Appendix I.5

Soil Management Plan

BODELWYDDAN BESS
AND SOLAR FARM

OUTLINE
SOIL MANAGEMENT PLAN

September 2025

KERNON
COUNTRYSIDE
CONSULTANTS
LIMITED

BODELWYDDAN BESS AND SOLAR FARM

OUTLINE SOIL MANAGEMENT PLAN

September 2025

Authorised By APK 09/25

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CONTENTS

1 INTRODUCTION

1.1 This Outline Soil Management Plan (oSMP) accompanies a Development of National Significance (DNS) planning application which seeks consent for the following Proposed Development:

"**The construction, operation and maintenance of a proposed solar photovoltaic electricity generating system and battery energy storage system ('BESS'), associated solar arrays, inverters, transformers, cabling, substations, access tracks, landscaping, ecological enhancement areas and associated ancillary development**".

1.2 The Site comprises two separate parcels of land located to the northwest (Solar Site) and southeast (BESS Site) of Bodelwyddan, which are linked by a Cable Corridor. The Solar Site is approximately 168.95 ha and the BESS Site is approximately 6.52 ha.

1.3 Soil is an important resource, however. This outline Soil Management Plan (oSMP) sets out the key principles for handling soils during the construction, operation and decommissioning phases of the Proposed Development.

1.4 The oSMP draws on the detailed soil and agricultural land classification undertaken by Mike Palmer of Land Research Associates (LRA).

Structure of the Report

1.5 The purpose of the oSMP is to set out the key principles, based on current design information, to ensure that there is no significant loss of agricultural land or soils, and no significant adverse impacts on soil resources, during the key stages of construction, operation and decommissioning.

1.6 This oSMP:

- describes the soils and land quality in section 2;
- sets out key principles in section 3;
- describes how to carry out soil suitability tests in section 4;
- sets out principles for construction compounds in section 5;
- sets out principles for the construction of the solar PV arrays and associated works in section 6;
- sets out principles for the BESS and substations in section 7;
- covers operational soil management in section 8;
- and key principles for the decommissioning phase in section 9.

1.7 Implementation of the principles will be the responsibility of the site manager.

2 THE SOILS AND LAND QUALITY

2.1 The Solar Site extends to 168.95 ha and wraps around an existing solar farm. The BESS Site extends to 6.52 ha and lies to the west of the existing National Grid Bodelwyddan substation south of Bodelwyddan.

Solar Site

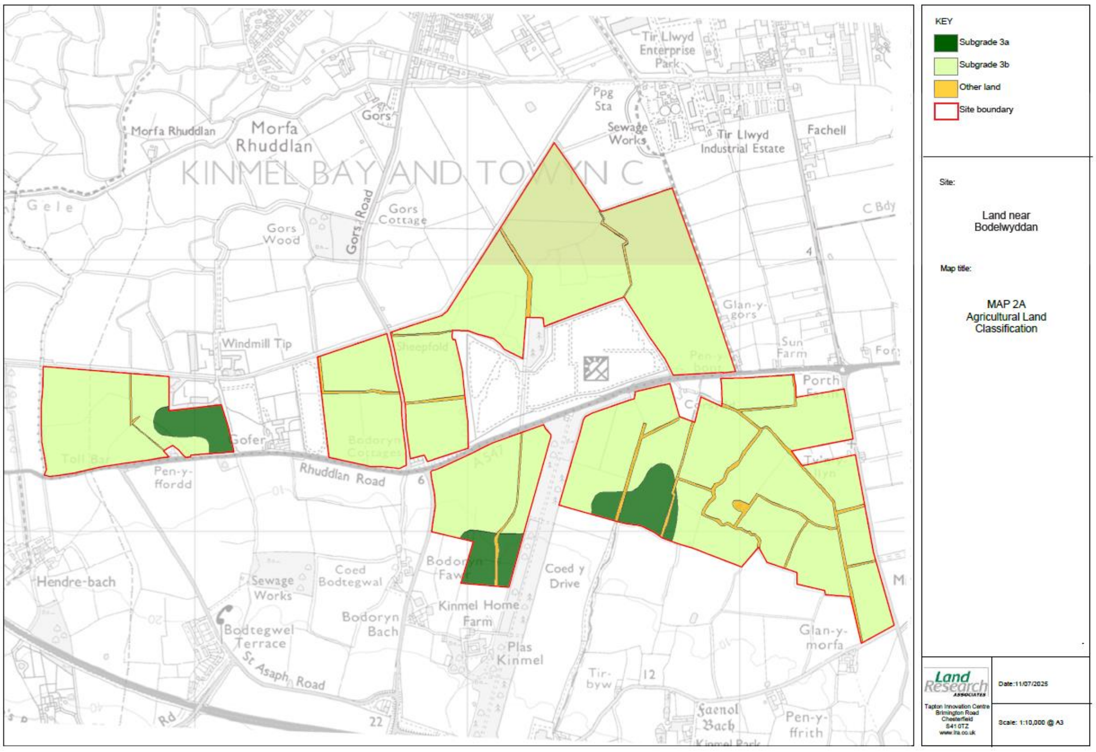
2.2 The soils across the majority of the Solar Site comprise alluvial clay soils, being soils formed in clayey marine alluvium. These soils are described as **Type A** soils, and dominantly comprise stoneless silty clay or clay topsoil (occasionally silty clay loam, sandy clay loam or clay loam), over clay or silty clay subsoils. The subsoils show evidence of seasonal waterlogging (greyish colours with ochreous mottles) to shallow depth. The subsoils are moderately porous and permeable at depth in places, but the upper layers are mainly weakly structured (dense) and slowly permeable.

2.3 In places more silty permeable soils were found. These are mainly interpreted as infilled tidal creek channels occurring in narrow isolated strips; in some patches in the north-west and south these areas are more extensive.

2.4 The southern part of the Solar Farm contained soils described in the ALC as fine loams over clay formed in glacial till. These are described as **Type B** soils and chiefly comprise very slightly stony medium clay loam or sandy clay loam topsoil and upper subsoil, over slowly permeable clay. The subsoils show greyish or pale colours with ochreous mottles at shallow depth and the slowly permeable clay typically occurs at less than 45 cm depth: these soils are judged poorly-draining under the local climate (Soil Wetness Class IV).

