Steeple Renewables Project

Appendix 15.2: Outline Soil Management Plan

Environmental Statement – Volume 2

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Outline Soil Management Plan

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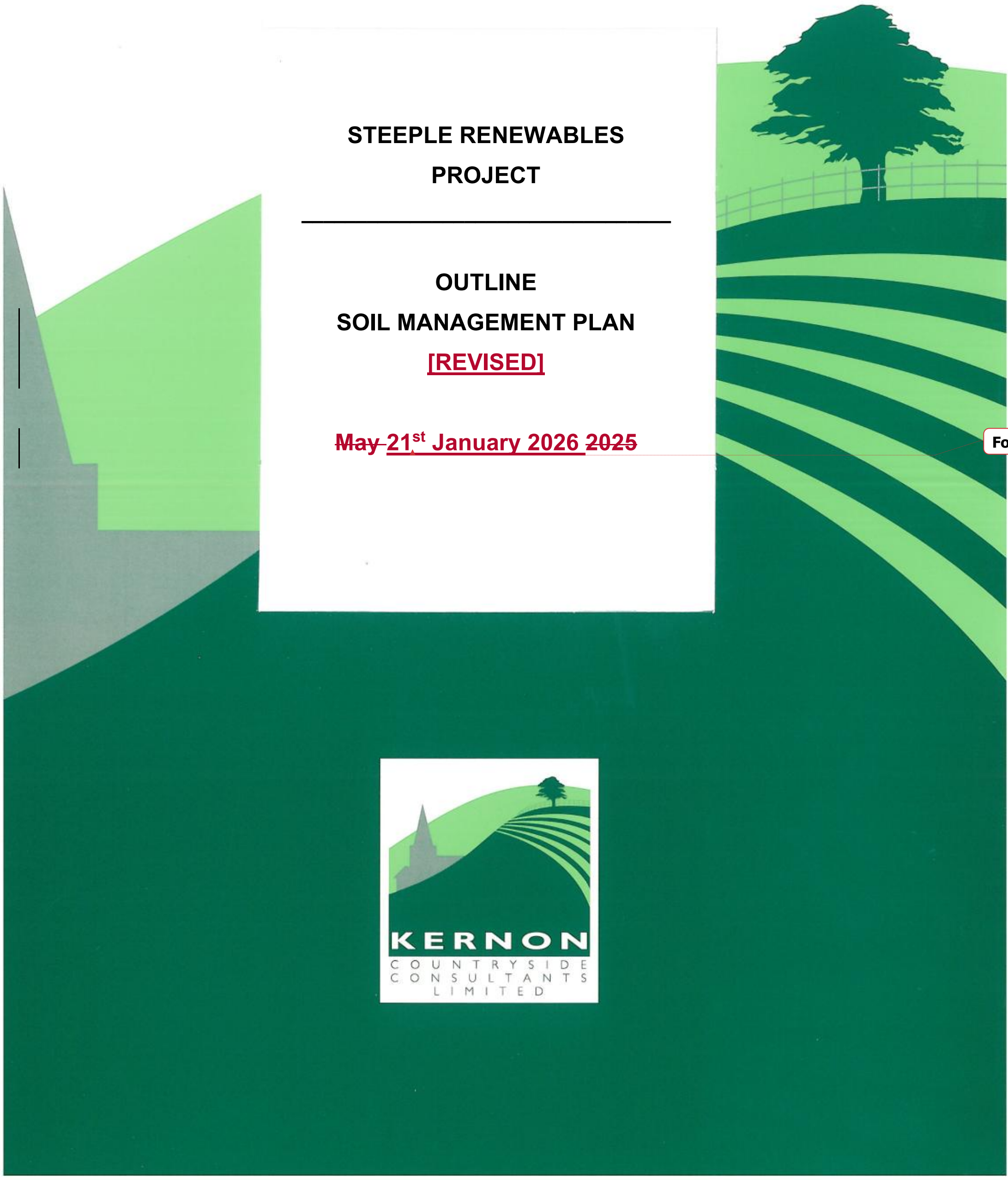

STEEPLE RENEWABLES PROJECT

OUTLINE SOIL MANAGEMENT PLAN

[REVISED]

~~May~~ 21st January 2026 ~~2025~~

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STEEPLE RENEWABLES PROJECT

OUTLINE SOIL MANAGEMENT PLAN

[REVISED]

21st January 2026

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~~**May 2025**~~

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1 INTRODUCTION

Purpose and Scope of the Document

1.1 The outline Soil Management Plan (oSMP) sets out the key principles and considerations for the handling of soils for the Proposed Development. It is intended that this is an outline of a Soil Management Plan that will be required under the Development Consent Order (DCO).

1.2 The document therefore needs to be read as one setting out the principles.

1.3 The oSMP has been prepared by Tony Kernon of Kernon Countryside Consultants Ltd. It draws on a detailed Agricultural Land Classification (ALC) and soil survey carried out by Roberts Environmental Ltd. Relevant extracts are reproduced in **Appendix SMP1**.

1.4 This revised oSMP has been revised following the relevant representation of Natural England (NE) dated 28 August 2025, and addresses those comments. NE's comments were that:

(i) pre-commencement soil information for the cable route and enhancement areas should be included. This has been addressed with new sections (now 10 and 14);

(ii) temporary construction compound areas should be measured if possible and recorded pre-entry. Section 7 has been expanded to provide greater details on these areas;

(iii) clarity is required in the text to confirm that all land temporarily affected will be restored to comparable ALC grade. This was always intended, and this has been addressed by amendments to the text to confirm this commitment, with edits to sections 2, 7, 8, 9 and 11.

1.5 A revised oSMP has been submitted to NE for comments and has been amended in response to further comment, in particular in section 14 to clarify the Ecological Enhancement Areas covered by the oSMP.

Structure of Report

1.46 This oSMP:

- sets out the key recommendations in section 2;
- describes the soil resource in section 3;
- describes and sets out the key principles of soil management in section 4;
- describes soil suitability tests in section 5;
- summarises the construction phasing and timing in section 6;
- sets out the soil handling methodology for construction compounds in section 7;

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- sets out soil methodology for the access tracks and bases in section 8;
- sets out soil methodology for the solar PV arrays in section 9;
- sets out the soil survey and works for inter-area cabling in section 10;
- sets out the substation and BESS in section 101;
- sets out the on-site fencing in section 121;
- sets out drainage in section 132;
- sets out soil survey and works for the ecological enhancement areas in section 14;
- sets out operational phase soil management in section 153;
- and sets out the principles for decommissioning in section 164.

1.57 Implementation of this oSMP, and adherence to its principles, will be the responsibility of the site manager.

1.8 The May 2025 draft oSMP contained many pages of extracts from key documents. In this revision these have been referenced but the extracts have not been appended, to keep the document size down. Full references are at section 17.

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2 KEY OBJECTIVES AND RECOMMENDATIONS

Objectives

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2.1 The objectives of the oSMP are to set out the principles for soil handling and management to minimise disturbance to soils and to ensure, and the Applicant commits to, restoration of disturbed land to the same ALC grade following construction works or at decommissioning, whichever is relevant.

Key Recommendations

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2.~~1~~2 The soils are generally fairly resilient in this relatively dry part of the country.

2.~~2~~3 The soils across the site are a mix of Grades 1 and 2 and Subgrades 3a and 3b. Those graded Subgrade 3b are more susceptible to being damaged if moved when wet. Whilst these soils can be recovered and restored easily, it is recommended that the phasing and site works are programmed so far as possible to aim to complete the installation of the panel legs and the fixing of the solar PV arrays to minimise trafficking between November and March.

2.~~3~~4 Whilst there will be a few periods when they will be too wet to be worked (depending upon the weather), works into the winter will not generally require extensive restoration, as the soils will be resilient, but should be avoided if possible. Therefore whilst this oSMP seeks to minimise trafficking over land in the November to March period, if ground conditions are suitable then works can continue in that period. Adherence to the soil suitability tests described in this oSMP will enable flexibility of construction periods.

2.~~4~~5 It is recommended that the key managers read and follow the soil suitability tests set out in this report, thus reacting to seasonal variations and providing flexibility. There is also some variation between the soil types as set out in this oSMP.

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3 THE SOIL RESOURCE

3.1 The soils are described in the Agricultural Land Classification (ALC) report by Roberts Environmental Ltd, the text and plans from which are reproduced in full in **Appendix SMP1**.

3.2 Four soil types have been identified, as described below:

- **Soil Type 1.** Comprised mainly heavy silty clay loam topsoil to typically 20cm with subangular blocky structure. Subsoil was regularly observed as silty clay with a coarse prismatic, defining the Slowly Permeable Layer at 20cm depth. These profiles were assessed as Wetness Class III and are predominantly limited in their agricultural capability by wetness, resulting in ALC Grade 3b for this Soil Type.
- **Soil Type 2.** Typically identified as heavy clay loam topsoil to an average depth of 42cm with subangular blocky structure. Subsoil was typically observed as a coarse prismatic clay, resulting a Slowly Permeable Layer assessed at 42cm. This profile was assessed as Wetness Class II and was limited to ALC Grade 3a due to soil wetness limitations.
- **Soil Type 3.** Soil Type 3 was identified with variable characteristics, but typically having a heavy silty clay loam topsoil of an average 34cm thickness and a subangular blocky structure. The initial subsoil was identified as a subangular blocky clay, which further developed into a well-drained fine sand of single grain structure at 90cm. Soil Type 3 was determined to be well drained (Wetness Class I) which resulted in ALC Grade 2 due to both droughtiness and wetness limitations on this soil type.
- **Soil Type 4.** Typically encountered as a freely draining fine sandy silt loam topsoil of average 39cm thickness, underlain by a fine sand of single grain structure. This soil type was defined as well drained (Wetness Class I) with no limitations relating to the soil physical characteristics.

3.3 These soil types are shown below.

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Insert 1: Type 1

Insert 2: Type 2

Insert 3: Type 3

Insert 4: Type 4

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4 KEY PRINCIPLES

Guidance

4.1 Soil management principles are set out in a number of documents, but those of most relevance are:

- Code of Practice for the Sustainable Use of Soils on Construction Sites, Defra (March 2011) ~~(extracts in **Appendix SMP2**)~~;
- Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction, British Society of Soil Science (v 3 January 2022) ~~(**Appendix SMP3**)~~;
- Good Practice Guide for Handling Soils in Mineral Workings, The Institute of Quarrying (July 2021) ~~(extracts in **Appendix SMP4**)~~;
- Building on Soil Sustainability: principles for soils in planning and construction, Cornwall Council and others (September 2022) ~~(**Appendix SMP5**)~~;
- Planning and aftercare advice for reclaiming land to agricultural use, Natural England (April 2022), especially in respect of soil bund management. ~~(**Appendix SMP6**)~~

Overview

4.2 For much of the installation process there is no requirement to move or disturb soils. Soils will need to be moved and disturbed to create temporary working compounds, and to create the tracks and small fixed infrastructure bases. Soils will need to be disturbed to enable cables to be laid, but the soils will be reinstated shortly after they are lifted out (ie this is a swift process).

4.3 For those areas where soil needs to be disturbed to create the bases for the substation and some fixed equipment, the soil will be stored in suitably-managed areas. The soil needs to be looked after because it will be needed at the decommissioning phase to restore the land under the bases back to agricultural use.

4.4 It is unlikely that subsoil will need to be removed to create the shallow bases, but if subsoil does need to be moved and stored, it should be stored separately to the topsoil, and clearly marked.

4.5 It will be evident where topsoil becomes subsoil. In most places the topsoil is about 30cm – 35cm deep, with a graduation to a lighter-coloured subsoil, as shown in the photographs in section 3 describing the soil resource.

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4.6 Purely for illustration the following pit, and soil profile, from some of the Grade 2 land within the Site shows the clear distinction between topsoil and subsoil. Operatives should familiarise themselves with this distinction.

Photos 1 and 2: Soils in Grade 2 Area

4.7 For the majority of the proposed development soils do not need to be disturbed. The effects on agricultural land quality and soil structure are therefore limited to the effects of vehicle passage. Therefore the key consideration is to ensure that soils are passed over by vehicles (trafficked) when the soils are in a suitable condition, and that if any localised damage or compaction occurs (which is common with normal farming operations too), it is ameliorated suitably.

4.8 The key principles for successfully avoiding damage to soils are:

- timing;
- retaining soil profiles;
- avoiding compaction;
- ameliorating compaction.

<u>Timing</u>

4.9 The most important management decision/action to avoid adverse effects on soils is the timing of works. If the construction work takes place when soil conditions are sufficiently dry, then damage from vehicle trafficking and trenching will be minimal.

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4.10 Vehicle travel over soils creating limited impact is shown below. This is good practice and is to be aimed-for, so far as possible.

Photo 3: Soils Suitable for Trafficking

4.11 Poor practice is shown below. If this type of soil disturbance occurs it can be rectified, as set out below, but as a point of principle if soils are rutting as shown below they are not well suited to being trafficked. Work should, so far as possible, be delayed until soils dry out.

Photo 4: Soils not Suitable for Trafficking

4.12 The heavier silty-clay and clayey soils identified in section 3, which are widespread across the site, will be most susceptible to this type of damage. Minimising travel over those soils from November to March in most years is recommended, but in wet years this period could be extended.

4.13 The lighter Type 4 soils of the eastern area are less prone to damage, and can be worked for much of the year, generally requiring extra care in the December to February period after prolonged rain. However, as these areas are intermixed with heavier soils, separate working practices are not considered to be feasible.

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4.14 As a general rule any activity that requires soil to be dug up and moved, such as cabling works, should be minimised during the winter. Soils handled when wet tend to lose some of their structure, and this results in them taking longer to recover after movement, and potentially needing restorative works (eg ripping with tines) to speed recovery of damaged soil structure. The period when soils are most likely to be saturated, and therefore assessing soils before works commence is important (see below), is shown below.

Table 1: Unsuitable Period for Working with Soils

Soil Type	**Likely Period When Soil Suitability Tests Are Important**
Subgrade 1, 2 and 3a	November to March
Subgrade 3b	November to March

4.15 Works within these periods may be able to take place, but it will be necessary to carry out soil suitability tests more frequently as there will be times within those periods when soils will be too wet to handle.

4.16 Soil handling/assessment guidelines are set out in section 5.

4.17 The equipment used to construct solar farms is generally lightweight, as explained later in section 9. It is unlikely that deep compaction will be caused, even with travel in suboptimal conditions.

4.18 In localised instances where it is not possible to avoid undertaking construction activities when soils are wet and topsoil damage occurs then soils can be recovered by normal agricultural management, using normal agricultural cultivation equipment (subsoiler, harrows, power harrows etc) once soils have dried adequately for this to take place. There may be localised wet areas in otherwise dry fields, for example, which are difficult to avoid.

Retaining Soil Profiles

4.19 The successful installation of cabling at depths of >60cm requires a trench to be dug into the ground. Topsoils vary across the site but the coverage is generally about 30cm, with subsoils below that being generally similar to depth. As set out in the BRE Agricultural Good Practice Guidance for Solar Farms ~~(extract at **Appendix SMP7**)~~ at page 3:

"**When excavating cable trenches, storing and replacing topsoil and subsoil separately and in the right order is important to avoid long-term unsightly impacts on soil and vegetation structure. Good practice at this stage will yield longer-term benefits in terms of productivity and optimal grazing conditions**".

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4.20 In those areas where the soil is dug up (trenching and for compounds and access roads), the soils should be returned in as close to the same order, and in similar profiles, as it was removed.

Avoiding Compaction

4.21 It is stressed that the objective of the oSMP is to avoid causing compaction. Compaction by normal machinery is very unlikely to affect land quality, but it results in the need for physical ameliorating with consequent cost implications. It should be avoided wherever possible.

4.22 This oSMP sets out when soils should generally be suitable for being trafficked. There may be periods within this window, however, when periodic rainfall events result in soils becoming liable to damage from being trafficked or worked. In these (likely rare) situations, work should only continue with care, to minimise structural effects on the soils, until soils have dried, usually within 48 hours of heavy rain stopping.

Ameliorating Compaction

4.23 If localised compaction occurs during construction, it should be ameliorated. This can normally be achieved with standard agricultural cultivation equipment, such as subsoilers (if required), power harrows and rolls.

4.24 The amount of restorative work will vary depending upon the localised impact. Consequently where the surface has become muddy, for example in the photograph below, this can be recovered once the soil has dried, with a tine harrow and, as needed, a roller or crumbler bar.

Photos 5 and 6: Inter-row Localised Soil Disturbance and Subsequent Restoration

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4.25 If there are any areas where there has been localised damage to the soils due to vehicle passage, for example, a low wet area within a field which despite best efforts could not be avoided, this should be made good and reseeded at the end of the installation stage, when conditions are suitable. This is illustrated below

Photo 7: Localised Restoration

4.26 The soils across the site, provided they have dried sufficiently, will readily restore. The ruts need to be harrowed level when the ground is dry, and then they will naturally restore.

4.27 Accordingly the ground surface should be generally levelled prior to any seeding or reseeding.

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5 SOIL SUITABILITY TESTS

5.1 The soils across the site are generally able to be worked between April and October. Avoiding the November to March period if possible is recommended.

5.2 The heavier clayey soils are most susceptible to traffic damage when wet. They will therefore need to be assessed after prolonged rain, depending upon the activities proposed.

5.3 Guidance on determining soils suitability to be handled is set out in the Good Practice Guide for Handling Soils, **Appendix SMP42**.

5.4 If you can roll soil into a ball or a sausage easily and the soil holds that shape, it is too wet to travel over or move soils. This is illustrated in the photograph below.

Photo 8: Indication of When Soils are Too Wet (not taken at this site)

5.5 If the soils once rolled then cannot be held in this manner and break or crumble, as shown below, they are likely to be suitable for being handled. See the test methodology in **Appendix SMP42**.

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Photo 9: Soils Suitable

5.6 The following soils, from some of the Grade 2 land within the Site, crumble and are suitable for being moved and handled.

Photos 10 and 11: Suitably Dry Soils

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6 CONSTRUCTION PHASING AND TIMING

6.1 Works will start with the construction of the access bellmouths, then the construction compounds, internal drainage works etc.

6.2 The access tracks will then be laid. It will be possible to construct the tracks from the highway in, minimising the need to travel over surrounding agricultural land, if the soils are damp. There are existing tracks around the site that will facilitate access.

6.3 Works to install and connect the solar PV arrays will then take place. This will be planned, so far as possible, to mostly take place from late spring and should be complete by November. Cable connections will continue thereafter.

6.4 The construction programme obviously involves the potential to slip into winter work, and so care will be taken to minimise soil disturbance as much as possible.

6.5 Restoration of areas that have been trafficked will take place towards the end of the construction period, in about October/early November, prior to seeding with grass. If the programme, or the weather, means that the ground conditions are not suitable then this work will be delayed until ground conditions are suitable the following spring.

6.6 The construction compounds will be removed in suitably dry conditions after the construction is complete, and those areas restored and seeded.

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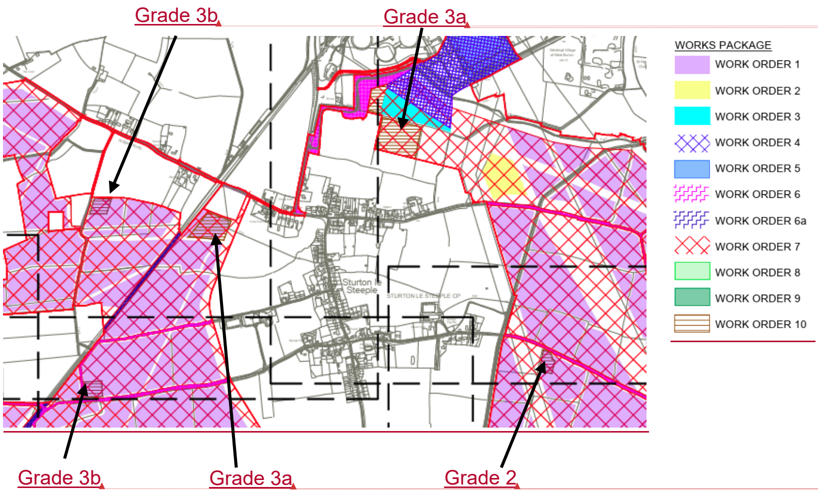
7 CONSTRUCTION COMPOUNDS

Construction ~~Methodology~~Compound Location

7.1 ~~A t~~Temporary construction compounds will be created at the start of construction and reinstated at the end. These are Works Order 10.

7.2 The locations are shown as Works Order 10 on the extract from 2.2 Works Plan [**APP-007**] below.

Insert 5: Extract from Works Plan



7.3 The two primary construction compounds are shown as being on subgrade 3a quality land. Of the secondary construction compounds, one is on Grade 2 and two are on subgrade 3b.

7.4 The secondary compound on Grade 2 needs to be located south of Littleborough Road, and so the use of Grade 2 was not avoidable.

Construction Methodology

7.5~~2~~ Construction compounds are built by either matting over the top of the topsoil, or by stripping topsoil and storing that on the edge of the site. A matting is then laid down, and stone imported and levelled, as shown below.

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Photo 12: Newly-laid Construction Compound (Elsham-Lincoln Pipeline)

7.~~6~~3 The matting prevents the stone from mixing with the subsoil, as shown below.

Photo 13: Matting

7.~~7~~4 Topsoil if removed will need to be stored short-term, such as shown below. If soils are still wet when moved, the storage should be no higher than 1m, but otherwise temporary storage can be up to 3m in height.

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Photo 14: Topsoil Storage Example

<u>Movement of Soils</u>

7.85 The soils need to be sufficiently dry to handle. The works will be scheduled to start when soils should be dry.

7.96 Guidance on determining soils suitability to be handled is set out in the Good Practice Guide for Handling Soils, **Appendix SMP42** and in section 5.

7.107 As described in this oSMP, most of the soils across the site will be suitable for being moved for much of the year. However after prolonged periods of rain, especially in the November to March period, the advice in section 5 on assessing suitability should be followed. Generally the programme seeks to avoid working the soils in this period.

7.118 The topsoils will be stripped to a depth of 30cm, and placed in short-term storage in locations not at risk of flooding.

7.129 Short term storage of soil is shown above. If the soil is likely to be stored for in excess of six months then, depending upon timing, it should be seeded with grass. This binds the soil together and minimises erosion.

7.130 Therefore if the construction compounds are not to be removed before the wet weather in the autumn, the bunds should be seeded with grass, as per the example below, at a suitable time of the year. The compound can then be reinstated after April the following year.

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Photo 15: Grass-seeded Soil Storage

Removal

7.14~~1~~ The removal of the construction compound should be timed for dry weather. That will be before November or in the following spring.

7.15~~2~~ At the end of the construction process, the aggregate will be removed. This can be seen in progress below.

Photo 16: Start of Restoration of Construction Compound

7.16~~3~~ The base area should be loosened when soils are dry and the topsoil then spread over the site to the original depth. This should be lightly cultivated.

7.17~~4~~ Panels can then be installed over the construction compound, or the area returned to agricultural use.

~~7.15 The underlying land quality will be restored and retained.~~

Land Quality Following Reinstatement

7.18 The soils will be returned to the same depth. The ALC grade will be unaffected. The Applicant commits to restoration back to comparable ALC grade.

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8 TRACKS AND INVERTER SUBSTATIONS

Construction Methodology

8.1 Track construction involves removing the topsoil, normally to a depth of 30cm, and placing it to the side of the track (therefore enabling easy return to the same place on decommissioning). A geotextile membrane is then spread over the upper subsoil, and the track surface is laid onto this.

8.2 The small areas of fixed equipment will stand on a similarly-constructed hardstanding or concrete foundations, requiring some removal of soil to create the foundation.

Soil Management

8.3 Soil should be stripped when the soil is sufficiently dry and does not smear. This is a judgement that is easily made. If the soils can be rolled into a sausage shape in the hand which is not crumbly, or if rubbing a thumb across the surface causes a smudged smooth surface (a smear), the soil is generally too wet to strip or move without risk of structural damage. Topsoil depths are consistent across the site and a stripping depth of 30cm will be a suitable maximum depth for topsoil in most cases, although rarely will it need to be stripped to such a depth. See section 5 for the tests.

8.4 Soil stripping should be carried out in accordance with Defra's "Construction Code of Practice for the Sustainable Use of Soils on Construction Sites" (Defra, 2009). The removed soil should be stored in bunds in accordance with the Construction Code of Practice.

Replacement

8.5 The soils will be replaced on decommissioning (see section 16) and the Applicant commits to restoration back to comparable ALC grade.

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9 SOLAR ARRAYS AND ON-SITE TRENCHING

The Areas

9.1 The PV Arrays will be distributed across the Solar PV Site as shown on the application plans.

Construction Methodology

9.2 The installation should be carried out so far as is practicable and possible when the ground conditions are suitable (ie the soil is not so wet that vehicles cause tyre marks, such as shown below, deeper than about 10cm when travelling across the land). This will be possible for most of the year, but extra care will be needed between November and March, and this period should be avoided if possible. If conditions are suitable, this stage of the installation should create no soil structural damage or compaction, as shown below.

Photos 17 and 18: Ground After Construction

Soil Management

9.3 A suitability test, as described in section 5, should be used to determine suitability of the soils for working or access. In simple terms, if the soil is so wet that vehicles cause tyre marks, such as shown below, deeper than about 10cm when travelling across the land, conditions are not yet suitable.

Photo 19: Track Marks

9.4 In most years work access to the land is not restricted between March and November. Between those periods the ground conditions will normally be resilient to vehicle trafficking.

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9.5 In winter periods the soils are more likely to be saturated, especially to the west, and the propensity to being damaged, albeit in a way capable of rectification, is greatest. As a general rule, vehicular travel in these periods should be limited as much as possible. It is recognised that rainfall is the factor that wets the soils, so a dry spring will offer different conditions to a wet spring, and this may mean that soil structural damage will inevitably result.

9.6 Work in suboptimal conditions should be minimised. The layout includes a network of access tracks and in most cases once legs have been installed, only small numbers of vehicle movements will be needed between each string of panels.

9.7 The machinery normally used is small, lightweight and tracked, and damage to soils will generally be minimal.

Insert 65 and Photo 20: Example or Leg Piling and Panel Moving Equipment

9.8 Any surface disturbance will be limited, will not result in deep compaction, and can be ameliorated easily in the spring, as described above.

9.9 It is very unlikely that trafficking during construction when soils are relatively dry will result in compaction sufficient to require amelioration. However, if rutting has resulted the soil should be levelled by standard agricultural cultivation equipment such as tine harrows, once the conditions suit, and prior to seeding. This can be done with standard agricultural machinery, or with small horticultural-grade machinery such as is shown below.

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Photos 21 and 22: Horticultural Machinery

9.10 The objective is to get the surface to a level tilth for seeding/reseeding as necessary, as was shown earlier.

9.11 Grass growth will then recover or establish rapidly.

Construction Methodology

9.12 Cabling is done mostly with either a mini digger or a trenching machine. The cable routing areas are shown on the plans. Trenches will be at varying depths. An example trench, with the topsoil, placed on one side (0-30cm) and subsoil on the other (below 30cm), is shown below, and with the soil put back after cable installation. This methodology should be followed.

Photos 23 and 24: Cable Installation

9.13 It is important that topsoils are placed separately to the subsoils, and that they are then put back in reverse order, ie subsoils first.

9.14 The type of machinery used for trenching is shown below, taken from the BRE National Solar Centre “Agricultural Good Practice Guidance for Solar Farms” (2013).

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Insert ~~6~~7: Machinery Used (extract from BRE Good Practice Guidance)

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesy of British Solar Renewables)

9.15 The trenches are narrow (mostly 40-70cm). If the topsoil was from grassland the grass will probably recover rapidly without the need to reseed. In bare soils the trench can be cultivated with the wider area for seeding to grass post installation.

Photo 25: Grass After 4 Weeks (natural recovery)

(The photos in this section were taken on heavy, clay soils with poorly draining subsoil, and the work was photographed in July and August 2015)

<u>Soil Management</u>

9.16 All trenching work will be carried out when the topsoil is dry and not plastic (ie it can be moulded into shapes in the hand).

9.17 The top 30cm will be dug off and placed on one side of the trench, for subsequent restoration. There is no need to strip the grass first.

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9.18 The subsoils will then be dug out and placed on the other side of the trench, as per the example below.

Photo 26: Subsoils Dug out of the Trench

9.19 Once the cable has been laid, the subsoils will be placed back in the trench. Where there is a clear colour difference within the subsoils, so far as practicable the lower subsoil will be put back first and the upper subsoil above that, which is likely to happen anyway as the lower soil is at the top of the pile.

9.20 If dry and lumpy the subsoils will be pressed down by the bucket to speed settlement. If the soils are settling well no pressing-down is required.

9.21 The topsoil will then be returned onto the top of the trench. It is likely, and right, that the topsoil will sit a few centimetres higher than the surrounding level. This should be left to allow it to settle naturally as the soils become wetter.

9.22 If there is a surplus of topsoil this may be because the lower subsoils were dry and blocky and there are considerable gaps in the soil. These will naturally restore once the lower soils become wet again. If the trench backfilling will result in the soil being more than 5-10cm proud of surrounding levels, which is unlikely but possible, the topsoil should not be piled higher. It should be left to the side, and the digger returned to add back the surplus soil once the trench has settled and add the rest of the topsoil onto the trench at that point.

9.23 Any excess topsoil should not be piled higher than 5 – 10cm above ground level.

9.24 If considered appropriate, a suitable grass seed mix could be spread by hand over any parts of the trenches that would seem likely to benefit from extra grass.

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Restoration

9.25 These works will restore the land without any adverse effects on ALC grade. The Applicant commits to restoration back to comparable ALC grade.

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10 INTER-AREA CABLING

10.1 Cable infrastructure is required connecting the panel areas, as shown below.

Insert 8: Area for Cabling

Proposed Pre-Entry Soil Survey

10.2 As part of the preparation of the SMP a soil survey will be completed along the line of the proposed cable using a soil auger and, as needed, a spade, sampling where possible down to 1.2m. The soil survey will sample on a regular 100m grid pattern, along the central line of the proposed cable route.

10.3 The survey will identify the soil resource. In particular it will identify and map:

- topsoil type;
- topsoil depth;
- subsoil type and depth;
- any limitations from poor drainage.

10.4 This detailed survey will be undertaken across all areas where soils will be disturbed.

10.5 The ALC grade along the route will be calculated so as to inform the works and so as to enable the ALC grade to be retained post-installation of the cable.

10.6 The detailed pre-entry survey will be written up recording ALC grade, topsoil depth, subsoil conditions and texture to inform the SRMP.

Construction Methodology

10.7 The works will involve:

(i) the potential stripping of topsoil across the working width, to be stored temporarily in a

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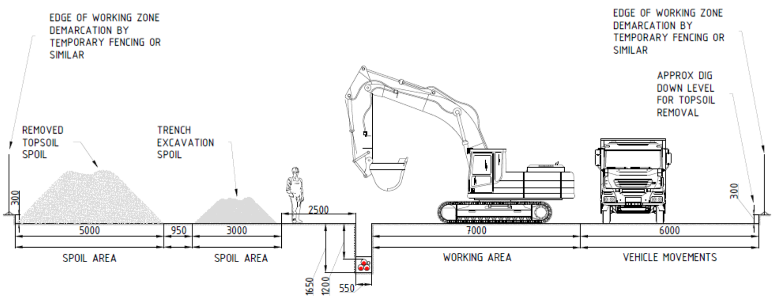
bund, as per the example below. In some cases the working width may not need to be stripped. The working width in most places is anticipated to be around 30m wide;

Insert 9: Example of temporary bund (example shown in a water pipeline)

(ii) the trench will then be dug, with the subsoil placed separately to the topsoil. An example is shown below, but the details will be determined prior to survey works;

Insert 10: Example of soil storage



(iii) the cable is then laid into the trench, possibly with some material as protection against stones etc.

(iv) following cable installation, the subsoil will then be replaced in the trench;

(v) subsequently the topsoil will be replaced across the working width, following the soil handling and management principles to be set out in the SRMP, and the land returned to the landowners for continued farming.

10.8 Working widths will vary, narrowing for gaps through hedgerows or widening for deeper excavation areas (eg for boring under transport routes or watercourses). The details will be developed pre-soil survey, and the soil survey will cover the working corridor.

