National Contaminated Land Officers Group

A Regulator's Guide to Cover Systems and their Verification

Courtesy of the AGS Contaminated Land Working Group

2024

Contents

1. Foreword

1.1. About NCLOG

The National Contaminated Land Officers Group (NCLOG) is formed of a membership of likeminded local authority contaminated land officers (CLOs). NCLOG aims to enable the voice of contaminated land local authority regulators to be heard nationally, at government and industry level, and to be the 'go to' organisation when people want to reach Local Authority Contaminated Land Officers (CLOs) on national contaminated land matters. NCLOG provides a focus for working towards consistency in how CLOs deal with land contamination issues, such as cover systems.

1.2. Acknowledgements

This guidance was prepared by voluntary members of the NCLOG technical guidance subgroup, in a working group. The authors were:

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- Rae Watney, Senior Land Quality Officer at Sheffield City Council
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NCLOG would also like to thank the following organisations who have kindly given their permission for the use of figures throughout the document:

- Bosky Trees
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1.3. Note to Practitioners

This guidance has primarily been produced for use by appropriately qualified local government CLOs, however it is understood that land contamination consultants may also reference the guidance within their own reporting, when developing strategies to investigate and remediate land. It is for each local authority to decide which parts of this guidance should apply in their own area and in many cases, local authorities will have their own planning requirements for land affected by contamination. It is therefore essential that contaminated land consultants continue to meet local requirements and engage with planning authorities and CLOs to agree strategies to investigate and remediate land affected by contamination. It is hoped that this guidance will promote good practice and result in better outcomes, where a cover system is the chosen remedial solution.

While LCRM is not currently formally adopted for use within Scotland due to an ongoing review of certain divergences in regulatory policy and terminology, SEPA consider it to present good practice guidance on the approach to the assessment of potential land contamination constraints. This guidance can be used where it is demonstrated to be appropriate for site specifics and the relevant regulatory regime(s). If you are unsure regarding the application of any aspects of this guidance, please refer to your regulator.

This guidance is intended to serve as an informative and helpful source of advice. NCLOG will review this guidance every five years (or following significant updates to legislation), 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.

A summary reference sheet is appended to this document. This reference sheet should be read in conjunction with the rest of the document, and is intended as an aide memoire only.

1.4. Before using this guidance

This guidance assumes that an appropriate risk assessment has been completed along with a remedial options appraisal and that a soil cover system has been identified as a suitable remedial measure. The process of considering a soil cover system within a remedial options appraisal is briefly discussed in Section 3.1.

The risk assessment should be based on enough samples having been taken in accordance with relevant guidance (BS10175[1],LCRM[2] or local authority produced guidance). Where appropriate the risk assessment may incorporate aspects such as those highlighted in Section 3.4.1. It is poor practice to default to the use of a soil cover system without sufficient sampling and risk assessment first having been completed.

1.5. Legal Status and Disclaimer

This report is published by the National Contaminated Land Officers Group (NCLOG) and is non-statutory. It presents work undertaken by a NCLOG sub-group composed of volunteers listed in the Acknowledgments above. The publication describes cover systems as a remedial option for land affected by contamination, and their verification, which suitably qualified and experienced local government officers may choose to use to help in option appraisal and the development of remedial strategies for planning and statutory land contamination/Environmental Damage purposes. Regulators are under no obligation to use this guidance. This document provides a summary of other guidance and broadly acceptable industry practices and so it is imperative that users do not rely solely on any advice and direction provided, but also consider other relevant guidance and the specific characteristics of their Local Authority and the site. It is imperative that users understand the limitations of cover systems as a remedial option and consider these when using this guidance.

This report is made available on the understanding that neither the contributors nor the publishing organisation is engaged in providing a specific professional service. Whilst every effort has been made to ensure the accuracy and completeness of the work and this document, no warranty as to fitness for purpose is provided or implied. Neither NCLOG nor the authors of the report accept any liability whatsoever for any loss or damage arising in

2. Introduction

2.1. What is a Cover System?

The term 'cover system' refers to a range of solutions which can be carried out as part of land remediation. The Environment Agency's Land Contamination Risk Management guidance (LCRM)[3] states that 'Remediation is the action required to prevent, minimise, remedy or mitigate the effects of the unacceptable risks' and so, put in the context of a Source – Pathway – Receptor contaminant linkage, a cover system can act as a barrier to remove or minimise the pathway to underlying contamination. It is one of the most common remedial actions used by developers in garden and landscaped areas.

A simple cover system (see BRE 4654,) seeks to reduce exposure to contamination by placing layers of topsoil and subsoil over the contaminated soils, sometimes incorporating a visual marker or separation layer. It should be noted that many Local Authorities do not routinely accept the use of BRE 465[4]; further information is provided in Sections 2.4 and 6.1. Engineered cover systems (see CIRIA SP124[5]), which are not covered in detail within this guidance, are designed to block or break the pathway to contamination by providing complete separation, for example incorporating robust layers of clay or concrete.

2.2. Scope of the Guidance

This guidance aims to provide an overview of cover systems and when cover systems may or may not be a suitable option. The types and components of a cover system and the different elements to take into consideration during design, implementation and verification are included.

Whilst this guidance does not set cover system depths and sampling frequencies, it does refer to standard depths of cover routinely specified by environmental professionals and ranges of verification rates accepted by some Local Authorities. However, greater importance is placed on determining cover depths and verification rates on a site-specific basis.

This guidance mainly considers simple cover systems and does not include detailed information on the design of barriers within a cover system (intended to address the presence of more significant contamination), or other engineering considerations.

This guidance considers the use of cover systems as a measure to protect human health. The protection of other receptors, which may also need to be considered, is not covered.

The guidance does not address geotechnical issues.

The guidance makes references throughout to various policy documents and regulations, some of which do not apply in the devolved administrations (Wales, Scotland and Northern Ireland). Attempts have been made to reference corresponding documents and regulations where possible, but readers should be aware that alternative and equivalent documents may need to be referred to in the devolved administrations.

2.3. Why is Guidance Needed?

Currently available guidance relating to cover systems is either limited or outdated, particularly regarding where they should be used, the depth of cover and their verification. This guidance provides a single point of reference for Local Authority CLOs and is intended to help ensure that, where cover systems form part of a remediation strategy, design and verification is in accordance with LCRM. This guidance may be used in the following situations:

Planning

England

The National Planning Policy Framework (NPPF[6]) states that Local Authority (LA) planning policies and decisions should ensure "a site is suitable for its proposed use…" and that "after remediation, as a minimum, land should not be capable of being determined as Contaminated Land under Part IIA of the Environmental Protection Act 1990."

Scotland

National Planning Framework 4 (NPF4[7]) states that "where land is known or suspected to be unstable or contaminated, development proposals will demonstrate that the land is, or can be made, safe and suitable for the proposed new use". Planning Advice Note 33: Development of Contaminated Land (PAN 33[8]) states that land should be "suitable for use" and that it is ensured "that land is made suitable for any new use, as planning permission is given for that new use".

Wales

Planning Policy Wales (PPW[9]) states that the onus is with the developer to "ensure that the development of the site will remove any unacceptable risks and the planning authority in making development management decisions will need to ensure that the land is suitable for its proposed use and would not meet the legal definition of Contaminated Land under Part IIA". Additional information is available in Welsh Office Circular 22/87[10].

Northern Ireland

The DAERA Practice guide: Redeveloping Land Affected by Contamination[11] states that "developers must ensure that all risks associated with potential land contamination have been identified and addressed so that the land is suitable for its new use".

Part 2A of the Environmental Protection Act 1990 (Part IIA) (England, Scotland and Wales)[12]

Where land has been determined as Contaminated Land under Part 2A, remediation is required to reduce or remove all unacceptable risks considering the current land use.

Part III of the Waste and Contaminated Land (Northern Ireland) Order 1997[13]

At the time of writing this document, the Contaminated Land Regime for Northern Ireland (as set out in the above legislation) has been enacted but is not yet in force. A timetable for the implementation of the regime in Northern Ireland had not been agreed at the time of this report's publication.

Where land has been determined as Contaminated Land under Part 2A, remediation is required to reduce or remove all unacceptable risks considering the current land use.

The Contaminated Land (Scotland) Regulations 2005[14]
Part IIA of the Environmental Protection Act in Scotland is further established by these regulations, which additionally regulate the water environment and special sites, and provide detailed information on the provision and enforcement of Part IIA in Scotland.

Environmental Damage Regulations (England)[15]
Where environmental damage has been caused as defined in The Environmental Damage (Prevention and Remediation) (England) Regulations 2015, remedial measures are required to ensure the land, taking account of current use or any planning permission existing at the time of the damage, no longer poses any significant risk of adverse effects on human health.

2.4. Other Guidance

Several other guidance documents, addressing cover systems, have been referred to during the preparation of this cover systems guidance. The key documents are summarised below, however individual Local Authorities may also produce their own guidance specific to that Local Authority's area, sometimes in the form of a Supplementary Planning Document or Developer's Guide, which should (or must, if required by a condition) be consulted to determine any additional issues or requirements.

Land Contamination Risk Management[3]
LCRM is the government guidance on how to assess and manage risks from land contamination. The guidance sets out a three-stage process of risk assessment, options appraisal and remediation and verification. The guidance is intended to be referred to by all those responsible for managing land contamination.

BRE 465 Cover Systems for Land Regeneration (2004)[4]
BRE 465 focuses on the design aspects of simple cover systems where soil mixing will occur. The guidance has been archived with BRE advising that some of the information within it has been superseded by more recent research and standards. The document provides an approach to calculating the thicknesses of soil cover layers for suitably reducing exposure to contamination. The guidance is not appropriate for situations where contamination is so significant that exposure must be completely prevented. **The guidance is not routinely accepted by all local authorities and consultation with the regulator is strongly advised before use**. The AGS have published a position statement on BRE 465 (AGS Review and Position Statement – Cover Systems for Land Regeneration, 1st July 2019[16]) setting out some of the concerns that regulators have expressed in the past with the guidance.

CIRIA Special Publication 124: Barriers, Liners and Cover Systems for Containment and Control of Land Contamination (1996)[5]
CIRIA SP124 details design criteria, theory and practice for a range of physical barriers such as in-ground barriers, multi-layer cover systems and liners. It presents the theoretical basis for these systems and provides methods for in-situ and laboratory testing for the design and monitoring of performance. This guidance will apply to most situations where land affected by contamination is present.

CIRIA Special Publications 106: Remedial Treatment for Contaminated Land Volume VI: Containment and hydraulic measures (1996)[17]

CIRIA SP106 focuses on engineering based remedial methods, specifically physical containment and hydraulic control systems. Cover systems are discussed as a principal physical containment method.

YALPAG Verification Requirements for Cover Systems (2021)[18]

The YALPAG guidance focuses on the verification of cover systems, setting out requirements to verify the suitability for use of material being used for a cover system, storage of material prior to placement and verification of a cover system's depth. The document includes guidance on reporting requirements and supporting documentation that should be included in any verification report.

2.5. Professional Competence

It is essential that those determining a need for and designing cover systems are appropriately qualified and competent as required in relevant guidance, including:

- Contaminated Land Statutory Guidance (England) (2012)[19]
- Contaminated Land Statutory Guidance (Wales) (2012)[20]
- Contaminated Land Statutory Guidance (Scotland)[21]
- National Planning Policy Framework (NPPF)[2]
- Environment Agency - Land Contamination: Risk Management guidance (LCRM)[3]
- DAERA Practice guide – Redeveloping Land Affected by Contamination (Northern Ireland)[11]

3. Establishing Whether a Cover System is a Suitable Option

3.1. Options Appraisal

Under LCRM[3] (*Stage 2*), where remediation has been proposed, it is essential that sufficient information has been collected for a site to show that the identified risks have been adequately assessed in line with Stage 1 of the LCRM process, and that the proposed remediation approach is viable, acceptable, and an appropriate risk management action.

A decision-making framework, such as that set out in Guidelines for Environmental Risk Assessment and Management (Green Leaves III)[22] offers environmental risk assessment and management tools that can be explained to stakeholders and provide an evidence-based process for selecting the most appropriate remediation solution. Remediation should manage the risks identified during the site investigation and risk assessment or reduce them to an acceptable level.