2.5 The ALC results are shown on Insert 1.

Insert 1: ALC Results, Solar Site

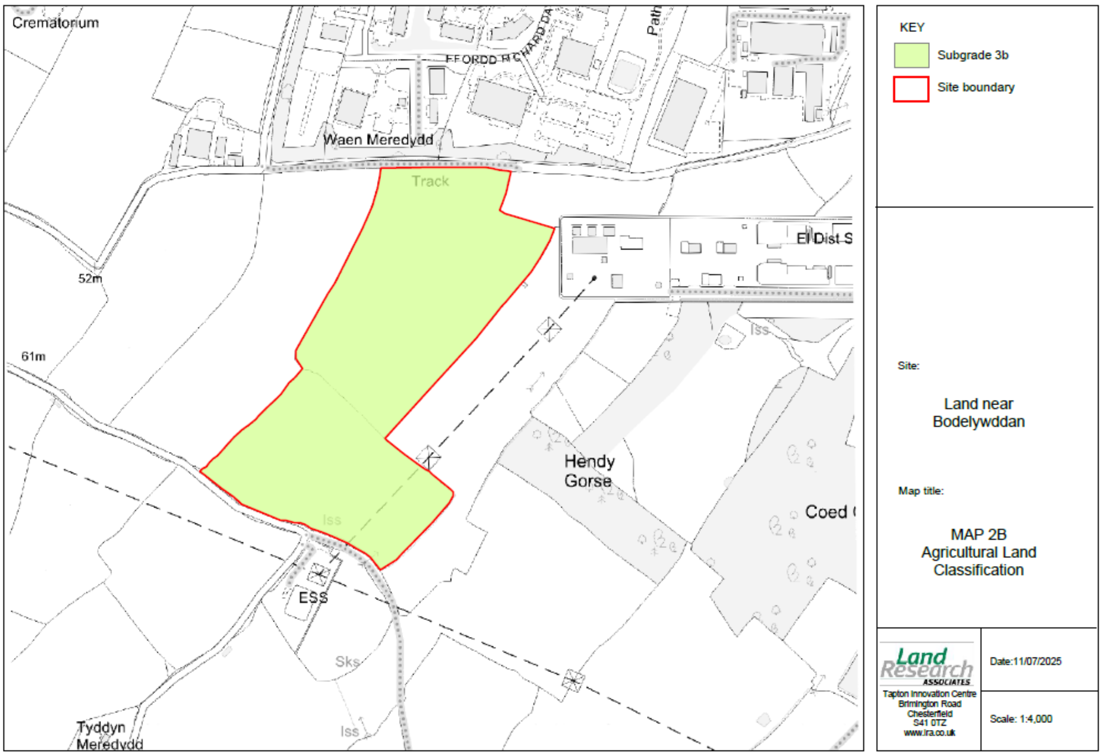


BESS Site

2.6 The BESS site is covered in **Type B** soils similar to the southern part of the Solar Site. Therefore the soils chiefly comprise very slightly stony medium clay loam or sandy clay loam topsoil and upper subsoil, over slowly permeable clay. The subsoils show greyish or pale colours with ochreous mottles at shallow depth and the slowly permeable clay typically occurs at less than 45 cm depth: these soils are judged poorly-draining under the local climate (Soil Wetness Class IV).

2.7 The ALC of the BESS Site is shown on Insert 2.

Insert 2: ALC Results, BESS Site



3 KEY PRINCIPLES

Guidance

3.1 The proposal comprises three principal works:

(i) the solar PV array areas, which will include the panel arrays, internal trenching, tracks, small items of equipment (such as power conversion boxes);

(ii) the BESS and substation transformer; and

(iii) the interconnecting cables.

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

- Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction, British Society of Soil Science (v 3 January 2022) (**Appendix SMP1**);
- Good Practice Guide for Handling Soils in Mineral Workings, The Institute of Quarrying (July 2021) (extracts in **Appendix SMP2**);
- Building on Soil Sustainability: principles for soils in planning and construction, Cornwall Council and others (September 2022) (**Appendix SMP3**).

Overview

3.3 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 the 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 these soils will be reinstated shortly after they are lifted out (ie this is a swift process).

3.4 For those areas where soil needs to be disturbed to create the bases for the various items of 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.

3.5 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 will be stored separately to the topsoil, and clearly marked. The soil pits shown earlier have identified that the topsoil is about 20-30cm deep across the whole site, with a clear colour distinction.

3.6 For the fixed equipment area, the topsoil stripped will be to a depth of 25-30 cm, as soil depths vary.

3.7 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.

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

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

<u>Timing</u>

3.9 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.

3.10 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 1: Soils Suitable for Trafficking

3.11 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 2: Soils not Suitable for Trafficking

3.12 Soils on this site are not suitable for being moved or trafficked extensively when they are wet.

3.13 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.

3.14 There is no significant difference between Type A and Type B soils, and therefore this oSMP advises that all the Site is treated in the same way. This means that, in general terms:

(i) a soil suitability test will be needed before works start (set out in section 4);

(ii) the land is likely to be too wet for extensive construction works between early November and mid-April.

3.15 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 significant times within those periods when soils will be too wet to handle.

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

3.17 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

3.18 The successful installation of cabling at depths of >60cm requires a trench to be dug into the ground. Topsoil 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 SMP4**) 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**".

3.19 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

3.20 This SMP 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

3.21 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.

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

3.23 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 3: Localised Restoration

3.24 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.

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

4 SOIL SUITABILITY TESTS

4.1 The topsoil across the site is mostly clay or clay loam. Clay loam soils are least resilient to structural damage if wet when they are handled or driven across, so their handling in this construction process needs to be done carefully.

4.2 As a key principle, soils should not be affected (by vehicle movement or by physical movement) when they are wet. To determine if soils are too wet the Soil Suitability test needs to be followed. This is set out in an extract from the Good Practice Guide for Handling Soils, and extracts are reproduced in **Appendix SMP2**.

4.3 The Field Test from Supplementary Note 4 has a typing error. The table from Work Sheet A is reproduced below, given its importance for these soils. This sets out the tests for Dry and Friable Soils.

Insert 3: Test for Dry and Friable Soils

Box A.3 - Test for Dry and Friable Soils

Soil tests are to be undertaken in the field. Samples shall be taken from at least five locations on 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 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 sample is moist (i.e. there is a slight 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 because the soil is too loose and wet means no soil handling to take place
- Possible - GO TO SECOND TEST

Second Test
Attempt to roll ball into a 3mm diameter thread by hand:

- Impossibe because soil crumbles or collapses means **soil handling can take place**
- Possible means **no soil handling to take place**

NB: It is impossible 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.

Box A.4 - Rainfall Criteria:

- In light drizzle soil handling many 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, after rain has ceased, soil tests shall be applied to determine whether handling may re-start, provided that ground conditions are safe to do so.

interruptions from rainfall events. The soil based criteria set out in Box A.4 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

A.4 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable safe and efficient operation. Otherwise the operation is to be suspended until suitable remedial measures can be put in place.

A.5 The operation should follow the detailed stripping plan set out in the SRMP showing soil units to be stripped, haul routes and the phasing of vehicle movements. The different soil units to be kept separate are to be marked out and information to distinguish types and layers, and ranges of thickness needs to be conveyed to the operational supervisor/operator. The haul routes and soil storage areas must be defined and should be stripped first in a similar manner. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

A.6 Within each soil unit the soil layers above the base/formation layer are to be stripped in sequential strips with the topsoil layer stripped first, followed by the subsoil layers; each layer stripped to its natural thickness without incorporating material from the lower layers. The next strip is not started until the current strip is completely stripped to the basal layer. The system involves the progressive stripping of the soil in strips (**Figure A.1**).

Unsuitable Soils

4.4 Clay soils are not suitable for widespread trafficking, or being moved, when they are saturated. As set out in the Suitability Test, if the soil rolls into a ball or, more easily assessed, a thread (basically a sausage) and keeps its shape, it is too wet to be handled.

Photos 4 and 5: Clayey Soils Too Wet to be Handled


4.5 Clay soils that are almost dry enough for being travelled across, in that they break up when pushed with a thumb, are shown below.

Photos 6 and 7: Clayey Soils Almost Sufficiently Dry


4.6 Clay soils when dry are impossible to roll into a ball or thread. An example of a clay soil is shown below.

Photos 8 and 9: Dry Clay Soils

5 TEMPORARY CONSTRUCTION COMPOUNDS

Construction Methodology

5.1 The temporary construction compounds (three in total) will be created at the start of construction and reinstated at the end. Construction compounds are built by either matting over the top of the topsoil, or by stripping topsoil and storing that in a bund on the edge of the site. A matting is then laid down, and stone imported and levelled, as shown below.

Photo 10: Newly-laid Construction Compound (Elsham-Lincoln Pipeline)

5.2 The matting prevents the stone from mixing with the subsoil, as shown below.

Photo 11: Matting

5.3 Topsoil if removed will need to be stored in a bund, as shown below. If soils are still wet when moved, the bund should be no higher than 1m, but otherwise temporary bunds should be no more than 3m in height, to protect the aerated nature of the soil resource.

Photo 12: Topsoil Storage Bund

Movement of Soils

5.4 The soils need to be sufficiently dry to handle. Guidance on determining soils suitability to be handled is set out in the Good Practice Guide for Handling Soils, **Appendix SMP4** and in section 4.

5.5 The soils across the site are not expected to be suitable for being moved between November and March, so the construction compound should be planned for being built outside that period.

5.6 The topsoils will be stripped to a depth of 20-30cm, and placed in bunds on the edge of the compound, as shown above.

5.7 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. Seeding should take place at a suitable time of the year, normally spring or autumn.

5.8 Therefore if the construction compounds are not to be removed before the wet weather in the following winter, 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 the following spring.

Photo 13: Grass-seeded Bund

Removal

5.9 The removal of the construction compound should be timed for dry weather.

5.10 At the end of the construction process, the aggregate will be removed.

5.11 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.