Soil Suitability Testing

10.9 Soil suitability testing, as described in section 5, will be essential.

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Restoration

10.10 The detailed SMP will refine the methodology and timing, following soil survey, and will enable the Applicant to commit to restoration of the land back to comparable ALC grade, so that there is no long-term degradation of agricultural land quality as a result of the works.

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~~10~~11 SUBSTATION AND BESS

~~10~~11.1 The substation and BESS are proposed to the north of the site, in an area of Subgrade 3a land, as shown below.

Inserts ~~7~~ 11 and ~~8~~12: Proposed Substation, BESS and ALC Plan Extract

~~10~~11.2 The works include removing the topsoil, for storage, and in places removal of some of the subsoil. Bases and in places foundations will be built. The water basins will require deeper excavation. The whole area will be restored on decommissioning.

~~10~~11.3 The key is to remove and store the topsoil when conditions are right, following the principles set out in the oSMP. Long-term storage against the guidance in the Defra Code of Practice for the Sustainable Use of Soils on Construction Sites~~(**Appendix SMP2**)~~ and IQ ~~(**Appendix SMP4**)~~ guidance Field Tests for Soil Sustainability (an extract is in **Appendix SMP2**) will ensure that soils remain in good condition for the duration of the operational period.

~~10~~11.4 Subsoil must be stored separately to the topsoil.

~~10~~11.5 Details of the location and size of the soil storage will be presented in the oSMP, including annual maintenance of the bunds.

Restoration

11.6 Further details are provided in section 16. The works will restore the land back to the comparable ALC grade, and the Applicant commits to achieving that.

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1112 SITE FENCING

The Areas

1112.1 Fence designs can vary, but they all involve a post being inserted into the ground. Pole mounted internal facing closed circuit television (CCTV) systems are also likely to be deployed around the perimeter of the operational areas. Access gates will be of similar construction and height as the perimeter fencing.

Construction Methodology

1112.2 The site fencing is likely to be metal mesh or deer fencing. This can be erected at any time, if soil conditions allow. The following photographs show fencing installed early in the process.

Photos 27 and 28: The Fencing

1112.3 Similarly CCTV poles are inserted in the same way.

Photos 29 and 30: CCTV Poles and Fencing

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Soil Management

~~11~~12.4 If the movement of vehicles is not causing significant rutting (i.e. more than 10cm), then fencing could be erected outside of the key working period.

~~11~~12.5 Any rutting that results from fencing can be made good with standard agricultural equipment.

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1123 DRAINAGE

Known Field Drainage

1213.1 There is the potential for parts of the site to have in place underfield drainage schemes. At the outset, prior to construction, all efforts will be made with landowners to identify historic maps and records of any known underfield schemes.

Key Considerations

1213.2 The extent to which there is the potential for an adverse effect will depend upon a number of factors including:

- the depth of drainage;
- the direction and spacing of any underdrainage;
- the extent to which the underdrainage is operational;
- the type of works being undertaken.

1213.3 Further detailed investigation of the drainage will be needed before construction. Scanning for clay and plastic pipe field drainage is not possible, and the depth of drainage is not known.

1213.4 The Agricultural and Horticultural Development Board advisory guide "Field Drainage Guide: principles, installations and maintenance" (2024) should be reviewedis reproduced in **Appendix SMP8**. This notes that given good maintenance a useful life of a system is at least 20 years, but some systems can last many decades longer (page 4 refers).

1213.5 The key consideration in minimising the effects on under-field drainage is to identify the location and depth of the drainage. Page 11 sets out a methodology for identifying the location of field drainage.

Effects on Land Quality

1213.6 The land classification system (Defra, updated 2025) assumes that "**where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate underdrainage scheme, the land is graded according to the severity of the remaining limitations**". This is reproduced in **Appendix SMP9**.

1213.7 Consequently any adverse effects on field drainage will not result in a downgrading or change to the ALC grading of the site.

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Installing Cabling and Repairing Drains

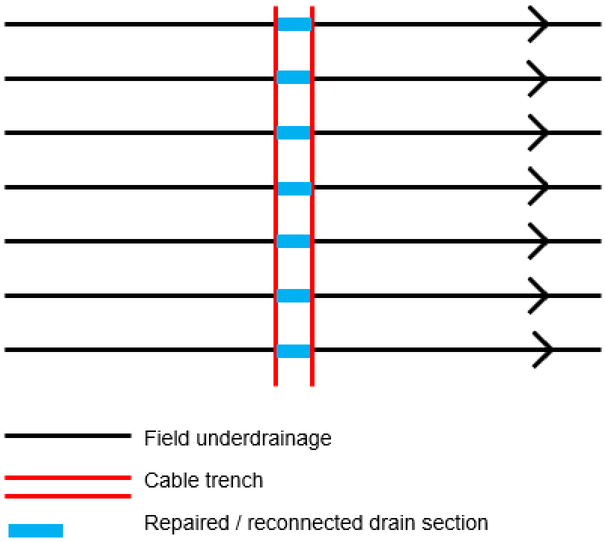
~~12~~13.8 The installation of cabling will be supervised by an experienced advisor. He or she will know where to expect drainage, and will be able to identify if drainage pipes are broken as either clay pipe fragments or plastic pipe will be evident in the material dug out.

~~12~~13.9 Those areas affected by cable damage will be repaired in one of two ways:

(i) either the individual drains will be reconnected with new sections across the pipe, as illustrated below;

(ii) or a collector drain will be laid along the cable trench and will then connect, at a low point, to a new drainage pipe to take water away.

Insert ~~9~~13: Drainage System Repair Option



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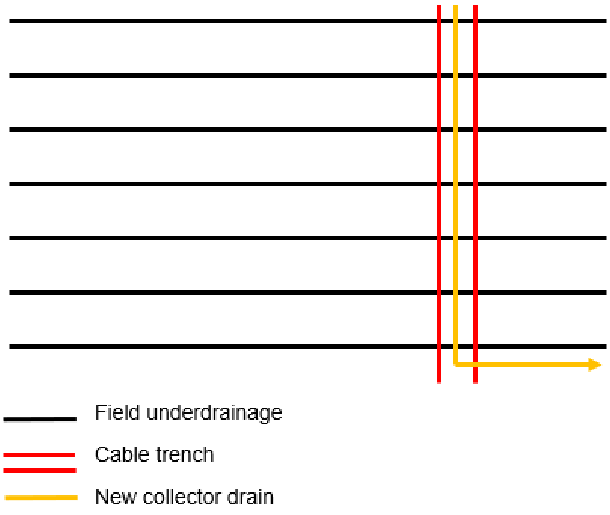
Insert ~~10~~14: Drainage System Repair Option



Drains Affected by Piling

~~12~~13.10 Drains affected by piling will be repaired locally, if required.

~~12~~13.11 The purpose of under-field drainage is to help crop growth and to extend the time that land can be accessed. Drainage allows earlier and later access to the land, and evens out the drainage across the land to help with cultivations etc.

~~12~~13.12 That is not important for the solar farm. Vehicular access is normally only needed in the summer months, when panels are cleaned. Having under-field drainage working is not, therefore, important unless there are areas of standing water due to broken drainage.

~~12~~13.13 Localised wet areas where drainage has been impeded such that surface puddling occurs, will be repaired with new sections of plastic drainage pipes dug around the blocked section to connect the old system.

Monitoring

~~12~~13.14 Two winter inspections after heavy rain will be carried out in years 1 and 2 following commissioning. Thereafter works will only be carried out if site engineers report problems.

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14 ECOLOGICAL MITIGATION AREAS

14.1 Ecological mitigation areas are proposed.

14.2 Across the majority of the areas covered by the landscape and mitigation strategy plans (Sheets 1-6 reproduced in small scale in **Appendix SMP3**) no physical movement of soil is proposed. Physical works (ponds) are limited to two areas, shown on Sheet 3 and Sheet 6.

14.3 Land to the west of the Order Limits is proposed for grassland and arable cropping, with some woodland/copse planting, and some small ponds. This section is shown below.

Insert 15: Western Area, Planting and Ponds

14.4 Land to the east will be managed as a mixture of continued arable cropping, grassland mix and species rich grassland seed mix. In addition, new pond creation (intended to be permanent) and scrub planting (also intended to be permanent) are proposed. The details are not fully refined, but are indicated on the extract from the Landscape and Ecological Mitigation Strategy (Sheet 6 of 6) as shown on the insert below.

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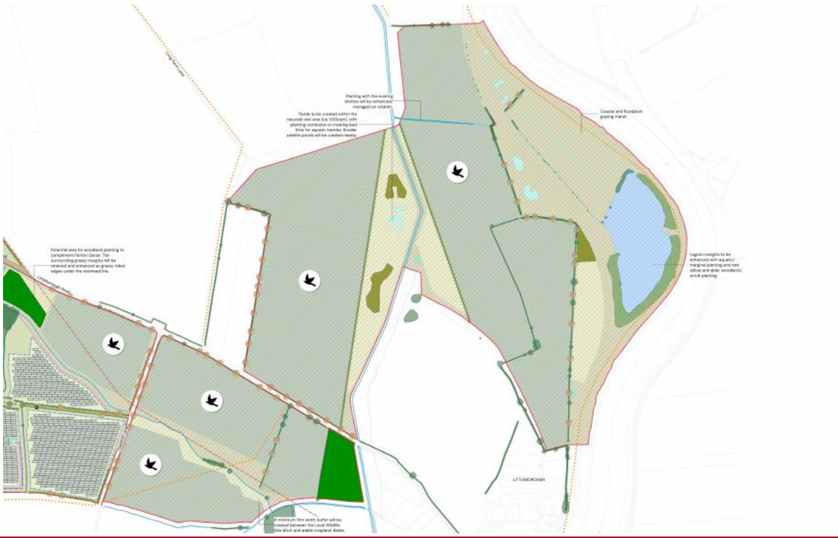
Insert 16: Extract from Landscape Plan



14.5 Whilst the details are not fully refined, the indicative locations in part utilise areas of existing scrub or non-farmed areas, as shown below.

Insert 17: Extract from Google Earth

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14.6 It is possible that the landowners will require these areas to be returned to comparable grade on decommissioning. Accordingly prior to the construction of any ponds the soils and ALC grade will be determined for that particular area. Topsoil depths will be recorded, and topsoil and subsoil will be stored near to the ponds, and can therefore be restored on restoration.

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~~13~~15 OPERATIONAL PHASE: LAND MANAGEMENT

Solar PV Arrays

~~13~~15.1 The land around the Solar PV Arrays will be managed including potentially by the grazing of sheep.

~~13~~15.2 Panels grazed by sheep tend to be free of weeds, as shown below.

Photo 31: Sheep Grazing Under Panels

~~13~~15.3 Any localised weed treatment can be carried out at the appropriate time of the year using a quad-mounted sprayer, or by hand using a strimmer or knapsack sprayer.

Ongoing Maintenance

~~13~~15.4 There are many different cleaners on the market, some tractor based and some operated from smaller machines, such as below.

Photo 32: Cleaning of Solar Arrays

~~13~~15.5 The normal cleaning period is early summer, so that panels are clean for the maximum light period, so damage is unlikely.

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~~13~~15.6 If vehicles, including farm vehicles, cause ruts in the soil these will naturally repair in time, especially as the land is grazed by sheep and their feet are excellent at levelling land. Alternatively a light harrow or rolling will restore the ruts, when the soil is still soft enough to roll but hard enough to not rut more.

Photo 33: Ruts Caused by Vehicles

~~13~~15.7 If vehicles have caused rutting it is probably, as per the example above, only localised. In the photograph above this is a wet spot, and on the land either side of the ruts within the row there is no evidence of wheel indentation. If these areas are not levelled they will tend to sit with water in them.

~~13~~15.8 Localised, small rutting should be repaired by either treading-in the edges with feet, by light rolling or harrowing, or adding a small amount of soil simply to fill-in the depression so that water does not collect there.

~~13~~15.9 Deeper rutting will require either light harrowing in the drier period, or some soil adding, or both, before reseeding.

Emergency Repairs

~~13~~15.10 For the duration of the operational phase there should be only localised and infrequent need to disturb soils, such as for repair of a cable. Any works involving trenching should be carried out, ideally, when the soils are dry but recognising that any works will be those of emergency repair, that may not be possible.

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~~13~~15.11 Accordingly if new cabling is needed and has to be installed in wet periods, it can be expected that the trench will look unsightly initially, such as the example below.

Photo 34: Trench During Wet Period

~~13~~15.12 Any area disturbed should be harrowed or raked level once the soils have dried, and be reseeded. These areas will be small, and this can probably be done by hand.

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~~14~~16 DECOMMISSIONING PRINCIPLES

~~14~~16.1 Given the length of time before decommissioning it is likely that the ALC methodology will have been amended by then. Further, unless we are successful as a world, climate change may have altered the seasons and rainfall patterns. Therefore this guidance is prefaced with a requirement for a suitably qualified soil scientist to revisit the site prior to decommissioning, and to update the guidance and timing.

~~14~~16.2 The objective is to remove panels and restore all fixed infrastructure areas to return the land to the same ALC grade and condition as it was when the construction phase commenced.

Removal of Panels

~~14~~16.3 A qualified soil scientist should advise prior to decommissioning time. The effects of climate change in 40 years time may mean that these dates, applicable in 2024, are no longer applicable.

~~14~~16.4 Once the panels have been unbolted and removed, the framework will then be a series of legs, as shown below.

Photos 35 and 36: The Framework

~~14~~16.5 These will be removed by low-ground pressure machines, in a reverse operation to the installation. These machines will provide a pneumatic tug-tug-tug vertically upwards. This will break the seal between soil and leg, and once that surface tension is released the leg will come out easily.

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~~14~~16.6 The legs will be loaded onto trailers and removed.

~~14~~16.7 There will be no significant damage to the soils, and no significant compaction.

Removal of Cables

~~14~~16.8 Cables buried less than 1 metre deep will be removed. This is likely to need a trench to be dug. This will be done is done mostly with either a mini digger or a trenching machine. An example trench, with the topsoil placed one side (0-30cm) and subsoil on the other (below 30cm), is shown below, and with the soil put back after cable installation.

Photo 37: Example Trench

Photo 38: Topsoil Replaced

~~14~~16.9 The type of machinery used for trenching is shown below, taken from the BRE National Solar Centre "Agricultural Good Practice Guidance for Solar Farms" (2013).

Insert ~~11~~18: Machinery Used for Trenching

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesy of British Solar Renewables)

~~14~~16.10 Once the trench has been backfilled it can be left for cultivation with the rest of the field post removal of panels.

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Removal of Fixed Infrastructure

~~14~~16.11 Switchgear, such as that shown below, will need to be removed.

Photo 39: Switchgear

~~14~~16.12 Low ground pressure vehicles, and cranes, will be needed to lift the decommissioned units onto trailers, and removed from site. An example is shown below.

Insert ~~12~~19: Example of Low Ground Vehicles

Case Steiger Quadtrac used to deliver inverters and other heavy equipment to site under soft ground conditions (photo courtesy of British Solar Renewables)

~~14~~16.13 Any concrete bases will need to be broken up. This will most likely involve breaking with a pneumatic drill to crack the concrete, after which it can be dug up and loaded onto trailers and removed.

~~14~~16.14 The ground beneath the base may then benefit from being subsoiled, to break any compaction. This can be done by standard tractor-mounted equipment, such as the following examples.

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Inserts ~~13~~ 20 and ~~14~~21: Example of Tractor Mounted Equipment

Tracks

~~14~~16.15 The tracks will be the last fixed infrastructure removed. The tracks will have been used for vehicle travel during the decommissioning stage. The tracks will also be used for removal of material from the tracks themselves, which will be removed from the furthest point first.

~~14~~16.16 The stone will be removed and any matting removal. The base will then be loosened by subsoiler or deep tine cultivators, depending on specific advice given by the soil expert at the time following and analysis of soil compaction and condition.

Reinstatement of Soils

~~14~~16.17 Topsoil from the storage areas will then be returned and spread to the depth removed. The area will then be cultivated, probably in combination with the whole of each field.

Fences and Gates, and CCTV Cabling

~~14~~16.18 The cabling be removed in the summer months, after the panels have been removed. This will involve a tractor and trailer. The CCTV cabling is shallow buried and will probably pull out without the need for trenching, but if required tranches will be dug, as described above, and replaced in order once the cables have been removed.

~~14~~16.19 Fences and gates will be rocked by machinery and pulled out. The holes are generally small and will fill in easily, but the bucket could be used to loosen the surface so that soil fills the void, if there is a risk of injury from the small holes.

Cultivation

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~~14~~16.20 The fields will be handed back to the farmers. Whether they are handed back as grassland or sprayed off and cultivated, will be determined in discussions with each landowner.

Land Quality Following Decommissioning

16.21 The restoration will enable the land to be restored without loss of quality. The Applicant commits to restoration back to comparable ALC grade.

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17 REFERENCES

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- Defra (2009), Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.
- British Society of Soil Science (2022), Benefitting from Soil Management in Development and Construction.
- Institute of Quarrying (2021), Good Practice Guide for Handling Soils on Mineral Workings.
- Cornwall Council and Others (2022), Building on soil sustainability: principles for soils in planning and construction.
- Natural England (2022), Planning and Aftercare Advice for Reclaiming Land to Agricultural Use.
- BRE National Solar Centre (2014), Agricultural Good Practice Guidance for Solar Farms.
- AHDB (2024), Field Drainage Guide: principles, installations and maintenance.
- Defra (2025), Agricultural Land Classification of England and Wales: Guidelines and Criteria for Grading the Quality of Agricultural Land (updated 2025).

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Appendix SMP1

Excerpts from Roberts Environmental Ltd ALC Report

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Agricultural Land Classification (ALC) Report

Steeple Solar Farm

April 2025

Renewable Energy Systems Ltd

Reference: 240424.AC.05

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Agricultural Land Classification (ALC) Report

Steeple Solar Farm

Client: Renewable Energy Systems Ltd

Reference:	Current Version:	Date:
240424.AC.05	Version 5.0	April 2025

Reference:	**Previous Versions**	**Date**
240424.AC.01	Version 1.0	October 2024
240424.AC.02	Version 2.0	November 2024
240424.AC.03	Version 3.0	November 2024
240424.AC.04	Version 4.0	November 2024

Author:	**Checked / Approved by:**
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[redacted]	[redacted]
Position: Graduate Consultant	**Position:** Principal Consultant

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1. Scope & Objectives

The Services	Agricultural Land Classification (ALC) Report	
The Client	Renewable Energy Systems Ltd	
Appointment Details	The Services have been carried out in accordance with the Proposal dated 17th April 2024 and REL's Terms and Conditions of Engagement, (together "**the Agreement**") as accepted by the Client on 22nd April 2024.	
Site Name	Steeple Solar Farm	
Site Address	Steeple-le-Sturton, Nottingham, DN22 9HW ("**the Site**")	
Proposed Development	It is understood that the site is to be developed for a solar farm with the capacity of up to 400 MW of solar energy generation and a 200 MW Battery Energy Storage System (BESS) with associated infrastructure and equipment.	
Planning Application	The Proposed Development falls within the definition of a 'Nationally Significant Infrastructure Project' (NSIP) under Section 14(1)(a) and 15(2) of the Planning Act 2008 as the construction of a generating station with a capacity of more than 50MW, with a capacity in the region of 400MW and hence will require a Development Consent Order (DCO) application to be submitted to the Planning Inspectorate (PINS), who will be the Examining Authority on behalf of the Secretary of State (SoS).	
Information Sources (Where appropriate documents are contained in appendices with data extracts provided and summarised within pertinent sections of this report. List not exhaustive)	**Online Source**	Natural England Provisional Agricultural Land Classification Grade (pre-1988), accessed via Magic Web Mapping Service, DEFRA, 2025.
		Natural England Agricultural Land Classification Grades Post-1988 Surveys (Polygons) Database and Mapping, accessed via Magic Web Mapping Service, DEFRA, 2025.
		British Geological Survey (BGS) Database and Mapping.
		BGS Geoindex Web Mapping Service.
		BGS 1: 50,000 scale Provisional Series, Geological Map, England and Wales, Sheet No.101 (East Retford), available on the BGS map portal.
		Google Historic Satellite Imagery.
		National Library of Scotland Historical Ordnance Survey England and Wales, 1830-1956 Maps.
	Documentation Source	Soil Classification for Soil Survey, Monographs on Soil Survey, Butler, B E (1980), Clarendon Press, Oxford.
		Hodgson, J.M (ed.) (2022). *Soil Survey Field Handbook*. Soil Survey Technical Monograph No. 5, Cranfield.
		Meteorological Office (Met Office), 1989, Climatological Data for Agricultural Land Classification – Gridpoint Datasets of Climatic Variables, at 5km intervals, for England and Wales.
		MAFF, 1988, Agricultural Land Classification of England and Wales – Revised Guidelines and Criteria for Grading the Quality of Agricultural Land.
		Natural England, Technical Information Note TIN049 Second Edition, 2012.
		Soils and their use in Eastern England, 1984, Soil Survey of England and Wales Memoir and accompanying 1:250,000 scale map.
	Previous Reports	No previous reports, including Post-1988 ALC surveys, are available for the site.
	Site Works	The site works were undertaken by REL during July to September 2024.

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2. Site Details

National Grid Ref.	Approximate centre of the site: 479360, 383238
Ground Level Topography	Range 30-35m AOD, average for site: 32.5m AOD.
Site Area	892 hectares (ha).
Survey Area	722 ha.
Location	The subject site is located around the town of Sturton-le-Steeple, adjacent south of West Burton power station, approximately 10km east of Retford and approximately 700m to the west side of the River Trent.

Figure 1: Site Boundary (highlighted in red)

Current Site Description and Usage	The subject site comprises mainly agricultural fields which are currently used for arable crop (based on observations made during the site visit).
Surrounding Land Uses	Surrounding land uses comprise agricultural fields around the entire site, with West Burton power station located adjacent north.
Site History	From the earliest mapping dated 1830, the site is shown as agricultural land.
Current Grading	The site is currently mapped as **Grade 3** on the provisional 1: 250,000 scale ALC map (MAFF, 1983) see **Appendix V** for key to the gradings.

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3. Methodology

Desk Study

Using published data sources, an initial desk-based study has been undertaken to provide a reconnaissance of the general site characteristics, including soil type(s) and agricultural classification.

Where available, Post-1988 ALC Surveys (undertaken at varying scales and levels of detail, ranging from 1:5,000 to 1:50,000 scale) have been consulted. Surveys included on this map provide the most detailed and up to date ALC grading following surveys between 1989 and 1999 by MAFF (now part of DEFRA).

Climatological data provided by the Met Office has been used to determine the overriding agroclimatic site limitations, using interpolated values based on the central point of the site.

Intrusive Soil Survey

The intrusive soil survey comprised at least one hand auger boring per hectare to a depth of 1.20m below ground level (where achievable) in accordance with current guidance. These were undertaken to examine the soil profiles, using standard soil survey methods.

In addition, in order to determine subsoil structure, at least one inspection pit has been excavated for each soil type encountered.

The application boundary has altered since the site survey works were undertaken, therefore the survey area boundary differs to the site boundary and the application boundary.

ALC Grade Assessment

All potential limiting ALC grade factors (listed in **Appendix V**) have been considered as part of the assessment, including those which pose no limitation on the ALC grading for the site.

Using the information collected during the site survey and the MAFF ALC guidance documents, an ALC grade was then determined for the site, or for each soil type based on the most limiting ALC grade (**Appendix I**). A brief overview of relevant terminology is included in **Appendix V**.

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4. Desk Based Reconnaissance

Prior to the intrusive site investigation, a review of available desk-based information was undertaken. Pertinent information has been summarised below.

Climate Data

Using the climatological data set (Met Office, 1989) the following information (**Table 1**) has been calculated for the site. Calculations comprised altitude adjustment and interpolation, using the formula presented within the data set.

Table 1: Summary of Agroclimatic Data for the Site

(Site Centre Grid Reference: 479360, 383238)		
Average Annual Rainfall (mm)	AAR	568.90
Accumulated Temperature (°C)	ATO	1392.44
Field Capacity Duration (Days)	FCD	111.20
Moisture Deficit Wheat (mm)	MDWHT	115.61
Moisture Deficit Potatoes (mm)	MDPOT	109.23

The site is identified to have an average ATO, with below average AAR and FCD when compared to the mapped values for the area between Lincoln and Worksop (Soils and their Use in Eastern England, 1984).

Using the AAR and ATO values within **Table 1**, the site is not considered to be limited by climate (Figure 1, MAFF 1988).

Topography

The site was identified to have a gradient between 0° and 2°, therefore topography is identified to not be a limiting factor of the ALC grade of the site (Table 1, MAFF 1988).

BGS Published Data

A review of BGS information has identified that no Made Ground areas are indicated across the site.

The eastern section of the site is indicated as having superficial deposits of the Holme Pierrepoint Sand and Gravel Member, with some potential discrete areas of Alluvium (Clay, Silt, Sand and Gravel), particularly encroaching onto the northern and southern site boundaries. The remainder of the site is indicated to be free from superficial deposits.

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The bedrock geology is indicated as the Mercia Mudstone Group across the whole site.

Published Soils Data

Soils mapping for the area as shown on *Soils and their use in Eastern England*, 1984, Soil Survey of England and Wales Memoir and accompanying 1:250,000 scale map has been reviewed as part of this assessment. The approximate location of the site is shown in the soils mapping extract below in **Figure 2**.

The soil mapping suggests the soils on site comprise the Worcester Association across the majority of the site, with the potential for soils of the Brockhurst 2 Association and Blackwood Association to encroach on to the east of the site. The soils are described as follows:

- **Worcester Association (431)** - Slowly permeable non-calcareous and calcareous reddish clayey soils over mudstone, shallow on steeper slopes. Associated with similar non-calcareous fine loamy over clayey soils. Slightly risk of water erosion.
- **Brockhurst 2 Association (711c)** – Slowly permeable seasonally waterlogged reddish fine loamy over clayey and clayey soils. Some reddish clayey alluvial soils affected by groundwater.
- **Blackwood Association (821b)** – Deep permeable sandy and coarse loamy soils. Groundwater controlled by ditches.

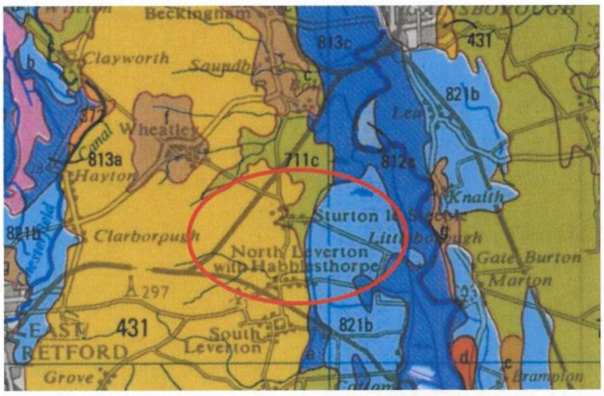

Figure 2: Soils Mapping for the Site and Surrounding Area (approximate site location indicated in red)

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Previous Reports

No previous ALC reports are available for the site or adjacent surrounding areas.

Flood Risk Assessment

Flooding is not anticipated to affect the cultivation potential on site and therefore does not limit the ALC grade.

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5. Intrusive Survey Findings

The survey identified Four Soil Types across the entire site. Generalised profiles of the soil types encountered have been described as below (**Table 2**) however, please note some localised variations were recorded. Complete soil logs are provided in **Appendix II** and photographs of the surveyed soils are presented in **Appendix III**.

Table 2: Summary of Soils Identified on Site

	Depth (cm)	Texture	Munsell Colour	Stones (%)	Mottles	Structure
Soil Type 1	0-20	Heavy Silty Clay Loam (HZCL)	Dark Brown (7.5YR 3/4)	5	No	Subangular Blocky
	20-120	Silty Clay (ZC)	Reddish Brown (5YR 4/4)	15	Many Medium Grey (GLEY 2 7/1 5B) and Ochreous (10YR 6/8)	Coarse Prismatic
Soil Type 2	0-42	Heavy Clay Loam (HCL)	Dark Brown (10YR 3/3)	5	No	Subangular Blocky
	42-120	Clay (C)	Dark Reddish Brown (5YR 3/4)	5	Few Ochreous (7.5YR 5/8)	Coarse Prismatic
Soil Type 3	0-34	Heavy Silty Clay Loam (HZCL)	Dark Brown (7.5 YR 3/3)	5	No	Subangular Blocky
	34-90	Clay (C)	Dark Yellowish Brown (10YR 4/4)	5	No	Subangular Blocky
	90-120	Fine Sand (fS)	Pale Olive (5Y 6/4)	5	No	Single Grain
Soil Type 4	0-39	Fine Sandy Silt Loam (fSZL)	Dark Brown (7.5YR 3/3)	5	No	Subangular Blocky
	39-120	Fine Sand (fS)	Strong Brown (7.5YR 4/6)	5	No	Single Grain

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The general profiles for the soil types identified on the Site has been used to assess the Wetness Class (WC) for the Soil Type (see **Appendix V** for the MAFF decision flow chart). The general profile is reflective of the findings in the soil pit associated with the Soil Type identified on site. The assessment process and results of the in-field wetness assessment is provided within **Table 3** below with a plan of the distribution of the soil types across the site shown in **Appendix I**.

Table 3: Wetness Class Assessment for Soil Types Encountered on Site

Soil Type	Parameters (Figure 6, MAFF)						
	Disturbed	FCD	SPL (depth cm) Justification	Colour	Gleying (depth cm) Justification	Ref	Wetness Class
Type 1	No	111.20	At a depth of 20 cm, the SPL was identified to be present due to the following characteristics: Silty Clay (ZC) coarse prismatic structure less than 0.50% biopores greater then 0.50 mm diameter evidence of wetness in the layer; gleying	Other	Gleyed (<40cm), reddish colours dominant in the matrix with ochreous and grey mottles.	Figure 7	III
Type 2	No	111.20	At a depth of 42 cm, the SPL was identified to be present due to the following characteristics: Clay (C) coarse prismatic structure less than 0.50% biopores greater then 0.50 mm diameter evidence of wetness in the layer; gleying	Other	Gleyed (>40cm), reddish colours dominant in the matrix with ochreous mottles.	Figure 8	II
Type 3	No	111.20	No SPL	Other	Not gleyed.	N/A	I
Type 4	No	111.20	No SPL	Other	Not gleyed.	N/A	I

Notes: This Table follows the flow chart of Figure 6 of the MAFF ALC guidance to identify the wetness classification per Soil Type.

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6. Conclusions

The ALC grading for the site area is summarised below within **Table 4**, overall findings of this assessment can be found in **Appendix IV**. The table below identifies the grades of the areas of agricultural land present across the site (**Appendix I**).

Table 4: ALC Classification

ALC Grade	Area (Ha)	Percentage
Grade 1	56.36	7.81%
Grade 2	153.57	21.27%
Subgrade 3a	430.32	59.60%
Subgrade 3b	81.76	11.32%
Grade 4	0.0	0.0%
Grade 5	0.0	0.0%
Non-Agricultural	0.0	0.0%
Total BMV	640.24	88.68%
Total Non-BMV	81.76	11.32%
Total Site Area	**722.0**	**100%**

Soil Type 1 – Wetness Limitation

The combination of the topsoil texture (Heavy Silty Clay Loam), Wetness class (III) and the number of Field Capacity Days (111.20) results in **ALC Grade 3b** for Type 1 soils with a Wetness limitation.

Soil Type 2 – Wetness Limitation

The combination of the topsoil texture (Heavy Clay Loam), Wetness Class (II), and the number of Field Capacity Days (111.20) results in **ALC Grade 3a** for Type 2 soils with a Wetness limitation.

Soil Type 3 – Wetness Limitation

The combination of the topsoil texture (Heavy Silty Clay Loam), Wetness Class (I), and the number of Field Capacity Days (111.20) results in **ALC Grade 2** for Type 3 soils with a Wetness limitation.

Soil Type 3 - Droughtiness Limitation

The water availability of the soil type and the local climate results in **ALC Grade 2** for Type 3 soils with a soil Droughtiness limtation with respect to the crop adjusted available water capacity for potatoes.

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Soil Type 4 – No Limitation

No limitation to the ALC Grade for Type 4 soils have been identified.

