediation works commencing. The methodology used to decommission the boreholes should be in accordance with EA document: 'Decommissioning Redundant Boreholes and Wells' and approved by the Engineer who should be present during the decommissioning works.

During earthworks, a watching brief shall be in place during excavation of made ground within the vicinity of the former well in the north. If located, the well should also be decommissioned in line with the Environment Agency document: 'Decommissioning Redundant Boreholes and Wells' and approved by the Engineer who should be present during the decommissioning works.

5. VERIFICATION

5.1 General

In accordance with LCRM[10], on completion of remediation works, a Verification Report shall be prepared by the Engineer. The Verification Report should include:

- Overview of the works undertaken, including any divergence from this Strategy due to unexpected ground conditions.
- Source information, chemical test results and delivery records for any imported material.
- Verification test results from sidewalls and base of any hotspot excavations
- Geotechnical test results (labs and in-situ testing) for material used in the piling mat, and any other material placed to a specification.
- Refence to the MMP and any deviation from it.
- Final destination of any contaminated soils (including evidence of off-site disposal where appropriate in the form of haulage records).
- Summary of the volumes of materials used.
- Copies of consignment notes and chain of custody documents relating to the disposal of soils and asbestos containing materials from the site; and including copies of any correspondence with regulators relating to the works.
- Certification of installation of any protective barrier pipes for water supply.
- Signed Declaration from the QP.
- Certification for the installation of gas protection measures, prepared by a competent person (see further details in Section 4.14).
- Survey data including:
    - Natural ground levels where exposed during earthworks
    - Location and extent of obstructions left in place
    - Location and extent of backfilled 'hollows' arising from excavation of hotspots, obstructions etc
    - Location of contaminated materials where redistributed on site
    - Location and volumes of stockpiles remaining on site
    - site
    - Location and volumes of stockpiles remaining on site

5.2 Supervision

In order for the Engineer to confidently verify works have been undertaken correctly, on-site supervision is required. Activities such as plate load testing and removal of contaminated soils should be supervised full time, whereas other activities could be supervised on a part-time basis.

The Contractor shall ensure a good line of communication with the Engineer regarding site progress to ensure that the Engineer is able to visit site during critical stages of works.

[10] Land Contamination Risk Management (8th October 2020)

When on site, the Engineer shall record the day's activities including all plant, personnel and materials involved.

5.3 Soil cover validation

Placement of soil cover requires validation by the Engineer; the testing and inspection requirements are given in Section 4.12.

However, soil cover is often imported at later stages during remediation works. Therefore, the validation report for areas of landscaping could be submitted as a separate addendum once this element is completed.

5.4 Gas Verification Plan

As noted in Key Point 4 of YALPAG Guidance, the qualification and experience of the installer of gas protection measures will determine the level of verification required.

The site has been classified as CS2 and requires basic radon protection measures; and protection measures will likely comprise a ventilated sub-floor void and installation of a gas membrane (see Section 4.12).

Once gas protection measures have been finalised, a Gas Verification Plan should be produced which will include:

- A summary of the ground gas risk assessment.
- Details of the proposed gas protection measures, including technical specifications and drawings for the product(s) to be used.
- Details of the Verifier and Installer, including all relevant qualifications and experience.
- Details of how the works will be verified/tested and by who.
- How the works will be reported.

Once designs are finalised and details of the aforementioned parties are known, this Remediation Strategy should be updated and submitted to the Local Authority for their approval.

Apex Consulting Engineers

Unit 3 Acres Hill Business Park
Acres Hill Lane
Sheffield
S9 4LR

0114 241 9360

Appendix A – Soil Screening Values

Notes	
Definitions for the various land-use scenarios are given in SP1010[1] and SR3[2]; a summary is below:	
RwHP	Residential end-use with priavte garden and home-grown produce
RwoHP	Residential end-use with priavte garden and no home-grown produce
Allotments	Plot of open space for growing of produce for human consumption
Commercial	Commerical/light industrial property, 3 storeys and employees based indoors
POS_{resi}	Public Open Space in close proximity to residential housing
POS_{park}	Public park for recreational use (picnics, playground, sports, dog walking)

References

1 - SP1010 - Development of Category 4 Screening Values for Assessment of Land Affected by Contamination - CL:AIRE (2014)

2 - Science Report; SC050021/SR3 Updated technical backgroud to the CLEA model - Environment Agency (2009)

Contaminant	Screening Values (soils) - inorganics					
	RwHP	RwoHP	Allotments	Commercial	POS_{resi}	POS_{park}
Arsenic	37	40	43	654	79	170
Berlyllium	1.7	1.7	35	12	2.2	63
Boron	290	11000	45	240000	21000	46000
Cadmium	11	85	1.9	190	120	532
Chromium III	910	910	18000	8600	1500	33000
Chromium VI	6	6	1.8	33	7.7	220
Copper	2400	7100	520	68000	12000	44000
Lead	200	310	80	2300	630	1300
Mercury (inorganic)	40	56	19	1100	120	240
Nickel	180	180	230	980	230	3400
Selenium	250	430	88	12000	1100	1800
Vanadium	410	1200	91	9000	2000	5000
Zinc	3700	40000	620	730000	81000	170000
Asbestos	Not detected*	Not detected*	Not detected*	Not detected*	Not detected*	Not detected*

* As an initial screen, not detected shall be used as a screening value for asbestos. Further analysis (quantification) and risk assessment is required where asbestos screening shows a positive ID.

Contaminant	Screening Values (soils) - organics		
	RwHP		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	0.087	0.17	0.37
Toluene	130	290	660
Ethylbenzene	47	110	260
o-xylene	60	140	330
m-xylene	59	1410	320
p-xylene	56	130	310
Aliphatic 5-6	42	78	160
Aliphatic >6-8	100	230	530
Aliphatic >8-10	27	65	150
Aliphatic >10-12	130 (48)[vap]	330 (118)[vap]	760 (283)[vap]
Aliphatic >12-16	1100 (24)[sol]	2400 (59)[sol]	4300 (142)[sol]
Aliphatic >16-35	65000 (8.48)[sol]	92000 (21)[sol]	110000
Aliphatic >35-44	65000 (8.48)[sol]	92000 (21)[sol]	110000
Aromatic 5-7	70	140	300
Aromatic >7-8	130	290	660
Aromatic >8-10	34	83	190
Aromatic >10-12	74	180	380
Aromatic >12-16	140	330	660
Aromatic >16-21	260	540	930
Aromatic >21-35	1100	1500	1700
Aromatic >35-44	1100	1500	1700
Aliphatic & Aromatic >44-70	1600	1800	1900
Acenaphthene	210	510	1100
Acenaphthylene	170	420	920
Anthracene	2400	5400	11000
Benz[a]anthracene	7.2	11	13
Beno[a]pyrene	2.2	2.7	3
Benzo[b]fluoranthene	2.6	3.3	3.7
Benzo[ghi]perylene	320	340	350
Benzo[k]fluoranthene	77	93	100
Chrysene	15	22	27
Dibenz[ah]anthracene	0.24	0.28	0.3
Fluoranthene	280	560	890
Fluorene	170	400	860
Ideno[12-cd]pyrene	27	36	41
Naphthalene	2.3	5.6	13
Phenanthrene	95	220	440
Pyrene	620	1200	2000
Coal tar	0.79	0.98	1.1

Contaminant	Screening Values (soils) - organics		
	RwoHP		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	0.38	0.7	1.4
Toluene	880[vap] (869)	1900	3900
Ethylbenzene	83	190	440
o-xylene	88	210	480
m-xylene	82	190	450
p-xylene	79	180	430
Aliphatic 5-6	42	78	160
Aliphatic >6-8	100	230	530
Aliphatic >8-10	27	65	150
Aliphatic >10-12	130 (48)[vap]	330 (118)[vap]	770 (283)[vap]
Aliphatic >12-16	1,100 (24)[sol]	2400 (59)[sol]	4400 (142)[sol]
Aliphatic >16-35	65000 (8.48)[sol]	92000 (21)[sol]	110000
Aliphatic >35-44	65000 (8.48)[sol]	92000 (21)[sol]	110000
Aromatic 5-7	370	690	1400
Aromatic >7-8	860	1800	3900
Aromatic >8-10	47	110	270
Aromatic >10-12	250	590	1200
Aromatic >12-16	1800	2300 (419) [sol]	2500
Aromatic >16-21	1900	1900	1900
Aromatic >21-35	1900	1900	1900
Aromatic >35-44	1900	1900	1900
Aliphatic & Aromatic >44-70	1900	1900	1900
Acenaphthene	3000 (57) [sol]	4700 (141) [sol]	6000 (336) [sol]
Acenaphthylene	2900 (86.1) [sol]	4600 (212) [sol]	6000 (506) [sol]
Anthracene	31000 (1.17) [vap]	35000	37000
Benz[a]anthracene	11	14	15
Beno[a]pyrene	3.2	3.2	3.2
Benzo[b]fluoranthene	3.9	4	4
Benzo[ghi]perylene	360	360	360
Benzo[k]fluoranthene	110	110	110
Chrysene	30	31	32
Dibenz[ah]anthracene	0.31	0.32	0.32
Fluoranthene	1500	1600	1600
Fluorene	2800 (30.9) [sol]	3800 (76.5) [sol]	4500 (183) [sol]
Ideno[12-cd]pyrene	45	46	46
Naphthalene	2.3	5.6	13
Phenanthrene	1300 (36.0) [sol]	1500	1500
Pyrene	3700	3800	3800
Coal tar	1.2	1.2	1.2

Contaminant	Screening Values (soils) - organics		
	Allotments		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	0.017	0.034	0.075
Toluene	22	51	120
Ethylbenzene	16	39	91
o-xylene	28	67	160
m-xylene	31	74	170
p-xylene	29	69	160
Aliphatic 5-6	730	1700	3900
Aliphatic >6-8	2300	5600	13000
Aliphatic >8-10	320	770	1700
Aliphatic >10-12	2200	4400	7300
Aliphatic >12-16	11000	13000	13000
Aliphatic >16-35	260000	270000	270000
Aliphatic >35-44	260000	270000	27000
Aromatic 5-7	13	27	57
Aromatic >7-8	22	51	120
Aromatic >8-10	8.6	21	51
Aromatic >10-12	13	31	74
Aromatic >12-16	23	57	130
Aromatic >16-21	46	110	260
Aromatic >21-35	370	820	1600
Aromatic >35-44	370	820	1600
Aliphatic & Aromatic >44-70	1200	2100	3000
Acenaphthene	34	85	200
Acenaphthylene	28	69	160
Anthracene	380	950	2200
Benz[a]anthracene	2.9	6.5	13
Beno[a]pyrene	0.97	2	3.5
Benzo[b]fluoranthene	0.99	2.1	3.9
Benzo[ghi]perylene	290	470	640
Benzo[k]fluoranthene	37	75	130
Chrysene	4.1	9.4	19
Dibenz[ah]anthracene	0.14	0.27	0.43
Fluoranthene	52	130	290
Fluorene	27	67	160
Ideno[12-cd]pyrene	9.5	21	39
Naphthalene	4.1	10	2.4
Phenanthrene	15	38	90
Pyrene	110	270	620
Coal tar	0.32	0.67	1.2

Contaminant	Screening Values (soils) - organics		
	Commercial		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	27	47	90
Toluene	5600[vap] (869)	110000[vap] (1920)	180000[vap] (4360)
Ethylbenzene	5700[vap] (518)	13000[vap] (1220)	27000[vap] (2840)
o-xylene	6600[sol] (478)	15000[sol] (1120)	33000[sol] (2620)
m-xylene	6200[vap] (625)	14000[vap] (1470)	31000[vap] (3460)
p-xylene	5900[sol] (576)	14000[sol] (1350)	30000[sol] (3170)
Aliphatic 5-6	3200 (304)[sol]	5900 (558)[sol]	12000 (1150)[sol]
Aliphatic >6-8	7800 (144)[sol]	17000 (322)[sol]	40000 (736)[sol]
Aliphatic >8-10	2000 (78)[sol]	4800 (190)[vap]	11000 (451)[vap]
Aliphatic >10-12	9700 (48)[sol]	23000 (118)[vap]	47000 (283)[vap]
Aliphatic >12-16	59000 (24)[sol]	82000 (59)[sol]	90000 (142)[sol]
Aliphatic >16-35	1600000	1700000	1800000
Aliphatic >35-44	1600000	1700000	1800000
Aromatic 5-7	26000 (1220)[sol]	46000 (2260)[sol]	86000 (4710)[sol]
Aromatic >7-8	56000 (869)[vap]	110000 (1920)[sol]	180000 (4360)[vap]
Aromatic >8-10	3500 (613)[vap]	8100 (1500)[vap]	17000 (3850)[vap]
Aromatic >10-12	16000 (364)[sol]	28000 (899)[sol]	34000 (2150)[sol]
Aromatic >12-16	36000 (169)[sol]	37000	38000
Aromatic >16-21	28000	28000	28000
Aromatic >21-35	28000	28000	28000
Aromatic >35-44	28000	28000	28000
Aliphatic & Aromatic >44-70	28000	28000	28000
Acenaphthene	84000 (57) [sol]	97000 (141) [sol]	100000
Acenaphthylene	83000 (86.1) [sol]	97000 (212) [sol]	100000
Anthracene	520000	540000	540000
Benz[a]anthracene	170	170	180
Beno[a]pyrene	35	35	36
Benzo[b]fluoranthene	44	44	45
Benzo[ghi]perylene	3900	4000	4000
Benzo[k]fluoranthene	1200	1200	1200
Chrysene	350	350	350
Dibenz[ah]anthracene	3.5	3.6	3.6
Fluoranthene	23000	23000	23000
Fluorene	63000 (30.9) [sol]	68000	71000
Ideno[12-cd]pyrene	500	510	510
Naphthalene	190 (76.4) [sol]	460 (183) [sol]	1100 (432) [sol]
Phenanthrene	22000	22000	23000
Pyrene	54000	54000	54000
Coal tar	15	15	15