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

5.13 The underlying land quality will be restored and retained.

6 SOLAR SITE CONSTRUCTION WORKS

Tracks and Equipment Bases

6.1 The tracks will be created by placing a capping layer onto a geotexture membrane on top of the existing soil, as shown below, or with a shallow removal of topsoil with this spread either side.

Photo 14: Solar Farm Track (typical example)

6.2 The small areas of fixed equipment (eg power conversion units and 33 kV sub-distribution switchroom) will stand on concrete foundations or hardcore, requiring some removal of soil to create the hardcore foundation. Typical equipment is shown below.

Photo 15: Typical Transformer

6.3 Soil should be stripped when the soil is sufficiently dry and does not smear. This is a judgement that is easily made. Following the Suitability Test described above, if the soil can be rolled into a ball or a thread, and that holds its shape, the soil is not suitable for being worked. If the ball crumbles, or the thread breaks into small sections, or if the soil is too dry to roll into a ball or thread, it is suitably dry.

Solar PV Arrays

6.4 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 deeper than about 10cm when travelling across the land). This will be possible for most of the year, but is not likely to be possible 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 16 and 17: Ground After Construction

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

6.6 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.

6.7 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.

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

Photos 18 and 19: Example or Leg Piling and Panel Moving Equipment

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

6.10 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.

Photos 20 and 21: Horticultural Machinery

6.11 The objective is to get the surface to a level tilth for seeding/reseeding as necessary, as was shown earlier. Grass growth will then recover or establish rapidly.

<u>Trenching</u>

6.12 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 depths of up to 1.2m where soil depth permits, although the CCTV trenching around the periphery could be shallower. 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 22 and 23: Cable Installation

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

6.14 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).

Insert 4: 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)

<u>Fencing and Cameras</u>

6.15 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.

6.16 The site fencing for the Solar Site will be deer fencing. This can be erected at any time, if soil conditions allow. The following photographs show fencing installed early in the process.

Photos 24 and 25: The Fencing

6.17 Similarly CCTV poles are inserted in the same way.

Photos 26 and 27: CCTV Poles and Fencing

6.18 Fencing around the substation will be weldmesh with palisade fencing around the BESS.

6.19 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.

6.20 Any rutting that results from fencing can be made good with standard agricultural equipment.

Drainage Works

6.21 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.

6.22 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.

6.23 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.

6.24 The Agricultural and Horticultural Development Board advisory guide "Field Drainage Guide: principles, installations and maintenance" (2024) is reproduced in **Appendix SMP5**. 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).

6.25 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.

6.26 The land classification system 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 SMP6**.

6.27 Consequently any adverse effects on field drainage will not result in a downgrading or change to the ALC grading of the land within the Site.

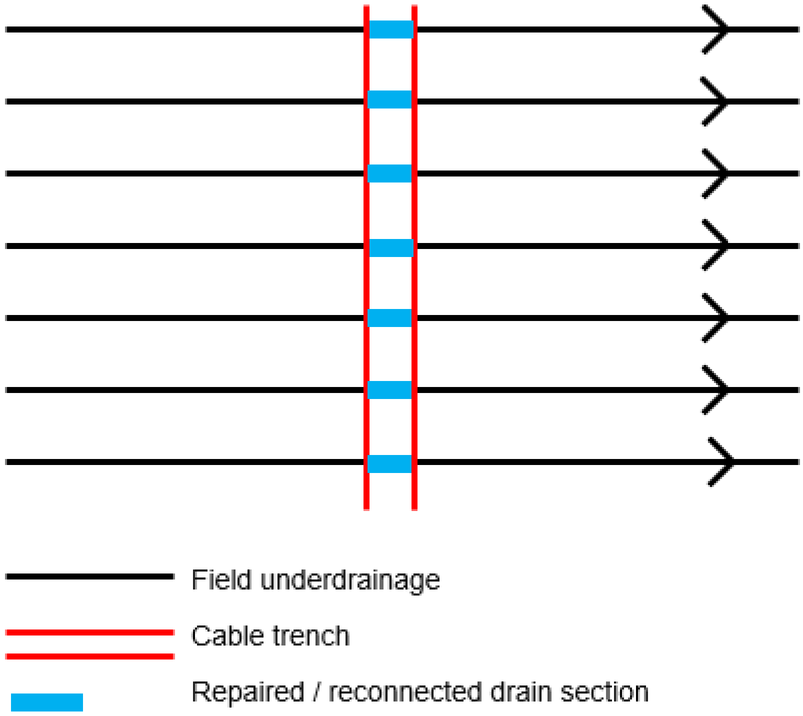
6.28 The installation of cabling will be supervised by an experienced advisor. He or she will know where to expect drainage, and will be able to identify if drainage pipes are broken as either clay pipe fragments or plastic pipe will be evident in the material dug out.

6.29 Those areas affected by cable damage should be repaired in one of two ways:

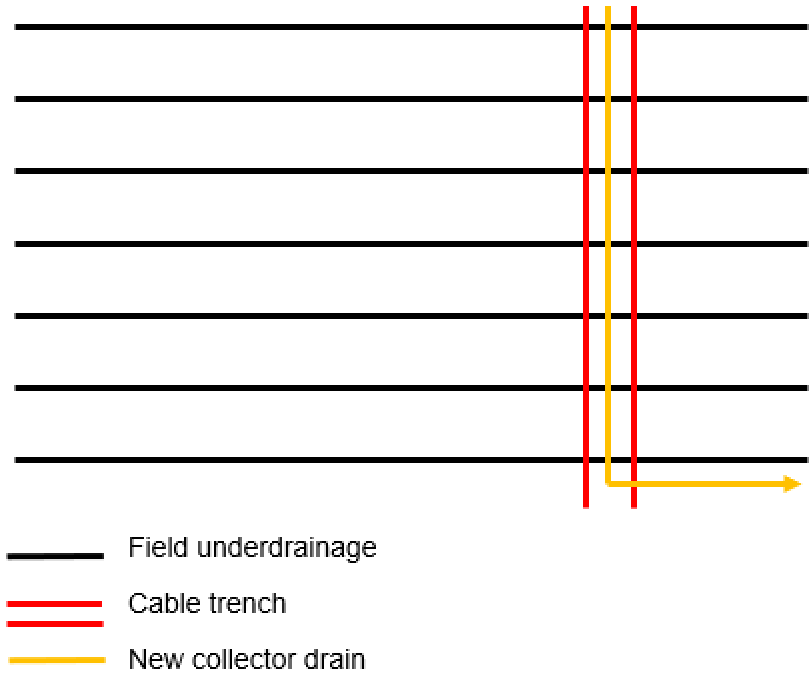
(i) either the individual drains will be reconnected with new sections across the pipe, as illustrated below;

(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 5: Drainage System Repair Option



Insert 6: Drainage System Repair Option



6.30 Drains affected by piling will be repaired locally, if required.

6.31 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.