Overall Site ALC Grade and Conclusions

The land surveyed as part of this assessment has been identified as a mixture of **ALC Grades 1, 2, 3a** and **3b**. As such, 640.24ha (88.68%) of the site has been assessed to be BMV land and 81.76ha (11.32%) has been identified as non-BMV land.

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Appendix I Site Plans

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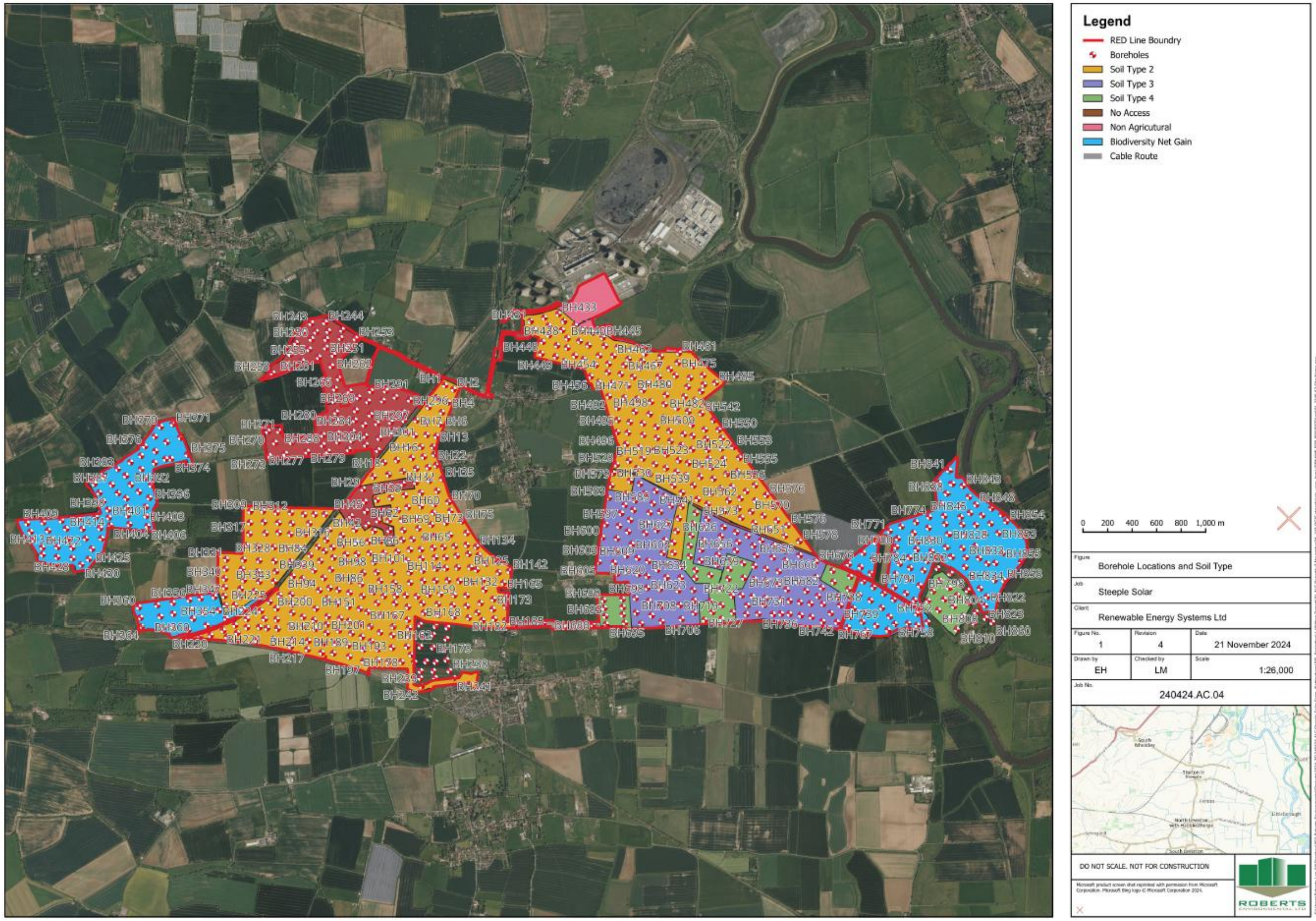

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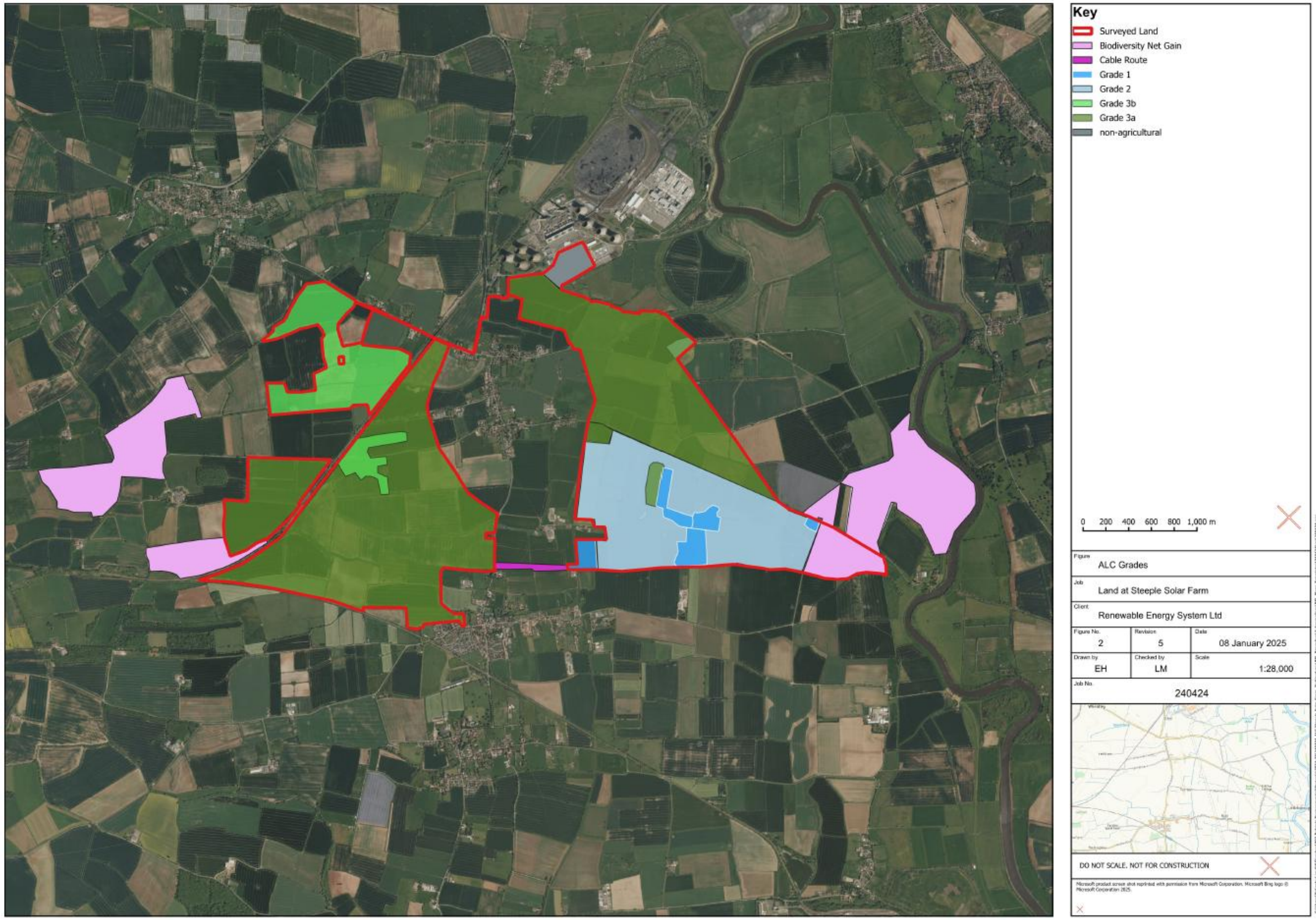

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Appendix SMP2

~~**Extracts from the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009)**~~

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Construction Code of Practice for the Sustainable Use of Soils on Construction Sites

BIS | Department for Business Innovation & Skills

wrap Material change for a better environment

defra Department for Environment Food and Rural Affairs

5.4 Soil stockpiling

Why?

1. Soil often has to be stripped or excavated during the construction process. In order to enable its reuse on site at a later stage, soil needs to be stored in temporary stockpiles to minimise the surface area occupied, and to prevent damage from the weather and other construction activities.

How?

2. The main aim when temporarily storing soil in stockpiles is to maintain soil quality and minimise damage to the soil's physical (structural) condition so that it can be easily reinstated once respread. In addition, stockpiling soil should not cause soil erosion, pollution to watercourses or increase flooding risk to the surrounding area.

3. When soil is stored for longer than a few weeks, the soil in the core of the stockpile becomes anaerobic and certain temporary chemical and biological changes take place. These changes are usually reversed when the soil is respread to normal depths. However, the time it takes for these changes to occur very much depends on the physical condition of the soil.

4. Handling soil to create stockpiles invariably damages the physical condition of the soil to a greater or lesser extent. If stockpiling is done incorrectly the physical condition of the soil can be damaged irreversibly, resulting in a loss of a valuable resource and potentially significant costs to the project. The Soil Resource Survey and Soil Resource Plan should set out any limitations that the soil may possess, with respect to handling, stripping and stockpiling.

5. The size and height of the stockpile will depend on several factors, including the amount of space available, the nature and composition of the soil, the prevailing weather conditions at the time of stripping and any planning conditions associated with the development. Stockpile heights of 3-4m are commonly used for topsoil that can be stripped and stockpiled in a dry state but heights may need to be greater where storage space is limited.

6. Soil moisture and soil consistency (plastic or non-plastic) are major factors when deciding on the size and height of the stockpile, and the method of formation. As a general rule, if the soil is dry (e.g. drier than the plastic limit) when it goes into the stockpile, the vast majority of it should remain dry during storage, and thereby enable dry soil to be excavated and respread at the end of the storage period. Soil in a dry and non-plastic state is less prone to compaction, tends to retain a proportion of its structure, will respread easily and break down into a suitable tilth for landscaping. Any anaerobic soil also usually becomes re-aerated in a matter of days.

7. Soil stockpiled wet or when plastic in consistency is easily compacted by the weight of soil above it and from the machinery handling it. In a compacted state, soil in the core of the stockpile remains wet and anaerobic for the duration of the storage period, is difficult to handle and respread and does not usually break down into a suitable tilth. A period of further drying and cultivation is then required before the soil becomes re-aerated and acceptable for landscaping.

Stockpiling methods

8. There are two principal methods for forming soil stockpiles, based on their soil moisture and consistency.

9. Method 1 should be applied to soil that is in a dry and non-plastic state. The aim is to create a large core of dry soil, and to restrict the amount of water that can get into the stockpile during the storage period. Dry soil that is stored in this manner can remain so for a period of years and it is reuseable within days of respreading.

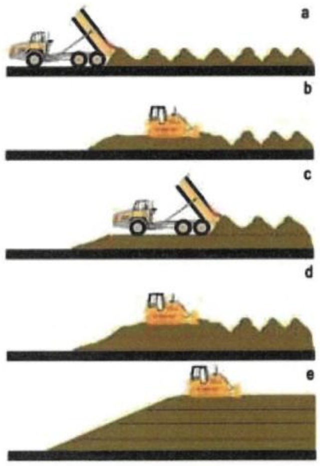
10. Method 2 should be applied if the construction programme or prevailing weather conditions result in soil having to be stockpiled when wet and/or plastic in consistency. This method minimises the amount of compaction, while at the same time maximising the surface area of the stockpile to enable the soil to dry out further. It also allows the soil to be heaped up into a 'Method 1' type stockpile, once it has dried out.

Soil stockpiling

Soil should be stored in an area of the site where it can be left undisturbed and will not interfere with site operations. Ground to be used for storing the topsoil should be cleared of vegetation and any waste arising from the development (e.g. building rubble and fill materials). Topsoil should first be stripped from any land to be used for storing subsoil.

Method 1 – Dry non-plastic soils

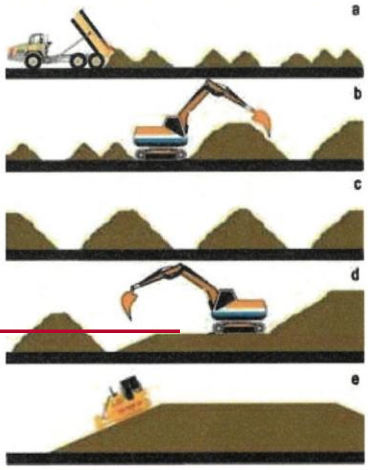
The soil is loose-tipped in heaps from a dump truck (a), starting at the furthest point in the storage area and working back toward the access point. When the entire storage area has been filled with heaps, a tracked machine (excavator or dozer) levels them (b) and firms the surface in order for a second layer of heaps to be tipped. This sequence is repeated (c & d) until the stockpile reaches its planned height. To help shed rainwater and prevent ponding and infiltration a tracked machine compacts and re-grades the sides and top of the stockpile (e) to form a smooth gradient.



Method 2 – Wet plastic soils

The soil is tipped in a line of heaps to form a 'windrow', starting at the furthest point in the storage area and working back toward the access point (a). Any additional windrows are spaced sufficiently apart to allow tracked plant to gain access between them so that the soil can be heaped up to a maximum height of 2m (b).
To avoid compaction, no machinery, even tracked plant, traverses the windrow.

Once the soil has dried out and is non-plastic in consistency (this usually requires several weeks of dry and windy or warm weather), the windrows are combined to form larger stockpiles, using a tracked excavator (d). The surface of the stockpile is then regraded and compacted (e) by a tracked machine (dozer or excavator) to reduce rainwater infiltration.



Stockpile location and stability

11. Stockpiles should not be positioned within the root or crown spread of trees, or adjacent to ditches, watercourses or existing or future excavations. Soil will have a natural angle of repose of up to 40° depending on texture and moisture content but, if stable stockpiles are to be formed, slope angles will normally need to be less than that. For stockpiles that are to be grass seeded and maintained, a maximum side slope of 1 in 2 (25°) is appropriate.

Stockpile protection and maintenance

12. Once the stockpile has been completed the area should be cordoned off with secure fencing to prevent any disturbance or contamination by other construction activities. If the soil is to be stockpiled for more than six months, the surface of the stockpiles should be seeded with a grass/clover mix to minimise soil erosion and to help reduce infestation by nuisance weeds that might spread seed onto adjacent land.

13. Management of weeds that do appear should be undertaken during the summer months, either by spraying to kill them or by mowing or strimming to prevent their seeds being shed.

Clearly defined stockpiling of different soil materials

Long term stockpile of stripped topsoil left with only weed vegetation

Landscape, habitat or garden creation

6.1 Soil placement

Why?

1. The establishment of new landscapes, gardens, or other greenscapes on construction sites often involves the respreading of stockpiled soil or the importation of soil. The manner in which this is carried out has a significant bearing on the soil's function, and particularly its ability to support new trees, shrubs and grass.

2. It is essential to provide a structured, uncompacted and well-aerated soil profile for the successful establishment and subsequent growth of plants and grass. However, where heavy machinery and large volumes of soil are excavated and stored, soil structure can easily be destroyed by over-compaction. This leads to problems of waterlogging and anaerobism, which are detrimental to plants in two main ways. Anaerobic bacteria produce ammonia and methane gases harmful to plant roots, and, without oxygen, plant roots are unable to take up water and nutrients. Restricted rooting increases the risk of trees being affected by wind throw (the uprooting of trees by wind).

3. The consequence of over-compacted soil is not only poor establishment or failure of plantings but also increased surface water runoff and surface ponding that reduces the visual and physical amenity of the landscape or garden and can contribute to localised flooding.

The symptoms of over-compaction of soil on the amenity areas of new housing estates: struggling trees; poor grass growth; and surface ponding after heavy rain.

How?

4. Almost all soil is physically degraded to a greater or lesser extent during soil stockpiling, handling and placement. The potential quality and the ultimate suitability of the soil depends on how well its soil structure is restored during placement.

5. Provided the soil is spread and prepared correctly, damage to soil structure can be kept to a minimum and the soil can usually recover to a healthy state quickly. In order to achieve this, it should be handled only when dry or slightly moist and using suitable machinery in an appropriate way. Multiple handling of soil materials increases the risk of damage to soil structure, so should be minimised.

6. The 'loose tipping' method, using dump trucks and hydraulic excavators to move and spread the topsoil, is the most appropriate method to use.

Landscape, habitat or garden creation

Loose-tipping method

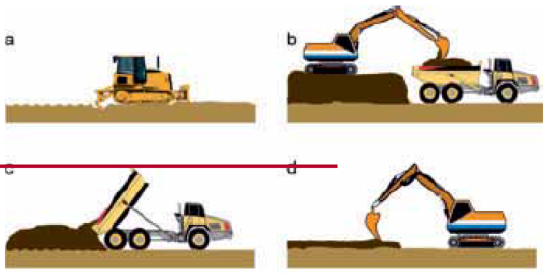
This method entails working to a strip system (the width of the strip determined by the reach of the excavator), and replacing soil sequentially across the soiling area. The receiving ground, whether a basal layer or compacted subsoil is first loosened with a wing-tine ripper.

A hydraulic excavator, fitted with a toothed-bucket to avoid excessive smearing, should be used to load the soil materials from the source area or stockpile into a dump truck which then discharges them onto the receiving surface. An excavator stands next to the newly dropped soil and spreads this to the required thickness. If there is to be more than one soil layer (i.e. if both topsoil and subsoil are being replaced) then the whole length of the strip is restored with subsoil before the process is repeated with topsoil. The topsoil is lifted onto the subsoil without the excavator travelling on the newly placed subsoil. Only when the strip has been completed is the next one started.

If soil is cloddy in structure, the excavator bucket can be used to break up the clods. Large stones can be removed during the operation.

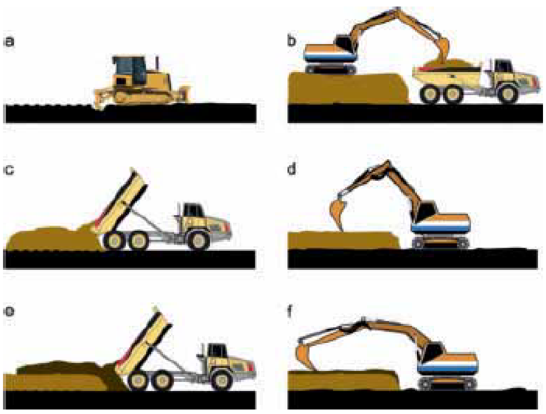
Modified versions of the loose-tipping method, for use when both subsoil and topsoil are to be placed, include spreading the subsoil as described above but then spreading the topsoil layer out using a low ground pressure dozer. Providing that soil conditions are suitably dry and dozer movements are minimised, this can gently consolidate the placed soil without causing over-compaction.

The loose-tipping method (topsoil spreading only)



a) *loosening the subsoil of the receiving ground*
b) *loading of topsoil from stockpile*
c) *backtipping topsoil onto loosened subsoil*
d) *levelling topsoil*

The loose-tipping method (topsoil and subsoil spreading)



a) *loosening the substrate of the receiving ground*
b) *loading of subsoil from stockpile*
c) *backtipping subsoil onto loosened substrate*
d) *levelling subsoil*
e) *backtipping topsoil*
f) *spreading topsoil over subsoil using excavator working on substrate*

Relief of compaction

7. On most construction sites, the receiving layer will have been compacted by vehicles, foot trafficking or the storage of building materials. Therefore, prior to spreading soil the substrate should be properly decompacted to break up any panning to reduce flood risk and to promote deeper root growth. A small (1-5 tonne) to medium sized (13 tonne) tracked excavator, fitted with a single rigid tine is effective in restricted areas, such as in planting beds and road verges. In more open areas, a tractor-drawn subsoiler is capable of loosening soil that is not too heavily or deeply compacted. In some instances, compressed air injection can be used to decompact the soil profile.

8. Deep compaction can only be effectively relieved using heavy duty ripper equipment, such as the single rigid tine device pictured below. For loosening to be most effective, it should be carried out when the soil is sufficiently dry to the full depth of working, otherwise the tine merely cuts and smears the subsoil rather than lifting, fracturing and loosening it. A toothed excavator bucket is not an appropriate tool for ripping soil.

Top (from left to right): *Ripping by tractor-drawn tines, Large winged-tine ripper, Topsoil rake used on a 3 tonne excavator*
Bottom: *Single ripper tooth used for relieving compaction to a depth of 600 mm*

Topsoil thickness

9. Topsoil placement thickness will depend on the anticipated rooting depth of the plants to be established and the quality of the underlying subsoil. Trees and shrubs require a much greater rooting depth than grasses, though this does not have to be made up entirely of topsoil. Topsoil at least 150mm deep is desirable for lawns and mown amenity grass and can beneficially be placed more deeply (up to 400mm thick) for trees and shrubs. However, topsoil does not normally perform well below a depth of 400mm from the surface, where there is an increase in self-compaction and where the biochemical oxygen demand (BOD) often exceeds the rate of aeration. This often results in the development of anaerobic conditions that are detrimental to plant root functions. Subsoil, which has a lower BOD, should, therefore, always be used to create rooting depths in excess of 400mm.

Topsoil cultivation

10. After respreading topsoil, any large, compacted lumps should be broken down by appropriate cultivation to produce a fine tilth suitable for planting (<50mm maximum aggregate size), turfing and seeding (<10mm maximum aggregate size).

11. Topsoil that has been stored in a stockpile is often compacted and anaerobic. It should therefore be cultivated to its full depth using appropriate tillage equipment to decompact and fully re-aerate. Only when the topsoil has been fully re-aerated will it be satisfactory for planting, turfing or seeding. More than one cultivation may be required to re-aerate the entire thickness of topsoil. Undesirable material (e.g. stones, fill materials and vegetation larger than 50mm in any dimension) brought to the surface during cultivation should be removed by picking or raking.

Adverse weather

12. If sustained heavy rainfall (e.g. >10mm in 24 hours) occurs during soil handling operations, work must be suspended and not restarted until the ground has had at least a full dry day or agreed moisture criteria (such as 'drier than the plastic limit') can be met. Lighter soil can generally be moved at a higher moisture content without damage than a heavy soil.

13. The earlier or later in the year that soil is moved, the greater the risk of causing damage or having work suspended by adverse weather, although the period when soil can be safely handled is longer in the drier eastern parts of the UK than in the west. Where the soil handling technique is such that trafficking over the soil is minimal (e.g. the 'loose tipping method' described above) the period for soil stripping may be extended.

Do

- ✓ Handle and place soil in the driest condition possible.
- ✓ Use tracked equipment wherever possible to reduce compaction.
- ✓ Decompact subsoil before placing topsoil.
- ✓ Fully re-aerate anaerobic topsoil before planting, turfing or seeding.
- ✓ Ensure that the physical condition of the entire soil profile (topsoil and subsoil) will promote sufficient aeration, drainage and root growth.

Don't

- ✗ Place or cultivate soils during or after heavy rainfall or when soils are plastic.
- ✗ Take construction machinery over topsoil or subsoil that has been placed.
- ✗ Place topsoil too deeply – 'more' is not necessarily 'better'.
- ✗ Plant into anaerobic topsoil.

Case Study 4: Decisions not to follow soil specifications cost company £25,000

1. Even where a good specification has been prepared for subsoil and topsoil management, there is seldom quality control of the works to ensure that desired outcomes are achieved.

2. An example is from a small development of 37 houses in Lancashire which necessitated the tipping of subsoil excavated from the development platform onto an adjacent field, which was then to be turned into public open space under a Section 106 agreement. A detailed specification was prepared by the developer's consulting landscape architect and stated that:
   - subsoil to receive topsoil should be thoroughly broken up to a depth of 150 mm and cleared of all roots, stones and debris with any one dimension greater than 75 mm;
   - subsoil should be graded after loosening but not traversed by heavy machinery;
   - topsoil should conform to 'BS3882:1994 fertile agricultural soils of uniform composition throughout, of light or medium texture with stones not exceeding 50 mm in any one dimension'.

3. Despite the detailed soil specification, including recommended quality control stages, neither the landscape architects nor other suitably qualified professionals were retained to supervise the contractors and check that the specifications were followed. Site clearance soil was used rather than fertile agricultural soil, the local planning authority was dissatisfied, refused to adopt the open space and legal action ensued. Investigation showed that the substrate was very compact and probably hadn't been loosened or stone picked, the topsoil had an excessive inclusion

One of many items of debris encountered in the imported topsoil during remedial works

Appendix SMP3

BSSS Working with Soil Guidance Note

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Guidance Document 3

Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction

YEARS 1947–2022

The British Society of Soil Science (BSSS) exists to promote the study, public understanding and application of soil science. This guidance note is written for development planning and control professionals, site owners and developers to help promote the protection of soils and the important functions they support within the planning system and the development of individual sites.

Soils in the Planning System

Soils are protected in development to varying degrees by UK national planning policies. However, specific 'calls to action' regarding soils are generally lacking, and therefore explicit requirements of developers relating to soils are relatively rare in the planning approval process. The result is that the nature of the soils on a site is often poorly understood before construction starts. This stems from a failure to appreciate the variability of soils within the landscape and what effect this has on their specific hydrology, habitat potential and sensitivity to damage in particular. The inappropriate use and management of soil resources is often responsible for costly programme delays, the failure of planting schemes and higher incidence of surface runoff. This can mean non-compliance with planning conditions related to biodiversity net gain, tree protection, landscape enhancement and storm water management for example. There is therefore a strong argument for considering the nature and management of existing soil resources on a site at the design stage of a development, in accordance with planning policy relating to other sustainability priorities.

Recommendations

With the above in mind, **BSSS recommends** that planning consents for the development of green field sites are conditional on **the production and implementation of a comprehensive and site-specific Soil Resource Survey and Soil Management Plan,** the results of which are a consideration at the design stage of a development.

The Soil Resource Survey and Soil Management Plan should:

1. **be based on a detailed field survey of the soils of the proposed development site to bedrock or a depth of 1.2m.**
2. **be conducted by a professional soil scientist with the competencies set out in BSSS Working with Soil Professional Competency in Soil Science Documents 1 (Foundation skills in field soil investigation, description and interpretation), 4 (Soil science in soil handling and restoration), 5 (Soil science in land evaluation and planning) and 8 (Soil science in landscape design and construction) as appropriate.**

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3. comprise a map at a suitable scale showing the distribution of each soil type present on the site and a detailed report describing the suitability and volume of each soil resource present for specific after-uses (as per the proposed development).
4. Site/soil specific management advice on stripping, stockpiling and restoration to ensure soils are protected.
5. Where semi-natural vegetation is to be established within a development, soils should be sampled and analysed for the major nutrients and advice should be given on the depth of topsoil to be reinstated and the suitability of each soils for different plant communities.

Mitigation against Flooding

Natural soils store large volumes of rainfall during storm events, which has a significant mitigating effect on flooding. Planning applicants are required to demonstrate that a built development will not increase risk of surface flooding, and any increase in runoff rates from built surfaces compared to baseline soils needs to be offset through sustainable urban drainage systems (SUDS). However, it is frequently assumed that baseline runoff from *non-built* surfaces (gardens, landscape areas and public green space) within the development are unaffected by construction. Compaction caused by soil handling activities and construction traffic can cause profound reductions in soil infiltration rates, but this extra surface runoff is seldom considered in SUDS design. The result can be that post-development surface flood risk is much higher than anticipated.

BSSS recommends that Soil Management Plans include considerations of the runoff from natural and re-instated soils post development.

Creation and Support of Habitats

Increasingly, planning permission for built development is conditional on the provision of specific landscape planting schemes and/or the inclusion of habitat creation (e.g. species-rich meadow grassland). However, while planning conditions regularly include detailed planting specifications, it is rarely recognised that the success of this planting is highly dependent on appropriate soil being used as a planting medium. Soil resources on large development sites are often variable: some may be heavy (clayey), hard to handle and difficult to reuse in landscaping, while others are loamy or sandy, well-structured and easy to handle. Soils may also be acid or alkaline with a high lime content. Some have been used for intensive agriculture and are very high in nutrients and weed burden, while others are low in nutrients and well suited to use in habitat creation. If soil resources are not properly assessed at an early stage of the planning process, and appropriately re-used, there is a high probability that targeted landscaping and habitat creation will fail (and therefore planning conditions associated with landscape and ecology will not be satisfied), increasing project costs and delaying development completion.

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BSSS recommends that the underlying soil conditions should be taken into account in the choice and establishment of semi-natural vegetation.

Soil Biodiversity

Soils that have remained undisturbed for lengthy periods of time develop rich and diverse below-ground flora and fauna. Old parkland soils provide good examples of this and support equally rich above ground insect, bird and bat communities. Soil fauna form the foundation of diverse food chains. Needless to say, such soils are increasingly rare and BSSS believes that every opportunity should be taken to protect and preserve them.

BSSS recommends that where biologically-rich soils fall within a proposed development, they should be protected from any disturbance as far as is possible and be assigned to a future use as urban greenspace.

Further Reading

The Construction Code of Practice for the Sustainable Use of Soils on Construction Sites[1] provides examples of good practice and highlights the need for detailed Soil Resource Assessment as part of a Soil Management Plan for the construction phase of built development.

January 2022 – version 3

[1]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/716510/pb13298-code-of-practice-090910.pdf

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Appendix SMP4

Institute of Quarrying Field Tests for Soils Suitability

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The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

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Supplementary Note 4
Soil Wetness

Soil wetness is a major determinant of land use, and environmental and ecosystem services in the UK. It is also a factor in the occurrence of significant compaction arising from handling soils with earth-moving machines and the practices used (Duncan & Bransden, 1986).

Relative soil wetness can range from the waterlogged to moist (mesic) or dry (xeric) depending on rainfall distribution and depth to a water-table and duration of waterlogging. In the UK, soil wetness is largely seasonal with higher evapo-transpiration rates potentially exceeding rainfall in the summer resulting in the soil profile becoming drier where there is vegetation. Whilst soil wetness is largely weather system and equinox (climate) driven, it varies with geographical and altitudinal locations, and importantly the physical characteristics of the soil profile, such as texture structure, porosity, and depth to the water-table and topography including flood risk (MAFF, 1988). The Soil Wetness Class is based on the expected average duration of waterlogging at different depths in the soil throughout the year (days per year), and can be determined by reference to soil characteristics and local climate (MAFF, 1988). The likely inherent wetness and resilience status of a soil should be indicated in the SRMP (see **Part 1, Table 2 & Supplementary Note 1**), reflecting potential risks for soil handling such as low permeability, permanently high groundwater, or a wet upland climate.

Wet soils can also be a result of other circumstances. For example, the interception of water courses, drainage ditches and field land drains. Where these occur, the provisions are to be made in the SRMP to protect the soils being handled and the operational area.

Soils, when in a wet condition generally have a lower strength and have less resistance to compression and smearing than when dry. Lower strength when soils are wet also affects the bearing capacity of soils and their ability to support the safe and efficient operation of machines than when in a dry state.

In terms of resilience and susceptibility to soil wetness, the clay content of the soil largely determines the change from a solid to a plastic state (the water content at which this occurs is called the 'plastic limit' (MAFF, 1982)). This is the point at which an increasing soil wetness has reduced the cohesion and strength of the soil and its resistance to compression and smearing.

Whilst coarse textured sandy soils are not inherently plastic when wet, they are still prone to compaction when in a wet condition. Hence, handling all soils when wet will have adverse effects on plant root growth and profile permeability, which may be of significance for the intended land use and the provision of services reliant on soil drainage and plant root growth. It may be less so in other circumstances where wet soil profiles, perched water tables and ponding are the reclamation objectives, though drainage control, for example to control flooding, may still be important in these contexts.

In cases of permanently wet soils, such as riverine sites, upland or deep organic soils where there is a persistent high water-table throughout the seasons within the depth of soil to be stripped and/or the soil profile remains too wet, a strategic decision has to be made to be able to proceed with the development of the mineral resource. This may mean alternative and less favourable soil handling practices have to be agreed with the planning authority.