Contaminant	Screening Values (soils) - organics		
	POS_{resi}		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	72	72	73
Toluene	56000	56000	56000
Ethylbenzene	24000	24000	25000
o-xylene	41000	42000	43000
m-xylene	41000	42000	43000
p-xylene	41000	42000	43000
Aliphatic 5-6	570000 (304) [sol]	590000	60000
Aliphatic >6-8	600000	610000	620000
Aliphatic >8-10	13000	13000	13000
Aliphatic >10-12	13000	13000	13000
Aliphatic >12-16	13000	13000	13000
Aliphatic >16-35	250000	250000	250000
Aliphatic >35-44	250000	250000	250000
Aromatic 5-7	56000	56000	56000
Aromatic >7-8	56000	56000	56000
Aromatic >8-10	5000	5000	5000
Aromatic >10-12	5000	5000	5000
Aromatic >12-16	5100	5100	5000
Aromatic >16-21	3800	3800	3800
Aromatic >21-35	3800	3800	3800
Aromatic >35-44	3800	3800	3800
Aliphatic & Aromatic >44-70	3800	3800	3800
Acenaphthene	15000	15000	15000
Acenaphthylene	15000	15000	15000
Anthracene	74000	74000	74000
Benz[a]anthracene	29	29	29
Beno[a]pyrene	5.7	5.7	5.7
Benzo[b]fluoranthene	7.1	7.2	7.2
Benzo[ghi]perylene	640	640	640
Benzo[k]fluoranthene	190	190	190
Chrysene	57	57	75
Dibenz[ah]anthracene	0.57	0.57	0.58
Fluoranthene	3100	3100	3100
Fluorene	9900	9900	9900
Ideno[12-cd]pyrene	82	82	82
Naphthalene	4900	4900	4900
Phenanthrene	3100	3100	3100
Pyrene	7400	7400	7400
Coal tar	2.2	2.2	2.2

Contaminant	Screening Values (soils) - organics		
	POS_{park}		
	1% SOM (0.6% TOC)	2.5% SOM (1.5% TOC)	6% SOM (3.5% TOC)
Benzene	90	100	110
Toluene	87000[vap] (869)	95,000[vap] (1920)	100000[vap] (4360)
Ethylbenzene	17000[vap] (518)	22000[vap] (1220)	27000[vap] (2840)
o-xylene	17000[sol] (478)	24000[sol] (1120)	33000[sol] (2620)
m-xylene	17000[vap] (625)	24000[vap] (1470)	32000[vap] (3460)
p-xylene	17000[sol] (576)	23000[sol] (1350)	31000[sol] (3170)
Aliphatic 5-6	95000 (304) [sol]	130000 (558) [sol]	180000 (1150) [sol]
Aliphatic >6-8	150000 (144) [sol]	220000 (322) [sol]	320000 (736) [sol]
Aliphatic >8-10	14000 (78) [sol]	18000 (190)[vap]	21000 (451)[vap]
Aliphatic >10-12	21000 (48) [sol]	23000 (118)[vap]	24000 (283)[vap]
Aliphatic >12-16	25000 (24) [sol]	25000 (59) [sol]	26000 (142) [sol]
Aliphatic >16-35	450000	480000	490000
Aliphatic >35-44	450000	480000	490000
Aromatic 5-7	76000 (1220) [sol]	84000 (2260) [sol]	92000 (4710) [sol]
Aromatic >7-8	87000 (869) [vap]	95000 (1920) [sol]	100000 (4360)[vap]
Aromatic >8-10	7200 (613) [vap]	8500 (1500) [vap]	9300 (3850) [vap]
Aromatic >10-12	9200	9700	10000
Aromatic >12-16	10000	10000	10000
Aromatic >16-21	7600	7700	7800
Aromatic >21-35	7800	7800	7900
Aromatic >35-44	7800	7800	7900
Aliphatic & Aromatic >44-70	7800	7800	7900
Acenaphthene	29000	30000	30000
Acenaphthylene	29000	30000	30000
Anthracene	150000	150000	150000
Benz[a]anthracene	49	56	62
Beno[a]pyrene	11	12	13
Benzo[b]fluoranthene	13	15	16
Benzo[ghi]perylene	1400	1500	1600
Benzo[k]fluoranthene	370	410	440
Chrysene	93	110	120
Dibenz[ah]anthracene	1.1	1.3	1.4
Fluoranthene	6300	6300	6400
Fluorene	20000	20000	20000
Ideno[12-cd]pyrene	150	170	180
Naphthalene	1200 (76.4) [sol]	1900 (183) [sol]	3000
Phenanthrene	6200	6200	6300
Pyrene	15000	15000	15000
Coal tar	4.4	4.7	4.8

Appendix B – Drawings

Project

MAIN AVE, KIRKLEES

Title

001 - SITE LOCATION PLAN

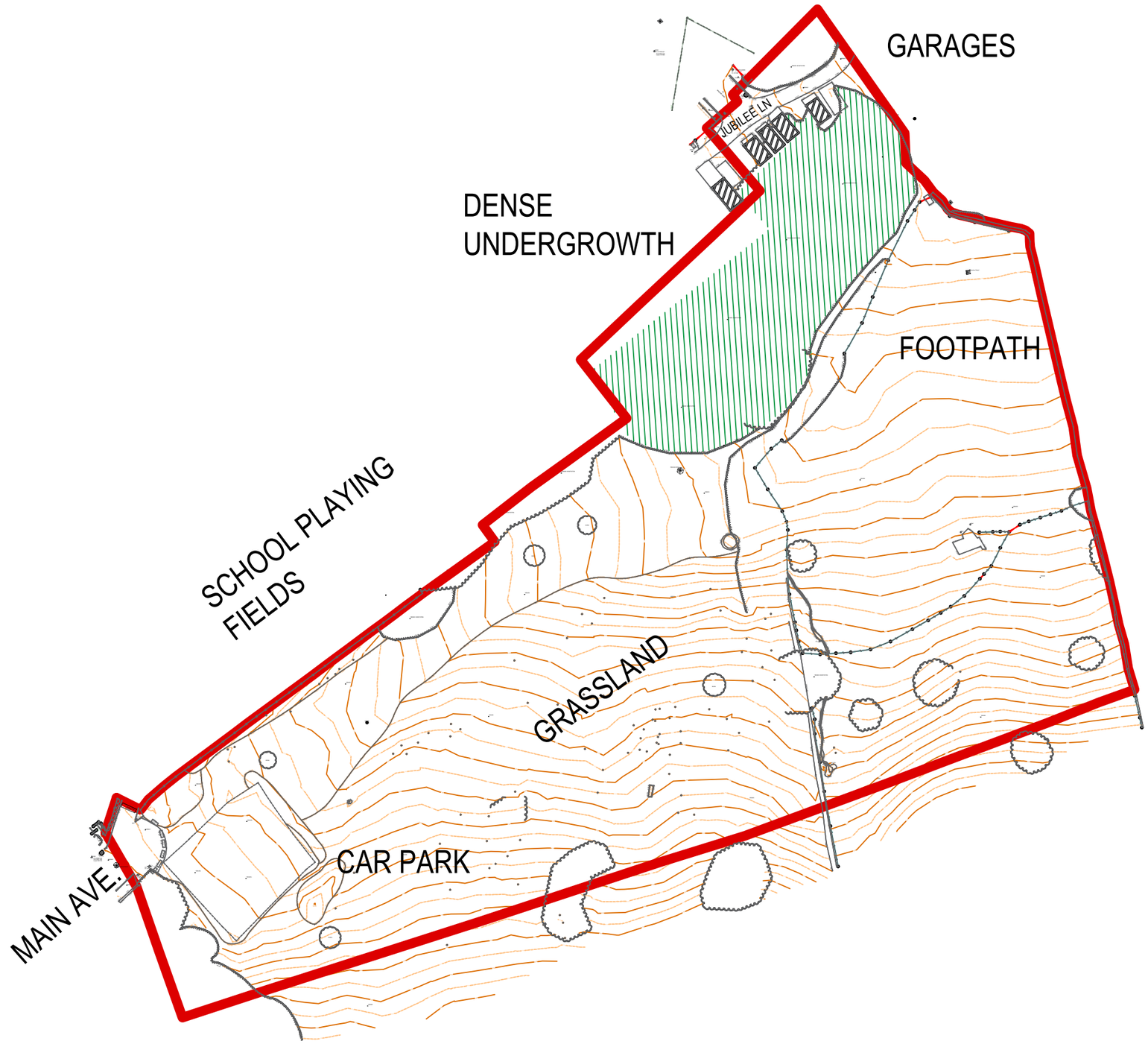
Job No.

1152

A4

APEX CONSULTING ENGINEERS

www.apexconsulting.co.uk | 0114 241 9360

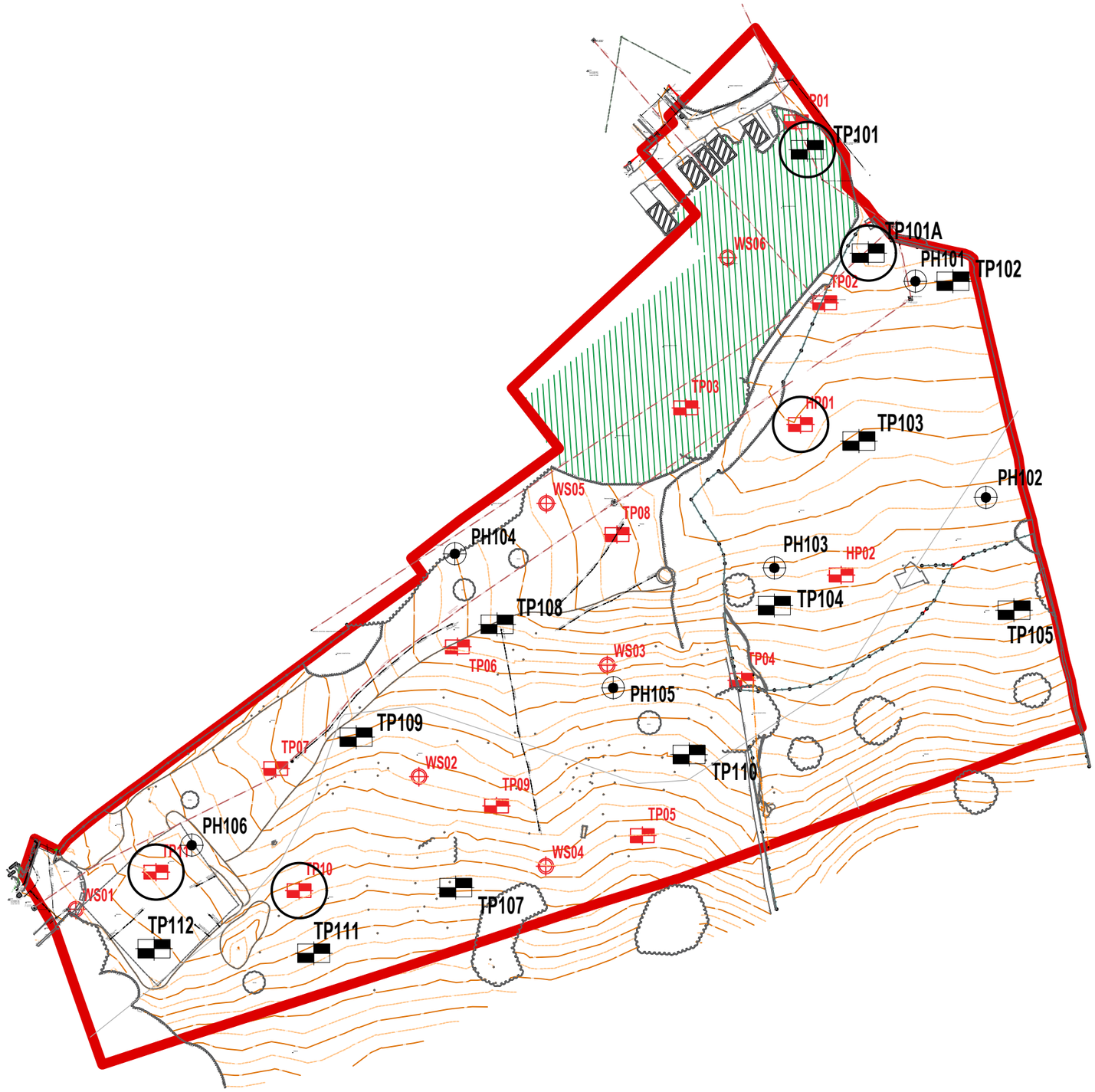


NORTH

APPROX. SITE BOUNDARY

Client	Project	Scale
STRATA HOMES	MAIN AVENUE, KIRKLEES	1:1,000 @ A3
		Date
		JUNE 2024
	Title	
	002 - SITE FEATURES	
A3		