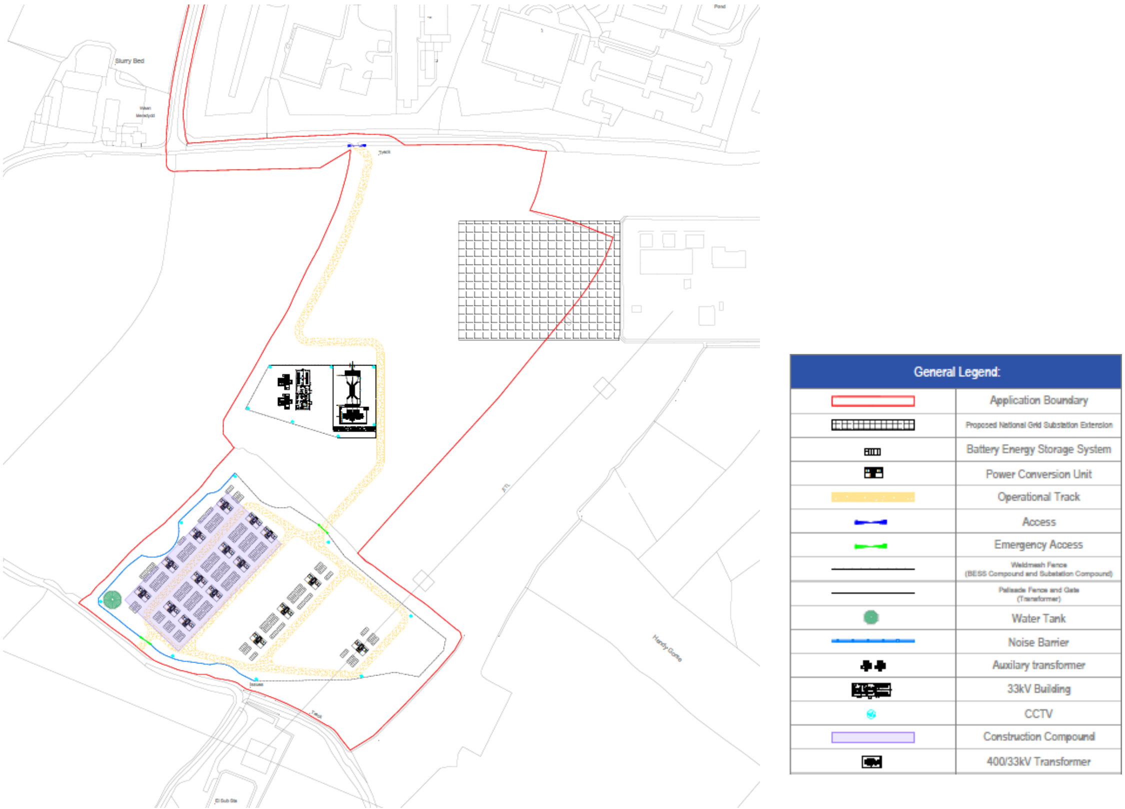
6.32 Allowing the land to drain less rapidly does not affect the operation of the solar farm. Vehicular access is normally only needed in the summer months, when panels are cleaned. Having under-field drainage working is not, therefore, important unless there are areas of standing water due to broken drainage.

6.33 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.

7 BESS

7.1 The layout of the BESS and related equipment is shown below, from the application plans.

Insert 7: Extract from BESS Proposals



7.2 These works involve only part of the site area surveyed.

7.3 The soils in this area are all similar. Therefore there is no requirement to separate topsoils, and all topsoil removed when creating operational tracks and as bases for the energy storage system and fixed equipment can be stored in one place if required.

7.4 Topsoil will need to be stripped for creating the base for the energy storage area. The topsoil depth, as recorded in the ALC, is 22 – 28cm across this area, so an average of 25cm. This will be stripped and a base created, in a similar manner to the temporary construction compounds, and as in the example below.

Photo 28: Example Base Construction

7.5 The topsoil will need to be stored in aerobic conditions. An example of bund construction, taken from Work Sheet B of the Institute of Quarrying's Good Practice Guide, is shown below.

Insert 8: Bund Construction

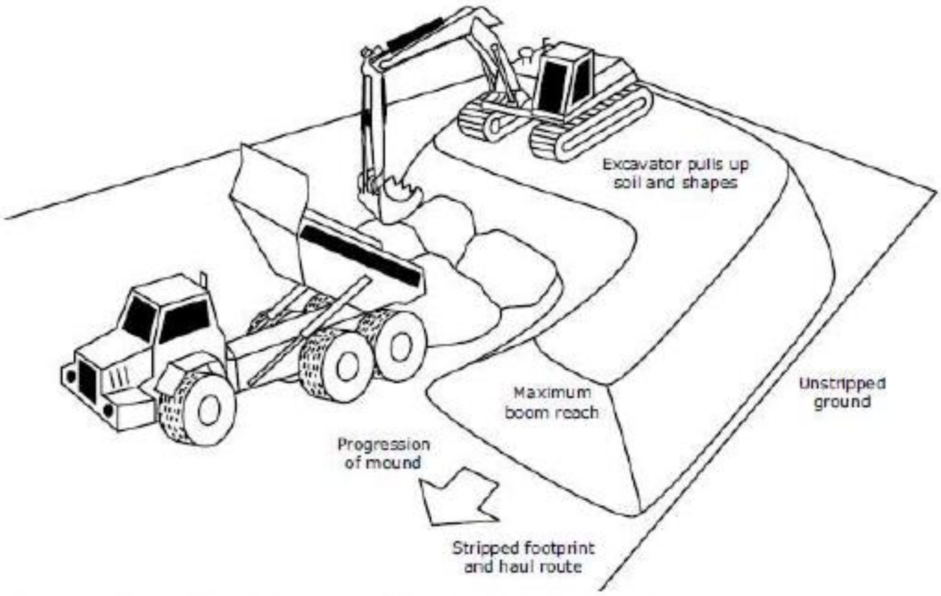


Figure B.1: Soil storage mound construction with excavators and dump trucks: Single tier mound.

7.6 Bunds should be sown with a suitable grass seed mix at an appropriate time of the year (usually spring or autumn), and managed mechanically at least once per year to prevent woody vegetation.

8 OPERATIONAL PHASE: LAND MANAGEMENT

Solar PV Arrays

8.1 The land around the Solar PV Arrays will be managed including potentially by the grazing of sheep. Details are set out in the LEMP (edp).

8.2 Panels grazed by sheep tend to be free of weeds, as shown below.

Photo 29: Sheep Grazing Under Panels

Ongoing Maintenance

8.3 There are many different mechanical cleaners on the market, some tractor based and some operated from smaller machines, such as below. These do not use chemicals resulting in any harm to the soil.

Photo 30: Cleaning of Solar Arrays

8.4 The normal cleaning period is early summer, so that panels are clean for the maximum light period, so damage is unlikely, but cleaning could take place at any time when ground conditions are suitable.

8.5 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 31: Ruts Caused by Vehicles

8.6 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.

8.7 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.

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

<u>Emergency Repairs</u>

8.9 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.

8.10 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 32: Trench During Wet Period

8.11 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.

9 DECOMMISSIONING PRINCIPLES

9.1 Given the length of time before decommissioning it is likely that 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. 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

9.2 A qualified soil scientist should advise prior to decommissioning time. The effects of climate change by the time of decommissioning may mean that these dates are no longer applicable.

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

Photos 33 and 34: The Framework

9.4 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.

9.5 The legs will be loaded onto trailers and removed.

9.6 There will be no significant damage to the soils, as the small void will naturally fill as adjacent soils swell. There will be no significant compaction.

<u>Removal of Cables</u>

9.7 Where cable removal is the most environmentally sustainable approach, which will include all the LV cables, there is likely to need a trench to be dug. This will be done with either a mini digger or a trenching machine.

9.8 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 9: 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)

9.9 Once the trench has been backfilled it should be left for cultivation with the rest of the field post removal of panels.

<u>Removal of Fixed Infrastructure</u>

9.10 Switchgear, such as that shown below, will need to be removed.

Photo 35: Switchgear

9.11 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 10: 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)

9.12 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 should be dug up and loaded onto trailers and removed.

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

Inserts 11 and 12: Example of Tractor Mounted Equipment

Tracks

9.14 The tracks will be the last fixed infrastructure removed, unless otherwise requested by the landowners. 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.

9.15 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 an analysis of soil compaction and condition.

Reinstatement of Soils

9.16 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

9.17 The cabling will 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 trenches will be dug, as described above, and replaced in order once the cables have been removed.

9.18 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

9.19 The fields will be handed back to the farmers.

Appendix SMP1

BSSS Working with Soil Guidance Note

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.