Predicting & Determination of Soil Wetness
There are well established methods to predict and determine soil wetness of undisturbed and restored soil profiles (Reeve, 1994). The challenge has been the prediction of the best time for soil stripping. Models based on soil moisture deficits and field capacity dates for a range of soil textures can provide indicative regional summaries (**Table 4.1**) that can help with planning operations at broad scale but cannot be relied upon in practice for deciding operationally whether to proceed on the ground given the actual variation in weather events from year to year and within years.

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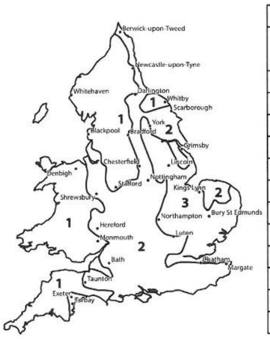

Soil Clay Content	Climatic Zones 1	2	3
Soil Depth <30cm			
<10%	Mid Apr - Early Oct	Late Mar – Early Nov	Late Mar – Early Dec
10 -27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
Soil Depth 30-60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-27%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
>27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
Soil Depth >60cm			
<10%	Late Apr - Early Oct	Mid Apr – Early Nov	Early Apr – Early Dec
10-18%	Late May - Early Oct	Early May – Early Nov	Early Apr – Early Dec
18-27%	Late June – Early Oct	Early June – Early Nov	Late May – Early Dec
>27	Mid July – Mid Sept	Early July – Mid Oct	Late June – Mid Oct

Table 4.1: Indicative on-average months when vegetated mineral soils might be in a sufficiently dry condition according to geographic location, depth of soil and clay content

The timing of most soil handling operations takes place between April and September. Although in western (Zone 1) and central (Zone 2) areas it typically can be a later start in May with an earlier termination in August. Whilst the return to climatically 'excess rainfall' is later in the eastern counties (Zone 3) and can be as late as November/early December, there is a need to maintain transpiring vegetation to keep the soils being handled in a dry as possible condition and to establish new vegetation covers as soon as possible (on replaced soils and storage mounds). Hence, soil handling operations generally need to be completed no later than the end of September (Natural England, 2021), unless appropriate provisions can be assured.

Where data is available, more realistic local and real-time predictions can be made, however, because weather patterns and events differ between and within years, and soils can be vary locally in their condition. Experience has shown that the most practical approach for operations is to inspect the site and soils in question near to/ at the time when soil handling is to take place. Professional soil surveyors can advise on the best time for soil handling (stripping, storage & replacement) and carry out site assessments of soil wetness condition prior to the start of operations.

A Practical Method for Determining Soil Wetness Limitation

During the soil handling season (see Table 4.1 above), prior to the start or recommencement of soil handling soils should be tested to confirm they are in suitably dry condition (**Table 4.2**). The 'testing' during operations can be done by suitably trained site staff and reviewed periodically by the professional soil surveyors.

The method is simply the ability to roll intact threads (3mm diameter) of soil indicating the soils are in a plastic and wet condition (MAFF, 1982; Natural England, 2021). Representative samples are to be taken through the soil profile and across the area to be stripped. It is the best available indicator of soils being too wet to be handled and operations should be delayed until a thread cannot be formed. For coarse textured soils which do not roll into threads, a professional's view as to soil wetness and the risk of compaction may have to be taken.

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Table 4.2: Field Tests for Suitably Dry Soils

Soil tests are to be undertaken in the field. Samples shall be taken from at least five locations in the soil handling area and at each soil horizon to the full depth of the profile to be recovered/replaced. The tests shall include visual examination of the soil and physical assessment of the soil consistency.

i) Examination
- If the soil is wet, films of water are visible on the surface of soil particles or aggregates (e.g. clods or peds) and/or when a clod or ped is squeezed in the hand it readily deforms into a cohesive 'ball' means **no soil handling to take place.**
- If the samples is moist (i.e. there is a sligh dampness when squeezed in the hand) but it does not significantly change colour (darken) on further wetting, and clods break up/crumble readily when squeezed in the hand rather than forming into a ball means **soil handling can take place.**
- If the sample is dry, it looks dry and changes colour (darkens) if water is added, and it is brittle means **soil handling can take place.**

ii) Consistency
First test
Attempt to mould soil sample into a ball by hand:
- Impossible because soil is too dry and hard or too loose and dry means **soil handling can take place.**
- Impossible becuase the soil is too loose and wet means no soil handling to take place.
- Possible - Go to second text.

Second test
Attempt to roll ball into a 3mm diameter thread by hand:
- Impossible because soil crumbles or collapses means soil handling can take place.
- Possible means no soil handling can take place.

N.B.: It is possible to roll most coarse loamy and sandy soils into a thread even when they are wet. For these soils, the Examination Test alone is to be used.

A Rainfall Protocol to Suspend & Restart Soil Handling Operations
Local weather forecasts of possible rainfall events during operations and the occurrence of surface lying water have been used to advise on a day-to-day basis if operations should stop (Natural England, 2021). Single events such as >5mm/day in spring and autumn months, and >10mm/day in the summer have been suggested as more precise triggers for determining soil handling operations (Reeve, 1994). However, in practice the following generic guidelines are often used:

- In light drizzle soil handling may continue for up to four hours unless the soils are already at/near to their moisture limit.
- In light rain soil handling must cease after 15 minutes.
- In heavy rain and intense showers, handling shall cease immediately.

In all of the above it is assumed that soils were in a dry condition. These are only general rules, and it is at the local level decisions to proceed or stop should be based on the actual wetness state of the soils being handled. After the above rain event has ceased, the soil tests in **Table 4.2** above should be applied to determine whether handling may re-start, provided that the ground is free from ponding and ground conditions are safe to do so.There can be extreme instances where soil horizons have become very dry and are difficult to handle resulting in dust and windblown losses. In these conditions the operation should be suspended. The artificial wetting of extremely dry soils is not usually a practice recommended but has been successful in some cases.

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Appendix SMP3

Reduced Scale Landscape Mitigation Plans (for reference only)

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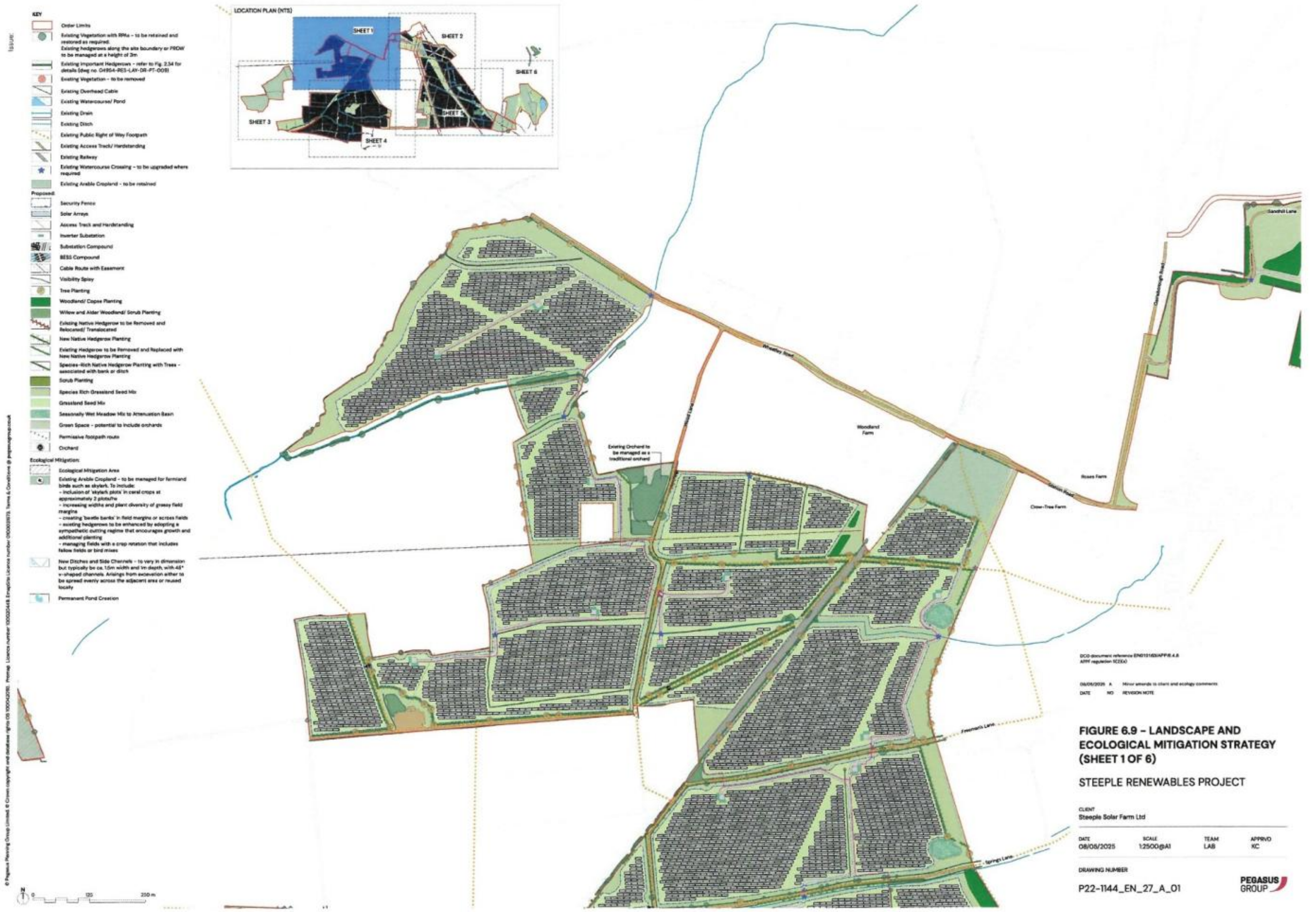

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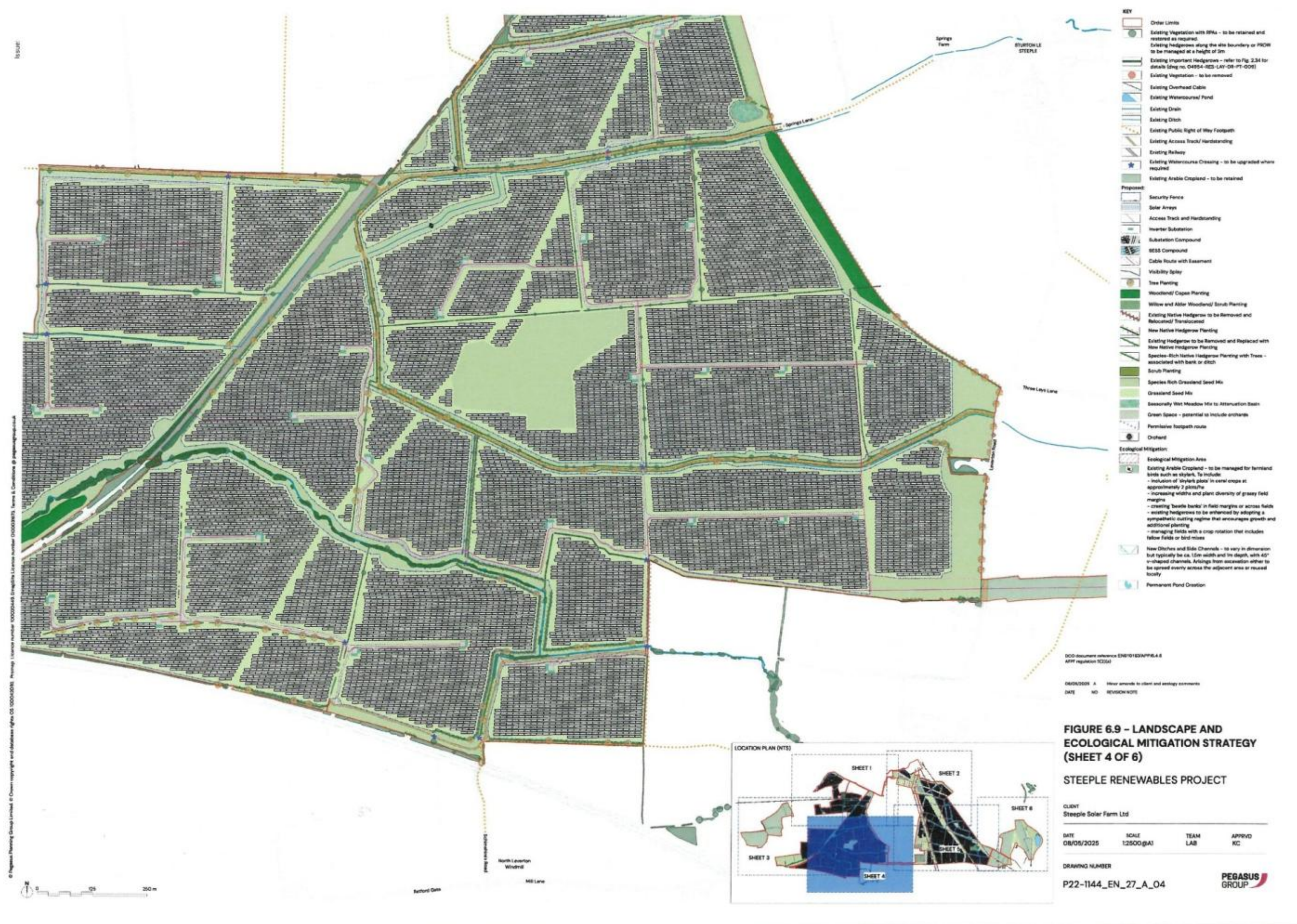

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Appendix SMP5

Building on Soil Sustainability

Cornwall Council and Others

(September 2022)

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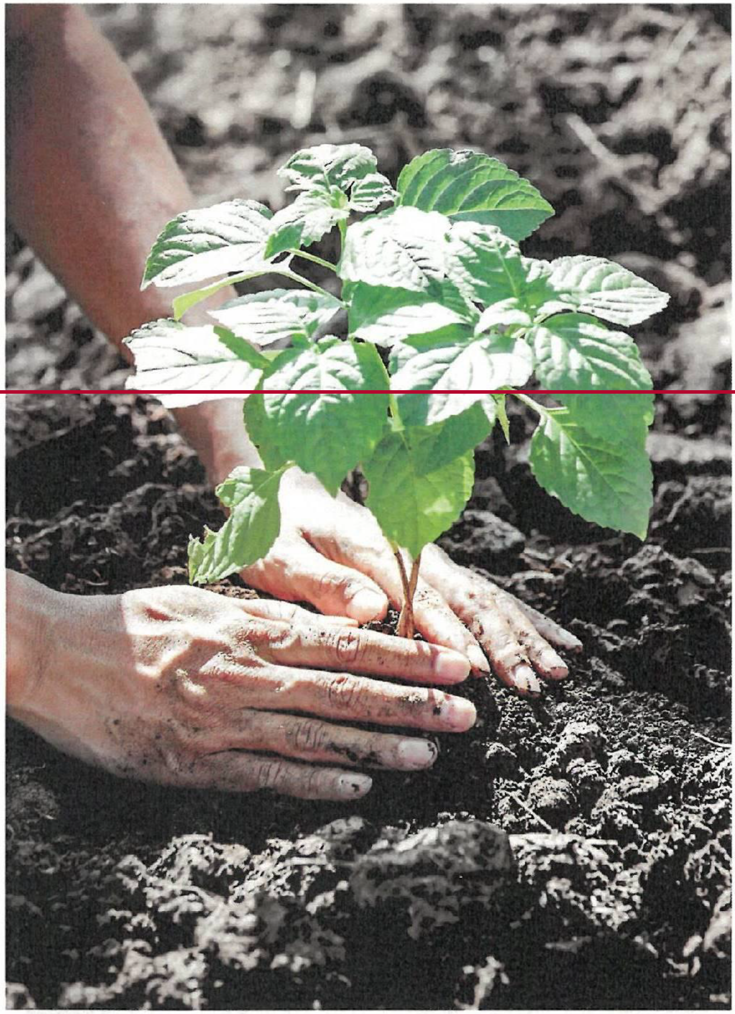


Foreword

This report is short, simple, important, revealing, and ultimately, just simple common sense. Soil is something we don't understand, see, or value. This must change.

I think we all know that soil is a source of nutrients for growing plants and crops. I think we know that healthy soil is important, and that with a bit of added compost, it will deliver real benefits for our roses! But when it's on a construction site it simply becomes unwanted muck to be removed so building work can commence.

You'll be shocked by the horrifying truth of the level of ignorance there is toward soil. Every single teaspoon of soil contains around one billion bacteria; every cubic metre of healthy soil captures between 12kg and 35kg of carbon. In the construction sector we destroy and throw it into landfill at a rate of nearly 30 million tonnes each year, worth nearly £3 billion!

This report lays bare just how important soil is, and how much we undervalue the dirty brown stuff. It highlights the extent of soil waste in construction and the costs of failing to recognise soil as an asset worthy of preservation and use – including the huge carbon release and loss of biodiversity when we disturb or compact it.

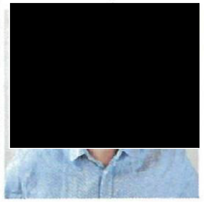
The report starts by highlighting the multiple and complex benefits of soil, its health, and its capacity to harbour mycorrhizal activity essential for life on earth. It highlights how soil is abused in construction, setting out the guidance and legislation that we rarely follow, and concluding just how misunderstood soil is. Finally, it proposes guidance for the key sectors that need to collectively deliver realistic and achievable change.

This is a practical and timely report, which I invite you to read and disseminate. In highlighting the key issues that compromise responsible soil management and setting out how to address them, the report empowers the policies that do exist and provides the imperative for us to unite and advance cross-sector action.

Finally, I urge non-construction audiences to read this report – because we are all contributors. Paving over our garden areas and turning them into outdoor living rooms or car parking bays contributes significantly to both soil loss and associated localised flooding.

We can all do our bit to preserve and enhance soil at home, and this report provides the basis for the construction sector to reverse present practice and see soil for what it is: a fragile, fundamental, and valuable asset for the planet and for us all.

[redacted]scape Institute
(Image © Clare Elliott)



Landscape Institute
Inspiring great places

Executive Summary

Soil provides a multitude of important functions and ecosystem services for society, including climate change mitigation and adaptation opportunities and supporting biodiversity. Yet, at present, soil is routinely undervalued, damaged and disposed of during construction and urban development. It is crucial that we not only stem the damage done to these vital ecosystems, but also actively consider how better planning and management of soil can result in environmentally and socially beneficial development. This report, collaboratively formed in consultation with a wide range of scientists, policy and industry representatives, aims to raise awareness of the importance of soil. It provides a set of guiding principles to help improve how soil is planned for and managed during construction and urban development.

What can you do?

Use these guiding principles for soils in construction:

1 **Plan, design and construct for soil functions** – including soil carbon storage and reducing CO2 emissions, water infiltration and flood mitigation, soil biodiversity, and optimal support for above ground vegetation and trees

2 **Engage** local communities and stakeholders on soil issues and development during the consultation process

3 **Reuse or share soil** – maximise use of soil on site and share excess soil to ensure there is no loss to landfill

4 **Maximise permeability** – minimise soil sealed area and maximise permeable paving to allow water to infiltrate and soil to respire; manage draining on-site using SuDS rather than off-site

5 **Minimise compaction** – plan haul routes and materials storage and designate Soil Protection Zones (SPZs) where soil is protected from traffic, stripping and stockpiling

6 **Stockpile correctly** – minimise the duration of stockpiling and size of stockpiles, ensure this is undertaken according to soil texture, moisture and weather conditions, and ensure topsoil and subsoil are separated and do not become mixed or contaminated

7 **Minimise erosion** – prevent sediment loss by use of vegetation cover, seeding, mulching, silt fences or rolls, or geotextiles, particularly on slopes and stockpiles

8 **Learn through training** – engage with soil professionals to continually develop best practice

Local Authorities – use a standard planning clause for soil that includes consideration of soil functions, requirement of a soil survey and soil management plan, and a method statement for soil prior to commencement of works. Encourage the use of Soil Protection Zones (SPZs) to minimise vehicle compaction in areas for future green spaces and private gardens.

Clients and Developers – include the importance of soils in tender briefs. Bring in a soil specialist early and encourage their collaboration with other disciplines (ecology, landscape architecture, arboriculture and engineering). Undertake a soil survey as part of the EIA and use this to write a soil management plan, going beyond engineering or contamination surveys. Consider levels and earthworks early in the process to maximise cost benefits of reusing soils.

Design Teams – consider soil early on in a collaborative way and design based on soil functions and soil survey information. Maximise synergies across disciplines (landscape architecture, architecture, ecology, engineering) to create better schemes for soils, tree protection, habitats, biodiversity net gain, open spaces and private gardens.

Contractors – include soils in ECSR targets and raise with clients, undertake toolbox talks on good practice for soil management, and undertake soil handling according to methods in the latest Defra guidance: Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.

Introduction

Soil provides a multitude of important functions and ecosystem services for society, including playing an important role in climate regulation and supporting biodiversity – two of the biggest existential threats to society. Yet, soil is routinely undervalued, damaged and disposed of during construction. The rising need for more homes and infrastructure to support growing populations and economies are putting increasing pressure on soils. It is vital that we better manage this non-renewable resource during construction so it can continue to provide its many crucial functions, and help us in our fight against climate change and biodiversity loss.

Currently in the United Kingdom, soils on construction sites fall within a gap in policy and legislation and large amounts of soil is being lost and damaged as a result. The key guidance document, the Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites is not often followed, and good practice is rarely seen. Whilst the total cost of the soil lost and damaged during construction to society is currently unknown, the initial evidence gathered together here indicates that in any terms the cost is large, and likewise, the scale of responsibility and opportunity for improving practice and delivering positive change is substantial.

This report aims to raise awareness of the importance of soil and why it needs to be better managed during construction. It has been developed by a cross-sector team of scientists and practitioners in consultation with a wide range of representatives from planning and construction industries. In developing and sharing this document, we hope to provide a valuable case for taking soils seriously in planning and construction, and a set of high-level useful principles for practice. The report is for anyone working in planning, development, design and construction, and focuses on the UK context. It provides a set of guiding principles to improve how soil is planned for and managed, and there are dedicated sections with specific actions for each industry to support project teams to manage soils more sustainably.

Soils in Planning & Construction Report | 7

Why is soil important?

Soil is a mixture of minerals, organic matter, living animals and micro-organisms, water and gas. It takes hundreds, thousands or even tens of thousands of years for soil to form – this means **it is a non renewable resource** and it is vital we look after it.

Soil provides many important functions and, as such, it is a valuable resource that we rely on for life on Earth. Soil provides nutrients for plants and crops to grow, it holds water and prevents flooding, it's an important store of carbon, is a cornerstone of biodiversity and habitats, and it filters pollution and contaminants from water.

Soil is a living system. **One teaspoon of topsoil contains around one billion bacteria**[1]. In urban parks, soil biodiversity can be very high. For example, in Central Park in New York, the breadth of soil microbes was similar to that found across the world in arctic, tropical and desert soils[2]. These soil micro organisms, along with soil insects and worms, decompose organic matter and recycle it into nutrients. In parks, gardens and new developments, these nutrients **support the growth of trees and green infrastructure**. Soil animals also burrow through the soil and help maintain the soil structure, creating pore spaces where oxygen is stored and water can infiltrate. Water movement and storage in the soil is key to mitigating flooding, so looking after soil helps to prevent waterlogging and reduce flood risk.

Soil also plays an important role in mitigating climate change. It is the largest store of carbon on land, storing nearly twice as much carbon as all the plants and atmosphere combined[3]. **When soil is disturbed, carbon is emitted to the atmosphere as CO2 – this means we need to manage soils carefully so that carbon remains stored in the soil.**

Why does soil in planning and construction matter?

Whilst only a small fraction of our total global soil resource is built upon (around 1% of habitable land supports human settlements and infrastructure[4]) towns and cities are the fastest growing use of land and a major driver of soil change. Whilst this is only a small land area, the scale of soil degradation that currently occurs in this small fraction of land is astounding. We are only just beginning to learn about the scale and costs of soil degradation from construction, but from the initial insights presented in what follows it is clear to see that the current approach to soils in planning and construction presents a major threat to national prosperity.

It is also important to note that these soils also matter because of their proximity to where the majority of people live and work. Soil's ability to function, for example by infiltrating water and reducing flood risk or supporting high quality green spaces, has direct effects on our daily lives. The opportunity is there to better plan and build for soil functioning and create positive benefits for communities and economies being developed.

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[3] Ontl and Schulte (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35).

[4] https://ourworldindata.org/land-use

29.5 million tonnes of soil from construction sites was sent to landfill in 2018: ten times that lost due to soil erosion across the whole of England and Wales

Once compacted, soil structure is damaged and the soil can no longer function – the best approach is to prevent compaction in the first place

Soil loss from construction sites

Topsoils can become mixed with subsoils, and both can be mixed with construction rubble or stones. If these soils no longer meet specifications following mixing or damage during construction, they will be disposed of to landfill. Soils need to be designated as a resource rather than a waste material and should be retained or reused on site as much as possible.

In 2018, **29.5 million tonnes** of soil from construction sites were disposed of in landfill in the UK[5]. Only 0.6 % of this was hazardous, which means a huge amount of this vital resource is being lost during construction. **This is 10 times greater than the 2.9 million tonnes of soil lost due to soil erosion each year in England and Wales**[6]. This soil has value and its loss constitutes a substantial material impact for schemes. The economic value at its most basic level is large. Topsoil has a sale value of between £80 – 100 a tonne bag, and even if only 10% of the soil lost to landfill was usable topsoil, this would equate to approximately £300m per year. However, when the broader functional value of this soil is considered, the cost of soil loss to landfill alone to the UK could be estimated to be in the order of £1.5bn per year.

In addition to soil lost to landfill, **soil erosion on construction sites can be 100 times greater than on agricultural soils** due to the removal of vegetation, disturbance of soil and alteration of topography through stockpiling[7,8].

Take action: Designate soil materials early through a soil survey, soil management plan and a materials management plan using the **CL:AIRE Definition of Waste Code of Practice** (DoW CoP)[9]. *The Routemap for Zero Avoidable Waste in Construction*[10] may also be useful. These actions, when combined with good erosion control, will help prevent the loss of valuable soil from construction sites. This will significantly enhance the sustainability credentials of projects and generate cost benefits if soil reuse can be maximised and earthworks minimised.

Soil compaction

Soil compaction occurs due to trafficking of heavy vehicles, laydown of materials and poor soil stockpiling. This can occur in both topsoils and subsoils on construction sites. When soil is compacted the structure is damaged and the pore spaces are lost, meaning water and oxygen can no longer get into the soil, plants will not grow, and micro-organisms will not survive.

Compaction can reduce water infiltration by 70-99%, and heavily compacted soil starts to resemble the infiltration characteristics of an impervious surface[11]. This leads to poor drainage, waterlogged sites and issues with flooding. Compacted soils also cause problems for plant establishment and growth due to a restricted rooting area, particularly for woody plants and trees[12]. Restoration of soil structure is very difficult, takes many years, and is dependent on soil texture and the damage caused[13]. Remediation of compacted soil adds costs and time to a project and will not immediately return the soil to its former state. Recovery will only occur with time and a lack of disturbance.

Take action: The best approach is to prevent soil compaction in the first place rather than mitigate afterwards. Soils that are protected from vehicle traffic and are stockpiled appropriately will be less likely to suffer from compaction and will continue to function as healthy soils.

5 Defra (2021) ENV23 - UK statistics on waste data

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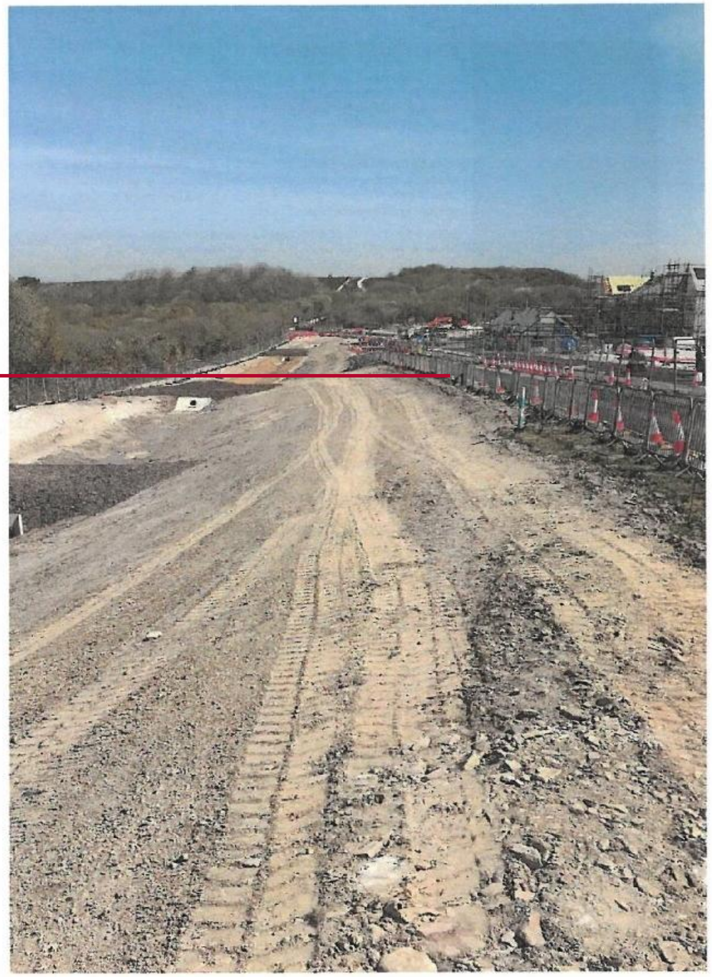

Soil biodiversity is harmed by compaction from stockpiling or heavy vehicle traffic because it leads to a lack of oxygen

Soil carbon storage

Typical construction soil management, where topsoil is stockpiled and then replaced onto compacted subsoil, leads to losses of carbon as CO2 emissions from the soil[14]. Earthworks disrupt soil aggregates, and the carbon stored in these aggregates and attached to soil minerals becomes more accessible to soil micro-organisms[14,15,16]. This makes the carbon more vulnerable to decomposition and it can then be lost as CO2.

Soil carbon stocks vary greatly depending on soil type, texture, climate, land use and management, and vegetation cover. In the UK, the top 1 metre of soil has been estimated to contain an average of 18 kg carbon per m2 soil (or 180 tonnes per hectare); in semi-natural habitats this is 32 kg per m2 soil, in woodlands it is 25 kg per m2 soil, and in arable land it is 12 kg m2 soil[17].

In 2013, **soil carbon losses due to development were estimated at 6.1 million tonnes of CO2**; this is greater than losses of greenhouse gases from other big emitting industries such as concrete production (6 million tonnes CO2 equivalent) and the chemical industry (5.2 million tonnes CO2 equivalent)[18].

Take action: To keep carbon in the soil there needs to be minimal disturbance, and ideally 'Soil Protection Zones' (SPZs) should be left completely undisturbed to maintain soil carbon storage. These SPZs could be combined with tree root protection areas and areas set aside for biodiversity net gain, where appropriate. Where movement and stockpiling is necessary, this should be done appropriately for the soil texture, water content and weather conditions.

Soil biodiversity

Soil animals and micro-organisms are affected by soil stockpiling, compaction, damage to soil structure and contamination. Most harm to soil biodiversity occurs due to the creation of anaerobic conditions, where soil oxygen is depleted due to compaction during stockpiling or vehicle movement. Anaerobic conditions can develop soon after stockpiling and persist at depths below 1 metre in large stockpiles, though smaller stockpiles can also become anaerobic over time[19]. Anaerobic stockpiles can lead to a reduction in mycorrhizal fungi and earthworm populations[20], and a reduction in the diversity of mycorrhizal species[21]. Compaction can also alter the community structure of soil invertebrates[22].

Take action: To maintain healthy soil life and biodiversity, reduce disturbances to soil structure and chemistry (i.e. avoid physical disturbance and contamination), and ensure that soil is kept oxygenated and is not compacted. This will allow soil insects, worms, bacteria and fungi to continue their ecological processes, helping to recycle nutrients, support vegetation growth, and store carbon in the soil.

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Soil sealing

Urban development seals the soil with impermeable surfaces such as road asphalt, paving and concrete. In England, an average of 15,800 hectares (158 square km) of undeveloped land was developed each year between 2013-2018[23]. This is a large increase from an average of 4,500 hectares per year in the 2000s[24], with a percentage increase of over 250 %. As soils are increasingly sealed over there is less water and gas exchange between the soil and atmosphere, and this prevents the soil providing its many functions[25].