APEX CONSULTING ENGINEERS
www.apexconsulting.co.uk | 0114 241 9360



NORTH

ROBERTS ENVIRONMENTAL - 2022

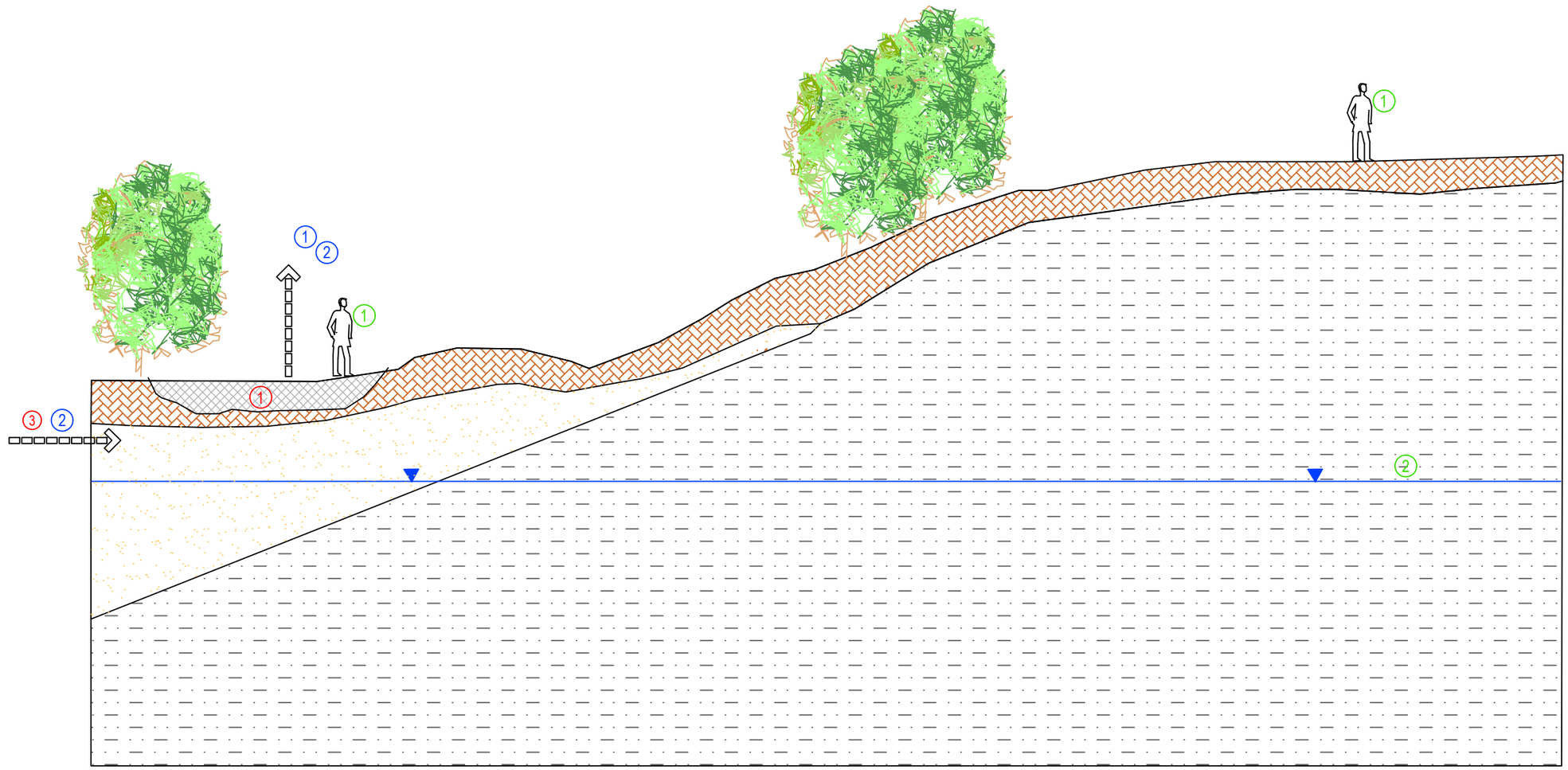
- TRIAL PIT LOCATION
- WINDOW SAMPLE LOCATION

APEX - MAY 2024

- TRIAL PIT LOCATION
- PROBEHOLE LOCATION
- APPROX. SITE BOUNDARY

Client: STRATA HOMES	Project: MAIN AVENUE, KIRKLEES	Scale: 1:1000 @ A3
		Date: MAY 2024
	Title: 004 - EXP HOLE LOCATIONS	
A3		

APEX CONSULTING ENGINEERS
www.apexconsulting.co.uk | 0114 241 9360



GROUND TYPES	SOURCES	PATHWAYS	RECEPTORS
MADE GROUND (JUBILEE PROPERTY & CAR PARK)	① MADE GROUND (ASBESTOS - JUBILEE/ GARAGES AND PAHs - CAR PARK)	① DERMAL CONTACT, INGESTION, INHALATION OF DUST	① HUMAN HEALTH
TOPSOIL	② OFF-SITE BACKFILLED QUARRIES	② GAS MIGRATION	② GROUNDWATER
HUDDERSFIELD WHITE ROCK SANDSTONE			
COAL MEASURES MUDSTONE			

Client
STRATA HOMES

A3

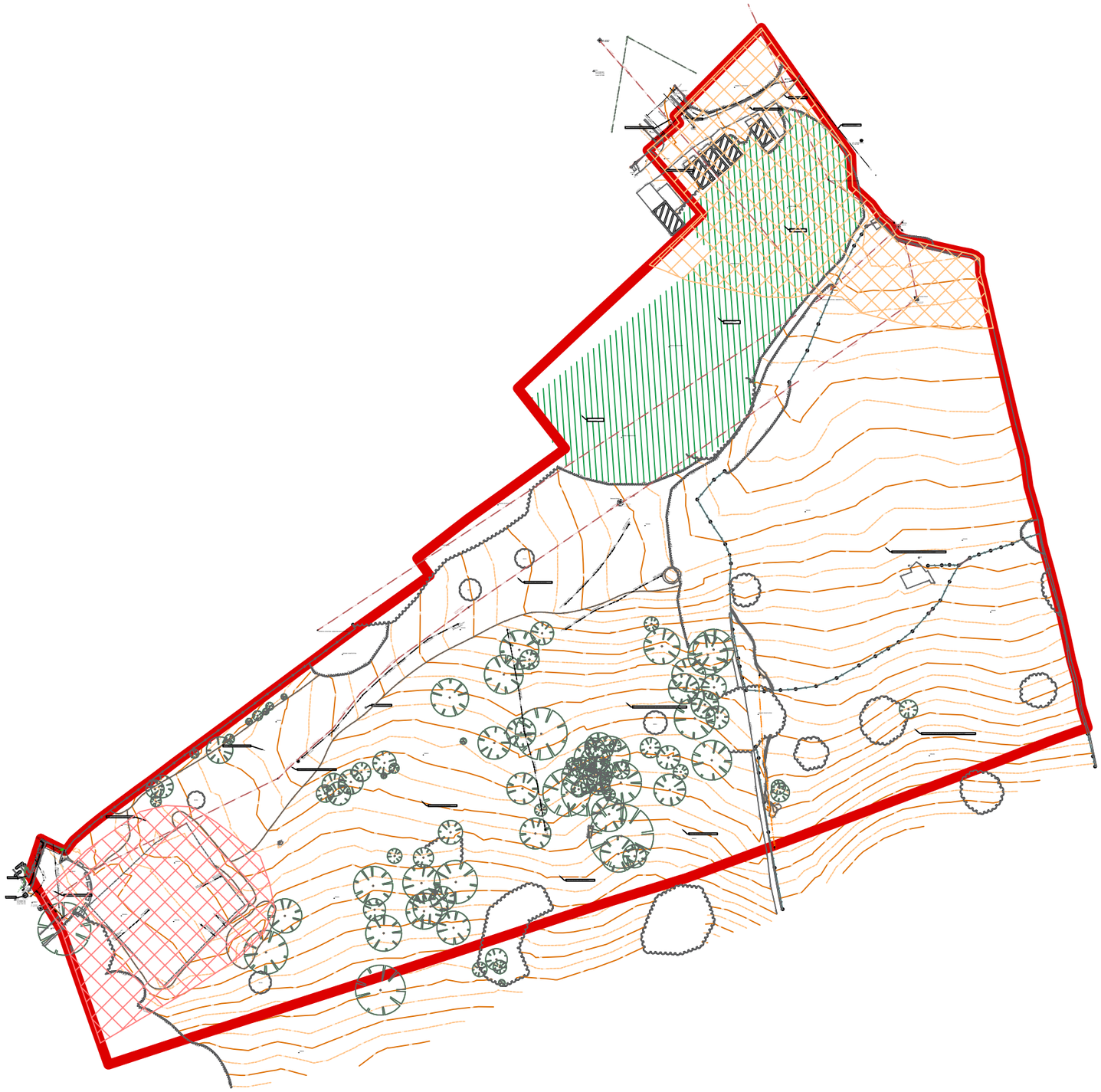
Project
MAIN AVENUE, KIRKLEES

Title
005 - REVISED CONCEPTUAL SITE MODEL

Scale
NTS

Date
JUNE 2024

APEX CONSULTING ENGINEERS
www.apexconsulting.co.uk | 0114 241 9360



NORTH

CAR PARK AREA

JUBILEE PROPERTY & GARAGES AREA

Client	Project	Scale
STRATA HOMES	MAIN AVENUE, KIRKLEES	1:1000 @ A3
		Date
		JUNE 2024
	Title	
A3	006 - TOPSOIL ZONING PLAN	

APEX CONSULTING ENGINEERS

www.apexconsulting.co.uk | 0114 241 9360

Appendix C – YALPAG Guidance (clean soil cover)

VERIFICATION REQUIREMENTS FOR COVER SYSTEMS

Technical Guidance for Developers, Landowners and Consultants

Yorkshire and Lincolnshire Pollution Advisory Group

Version 4.1 – June 2021

The purpose of this guidance is to promote consistency and good practice for development on land affected by contamination. The Local Authorities in Yorkshire, Lincolnshire, the North East of England, East Anglia, Greater Manchester and St Helens who have adopted this guidance are shown below:

Contents

Disclaimer

This guidance is intended to serve as an informative and helpful source of advice. YALPAG will review this guidance every three years, but readers must note that legislation, guidance and practical methods are inevitably subject to change and therefore should be aware of current UK policy and best practice. This note should be read in conjunction with prevailing legislation and guidance, as amended, whether mentioned here or not. Where legislation and documents are summarised this is for general advice and convenience, and must not be relied upon as a comprehensive or authoritative interpretation. Ultimately it is the responsibility of the person/company involved in the development or assessment of land to apply up-to-date working practices to determine the contamination status of a site and the remediation and verification requirements.

Acknowledgments

YALPAG would like to thank North Lincolnshire Council, Leeds City Council, City of Bradford Metropolitan District Council, Barnsley Metropolitan Borough Council, Rotherham Metropolitan Borough Council, Wakefield Council, and Tameside Metropolitan Borough Council, for producing this guidance.

YALPAG would also like to acknowledge Liverpool City Council's Contaminated Land Team, Coopers Consulting Engineers for allowing us to use their guidance document and photographs and WSP Environmental Ltd for also donating photographs.

Consultation

39 Local Authorities and 6 Environmental Consultants were consulted over a four week period in 2010 during the production of the initial guidance. At that time, consultation comments were considered by the review panel and a number of revisions were made to the guidance to reflect these comments.

49 Local Authorities and 25 Environmental Consultants were consulted in 2021, during the production of this version [4.1] of the guidance. Consultation comments were considered by the review panel and a number of revisions were made to the guidance to reflect these comments.

Introduction

This guidance has been produced to help developers ensure that they can demonstrate that material brought onto a development site for gardens or areas of soft landscaping are suitable for use and do not present harm to people, the environment and/or property. It is intended to improve the quality of reports submitted to Local Authorities on this matter and to give contractors/consultants a point of reference to obtain approval for such work from their client. This guidance does not cover the geotechnical suitability of soils or materials, chemical suitability that does not affect human health e.g. sulphates, or importing soils contaminated with invasive (or injurious) plants.

The verification of cover systems should be an integral part of the remediation project and agreed between developers and regulators at an early stage in the project.