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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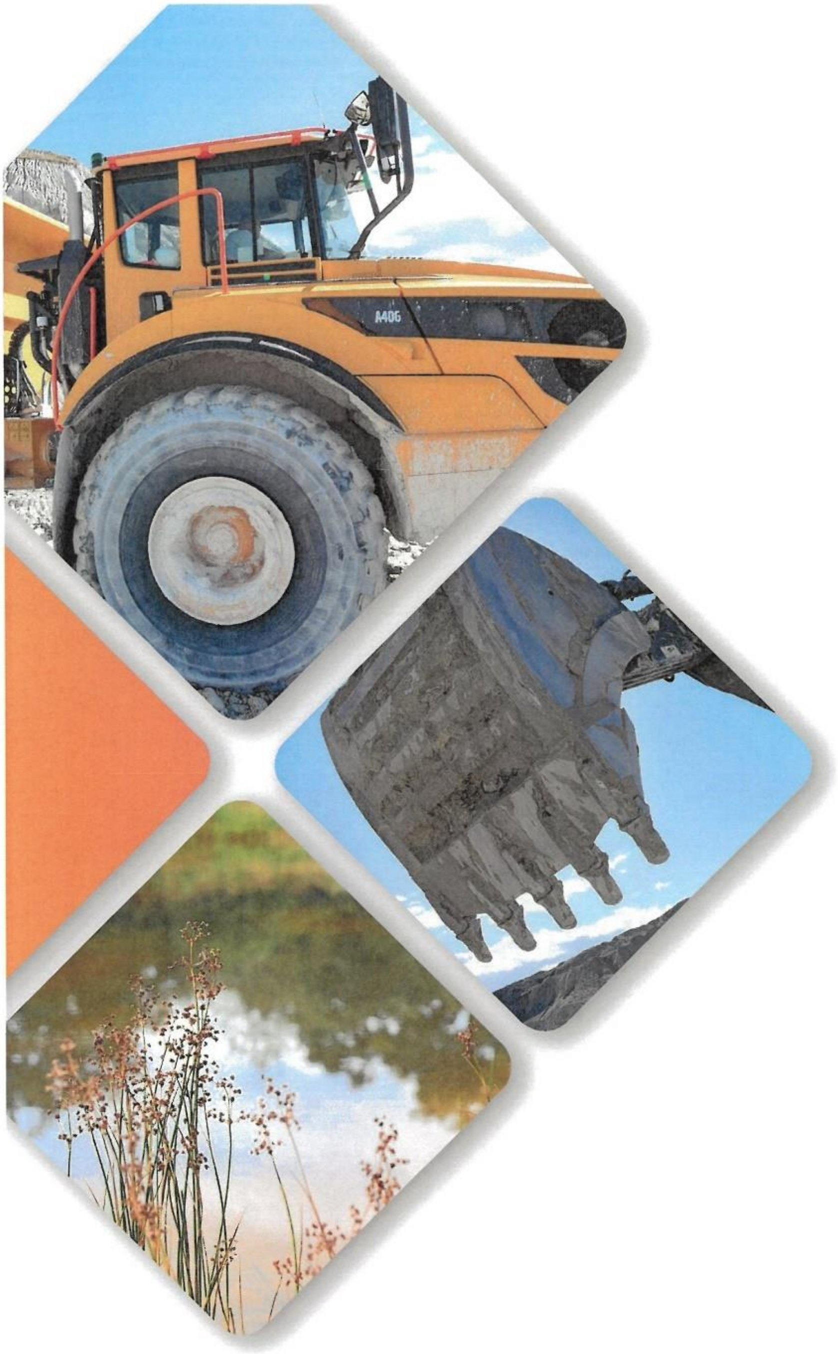
Appendix SMP2
Institute of Quarrying Field Tests for Soils Suitability



IQ

The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

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.

	Climatic Zones		
Soil Clay Content	**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.

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

Building on Soil Sustainability

Cornwall Council and Others

(September 2022)

Building on soil sustainability: Principles for soils in planning and construction

Soils in Planning and Construction Task Force

Sept **2022**

CORNWALL COUNCIL
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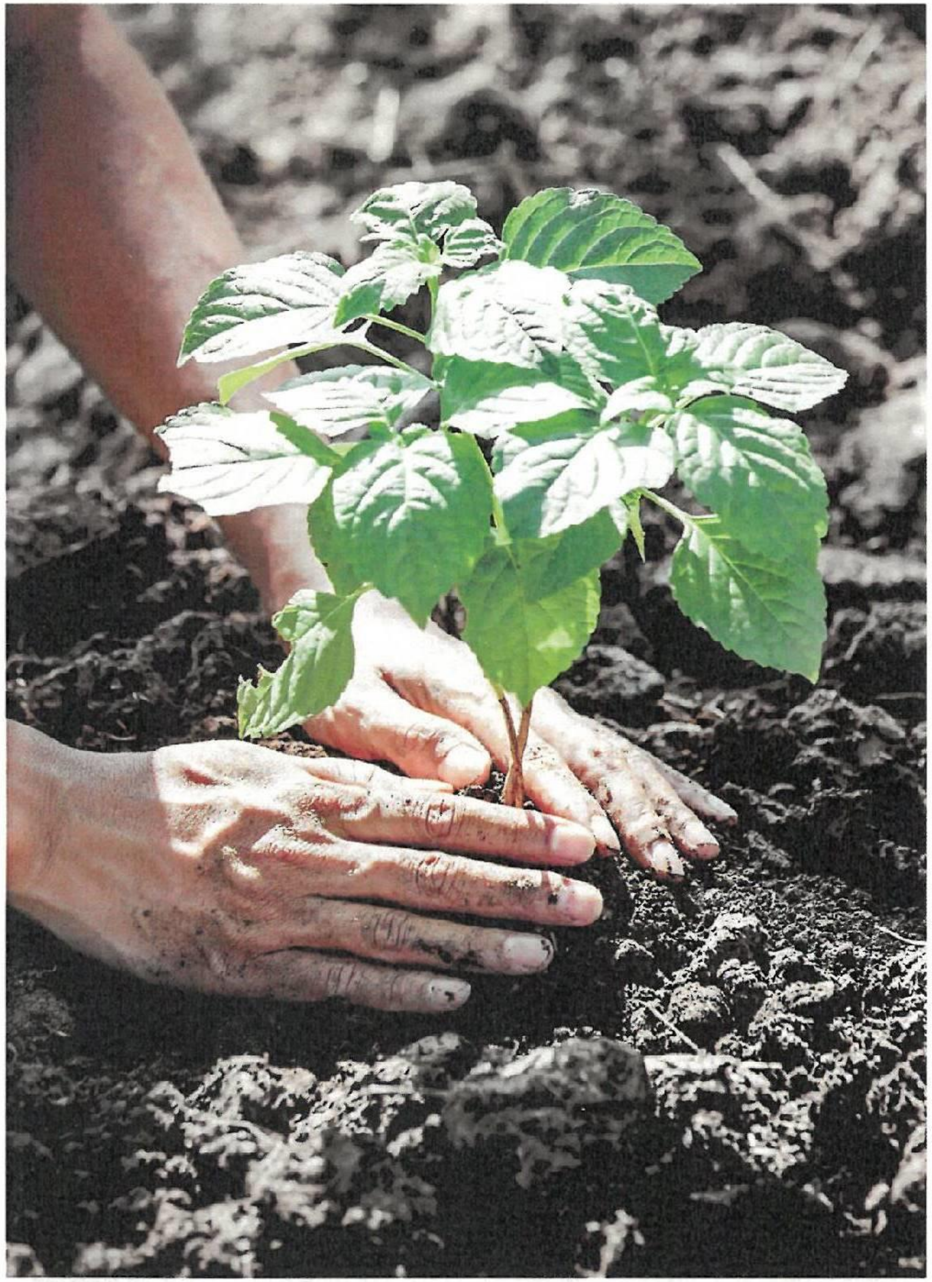
FARRER HUXLEY

jtp

LANCASTER CITY COUNCIL
Promoting City, Coast & Countryside

Lancaster University



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.

Noel Farrer PPLI FLI
Vice President of the Landscape 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.

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.

[1] Needelman (2013) What Are Soils? Nature Education Knowledge. 4(3)(2).

[2] Ramirez et al. (2014) Biogeographic patterns in below-ground diversity in New York City's Central Park are similar to those observed globally.
Proceedings of the royal society B. biological sciences. 281(1795).

[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

[6] Graves et al. (2015) The total costs of soil degradation in England and Wales. Ecological Economics, 119, 399-413.

[7] Hanif Ismail and Yee (2012) MUSLE Evaluation of Soil Loss on a Construction Site by Using Gauging Weirs. Advanced Materials Research 446-449, 2718-2721.

[8] Weil and Brady (2017) The nature and properties of soils. 15th edition.