Sealing also leads to increased surface run-off, risk of flooding, and pollution to surface water from roads. In urban areas, the proportion of front gardens in England that are paved over increased from 28% in 2001 to 48% in 2011[26], further exacerbating the problem of sealed surfaces in urban areas and putting pressure on urban drainage systems.

Take action: To reduce surface run-off and waterlogging on sites, green spaces and permeable paving should be maximised to enable water to infiltrate. SuDS and water management should be dealt with on-site.

Soil sealing increased from 4,500 hectares per year in the 2000s to 15,800 hectares per year between 2013-2018

Soil contamination

Contamination in soil can occur during construction through the misuse and spillage of materials or chemicals on site. Notable examples of this are the pollution of soil with hydrocarbons during storage of fuel, and asbestos fibres through the demolition or reuse of rubble materials. Historically, waste materials and rubble were used as fill and there may be legacy contamination in some urban soils and construction sites. Once soil is contaminated or earthworks expose older contaminated soils, rainfall and groundwater can move the contaminated soils and sediments across the site and to adjacent areas spreading the problem further.

Soil that is considered to be lightly contaminated may be reused for some purposes if it does not pose a risk. However, the uncertainty of environmental risk related to soil reuse can lead to resistance, and often new materials are sought as a preference[27].

Take action: Ensure all risk assessments and method statements are adhered to for materials and chemicals on site to prevent spillage and contamination. Be aware of the location of materials laydown and rubble storage in relation to soil stockpiling, water courses and the future landscape design to minimise contamination to both soil and water. Undertake toolbox talks on the importance of soils, good soil management techniques and prevention of contamination.

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Current state of UK policy and guidance or soils in construction

There are a number of relevant existing policies, reports and guidance documents that address soils in construction, as summarised in Table 1. These policies and documents contain a great deal of useful advice. However, the current state of soils in planning and construction is evidence that, to date, these have not gone far enough or have not been effectively implemented.

Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites

The Defra Code of Practice (2009) sets out the importance of soil functions and the issues that arise through poor management of soils on construction sites. The key messages in the Code of Practice are the need for a **soil resource survey** which can feed into a materials management plan, and a **soil resource plan**, which sets out how soil will be stripped, hauled and stockpiled.

The guidance sets out methods for soil handling including topsoil and subsoil stripping, stockpiling, reinstatement, and remediation of compaction. **This guidance is due to be updated in 2022/2023 – the most up-to-date version of the guidance should be used when making soil management plans and construction method statements.**

Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction – British Society of Soil Science (2022)

This BSSS (2022) guidance note sets out recommendations for **soil resource surveys** and **soil management plans**. It states that a soil resource survey should be conducted by a professional soil scientist with the appropriate competencies as set out in BSSS *Working with Soil Professional Competency in Soil Science* Documents. It also highlights some key recommendations around surface flooding, planting in relation to soil conditions, and soil biodiversity.

British Standards

The following British Standards are relevant when working with soils in construction:

- **BS 3882:2015 Specification for topsoil** – this specifies requirements for natural or manufactured topsoil brought in to a site rather than topsoils remaining in situ.
- **BS 5837:2012 Trees in relation to design, demolition and construction** – provides recommendations relating to tree care and Root Protection Areas. It recommends that there should no excavation, no changes of soil level and no compaction within the root protection area.
- **BS 8683:2021 Process for designing and implementing Biodiversity Net Gain** – sets out a process for implementing biodiversity net gain to ensure that development and land management leaves biodiversity in a measurably better state than before.
- **PAS 100:2018 Specification for composted materials** – provides a compost quality standard for the organics recycling sector.

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National Planning Policy

The National Planning Policy Framework (NPPF) for England (DLUHC, 2021) recognises the need for local planning policies that relate to the protection and enhancement of soils. Through the NPPF, mitigation and remediation of despoiled, degraded, contaminated and unstable land, where appropriate, is recommended. In relation to green field sites, the NPPF advocates that the best agricultural land is preserved from development and poorer quality agricultural land be used preferentially.

Soils in Environmental Impact Assessment

Depending on the type of development and statutory importance of the site, soils may be considered in Environmental Impact Assessment (EIA). The recent IEMA guidance: A New Perspective on Land and Soil in Environmental Impact Assessment (2022), provides a comprehensive methodology to assess the effects of developments on soil functions. Soil specialists in EIA teams should use it to assess the significance of development impacts on selected soil properties and the consequent changes in soil functions.

Local Planning Guidance

Soil in local planning is routinely dealt with through Agricultural Land Classification (ALC), however ALC data alone is not sufficient for assessment of a development site, as confirmed by Natural England[28]. Specific soil policies in local plan documents are not common, though two examples of local soil guidance and policy follow.

Worcestershire County Council set out the importance of soil and the implications of poor management during development in a technical research paper[29]. West Lothian Council provide a more recent example of local policy and guidance adopted in 2021. They set out a policy requirement for developers to provide a soil sustainability plan and to use their planning guidance document: *Soil Management & After Use of Soils on Development Sites*[30], which will be applied when making planning decisions. The aim of the guidance is to reduce flooding, water logging and failed landscaping due to poor soil handling.

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Table 1 – UK Policy and Guidance

Strategies, Plans & Legislation

Document Type	Date	How is soil considered?
Safeguarding our Soils: A strategy for England (Defra)	2009	The vision of the strategy is that by 2030 all England's soils will be managed sustainably and degradation threats tackled successfully. This includes soils in urban areas being valued during development and construction practices that ensure that vital soil functions are maintained.
25 Year Plan to Improve the Environment (Defra)	2018	The plan identifies actions to protect and improve soils with a focus on agricultural soils. The risks to soils from construction and subsequent loss of soil functions are not addressed in the plan.
The Environment Act (UK Parliament)	2021	The Act does not set specific soil targets. However, a Soil Health Action Plan for England (SHAPE) is expected to be produced which will provide soil targets.
The Scottish Soil Framework	2009	The aim of the Framework is to promote the sustainable management and protection of soils in relation to the economic, social and environmental needs of Scotland. It does this by identifying 13 soil outcomes.
EU Soil Strategy for 2030: Reaping the benefits of healthy soils for people, food, nature and climate (European Commission)	2021	The strategy provides a framework to protect and restore soils. It sets out a vision and objectives to achieve healthy soils by 2050, with actions by 2030; and announces a Soil Health Law to ensure a high level of protection.

National Planning Policy

Document Type	Date	How is soil considered?
National Planning Policy Framework (NPPF)	Updated 2021	The NPPF focuses on valued landscapes and sites of biodiversity, geological value or soils with a statutory status or identified quality. Soils are not valued or given statutory status unless they are peat soils or considered through Agricultural Land Classification (ALC).

National Planning Guidance

Document Type	Date	How is soil considered?
Code of practice for the sustainable use of soils on construction sites (Defra)	2009 – update in 2022	This voluntary code sets out the importance of soil functions, gives guidance on best practice, and highlights issues that arise through poor management of soils on construction sites. Key messages are the need for a soil resource survey which can feed into a materials management plan, and a soil resource plan, which sets out how soil will be stripped, hauled and stockpiled.
Planning Practice Guidance for the Natural Environment	2019	This guidance suggests planning can safeguard soils by referring to the Defra Code of practice.
Guide to assessing development proposals on agricultural land (Natural England)	Updated 2021	This sets out how the NPPF and 25 Year Environment Plan aim to protect agricultural land and soils, with a focus on using ALC to inform planning decisions.
A New Perspective on Land and Soil in Environmental Impact Assessment (IEMA)	2022	This provides guidance for soils and land in Environmental Impact Assessment. It provides an approach to assess the impacts of a development proposal on soil properties and soil functions and sets out how soils should be considered more substantially in EIA.
SEPA Position Statement on Planning and Soils	/	Sets out SEPA's role in relation to land use planning and the Scottish Soil Framework.

Local Planning Guidance

Document Type	Date	How is soil considered?
Technical research paper: Planning for Soils in Worcestershire (Worcestershire County Council)	2011	Highlights the importance of soil and the implications of not managing it well through development.
Planning Guidance: Soil Management & After Use of Soils on Development Sites (West Lothian Council)	2021	The local development plan sets out a policy requirement for developments to have a Soil Sustainability Plan and to use this planning guidance. The guidance aims to reduce flooding on development sites and failed landscaping due to unsuitable soil handling.

Other Resources

Document Type	Date	How is soil considered?
The Definition of Waste: Development Industry Code of Practice (CL:AIRE)	2011	This voluntary code describes good practice for assessing whether excavated materials are classified as waste or not, and determine whether treated material can be re-used.
Policy Position Statement: Protecting and Enhancing Soils (CIWEM)	2019	Highlights the multi-functional and non-renewable nature of soils. It calls for actions to reflect this, including increased legislation to protect soils, implementation of the 25 Year Environment Plan and improvements to the evidence base for policy decisions about soils.
Position Statement: Sustainable Urban Soils Health Initiative (SUSHI) (Sustainable Soils Alliance)	2020	The position statement sets out where policy and guidance is lacking, where current issues are arising, and makes the case for an update to the Defra Code of practice.
Guidance Note: Benefitting from soil management in development and construction (British Society of Soil Science)	2022	This note makes recommendations based on soil resource surveys and soil management plans. It also highlights key recommendations around surface flooding, planting in relation to soil conditions, and soil biodiversity.
Soils and Stones Report (Society for the Environment)	2021	This report recognises soil as a valuable resource and material, and aims to prevent it ending up in landfill by promoting its re-use in construction projects.

Three barriers to improving integration of soil sustainability into planning and construction

Consultation with policy, industry and academic experts presented three major barriers to better treatment of soils in planning and construction.

1 Soil is not understood or valued – earthworks are seen as something to be completed to get to the 'real work', and soil is seen as 'muck' to be removed. Project teams (including clients, designers and contractors) are often unaware of the importance of soils and how to design with soils in mind. Soil specialists are often brought into a project too late, leaving little opportunity to make useful plans for soil management and prevent soil damage.

2 Soil data availability – site-scale soil data is not always available and desk-based studies or ALC data is not sufficient to understand the soil resource, in particular for soil carbon storage. A full soil survey should always be done for EIA or during early stages of the project and the soil data shared throughout the design and construction stages.

3 Time and space constraints – project timelines can mean that topsoil stripping and stockpiling go ahead even in poor weather. Once the soil is damaged in this way it cannot be restored easily. Space limitations can also lead to poor stockpiling, where topsoils and subsoils become mixed. This means soil will be replaced incorrectly and will cause damage to the soil ecosystem, biodiversity and soil structure.

What would help?

Think about soil early on – this applies to all those involved in a project: developers, EIA consultants, masterplanners, designers and contractors.

Understand the soil resource on site – a soil survey (see appendix 1) will tell you what type of soil you have and help you understand the functions it provides. This must go beyond geotechnical or contamination properties and should include soil texture, water holding, nutrients and carbon storage capabilities.

Design for soil retention and reuse – consider levels and construction methods from the outset – aim to minimise cut and fill, locate road access on areas of lower soil quality, prioritise greater topsoil depth in gardens and open spaces, work with the existing soils and landscape.

Write a soil management plan (see appendix 2) – use the soil survey to plan how best to use the soil resource, including how and when to move, store, and respread the soil, and how to avoid contamination. Proper planning and management of the soil on site means it can be reused, reducing the need to buy in new topsoil and leading to cost savings. Functioning soil at project completion with minimum compaction or disposal should be the outcome.

Soil Protection Zones (SPZs) – fence off areas in a similar way to tree Root Protection Areas (as per BS 5837) to prevent disruption to soil in those areas – this will enable soil to continue to function and retain soil biodiversity, soil carbon storage and water storage capability in those areas.

Include soil in accreditation schemes – soil, its biodiversity, and carbon storage properties should be taken account of in sustainability, nature and carbon accreditation schemes and targets.

Education and training – this would be useful for contractors moving and storing soil on site, planners making planning decisions, and landscape architects writing soil specifications.

Integrate soil with existing regulations – biodiversity net gain could provide an opportunity to protect soil through protection of older trees and habitats.

Monitoring of soil at completion – the aim is to have a functioning soil following project completion, with minimum compaction and good soil structure which will benefit water infiltration, soil biodiversity, plant growth and carbon sequestration. Monitoring the soil after it is respread or topsoil is brought in, and subsequent compaction is avoided, would ensure soil is able to provide these functions.

Guiding Principles for Soils in Planning & Construction

1. Plan, design and construct for soil functions – including soil carbon storage and reducing CO_2 emissions, water infiltration and flood mitigation, soil biodiversity, and optimal support for above ground vegetation and trees
2. Engage local communities and stakeholders on soil issues and development during the consultation process
3. Reuse or share soil – maximise use of soil on site and share excess soil to ensure there is no loss to landfill
4. Maximise permeability – minimise soil sealed area and maximise permeable paving to allow water to infiltrate and soil to respire; manage draining on-site using SuDS rather than off-site
5. Minimise compaction – plan haul routes and materials storage and designate Soil Protection Zones (SPZs) where soil is protected from traffic, stripping and stockpiling
6. Stockpile correctly – minimise the duration of stockpiling and size of stockpiles, ensure this is undertaken according to soil texture, moisture and weather conditions, and ensure topsoil and subsoil are separated and do not become mixed or contaminated
7. Minimise erosion – and prevent sediment loss by use of vegetation cover, seeding, mulching, silt fences or rolls, or geotextiles, particularly on slopes and stockpiles
8. Learn through training – engage with soil professionals to continually develop best practice

What you can do

Local Authorities

- Include a specific soil policy in new local development plan documents – highlight the importance of soil functions and ensure soil is valued and protected in construction.
- Use a standard planning condition for soil that includes – consideration of soil functions, requirement of a soil survey and soil management plan, and a method statement for soil prior to commencement of works. It should also require evidence of good practice for soil management in construction, and monitoring of the soil following project completion. See West Lothian Council planning guidance for an example (see resources below).
- The construction method statement should include soil as a resource – ensure the order of work and project timings take account of soil management and that measures will be taken to minimise damage. Methods should be informed by the latest Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites
- Use Soil Protection Zones (SPZs) to minimise vehicle compaction in areas for future green spaces and private gardens
- Ask for details on how a scheme has considered and optimised synergies for soils, trees and biodiversity
- Request sustainable drainage (SuDS) and that permeable paving is maximised to enable soil to function, allowing water to infiltrate and enable flood mitigation.

What to look for in a soil survey

- Ensure that site-based data is included that is based on soil sampling from the site and laboratory analysis.
- Look at the soil texture, water content, pH, carbon content and any contamination – this will tell you about the soil's permeability, biology and chemistry and will give an indication of its functioning (see Appendix 1: What should a soil survey contain?)
- Look for evidence of liaison with the project ecologist, landscape architect and arboricultural consultant to ensure the soil survey provides data they require to inform their work.

What to look for in the soil management plan

- The soil management plan should be based on information in the soil survey.
- It should set out plans for: soil protection, soil handling, soil use and any soil remediation needed (see Appendix 2: What should a soil management plan contain?)

Resources:

- Example of planning guidance for soils in construction – West Lothian Council – Planning Guidance: Soil Management & After Use of Soils on Development Sites (adopted 2021).
- Defra – Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009) – due to be updated

Clients and Developers

- Include the importance of soil functions in tender briefs to consultants and contractors
- Bring a soil specialist in early before the scheme is set and ensure their liaison with the ecologist, arboricultural consultant and landscape architect at early project stages to achieve collaborative working and maximising synergies
- Consider levels and earthworks quantities early in the process and involve Quantity Surveyors to maximise cost benefits of retaining and re-using soils, feeding into the overall project viability analysis
- Undertake a soil survey for EIA and use the IEMA guidance for land and soil in EIA. Use the soil survey to write a soil management plan and construction method statement, going beyond engineering or contamination surveys (see Appendix 1: What should a soil survey contain? And Appendix 2: What should a soil management plan contain?).
- Use the latest Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites to inform the soil management plan and appropriate method for soil stockpiling.
- Make EIA soil data available to all consultants and contractors for all project stages
- Provide the design team with levels data from the outset and ask them to design to minimize cut and fill
- Write a materials management plan before work starts on site – retain the valuable soil resource and reuse it appropriately
- Plan for the use of excess soils across the site share with another site if it can't be reused
- Consider carbon calculations for projects that take account of soil carbon, and use such data to feed into project viability and sustainability credentials. Monitoring of soils following project completion can provide evidence of good soil management and the maintenance of soil carbon stores.
- Plan for rubble management – ensure it is not disposed of in gardens and green space areas
- Promote the understanding and importance of soil to contractors e.g. through training, and demand careful management of soil from contractors on site.

Benefits to clients and developers

- Shows you are taking environmental and climate change issues seriously – this could reduce planning uncertainty
- High standard private gardens and green spaces are a selling point for future home owners
- Involving a soil specialist early will help you get it right first time – this leads to reduced project time
- Careful management of existing soil resources will lead to less landfill tax and smaller topsoil import costs
- Lower transport and fuel costs – less need to move soil to and from the site
- Fewer complaints and claims, for example, from home owners when private garden soils fail, are waterlogged, the structure is damaged, large amounts of rubble is found etc.
- Help with ECSR targets

Resources

- Defra – Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009) – due to be updated
- CL:AIRE – DoW CoP – The Definition of Waste: Development Industry Code of Practice (2011)
- IEMA guidance – A New Perspective on Land and Soil in Environmental Impact Assessment (2022)
- Green Construction Board & Construction Leadership Council – The Routemap for Zero Avoidable Waste in Construction (2021)
- British Society of Soil Science – Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction (2022)
- Farm Carbon Toolkit – Monitoring Soil Carbon: a Practical Field, Farm and Lab Guide (2021) – though this is based on agricultural soil it provides a useful resource to understand monitoring for soil carbon.

Design Teams

- Consider soil early on in a collaborative way – design based on soil functions and soil survey information.
- Key disciplines to collaborate and advise on soil functions: soil specialist, ecology, arboriculture and landscape architecture.
- Key disciplines to design with soil in mind: landscape architects, architects and engineers. The lead designer must coordinate collaboration.
- Maximise synergies to create better schemes for soils, tree protection, habitats, biodiversity net gain, open spaces and private gardens
- Use these collaborations to inform the masterplan – plan to reuse the existing soil resource
- Design with levels in mind from the outset – explore options to minimise cut and fill, consider construction solutions, such as foundations, early to inform design solutions, ensure greater topsoil depths in private gardens and green spaces
- Maximise permeable paving in the design
- Soil specification – provide sufficient detail to allow soil to be stockpiled carefully, reused appropriately, and soil condition to be able to function to support the design.

Benefits to Design Teams

- Better and more sustainable masterplans that take advantage of the existing soil resource
- Show greater value for money to clients
- Greater sustainability credentials of schemes
- ECSR benefits

Resources

- Landscape Institute – Technical Information Note: Soils and Soil-forming Material (2017)
- Landscape Institute – Technical Information Note: Carbon and Landscapes (2018)
- Defra – Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009) – due to be updated
- British Society of Soil Science – Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction (2022)

Contractors

- Include soils in ECSR targets and raise with clients
- Undertake toolbox talks on the importance of soils and good practice for soil management
- Work to the soil management plan, construction method statement and planning recommendations
- Refer to the latest Defra Construction Code of Practice for the Sustainable Use of Soils on Construction Sites to inform methods for soil stockpiling
- Keep topsoil and subsoil stockpiles separate and label clearly
- Undertake stockpiling appropriately according to soil texture and weather conditions
- Consider soil compaction when planning haul routes and materials laydown – minimise subsoil compaction rather than remediating afterwards
- Stick to planned haul routes, and minimise soil compaction or damage in Root Protection Areas or Soil Protection Zones
- Work to rubble management plans – ensure it is not disposed of in private garden and green space areas.

Benefits to contractors

- Good soil management from the start will enable better functioning soils at completion – less risk, and less cost for remediation or replacement afterwards
- Help with ECSR targets

Resources

- Defra – Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009) – due to be updated
- CL:AIRE – DoW CoP – The Definition of Waste: Development Industry Code of Practice (2011)

Soils in Planning and Construction Task Force

Who we are

The Soils in Planning and Construction Task Force is made up of professionals from across soil science, local authorities, urban design and landscape architecture. The task force have come together to drive better management of soils through the planning and construction stages of development projects. Their aim is to protect and improve our vital soil resources, enabling soils in the built environment to function and provide crucial ecosystem services that support thriving places to live and work.

[redacted]

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[redacted]

www.lancaster.ac.uk/soilstaskforce

Network of Experts

A network of professionals and experts in planning, development, design and construction were consulted to inform and guide this document. The Task Force wishes to thank all those that provided expert advice and feedback in the development of this report.

[redacted]

Glossary

- **Organic matter** – is the organic material that comes from dead plant matter, including roots, leaves and stems, and dead organisms in the soil that all contribute organic compounds to the soil as they decompose.
- **Permeability** – is a measure of the ability of soil to allow water to infiltrate and pass through it.
- **Soil biology** – this encompasses all the insects, worms, fungi, bacteria and all micro-organisms that live in the soil and are important for key soil processes.
- **Soil carbon** – this is the carbon stored in soils globally. It includes soil organic matter and inorganic carbon as carbonate minerals.
- **Soil functions** – these are the important processes and services that soil provides, for example, the ability of the soil to hold water, provide nutrients to plants, and to enable food crops to grow.
- **Soil organic carbon** – this is the organic carbon that is stored in soils and originates from the ecological processes in soils, through plants, roots and organisms.
- **Soil processes** – this include all the biological, chemical and physical processes that occur in soil, for example, nutrient cycling, water cycling, organic matter storage and carbon sequestration.
- **Soil sealing** – this is the covering of soil with impermeable surfaces in urban areas, such as asphalt, concrete, stone or paving.
- **Soil structure** – the arrangement of pore spaces and solids within soil.

Photography courtesy of **Birgit Hontzsch** and **John Quinton**

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Appendix 1:
What should a soil survey contain?

A soil survey provides information about soil properties and functions beyond the information given in a geotechnical survey, contamination survey or agricultural land classification. It enables an understanding of how the soil functions, including the texture and structure, nutrient availability, water holding capacity, ability to store carbon and support vegetation growth.

The soil survey should

- Be based on representative site sampling and laboratory analysis
- Include a description of the soil types on site, their thickness and properties including soil texture, pH, water content, nutrient content, carbon content / stock, and any heavy metal or contamination issues.
- Include a map displaying areas of different soil types
- Include a report that describes the different soils on site and their suitability for future uses in the designed scheme.

What the soil survey data tells you

- **Soil texture and water content** – this will tell you about the soil's permeability, clay / sand content and ability for water to infiltrate and be stored in the soil.
- **Soil thickness** – gives an indication of the volume of soil resource available and will determine how earthworks will be undertaken.
- **pH** – this will tell you about the chemistry of the soil which controls nutrient availability, biological processes such as micro-organism and fungi activity, and the behaviour of contaminants or heavy metals.
- **Nutrient content** – provides information on how fertile the soil is. This should be used to determine the type of habitat and planting scheme that will be used in the design of the scheme.
- **Carbon content / carbon stock** – this gives an indication of the soil carbon storage of each type of soil at the time of the survey. It is often referred to as soil organic carbon (SOC). It should be used to consider which areas could be protected from soil handling and compaction to maintain the carbon in the soil and prevent its loss to the atmosphere. It could also be used to plan for planting and soil management to increase soil carbon storage.
- **Heavy metals and contamination** – this information will highlight risks from the soil which will need to remediated.

The British Society of Soil Science document: *Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction* (BSSS, 2022) makes similar recommendations for soil surveys and soil management plans. It states that a survey should be conducted by a professional soil scientist with the appropriate competencies as set out in BSSS *Working with Soil Professional Competency in Soil Science* Documents. See the guidance note for more details.

Appendix 2:
What should a soil management plan contain?

A soil management plan sets out how the soil will be planned for, handled, and managed so that the soil is able to function on completion of the project. The soil management plan will use data from the soil survey to inform plans for the site. It should include plans for:

Soil Protection

Plans for haul routes and laydown areas to minimise the extent of soil compaction across the site and ensure clear signage to prevent additional damage and compaction outside of these areas

The potential use of Soil Protection Zones (SPZs) where soil will be fenced off and protected from all disturbance or compaction from vehicle traffic. These will be clearly signposted.

Soil handling

- The location, size and duration of stockpiles that are appropriate for soil texture, moisture and weather conditions
- Methods of stripping and stockpiling
- The separation of stockpiles for topsoil and subsoils and clear labelling
- The prevention of mixing of soils with rubble or waste materials
- Haul routes and materials laydown to minimise soil compaction

Soil use

- How soil will be reused across the site, the volume that will be reused, and plans for any excess soil.
- Soil reinstatement that is appropriate in depth, nutrients and texture for future planting and green spaces, private gardens, and SuDs features.

Soil remediation

- How any damaged or compacted soil will be remediated.
- The plan should also state who will be responsible for supervising soil management on site.

Soil management plans should always refer to the latest Defra *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites*. This provides detailed soil handling guidance for soil stripping, stockpiling, reinstatement and remediation of compaction. See more in the Defra Code of Practice.

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Appendix SMP6

Planning Aftercare and Advice – Natural England (April 2022)

GOV.UK

NATURAL ENGLAND

Guidance

Planning and aftercare advice for reclaiming land to agricultural use

Updated 19 April 2022

Applies to England

Contents

This publication is available at https://www.gov.uk/government/publications/reclaim-minerals-extraction-and-landfill-sites-to-agriculture/planning-and-aftercare-advice-for-reclaiming-land-to-agricultural-use

1. Plan to reclaim land to agriculture

Natural England is a statutory consultee (https://www.gov.uk/guidance/consultation-and-pre-decision-matters#Statutory-consultees) in the planning process. Planners should use this advice to make sure developers understand what's needed to reclaim sites to agriculture.

It applies to planning and aftercare of:

- mineral extraction sites
- landfill and land raising sites (landforms created by above ground waste) - referred to as 'landfilling' in this guide

It provides advice to planners on:

- what to check for in planning applications
- how to manage development proposals

Refer to sections 4 and 5 in the Guide to reclaiming mineral extraction and landfill sites to agriculture (https://www.gov.uk/government/publications/reclaim-minerals-extraction-and-landfill-sites-to-agriculture) to make sure the proposed afteruse is appropriate.

2. What to check for in planning applications

You should check that development proposals for mineral extraction and landfill include considerations to reclaim land to agricultural use, where it's appropriate. Read this section for more information.

2.1 Restoration plan

Development proposals should have a restoration plan and statement that includes:

- an assessment of agricultural land and soil resource of the site before work started, refer to section 5 in the Guide to assessing development proposals on agricultural land (https://www.gov.uk/government/publications/agricultural-land-assess-proposals-for-development)
- how a developer intends to restore the site to agricultural use after mineral extraction or landfilling has finished

- an aftercare programme (usually for 5 years) to reach a satisfactory standard of agricultural afteruse from activities such as, cultivating, reseeding, draining or irrigating, applying fertiliser, or cutting and grazing the site

Maps to show the intended:

- landform after restoration showing contours on the map at appropriate intervals
- surface features, such as ditches, field boundaries and tracks
- habitat and water features

2.2 Agricultural land classification (ALC) report

Read section 4 in the Guide to assessing development proposals on agricultural land (https://www.gov.uk/government/publications/agricultural-land-assess-proposals-for-development).

2.3 Soil resources report

A soil resources report can use the same soil data as an ALC survey. The report should show how to deal with each soil type during the works and through restoration. It should include:

- soil profile and depth (usually to 1.2m)
- soil texture and stoniness
- soil structure
- volumes of soil types and suitability for reuse
- soil drainage status (a measure of its wetness)
- available water capacity (a measure of how dry and arid it is - its 'droughtiness')
- nutrient status, organic matter content, and pH (the acidity or alkalinity of the soil)
- chemical characteristics, such as salinity or potential contaminants (if appropriate)

Include soil data in the restoration plan to show:

- the intended stripping depths and volumes of each soil type
- the intended standard of restoration you expect to achieve

- how to replace lost soil that was part of the extracted mineral, such as stony or sandy subsoils, clay or brick earth
- how to safeguard soil with ecological significance, such as peats or woodland soil containing a seed bank and low nutrient soils

An experienced soil specialist should prepare these reports, such as a member of the British Society of Soil Science.

The reports should show soil and land quality comparisons at the beginning and end of workings so you can be sure restoration and aftercare provision will meet the required standard for agricultural use.

2.4 Soil handling plan

A soil handling plan should show how the developer proposes to:

- replace soil (for example its intended location, depth, composition and contour)
- handle soil to avoid mixing and contamination
- move and store soil to avoid compaction
- avoid double handling (to minimise soil losses, mixing and structural damage)
- keep different types of soil separate from each other when moved
- avoid compacting unstripped and partly-stripped soil especially on large-scale phased developments and show haulages routes
- avoid compaction
- remedy compaction (for example by ploughing into the subsoil or loosening hard layers of soil using agricultural machinery)

The plan should:

- show the intended storage location
- specify the equipment and technique needed for each soil type to strip, store and replace it (such as loose tipping from a truck with soil spreading using a 360 degree excavator) - read the Institute of Quarrying Good Practice Guide for Handling Soils in Mineral Workings (https://www.quarrying.org/soils-guidance)

Moving soil

Operators should use a soil specialist to advise on the methods for using and handling different soils and the best time to strip soil and move it to limit damage.

The proposals should include moving soil in the drier months from April to September. The drier season can be longer in the east and south of England.

Test soil wetness

Soil tests should include a visual examination of the soil and a physical assessment of the soil consistency. Refer to the Institute of Quarrying Good Practice Guide for Handling Soils in Mineral Workings Part One Table 4.2 (https://www.quarrying.org/soils-guidance) (this document may not be accessible to assistive technologies).

A soil moisture meter can test the wetness of soil samples. 80% of samples must meet the lower plastic limit for each soil type - that is the point at which the soil changes from pliable to crumbly. The lower plastic limit should be known for each soil type before using the moisture meter.

When not to move soil

Operators shouldn't move soil if:

- the soil wetness tests or moisture meter indicate the soil is too wet
- it's raining or just been raining
- there's heavy rain forecast
- there are puddles on the soil surface
- the ground is frozen or covered by snow
- from October to March, when it's wetter, unless you get permission from the mineral planning authority (MPA) - refer to section 1.2 in the Guide to reclaiming mineral extraction and landfill sites to agriculture (https://www.gov.uk/government/publications/reclaim-minerals-extraction-and-landfill-sites-to-agriculture) for a definition of MPA

Keep land vegetated for as long as possible before moving topsoil. Avoid soil erosion by planting quickly. This:

- allows natural drying through evaporation and transpiration
- develops the soil structure

2.5 Soil storage proposals

Store soil in mounds (known as 'bunds'). To store soil for more than 6 months (or over winter), you'll need to:

- seed it with grass
- treat it for weeds

- cut the grass at least twice a year

To keep soil aerated, reduce erosion, runoff and ponding, soil bunds should:

- be no more than 3m high for topsoil and 5m high for subsoil
- be located on dry level ground
- not disrupt natural surface drainage
- be stable structures with side slopes between 25 degrees and 45 degrees

Loosen soil under the bunds when you remove them.

Soil storage areas need to be large enough to store soils separately. To reduce mixing, soil bunds should be:

- of a single soil type including topsoils and other soil forming material
- located on similar material, for example remove topsoil to store subsoil and store topsoil on similar topsoil (like-on-like)

Single bunds should have different soils separated by another material, such as straw bales or a synthetic barrier (geotextile).

2.6 Drainage and landform

Restored land must drain properly. Proposals may need to include adding surface ditches and underground drainage systems to restore land to its previous quality, even if the land was free draining before.

Minerals such as sand, chalk and gravel act as natural drainage. You must take this into account if your development takes away any natural drainage.

You should:

- replace soil to a depth specified in your restoration plan, typically 30cm of topsoil and 90cm of subsoil
- fill all uneven surfaces with suitable soils
- remove stones (larger than 10cm across) from replaced soil to avoid danger to livestock and damage to machinery

For mineral sites that don't need filling with 'overburden' (the geological material above the mineral being extracted) or imported material, you should replace topsoil and subsoil directly onto a well prepared and loosened base layer.