The first step of Stage 2 of the LCRM process is to identify and produce a shortlist of feasible remediation options. The options appraisal process should run in tandem with the design and development control process. However, it is acknowledged that it is often challenging to align these processes due to differences in funding and contractor priorities and supply chain timelines.

An appropriate remediation option is established by identifying and evaluating feasible remediation options. When identifying if a cover system is a feasible option, either as a standalone option or in combination with one or more other options, site information must be up-to-date and appropriate remediation objectives set. Suitability of a cover system will depend on sustainability and management and technical objectives, such as planning for any regulatory controls that may apply to the specific cover system or the need to incorporate site infrastructure. These aspects are discussed further in Section 4. The final remediation option is developed within the remediation and verification strategies.

3.2. Suitability of a Cover System

The decision on suitability of a cover system will be based on the conceptual site model, considering the potential exposure pathways, the final land use and setting, how land will be managed, any other feasible land uses over the lifetime of the development, layout, topography, and finished levels. Factors such as climate change and whether a cover system is a sustainable option, are also important considerations. LCRM contains an options appraisal matrix[23] which sets out the broad capabilities of different remediation options, including cover systems. Capability is assessed depending upon the nature of the contamination and whether it is present in soil or water. Consideration of the above and consultation with regulators can reduce delays in obtaining regulatory or planning approval.

A cover system may not be appropriate in all instances, for example on sites with a shallow water table or sloping topography, which will be subject to significant excavation in later stages of development, or, very active burrowing animal populations. A cover system also may not be suitable where contamination is so significant that exposure or water infiltration must be completely prevented – the options appraisal exercise should demonstrate whether another option is the most appropriate to achieve this aim, such as bioremediation or an engineered system. The design of the cover system should also consider if the system will give rise to waterlogging, a reduction in available cover depth over time, flooding, over compacted soils, damage to protected trees or a poor growing medium in soft landscaped areas.

Considerations should also include whether long-term management actions are needed and if so, the types of management actions that should be considered to ensure the safe use of a site (See Section 5.9 for additional information). It should also be considered whether long term management actions can be guaranteed once the cover system is completed.

In some circumstances, unless long term management arrangements can be guaranteed, a cover system may not be a suitable remedial solution. This might be the case for residential developments associated with more significant levels of contamination where, despite any requirements included within the deeds or through planning controls to prevent harm, owners or occupiers may choose to dig below the cover system.

Information on the design of a cover system is discussed in more detail in Section 4.

3.3. Alternatives to a Cover System

Alternatives to a cover system are detailed within the Options Appraisal matrix in LCRM Stage 2[23] and could include in-situ or ex-situ treatment, barriers, encapsulation, soil stabilisation, source removal by excavation, or hand picking. Access to the source of contamination could be restricted by other means, such as hard coverings, fencing, planting, relocation of sustainable drainage systems, utilising more contaminated areas for less sensitive uses, restrictive covenants, or removal of permitted development rights.

3.4. Options Evaluation Exercise

Information on how to complete an Options Evaluation is in LCRM Stage 2[24]. Specific considerations that should be made regarding cover systems are detailed below. The type of cover system will depend on the findings of the site investigation and risk assessment and should consider the most suitable system for dealing with each relevant contaminant linkage. The evaluation process involves considering the costs, benefits and limitations of the cover system and the potential for using in combination with other remediation techniques. The onus is on the developer and their appointed specialist to design a suitable remedial option and demonstrate via appropriate justification how this is sufficient to break the relevant contaminant linkage.

3.4.1. Conceptual Site Model

During intrusive site investigation and risk assessment the conceptual site model (CSM) should be kept under review and should form the basis of the options appraisal process. It is important to refer back to the risk assessment throughout the process and to consider factors such as:

- Has sufficient risk assessment been undertaken to allow options appraisal?
- Have sufficient samples been taken in the area of interest to allow risk assessment, including, where appropriate, statistical analysis[25]?
- Are separate sample populations evident from chemical and statistical analysis of the ground conditions? Have these been assessed separately?

- Has bioaccessibility been considered?
- Could further robust site-specific risk assessment justify that an alternative or no remediation is more appropriate?
- Does the CSM support localised as opposed to site wide remediation?
- Are the characteristics and behaviour of the receptors clearly defined?
- Does a cover system address the exposure pathways identified?
- Is a cover system a sustainable option?

3.4.2. Effectiveness and Practicability

Practical constraints such as site size, layout or topography may inform the suitability of the cover system. Factors such as the effectiveness of the proposed cover system and whether it will successfully reduce risk to an acceptable level will need to be considered. A simple cover system is generally suitable on sites where exposure to contamination must be reduced, rather than removed entirely. An engineered cover system may be designed where a more permanent removal of the exposure pathway is required.

Where a cover system requires approval by a regulator, such as under Planning or Part 2A, suitability will be directed by factors such as whether installation and maintenance will satisfactorily reduce risks, and verification assessment or long-term monitoring are required to provide a greater level of confidence for regulators.

LCRM[3] suggests considering evidence of other successful remediation schemes using the chosen approach. This may be particularly important where the cover system is proposed in a particular situation, such as in specific ground conditions, or where ground or surface water may influence contaminant behaviour.

3.4.3. Timescales

The timescale should consider how long it will take to gain any permits or other approvals and to complete the cover system, including materials movements, other site work, regulatory 'sign off' and any longer-term maintenance. There may be a need to gather additional data to help inform the final design.

3.4.4. Health and Safety

The level of requirements to address health and safety issues associated with a cover system must be considered both during installation and in the longer term. This could include factors such as materials selection and use, plant movements, amenity issues and protection of workers (both for construction and maintenance), site users and off-site receptors.

3.4.5. Sustainable Remediation

The effect that the cover system will have on the quality of the environment on and off site, during and after completion, should be evaluated. LCRM[3], PAN 33[8], and the NPPF[2] stress the importance of a sustainable approach to remediation. The project manager will need to consider the benefits of doing remediation vs the environmental (including climate change), economic and social impacts. The design and implementation should not cause a greater adverse effect than the contamination it aims to address.

LCRM states that 'The remediation needs to manage the unacceptable risks in a safe and timely manner. It needs to aim to maximise the overall environmental, social and economic benefits across the whole supply chain.' There is extensive advice and information on sustainability available from SuRF UK (claire.co.uk).[26] The British Standard BS ISO 18504:2017 Soil quality: Sustainable remediation[27] sets out current concepts and procedures for sustainable remediation in legal, policy, socio-economic and environmental contexts. Increasingly local authority Local Development Plans are including policies, which require that more sustainable approaches to remediation are taken. As a result, reference should also be made to local planning policies and guidance.

3.4.6. Climate Change

Consideration of potential impacts from climate change on the remediation scheme is becoming more important. This may include sea level rise, rises in groundwater levels and extreme weather events. Impacts on the cover system could result from processes such as:

- Increased water infiltration.
- Vertical leaching of contaminants upwards or downwards.
- Flooding events.
- Erosion.
- Die-back of vegetation causing soil exposure.
- Treefall due to higher intensity storms.

Climate change is predicted to affect different parts of the UK in different ways, such as prolonged or more frequent storms or high winds, increased erosion, increased rainfall, and local conditions affecting the ability to drain run-off. The durability of the remediation should be assessed in this context based on the most recent available information and on local and national policy and associated guidance. Considerations during design are discussed in Section 5.7.

3.4.7. Cost

The affordability of the cover system should be based on the scheme's available resources and should also consider both installation and verification costs.

3.5. Remediation Strategy & Verification Plan

Where a cover system is the most suitable remediation option (as a single, multiple, or combined approach) this will form part of the remediation strategy. The remediation strategy needs to consider the above factors and include:

- Details of the remedial actions, including detailed design of the cover system and how it will be implemented.
- A verification plan to demonstrate and report that the cover system is successfully installed.
- Monitoring and maintenance requirements.
- Regulatory controls that need to be in place.

The remediation strategy will need to be approved by the regulators and issued to stakeholders (including remediation contractors and builders) before installation of the cover system commences. Verification of a cover system often needs evidence gathering during development (e.g., photographs of reduced level excavations, placement of break layers etc.) as well as once the development is completed (See Section 7).

4. Cover System Components

Cover systems are typically classified into two broad categories:

1. Simple cover systems; and
2. Engineered cover systems.

A simple cover system seeks to reduce or break exposure pathways by placing a layer (or layers) of material, such as soil or aggregate, between receptors and the residual contaminated material. An engineered cover system consists of several layers designed to perform a variety of functions such as:

- Reducing surface water infiltration;
- Improving drainage;
- Preventing upward migration of contaminants due to capillary rise;
- Reducing penetration of the cover system by flora, fauna, or site end users; and,
- Reducing differential settlement.

Examples of each are shown below in Figure 1 which has been adapted from Figure 3.15 of CIRIA SP124[5]. This figure is a diagram to show the relative positioning of the possible layers. In practice, only selected layers would be incorporated in any particular cover system.

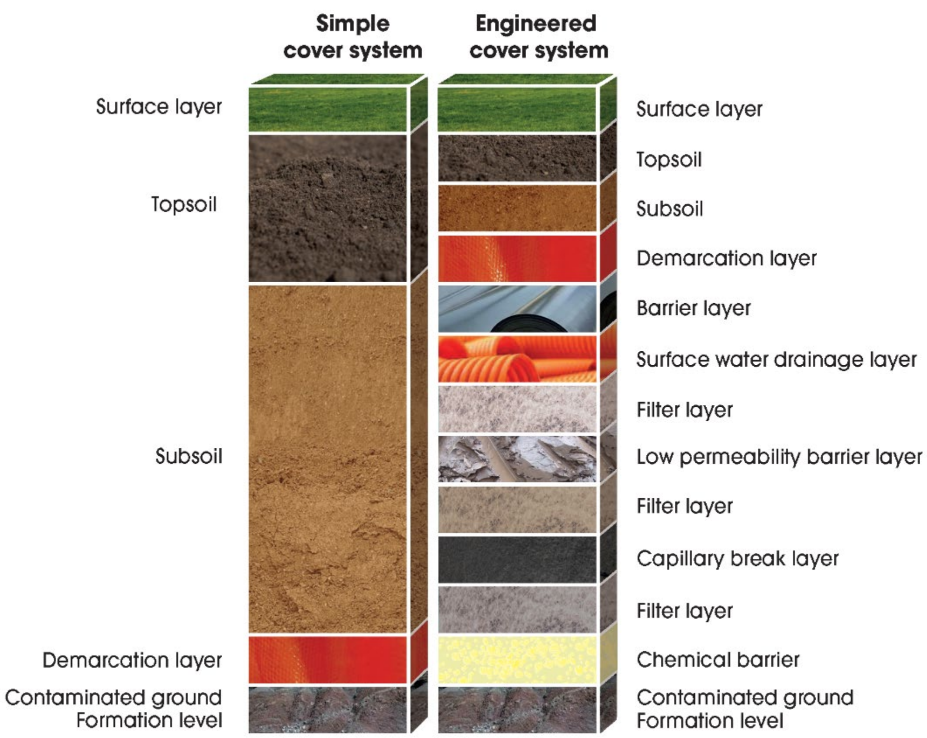

Figure 1: *Examples of the components of a simple and engineered cover system. (Note: cover system construction is very variable and the above are examples only. Some layers e.g., a demarcation layer, may serve a dual purpose of providing a visual demarcation layer whilst also preventing intermixing)*

The various components that may be found within a cover system are summarised in the following sections. Detailed guidance is available elsewhere including CIRIA Special Publications 106[17] and 124[5].

The role of Local Authority officers is to ensure that the cover system is protective of the identified receptors for the lifetime of the end use. The detailed information below is best practice design.

4.1. Formation Level

The formation level is the ground level upon which the cover system will be formed. Due to excavation, cut and fill, site clearance and site scrapes, the formation level may be quite different from ground surface levels that were present when the site investigation was conducted. As such, it is important to ensure that contamination within the formation level has been adequately investigated and assessed during the site investigation to ensure that the cover system design is appropriate. Additional sampling may be required as part of the remediation strategy following earthworks and/or demolition to fully characterise the site and ensure it is suitable for use.