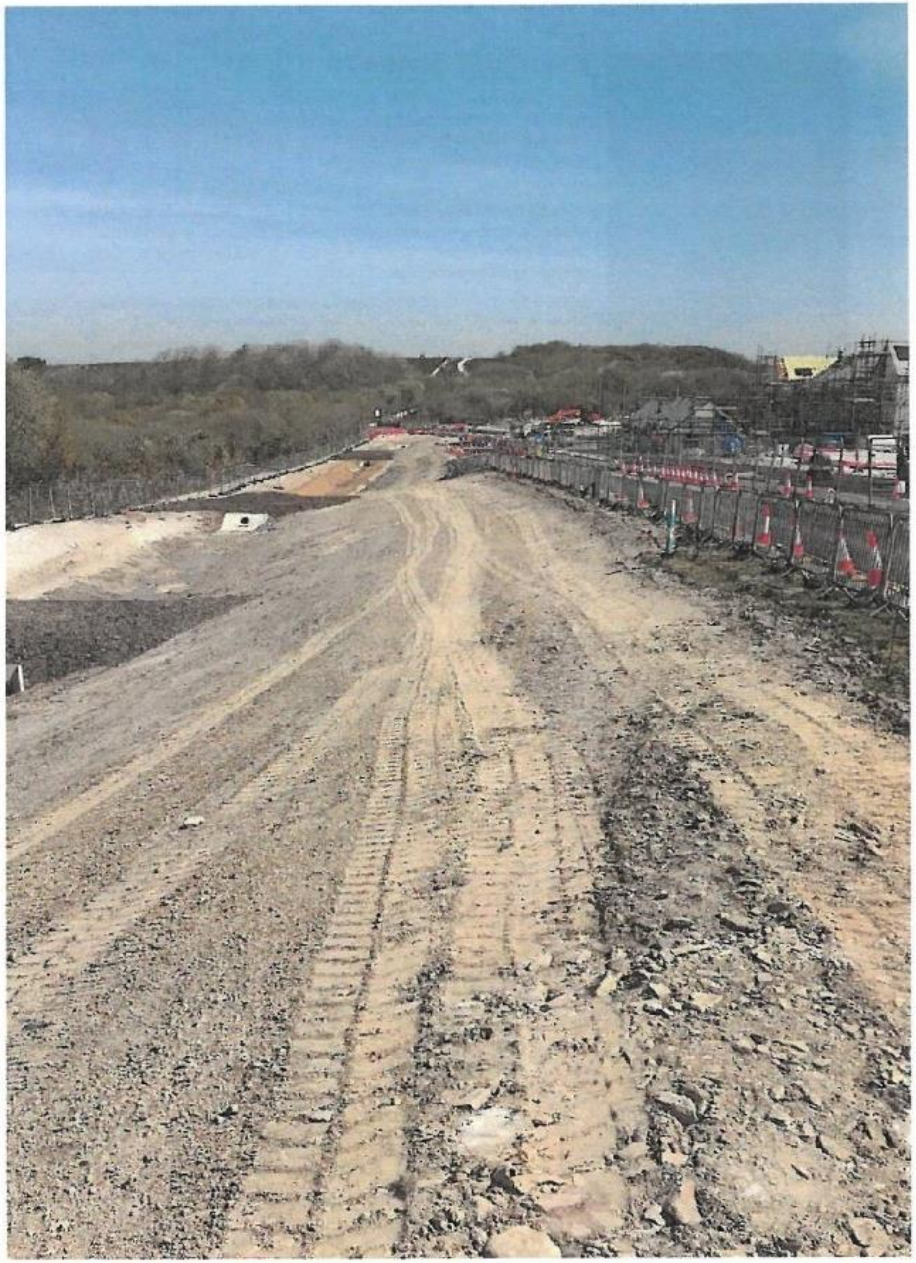
[9] CL:AIRE (2011) The Definition of Waste Development Industry Code of Practice.

[10] Green Construction Board (2021) The Routemap for Zero Avoidable Waste in Construction

[11] Gregory et al. (2006) Effect of urban soil compaction on infiltration rate. Journal of Soil and Water Conservation, 61(3), 117.

[12] Day and Bassuk (1994) A Review of the effects of soil compaction and amelioration treatments on landscape trees. Journal of Arboriculture, 20(1), 9-17.

[13] Horn et al. (2021) Consequences of gas pipeline hauling on changes in soil properties over 3 years. Soil and Tillage Research, 211, 105002.



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 CO_2 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 CO_2.

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 CO_2**; this is greater than losses of greenhouse gases from other big emitting industries such as concrete production (6 million tonnes CO_2 equivalent) and the chemical industry (5.2 million tonnes CO_2 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.

[14] Chen et al. (2013) Changes in soil carbon pools and microbial biomass from urban land development and subsequent post-development soil rehabilitation. Soil Biology and Biochemistry, 66, 38–44.

[15] Wick et al. (2009) Soil aggregation and organic carbon in short-term stockpiles. Soil Use and Management, 25(3), 311-319.

[16] Wilson and Karakouzien (2012) Assessing Soil CO2 at Project Sites in the Desert Southwest, United States, SEBUA-12 ICHMT International Symposium on Sustainable Energy in Buildings and Urban Areas, Turkey, 323-328.

[17] Bradley et al. (2005) A soil carbon and land use database for the United Kingdom. Soil Use and Management, 21(4), 363-369.

[18] Committee on Climate Change (2016) Environmental Audit Committee – Inquiry into Soil Health, Written Submission.

[19] Mackenzie and Naeth (2019) Native seed, soil and atmosphere respond to boreal forest topsoil (LFH) storage. PLOS ONE, 14(9).

[20] Abdul-Kareem and Mcrae (1984) The effects on topsoil of long-term storage in stockpiles. Plant and Soil, 76(1), 357-363.

[21] Fadaei et al. (2021) Impact of soil stockpiling on ericoid mycorrhizal colonization and growth of velvetleaf blueberry (Vaccinium myrtilloides) and Labrador tea (Ledum groenlandicum). Restoration Ecology, 29(1).

[22] Devigne et al. (2016) Impact of soil compaction on soil biodiversity – does it matter in urban context? Urban Ecosystems, 19(3), 1163-1178.

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.

[23] Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government (2020) 2017 to 2018 land use based change tables Live Tables.

[24] Environment Agency (2019) The state of the environment: soil.

25. FAO (2022) Urbanisation and soil sealing. Soil Letters no 5. Intergovernmental Technical Panel on Soils.

[26] Harley and Jenkins (2014) Research to ascertain the proportion of block paving sales in England that are permeable. Report for the Adaptation Sub-Committee of the Committee on Climate Change.

[27] Hale et al. (2021) The Reuse of Excavated Soils from Construction and Demolition Projects: Limitations and Possibilities. Sustainability, 13(11), 6083.

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**.