For landfill sites, replace soil over a capping layer - this forms a barrier to the waste products below.

The final landform should:

- have an even gradient for drainage and lets farm machinery operate safely and efficiently (for best and most versatile agricultural (BMV) land the gradient must be 7 degrees or less) - see section 4 in the Guide to assessing development proposals on agricultural land (https://www.gov.uk/government/publications/agricultural-land-assess-proposals-for-development) for a definition of BMV land
- have open-ended valleys to avoid drainage problems
- avoid a lower level restoration which could lead to wet soils and drainage problems
- merge with adjoining land to avoid sudden changes in levels and potential 'ponding' of water

3. Record keeping

Operators should keep records for:

- each soil bund - you should label every one you create
- all restoration operations including dates, volumes and types of soil moved and where the soil came from
- weather conditions during stripping and moving
- any problems encountered to help with future decisions

Operators should check their records each year to make sure they match the restoration plan, as this can change when works start. You can ask for these records when:

- deciding on planning permission
- monitoring the site at a later stage

4. Aftercare plan and conditions

You should check that operators have an aftercare plan to reclaim land for agricultural use. You should attach planning conditions to planning permission that sets out an appropriate outline strategy for aftercare for the site see section 4.2

Fully reclaimed land (that's restored land and its associated aftercare) should have topsoil and subsoil replaced as described in the restoration plan see section 2.1.

It must be cultivated and treated appropriately for up to 5 years to restore its structure and stability for normal agricultural use - this is often longer (by agreement) for woodland, amenity, or wildlife conservation.

You should refer to the planning practice guidance on restoration and aftercare (https://www.gov.uk/guidance/minerals#Restoration-and-aftercare-of-minerals) for more detail.

4.1 Operators' responsibilities for aftercare

Operators must pay for the restoration and aftercare of the site. Operators must discuss any extensions to their aftercare agreement with you.

4.2 Outline strategy for aftercare

Operators must submit an outline strategy for aftercare with their planning application. For projects with a long lifespan you can create a condition.

As part of the outline strategy, operators should:

- map all areas in the aftercare plan and include any operations taking place in different phases
- state when, where and how they'll establish grass or crops
- describe the hedgerows, trees and surface features they'll establish
- outline drainage plans and water supply if appropriate
- explain their plans for agriculture, soil management, using fertiliser and controlling weeds and pests
- commit to an annual meeting with you and other interested parties

4.3 Phased restoration and aftercare

Operators should agree care and maintenance plans with you (as an interim stage). You should do this when restoration of small parts of a larger site is taking place in phases, such as a landfill operation. The aftercare period starts when the smaller parts have made up a large enough area to start aftercare management. Operators should agree this size with you.

5. Annual report and annual meeting

All agricultural reclamation sites should have an annual aftercare report and annual meeting.

Operators should submit the annual aftercare report to you before an annual meeting of all interested parties. All interested parties should have time to read the report before the meeting. The report should include:

- work carried out that year (include soils analysis results and fertiliser and pesticide applications)
- details of work for the coming year
- any changes to original proposals set out in the outline aftercare strategy see section 4.2

The operator needs to agree with you:

- any further remedial work, such as improving drainage or removing soil compaction
- any changes to the aftercare plan, such as changing a crop

You can issue a 'certificate of compliance' if the aftercare plan meets the aftercare obligations. This can be in the form of a simple letter. This doesn't mean the restoration standard is met.

6. Government policies to protect agricultural land and soil

Read the Guide to reclaiming mineral extraction and landfill sites to agriculture (https://www.gov.uk/government/publications/reclaim-minerals-extraction-and-landfill-sites-to-agriculture) to make sure development proposals are appropriate and sustainable.

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~~Appendix SMP7~~

~~BRE Agricultural Good Practice Guide Extract~~

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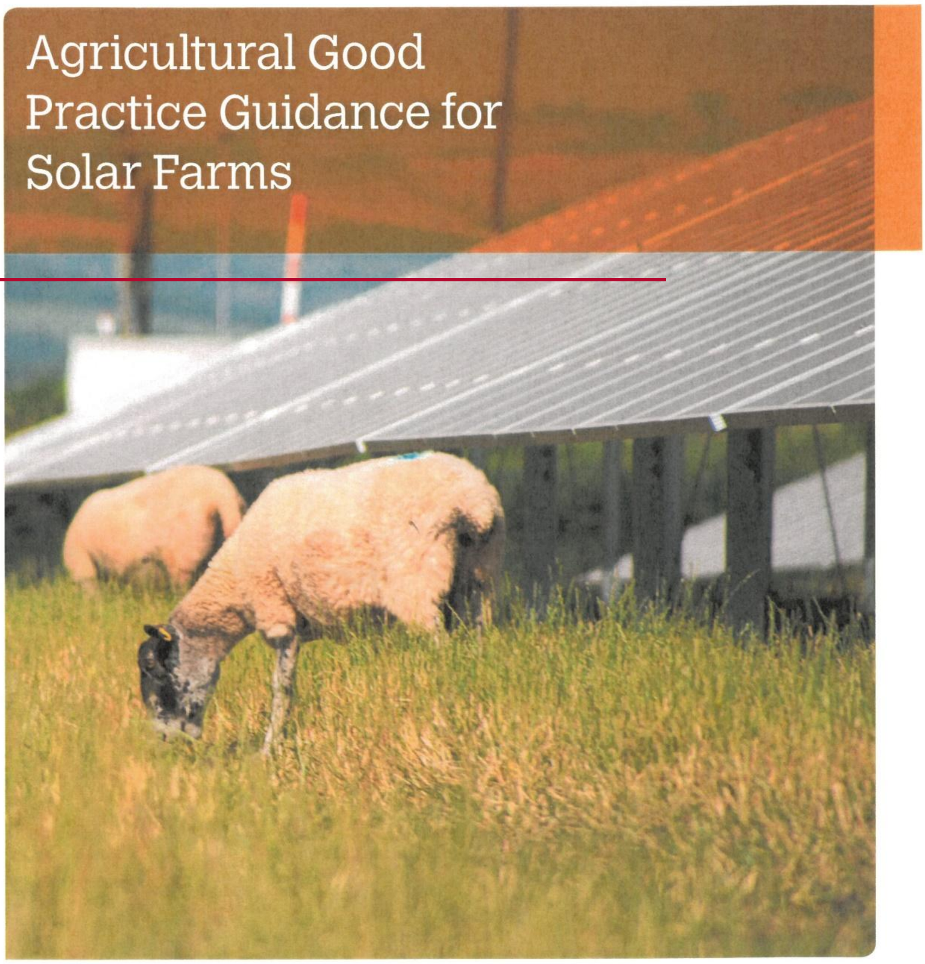
Agricultural Good Practice Guidance for Solar Farms



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Principal Author and Editor Dr Jonathan Scurlock, National Farmers Union

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Context

This document describes experience and principles of good practice to date for the management of small livestock in solar farms established on agricultural land, derelict/marginal land and previously-developed land.

Proposed for publication as an appendix to existing best practice guidelines by the BRE National Solar Centre[1], it should be read in conjunction with BRE (2014) Biodiversity Guidance for Solar Developments (eds. G.E. Parker and L. Greene).

The guidance presented here has been developed with, and endorsed by, a number of leading UK solar farm developers and organisations concerned with agriculture and land management.

Introduction

Field-scale arrays of ground-mounted PV modules, or "solar farms", are a relatively recent development, seen in Britain only since 2011, although they have been deployed in Germany and other European countries since around 2005. In accordance with the "10 Commitments" of good practice established by the Solar Trade Association[2], the majority of solar farm developers actively encourage multi-purpose land use, through continued agricultural activity or agri-environmental measures that support biodiversity, yielding both economic and ecological benefits.

It is commonly proposed in planning applications for solar farms that the land between and underneath the rows of PV modules should be available for grazing of small livestock. Larger farm animals such as horses and cattle are considered unsuitable since they have the weight and strength to dislodge standard mounting systems, while pigs or goats may cause damage to cabling, but sheep and free-ranging poultry have already been successfully employed to manage grassland in solar farms while demonstrating dual-purpose land use.

Opportunities for cutting hay or silage, or strip cropping of high-value vegetables or non-food crops such as lavender, are thought to be fairly limited and would need careful layout with regard to the proposed size of machinery and its required turning space. However, other productive options such as bee-keeping have already been demonstrated. In some cases, solar farms may actually enhance the agricultural value of land, where marginal or previously-developed land (e.g. an old airfield site) has been brought back into more productive grazing management. It is desirable that the terms of a solar farm agreement should include a grazing plan that ensures the continuation of access to the land by the farmer, ideally in a form that that enables the claiming of Basic Payment Scheme agricultural support (see page 2).

[1] BRE (2013) Planning guidance for the development of large scale ground mounted solar PV systems. www.bre.co.uk/nsc

[2] STA "Solar Farms: 10 Commitments" http://www.solar-trade.org.uk/solarFarms.cfm

Conservation grazing for biodiversity

As suggested in the Biodiversity Guidance described above, low intensity grazing can provide a cost-effective way of managing grassland in solar farms while increasing its conservation value, as long as some structural diversity is maintained. A qualified ecologist could assist with the development of a conservation grazing regime that is suited to the site's characteristics and management objectives, for incorporation into the biodiversity management plan.

Avoiding grazing in either the spring or summer will favour early or late flowering species, respectively, allowing the development of nectar and seeds while benefiting invertebrates, ground nesting birds and small mammals. Hardy livestock breeds are better suited to such autumn and winter grazing, when the forage is less nutritious and the principal aim is to prevent vegetation from overshadowing the leading (lower) edges of the PV modules (typically about 800-900mm high). Other habitat enhancements may be confined to non-grazed field margins (if provision is made for electric or temporary fencing) as well as hedgerows and selected field corners.

Agricultural grazing for maximum production

The developer, landowner and/or agricultural tenant/licensee may choose to graze livestock at higher stocking densities throughout the year over much of the solar farm, especially where the previous land use suggested higher yields or pasture quality. Between 4 and 8 sheep/hectare may be achievable (or 2-3 sheep/ha on newly-established pasture), similar to stocking rates on conventional grassland, i.e. between about March and November in the southwest and May to October in North-East England.

The most common practice is likely to be the use of solar farms as part of a grazing plan for fattening/finishing of young hill-bred 'store' lambs for sale to market. Store lambs are those newly-weaned animals that have not yet put on enough weight for slaughter, often sold by hill farmers in the Autumn for finishing in the lowlands. Some hardier breeds of sheep may be able to produce and rear lambs successfully under the shelter of solar farms, but there is little experience of this yet. Pasture management interventions such as 'topping' (mowing) may be required occasionally or in certain areas, in order to avoid grass getting into unsuitable condition for the sheep (e.g. too long, or starting to set seed).

Smaller solar parks can provide a light/shade environment for free-ranging poultry (this is now recognised by the RSPCA Freedom Foods certification scheme) – experience to date suggests there is little risk of roosting birds fouling the modules. Broiler (meat) chickens, laying hens and geese will all keep the grass down, and flocks may need to be rotated to allow recovery of vegetation. Stocking density of up to 2000 birds per hectare is allowed, so a 5 megawatt solar farm on 12 hectares would provide ranging for 24,000 birds.

Solar farm design and layout

In most solar farms, the PV modules are mounted on metal frames anchored by driven or screw piles, causing minimal ground disturbance and occupying less than 1% of the land area. The rest of the infrastructure typically disturbs less than 5% of the ground, and some 25-40% of the ground surface is over-sailed by the modules or panel. Therefore 95% of a field utilised for solar farm development is still accessible for vegetation growth, and can support agricultural activity as well as wildlife, for a lifespan of typically 25 years.

As described above, the layout of rows of modules and the width of field margins should anticipate future maintenance costs, taking into account the size, reach and turning circle of machinery and equipment that might be used for 'topping' (mowing), collecting forage grass, spot-weeding (e.g. of 'injurious' weeds like ragwort and dock) and re-seeding. Again, in anticipation of reverting the field to its original use after 25 years, many agri-environmental measures may be better located around field margins and/or where specifically recommended by local ecologists. All European farmers are obliged to maintain land in "good agricultural and environmental condition" under the Common Agricultural Policy rules of 'cross compliance', so it is important to demonstrate sound stewardship of the land for the lifetime of a solar farm project, from initial design to eventual remediation.

The depth of buried cables, armouring of rising cables, and securing of loose wires on the backs of modules all need to be taken into consideration where agricultural machinery and livestock will be present. Cables need to be buried according to national regulations and local DNO requirements, deep enough to avoid the risk of being disturbed by farming practice – for example, disc harrowing and re-seeding may till the soil to a depth of typically 100-150 mm, or a maximum of 200 mm. British Standard BS 7671 ("Wiring Regulations") describes the principles of appropriate depth for buried cables, cable conduits and cable trench marking. Note also that stony land may present a risk of stone-throw where inappropriate grass management machinery is used (e.g. unguarded cylinder mowers).

Eligibility for CAP support and greening measures

From 2015, under the Common Agricultural Policy, farmers will be applying for the new Basic Payment Scheme (BPS) of area-based farm support funding. It has been proposed that the presence of sheep grazing could be accepted as proof that the land is available for agriculture, and therefore eligible to receive BPS, but final details are still awaited from Defra at the time of writing. Farmers must have the land "at their disposal" in order to claim BPS, and solar farm agreements should be carefully drafted in order to demonstrate this (BPS cannot be claimed if the land is actually rented out). Ineligible land taken up by mountings and hard standing should be deducted from BPS claims, and in the year of construction larger areas may be temporarily ineligible if they are not available for agriculture.

Defra has not yet provided full details on BPS 'greening' measures, but some types of Ecological Focus Areas may be possibly located within solar farms, probably around the margins, including grazed buffer strips and ungrazed fallow land, both sown with wildflowers. Note that where the agreed biodiversity management plan excludes all forms of grazing, the land will become ineligible for BPS, and this may have further implications for the landowner, such as for inheritance tax.

Long-term management, permanent grassland and SSSI designation

Since solar farms are likely to be in place typically for 25 years, the land could pass on to a succeeding generation of farmers or new owners, and the vegetation and habitat within the fenced area is expected to gradually change with time. According to Natural England, there is little additional risk that the flora and fauna would assume such quality and interest that the solar farm might be designated a SSSI (Site of Special Scientific Interest) compared with a similarly-managed open field. However, there could be a possible conflict with planning conditions to return the land to its original use at the end of the project, e.g. if this is specified as 'cropland' rather than more generically as 'for agricultural purposes'. If the pasture within a solar farm were considered to have become a permanent grassland, it may be subject to regulations requiring an Environmental Impact Assessment to restore the original land use, although restoration clauses in the original planning consent may take precedence here. It is proposed that temporary (arable) grassland should be established on the majority of the land area that lies between the rows of modules. This would be managed in 'improved' condition by periodic harrowing and re-seeding (e.g. every 5 years), typically using a combination disc harrow and seed drill.

Other measures to maintain the productivity of grassland, without the need for mechanised cultivations or total reseeding, could include: maintaining optimum soil fertility and pH to encourage productive grass species; seasonally variable stocking rates to prevent over/under-grazing with the aim of preventing grass from seeding and becoming unpalatable. Non-tillage techniques to optimise grass sward content might include the use of a sward/grass harrow and air-seeder to revive tired pastures. When applying soil conditioners (e.g. lime), fertilisers or other products, consideration should be taken to prevent damage to or soiling of the solar modules.

Good practice in construction and neighbourliness

Consideration should also be given to best practice during construction and installation, and ensuring that the future agricultural management of the land (such as a change from arable cropping to lamb production) fits into the local rural economy. Site access should follow strictly the proposed traffic management plan, and careful attention to flood and mud management in accordance with the Flood Risk Assessment (e.g. controlling run-off by disrupting drainage along wheelings), will also ensure that the landowner remains on good terms with his/her neighbours.

Time of year should be taken into account for agricultural and biodiversity operations such as prior seeding of pasture grasses and wildflowers. Contractors should consider avoiding soil compaction and damage to land drains, e.g. by using low ground pressure tyres or tracked vehicles. Likewise, when excavating cable trenches, storing and replacing topsoil and subsoil separately and in the right order is important to avoid long-term unsightly impacts on soil and vegetation structure. Good practice at this stage will yield longer-term benefits in terms of productivity and optimal grazing conditions.

Evidence base and suggested research needs

A number of preliminary studies on the quantity and quality of forage available in solar farms have suggested that overall production is very little different from open grassland under similar conditions. A more comprehensive and independent evidence base could be established through a programme of directed research, e.g. by consultants (such as ADAS) or interested university groups (e.g. Exeter University departments of geography and biosciences), perhaps in association with seed suppliers and other stakeholders. Productivity of grasses could be compared between partial shade beneath the solar modules and unshaded areas between the rows. Alternatively daily live weight gain could be compared between two groups of fattening lambs (both under the same husbandry regime) on similar blocks of land, with and without solar modules present.

Case Steiger Quadtrac used to deliver inverters and other heavy equipment to site under soft ground conditions (photo courtesy of British Solar Renewables)

Cable trenching, showing topsoil stripped and set to one side, with subsoil placed on the other side ready for reinstatement (photo courtesy of British Solar Renewables)

Agricultural case studies

Benbole Farm, Wadebridge, Cornwall

One of the first solar farms developed in Britain in 2011, this 1.74 megawatt installation on a four-hectare site is well screened by high hedges and grazed by a flock of more than 20 geese. A community scheme implemented by the solar farm developers enabled local residents to benefit from free domestic solar panels and other green energy projects.

Higher Hill, Butleigh, Somerset

Angus Macdonald, a third-generation farmer, installed a five megawatt solar farm on his own land. Located near Glastonbury, the site has been grazed by sheep since its inception in 2011.

Eastacombe Farm, Holsworthy, Devon

This farm has been in the Petherick family for four generations, but they were struggling to survive with a small dairy herd. In 2011/12, a solar developer helped them convert eight hectares of the lower-grade part of their land into a 3.6 megawatt solar farm with sheep grazing, which has diversified the business, guaranteeing its future for the next generation of farmers.

Newlands Farm, Axminster, Devon

Devon sheep farmer Gilbert Churchill chose to supplement his agricultural enterprise by leasing 13 hectares of grazing land for a 4.2 megawatt solar PV development, which was completed in early 2013. According to Mr Churchill, the additional income stream is "a lifeline" that "will safeguard the farm's survival for the future".

Trevemper Farm, Newquay, Cornwall

In 2011, the Trewithen Estate worked with a solar developer to build a 1.7 megawatt solar farm on 6 hectares of this south-facing block of land, which had good proximity to a grid connection. During the 25-year lease, the resident tenant farmer is still able to graze the land with sheep at his normal stocking density, and is also paid an annual fee to manage the pasture.

Yeowood Solar Farm, North Somerset

Completed in 2012, this 1.3 megawatt installation on 4 hectares of land surrounds a poultry farm of 24,000 laying hens, which are free to roam the land between and underneath the rows of solar modules, as well as other fields. The Ford family, farm owners, also grow the energy crop miscanthus to heat their eco-friendly public swimming pool and office units.

Wyld Meadow Farm, Bridport, Dorset

Farmers Clive and Jo Sage continue to graze their own-brand Poll Dorset sheep on this 4.8 megawatt solar farm, established on 11 hectares in 2012. The solar farm was designed to have very low visual impact locally, with an agreement to ensure livestock grazing throughout the project's lifetime.

Wymeswold Solar Farm, Leicestershire

The author pictured in July 2014 at Britain's largest connected solar farm. At 33 megawatts, this development provides enough energy to power 8,500 homes. Built on a disused airfield in 2013, this extensive installation over 61 hectares (150 acres) received no objections during planning and is grazed by the landowner's sheep – just visible in the background.

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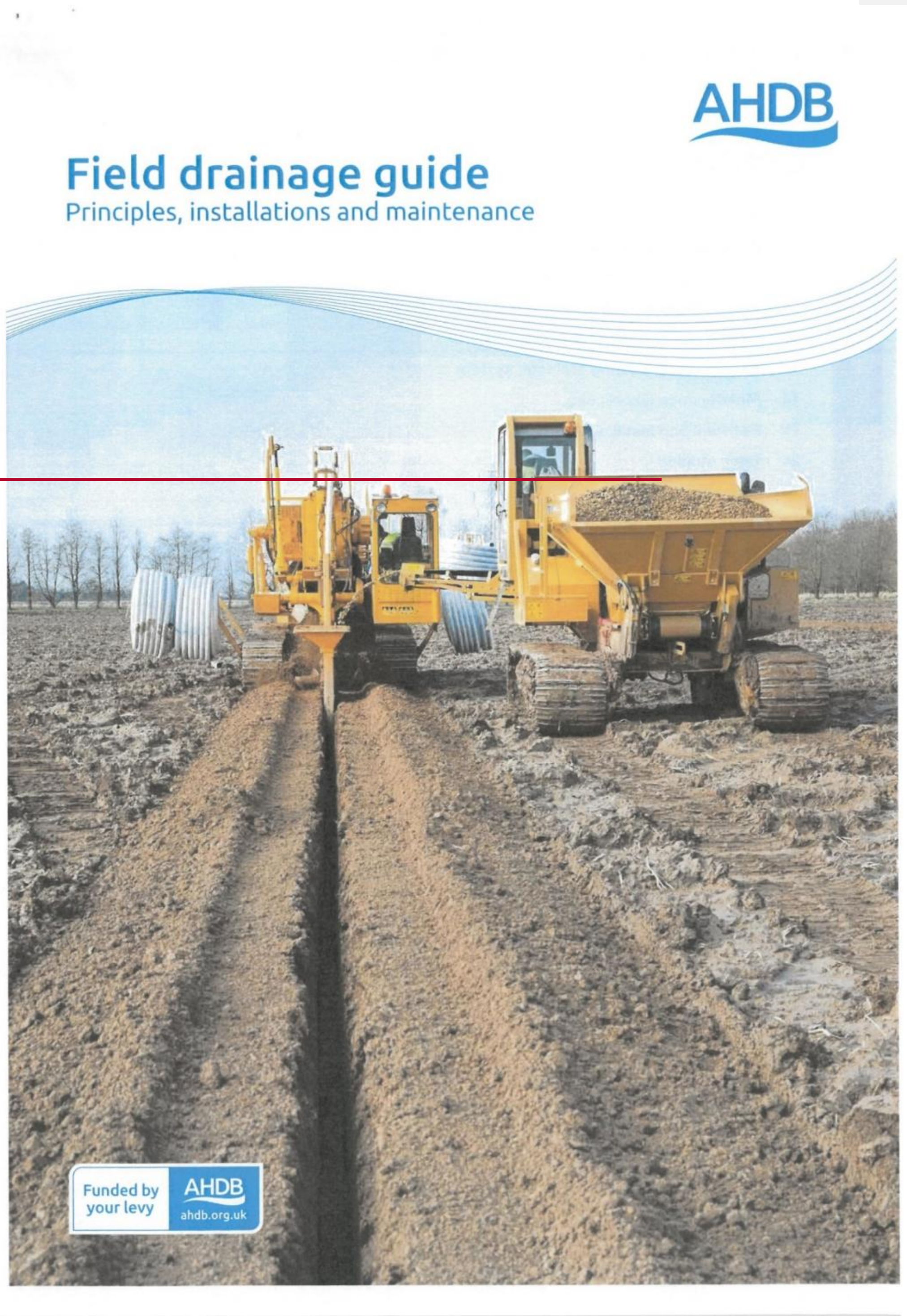
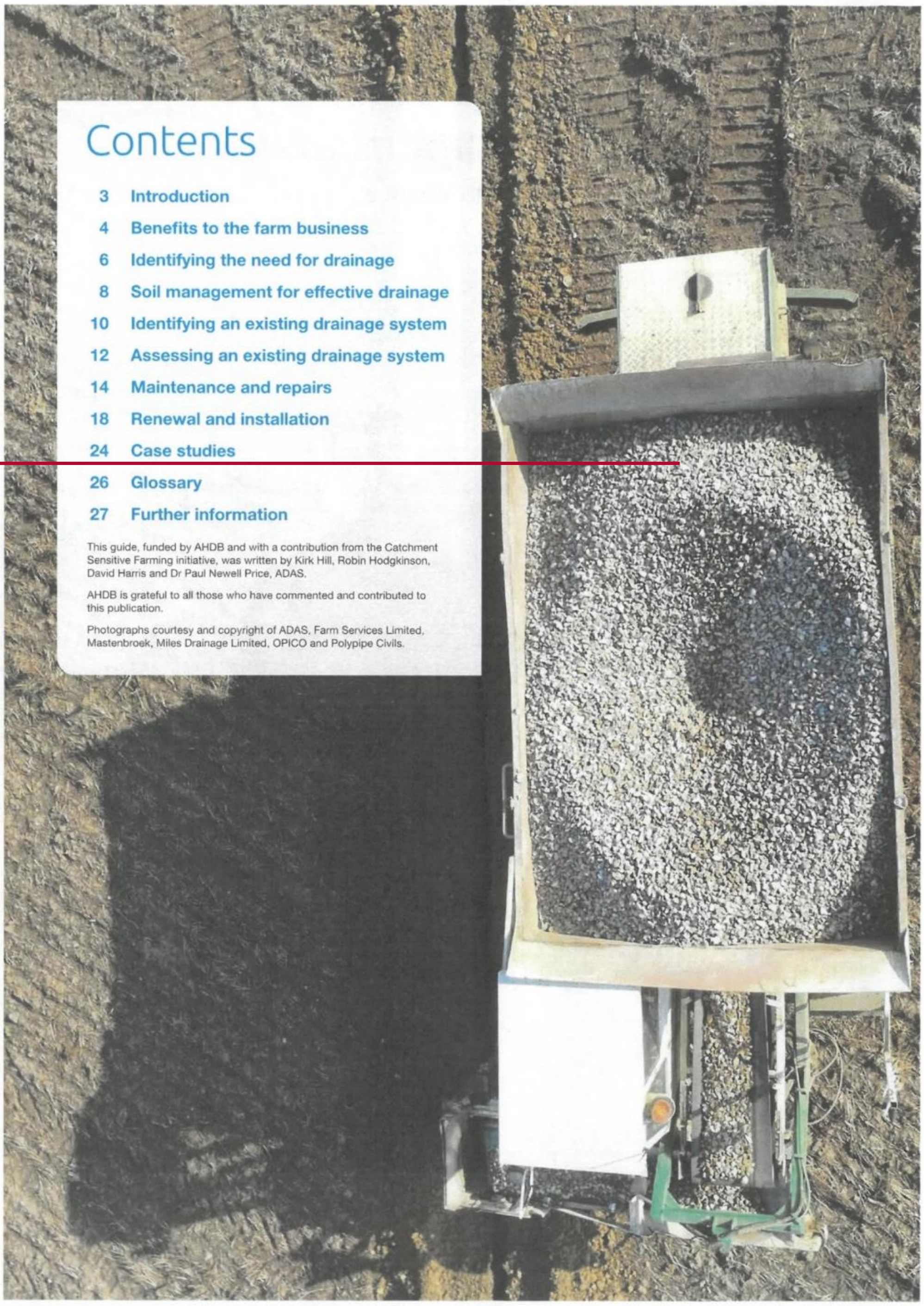
The BRE Trust uses profits made by BRE Group to fund new research and education programmes, that will help it meet its goal of 'building a better world together'.

Appendix SMP8

AHDB Field Drainage Guide


AHDB
Field drainage guide
Principles, installations and maintenance
Funded by your levy
AHDB
ahdb.org.uk



Contents

This guide, funded by AHDB and with a contribution from the Catchment Sensitive Farming initiative, was written by Kirk Hill, Robin Hodgkinson, David Harris and Dr Paul Newell Price, ADAS.

AHDB is grateful to all those who have commented and contributed to this publication.

Photographs courtesy and copyright of ADAS, Farm Services Limited, Mastenbroek, Miles Drainage Limited, OPICO and Polypipe Civils.

Introduction

What is field drainage?

Field drainage is installed to rapidly remove excess soil water to reduce or eliminate waterlogging and return soils to their natural field capacity. Drains can be used to control a water table or to facilitate the removal of excess water held in the upper horizons of the soil.

A good drainage system will reduce the risk of detrimental waterlogging to acceptable levels.

Where soils are coarsely textured and well structured, the soil may be freely draining enough to support field operations and crop growth without the need for artificial drainage systems. Field drains should be considered in the following situations:

- **Heavy clay soils:** These are slowly permeable and, without drainage, can be waterlogged for long periods, particularly in areas of high rainfall
- **Medium-textured soils in high-rainfall areas:** Drainage may be needed to reduce vulnerability to compression, slaking and compaction
- **Light-textured soils:** These soils are highly permeable, but drainage may be required to provide water table control in low-lying areas
- **Springs:** Drains are used to intercept springs before they reach the surface; this helps prevent erosion, localised waterlogging and poaching, and the intercepted water, if clean, may be used as drinking water for stock

There has been a general reduction in organic matter levels in arable soils over the past 70 years. This makes them more susceptible to waterlogging and more in need of drainage.

History of field drainage in the uk

Around 6.4 million hectares of agricultural land in England and Wales have been drained with piped systems.

The rate at which land was drained increased rapidly during World War II, as part of the drive to increase food production, and peaked during the 1960s to 1980s, when grant aid was available.

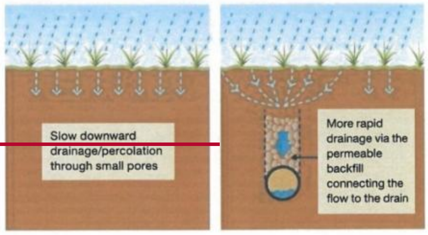


Figure 1. Drainage of heavy soil

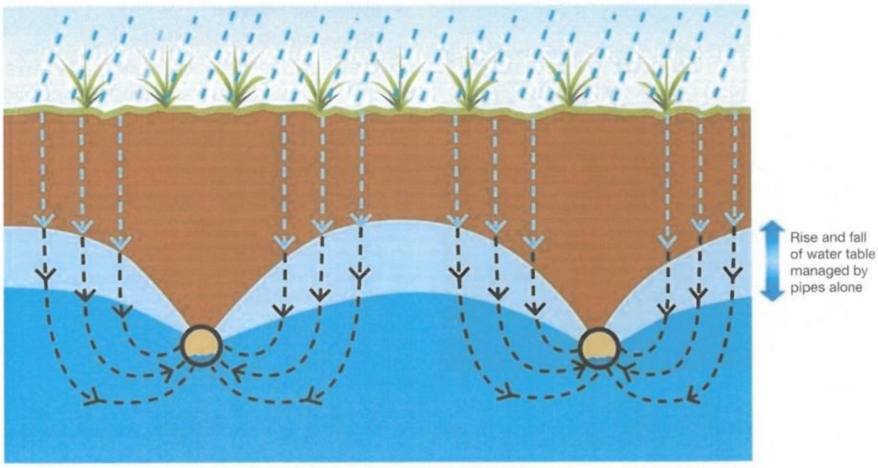


Figure 2. Water table control on permeable soils

Benefits to the farm business

In some years, drainage can make the difference between having a crop to harvest and complete crop loss; or whether or not the land can be accessed to harvest the crop.

The benefits of field drainage to the farm business are substantial, but installation can be expensive. The magnitude of the benefit varies considerably with climate, soil type and land use, so it is important to carry out both environmental and cost–benefit assessments before installing or managing field drainage systems.

Drainage is a long-term investment. Given good maintenance, a useful life of at least 20 years can be expected and some systems can last many decades longer.

Good field drainage reduces the peak surface water run-off rates by increasing the availability of storm-water storage within the soil. Rainfall then percolates down through the soil into the drains, producing a more balanced flow after storms. This reduces the risk of flooding and soil erosion, not only within the field but also further downstream in the catchment.

The cost of installation

The cost of installing a new comprehensive field drainage system varies greatly according to the scale and intensity of the system.