UK guidelines for remediation verification are set out within Land Contamination Risk Management[1] (LCRM) and the document on Verification of Remediation of Land Contamination[2]. This guidance note should be considered as supplementary advice in conjunction with these documents.

This guidance relates to the remediation of land contamination by using cover systems; however, the verification of the quality of imported material is equally important in other situations, such as raising levels for flood prevention or general landscaping works. This guidance could also be used in such instances.

The Process of Verification

Implementation plans for remedial works should always be site specific. Where a cover system and potentially, excavation, is the main remedial method or a component of an overall site remediation, specific goals will need to be set that are linked directly to the risk management strategy for the site in question.

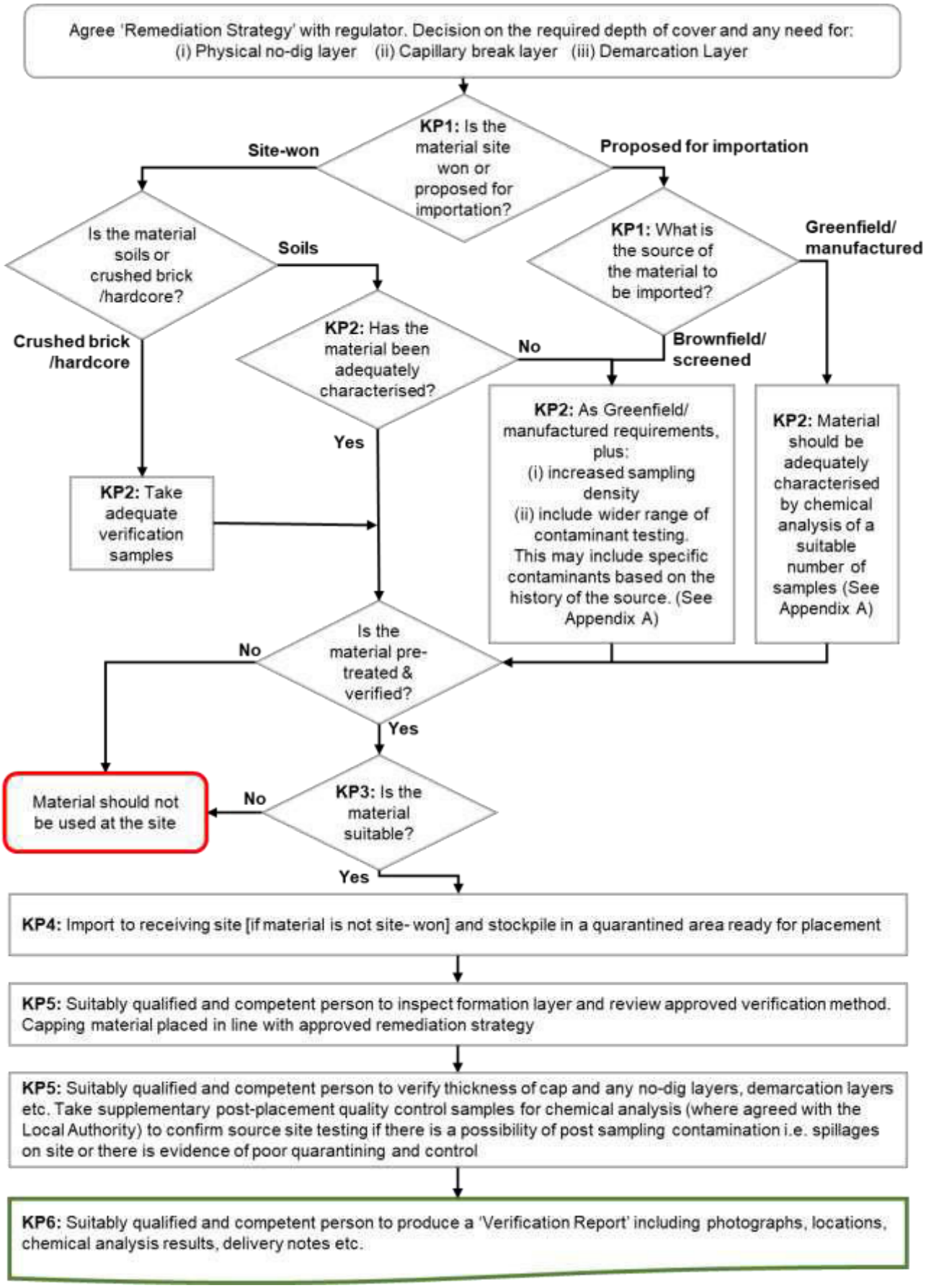
For cover and containment systems, verification will normally depend upon the provision of defensible measurements, observations and records. Critical factors to be considered are:

- What should be measured?
- When should they be measured?
- Where measurements need to be taken, what is the appropriate monitoring regime i.e. number and frequency of samples?
- Statistical constraints on sampling.

National Planning Policy Framework (NPPF) states that “planning policies and decisions should ensure that after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990”. The Verification Report is a key document to demonstrate compliance with NPPF, and the responsibility rests with the developer/applicant to submit the required Verification Report to complete the remediation and to discharge any planning conditions.

[1] Land Contamination Risk Management, Environment Agency, Oct 2020
[2] Verification of Remediation of Land Contamination. Environment Agency, Feb 2010

Overview Flowchart



Key Points

KP1: Source of Material

Material can be sourced from site won material i.e. crushed brick/hardcore or site-won soils from existing open or landscaped areas. In the interest of sustainability, Local Authorities promote the use of such site-won material providing that they are suitable for the intended end use of the site.

Alternatively, material can be sourced from other developments and commercial companies. Dependent on the source of the material it can be classified as either from a 'Greenfield/Manufactured' or 'Brownfield/Screened' source.

Broadly speaking material can be classified as follows:

Greenfield – Where documentary evidence is provided confirming that the source site has not been developed and that no past contaminative uses have occurred. Should evidence not be provided or approved by the Local Authority, please note that the source would be expected to be assessed as though it were a brownfield source.

Manufactured – from a commercial company who manufacture material by mixing or blending mineral soils (subsoil or sand) with an organic amendment (compost). If other soil component sources are used, documentary evidence should be provided confirming that the source site has not been developed and that no past contaminative uses have occurred. Should documentary evidence not be provided or approved by the Local Authority, please note that the source would be expected to be assessed as though it were a brownfield source.

Brownfield – material from a donor site that has previously been developed

Screened – material from a company who deal with skip/demolition waste which is screened for unsuitable material i.e. bricks, wood, plastic etc.

KP2: Characterisation of Material

It is essential that material is suitable for its intended use. Documentary evidence of the source of the material should be provided to the Local Authority. This may include desk study or site investigation reports. A defensible method is required to ensure the verification proposals are site specific and that the level of sampling reflects the need to ensure that imported material are suitable for their intended use.

Due to the diminishing supply of suitable Greenfield topsoil sources it has been found that the chemical quality of Greenfield sources is less reliable in certain areas. As a result the recommended analytical rate for the intended use of the development may vary between Local Authorities [see **Appendix 1a**].

When should this be done?

Sampling of material should be undertaken as early as possible i.e. prior to placement [for site won material] and prior to importation [for imported material]. This is to avoid the costly exercise of re-excavating unsuitable material and the possibility of cross contamination. Where the assessor has confidence that the material is of sufficient quality (i.e. tested by supplier, used previously) it is acceptable to test the material on site. Although, if it is deemed unsuitable it would have to be either removed off site or pre-treated at the cost and time of the developer. It is recommended that some verification samples are also taken once this material has been delivered to site to confirm suitability for use. Soils can become contaminated during transportation or when stockpiled on site.

What about certificates from commercial suppliers?

Where the material is provided by a commercial company, certificates or other industry Quality Protocol compliance i.e. WRAP, DoWCoP, will normally be accepted. This is on the proviso that it: (i) relates to the actual material being imported to the site and the type and amount of analysis is in line with what is prescribed in Appendix 1a; and, (ii) the certificates are less than two months old.

It is recommended that some additional verification samples are taken once this material has been delivered to site. Soils can become contaminated during transportation or when stockpiled on site.

Extreme caution should be given to importing material that has been recycled from demolition or skip waste as they could easily be contaminated e.g. asbestos containing materials. Please refer to "questions you should be asking your supplier" in **Appendix 1b** and include the responses in your report.

British Standard

Imported soils should be as specified in BS 3882:2015 for topsoil and BS8601:2013 for subsoil as 'suitable for their intended purpose'. Both British Standards relate mostly to nutrient content of topsoil and phytotoxic contamination and they do not consider contaminants that pose a risk specifically to human health. Soils should be tested for contaminants that are considered to pose a risk to human health in addition to those specified in the relevant British Standards to ensure that they are suitable for their intended use.

Initial screening

A visual / olfactory inspection of the material should be carried out by a suitably qualified and competent person to ensure that:

- It is a suitable growing medium;
- It is free from obvious contamination i.e. staining/free product etc.;
- It has not come from areas where Japanese Knotweed or other invasive or injurious plants, as specified by the Environment Agency, are suspected to have been growing;
- It is not odorous (could be considered a statutory nuisance);
- It is free from unsuitable material i.e. bricks, brick ties, timber and glass etc.); and,
- There are no visible signs of asbestos containing material (ACMs).

Testing schedule & number of samples

Chemical testing will normally be required on any materials that are to be used as cover material, even where this includes first generation quarried material. This should be carried out by a suitably qualified and competent person.

Appendix 1a explains in detail the sampling and testing requirements for a typical residential development. These are only guidelines and it may be necessary to deviate away from them depending on local and site-specific factors. It is recommended that the developer discusses any deviation with the Local Authority.

The following criteria sets out the requirements for sampling and testing:

- **Virgin Quarried Material** sampling needs to be 1 or 2 samples depending on the type of stone utilised, to confirm the inert nature of the material. Testing to include standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn).

- **Crushed Hardcore, Stone, Brick (excluding asphalt)** a minimum of 1 sample per 500m^3. Testing to include standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, total TPH. Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).

- **Greenfield/ Manufactured Soils** a minimum of 3 samples or, dependent on source and receptor, between 1 per 50m^3 and 1 per 250m^3. Testing to include standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, pH and soil organic matter (SOM) (or calculated from total organic carbon (TOC)).

- **Brownfield/ Screened Soils** a minimum of 6 samples or dependent on source and receptor, between 1 per 50m^3 and 1 per 100m^3. Standard metals/ metalloids (as above), PAH (16 USEPA speciation), TPH (CWG banded), asbestos, pH and SOM (or calculated from TOC). Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).

The assessment criteria need to be UK based, e.g. LQM S4ULs, Defra C4SLs or other similarly derived GACs.

KP3: Suitability of Material

Based on the characterisation of material above, the material should be either deemed suitable or unsuitable. Obviously unsuitable material should not be used (unless it is treated to reduce levels of contaminants below agreed target levels i.e. bioremediation – this would have to be agreed and included within the Remediation Strategy) and an alternative source of material should be sought by the developer. If the material is considered suitable it can be imported (if not site won) and stockpiled in a suitably quarantined area [refer to **KP4**].

KP4: Stockpiling & Quarantining of Material

It is essential that the 'suitable' material is either placed in its intended area straight away i.e. soft/landscaped areas or stockpiled in a suitable quarantine area to prevent on-site contamination.

In the event that an assessor finds material has been stored in an unsuitable area, samples should be taken to confirm that no cross contamination has occurred (including a visual/olfactory check of the material). The material should then be suitably quarantined or placed at its intended location immediately.

KP5: Verification of Required Depth

In line with the agreed Remediation Strategy, it is important to establish that the required depth has been achieved and is consistent across the site. There are two main ways to achieve this:

Depth testing in situ – small trial pit excavated to allow measurement of its depth by standardised tape measure or measuring staff.

Topographical surveys – accurate survey of the base and final formation layer height to establish the depth of cover.

Specific Local Authority Policy

Please check with the local Contaminated Land Officer to establish:

- Which type of method for testing depth is accepted; and,
- The number of verification areas per property, plot, landscaped area or garden area (some Local Authorities recommend at least 2 per plot for residential developments).

Important Note: Where demarcation, physical no-dig and capillary break layers exist they should be verified for their thickness and presence during the time of their installation. Details of the demarcation layer should be agreed with the Contaminated Land Officer prior to placement. This will include the design, type and strength of the geotextile separator or visual warning membrane. The verification of depth and confirmation of such layers should be carried out by a suitably qualified and competent person.

KP6: Reporting

The purpose of verification documentation is to provide transparent reasoning why the remediation was required, a methodology about how it was to be undertaken and proof that the specified works have been undertaken and to provide confirmation that the site is "suitable for its intended use".

The document is utilised not only to satisfy conditions of planning permissions but also is to be kept on record by the Local Authority should queries be raised during the lifetime of the development and to confirm to future purchasers that the site is suitable for use.

National Planning Policy Framework (NPPF) states that "planning policies and decisions should ensure that after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990". The Verification Report is a key document to demonstrate compliance with NPPF, and the responsibility rests with the developer/applicant to submit the required Verification Report to complete the remediation and to discharge any planning conditions.