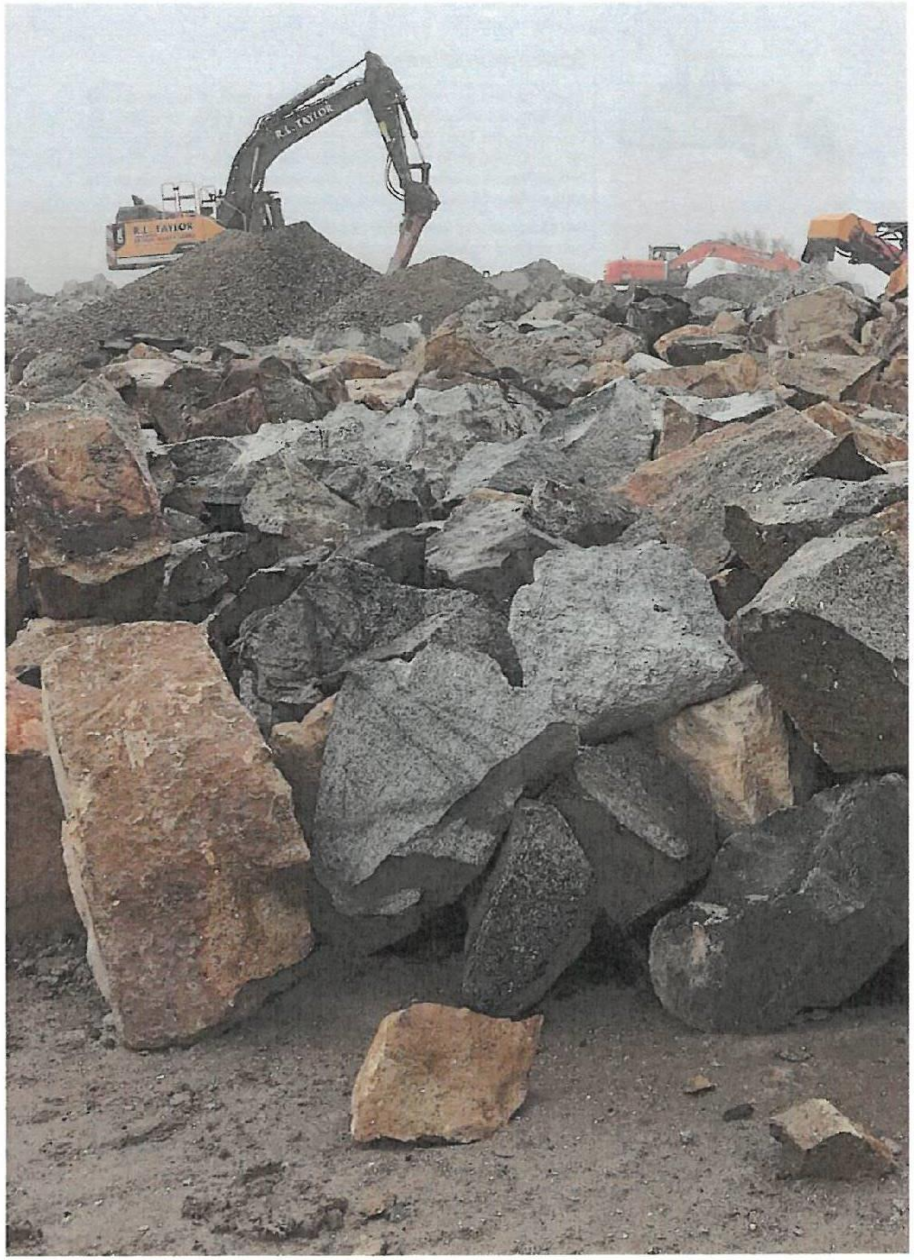
Working with Soil Guidance Note on Benefitting from Soil Management in Development and Construction – British Society of Soil Science (2022)

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.



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.

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.

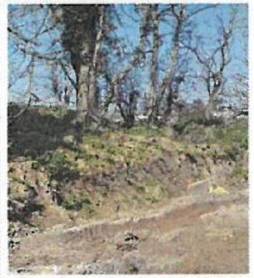
Soil Protection Zones (SPZs) – fence off areas in a similar way to tree Root Protection Areas (as per BS 5837) to prevent disruption to soil in those areas – this will enable soil to continue to function and retain soil biodiversity, soil carbon storage and water storage capability in those areas.

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.

Task Force members

- Professor John Quinton, Lancaster University
- Professor Jess Davies, Lancaster University
- Roisin O'Riordan, Lancaster University
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The report authors were Roisin O'Riordan, John Quinton and Jess Davies at Lancaster University, with support from all Task Force members.

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.

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- Bruce Lascelles – British Society of Soil Science, Arcadis
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- Nicholas Invernizzi – St James Group / St William Homes, Berkeley Group
- Olivia Dear – Countryside Properties
- Rob Askew – Askew Land and Soil
- Robert MacDiarmid – Countryside Properties
- Robin Nicholson – Cullinan Studio, Chair of Cambridgeshire Quality Panel
- Sue James, Trees & Design Action Group

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.

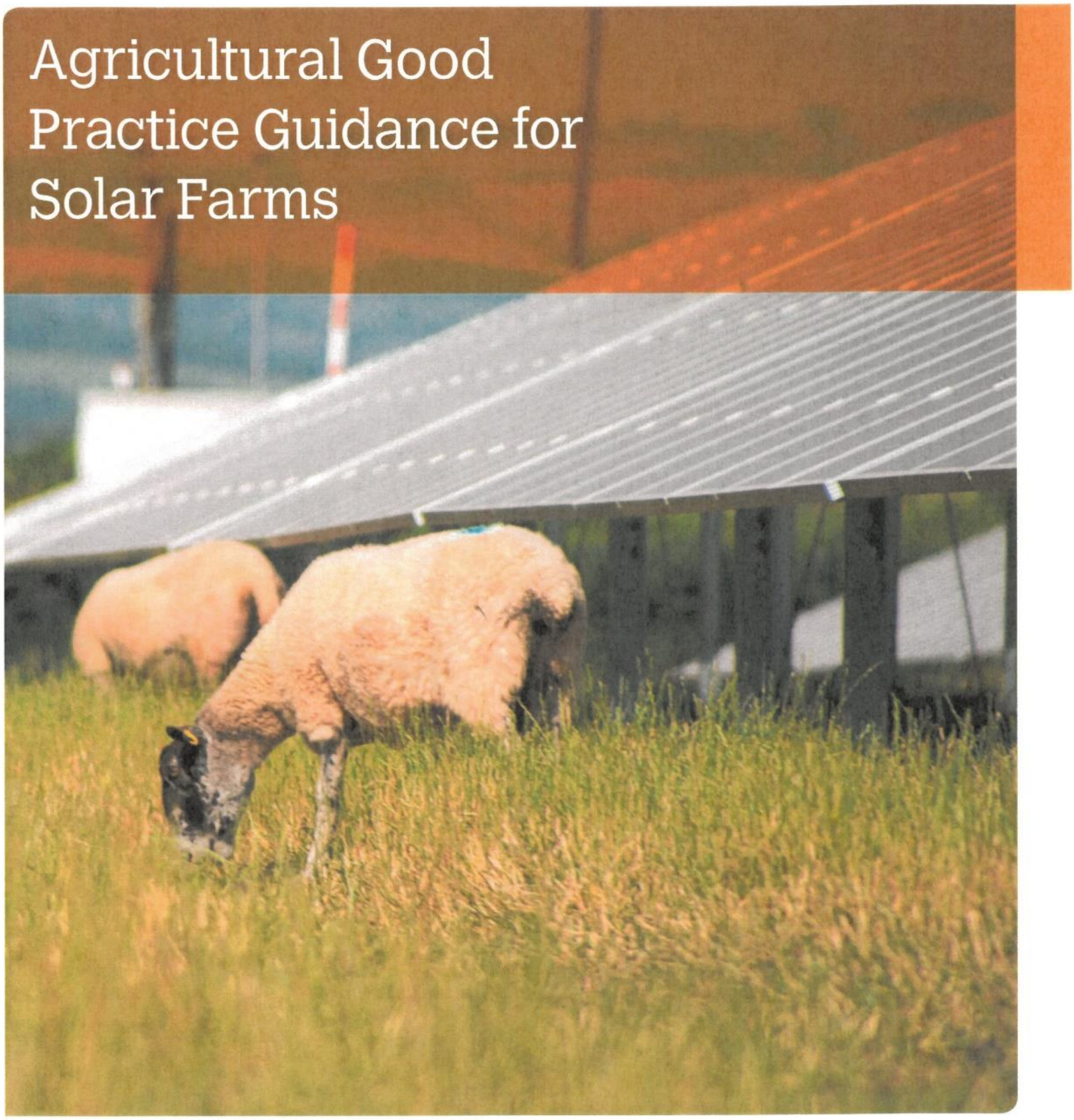
Appendix SMP4

BRE Agricultural Good Practice Guide Extract

bre

www.bre.co.uk/nsc

Agricultural Good Practice Guidance for Solar Farms



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BRE NATIONAL SOLAR CENTRE

Principal Author and Editor Dr Jonathan Scurlock, National Farmers Union

This document should be cited as: BRE (2014) Agricultural Good Practice Guidance for Solar Farms. Ed J Scurlock

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With thanks to NSC Founding Partners:

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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BRE Trust
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'.