Based on 2024 prices, typical costs per hectare are around:

- £2,500–£3,500 with permeable backfill
- £1,400–£2,000 without permeable backfill

Improved plant performance

- Improved crop yield and quality
- More rapid warming of soils in spring, improving germination
- Improved environment for soil organisms
- Better access to water and oxygen for plant roots
- Better crop uptake of soil mineral nitrogen

Better access to land

- Reduced duration/risk of autumn waterlogging
- Quicker accessibility of fields following any period of wet weather
- Crop inputs more likely to be applied at optimum time
- An extended growing and grazing season

Improved speed of work and fuel use

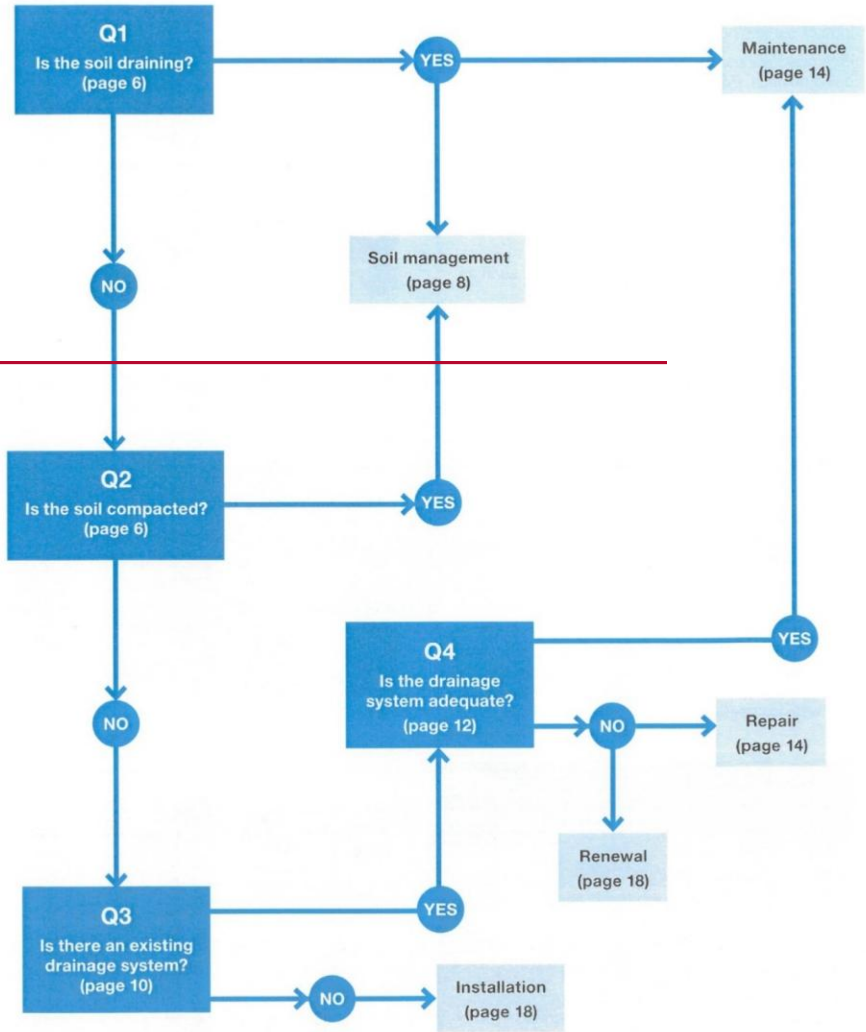
- Better traction
- Fewer cultivation passes
- Reduced draught forces
- Reduced wear and tear
- Fewer wet areas to avoid

Benefits to soil structure and the environment

- Less structural damage to soils
- Reduced frequency and extent of livestock poaching
- Better water infiltration
- Reduced surface run-off and erosion
- Reduced phosphorus and pesticide losses to water
- Decreased potential for slug activity and reproduction

Reduced risks to livestock health

- Reduced survival of parasitic larvae
- Snails carrying liver fluke do not thrive
- Footrot and foul of the foot are less common
- Udder hygiene for grazing stock is improved
- Reduced risk of soil contamination during silaging operations



Q1
Is the soil draining?
(page 6)
YES
Maintenance
(page 14)
NO
Soil management
(page 8)
Q2
Is the soil compacted?
(page 6)
YES
Q4
Is the drainage
system adequate?
(page 12)
YES
NO
NO
Repair
(page 14)
Renewal
(page 18)
Q3
Is there an existing
drainage system?
(page 10)
YES
NO
Installation
(page 18)

Identifying the need for drainage

Evidence of poor drainage

The evidence of poor drainage may be obvious in the form of surface ponding or saturated topsoils.

Prolonged waterlogging under the surface may not be so obvious. Poor drainage conditions may be identified by:

- Poor crop health or yields: overlaying a yield map onto a field drainage map can identify problem areas
- High surface run-off rates and soil erosion
- Limited field access without rutting or poaching (animal hoof damage) compared with other fields in the area
- The presence of wet-loving plant species, such as common rush and redshank
- Susceptibility to drought due to poor root development and limited rainfall percolation into the soil

If drainage problems are widespread across the field, it may be that:

- Soil management is not adequate
- No drains have been installed
- Mole drains need to be renewed
- In flatter fields, the outfall may simply be blocked
- The drainage system requires maintenance or has reached the end of its useful life

Environment

Surface run-off may occur, which can result in transport of faecal material, sediment, soilborne diseases (e.g. clubroot), nutrients or agrochemicals to watercourses.

Figure 3. Surface ponding

Figure 4. Areas of grassland may become heavily poached at times when soil conditions in other fields on similar soils do not lead to poaching

Figure 5. Saturated topsoils

Figure 6. Areas within arable fields may be waterlogged, resulting in crop loss or soil damage due to wheel ruts

Is the soil draining?

Examining the soils to determine if they are naturally freely or slowly draining or have damaged structure should be the first action when drainage problems are suspected.

Without good soil structure, soil drainage will be poor, whether it be by natural drainage or pipes.

Compacted layers can restrict surface water from reaching underlying drainage systems. If compacted layers are identified, remedial action should be undertaken to remove them before considering field drainage maintenance or reinstallation.

It is essential to routinely assess soil structure. This can easily be incorporated into the farm soil sampling programme and should be completed in spring or autumn. Examine the soil at several points in the field to a depth of:

- Arable land: at least 600 mm
- Grassland: at least 500 mm

Soil structure

✔ Well-developed structure is evident from the ease of digging and if the soil readily breaks down into small structural units with many vertical fissures

✗ Soils with poor structure are hard to dig and break down into larger dense blocks, with poor penetration by water, air and roots

Soil colour

Greyish-coloured soils and soils with rusty or grey-coloured mottles are signs of poorer drainage.

Soil texture

The higher the clay content, the more likely the soil is to be naturally poorly drained.

Root development

✔ Deep rooting indicates good structure

✗ Shallow rooting with many fine horizontal roots and tap roots that are diverted horizontally indicate the presence of compacted layers

Perched water table

Soil compaction occurs when soil particles are compressed, reducing the space (pores) between them. This restricts the movement of vital air and water through the soil.

When soil water is present, dig a pit (to a depth where the soil becomes drier) to aid diagnosis. Saturated soils overlying a layer of dry soil after a period of heavy rain may indicate the presence of a compacted layer preventing drainage.

It is not uncommon to find both naturally and artificially compacted layers (pans) in susceptible soils. Plough pans can develop if a field is repeatedly ploughed to the same depth.

If the pan, whether artificial or natural, is limiting water infiltration and/or root growth, it should be removed by subsoiling or topsoil loosening.

Figure 7. Natural pans – often very hard bands of soil particles cemented together by iron and manganese

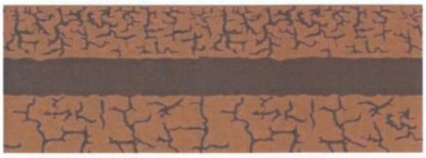


Figure 8. Compaction pans – dense layers caused by farm machinery operation; often 50–100 mm thick, they generally have a platy structure and frequently contain crop residues

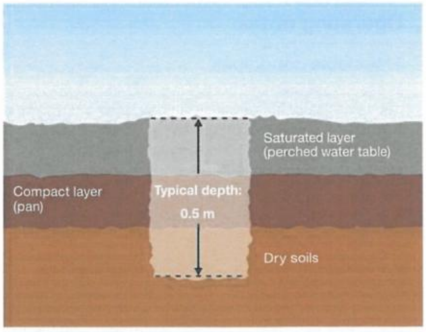


Figure 9. Soil inspection pit extending below the compacted layer

Soil management for effective drainage

Effective drainage relies on good soil management

If soil examination identifies compacted layers that act as a barrier to water movement, remedial action should be undertaken to remove them before considering new drainage.

Maintaining a good soil structure may avoid the need for capital investment.

Minimise soil damage by reducing:

- Field trafficking
- Weight of machinery
- Tyre pressures
- Poaching of livestock
- Overworking of the seedbed

Other potential solutions include the use of low-pressure tyres, minimum tillage, controlled traffic farming and fixed wheelings, avoiding turnout in poor soil conditions, and considering the placement of livestock feeders and drinkers and livestock tracks.

Subsoil and topsoil loosening

When soils are wet, they are easily damaged by cultivation, machinery traffic and livestock trampling. If the soil structure has been damaged, subsoil or topsoil loosening (normally referred to as 'subsoiling' and 'sward lifting', respectively) in suitable conditions can be used to help restore the structure of a damaged soil. It can also be used to improve subsoil permeability.

Slit aerators can also be used in grassland fields but should only target the top 10 cm. Research has shown that they can increase infiltration rates, but good conditions are needed below the target area or they can just move water more quickly towards a drainage problem.

Operating notes

1. Suitable conditions

Topsoil loosening and subsoiling should only be carried out when the soil at working and loosening depth is in a 'dry' and friable condition, so that it will shatter rather than smear. Examine soils early in the operation to ensure effective shattering is occurring.

For arable subsoiling, both the soil surface and the compacted layer should be 'dry' to avoid soil structural damage.

For topsoil loosening in grassland using a 'sward lifter'-type machine, the ideal conditions are when the soil surface is slightly moist, to allow disc and tine leg entry while avoiding excessive sward tear, and the lower topsoil is moist to dry, to enable 'lift' and loosening.

2. Choice of soil-loosening equipment

Winged subsoilers (as seen in Figure 10), developed in the 1980s, shatter the soil much more effectively than conventional subsoilers. They require higher draught force but can disturb a volume of soil two to three times greater than a conventional subsoiler, resulting in more effective disturbance.

The use of leading tines can result in an increased volume of soil disturbed without increasing the draught, but they are not suitable for grassland as they cause considerable surface disturbance.

Topsoil looseners (as seen in Figure 11) or 'sward lifters' for grassland incorporate a leading disc, a vertical or forward-inclined leg and a tine leg and a packer roller behind to minimise sward tear and surface disturbance.

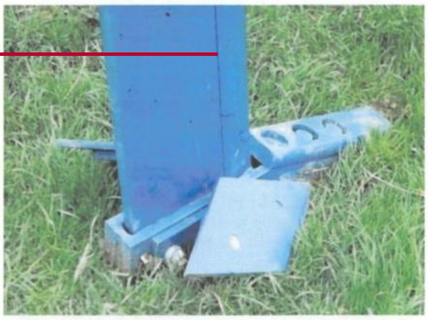


Figure 10. Winged subsoiler

Figure 11. Topsoil loosener for grassland

3. Depth

It is best practice to use a depth wheel or rear packer roller to maintain a constant tine depth.

Aim for tines to be about 25–50 mm below the base of the compacted layer, up to a maximum depth of approximately 450 mm below ground level.

Maximum depth may be limited by shallow field drains, rock or the critical depth of the tine (related to tine width and soil conditions). Normal drain depth is around 700 mm below the soil surface.

For subsoiling to result in improved drainage, the depth to which the soil is loosened must be just greater than the depth down to the top of the permeable backfill.

This will connect the fissures and allow water to move to the permeable fill over the drains.

4. Spacing between tines

- Conventional subsoiler: up to 1.5 times the tine depth
- Winged subsoiler: up to 2 times the tine depth
- With leading shallow tines: up to 2.5 times the tine depth

After a trial run, dig down and examine the effect. Spacing can be adjusted, where possible, to achieve the desired degree of soil disturbance.

Avoiding re-compaction

Recently loosened soils are very sensitive to re-compaction.

Avoid running over land that has already been subsoiled. In grassland, avoid grazing after autumn loosening and cut rather than graze in the first spring after treatment.

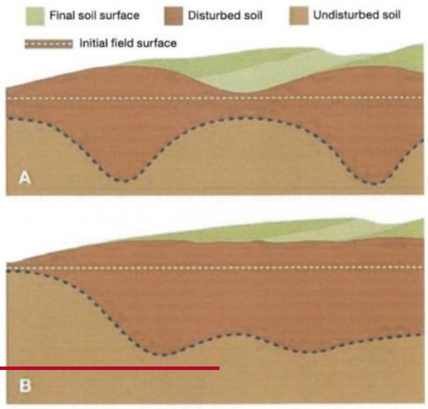


Figure 12. A is an example of tines set too wide and B shows tines correctly set

Further information

- A guide to better soil structure (Cranfield University) **landis.org.uk/downloads**
- Soil management **ahdb.org.uk/greatsoils**
- Think soils (Environment Agency) **gov.uk/managing-soil-types**
- Principles of subsoiling videos on the Practical Pig app (**practicalpig.ahdb.org.uk**)

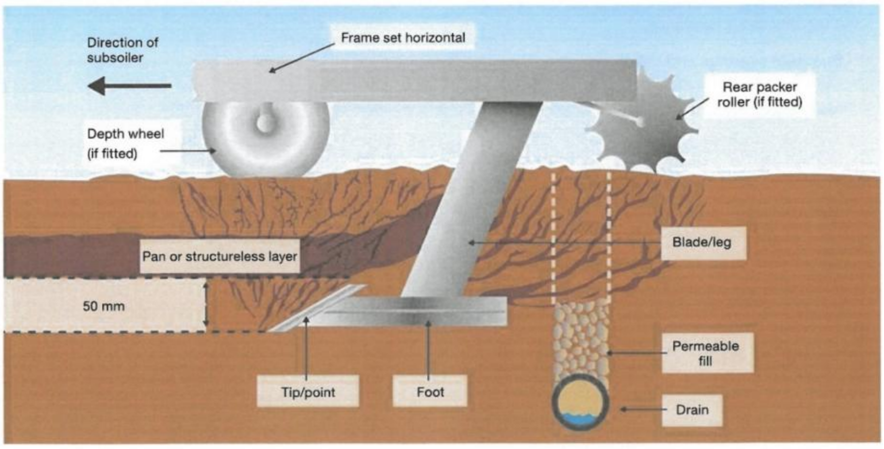


Figure 13. Subsoiler operation

Identifying an existing drainage system

Existing drainage

Fields are likely to already have some form of field drainage if they have heavy soils or medium soils in heavy rainfall areas or a naturally high water table. The system may, however, not be functioning properly or may be inadequate for the current farming needs.

Typical drainage layouts

A field can contain a combination of different layouts or be drained irregularly, depending on the surface slopes across the field. If smaller fields have been merged into one, the outfalls may be found at the low points of each original field and not the current field.

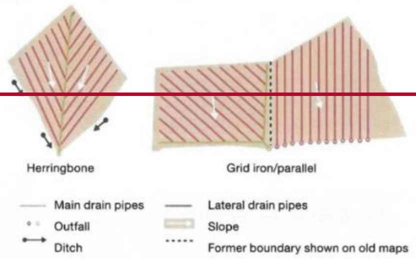


Figure 14. Typical drainage layouts

Understanding drainage plans

On many farms, final drainage plans are available that detail exactly what type of drainage was installed and where it is within each field. Final plans are normally accurate and, provided the key above-ground features shown are visible, should enable the drains to be found.

Ensure it is a final drainage plan, not a proposal. A final plan may include the words 'completion' or 'as built' and should always be signed.

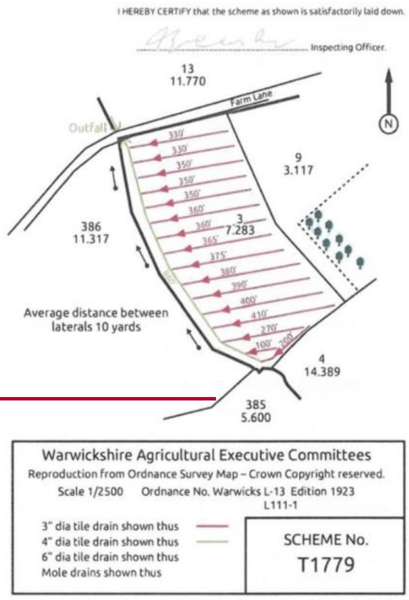
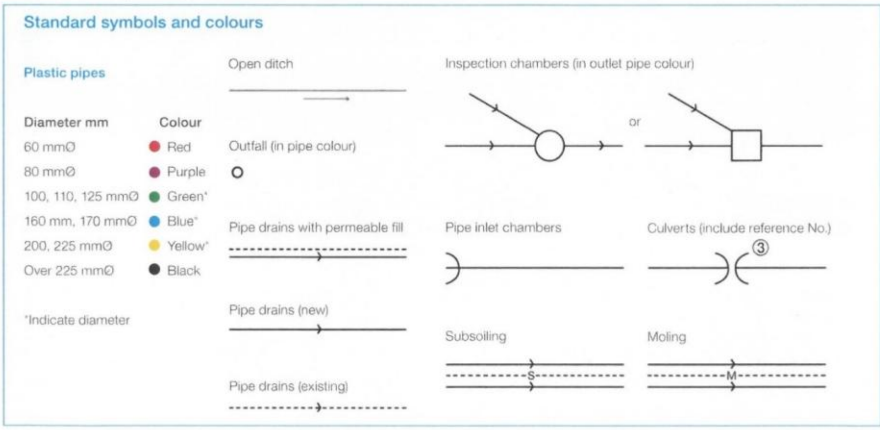


Figure 15. Example final drainage plan



In the absence of a final drainage plan

Local drainage contractors may hold copies of any final record plans. If the land has been recently acquired, the previous owners may hold the plans.

Creating your own drainage plan

1. **Produce a sketch map** showing the ditches and the direction in which they flow, along with the dominant direction of slope in each field. It may also be helpful to mark any removed field boundaries or ditches, as one large field may contain several small drainage schemes.
2. **Locate any visible outfalls.** These are generally found at the lowest points within a field. There may be more than one outfall, depending on the layout of the drainage scheme.

- Walk the ditches after rainfall: you may hear an outfall running that you cannot see
- The best time to look for outfalls is in winter when drains are running and vegetation growth is reduced
- Even if an actual pipe is not visible, seepage from the bank or an area where the bank has receded can indicate the location of a drain outfall
- If the ditch is badly overgrown, it may be necessary to clear vegetation
- If the ditch has become silted up or the pipe blocked, the ditch may first need to be cleared – typically, to at least 1 m below the adjacent field level

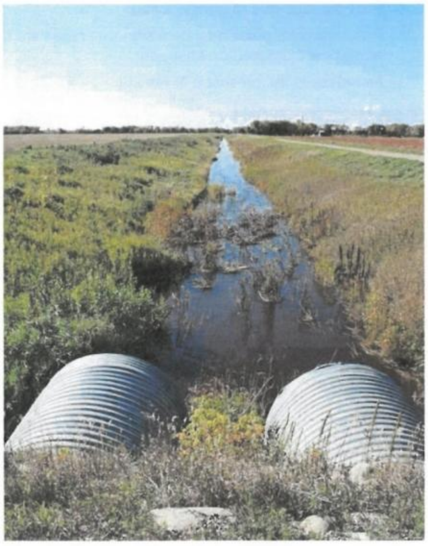


Figure 16. Drainage ditch

3. **Look for field surface signs.** Some features may only be apparent in a certain light during the day or during particular ground moisture conditions.

- Aerial photographs available online may reveal the lines of the drains, although they may be confused with other features, such as underground pipelines
- Slight linear depressions may be visible on the field surface
- The crop may vary in quality or colour over the line of a drain
- The soil may be drier directly over the drain than between drains
- Localised wet areas or small depressions ('blow holes') may be found upslope of a blocked drain

Figure 17. A 'blow hole'

4. If the outfall cannot be found by visual inspection alone, or surface signs need to be confirmed, it may be necessary to **dig trenches across the most likely locations** for drains.

Health and safety

Before excavating any trenches, ensure that:

- There are no underground cables or pipelines present that may be hazardous or damaged
- Personnel do not enter a trench unless adequate precautions have been taken to prevent trench collapse

Some helpful information can be found at **hse.gov.uk**

Figure 18. Signs indicating potential underground hazards

Assessing an existing drainage system

Risk management

An effectively designed field drainage system should afford a level of protection against waterlogging that is appropriate to the value of the crop, land access and other benefits. It should be designed to drain the field effectively up to an appropriate return period, usually based on crop value.

Thinking of drainage as insurance, a higher-value crop may justify a more intensive field drainage system than, for example, grassland, which may be able to better tolerate a small amount of waterlogging. Equally, improved drainage may attract high-value horticulture crops into the rotation, increasing the rental value.

The degree to which drainage systems provide protection against waterlogging should be matched with the value of the crops to be grown. A typical high-value crop would need to be protected against all rainfall, except very infrequent rainfall events, whereas grassland warrants a lower level of protection.

The following waterlogging risk frequencies are typically used for design:

- Very high-value specialist crops: 1 in 25 years
- Horticultural crops: 1 in 10 years
- Root crops: 1 in 5 years
- Intensive grass and cereals: 1 in 2 years
- Grassland: 1 in 1 year

Is the existing system adequate?

There are a number of reasons why an existing field drainage system may be inadequate for current needs:

- The scheme may have been designed to work with mole drains that have since collapsed and need renewal
- The drainage system may have reached the end of its useful life (e.g. blocked or collapsed)
- The land use may have changed since the system was installed
- The drains may have been installed without permeable backfill

On soils where permeable backfill is required for optimum performance, the scheme may work well initially due to the soil disturbance during trenching. With the passage of time, however, the soil will return to a more consolidated, less permeable condition that may limit water movement.

It can be difficult to recognise the signs of crop stress on fields where old drains are gradually becoming less effective and where only some crops in the rotation may be affected by stress. When deciding whether the existing field drainage system is adequate, take into account the history of the field and whether it has been deteriorating. Consider:

- Year-on-year variation in yield
- Instances of delayed cultivation or harvest due to field conditions
- Past damage due to poor drainage
- Frequent blow holes may be a sign that pipes are too small or are blocked downstream
- Increases in the presence of moisture-loving plants

Figure 19. Crop loss due to drainage problems

Assessing the costs and benefits of field drainage

While field drainage can have economic, practical and environmental benefits, installation can be expensive.

Drainage can also exacerbate water pollution and impact negatively on some habitats. It is, therefore, important to carry out an environmental and cost-benefit assessment before installing or carrying out maintenance on field drainage systems.

Production benefits resulting from drainage are most likely to be obtained in areas of high rainfall or on:

- Heavy clay soils, especially where arable or intensive livestock production is practised
- Medium soils where potatoes, other root crops or high-value crops are grown
- Low-lying permeable soils where the groundwater level comes close to the land surface in winter or after rainfall

In many cases, it is better for both agricultural production and the environment to remove excess water by field drainage, but there are cases when the production benefits are outweighed by the costs and there are opportunities to mitigate climate change, flooding, protect water quality or create wildlife habitats by allowing field drainage to deteriorate.

Waterlogged land may be low value agriculturally but it may have biodiversity benefits or help to reduce flooding risk.

Sacrificing an area of waterlogged land may reduce costs by acting as a sediment trap and reducing the need for costly activities, such as watercourse dredging. Suitable areas where drainage might be allowed to deteriorate could include land adjacent to watercourses, natural wetlands and ribbon areas at the base of steep slopes, particularly on intensive grassland on heavy soils in the centre and west of the UK.

For more information for farmers in priority areas at risk of water pollution, contact Catchment Sensitive Farming: **gov.uk/catchment-sensitive-farming**

Environment

In the Mires on the Moors project (a partnership between South West Water, two National Park Authorities and other organisations, such as the Environment Agency), drainage ditches on Dartmoor and Exmoor were blocked to restore peatland. This increases the carbon and water storage on the moor and slows the flow of water off the moor so that storm and flood damage is reduced, sediment settles out and drinking water quality is improved. Read more on **www.exmoormires.org.uk**

The impact of field drainage on pollution risk

The relationship between field drains and pollution can be contradictory.

Positive points

Maintaining good field drainage and good soil structure reduces waterlogging

↓

This reduces the likelihood of causing soil compaction through untimely field operations

↓

This decreases surface run-off, soil erosion and the loss of sediment and associated pollutants, such as phosphorus, to water

Negative points

When soils are wet or dry with deep cracks and rain falls within a few days of agrochemical application…

↓

…field drains can provide a rapid route for water enriched with ammonium, phosphorus, pesticides, fine sediment or other associated pollutants

↓

Drains are most effective at providing a conduit for agricultural pollutants when newly installed or in fields with deep cracking clays

Remember

- Best practice should always be followed when applying manures, fertilisers and agrochemicals to avoid losses via surface run-off or field drains
- Organic manures should not be applied to land within 12 months of pipe or mole drainage installation
- Organic manures should not be applied to drained land when soils are wet and drains are running
- Organic manures should not be stored within 10 m of a field drain

Maintenance and repairs

Ditches and outfalls

If ditches become infilled and outfalls are not kept clear, the field drainage system will cease to function effectively, leading to the need for more expensive maintenance or premature renewal.

In flat areas, in particular, blocked culverts and ditches can lead to waterlogging over large areas of land, restricting drainage upstream. This can cause flooding and soil erosion as the water backs up and tries to find an overland route to escape.

Given the significant cost of installing a new field drainage system, cleaning ditches and clearing outfalls is a simple, cheap and effective method of improving the effectiveness of existing systems.

Ditches are best cleared in autumn to minimise soil and crop damage.

Ditch maintenance

Fencing off ditches and watercourses from livestock can reduce maintenance needs by preventing bank damage and erosion.

It can also protect water from sediment and microorganisms in livestock manures, which impact water quality and ecology.

Blocked outfalls

The most common cause of drainage system deterioration is the failure to keep outfalls clear. This can cause the whole drainage system to fail, resulting in poor drainage, pipe siltation and possibly even blow holes across the field over time.

Environment

Ditches can be an important habitat for aquatic plants, invertebrates, amphibians, birds and small mammals. Timing of clearance operations or ditch maintenance may have implications for wildlife. Avoid disturbing breeding or nesting animals.

Localised over-digging of ditch beds can form small shallow pools that benefit invertebrates. The ditch will function as long as it has stable banks, the overall gradient is consistent such that it does not reduce drainage efficiency and it is deep enough to allow drainage outfalls to discharge.

Figure 20. Cleaning ditches is a simple way of improving the effectiveness of drainage systems

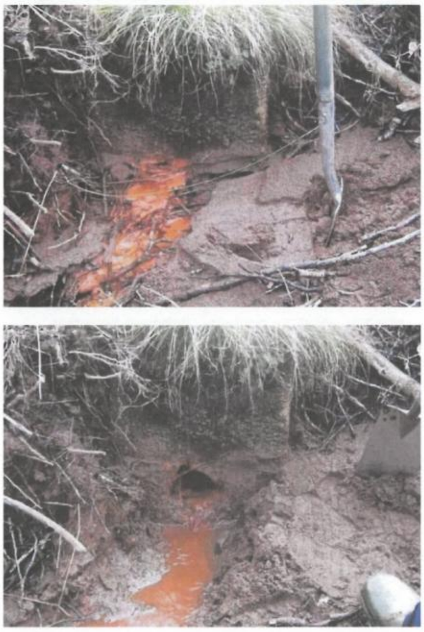


Figure 21. A blocked outfall can often be cleared in a matter of minutes with a spade

Pipes

Blockage by tree or hedge roots

When designing the drainage system, trees and hedges should be avoided wherever possible. When this is not possible, a sealed pipe should be used for any pipes within a tree rooting zone or within 1.5 m of a hedge.

If a blockage occurs, it may be possible to dig up the pipe on one or both sides of the blockage and use rods to clear the roots, but the section of pipe will often need to be replaced with a sealed pipe.

Environment

Take care to avoid unnecessary damage to tree roots or disturbing archaeological remains.

Pipe siltation

If drain outfalls are left submerged or blocked for a long period of time, siltation of the pipes may occur. This can be difficult or impossible to remedy.

Other than as a result of damaged or blocked pipes, siltation most commonly occurs on fine sandy and fine silty soils.

If pipe siltation is not too severe, it may be possible to rod the drains clear or to employ a contractor with specialist drain jetting equipment.

Figure 22. Silted clay drain

Where pipe siltation is a naturally recurring problem, a drainage system with separate outfall pipes for each drain is best. This allows easier access for cleaning operations.

Figure 23. Drain jetting

Ochre

Ochre is a generic term used to describe deposits that form in drains when soluble iron leaching out of the soil in drainage water comes into contact with air and is oxidised, at which point it becomes insoluble. It can also be caused by bacterial growths that secrete iron.

In some cases, a drainage scheme may fail completely due to ochre accumulation. In these cases, redrainage is only worthwhile if future ochre development is unlikely.

Preventing ochre formation

- Soils rich in iron may be prone to ochre and there is little that can be done to prevent ochre formation
- There are methods that attempt to prevent the build-up of ochre, but these can be specialist, intensive and often not very successful

Removing ochre

- Regular rodding or jetting may remove the ochre
- If the pipe slots or permeable fill is blocked, the benefits may be limited or nil

Design

- Where ochre is a problem, systems with separate outfall pipes for each drain are best, as they allow easier access for clearance operations

Figure 24. Drainage outfall blocked by ochre

Replacing field drains

When replacing a field drain, the same diameter (or metric equivalent) drain should be used as the drain being replaced. If the drain is a carrier drain or culvert, increasing the pipe diameter would reduce the risk of blockage or excess flows collapsing the pipe in the future. However, care may be needed to avoid increasing flood risk downstream. Expert advice should be sought if in doubt.

Mole drains

Mole drains are unlined channels formed in a clay subsoil. They are used when natural drainage needs improving in particularly heavy or calcareous clay subsoils that would require uneconomically closely spaced pipes for effective drainage.

Mole drains act as closely spaced pipe drains and conduct water to the permanent pipe drains or direct to open ditches.

Mole drains are not suitable for controlling rising groundwater or areas prone to flooding.

Soils should have a minimum of 30% clay for best results. Clay gives the soil the ability to hold together and reduces the chances of the channel collapsing after the mole is pulled.

Sand content should be less than 30%. The soil should be free of stones at the mole drain depth.

Mole drains are formed by dragging a 'bullet' (effectively, a round-nosed cylindrical foot shaped like a bullet, with slight tapering towards the tail) followed by an expander (a cylindrical plug of slightly larger diameter than the bullet) through the soil to form a circular semi-permanent channel – i.e. a natural pipe with fissuring in the soil above the channel.

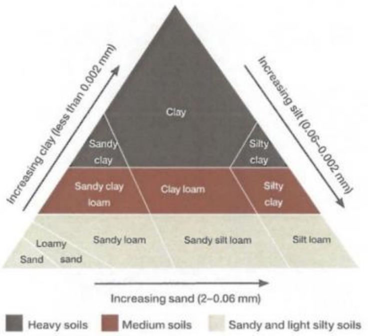


Figure 25. Soil texture classification
Source: Controlling soil erosion (Defra, 2005)

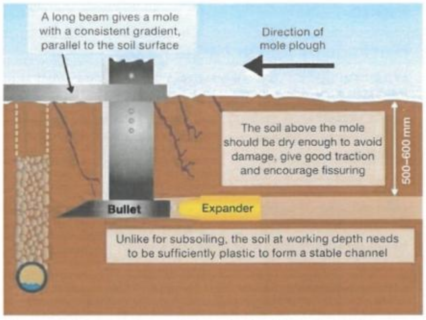


Figure 26. Appropriate conditions for forming mole drains

How long do mole drains last?

The longevity of mole drains depends on a number of factors, including:

- Soil texture (high clay content is better)
- Soil calcium content (high levels of calcium will increase longevity)
- Climate (wetter conditions will reduce longevity)
- Slope (too shallow or too steep will reduce longevity)
- The moisture conditions in which the moles were formed

Mole channels in very stable, clay soils (clay content ~45%) can last over 10 years, but the method can still be effective in soils with at least 30% clay, particularly calcareous soils.