It is also essential that other supporting documentation is included within a report carried out by a suitably qualified and competent person e.g. laboratory analysis results, delivery tickets for material, certificates for imported material (or if unavailable, documented evidence of the source of the Greenfield material), trial pit logs etc. A checklist has been included in **Appendix 2** to give an idea on what information should be recorded.

Additionally, any reporting should include details of any measures required to maintain the cover system integrity in the future e.g. successive construction phases (management plans) and longer term (restrictive covenants on title deeds).

Photographic evidence for validating the depth of cover

The Local Authority ideally would recommend the following programme of photographs to be taken of the placement of inert cover:

- Photographs of any stockpiles and quarantine areas
- Proof that the depth of inert cover has been installed
- Proof of the quality of the material to be used as inert cover
- Proof there is a geotextile separator and visual warning membranes if used between the underlying material and suitable for use soils.
- Proof of the method of placement and different layers if appropriate
- Proof of the completed project
- Inclusion of background features which will aid locating the photograph
- Inclusion of site identification boards within the photos which show the date, position taken i.e. corner of plot 3 and the site name.
- Inclusion of photographs of site stockpiles and quarantine areas.

The presence of good quality photographs is essential to prove beyond doubt that the remediation has been done as specified both by method and position, and that the images have been taken from the specific area stated.

Refer to **Appendix 3** for examples of good photographic evidence.

Appendix 1a – Sampling & Testing Matrix

Type	Number of Samples	Testing Schedule	Assessment Criteria
	Please note that these guidelines apply to a typical residential development, and relaxation of the guidelines or more stringent requirements may apply dependent on local and site specific factors. Therefore, <u>all parameters need to be agreed with the Local Authority</u>.		
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)	The assessment criteria need to be UK based, e.g. LQM S4ULs, Defra C4SLs or other similarly derived GACs.
Crushed Hardcore, Stone, Brick (excluding asphalt)	Minimum 1 per 500m^3	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, total TPH. Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).	
Greenfield/ Manufactured Soils	Minimum 3 Dependent on source and receptor, between 1 per 50m^3 and 1 per 250m^3	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, pH and soil organic matter (SOM) (or calculated from total organic carbon (TOC)).	
Brownfield/ Screened Soils	Minimum 6 Dependent on source and receptor, between 1 per 50m^3 and 1 per 100m^3	Standard metals/ metalloids (as above), PAH (16 USEPA speciation), TPH (CWG banded), asbestos, pH and SOM (or calculated from TOC). Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).	

Appendix 1b – Questions to Ask Your Soil Supplier Relating to Soil Quality

- What is the source of the material (refer to KP1)? If the source is Greenfield, can they provide evidence of this?
- Will all of the material be coming from the same source?
- Are you satisfied that the material is a suitable growing medium for the proposed end use?
- Has the supplier used an appropriate sampling protocol to ensure a representative sample is analysed? What volume of soil is represented by the analysis and does it comply with Appendix 1a?
- Does the testing include analysis of contaminants identified in Appendix 1a?
- Does the laboratory conducting the analysis have UKAS and MCERTS accreditation for the tests they are carrying out?
- Does the material comply with relevant waste regulations?
- Can I have a copy of the whole analysts report and does it include an interpretive section?
- Will the provided certificate be dated within the last 2 months?

Appendix 2 – Checklist for Verification Reports

Example only. Not to be considered as typical minimum requirements. Additional information should be included for non-cover systems aspects of the remediation i.e. gas protection measures etc.

Site Details	
Site Name / location	
Developer name	
Development use	
Plot No / description of landscaped area (inc plan of inspection areas)	
National Grid Reference	
Inspection visit date	
Supporting Evidence	
Description of remediation (as per agreed Remediation Method Statement including depths / thickness checks, topographical readings)	
Material tracking information (including way tickets etc.)	
Name of groundwork's remediation contractor	
Name of supervising environmental consultant	
Site Specific chemical analysis results	
Verification Photographs (inc. remarks)	
Recommendations	
Pass/fail	
If material fails, how will this be managed i.e. removed, treated	
Detail any further remedial works and/or inspection	
Signed off	

Failure to provide any of the above information may prevent planning conditions from being discharged.

Appendix 3 – Examples of Good Quality Photographs

© Coopers Consulting Engineers

Photograph 1:
Depth check of inert cover within area of public open space. Physical break layer and topsoil visible.

© WSP

Photograph 2:
Depth check of inert cover with Site & Location Information Board.

© Coopers Consulting Engineers

Photograph 3:
Depth check of inert cover within areas of front gardens.

© Coopers Consulting Engineers

Photograph 4:
Depth check of inert cover within areas of front gardens.

© Coopers Consulting Engineers

Photograph 5:
Depth check of inert cover within rear gardens. Taut string line spans across excavation.

© Coopers Consulting Engineers

Photograph 6: Depth check of inert cover within rear gardens. Taut string line spans across excavation.

© Coopers Consulting Engineers

Photograph 7: Shows the spatial location of the verification pit.

© Coopers Consulting Engineers

Photograph 8: Excavation within public open space and verification pit showing the presence of a remediation break layer at the base, a crushed sandstone inert fill overlain by topsoil.

© Coopers Consulting Engineers

Photograph 9: Inert crushed sandstone being delivered. The spatial area of the remediation can be observed from these photographs (old terrace housing).

© Coopers Consulting Engineers

Photograph 10: Inert crushed sandstone being delivered with visible remediation break layer. The spatial area of the remediation can be observed from these photographs (traffic lights).

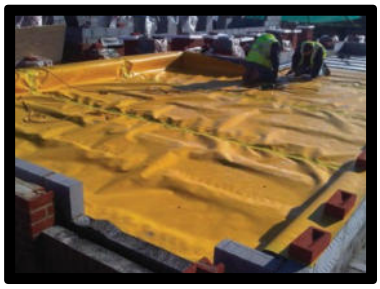
© Coopers Consulting Engineers

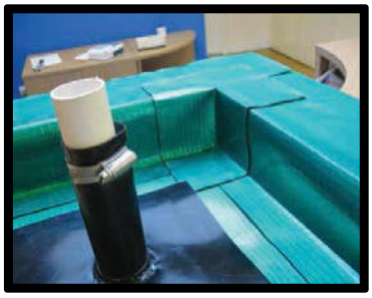
Photograph 11:
Shows the remediation of the rear garden, with a significant depth (1.0m) of inert cover. This photograph has been stitched to form a panoramic photograph and hence there is slight distortion

© Coopers Consulting Engineers

Photograph 12:
Shows the remediation of the rear garden, with a significant depth (1.0m) of inert cover. Remediation break layer visible at the base of the excavation.

Appendix D – YALPAG Guidance (gas protection measures)





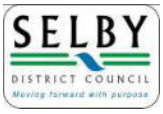
VERIFICATION REQUIREMENTS FOR GAS PROTECTION SYSTEMS

Technical Guidance for Developers, Landowners and Consultants

Yorkshire and Lincolnshire Pollution Advisory Group

Version 1.1 – December 2016

The purpose of this guidance is to promote consistency and good practice for development on land affected by contamination. The Local Planning Authorities in Yorkshire, Lincolnshire and the North East of England who have adopted this guidance are shown below:



Contents Page

Disclaimer

This guidance is intended to serve as an informative and helpful source of advice. It is intended to review this guidance annually, but readers must note that legislation, guidance and practical methods are inevitably subject to change and therefore should be aware of current UK policy and best practice. This note should be read in conjunction with prevailing legislation and guidance, as amended, whether mentioned here or not. Where legislation and documents are summarised this is for general advice and convenience, and must not be relied upon as a comprehensive or authoritative interpretation. Ultimately it is the responsibility of the person/company involved in the verification of land contamination to apply up-to-date working practices and requirements.

Acknowledgments

The authors and YALPAG would like to specifically acknowledge and thank CIRIA for the permission to use sections, including tables and photographs, of the CIRIA C735 document. Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) *Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

The author, Leeds City Council (Brad Hall, Julia Reynolds), would like to acknowledge the assistance provided by the following people and organisations: East Riding of Yorkshire Council, Doncaster Metropolitan Borough Council, Wakefield Council, Hugh Mallett of BuroHappold, Neil Salvage of PAGeotechnical and John Naylor of Ground-Gas Solutions.

Consultation

The YALPAG Local Planning Authorities were consulted over a four week period in 2015 during the production of this guidance. Consultation comments were considered by the review panel and a number of revisions were made to the guidance to reflect these comments.

Introduction

This guidance has been produced to help developers ensure that they can demonstrate that gas protection systems are appropriate for the development and level of risk associated with a site and that they have been installed correctly and can be relied upon to provide the required level of protection and ultimately demonstrate that, in terms of gas risk, the development is suitable for use. It is intended to improve the quality of reports submitted to Local Planning Authorities on this matter and to give contractors/consultants a point of reference to obtain approval for such work from their client.

The verification of gas protection systems should be an integral part of remediation and agreed between developers and Local Planning Authorities at an early stage in the development.

Failure to comply with this guidance may result in delays to the development. Relevant planning conditions cannot be discharged until the Local Planning Authority is satisfied appropriate verification has been undertaken to confirm that the development is safe.

Available UK guidance regarding gas risk assessment includes:

- CIRIA C665 Assessing risks posed by hazardous ground gases to buildings;
- NHBC Report Edition No: 4 Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present;
- BS 8485:2015 Code of practice for the design of proactive measures for methane and carbon dioxide ground gases for new buildings.

In particular, readers of this document should refer to the detailed guidance on verification published by CIRIA (CIRIA C735 Good Practice on the testing and verification of protection systems for buildings against hazardous ground gases, 2014). This guidance note should be considered as supplementary advice to be used in conjunction with these documents.

This document does not cover risks associated with radon. Please contact individual Local Planning Authority for further information.

The following YALPAG technical guidance documents for developers, landowners and consultants are also available;

- Verification Requirements for Cover Systems.
- Development on Land Affected by Contamination.

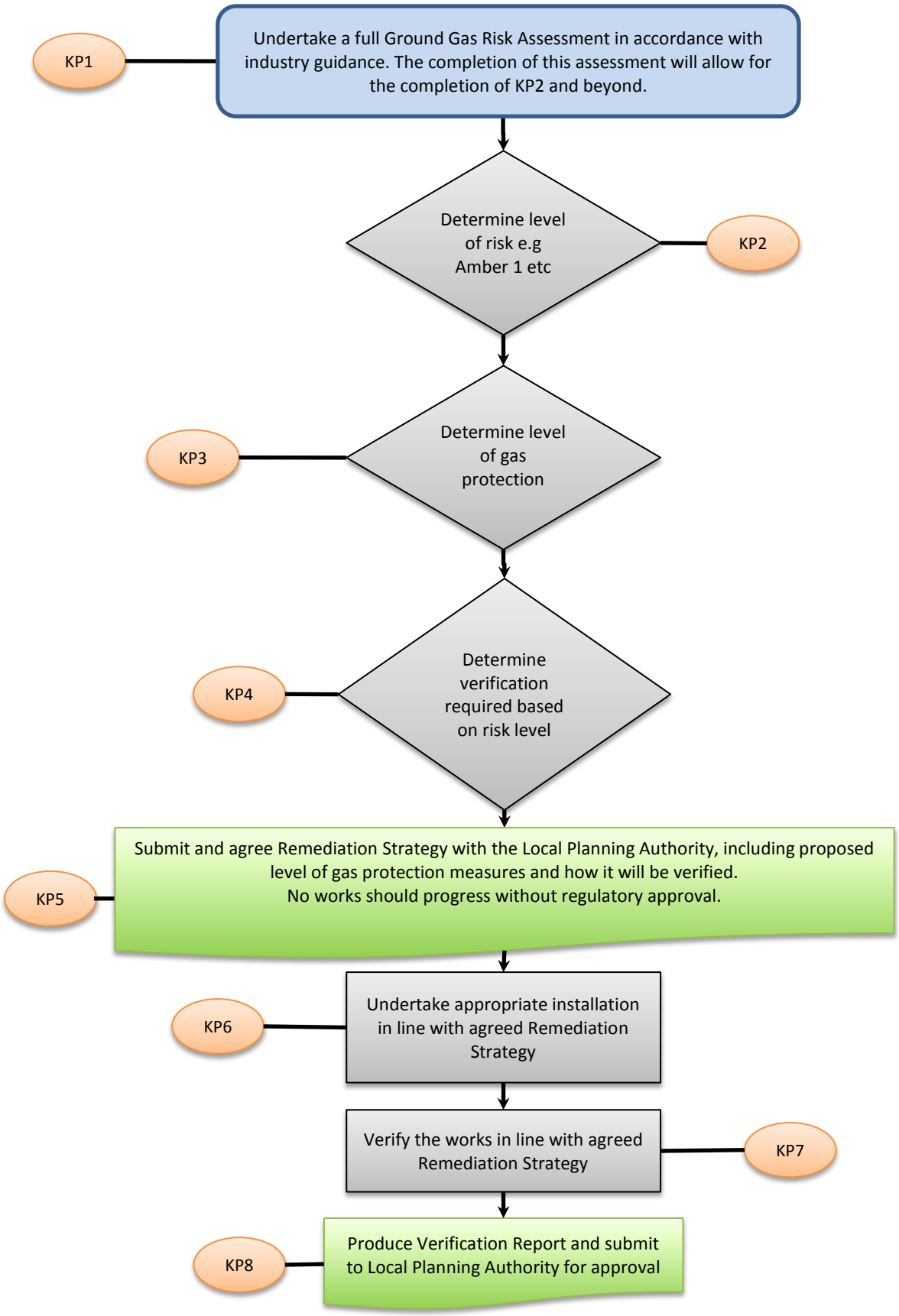
The Process of Verification

Implementation and verification plans for gas protection systems should always be site specific and based on the gas risk assessment and conceptual site model (CSM) for the site in question.