Compaction of the formation level prior to the placement of the cover system is often desirable as it can inhibit root penetration, infiltration, burrowing animals, instability, and differential settlement. However, consideration must be given to the impact that any compaction may have on drainage. The formation level should be free from vegetation and any other putrescible material prior to placement of the cover system.

On many sites a piling mat, typically comprising recycled aggregate may have been imported. Often the piling mat extends beyond the footprint of buildings and remains on site, ultimately being incorporated into the formation layer. Any material being imported to site to form a piling mat (or for any other purpose e.g., SUDS features) should be verified to ascertain its physical and chemical suitability (see Section 7.5.1).

4.2. Surface Layer

The surface layer is the most exposed to the elements and the activities of animals and site users. This layer may be required to perform several functions including infiltration reduction, erosion reduction, deterrence of incursion into the cover system by animals or site users, soil stability improvement and dust generation inhibition.

Surface layers may consist of a variety of materials including vegetation, aggregates, paving or synthetic materials.

Vegetation

When considering vegetation, it is important to ensure that the chosen species are suitable for the conditions present at the site, including climate, drainage, soil type, characteristics, and any after-care or future management. It is also important to ensure that roots will not damage subsequent layers of the cover system or, in some instances, penetrate the underlying contaminated formation layer. Should the latter happen, contamination may be taken up by plants and transported to the surface through leaf drop or brought to the surface as plant growth displaces soil or soil erodes around the base of plants. In some instances, vegetation can be used to discourage regular access to an area or stabilise soil, preventing erosion.

Hardstanding

Hardstanding may be used as an alternative to topsoil. Hardstanding can reduce surface water infiltration and provides potentially robust protection against incursions into the cover system by animals and future site users. However, on sites where the future activities of site users cannot be effectively managed (such as residential gardens), consideration must be given to the robustness of the surface layer and the likelihood of future disturbance or removal. Subject to the likely permanence of any hardstanding it may still be necessary to achieve the required cover system depth, beneath the hardstanding.

Aggregates

Aggregates, such as decorative gravels, will permit water infiltration and offer very little protection against the possibility of future incursions into the cover system.

Synthetic Materials

The use of synthetic materials such as artificial turf are now becoming more common. A synthetic surface layer should not, in isolation, be regarded as a suitable means of guarding against the presence of underlying contamination. Artificial turf has a limited lifespan and there can be no guarantee that it will not be removed in the future in preference for topsoil and vegetation. If synthetic materials are to be used then the same depth of cover, as dictated by the risk assessment and remediation strategy, will need to be applied.

4.3. Topsoil

The primary functions of a topsoil layer are to support the vegetative surface layer and, in conjunction with the other components of the cover system, provide a barrier layer over the underlying contamination. The topsoil layer should:

- Conform to BS 3882:2015[28] and be able to support plant growth;
- Be free from invasive, non-native plants[29];
- Be free from odours and physical contamination such as asbestos, brick, glass, concrete, metal, and plastic; and
- Be chemically suitable such that it is protective of human health and, where relevant, controlled waters/ water environment.

BRE 465[4] recommends that the topsoil layer in a simple cover system should be at least 150mm thick or 30% of the cover system depth, whichever is greatest. BS 3882[28] specifies that the depth of topsoil should not normally exceed 300mm. Further information is presented in Section 6. The depth of topsoil placed should take into consideration compaction and degradation, to ensure that the specified cover depth is maintained. In some instances, it may therefore be necessary to place a greater depth of some topsoil to maintain topsoil depths.

Careful consideration should be given to the handling and management of the topsoil to ensure that its structure is not compromised, for example through compaction, waterlogging or inhibition of root development. In the interests of sustainability topsoil should, wherever possible be sourced and reused on site and the possibility of treating any contaminated topsoil should be explored. Further guidance on the sustainable use of soils has been published by DEFRA[30].

4.4. Subsoil and Fill Materials

The primary functions of a subsoil or fill layer is to provide appropriate support to any overlying layers (such as topsoil) or structures as well as forming part of a barrier layer above any residual contamination. Typically, this fill layer will comprise subsoil but occasionally may consist of sand or other fill materials.

Subsoil provides additional rooting depth, moisture storage and drainage. The structure of the subsoil is critical to these functions and must therefore be maintained throughout transport, handling, storage, and placement. Further advice is available within DEFRA guidance[30]. The subsoil layer should conform to the topsoil requirements bullet pointed above with the exception that the relevant British Standard is BS 8601: 2013[31].

4.5. Separation and Demarcation Layers

Demarcation layers typically take the form of a synthetic geotextile placed at the interface of the clean cover and the underlying contaminated soils. They can act as a visual warning, prevent intermixing, and discourage deeper excavation. It is important that the intended purpose of a demarcation layer is considered and that a product is selected on this basis. Specific guidance on the use of geotextiles for basic separation and filtration can be found in BS 8661[32]. A specification for the product to be used should be included in the remediation strategy. Separation and demarcation layers should not be viewed as a physical barrier or break layer that will prevent excavation into underlying contaminated soils as they are typically capable of being easily cut through.

Some guidance on the use of geotextiles is included in CIRIA publication C733[33]. Whilst this guidance specifically relates to managing risks where asbestos containing soils are present it is considered good practice that could be applied wherever a geotextile demarcation layer is being used. C733 advises that geotextiles should be water permeable, rot proof, chemically resistant and have a high tensile strength.

What constitutes a sufficiently high tensile strength will depend upon the situation and the function required. For most routine cover system applications where the geotextile is intended to provide separation of two materials in an area that will not be subject to vehicle loads, settlement or other significant forces, tensile strength is of less importance. Tensile strength is likely to be more critical when a geotextile is anchored into position, as opposed to loose laid, and then placed under tension from an overlying load. Many products commonly used in loose lay applications have a tensile strength of 8 kN/m.

Geotextiles can be either woven or non-woven. Woven geotextiles are made by weaving polypropylene tapes together. They are typically strong and durable with a high load capacity. However, they can be limited in their drainage and filtration capabilities and can be susceptible to losing strength over time. Non-woven geotextiles are made by bonding materials together through heat or chemicals, and then finished by needle punching or heat bonding. Non-woven geotextiles have excellent drainage properties and tend to retain their strength over time when fitted underground[34].

C733[33] advises that geotextiles should be applied across the total surface area of the contaminated soils (preferably extending beyond the boundary) and parallel layers should be suitably secured together or overlapped by at least 20cm.

The use of plastic sheeting (e.g., polyethylene) should be avoided. Plastic sheeting is unsustainable and typically not fit for purpose due to the potential for degradation over time.

Where tensile strength is an important consideration care should be taken to ensure the test method employed is appropriate (e.g., ISO 10319[35]). When comparing products, it is also important to ensure that test methods are comparable.

4.6. Barrier Layers

An engineered cover system may contain a number of different barrier layers designed to perform different functions. Detailed guidance on barrier layers is beyond the scope of this document and the reader is invited to consult additional guidance documents such as CIRIA Special Publications 106[36] and 124[5]. A brief summary of the various barrier layers is provided in Table 4-1 below.

Table 4-1 Types of barrier layer used in some engineered cover systems.

Type of barrier layer	**Principal functions**	**Notes**
Capping layer	Reduce surface water infiltration	Typically compacted, low hydraulic conductivity mineral layer (such as clay) or a low permeability synthetic layer such as a geomembrane.
Gas barrier	Reduce exfiltration of ground gases or vapours	
Bio barrier (no dig layer)	Prevent penetration by humans, animals, or vegetation	Can be formed by compacting fill materials, cobbles, hardcore or use of synthetic materials such as geogrid.
Insulation barrier	Reduce heating of subsurface combustible materials from any above-ground thermal source	CIRIA SP124 recommends that 1m thickness of material will usually provide sufficient insulation.
Chemical barrier	To constrain and attenuate certain contaminants	Will comprise materials tailored specifically to target the contaminants of concern. E.g., limestone layers have been used to control acid generation and upward migration of heavy metals[5].
Filtration layer	Prevent fines from entering and clogging layers which require high porosity.	Layers which typically require protection from clogging include drainage, capillary breaks, and gas collection.

4.7. Capillary Breaks

Some liquid contaminants (such as polluted groundwater or light non-aqueous phase liquids - LNAPLs) and soluble contaminants can migrate upwards through the ground due to capillarity. This phenomenon occurs due to the surface tension arising between the soil grains, air, and permeating fluid[5] and is influenced by a number of factors, including:

- Soil saturation levels: the drier the soil the greater the soil suction;

- Soil grain size: as grain size, and thus intergranular pore size, decreases the height of capillary rise increases; and
- Hydraulic conductivity: the ability of water to flow through the soil.

A capillary break layer seeks to prevent the upward migration of contamination due to capillarity. Most often this is achieved by using a material with a large pore space which effectively prevents surface tension from arising. Suitable materials include:

- A course, clean, granular material; or
- A geosynthetic drainage material.

Where granular material is used, it should be smooth and non-porous to ensure that capillary rise cannot occur through pore space within the material itself or due to surface roughness. Material with the propensity to break down and form fines e.g., reclaimed aggregate, should not be used to form a capillary break layer. It is likely that any effective drainage layer incorporated into a barrier design could also prevent capillary rise, but this should be assessed as part of the barrier design. A capillary break layer will require protection, typically using a filtration layer (see Table 4-1). This is to prevent fines from clogging the larger void spaces as it is these voids that prevent surface tension and inhibit capillarity.

The need for a capillary break layer should be considered on all sites where contaminants are present which could migrate upwards due to capillary action. The impact of a rise in groundwater, for example due to the impact of climate change, should also be factored into the design of capillary break layer. Further guidance is available in CIRIA publications SP106[17] and SP124[5]. Where appropriate, the Remediation Method Statement should include details on the decision making with regards to capillary action and the need for a break layer and, where it has been decided not to include one, justification should be provided.

5. Cover System Design

There are many factors that must be considered when designing a cover system, although not all of them will need to be factored into the final cover system design. Each site should be assessed using a site-specific CSM including the relevant regime under which the cover system is being implemented. Some engineered solutions can provide additional benefits (in terms of remediation, sustainability, cost, and climate change), and elements of these designs may need to be considered alongside any consideration for a cover layer. A cover system should be designed to be effective for the estimated lifespan of the proposed development. Other environmental or engineering factors may also be present which require additional considerations.

5.1. Changes in Site Levels

The required depth of a cover system can be achieved at a site by reducing the existing site levels by the depth of the cover system, increasing site levels by the depth of the cover system, or a combination of these two approaches.

Where the site is increased in height, or a cut/fill exercise is being undertaken, there is the potential scope to reduce the amount of material exported from or imported onto a site. Associated sustainability benefits may include reduced heavy goods vehicle movements, reduction of soils being sent to landfill and related landfill taxes. However, any raise in site level would need to be carefully considered to ensure that it is achieved in a manner which does not compromise the robustness of the cover system or create other potential problems, such as interfering with surface water run off or drainage.

The potential for there to be future interference with the cover system, such as the removal of soil or excavation through the cover system, is reduced on managed sites, such as commercial properties or managed communal gardens. Where partial land raises have been undertaken, there is an increased likelihood that this removal or interference may occur. Raised cover systems which provide only partial site coverage or rely on retaining walls should not usually be regarded as suitable for residential sites unless they are constructed in such a robust manner that future removal or disturbance would be extremely unlikely.

Any changes in site levels may need to be made in consultation with an appropriate flood risk consultant and must comply with planning requirements, which would typically require planning permission where site levels increase by 300mm or more.

5.2. Slopes and Terraces

Careful consideration should be given to the use of cover systems on or near sloping ground. Several factors can contribute to the instability of a cover system on or near a gradient, including gravity, pore pressure, and the use of smooth geosynthetic materials within the cover system.

There is conflicting advice on the use of cover systems on gradients. CIRIA SP124[5] recommends that failure due to slope instability should be specifically assessed on gradients greater than 1:6 but BRE465[4] advises that cover systems should not be used on gradients greater than 1:12. If it is proposed to install a cover system on a gradient, this should be discussed with a geotechnical specialist and, where necessary, agreed with the Local Authority , ideally at an early stage. The cover system designer should be prepared to demonstrate that the stability of the cover system has been thoroughly considered and assessed and that their cover system is stable, will not result in instability on or off site, and will resist erosion from surface water run-off. Advice on minimising cover system erosion is provided in CIRIA SP124[5].