Typical lifespan in suitable soils ranges from five to ten years, but it can be reduced where patches of sandier soil occur, leading to premature collapse. Bad soil management can seal off the routes by which water reaches the mole drains.

If the pipe drainage system was designed to be supplemented by mole drains, it is good practice to renew mole drains on a cycle of around once in every five years.

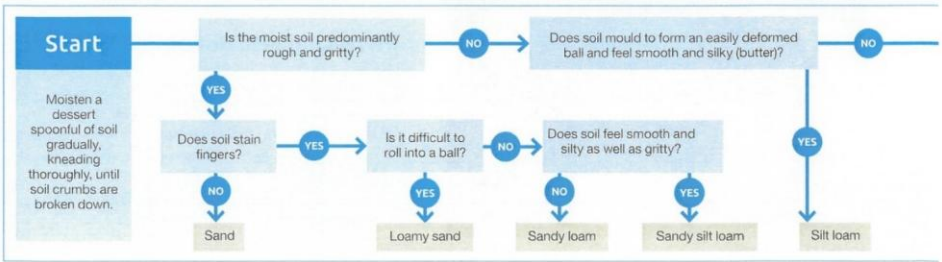


Figure 27. Appropriate conditions for forming mole drains
Source: Controlling soil erosion (Defra, 2005)

Installing mole drains

1. Suitable conditions

To achieve satisfactory results, the soil in the vicinity of the mole channel needs to be moist enough to form a channel but not dry enough to crack and break up and not soft enough to slough off and form a slurry.

Moling should be undertaken when:

- The soil at working depth is plastic, i.e. it forms a 'worm' without cracks when rolled on the hand
- The soil surface is dry enough to ensure good traction and avoid compaction

The drier the soil above moling depth, the greater the fissuring produced and the more efficient the water removal.

These conditions are most likely to arise during May to September/October, depending on the season and location.

2. Depth

Optimum mole depth depends on the soil type and the conditions when the moles are installed.

Generally, moles are pulled at 500–600 mm depth. Often, when first mole draining, the shallower depth is used, due to tractor limitations in tight, compacted soils. As the soil structure improves over time, they can often be pulled deeper, although care must be taken not to damage piped drains.

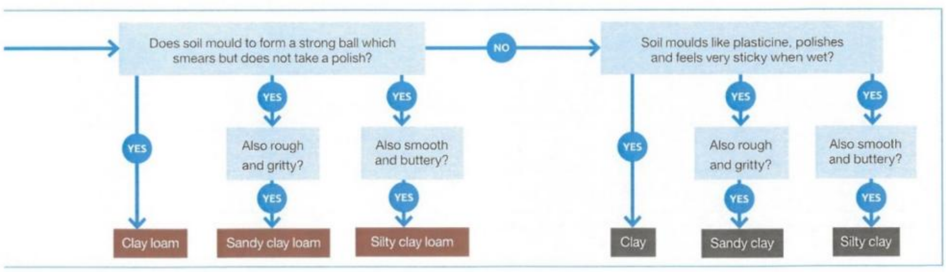
Moles less than 400 mm deep are liable to be damaged by tractors and animals during, or immediately after, rain and tend to be short-lived.

A rule of thumb is that the expander to mole-draining depth ratio is 1:7 (for example, a 70 mm diameter should have a mole depth of 490 mm).

3. Points to note

- It is essential that the 'bullet' is drawn through the permeable backfill over the pipe drains
- The mole plough should be in good condition, with minimal wear to the 'bullet' and tip
- Set up the mole plough so the 'bullet' is parallel to the ground surface when at working depth; a poorly set up mole plough will produce a poor channel and increase the draught requirement
- If the soil is liable to smearing, removal of the expander will reduce channel smearing, increasing the potential for water to enter the mole drain and reducing draught requirements
- When moling, dig a pit to expose the channel formed; it should be round and there should be fissuring above it
- Install moles at 2–3 m spacing, or closer on unstable soils
- Moles should be drawn up and down the slope across the lateral drains, making sure that they cross and connect with the permeable backfill over the drains
- Pull the plough out as soon as the mole plough has crossed the last drain: blind ends accumulate water
- If large stones are encountered, pull all the moles uphill and pull out after the channel has been disrupted

To aid decision-making, keep a record of where at least one of the most recent mole drains was pulled to allow examination of the mole drains by excavating a profile pit. This should be done just downslope of a lateral drain and, if still functioning, the mole drain should be reinstated afterwards with a short length of pipe.



Renewal and installation

Figure 28. Installing land drains and stone backfill

Factors to consider when designing a new drainage system

Drain depth

In slowly permeable soils, research has shown that (unless there is a specific crop need) lateral drain depths greater than 0.75 m give no additional benefit. Drains simply need to be deep enough to avoid damage from soil implements.

In permeable soils, where the drains control the depth of the water table, deeper drains allow the spacing between drains to be increased. Drain depths in such soil types are typically 1.2–1.5 m.

Maximum drain depth is often limited by the depth of the ditches or watercourses into which the drains discharge. These can be deepened, but only to the level of the downstream channel.

Figure 29. Recently installed drains

Drain spacing

Drain spacing has always varied according to local custom, but it has become more standardised in recent years. The correct spacing can be calculated using theoretical equations, but this is not often done in practice.

In heavy clay soils, the theoretical correct drain spacing will almost always be so small as not to be economically viable. Where soil conditions are appropriate, wide-spaced drains with permeable backfill supplemented with mole drains are the best choice. Pipe drain spacing for a mole drainage system can be as wide as 80 m, although 40 m is more typical. The main limiting factors are soil stability and landform.

On land with soils not suitable for moling, a modern system would have a spacing of 20–25 m with permeable backfill over the drains. The effectiveness of this type of system will rely greatly on maintaining good soil structure, sometimes aided by subsoiling.

Figure 30. Installing mole drains

If permeable backfill is not used, drain spacing in the region of 10 m will be needed, but this is unlikely to be as effective as a scheme using permeable backfill.

In permeable soils with a rising groundwater, the drain spacing will be determined by the depth of the drains and the level at which the groundwater is to be controlled. Permeable backfill is not usually needed.

Outfall availability and gradient

Outfall availability and gradient have an impact on the efficiency of the drainage system. As a comparison, a bath/shower is designed to slope and has a strategically positioned plughole (outfall) to drain the water. Lack of available outfall and/or gradient to enable water to drain away materially affects the efficiency of the field drainage system.

Drain diameter

In the UK, drain diameters are calculated using the procedures set out in MAFF/ADAS Reference Book 345 (The design of field drainage systems). This method takes account of:

- Soil type and slope: speed of water movement
- Land use: the degree of risk that is acceptable depending on the crop value
- Climate: rainfall intensity
- Type of drainage system: for example, mole drains must not be left submerged for more than 24 hours and, therefore, excess water must be evacuated rapidly

The rainfall figures used in the method set out in MAFF/ADAS Reference Book 345 are now outdated and in some areas may not match current rainfall patterns. They also take no account of potential future increases in storm intensities due to climate change. However, these remain the current guidelines.

Figure 31. Installing land drains with laser gradient control

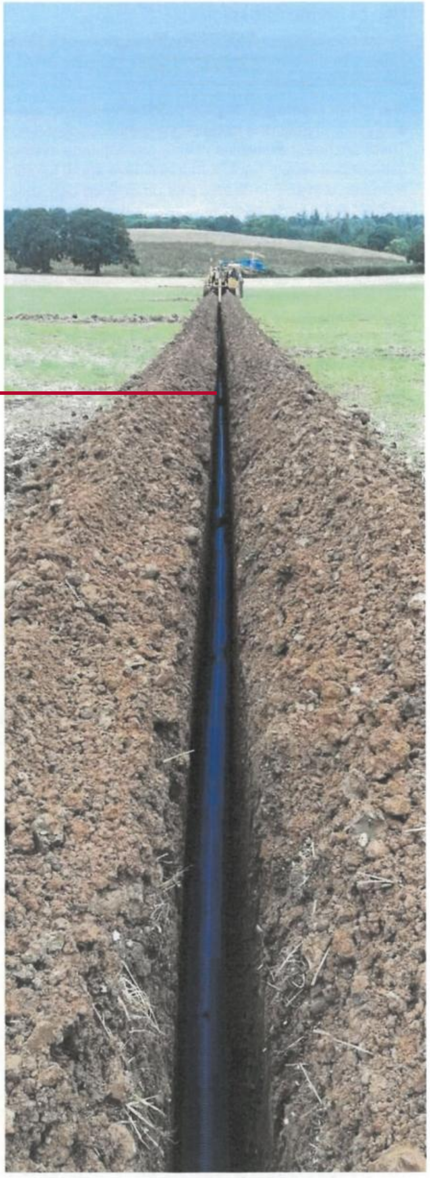


Figure 32. Install drains at an appropriate depth and constant gradient (fall)

Renewal and installation

Use of permeable backfill

Permeable backfill refers to the gravel/stone chippings applied to the trench above the drain, typically to the base of the topsoil.

The use of permeable backfill has been a long-debated subject, primarily due to the significant associated cost. There are many examples of very old drainage systems without permeable backfill that still have some function; however, research indicates that on drained clay soils without permeable backfill, while the drains may initially function well, the permeability of the soil in the drain trench decreases with time.

Best practice is to install sufficient permeable backfill so that a connection exists between the drain trench and the cultivated layer. As a minimum, the permeable backfill layer should connect with the mole drains or any fissures caused by subsoiling.

If mole drains are to be installed over the pipes, the use of permeable backfill is essential to provide a hydraulic connection between the mole channels and the drain.

The performance of drains installed without permeable backfill cannot be rejuvenated by subsoiling.

The one circumstance where permeable backfill is never required is where the function of the drainage is to control a rising water table in a coarsely textured soil.

Figure 33. Mole plough

Figure 34. Permeable backfill in trench over drain

Site

Field drainage should be planned carefully to avoid negative impacts on water bodies used for drinking-water abstraction, fisheries or Sites of Special Scientific Interest (SSSIs) sensitive to raised nitrate levels. Field drains and outfalls could be designed to discharge into a wetland buffer area before flows enter a watercourse or be directed away from sensitive water bodies. Field drains should not be installed within at least 10 m of a slurry or silage store.

Sustainable drainage systems (SuDS) or novel approaches, such as bioreactors, can be used with field drainage systems to trap sediment and slow water/soil run-off and to filter pollutants in drainage water.

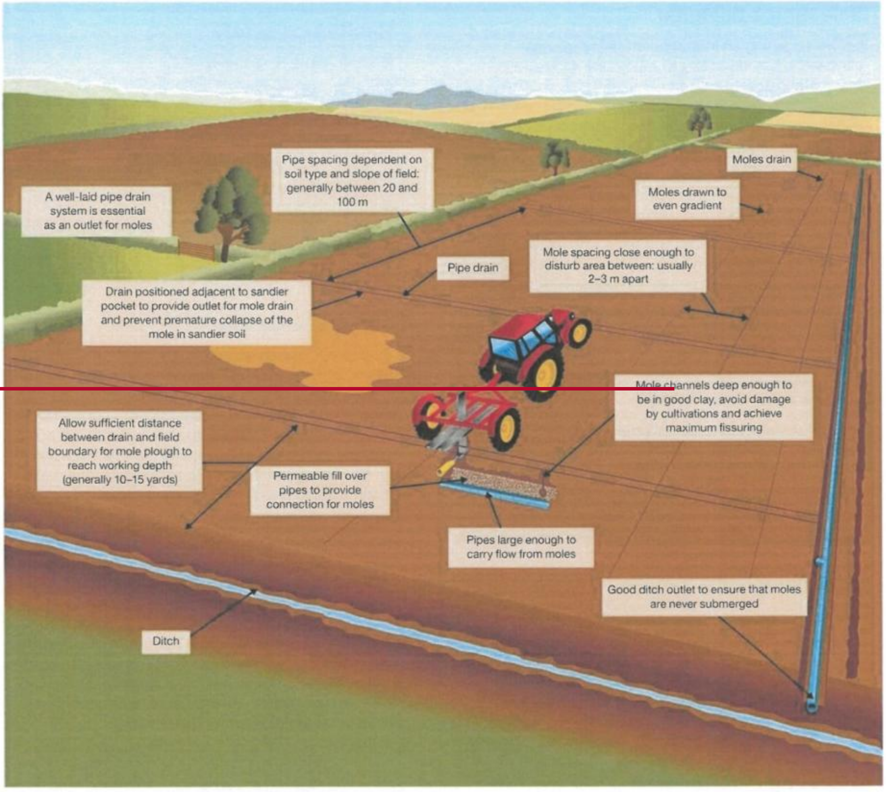


Figure 35. Layout of piped drainage and mole drains

Environment

Outfalls

New outfalls should be positioned sensitively at ditches and ponds to avoid damaging habitat. Land drains should not divert water away from areas that may depend on this water for drinking, washing or habitat. Diverting flows can also increase the risk of flooding and infrastructure failure.

Conservation

A new drainage scheme can provide an opportunity to create new conservation features. Old farm ponds that have silted up could be reopened to provide a habitat and catch pit for eroding soils, and ditches could be over-dug into localised ponds.

Government-funded schemes may be available for a range of land management options and capital items that can be used to reduce the negative impacts of field drainage on water quality or to create/improve wetlands and ditch habitats. These include the creation of wet grassland, ditch management and buffering of water bodies. For more information, see **gov.uk/guidance/countryside-stewardship-manual**

Selecting a designer

Before engaging an independent field drainage consultant, it is important to determine if they have adequate experience and qualifications. A specialist designer will have a thorough understanding of the needs and management of the soils, as well as of field drainage.

To enable them to determine if a new drainage system is required or whether maintenance of the existing system and/or improved soil management may be adequate to resolve the problem, a designer should always:

- Discuss any problems you have with the site and how you intend to manage the site in the future
- Survey the soil types, soil conditions, existing drainage systems, field topography, proximity to utility services and other features that may affect the final design
- Consider potential environmental impacts, drainage law and economic feasibility

Given the scale of the investment that a new drainage system represents, it is recommended that independent advice is sought with regard to the design.

Using an experienced consultant designer will ensure that the scheme is the best and most economically appropriate to meet the requirements.

Environment

Archaeological features can be damaged by field drain installation and drains may conflict with the conservation of a wetland or water habitat or species. Where relevant, contact Natural England, the drainage authority or a county archaeologist before commencing work.

Selecting a contractor

To install a new comprehensive field drainage system, it is essential to employ a specialist land drainage contractor with access to specialist machinery that can install and backfill drains rapidly. A drainage machine shapes the trench bed and can set a consistent gradient, even in the flattest of fields. A specialist contractor should fully understand field drainage requirements and employ the approved standards and materials.

The National Association of Agricultural Contractors (NAAC) is a trade association and has a list of members on its website (**naac.co.uk/findacontractor**) which can be a useful starting point for selecting a land drainage contractor. Not all drainage contractors are members of the NAAC, however.

Recommendations from others in the local farming community can be another helpful source of information.

Contractors may have different approaches to dealing with the scale, access and physical aspects of the location, so quotes may vary.

Health and safety

It is advisable to request:

From the contractor:

- A risk assessment and method statement (RAMS)
- Verification that they have sufficient public liability insurance cover

From the designer:

- Verification that they have sufficient professional indemnity insurance cover

Land drainage law

A landowner has an obligation to accept the natural flows of water from adjoining land and must not cause any impedance to these flows that would cause injury to adjoining land. 'Natural water flows' refers to water that has not been diverted from its natural path, artificially increased or had the run-off flow rate changed (e.g. by the construction of unauthorised paved areas within the catchment).

This means that if a landowner neglects or fills in their ditch, such that water may not freely discharge from higher neighbouring land, the landowner is guilty of causing a nuisance. In this situation, the landowner or occupier of the higher land may ask the Agricultural Land Tribunal to make an order requiring the landowner guilty of nuisance to carry out the necessary remedial works. It must be emphasised, however, that it is usually far better to attempt to resolve such situations by amicable discussions with the offending party first, as they may be unaware of the nuisance.

If the neglected ditch in question runs directly along the boundary between respective ownerships, the assumption that would be made is that the owner of the original hedge is also the owner of the ditch. On watercourses, the ownership boundary is assumed to be down the middle of the bed. Only clear evidence to the contrary, such as the deeds to the land, will rebut this assumption.

No ditch or watercourse should be piped, filled in, restricted or diverted without the approval of the regulatory authority, for example, the local authority or the EA, NRW, SEPA, NIEA or the local internal drainage board. Consent may be needed for works within 8–10 m of the bank top of a watercourse. Uncultivated or semi-natural land is protected under the Environmental Impact Assessment Regulations (Agriculture) and should not be drained without prior approval from the relevant national body.

Standards, materials and quality

There are two fundamental standards to which any designer will be working:

- Reference Book 345: The design of field drainage pipe systems (MAFF/ADAS, 1982)
- Technical Note on Workmanship and Materials for Land Drainage Schemes (ADAS, 1995)

Within these primary standards, there will be a number of decisions to be made about the design specification.

Pipe type

Currently, all new drainage schemes are installed using plastic pipes, although many older schemes were installed with clay pipes and may be replaced with the same.

It is essential that a material designed for use in field drainage is used.

Consideration should be given to the use of twin-wall or ductile iron pipes or gravel pipe surround where there is a risk of pipe crushing.

Figure 36. Modern perforated plastic drainage pipe

Permeable backfill type

- The material used must be hard and durable when wet and when dry
- The bulk of the material should be in the range 5–50 mm
- The material should not contain more than 10% fines

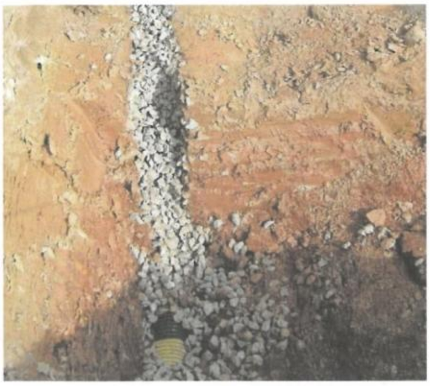


Figure 37. Washed gravel permeable fill over drain

Outfall type

Most modern outfalls are installed with glass-reinforced concrete headwalls; however, the actual outfall type may vary according to its location.

Figure 38. Precast concrete headwall (type K)

Filter wrap

Filter wrap is a geotextile barrier around the outside of the pipe to prevent soil particles entering the drain. It is not commonly used in the UK, as research has shown that pipe sedimentation is not usually a problem if the pipes have been laid and maintained properly. There are, however, some cases with fine, sandy soils when filter wrap can be beneficial.

Filter wrap should never be used where there is a risk of ochre.

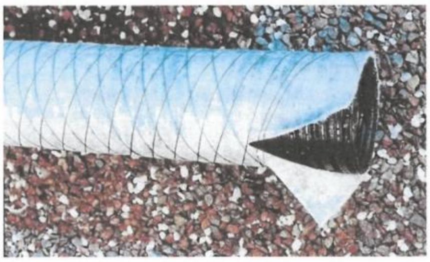


Figure 39. Single-wall pipe wrapped in geotextile

Case studies

Molescroft Farm, Beverley, East Yorkshire

The farm

- 485 ha farm with deep loam and alluvial clay soils
- Land is at or below 5 m above sea level and suffers from waterlogging
- Arable cropping: wheat, barley, oilseed rape, field beans and vining peas
- 10% of the farm is in Higher Level Stewardship and grazed by cattle and sheep appropriate to meet the requirements

The problem

The problem field had a full tile drainage system installed in the 1980s, but:

- Wet patches had started to appear
- Crops had to be drilled early to avoid soil damage and poor establishment
- The cost of weed control had increased due to the lack of opportunity for stale seedbeds
- Recent wet seasons had resulted in patchy crops with increased weed problems and soil damage

The main drain was found to be completely blocked by willow roots and some tiles were misaligned.

The solution

The solution was to drain a 6 ha area of the field, with new plastic pipes installed between the existing tiles and gravel backfill used to improve effectiveness.

The outcome

- New drainage has made the field far easier to work and manage
- It was the highest-yielding field in the following harvest year
- Lower inputs of herbicides were required

The cost

The total cost of the upgrade was £14,500 (£2,417/ha).

Maintenance costs estimated at approximately 1% of capital cost (£25/ha/year).

Benefits estimated at a total of £229/ha/year:

- Typical yield increased from 7 t/ha to 8.75 t/ha, a total of £175/ha/year
- Herbicide costs were reduced by £30/ha/year
- Better soil structure reduced subsoiling costs by 25%, saving £3/ha/year, and cultivation costs by £21/ha/year

Simple payback period

$$\frac{\text{Cost}}{\text{Benefits}} = \frac{£2{,}417}{£229 - £25} = 12 \text{ years}$$

Comment

Once the investment has been paid off, the benefits may continue to be received for many years (provided maintenance is sustained).

These calculations assume average changes to costs and returns; however, extreme weather will have a far greater effect. It is difficult to factor in random occurrences, such as the avoidance of significant crop loss due to waterlogging, and the decision to invest in drainage should be made on a field-by-field basis. The costings do not take into account the cost of finance or increased land value.

Evershot Farms Ltd, Melbury Osmond, Dorset

The farm

- 1,500 ha farm, largely on heavy, poorly drained soils
- Rainfall is over 1,000 mm/year
- Stocking: 900 cows and 2,500 mule ewes; heifers are contract reared off the farm
- Cropping: mainly grassland with about one-third cut for silage; maize is no longer grown
- The farm has a 750 kW biogas plant

The problem

The aim is for cows to be turned out in late March and housed from mid-September, but the grazing season can be very variable from year to year.

Maize was causing significant soil damage.

The solution

The solution was to replace maize with Italian rye-grass, introduce whole-crop wheat to balance the ration (and save on purchased straw) and drain a 10.2 ha field, including:

- A main drain with laterals and headwalls at outlets
- Digging out the ditches downstream to obtain sufficient fall
- Moling to increase connectivity every five years at reseeding

The outcome

- Soil problems are now avoided and increased rainfall infiltration minimises run-off
- The field is accessible two weeks earlier and for two weeks longer
- The Italian rye-grass has increased yield (from 37 t/ha to 45 t/ha) and forage value
- Reduced risk to operations and increased forage quality and dry matter yield

The cost

The total cost of the drainage was £5,245/ha (£48,500 for the drainage, plus £5,000 on ditching), plus maintenance at £52/ha and additional annual silage-making costs of £132/ha.

Benefits estimated at a total of £595/ha/year:

- The change from maize to grass silage has produced a higher dry matter yield and greater forage value from four cuts
- The change to Italian rye-grass resulted in an increase in forage value
- Cultivation savings:
  - Moving to grass, the cultivation savings were £105/ha/year
  - The average annual cost of moling was the same as subsoiling
- Forage savings (total of £490/ha) from:
  - Increased value of silage (at previous yield level): 37 t/ha at £4/t gives £148/ha
  - Increased yield of silage: 8 t/ha at £34/t gives £272/ha
  - Value of additional grazed forage: £70/ha

$$\frac{\text{Cost}}{\text{Benefits}} = \frac{£5,245}{£595 - £52 - £132} = 13 \text{ years}$$

Comment

Once the investment has been paid off, the benefits may continue to be received for many years (provided maintenance is sustained).

These calculations ignore the potential for extreme weather, without drainage, to result in significantly lower forage yields, soil damage and increased housing and forage requirements. Wet conditions during silage making can result in contamination from soil, leading to poor fermentation, poor milk yield and potential health problems. The costings do not take into account the cost of finance or increased land value.

Glossary

Compaction	The process by which the soil density increases due to trafficking or soil working when conditions are unsuitable, i.e. too wet
Culvert	A short length of pipe installed to allow access over the ditch or watercourse
Drain jetting	Removal of deposited sediment from a drain using a high-pressure water jet
Field capacity	The moisture content of the soil after excess water has drained away
Filter wrap	A geotextile barrier wrapped around the pipe to prevent particles entering the pipe
Friable	Soil where the aggregates crumble easily into smaller pieces
Infiltration	Water entering the soil e.g. through rainfall
Laterals	The drains installed, usually parallel to each other, to intercept soil water and transport flows to the main drain
Mains	Drains installed to collect the water from several laterals and transport it to a ditch
Mole drains	Unlined channels formed in a clay subsoil
Natural water flows	Water that has not been diverted from its natural path, artificially increased, or had the run-off flow rate changed, such as by the construction of unauthorised paved areas within the catchment
Ochre	Insoluble deposits that form in drains when soluble iron leaches out of the soil, into drainage water, and becomes oxidised. It can also be caused by bacterial growths that secrete iron
Outfall	Point at which the main drains or individual laterals discharge into a ditch
Percolation	The process of water moving down through the soil to depth
Perched water table	Saturated layer above compacted soils
Perforated drainage pipe	A slotted drainage pipe, which is used to collect water from the soil
Poaching	Damage to the soil surface caused by animal hooves
Slaking	The collapse of the soil aggregates as the soil wets up rapidly
Water table	The saturated zone of the soil

Further information

Other sources of information

Catchment Sensitive Farming:
gov.uk/catchment-sensitive-farming

Catchment Sensitive Farming officers provide free advice and support to farmers in priority catchments to reduce water pollution. This includes information on soil and water management and a review of field drainage.

National Association of Agricultural Contractors (NAAC):
naac.co.uk

Think soils (Environment Agency):
ahdb.org.uk/thinksoils

A guide to better soil structure (Cranfield University):
www.landis.org.uk/downloads

Geographic information for Great Britain:
magic.gov.uk

Countryside stewardship manual (Natural England):
gov.uk/guidance/countryside-stewardship-manual

Environmental permits for flood defence:
gov.uk/permission-work-on-river-flood-sea-defence

Guidance on owning a watercourse:
gov.uk/guidance/owning-a-watercourse

Flood and coastal erosion risk management R&D (Environment Agency):
gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2

Pinpoint best practice information sheets (The Rivers Trust):
theriverstrust.org/our-work/farm-advice/best-practice-advice-sheets-for-farmers

Constructed farm wetlands: A guide for farmers and farm advisers in England (Wildfowl and Wetlands Trust):
wwt.org.uk/farmwetlands

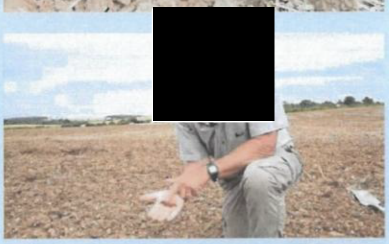
Sustainable drainage systems: Maximising the potential for people and wildlife (RSPB and Wildfowl and Wetlands Trust):
www.wwt.org.uk/uploads/documents/2019-07-22/1563785657-wwt-rspb-sustainable-drainage-systems-guide.pdf

Godwin, R. J. and Spoor, G. (2015). Choosing and evaluating soil improvements by subsoiling and compaction control. In Ball, B. C. and Munkholm,L. J. (eds). *Visual Soil Evaluation: Realising Potential Crop Production with Minimum Environmental Impact.* CABI, Wallingford, UK.

Video demonstrating the principles of subsoiling

AHDB Pork has produced a series of videos demonstrating the general principles of subsoiling. The videos look at cultivation depth, choice of machine and the effects of tines and wings.

The videos are available to watch online at **youtube.com/AHDBPork** and on the Practical Pig app (**practicalpig.ahdb.org.uk**).



Further information

AHDB GREATsoils

AHDB provides a range of practical information on improving soil management for farmers, growers and advisers. Whether you need an introduction to soil biology or a detailed guide to soil structure, AHDB has the information and guidance to support you.

Information for grassland, pig producers, arable and horticultural crops is available at **ahdb.org.uk/greatsoils**

Visit ahdb.org.uk to:

- Find resources on our **knowledge library**
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- Visit **farm events and agricultural shows**
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APPENDIX SMP9

Extracts from MAFF's ALC Guidelines

Ministry of Agriculture, Fisheries and Food

Agricultural Land Classification of England and Wales

Revised guidelines and criteria for grading the quality of agricultural land

OCTOBER 1988

SECTION 1

INTRODUCTION

The Agricultural Land Classification provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. The limitations can operate in one or more of four principal ways: they may affect the range of crops which can be grown, the level of yield, the consistency of yield and the cost of obtaining it. The classification system gives considerable weight to flexibility of cropping, whether actual or potential, but the ability of some land to produce consistently high yields of a somewhat narrower range of crops is also taken into account.

The principal physical factors influencing agricultural production are climate, site and soil. These factors together with interactions between them form the basis for classifying land into one of five grades; Grade 1 land being of excellent quality and Grade 5 land of very poor quality. Grade 3, which constitutes about half of the agricultural land in England and Wales, is now divided into two subgrades designated 3a and 3b. General descriptions of the grades and subgrades are given in Section 2.

Guidelines for the assessment of the physical factors which determine the grade of land are given in Section 3. The main climatic factors are temperature and rainfall although account is taken of exposure, aspect and frost risk. The site factors used in the classification system are gradient, microrelief and flood risk. Soil characteristics of particular importance are texture, structure, depth and stoniness. In some situations, chemical properties can also influence the long-term potential of land and are taken into account. These climatic, site and soil factors result in varying degrees of constraint on agricultural production. They can act either separately or in combination, the most important interactive limitations being soil wetness and droughtiness.

The grade or subgrade of land is determined by the most limiting factor present. When classifying land the overall climate and site limitations should be considered first as these can have an overriding influence on the grade. Land is graded and mapped without regard to present field boundaries, except where they coincide with permanent physical features.

A degree of variability in physical characteristics within a discrete area is to be expected. If the area includes a small proportion of land of different quality, the variability can be considered as a function of the mapping scale. Thus, small, discrete areas of a different ALC grade may be identified on large scale maps, whereas on smaller scale maps it may only be feasible to show the predominant grade. However, where soil and site conditions vary significantly and repeatedly over short distances and impose a practical constraint on cropping and land management a 'pattern' limitation is said to exist. This variability becomes a significant limitation if, for example, soils of the same grade but of contrasting texture occur as an extensive patchwork thus complicating soil management and cropping decisions or resulting in uneven crop growth, maturation or quality. Similarly, a form of pattern limitation may arise where soil depth is highly variable or microrelief restricts the use of machinery. Because many different combinations of characteristics can occur no specific guidelines are given for pattern limitations. The effect on grading is judged according to the severity of the limitations imposed by the pattern on cropping and management, and is mapped where permitted by the scale of the survey.

The guidelines provide a consistent basis for land classification but, given the complex and variable nature of the factors assessed and the wide range of circumstances in which they can occur, it is not possible to prescribe for every possible situation. It may sometimes be necessary to take account of special or local circumstances when classifying land. For this reason, the physical criteria of eligibility in this report are regarded as guidelines rather than rules although departures from the guidance should be exceptional and based on expert knowledge. Physical conditions on restored land may take several years to stabilise; therefore, the land is not normally graded until the end of the statutory aftercare period, or otherwise not until 5 years after soil replacement.

To ensure a consistent approach when classifying land the following assumptions are made:

1. Land is graded according to the degree to which physical or chemical properties impose long-term limitations on agricultural use. It is assessed on its capability at a good[1] but not outstanding standard of management.

2. Where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate underdrainage system, the land is graded according to the severity of the remaining limitations. Where an adequate supply of irrigation water is available this may be taken into account when grading the land (Section 3.4). Chemical problems which cannot be rectified, such as high levels of toxic elements or extreme subsoil acidity, are also taken into account.

3. Where long-term limitations outside the control of the farmer or grower will be removed or reduced in the near future through the implementation of a major improvement scheme, such as new arterial drainage or sea defence improvements, the land is classified as if the improvements have already been carried out. Where no such scheme is proposed, or there is uncertainty about implementation, the limitations will be taken into account. Where limitations of uncertain but potentially long-term duration occur, such as subsoil compaction or gas-induced anaerobism, the grading will take account of the severity at the time of survey.

4. The grading does not necessarily reflect the current economic value of land, land use, range of crops, suitability for specific crops or level of yield. For reasons given in the preface, the grade cut-offs are not specified on the basis of crop yields as these can be misleading, although in some cases crop growth may give an indication of the relative severity of a limitation.

5. The size, structure and location of farms, the standard of fixed equipment and the accessibility of land do not affect grading, although they may influence land use decisions.

[1] Previously described as 'satisfactory'; no change in the assumed standard of management is intended.


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