For gas protection systems, acceptable verification will normally comprise the provision of clear evidence that the level of protection is appropriate to the established risk and has been installed by suitably experienced personnel in line with the manufacturer's instructions and appropriate guidance. Critical factors to be considered are:

- What should be installed?
- How should it be installed?
- Who should install it?
- How will correct installation be demonstrated?

Overview Flowchart



Key Points

KP1 Ground Gas Risk Assessment	Undertake an appropriate gas risk assessment for the site in accordance with industry guidance*. On completion of the risk assessment and the generation of the appropriate Gas Screening Value (where required) and on a full understanding of the gas regime/ CSM, move to KP2 to determine the level of risk for the site. **Where the desk study has identified the need for gas monitoring to be carried out it would always be **expected** that site specific gas monitoring data would be used in the gas risk assessment.*
KP2 Level of Risk	The level of gas risk needs to be determined by using the appropriate gas guidance document/s relative to the development (e.g. low rise housing, residential apartment blocks with areas of public open space, commercial or public buildings etc). For example Amber 1 (Low rise housing) equates to Low Risk in Table A1 CIRIA 735. Once the level of risk has been determined move to KP3 and determine the appropriate level of gas protection.
KP3 Level of Gas Protection	The level of gas protection should be based on the level of risk established by the gas risk assessment and CSM. It should provide the appropriate gas protection for the ***lifetime of the development***. Detailed specification of gas protection measures in accordance with appropriate guidance to include (but not be limited to): • Submission of appropriate drawings (site specific plans and details to clearly show where the measures will be installed and how they fit into the design of the building and foundations). • Full written description of the protection measures to be included. • Detailed justification of the protection measures being used along with reference to the guidance document(s) being used.
KP4 Level of Verification Required	The level of qualification and experience of the installer will determine the level of verification required. Verification should always be carried out by an appropriate independent person such as an experienced and suitably trained verification consultant or third party qualified **and** experienced installer (see KP6). **See Appendix 1 for full details of verification requirements for installation of gas protection measures and the associated verification requirements.**

KP5 Submission and Agreement of Remediation Strategy	No installation of gas protection measures should be carried out at the site until the full details (KP1 to KP4) have been approved by the Local Planning Authority and formalised in an agreed Remediation Strategy (including Verification Plan). The Remediation Strategy, incorporating the detailed Verification Plan, should include (but not be limited to): • A summary of the ground gas risk assessment. • The gas protection measures proposed. • Who will undertake the installation including levels of experience and/ or qualifications. • How the works will be verified/ tested and by who. • How the works will be reported to the Local Planning Authority. **See Appendix 2 for details of Remediation Strategy requirements.**
KP6 Installation of Gas Protection	Installation should only be done once the Remediation Strategy has been agreed with the Local Planning Authority and should be carried out in line with the agreed Remediation Strategy. Any deviation away from the agreed Remediation Strategy should be agreed in writing with the Local Planning Authority prior to commencement of installation. **See Appendix 4 for examples of good and poor gas protection installation.**
KP7 Verification of Gas Protection	The verification of the gas protection measures should be undertaken in accordance with the Verification Plan set out in the agreed Remediation Strategy. Any deviation to works away from the agreed Remediation Strategy should be agreed in writing with the Local Planning Authority prior to installation. **See Appendix 5 for an example Verification proforma.**
KP8 Submission of Verification Report	The Verification Report must be produced in line with the agreed Remediation Strategy and Verification Plan. All aspects of the Remediation Strategy must be addressed in the Verification Report along with full details and justification of any deviation. **See Appendix 3 for details of the required contents of the Verification Report. Please note, the required contents should be agreed within the submitted and approved Remediation Strategy at KP 5.**

Appendix 1 – Requirement for Installation and Verification

Copied directly from Annex 1 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

The tables in this appendix should be used for guidance only and are not intended to be used in lieu of sound professional judgment, which should take into account the risk factors affecting the development (the gas regime, the number of buildings, the complexity of design, and the expertise of the installation workforce) on a site-specific basis. The tables should not be used independent of, and without reference to, the accompanying text in the main guide C735.

Situation A – all development types except situation B – non reinforced slabs (from Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk CS2 (*with venting) Basic radon protection area	Non reinforced All slabs	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including photographs to independent verifier.
		Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min one visit). Installer to supply sign off sheets (verification evidence) including photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area		General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations etc independently air lanced to ASTM D4437. Contractor to supply sign off sheets (verification evidence) including photographs to verifier. Consideration given to need for/scope of integrity testing (eg initially on say 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).
Gas regime/risk	**Slab type**	**Installer experience**	**Suggested levels of verification and integrity testing**
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area	Non reinforced All slabs	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min two visits). 25 per cent all joints, pipe penetrations etc independently air lanced to ASTM D 4437. Remaining 75 per cent joints, pipe penetrations etc tested to recognised standard by installer (as detailed in method statement/CQA plan). Installer to supply sign off sheets (verification evidence) to verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).
High risk VOCs etc CS3 (no venting) or CS4 and above (*with venting)		Qualified[1] and experienced installer (50 per cent of operatives to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations independently air lanced to ASTM D 4437. Installer to supply sign off sheets (verification evidence) to verifier for all pours. Consideration given to need for scope of integrity testing (eg initially on 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).

Notes

* Assumes venting designed to keep steady state concentration of CH4 below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate

1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).

2 Before works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.

3 Consideration should be given to carrying out leak detection (ie smoke, tracer gas or dielectric testing) on the first plots on higher end sites CS3 and above. If an unacceptable amount of holes are found during these tests then the verification consultant should discuss with the relevant personnel, strategies to prevent this occurring, these could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.

4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.

5 Air lancing is the only integrity test that has an independently recognised international standard that is suitable for testing taped and welded seams.

Situation A – all development types except situation B – reinforced slabs (from Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk CS2 (*with venting) Basic radon protection area	Reinforced All slabs	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including sub grade acceptance forms and photographs to independent verifier.
		Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 25 per cent concrete pours (min two visits), including vented void, subgrade etc. Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area		General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours including vented void, subgrade etc. All joints, pipe penetrations etc independently air lanced to ASTM D4437. Consideration given to the need for and scope of integrity testing (eg initially on say 50 to 25 per cent of pours then falling to 25 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections.
		Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 50 per cent of concrete pours, including vented void, subgrade etc 25 per cent of joints, pipe penetrations etc independently air lanced to ASTM D4437. Remaining joints, pipe penetrations, corners etc tested to a recognised standard by installer (as detailed in method statement and CQA plan). Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs etc to independent verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results and no concerns raised by visual inspections).
High risk VOC and hydrocarbons CS3 (no venting) or CS4 and above (*with venting)		Qualified[1] and experienced installer (50 per cent of operatives to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours including vented void, subgrade etc. All joints, pipe penetrations etc independently air lanced to ASTM D4437. 100 per cent leak detection considered on VOC/ hydrocarbon contaminated sites.. Consideration given to need for/scope of integrity testing (eg initially on 50 to 25 per cent of pours then falling to 25 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).

Notes

* Assumes venting designed to keep steady state concentration of CH4 below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate.

1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).

2 Before works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.

3 Consideration should be given to carrying out leak detection (ie smoke, tracer gas or dielectric testing) on the first plots on higher end sites CS3 and above. If an unacceptable amount of holes are found during these tests then the verifier should discuss with the relevant personnel, strategies to prevent this occurring, these could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.

4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.

5 Air lancing is the only integrity test that has an independently recognised international standard that is suitable for testing taped and welded seams.

6 Where a sufficiently robust protection layer (protection fleece, protection boards or insulation) are laid directly on the membrane, inspection after placement of the reinforcement should not be necessary.

Situation B – low rise housing with ventilated void (from NHBC and Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk Amber 1	All slabs with min 150 mm ventilated sub floor void	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 10 plots (minimum 5). Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections[3].
		Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections[3].
Intermediate risk Amber 2		General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of first 10 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at approx. frequency of 1 in 20 plots Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections).
		Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of the first 5 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at a frequency of about 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/ scope of integrity testing (eg initially on 10 to 25 per cent of plots then falling to 0 5 per cent of plots if acceptable results obtained and no concerns raised by visual inspections)[3].
High risk Red VOC and hydrocarbons		Qualified[1] and experienced installer (all operatives to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of all plots, and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections)[3].

Notes

* Gas regime defined by characteristic situation as set out by Wilson *et al* (2007), and all other recent good practice guidance and British Standards.

** Assumes venting designed to keep steady state concentration of CH4 below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate.

1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).

2 Before the works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.

3 Consideration should be given to carrying out integrity testing/leak detection (ie smoke, tracer gas or dielectric testing) on the above basis and/or if an unacceptable amount of damage/loss of integrity is found during visual inspections. In this instance the consultant should discuss with the relevant personnel, strategies to prevent this recurring. This could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.

4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.

5 Air lancing is the only integrity test that has an independently recognised international standard suitable for testing taped and welded seams and should be used at the frequency suggested in the table.

Appendix 2 – Remediation Strategy and Verification Plan for Gas Protection Systems

The Remediation Strategy should include a detailed verification method statement. This should address how the gas protection measures will be installed and what verification information will be provided to demonstrate the installation has been carried out in accordance with the appropriate guidance.

As a minimum the report should include (but not be limited to):

- A summary of the gas risk assessment.
- The gas protection measures proposed (including reference to the appropriate guidance documents) and confirmation they will meet the gas protection requirements for the lifetime of the development.
- Technical drawings showing how the gas protection measures will be incorporated.
- Formal qualifications/experience/training of the person carrying out the installation.
- Formal qualifications/experience/training of the person carrying out the verification.
- Clear demonstration of the independence of the person carrying out the verification.
- The manufacturer's specification of the gas protection membrane to be used.
- Full details of what the verification process will comprise and at what stage verification will be carried out.
- Details of how any non-conformance will be dealt with.
- Details of the number of plots to be validated. (Deviation from verification of every plot will need to be justified and agreed with the Local Planning Authority in line with Appendix 1 of this document).
- Timeline of when during the build, each of the gas protection measures will be installed.
- Details of management measures proposed to ensure how damage to the membrane will be prevented prior to the floor being installed, post installation.
- Details of how **all** site personnel (including follow on trades) will be made aware of the presence of the membrane and that damage to the membrane must be prevented.
- Details of the extent of overlap and method of sealing (these must be in line with manufacturer's instructions and evidence provided).
- Confirmation that a signed (plot specific unless agreed otherwise) statement confirming that the gas protection measures were installed as agreed and that the membrane was free from tears and punctures and was lapped and sealed as agreed at joins and around services and sub floor voids were clear and free from debris will be included in the Verification Report.
- Confirmation that plot specific photographs showing the installed membrane will be included in the Verification Report.

Appendix 3 – Checklist for Gas Verification Reports

The Verification Report should include a summary of all the works undertaken, relating to gas protection measures including all elements detailed within the Remediation Strategy.

As a minimum the report should include (but not be limited to):

- Site details.
- Planning Application details.
- Summary of Gas Risk Assessment (including original CSM).
- Details of who carried out installation (qualifications/experience/training).
- Details of who carried out verification (qualifications/experience/training).
- Description of protection measures installed with reference to method statements and drawings and manufacturers specification of the materials used.
- Details of the verification inspection regime.
- Supporting information, plans, air vent installation, photographs, as built drawings.
- Summary of verification data (completed proformas, test results)
- Details of non-conformances and how they were rectified.
- Clear statement saying remedial objectives been achieved supported by lines of evidence including reference to CSM.
- Where necessary further works and/ or long term management.