Gradients can be removed through terracing, but care must be given to such a design to ensure that it is robust and will not be compromised by future site occupants. In all situations involving the installation of a cover system on or near to sloped or terraced sites, consideration must be given to drainage, contamination migrating down the gradient due to the movement of surface and shallow ground water, through soil creep or via the collapse of adjoining slopes.

5.3. Boundaries and Intersections

Newly constructed gardens that adjoin one another would typically have a continuous cover layer. However, the intersections between a cover system and the surrounding soils/environment need to be considered as part of design e.g. at a site boundary or against pavements/roads. Ideally a cross sectional plan should be provided showing such details. In some circumstances a vertical barrier may be needed at the abutment to prevent soil mixing. Unless it can be demonstrated to be suitable, tapering a cover system at the site boundaries should typically be avoided, particularly at residential properties. Flower beds, where excavation and future disturbance are most likely to occur, are typically formed at the edges of gardens and tapering of the cover system is unlikely to provide sufficient protection.

5.4. Services and Utilities

Services and utilities may be installed entirely within a cover system, in some instances as a means of isolating them from the underlying ground and preventing future maintenance workers from being exposed to residual contamination. If this is the case, there is a need to consider where the services will be located, whether any are located in sensitive parts of the site (i.e. private gardens or landscaped areas), and what depth they will sit at. Alternatively, services and utilities may be installed beneath the cover layer, within clean service corridors. If services are being installed post placement of a cover layer, then the potential for cross contamination during excavation and reinstatement of the soils will require careful consideration. If services are being installed prior to the cover soils being placed, then the depth at which they are installed must not preclude subsequent installation of the cover soils. This is often a consideration in front gardens of residential developments, where the majority of services will typically enter a property. The key point for regulators is to ensure that developers/consultants have considered the presence of services and utilities and are able to demonstrate that their installation will not impact upon the overall integrity of the cover system.

5.5. Combustible Material

If materials are present in the ground that may potentially combust in the presence of a heat source e.g. cables, then this will require consideration in the design of a proposed cover system. This is likely to be a particular issue in former mining areas where a high colliery spoil content may be present within made ground. ICRCL 61/84[37] provides guidance for the assessment of potential for combustibility – variables considered include the calorific value. Detailed consideration of combustion and spontaneous combustion is beyond the scope of this guidance.

5.6. Sustainability

Soil cover systems are typically not a sustainable remedial solution, as they result in significant vehicle movements to transport waste soils off site and increase pressure on landfills. They also typically involve the import of clean soils onto a site, using up a valuable resource in subsoil and topsoil.

Wherever possible, more sustainable approaches should be considered. A sufficiently detailed and informed risk assessment may demonstrate that there is no requirement for a cover system or that requirements can be restricted in depth or limited to a part of a site. Sourcing soils from on-site and minimising the off-site disposal of soil may also make a cover system a more sustainable option.

Consideration should be given as to whether any of the impacts outweigh the economic, social and environmental benefits to public health, air quality or controlled waters etc. As specific guidance on sustainability is available elsewhere (SuRF UK, March 2010[38]), this document does not aim to reproduce it. However, the following factors are among those that should be considered when assessing the sustainability of a cover system:

- Impacts of the excavation processes and materials preparation
- Implications of transporting material or operating equipment
- Quantity of off-site disposal required to accommodate the cover system
- Potential reuse of excavated materials on or off site as soils and fills
- Quantity of imported soil required
- Impacts of any off-site processes

Provided it is legislatively compliant from a waste perspective, or undertaken in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice (DoWCoP)[39] or SEPA's Land Remediation & Waste Management Guidelines[40], there may be scope to reuse materials on site, to minimise the amount of material requiring export and import. Where the transport of soils to or from site is required, sustainable haulage options should be encouraged. Local authorities may wish to consider developing specific policy on sustainability.

5.7. Climate Change

Many Local Authorities have now declared a climate emergency and as a result have set out priorities intended to help mitigate climate change. An authority's Local Plan may also require that development is sustainable and that it meets climate change objectives. Regulators should therefore seek to ensure that consultants have accounted for the possible effects of climate change on the long-term performance and durability of a cover system. Climate change is predicted to affect different parts of the UK in different ways, such as prolonged and more frequent storms, increased or reduced rainfall and more frequent drought conditions. Consideration should therefore be given to regional climatic conditions and future climate projections in the context of the CSM. The following are factors which may warrant consideration during the design process:

- Differential soil erosion rates during increased periods of heavy rainfall and drought.

- Possible requirement for soil treatment to mitigate against possible effects of erosion, such as compaction to a specified standard.
- The use of a geogrid could serve as a barrier layer as well as mitigating against the effects of erosion.
- Some soil types may be prone to the effects of desiccation during prolonged hot and dry spells.
- Increased infiltration during heavy and/or prolonged rainfall events may result in increased leaching or mobilisation of contaminants in the future.
- Flooding from groundwater and surface water may affect the site in future (further details in Section 5.8).
- Heavy winds or desiccation of the cover soils may result in treefall, which could result in contaminated soils being exposed at the surface.

This is not an exhaustive list and the factors to be considered will be dependent upon the site circumstances. However, appropriate consideration of the effects of climate changes and extreme weather events during the design stage should be demonstrated by consultants.

5.8. Groundwater and Flooding

Groundwater and surface water flooding has the potential to mobilise contaminants within soil and groundwater beneath a cover system, resulting in contamination of clean cover soils. Surface water flooding can also damage or erode a cover system. The potential for mobilisation of contaminants is increased at sites that are in close proximity to surface water courses, within a flood plain, and/or situated on permeable deposits with shallow groundwater. Regulators should therefore seek to ensure that the hydrogeology is sufficiently understood, groundwater levels have been sufficiently characterised and, where necessary, the monitoring programme has accounted for seasonal variations and potential future variations due to climate change. Where necessary, cover system designers should be encouraged to consult relevant sources of information such as the Lead Local Flood Authority (LLFA) data and mapping [41] , Environment Agency flood maps[42] and SEPA flood maps[43].

Emplacement of very clayey soils without sufficient drainage may result in localised waterlogging, pooling and even flooding of gardens and properties. Soils used in simple cover systems must be sufficiently well-draining or sub-surface drainage should be included in design of the cover system. If de-compaction methods are to be used on soils, then they should be assessed to confirm that they will not result in mobilisation of sub-cover system contamination.

If there are serious doubts about the applicability or effectiveness of a cover layer in the long term, due to the potential for flooding, then a cover system may not be an appropriate solution unless a land raise can be accommodated, or long-term management and maintenance arrangements can be put in place (see Section 5.9).

5.9. Long-term Management and Exposure Mitigation

Planning decisions require consideration for the potential risks to site users which could occur without further planning consents being required. For sensitive end-use sites, the cover system depth requirement should be extended throughout all areas of the site which could be removed in future, such as non-permanent surface layers (e.g. patios or artificial grass).

Design decisions might also consider the nature and size of the area of hardstanding and the associated sub-base construction. Hardstanding above services, driveways, or an area of car parking, would typically be regarded as permanent and so lesser depths of sub-base or soil may be acceptable (See Section 6).

The cover system should be designed to minimise the need for long term management. However, there will be instances where the disturbance of potentially contaminated soils beneath a cover system is unavoidable, for example where future development, gardening or maintenance work requires excavations to a greater depth. The design of long-term management actions therefore depends on the degree of contamination beneath and adjoining a cover system and the likelihood of exposure occurring.

For reports submitted under the development control process, the remediation strategy and the associated verification report and any other associated information should be uploaded to the publicly accessible planning portal by the Local Authority, where it is freely viewable by future owners and occupiers, as well as prospective purchasers of properties. In the case of managed residential or commercial developments, details of the remedial measures (including a detailed plan) should be included in the health and safety file for the site and, where relevant, the asbestos register. Wherever a soil cover system has formed part of the remediation strategy for a site, the strategy and verification report must contain a clear and unequivocal statement identifying:

- The purpose of the cover layer i.e. usually to protect human health.
- Details of any residual contamination that is present beneath the cover system.
- The extent to which exposure to residual contamination needs to be avoided.
- How the cover system should be managed.

The remediation strategy and/or verification report should set out long term management actions and measures to be adopted where a breach of the cover system cannot be avoided. For all sites where a cover layer has been installed, under either the Planning regime or under Part 2A, long term management measures should include:

- Setting out long-term management requirements within verification reporting.
- Where appropriate, and dependent on proposed site uses, installation of a visual geo-membrane and/or a no-dig layer.
- Appropriate measures (e.g., use of appropriate PPE) to prevent exposure.
- Where excavations beneath the cover system cannot be avoided, ensuring cross contamination between the soils within the clean cover system and potentially contaminated underlying soils is prevented.
- Where it is disturbed, fully reinstating the cover system and ensuring any surplus materials are suitably disposed of.
- Investigating any contamination that is encountered and where necessary, carrying out further remediation.
- Consideration of the potential effects of trees (See Section 5.10.3 for additional information).

At sites where the degree of contamination will, or is more likely to, result in harm, the following additional management arrangements should also be considered:

- Being maintained by a third-party professional management company;
- Periodic checks for new developments or features that may reduce the effectiveness of a cover system;
- Clear maintenance requirements within deeds, property information and health and safety files;
- Arrangements to deal with any contamination incidents, for example resulting from impacts of climate change, such as flooding.

The responsibility for long-term management should fall to the landowner, leaseholder, tenant and/or person/company responsible for managing the land.

5.10. Trees and Root Protection Zones (RPZ)

Often a development site will contain trees scheduled for retention or covered by a tree preservation order (TPO). BS 5837 (2012)[44] details the steps to be taken to ensure that trees are appropriately and successfully retained during development. Root protection zones (RPZs) associated with larger or numerous trees, including any off site, may be significant when considering cover system design. Where existing trees are present, planning applications will usually be supported by an arboricultural report. This will identify the condition of the trees, highlight those that are scheduled for retention (subject to agreement with the relevant Local Authority Officer) and identify RPZs. Any site investigation risk assessment or remedial works should consider the potential effect on trees, particularly those associated with a TPO.

Where the landscaping scheme for a proposed development includes the planting of new trees, this requires specific consideration at the cover system design stage. A poorly formed cover system has the potential to affect the stability of mature trees, increasing the chances of treefall and subsequent breaches of the cover system.

5.10.1. The Impact of Cover Systems on Existing Trees

While mulches and other similar well drained substrates can be placed over root systems to greater depths, it is not possible, without specific design, to construct a substantial soil cover system over large portions of a root system. This would compress the ground, starve the roots of oxygen, suppress growth, and ultimately lead to the death of the tree. The amount of soil that can be accommodated without detriment to the tree will vary depending upon species and circumstance but will typically range from 50-200mm. In some instances, it may not be appropriate to add any soils. In some instances, where only a small area of a RPZ is affected, it may be possible to remove a portion of the root system to install the intended cover system. The advice of an arboriculturist should always be sought.

For managed areas, where an RPZ only forms a small portion of the site requiring remediation, the placement of a geotextile could be used to form a marker layer, preventing exposure to the underlying contaminated ground. This could be topped with a layer of mulch or decorative stone. Alternatively, a limited topsoil thickness may be applied, with or without the removal of a superficial layer of soil and potentially with a geotextile layer. The use of self-compacting gravels, resins or permeable paving could also be considered. These techniques would typically only be suitable in communal landscaped areas with an associated management plan and not within private gardens.

Exposure to soils within RPZs can be restricted via the use of fencing or, dependent upon planting requirements, through planting species that would discourage access, such as Hawthorn or Blackthorn. This approach is unlikely to be suitable in private gardens but may potentially be appropriate in managed landscaped areas. For unmanaged areas, for example private gardens, the engineered methods discussed below may need to be considered. If such measures are not considered suitable then it may not be possible to safely protect a development from contamination risks without compromising existing trees. In such instances the aim should be to establish this prior to planning consent being granted with the development layout adjusted accordingly where necessary.

The approach adopted should consider the potential for soil beneath the immediate root mass to erode or be forced up as the tree grows, releasing contamination situated around and beneath roots into a cover system and towards the site surface.

By undertaking additional sampling within the RPZ, it may be possible to demonstrate that the requirement for a cover system need not extend into the RPZ, or that a reduced level of cover will suffice.

Additional site-specific risk assessment may be required to define health risks where RPZs comprise a significant proportion of the area of soft landscaping.

5.10.2. Engineered Tree Root Protection within Cover Systems

A cellular confinement system or well and drainage system may be suitable where cover systems are installed without, or with limited, excavation of existing ground. It should be noted that such solutions need careful consideration and so the advice of an arboriculturist should always be sought. Such systems will require ongoing management and maintenance which may not be suitable in all situations.

Cellular Confinement System

A cellular confinement system is a series of geocells with perforated walls arranged in a honeycomb-like formation that is combined with an underlying geotextile; see Figure 2 and Figure 3.

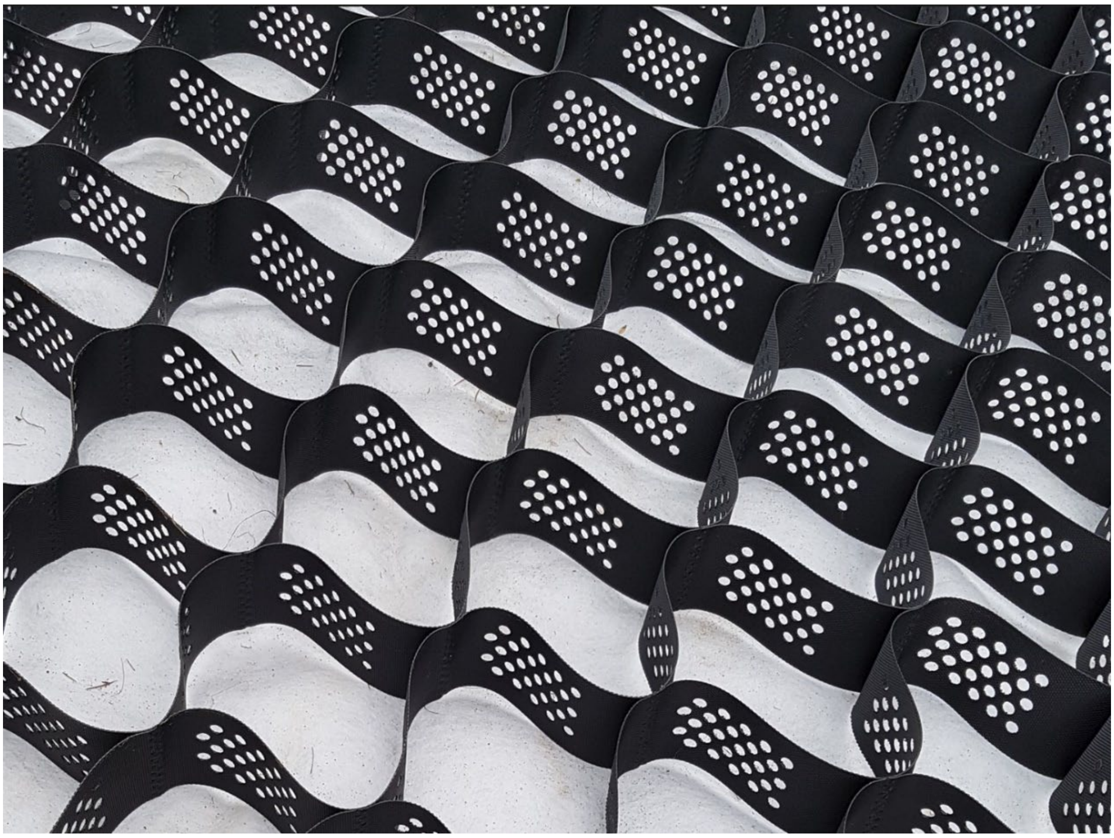

Figure 2*: A close-up image of a geocell sheet (image courtesy of Bosky Trees)*

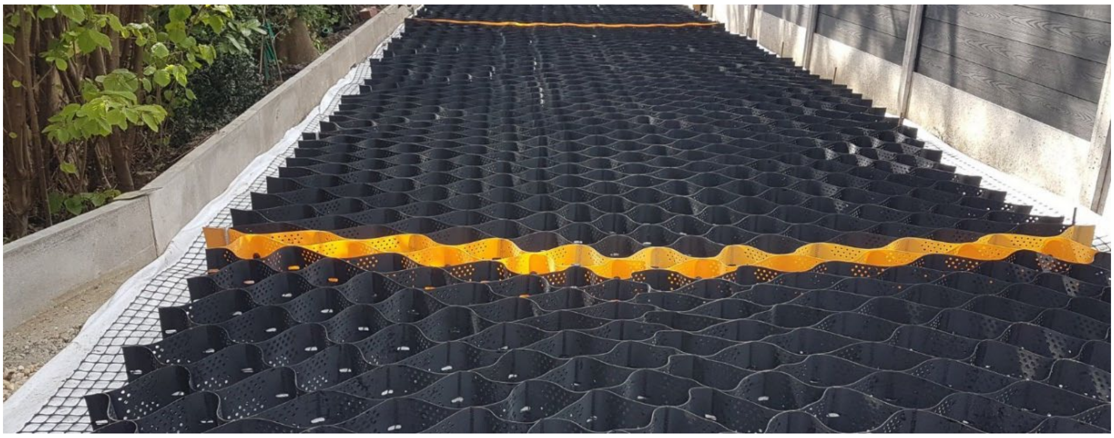

Figure 3*: A geocell sheet laid in place prior to being filled with stone (image courtesy of Core LP)*

Following placement of the system across the ground surface, the cells are filled with angular stone to laterally dissipate loads in a way that minimises compaction of the underlying soil whilst maintaining air and nutrient supply to the roots. This can enable a soil cover system or hard surface to be built up to greater depths, with the stone filled geo cells also serving as a hard to dig layer, as illustrated in Figure 4. Where soil is placed over a geocell system, measures must be taken to prevent the silting up of the granular layer. Further guidance can be found in the Arboricultural Association publication "The use of Cellular Confinement Systems Near Trees: A guide to good practice", September 2020).[45]

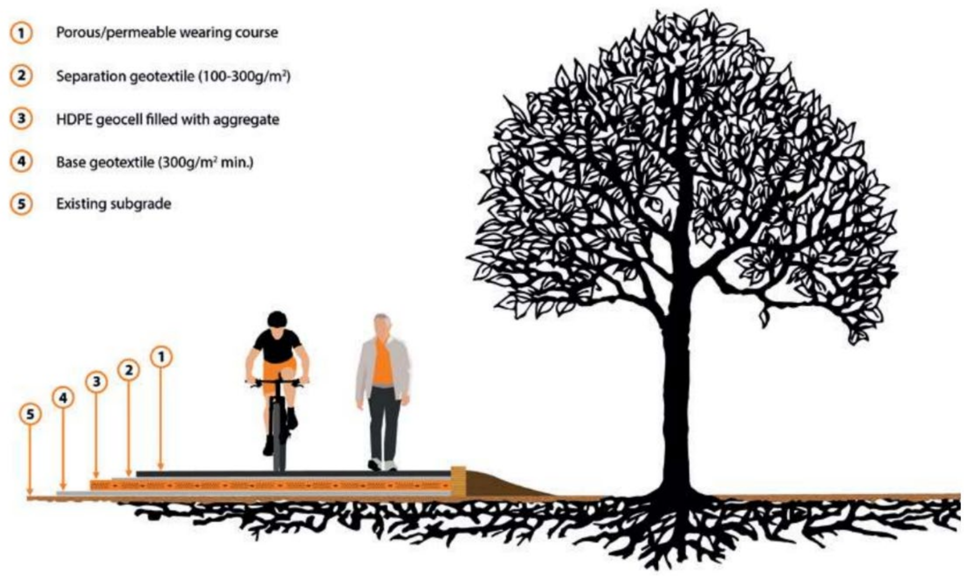

Figure 4: *The basic approach to using cellular confinement systems near trees (image courtesy of Core LP)*

Well and Drainage System

A well and drainage system involves constructing an open-joint retaining wall to at least the height of the proposed cover layer in a circle (thereby resembling a well) around the tree trunk. An aeration system can then be constructed using perforated plastic pipes arranged in 5 to 6 horizontal lines radiating from the tree well to a point beyond the canopy. The outer ends of the radiating system are then connected with a circle of perforated plastic pipe. Plastic pipes extending to the height of the proposed cover layer are then placed upright at the junction of the radial lines with the outer circle before the cover soils are placed. This again serves to maintain air and water supply to the roots. These systems need maintaining for the lifetime of the cover system, to ensure that they do not silt up. Further discussion and examples are provided in Collier (1973)[46] and examples of different construction techniques are shown in Figure 5 below.

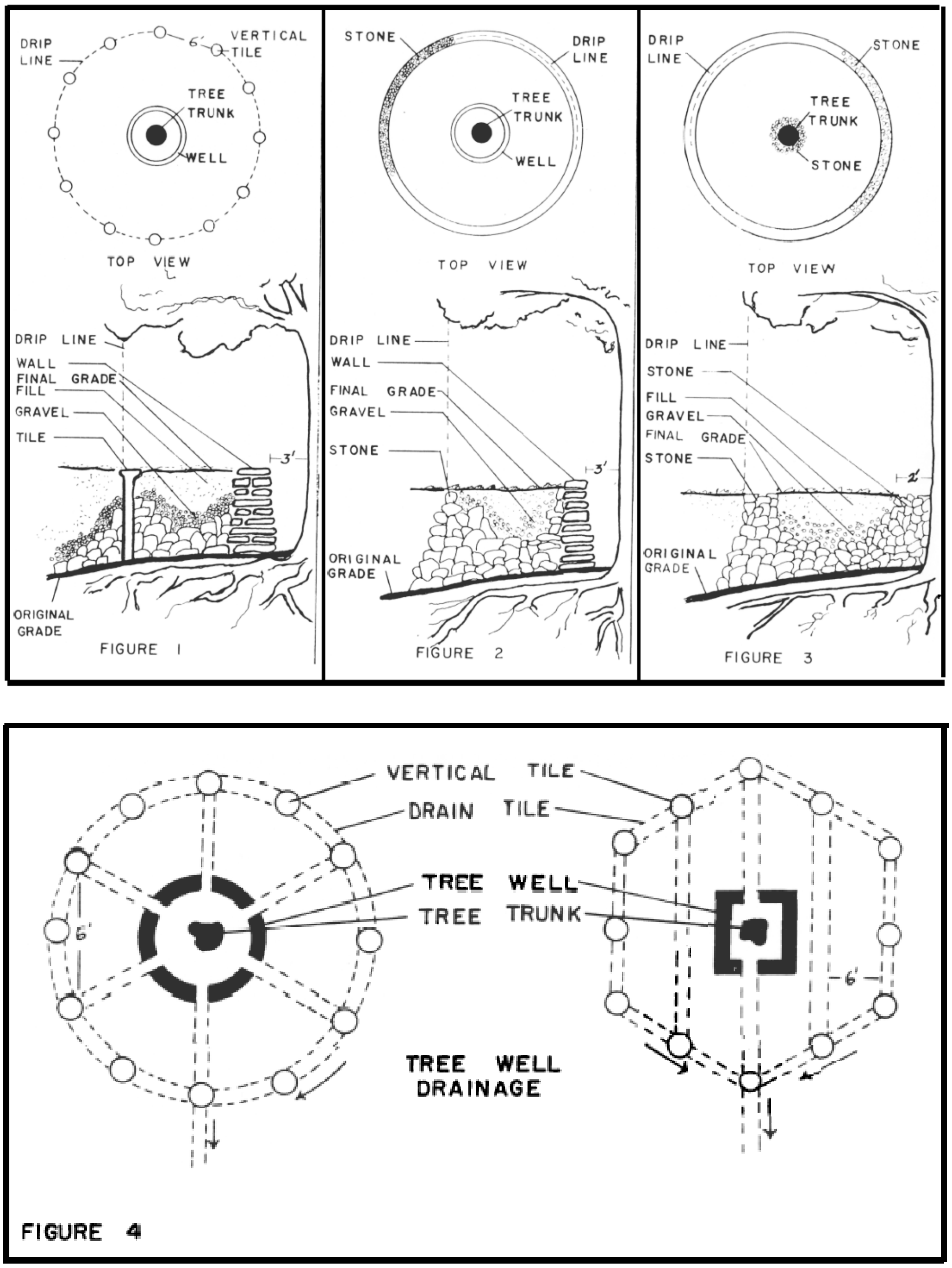

Figure 5: *Explanatory Figures 1-4 from Collier CW, 1973, Tree Wells, Design for Everyday Living, Misc. Pub. 355, Cooperative Extension Service, West Virginia University. The figures show examples of different construction techniques for tree wells.*

5.10.3. Ways in Which Trees Affect Cover Systems

As well as cover systems compromising trees, trees have the potential to compromise a cover system and associated demarcation layers through root growth or tree fall. Where existing trees are present, soil beneath the immediate root mass can erode or be forced up as the tree grows, releasing contamination situated around and beneath roots into a cover system and towards the site surface.