Appendix 4 – Examples of Good and Poor Installation

Copied directly from Appendix A4 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

GOOD PRACTICE PHOTOGRAPHS

Figure A4.7 *Geovent protruding out of the frontage of the unit. Gas membrane along the sides of the slab preventing lateral gas ingress (courtesy Alderburgh Group)*

Figure A4.8 *Geovent beneath the 2000g taped gas membrane lined up with collector pipes (courtesy Alderburgh Group)*

Figure A4.9 *On site schematics to aid construction workers build the gas protection system (courtesy Alderburgh Group)*

Figure A4.10 *Almost complete coverage available for inspection, minimal jointing, service entries suitable distance from walls, light traffic (courtesy Smith Grant)*

Figure A4.11 *Gas membrane continued through cavity wall and above air bricks (courtesy Hydrock)*

Figure A4.12 *Good edge detail across cavity (courtesy PAGeotechnical Ltd)*

Figure A4.13 Gas proof DPC adhered on top of gas membrane using butyl strips across cavity space (courtesy NHBC)

Figure A4.14 Good perimeter seal (courtesy PAGeotechnical Ltd)

Figure A4.15 LDPE type gas membrane overlap and double sided tape. Sand blinding to protect underside of gas membrane (courtesy A Proctor Group)

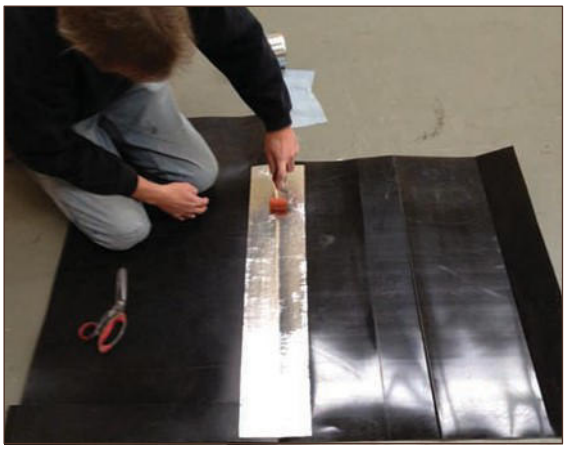


Figure A4.16 Example HDPE type gas membrane and steam roller used to ensure self-adhesive tape is correctly installed (courtesy A Proctor Group)

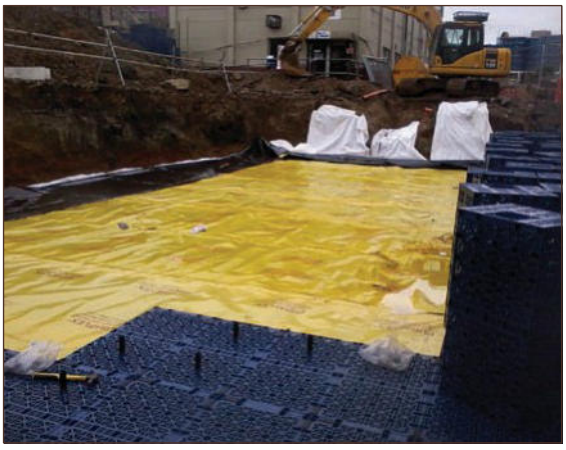


Figure A4.17 Gas membrane installed in attenuation tank (courtesy Industrial Textiles & Plastics Ltd)

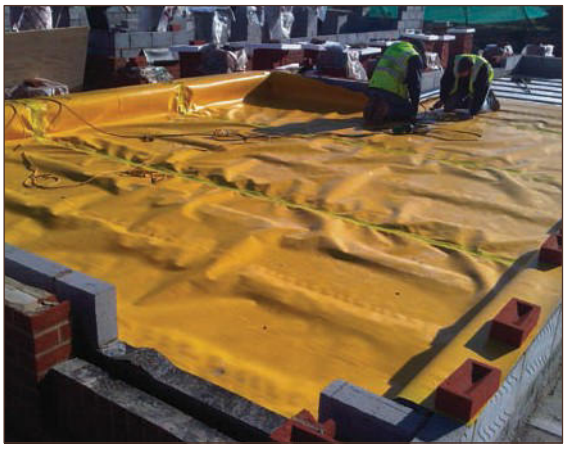


Figure A4.18 Gas membrane installed as part of foundation barrier (courtesy Industrial Textiles & Plastics Ltd)

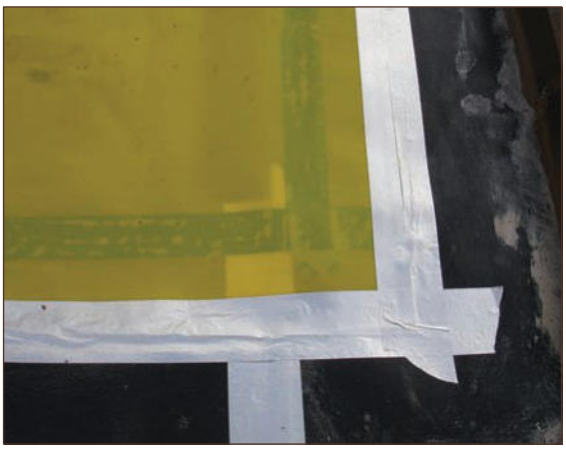


Figure A4.19 *Well-constructed joints with gas resistant DPC, lap and double sided butyl joints visible beneath semi-transparent gas membrane, secondary seal with proprietary single sided tape (courtesy Smith Grant)*

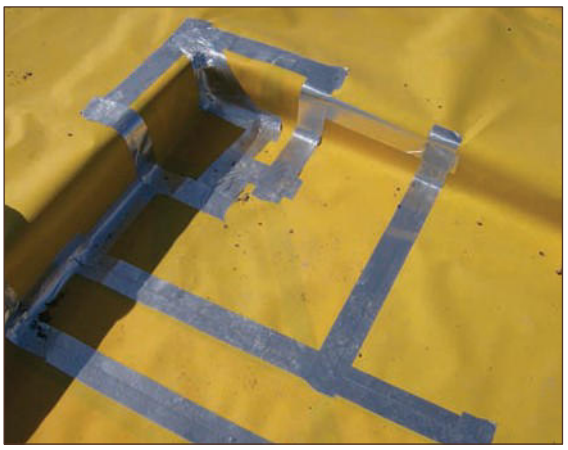


Figure A4.20 *A pre-formed corner unit would have been preferable as fewer joints would have been formed, however the installer has achieved a good level of workmanship in this corner detail (courtesy Smith Grant)*

Figure A4.21 *Good prefabricated corner detail (courtesy MEC Environmental Ltd)*

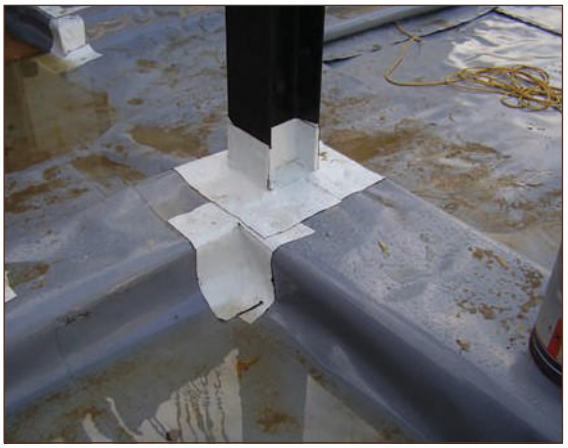


Figure A4.22 *Good detail around stanchion and corner (courtesy PAGeotechnical Ltd)*

Figure A4.23 *Complex column seal (courtesy PAGeotechnical Ltd)*

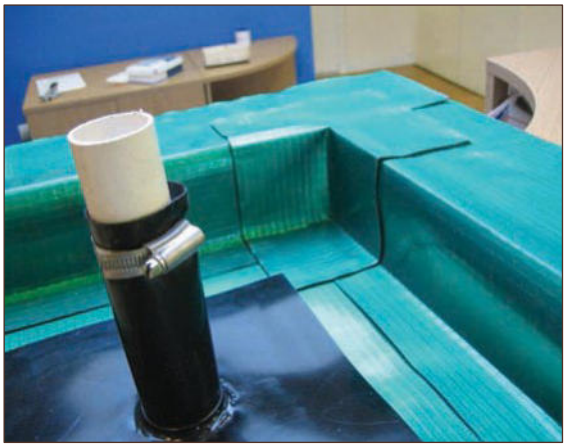


Figure A4.24 *Prefabricated corner detail and top hat (courtesy A Proctor Group)*

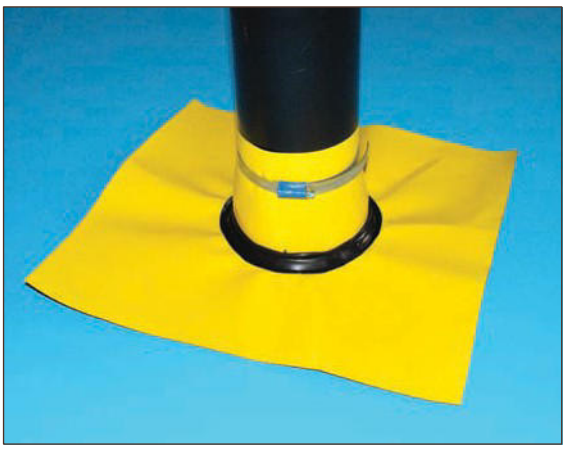


Figure A4.25 *Top hat around service entry (courtesy Industrial Textiles & Plastics Ltd)*

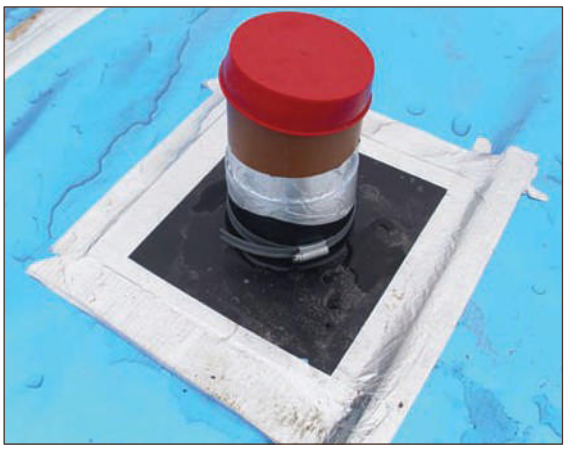


Figure A4.26 *Well-constructed service entry: top hat fits well with service pipe and taped down to gas membrane, secondary seal with proprietary single sided tape (courtesy Smith Grant)*

Figure A4.27 *Top hats placed around service entries secured with jubilee clip seals. Top hats secured to gas membrane with double sided butyl tape (courtesy Hydrock)*

Figure A4.28 *Bead of double sided butyl tape provided between interfaces of ID top hat and OD service pipe. When compressed with jubilee clip, forms an effective seal (courtesy Smith Grant)*

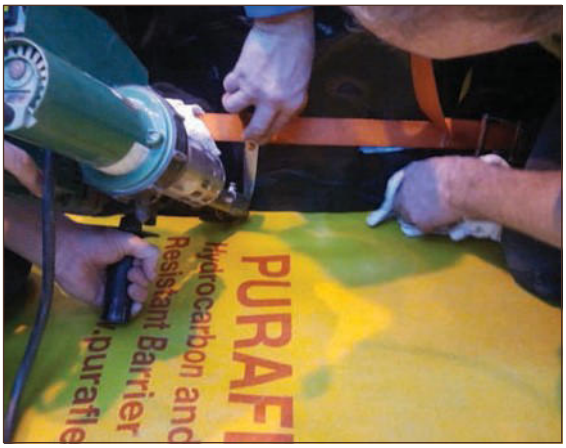


Figure A4.29 *Extrusion welding technique (courtesy Industrial Textiles & Plastics Ltd)*

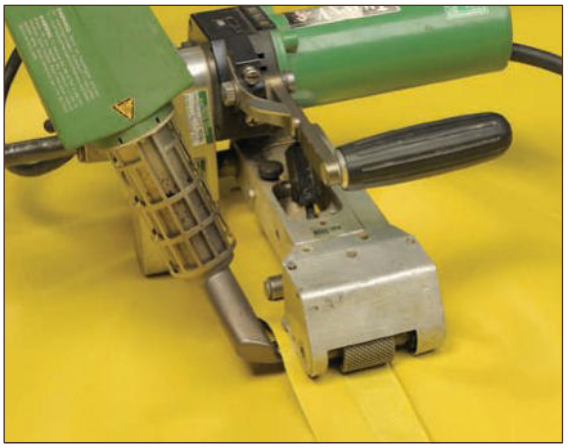


Figure A4.30 *Thermal welding technique (courtesy Industrial Textiles & Plastics Ltd)*

Figure A4.31 Extrusion welding (courtesy PAGeotechnical Ltd)

Figure A4.32 High quality installation of liquid gas membrane to lift pits, including resin gas protection on all screw penetrations (courtesy Card Geotechnics Limited)

A4.2.2 Good practice – passive venting systems

Figure A4.33 Good ventilation in internal sleeper walls, cast into prefabricated beams (courtesy Smith Grant)

Figure A4.34 Open void >300mm deep, good ventilation through internal sleeper walls (courtesy Smith Grant)

Figure A4.35 Good installation of passive gas venting trenches and 'egg-crate' (courtesy Card Geotechnics Limited)

Figure A4.36 Raised air bricks are preferable due to the reduced potential for blockade but the vent trench specified is provided with clean single sized stone (courtesy Smith Grant)

A4.2.3 Good practice – integrity testing

Figure A4.37 Tracer gas testing, whereby gas or smoke is applied under pressure beneath the installed gas membrane and detectors are used to screen for leaks above (courtesy NHBC)