Where new trees are intended to be planted, it may be necessary to accommodate them within raised tree pits designed to prevent the roots from extending beneath the cover layer. Alternatively localised deeper excavations, or excavated tree pits, may be required to fully accommodate the roots and allow for future growth. If root systems are not segregated from the underlying contaminated ground, although likely to be mild, leaf fall in species that accumulate contaminants may result in localised contamination. Soil-forming materials used should be appropriate to maintain the long-term growth and stability of any new trees.

6. Cover System Design Depths

Cover system depth is a contentious issue in the UK as there is no official guidance on appropriate depths for different uses. This section considers the available guidance on cover depth and sets out factors that regulators may wish to consider for cover system depth and engineering design.

6.1. Available Guidance for Cover System Depths

It was concluded in BRE 465[4] that during routine gardening activities, the worst-case scenario was likely to comprise 'double digging' to 600mm, assuming a standard spade depth of 300mm. 600mm was anticipated to be protective of digging by children and pets, other burrowing animals, earthworm activity and root penetration. On this basis, BRE 465 identifies 600mm as the maximum depth for a simple cover system. However, where a cover system has been identified as a suitable means of remediation, this depth is routinely proposed within remedial strategies without justification.

Although BRE 465 has been archived and is not widely accepted as standard amongst regulators, it represents a possible approach which, under specific circumstances, might be considered appropriate or provide one line of evidence. CLOs may consult the AGS position statement[16] when considering its applicability. Any intended use of BRE 465 should be agreed at the outset between the environmental consultant and the CLO.

Although 600mm could be considered sufficient for routine gardening activities, some activities may involve deeper excavations e.g., garden landscaping, pond installation, construction of footings for an extension, and removal of mature trees. BS3882[28] states that the minimum rooting depth should normally be 900mm for trees. BRE 465[4] referenced a suggested minimum soil thickness of 1 to 1.5m for fruit and specimen trees.

The Contaminated Land Statutory Guidance (for England[19]) (for Wales[20]) (for Scotland[21]) advises that risks should be considered in relation to the current use of the land and defines 'current use', amongst other things, as reasonable likely future uses of the land that would not require a new or amended grant of planning permission. In instances where future development at a residential property would require a planning consent this provides a potential mechanism for ensuring that any breach of the cover system is undertaken in a controlled way. However, where works constitute permitted development (and where permitted development rights have not been removed) the residents or other relevant receptors may be unaware of the potential risks and there is no mechanism for suitable controls to be put in place should the cover system be breached. As a result, a simple cover system may not be an appropriate remediation solution in all instances.

6.2. Factors and Consideration of Cover System Thickness

This Section is predominantly concerned with simple cover systems. Where significant risks are present, an engineered cover system may be a more appropriate solution.

CIRIA SP124[5] advises that each cover system should be designed on a site-specific basis since requirements will differ depending upon the potential receptors at risk, the types of contaminants to be contained and their concentrations, the underlying geology and hydrogeology, the design life and any secondary functions needing to be fulfilled.

LCRM's remediation option applicability matrix[23] identifies cover systems as a suitable remedial solution for all types of contamination that might be present in the soils. It is the degree of contamination, considered in the context of the proposed end use, which is one of the critical factors in deciding upon a suitable depth. This is included within the table of factors and consideration (Table 6-1) discussed in more detail below:

Current and Proposed Site Use

The current and/or proposed site use will affect the potential contaminant linkages within the CSM and subsequently the potential for exposure. It should be noted that the proposed use should consider any lawful use that may be made of the land in the context of the planned use. Increased depths of cover may be required where features of the use may penetrate the cover system, for example where deeper rooting fruit trees (for example in orchards, allotments and potentially gardens) might be grown and the root systems are required to be restricted to clean cover soils. Lesser depths of cover may be acceptable in managed residential gardens and areas of public open space.

Contamination Type and Concentration

Specific consideration of the type of contaminant is required, as some contaminants may require an increased cover thickness, even at relatively low concentrations (e.g., asbestos). CIRIA C733[33] advises where significant levels of asbestos contamination are identified for a privately owned housing end use, a depth of 0.6 to 1m of cover may be required to provide adequate protection. However, depending on the specific circumstances of the use and likelihood of asbestos being disturbed, an additional thickness of soil cover may be required. If non-aqueous phase liquids (NAPL) and/or volatile contaminants are present, there may be an engineering requirement to use cohesive soils, compacted to a low permeability to inhibit vapour migration.

Types of contaminants that have a particularly high toxicity risk or that are present at concentrations posing a potential acute risk may warrant an increased cover thickness. In such situations, complimentary remediation may be required. This may include, for example, localised excavation and/or treatment of more contaminated soils where an appropriate risk assessment supports such an approach. Further guidance on calculating acute toxicological threshold criteria is available from SoBRA[47].

Higher concentrations of contaminants relative to assessment criteria may require increased cover thicknesses. Further testing and/or more detailed risk assessment could be undertaken to generate site specific assessment criteria.

Different types of contaminants may be more or less bioaccessible to human health receptors based on site-specific physical soil properties. Generic assessment tools use an assumed bioaccessibility to generate criteria which may over or underestimate risk. Contamination that is found to be more bioaccessible may warrant a greater cover thickness, whereas contamination that is less bioaccessible may warrant a lesser cover thickness. CIEH, 2009[48] & BS ISO 17924:2018[49]) provide guidance regarding site-specific bioaccessibility testing.

As noted in Section 5.5, combustible materials warrant consideration when considering the depth of a cover system. SP124[5] advises that a 1m thickness of material usually provides sufficient insulation.

Source Type

A continuous contaminant source that is widespread and will remain in place or cannot be removed is likely to warrant a greater cover thickness. If the source is not continuous/widespread, or more significant areas of contamination have been removed and the process has been appropriately validated, then a reduced cover thickness, or potentially no cover, may be required.

Public Perception

It is possible that public perception may need to be factored into the decision-making process where it results in there being an increased perception of risk. For example, if there are particular concerns over the site in the local community, for example due to a history of previous incidents or if there is visible contamination present, then there may be a need to provide greater reassurance to the public, irrespective of the outcome of any risk assessment. This may warrant actions to provide greater reassurance, which in some instance might include an increased cover thickness.

Regulatory Requirements, Deeds and Agreements

Planning conditions may prescribe a specific minimum cover layer depth e.g., where the Local Authority require the assurance of a minimum cover thickness. Similarly, the deeds or agreements (such as Section 106 agreement through planning) relating to a piece of land may contain stipulations regarding the thickness of a cover system, which may need to be maintained or potentially increased depending upon the proposed development. Any future changes made under planning consent may add, remove, or amend conditions or stipulations relating to cover layer thickness or management, in the context of current guidance.

Long-term management may be stipulated as part of a tenancy agreement or ownership deeds. These agreements may list restrictions aimed at preventing residents from excavating, planting, growing vegetables etc. This is more common for areas of communal landscaping. Further information is detailed in Section 5.8.

Long-Term Considerations

The presence of long-term management plans and restrictions may potentially justify a lesser cover thickness. The design of any cover layer should include consideration of any potential future uses under permitted development rights.

Climate Change and Sustainability

Increased depth of cover may be required where there is the potential for shallow rising groundwater or potential future erosion. Alternatively, where a cover system has been overdesigned, for example as part of a planning condition, it may be appropriate to require that an applicant considers whether the cover system may be reduced in thickness. Further information on considerations relating to climate change is detailed in Section 5.7.

Other Site-Specific Constraints or Engineering Considerations

Examples of site-specific considerations that may warrant an increased cover thickness include:

- **Burrowing animal populations.** If burrowing animals are already present on site, the extent of their burrows may affect the proposed cover system design.

The effect of the proposed development on the burrowing animal population should be considered. There may be a requirement to introduce a population to a site e.g., if an ecological assessment determines that relocation is necessary due to development of their current habitat.

- **Where settlement of imported soil is more likely to occur**. In such scenarios the cover depth may need to be adjusted accordingly to account for any such settlement.
- **Service Access.** Where services are likely to be required to be accessed in future, or where engineers may be at risk from contamination by undertaking foreseeable maintenance work, greater cover depths may be required to place these services within the cover system.

Examples of site-specific considerations that may warrant a decreased cover thickness include:

- **Slopes and gradients**. See Section 5.2. Dependent on the CSM, a lesser cover thickness may be appropriate in these areas.
- **Earthworks including land raise or fill operations.** See Section 5.1. Reduced depth of cover may be appropriate if a substantial layer of clean verified engineered fill is present between the formation layer and any underlying contamination.
- **Root protection zones.** See Section 5.10. Where engineered options are unsuitable, reduced thickness of cover may be justifiable. If not, the development layout may need to be reconsidered and it may not be appropriate to grant planning permission.
- **Barrier layer.** See Section 4.6. Where barrier layers or demarcation layers are sufficiently robust, a reduced overall cover depth may be justifiable. Barrier layers formed of stone, hardcore or geogrid will provide a more robust physical barrier.
- **Natural soils.** Where natural uncontaminated superficial deposits or solid geology is encountered at less than the depth of the cover system.
- **Elevated background concentrations.** In some specific cases, where contaminant concentrations fall below robust locally derived normal background concentrations, it may be possible to reduce the thickness of a cover system, or rule one out entirely. Many Local Authorities would not accept this justification for remediation undertaken under planning but might consider this as a line of evidence for remediation undertaken under Part 2A.
- **Voluntary Remediation.** Where sites have been identified to have elevated contamination risks, but do not meet the threshold for regulatory action. For example, in England and Wales, under Part 2A, for sites that are designated as Category 3 and do not meet the requirements for designation as Contaminated Land, the onus is on the owner or occupier to reduce risks from land contamination further. An owner or occupier may therefore choose not to undertake mitigation or, where a cover system is installed, use a lesser thickness of soil. (Note: voluntary remediation is often not regulated by Local Authorities).

Table 6-1 : Factors and considerations for cover layer thickness. Based on the considerations in the left-hand column, increased or decreased thickness of cover system, or other engineering considerations, may be appropriate. This table is intended as a starting point to consider site-specific issues, and as such does not recommend specific thicknesses for different scenarios.

Factors and considerations for cover layer thickness	**Factors which may imply the requirement for increased thickness of cover system, or other engineering considerations**	**Factors which may indicated that reduced cover system thickness may be appropriate, with sufficient justification and agreement from the relevant regulator.**
Current and proposed site use	Residential, allotments, orchard, tree pits	Ornamental landscaping, Public Open Space (POS), commercial land use, managed residential landscaping, root protection zones (RPZ)
Contamination type and concentration	Asbestos fibres, volatile contaminants, NAPL, high toxicity risk, bioaccessible contaminants, combustible materials	Non-bioaccessible contaminants
Source type	Continuous source	Source removed (and validated)
Public Perception	Visible contamination, historical incidents, known local contamination, local concerns	
Regulatory requirements, deeds, and agreements	Planning conditions, land deeds, tenancy agreements	
Long-term considerations	Possible future sensitive uses under permitted development	Site subject to long term management
Climate change and sustainability	Possible rising groundwater or future erosion	Overdesign of remediation measures using more resources than required
Additional site-specific constraints, receptors, or engineering considerations	Burrowing animals, settlement of imported soil, service access	Slopes and gradients, fill earthworks, root protection zones, inclusion of a barrier, natural soils, elevated background concentration, voluntary remediation

It is the responsibility of the consultant, engineer, agent, or applicant (as relevant) to justify the design and chosen depth of cover system. It is the responsibility of the regulator to decide whether that justification is acceptable under relevant policy, legislation and guidance.

7. Verification

7.1. The Process of Verification

Verification, as set out in stage 3 of LCRM, is the process of demonstrating that the risks have been reduced to acceptable levels and that the remediation objectives and criteria have been met. Verification Plans for remedial works should be detailed as part of the remediation strategy and agreed with the local authority. Where a cover system, and potentially excavation, is the main remedial method or a component of an overall site remediation, specific verification 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:

- Will the data meet the lines of evidence requirements?
- What should be measured?
- Who should measure it?
- 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.
- The potential for the engineered solution to change over time (e.g., settlement of soils).

Under planning, the NPPF[2] and PAN 33[8] state 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[12]". The Verification Report is a key document to demonstrate compliance with the NPPF and PAN 33[8], and the responsibility rests with the developer/applicant to submit the required Verification Report (prepared by a suitably qualified and competent person) to complete the remediation and to discharge any planning conditions.

Verification plans should be site specific, taking the CSM into account with careful consideration of the history of the site, encountered material, and the development end use. Consequently, verification plans which may be considered appropriate for one site may not be appropriate for another, even where these sites are adjacent. Additional considerations beyond those listed here may be appropriate for engineered cover systems – for further information, consult SP124[5].

The sample frequency of imported materials should reflect the importance of ensuring that they are suitable for their intended use. Details of the contents of the Verification Report need to be agreed with the Local Authority as part of the remediation strategy. The expectation would be that evidence is provided to demonstrate that the requirements for remediation have been met.

Soils used to form a cover system should be 'suitable for their intended purpose' as specified in BS 3882:2015[28] for topsoil and BS 8601:2013[31] for subsoil. Both British Standards relate mostly to nutrient content of topsoil and phytotoxic contamination. Soils should be tested for relevant contaminants that are considered to pose a potential risk to human health in addition to those specified in the relevant British Standards to ensure that they are suitable for their intended use.

Please refer to Sections 7.5 and 7.6 for further information of specific verification measures that should be considered in relation to verification of material quality and depth, respectively.

7.2. Variations in Approach (Regionally and between Local Authorities)

Soil type, reliability of source, and general land use type differs between Local Authorities. Different Local Authorities have different local plans and different strategic guidance. Therefore, the approach to verification requirements is not only site specific, but region and Local Authority specific.

7.3. Warranty Providers Requirements

Warranty providers, such as NHBC, require sites potentially affected by land quality hazards to be properly investigated and appropriately assessed. Any hazards identified require appropriately designed remedial measures be implemented, along with suitable accompanying verification.

Warranty providers will normally require all investigation, assessment, remediation and verification undertaken on sites affected by potential land quality concerns, to be carried out by appropriately competent persons.

NHBC advise that verification requirements for clean cover systems, including testing frequency and chemical analysis, should be agreed in advance, and early engagement with warranty providers is strongly recommended. In some instances, the requirements of a warranty provider for a specific project might vary from the standard guidance set-out in this, and other guidance documents.

A warranty provider's acceptance of imported soil materials on a specific project should not be solely relied upon as sufficient evidence that the materials meet the 'safe and suitable for use' requirement of the NPPF[2].

Further guidance is available in the NHBC Technical Extra 08 publication (November 2012)[50] which can be found on the NHBC website[51].

7.4. Independent Verification

Where possible, it is recommended that independent verification is undertaken on site, to ensure that the cover system has been installed to the agreed specifications. Best practice for independent verifiers may include the following:

- Independent selection of locations for chemical sampling (e.g., sampling of stockpiles, or post-placement)
- Independent selection of locations for depth verification (visual trial holes, measurements, or survey points)
- Where applicable, ensuring that trial holes are dug in the presence of the independent verifier.

There have been reports of some instances where some cover system installers have filled material around a plastic pipe and then remove this, to serve as a verification trial hole location. Independent verifiers should be aware of the potential for materials thickness to be artificially increased at these locations due to the method of installation. Local Authorities may decide not to consider this style of trial hole to be independent verification and any disputes may be avoided by agreeing the precise means of verification during review of the remediation strategy.

7.5. Verification of Material Quality

This section provides clarification and suggestions for the verification of both imported material and site-won soils for use in cover systems. Information on required contents of the verification reporting is detailed within LCRM Stage 3[3]. For information regarding the verification of the depth of cover systems, please refer to Section 7.6.

7.5.1. Imported Materials

Chemical testing is normally required to be undertaken on any materials that are to be used as cover material, in cases even where this includes first generation quarried material. Any representative samples taken should be of the actual material imported to site. It should be noted that any imported material must be glass free and that there is a requirement for suitable management and controls on site to prevent cross contamination of imported clean materials.

Developers may wish to commission testing at source for the purposes of reassurance/due diligence, however, verification samples should ideally be taken post placement, to capture any potential mixing or cross contamination during handling, transport, and storage. Chemical testing undertaken at source may be sufficient for verification purposes (dependent on the Local Authority) if it can be demonstrated that the samples taken are of the actual soil, and that no potential cross-contamination could have occurred. Sampling should be carried out by a suitably qualified and competent person and chemical testing should be suitably accredited including UKAS and where relevant MCERTS.

Certificates are often available from the supplier, detailing chemical test results from the source, or storage facility. These can be useful as supporting information to provide confidence that the material is likely to be of a suitable quality, however, these certificates will usually be insufficient by themselves, and additional sampling should be required. If demonstrable processes have been put in place to ensure that batches of soil have been kept clean and have been transported properly, then source testing may be considered sufficient or capable of contributing towards the agreed testing frequency.

Chemical testing suites are variable and site-specific, however, laboratory testing suites for a typical residential development may include the following:

Table 7-1 Example verification testing suites for a typical residential development

Material type	Typical testing schedule*
Virgin quarried material	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)
Crushed hardcore, stone, brick (excluding asphalt)	Asbestos Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn) PAH (16 USEPA speciation) Total TPH
Greenfield/blended** soils	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn) PAH (16 USEPA speciation) Asbestos Soil Organic Matter (SOM, or calculated from total organic carbon (TOC)) Total TPH
Brownfield/Screened soils	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn) PAH (16 USEPA speciation) TPH (CWG banded) Asbestos pH Soil Organic Matter (SOM, or calculated from total organic carbon (TOC))

***Additional analysis may be required dependant on the individual Local Authority and the history of the donor site (e.g., phenol, total cyanide, BTEX, MTBE, SVOC, VOC, or emerging contaminants etc). Should the potential for cross-contamination be present, additional consideration or analysis may be required.**

**** Blended: From a commercial company who manufacture material by mixing or blending greenfield mineral soils (subsoil or sand) with an organic amendment (compost). Any topsoil manufactured under RPS 190[52] (applicable to England only) should only be used in site landscaping and should not be used in domestic gardens, unless exceptions are met. See detail below.**

Wales has its own national guidance on imported material which CLO's working for Welsh local authorities may wish to consult[53].

Chemical testing results should be assessed against suitable relevant criteria and agreed with the Local Authority as part of the Remediation Strategy. Such criteria may comprise, for example, LQM S4ULs[54], Defra C4SLs[55], other similarly derived GACs, or SSACs. It should be noted that S4ULs and C4SLs are based solely on human health; dependent upon the site in question, such criteria may not be sufficiently protective of other receptors e.g. controlled waters, and other assessment criteria may be appropriate. Imported soils for use within cover systems should typically not contain any detectable asbestos, particularly for residential developments.

If exceedances are identified, the material should be rejected, removed, or a risk assessment should be undertaken in accordance with LCRM[3] to demonstrate that the material is suitable for use. In such instances it may be that an addendum to the remedial strategy or a revised remedial strategy needs to be submitted. This may require formal resubmission through the planning system, but this would be for individual local planning authorities to decide. Should imported material prove unsuitable and require removal from site the process should be appropriately documented.

Rates for testing should be agreed with the Local Authority as part of the Remediation Strategy. Different rates may be required based on considerations such as the source of the material, the type of material, the materials movement strategy for the site, and whether the material is intended to be used as topsoil, subsoil, or other uses. These rates may vary between 1/50m^3 and 1/500m^3 and a minimum number of tests may be applicable. Local guidance (such as guidance produced by a Local Authority or YALPAG[18]) may provide more detailed specific advice. 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.

Following the import of soils to site, an 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., visible asbestos containing material, staining, glass, free product, olfactory evidence of contamination etc.;
- There is no evidence of Japanese Knotweed, or other invasive or injurious plants as specified by the Environment Agency[29]. In addition to checks on site following import, checks should always be undertaken that soils have not been sourced from areas where such plants, are suspected to have been growing; and,
- It is free from unsuitable material i.e., bricks, brick ties, timber, and glass etc.

An environmental permit is usually required for the use of manufactured topsoil that has been made from waste. However, if the conditions within the Environment Agency regulatory position statement (RPS 190[52]) are followed, up to 1,000 tonnes of certain manufactured topsoils to establish a vegetative layer may be used without an application for an environmental permit. This includes soils derived from fruit, vegetable and sugar beet washings and topsoil manufactured using soil and stones from greenfield sites. Any topsoil manufactured under RPS 190 should only be used in site landscaping and should not be used in domestic gardens unless the manufactured topsoil in question has received a specific opinion from the Environment Agency confirming they are satisfied that end of waste status has been met.

7.5.2. Re-use of Site Sourced Soils and virgin aggregates

Where site-won **natural** soils (including superficial deposits and solid geology) are to be re-used as part of cover layers, it must be demonstrated that the material is suitable for its intended use. Sampling of materials should be undertaken, similar to the rates and suites required for imported materials. Where a sufficient level of intrusive site investigation has been undertaken of soil intended for reuse onsite, and it has been appropriately stored to prevent cross contamination, this may reduce or remove the need for post-placement verification testing.

Further sampling or detailed quantitative risk assessment, to generate site specific assessment criteria, will be required where:

- Insufficient samples have been taken to meet the agreed sampling rate;
- Potential cross-contamination may have occurred during on-site transport or stockpile storage; and/or,
- Verification sampling identifies exceedances of assessment criteria.

7.5.3. Virgin Quarried Aggregates

Virgin quarried aggregates are products that have been newly mined from the ground and are most used for pipe bedding and as a sub-base beneath areas of hardstanding. They are typically derived from granular or crystalline rocks, for example, quarried limestone or sand. Limited sampling may be required by some authorities to demonstrate the inert nature of the material. In some instances, manufacturer testing at source may be sufficient to show that the material is safe and suitable for use. A suggested analytical suite for virgin aggregates is included in Table 7-1.

7.5.4. Recycled Aggregates

Recycled aggregate is a product manufactured from crushed concrete. If recycled aggregates are imported to site, they should be demonstrably compliant with a WRAP protocol[56]. A WRAP protocol identifies the point at which waste, having been fully recovered, may be regarded as a non-waste product. If recycled aggregates without the benefit of a WRAP protocol are to be imported, they will need to be subject to waste management controls. Extreme caution is required for material that has been recycled from demolition/skip waste, as this can easily be contaminated, and is at a higher risk of containing asbestos. A suggested analytical suite for recycled aggregates is included in Table 7-1.

7.6. Verification of Depth of Cover System Material

Information on the required contents of a verification report is included in LCRM Stage 3[3]. There are several different methodologies for verifying the depth of cover system material. The verification methodology chosen should be relevant to the type of cover system, the components used, and the relative identified risks. It is important that the verification methodology is stated within the Verification Plan or Remediation Strategy and agreed with the relevant regulatory body. The verification plan should allow for contingencies e.g. if during verification inspections conditions are not as expected (e.g. insufficient depth), consultants may wish to increase the agreed scope to improve confidence. Several possible verification techniques (and the benefits and drawbacks of each) are detailed in the following sections. Local Authorities may publish their own guidance on acceptable methods for verification of depth of fill material, or they may use the YALPAG guidance for verification of cover systems[18].

7.6.1. Post Material Placement Depth Verification Pits

This method comprises the excavation of a suitable number of pits to the base of the cover material, using a tape measure or measuring staff to record the depth of placed material, and taking photographs. This has the benefit of providing a visual record of the type of fill material, its thickness, and evidence of any demarcation layer/no-dig layer/capillary break layer.