Figure A4.38 Tracer gas testing (courtesy PAGeotechnical Ltd)

Figure A4.39 Scanning for leaks (courtesy PAGeotechnical Ltd)

Figure A4.40 CO_2 injection integrity testing (courtesy Landline Ltd)

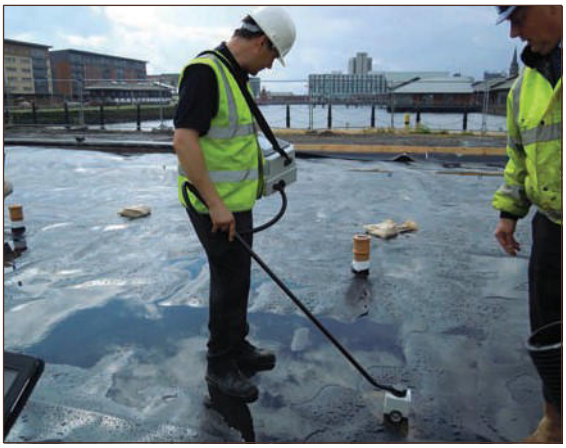


Figure A4.41 Small sand bags are marking holes made in the gas membrane used to check whether injected CO2 has worked its way beneath whole area (courtesy Landline Ltd)

Figure A4.42 Air pressure testing (courtesy GSE Environmental)

Figure A4.43 Dielectric porosity testing for housing scheme (courtesy NHBC)

Figure A4.44 Air lance test, used to test the quality of welded seams along gas membrane joints (courtesy MEC Environmental Ltd)

Figure A4.45 Spark testing (courtesy GSE Environmental)

Figure A4.46 Testing a weld with 'dog bone' grips (courtesy MEC Environmental Ltd)

BAD PRACTICE PHOTOGRAPHS

Figure A4.47 Follow-on works purposefully penetrating gas membrane (courtesy Card Geotechnics Limited)

Figure A4.48 Loose nails and over construction debris likely to be left in place beneath gas membrane – poor preparation of gas membrane prior to sealing service penetration (courtesy Card Geotechnics Limited)

Figure A4.49 Lifted gas membrane at corner position. Light penetrating through confirms damage to aluminium internal core layer (courtesy NHBC)

Figure A4.50 Large/heavy/sharp objects being moved over unprotected gas membrane (courtesy Card Geotechnics Limited)

Figure A4.51 Gas membrane torn by reinforcement (courtesy MEC Environmental Ltd)

Figure A4.52 Gas membrane cut by scaffolders and bricklayers after installation (courtesy MEC Environmental Ltd)

Figure A4.53 Gas membrane left exposed for long period of time, shows significant fraying at cavity edge (courtesy NHBC)

Figure A4.54 Gas membrane damage/tearing at edge of ground floor slab screed layer where it was left exposed to elements for period of time (courtesy NHBC)

Figure A4.55 *Gas membrane at stepped junction of slab to integral garage, appears to be susceptible to tearing when screed is poured. Screed may also weigh down on gas membrane if fitted too tight (courtesy NHBC)*

Figure A4.56 *Gas membrane at edge of concrete screed. Screed has been grinded to achieve desired levels, gas membrane shows extreme wear and damage as a result (courtesy NHBC)*

Figure A4.57 *Unprotected gas membrane damaged by heavy traffic (courtesy MEC Environmental Ltd)*

Figure A4.58 *Damage caused to gas membrane by follow-on trade who cut/shaped the dry lining board directly on the unprotected installed gas membrane (courtesy NHBC)*

Figure A4.59 *Gas membrane slit at the bottom of a cavity tray to enable water to drain away (courtesy Smith Grant)*

Figure A4.60 *Some stones could penetrate gas membrane if sufficient force is applied (courtesy Smith Grant)*

Figure A4.61 *'Stripping' occurs on gas membranes that contain aluminium foil. The foil gets too hot under the outer layer of LDPE or PP and the top layer of the gas membrane sticks to the roller which strips it off, leaving the aluminium completely exposed (courtesy MEC Environmental Ltd)*

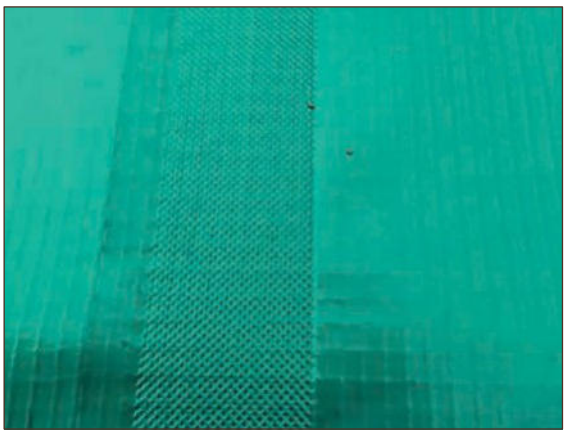


Figure A4.62 *Wedge weld on an LDPE aluminium gas membrane, where the installer used metal nip rollers. This destroyed the top layer and probably the bottom layer, leaving aluminium exposed between the weaves. This failed dielectric testing along all joints (courtesy MEC Environmental Ltd)*

A4.3.2 Bad practice – gas membranes installed incorrectly

Figure A4.63 *Absence of surface preparation prior to laying of gas membrane, debris likely to pierce gas membrane (courtesy Card Geotechnics Limited)*

Figure A4.64 *Insufficient length of gas membrane protruding through wall to overlap with gas membrane within building (courtesy Card Geotechnics Limited)*

Figure A4.65 *Wrinkling of gas membrane over joint has resulted in gaps (only visible due to the use of a transparent gas membrane) and the secondary seal uses ordinary gaffer tape rather than a proprietary product (courtesy Smith Grant)*

Figure A4.66 *Follow-on trades proceeded work before gas membrane joints sealed (courtesy Card Geotechnics Limited)*

Figure A4.67 *Traffic over mesh resulted in several punctures, in addition most joints were found to be poorly constructed. Taped joints are difficult to construct in adverse weather (courtesy Smith Grant)*

Figure A4.68 *A pre-formed corner unit would have been preferable. The installer could not produce sufficient quality despite the amount of tape applied (courtesy Smith Grant)*

Figure A4.69 *Attempt at corner detailing using non-proprietary duct tape (courtesy Smith Grant)*

Figure A4.70 *Inadequate corner detailing. The use of preformed proprietary products would have avoided such bad practice (courtesy NHBC)*

Figure A4.71 *No corner detailing leading to stress point on gas membrane (courtesy Smith Grant)*

Figure A4.72 *Joint between top hat and gas membrane has lifted due to poor fit and attempt to construct in very wet conditions (courtesy Smith Grant)*

Figure A4.73 *No bead of double sided butyl tape provided between interfaces of ID top had and OD service pipe: cannot be compressed enough to form seal (courtesy Smith Grant)*

Figure A4.74 *Gap between OD of service pipe and ID of top hat to large: cannot be compressed enough to form seal, even with the application of additional tape (courtesy Smith Grant)*

Figure A4.75 *Jubilee clip on service entry insufficiently tightened so joint is uncompressed (courtesy Smith Grant)*

Figure A4.76 *No double sided tape used in joints (courtesy Smith Grant)*

Figure A4.77 *Small lap and no single sided tape used to achieve secondary seal (courtesy Smith Grant)*

Figure A4.78 *Gap in jointing over wall cavity big enough to insert fist (courtesy Smith Grant)*

Figure A4.79 Gas membrane not continuous over internal wall. It had been deliberately cut open for unknown purpose (courtesy Smith Grant)

Figure A4.80 Column left unsealed (courtesy PAGeotechnical Ltd)

Figure A4.81 No seal to perimeter pipe (courtesy PAGeotechnical Ltd)

Figure A4.82 Gas membrane used to bridge cavity wall instead of DPC, leaving it exposed to damage by follow-on trades (courtesy Smith Grant)

Figure A4.83 Poor quality installation of liquid gas membrane. Liquid gas membranes come in two colours (black and white) allowing coverage of each coat to be easily assessed. Here the gas membrane has been spread too thinly and inconsistently. In addition, it appears to have been applied to a damp surface, causing blistering (courtesy Card Geotechnics Limited)

Figure A4.84 Taped joints are difficult to construct in adverse weather. Also difficult to inspect if covered with snow (courtesy Smith Grant)

A4.3.3 Bad practice – passive venting systems

Figure A4.85 *Clean single sized stones with no fines acting as venting media, however no ventilation gaps in internal sleeper walls (courtesy Smith Grant)*

Figure A4.86 *Cavity is becoming blocked with detritus. The vent holes in the beam are no longer visible (courtesy Smith Grant)*

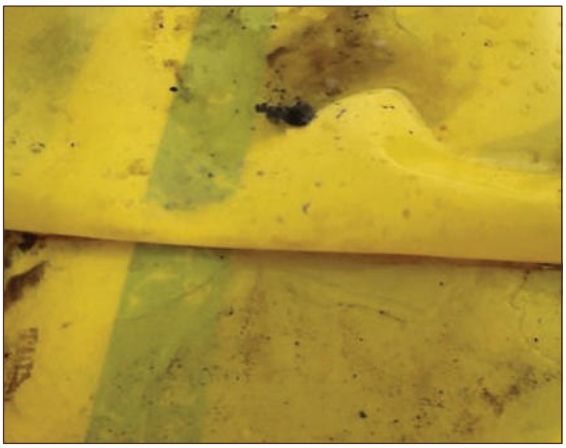


Figure A4.87 *Tape joint with crease running through and air bubbles where gas membrane not in complete contact with tape. Rollers should have been used to produce a consistent seal (courtesy MEC Environmental Ltd)*

Figure A4.88 *Ventilator becoming detached to fit to external block work. This is due to builders requiring increased cavity widths to achieve thermal properties expected by Building Regulations (courtesy NHBC)*

Figure A4.89 *No ventilation in internal sleeper wall (courtesy Smith Grant)*

Appendix 5 –Verification Proforma

Copied Directly From Appendix A5 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

VISUAL INSPECTION OF GAS PROTECTION MEASURES

Site name:	Gas characteristic situation:
Job number:	Type of development and building/block checked: (residential/ commercial/other)
Date:	Building description:
Visit by:	Foundation type: (suspended floor/raft/other)
Weather at time of inspection:	Gas protection type: passive/active

No.	Item	Comments (see notes)
1 Gas membrane		
1.1	Condition of sub-grade and underside of gas membrane	
1.2	Gas membrane type	
1.3	Gas membrane condition	
1.4	Joining tape product	
1.5	Lapping design	
1.6	Laps, welds and joints seals	
1.7	Service entries seals	
2 Passive venting		
2.1	Sub-floor void	
2.2	External wall airbricks	
2.3	Internal sleeper walls	
2.4	External vent trenches/ducts	
3 Active venting		
3.1	System details	
Additional notes:		

Notes: inspection checklist

1.1	Underside of gas membrane	Check that the sub grade does not contain rough/uneven surfaces, is appropriately clean and that there are no hard/sharp objects. That protective sand blinding or geotextile (if specified) is present and meets the design criteria.
1.2	Gas membrane type	Manufacturer and product specification, gauge, colour, brand/name, material batch/roll numbers, storage arrangements (protected from dirt/damage?)
1.3	Gas membrane condition	Open punctures, tears, rips, stretching? Excessive footprints/evidence of traffic? Presence of debris? Repairs? Signs of weakness such as raised or sunken indentations? Protection plan in place to restrict access to lain gas membrane?
1.4	Joining tape product	Product type, brand, thickness, material, width, colour? Use of double sided tape?
1.5	Lapping design	Joints lapped and sealed in accordance with manufacturer's requirements/ specification? Minimum overlap insured? Sections taped twice?
1.6	Laps and joints sealed	Welds complete? Appropriate joining/double sided tape used?
1.7	Service entries sealed	Top hats seal arrangements fixed around service entries? Use of Jubilee clips?
2.1	Sub-floor void	Is a check possible? Void former? Gravel (type/specification)? Height of void space? Is it clear?
2.2	External wall airbricks	Numbers, size, positions as design drawing?
2.3	Internal sleeper walls	Ventilation holes (honeycomb brickwork/pipe crossings?) – size, spacing, location in accordance with design?
2.4	External vent trenches/ducts	Located and constructed in accordance with design drawings? If open-topped gravel – gravel type/presence of fines? If pipe or other vent, check position and construction for functionality and absence of blockages. Ability of void former to withstand bearing of the superstructure?
3.1	Active venting	Type of air supply: mechanical, natural, combined? Location/condition/number of fans and vents? Location and size of inlets? Provision of air-cleaning devices and air heaters? Supply and exhaust ductwork? Alarm provision/installation? Gas monitoring system in under-floor void?

Photographs

No.	**Description**

The gas protection measures inspected:	a Are acceptable and comply with the specification
	b Are acceptable but attention is drawn to issues related to item no. xxx
	c Are not acceptable due to the issues related to item no. xxx

Name: **Signature:** **Date:**