When creating a photographic record, it is important to provide good quality photographs (noting the requirement for sufficiently high resolution) ensuring the photographs include a point of reference e.g., a building to aid in demonstrating the location. Photographs should include a reference to the test pit location such as a legible site identification board detailing date, site name and test location. The photographs should clearly show both the base of the pit and the measuring tape/staff. It is good practice to place a line or staff across the surface of the pit to provide an accurate reference point when taking measurements and photographs. The depth measurement needs to be legible in the photographs. More than one photograph per pit is likely to be required and photographs of the arisings from the pit should ideally be included.

Depth verification pit location and density should always be determined on a site-specific basis and agreed with the Local Authority via the Verification Plan or Remediation Strategy. Overall consideration should be given to the number of, and confidence in, the lines of evidence being provided to justify any particular number of verification locations. Consideration should be given to the following factors which may be used to justify a resulting verification location density:

End Use

If the end use is a residential garden, consideration should be given to whether the front and back gardens are likely to be used differently. Size of any front and back gardens may also be a factor in how it is to be used. If the end use is public open space or a commercial use, then verification location densities are likely to be less than for residential areas.

Development Size

If a residential development comprises only a small number of plots, then a minimum of one depth verification trial hole for each plot is likely to be appropriate. Whilst a lesser frequency of depth verification pits may be appropriate for larger developments this would need to be subject to sufficient justification. In addition to the overall number of plots, consideration should also be made to plot size as larger plots may warrant more than one sample location.

Magnitude of Identified Potential Risk

If significant contamination is present below the cover system, then a higher verification location density may be required to provide greater confidence in the undertaken remediation. On sites where lower potential risks to human health have been identified, then a lower density may be justified.

Sampling Pattern

Variable selection of measurement locations, to include locations around the edges of garden plots, as well as in the middle. The borders of residential gardens are locations where home-grown produce may be planted and/or where excavation is more likely to occur, so it is important that these areas are verified. Where rows of gardens are verified prior to the installation of boundary fences, it should be ensured that a sufficient number of pits or survey points are undertaken in each garden.

Design Considerations

Depth verification pits should also target specific remediation design elements (e.g., tree protection design, geotextile membranes, no-dig layers etc.).

7.6.2. Relative Measurement Against a Fixed Point

Where materials are to be placed within a well-defined area excavated below finished levels, it may be possible to show the original depth of the excavation, using a tape measure or measuring staff, and the subsequent filling to the appropriate levels, using a stake, string, or levelling device. Pre- and post-fill photographs will be required to be taken.

Contamination may also be associated with a visually distinct stratum. Photographs can demonstrate where these strata have been reached, should this form part of the criteria for depth of cover e.g., where they have been proven through prior investigation to be less or more contaminated. However, additional verification methodology will be required to show that a sufficient thickness of material has been placed.

When creating a photographic record, it is important to provide good quality photographs ensuring the photographs include a reference to the measurement location such as a site identification board detailing date, site name and test location. The photographs should clearly show the measuring tape/staff in the context of the site with the board and measuring staff being clearly legible.

7.6.3. Topographical Survey

Topographical surveying may be undertaken pre- and post- placement of a cover system using an accurate survey to establish the thickness of cover. This has the benefit of being able to generate a contour plan of cover thicknesses across the site, however, does not provide confirmation of the nature of fill material or the placement of any other component of a cover system such as no-dig or capillary break layers etc.

The quality of the topographical survey is dependent on the number of survey points. It should be ensured that sufficient survey measurement points are included within the survey to ensure that the data is adequate to meet the agreed verification needs.

Additional verification methodology may be required to show that the cover layer has been installed in accordance with the agreed design.

7.6.4. Mass Balance

An overall mass balance calculation may be provided incorporating depth of placed soil, area of soil placement and volume of soil brought to site to give confidence that material has been placed to correct depth. However, this is dependent on accurate measurements of the site, and, depending on the sensitivity of the site, additional lines of evidence may be required to show that sufficient depth of material has been placed. A mass balance would typically only be undertaken as an additional cross check to support other verification activities.

7.7. Other Verification

In addition to verification of material quality and depth of material placed, verification of other aspects may also be required. Further information is detailed in LCRM Stage 3[3]:

Compliance with Design

Comparison should always be made with the original cover system design agreed within the remediation method statement. Any deviation from the agreed design should be discussed with the CLO prior to undertaking the work and full justification for any changes to design should be provided within the verification report to ensure transparency to future readers.

Material Transport Tickets

Where excavated material is being removed off site or material is being imported to site, confirmation of its appropriate disposal or provenance of the source should be included within a verification report, or be made available upon request, in the form of waste transfer documentation and/ or material transport tickets.

Geotextile Membranes

Where geotextile membranes are incorporated into the cover system design, verification of their correct installation, including installation depth and lapping, is best provided by photographic evidence prior to soil placement. (C733[33] section 15.2.1)

On-site Observations

Upon the completion of all groundworks, the on-site manager/builder should provide a written statement to the Planning Authority identifying whether any significant unexpected ground conditions or contamination were encountered during the ground works. Where unexpected ground conditions were encountered, a full description and details should be provided along with any subsequent actions. For further information, refer to Section 8.1.

Receipts

Although not usually sufficient in isolation, delivery receipts for cover system components e.g. geotextile membranes, geogrids etc. when presented in conjunction with photographic evidence can help demonstrate that sufficient quantities of such components have been purchased and delivered to site.

8. Additional considerations

8.1. Unexpected Ground Conditions and Contamination

Where unexpected ground conditions or unexpected contamination are encountered on site during groundworks, additional remedial actions may be necessary to protect end users.

If the encountered material will be entirely removed or will be sufficiently mitigated by the proposed remediation works, additional remedial actions are unlikely to be required. However, justification (via an appropriate investigation and/or risk assessment) is likely to be required.

Where unexpected ground conditions or contamination will remain onsite or is present at the site boundary and the existing cover system design is not sufficiently protective or may be compromised, further action will be required. This will normally include investigating the type, degree and extent of contamination and considering one or more additional remedial measures, for example increasing the depth of the cover system, incorporating a barrier or capillary break layer and/or treating or removing the unexpected contamination. For known offsite sources of contamination at the site boundary, other measures may be needed to prevent contamination migrating onto the site.

Under a planning scenario, where unexpected ground conditions or contamination are encountered during groundworks, the developer must comply with any relevant planning conditions and/or requirements of the remediation strategy. This will normally include requirements to stop work, report the incident to the planning authority, agree and undertake further intrusive site investigation work and potentially agree and implement an updated remediation strategy.

Under Part 2A or the Environmental Damage Regulations, unexpected ground conditions or contamination that reduces the effectiveness or durability of a cover system should be reported to the enforcing authority so that, where necessary, additional informal or formal actions may be agreed. Full details should be provided within a verification report, as would be expected under the planning process.

Summary Reference Sheet

Stage	Expected considerations	References
Options Appraisal	Competent person Shortlist of feasible remediation options Options must be able to reduce or control the risks to an acceptable level Factors that might affect the options Feasible remediation options which will meet options appraisal	*LCRM "Before you start" and "Stage 2"*[3]
Options Appraisal Suitability	Preliminary risk assessment, GQRA, DQRA, conceptual site model Options appraisal matrix Nature of contamination Potential exposure pathways Remediation objectives and criteria Simple or engineered Final land-use, layout, topography, finished levels Long term management options	*BS 10175:2011+A2:2017*[1]
Options Appraisal Alternatives	Barriers Encapsulation Soil stabilisation Source removal by excavation or hand picking In-situ or ex-situ treatment Restricted access to the source of contamination e.g., hard coverings, fencing, planting, relocation of sustainable drainage systems, utilising for less sensitive uses, restrictive covenants, or removal of permitted development rights	

Stage	Expected considerations	References
Options Evaluation	Planning or Part 2A requirements? Costs Benefits **Effectiveness and Practicability:** Public perception (consider other successful schemes) Cost saving Re-use of materials Environmental outcome Durability **Limitations:** Timescales Health and safety requirements, accessibility, services, security Costs and funding constraints Regulatory requirements or certification, stakeholder views Long-term considerations Site-specific, e.g. burrowing animals, groundwater levels, flooding, slopes, requirements for land raising or fill, current use, biodiversity, and amenity value Potential for combination with other remediation techniques Demonstration of how the cover system breaks relevant contaminant linkage Legal, financial, and commercial context of the site Sustainable Remediation Impacts from climate change Final Remediation Option	*NPPF*[2] *PAN 33*[8] *Part IIA of the Environmental Protection Act 1990*[12] *Contaminated Land Statutory Guidance (England)*[19] *Contaminated Land Statutory Guidance (Wales)*[20] Contaminated Land Statutory Guidance (Scotland)[21] *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*[30] *BS ISO 18504:2017*[27] *CL:AIRE DoWCoP*[39] *LCRM Stage 2*[3] *SuRF UK user guides*[38]

Stage	Expected considerations	References
Remediation Strategy	Competent person Site details Site assessment including CSM Environmental setting Details of the remediation actions including preparatory works, phasing, environmental protection Detailed design Implementation plan Regulatory controls Record keeping Monitoring and maintenance requirements	*LCRM Stage 3*[3]
Verification Plan	Establish a 'lines of evidence' approach. How will the remediation strategy demonstrate and report that the cover system is successfully installed, and remediation is working? **Data requirements:** Compliance criteria and monitoring details Site notes, plans & photographs Progress reports Monitoring and maintenance reports Evidence of components of cover system Chemical analysis certificates Material transfer documents	*LCRM Stage 3*[3] *YALPAG Verification Requirements for Cover Systems*[18]

Stage	Expected considerations	References
Cover System Design	**Components:** Formation Level Surface layer Design depths and thicknesses Topsoil Subsoil Fill materials Demarcation layers Barrier layers (type and function) Capillary breaks **Changes in site levels:** Cut and fill Slopes and terraces Boundaries and Intersections **Other considerations:** Services and utilities Combustible material Trees and root protection zones **Sustainable Remediation** Excavation processes and materials preparation Implications of transporting material or operating equipment Materials re-use on-site or off-site, DoWCoP Import of material Off-site disposal Impact of any off-site processes Impact of climate change, extreme weather, or temperature on performance and durability Groundwater and flooding Long-term Management and Exposure Mitigation	*BRE 465*[4] *BS 8601:2013*[31] *BS 5837:2012*[44] *CIRIA SP124*[5] *CIRIA SP106*[17] *AGS Review and Position Statement, Cover Systems for Land Regeneration*[16]

Stage	Expected considerations	References
Verification	Reference to Local Regulators Guidance Planning or Part 2A requirements Warranty providers requirements Independent verification Site details, risk assessments, CSM, remediation objectives and criteria Sequence of activities **Materials quality:** Imported materials Re-use of material Chemical analysis Materials handling Suitability for use, growing medium, physical properties **Verification of design:** Depth and thickness of fill Excavation to formation or natural material Topographical survey Mass balance Material transport tickets Receipts for imported materials: soils, aggregates, membranes, geogrids Evidence of installation of membranes, marker layers, textiles, grids On-site observations, photographs, plans, maps, diagrams, relevant correspondence Long term maintenance or restrictions on land use	*LCRM Stage 3*[3] *EA RPS 190*[52] *NHBC Technical extra 08*[50] *YALPAG Verification Requirements for Cover Systems*[18]
Unexpected ground conditions and contamination	Further investigation, risk assessment Revisions to remediation strategy Conditions on planning consent Requirements under Part 2A Include in verification report	

References

[1] BSI - British Standards Institution, 2017, BS 10175:2011+A2:2017, Investigation of potentially contaminated sites. Code of practice
[2] Ministry of Housing Communities and Local Government, 2012, National Planning Policy Framework
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[6] Ministry of Housing Communities and Local Government, 2012, National Planning Policy Framework
[7] Scottish Government, 2023, National Planning Framework 4, accessed July 2023, <https://www.gov.scot/publications/national-planning-framework-4/>
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[10] Welsh Office, 1987, Circular 22/87, Development of Contaminated Land, 17 August 1987
[11] Department of Agriculture, Environment and Rural Affairs (DAERA – Northern Ireland), 2019, Practice guide, Redeveloping Land Affected by Contamination
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