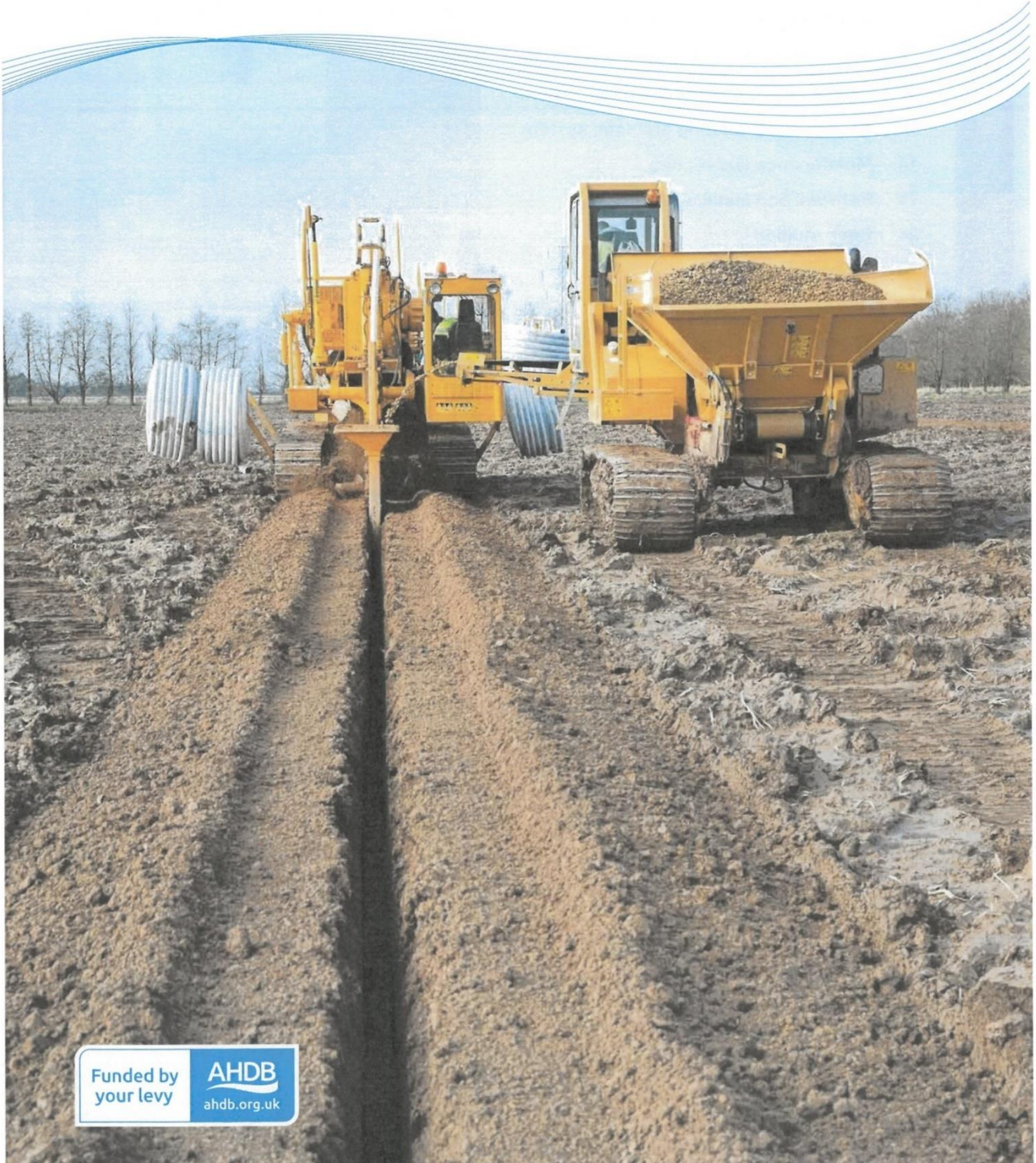
Appendix SMP5

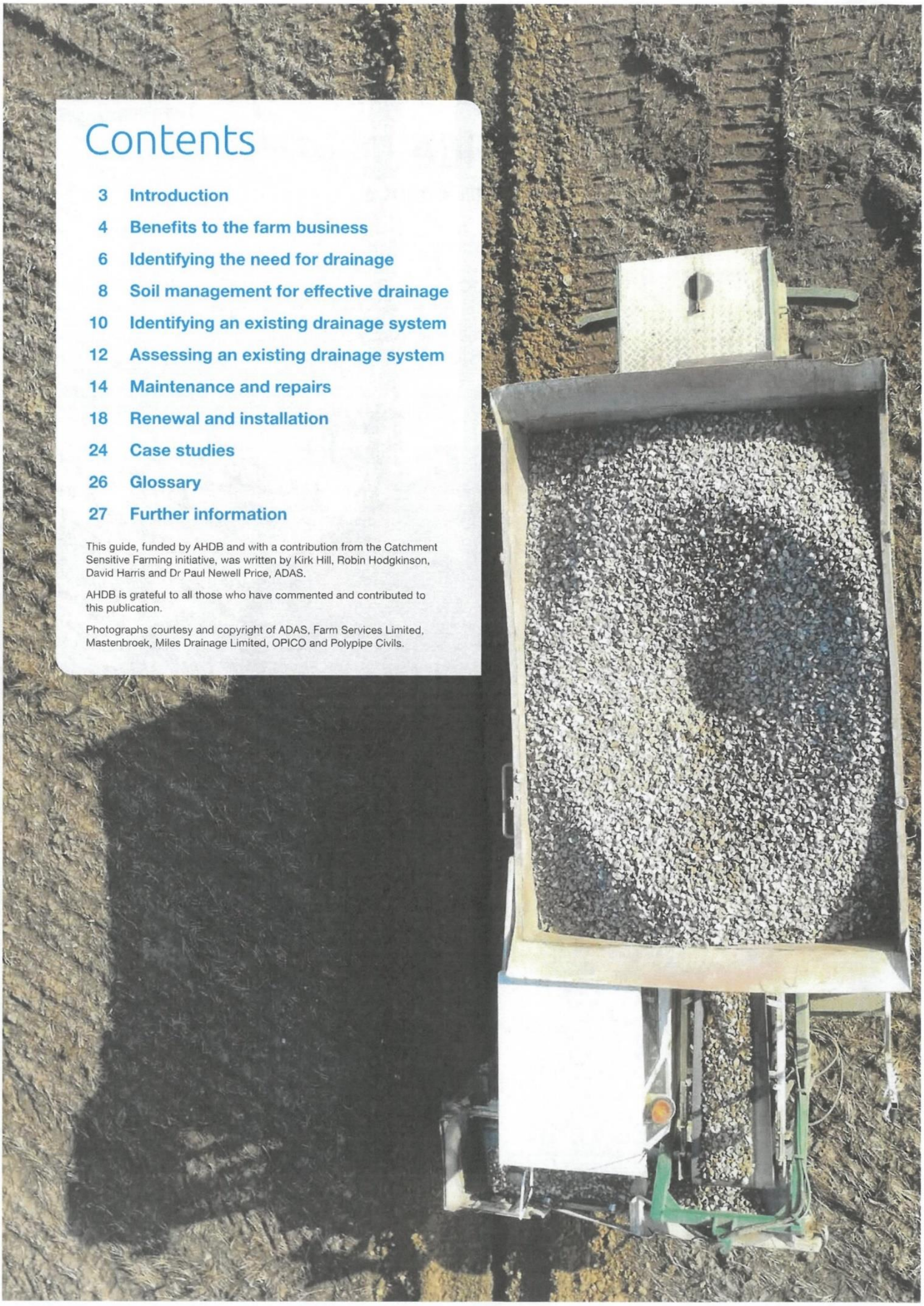
AHDB Field Drainage Guide

AHDB

Field drainage guide

Principles, installations and maintenance





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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.

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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.

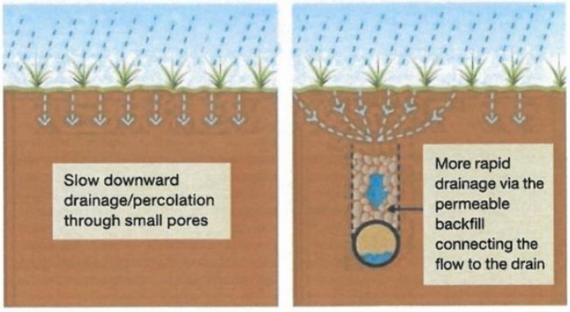


Figure 1. Drainage of heavy soil

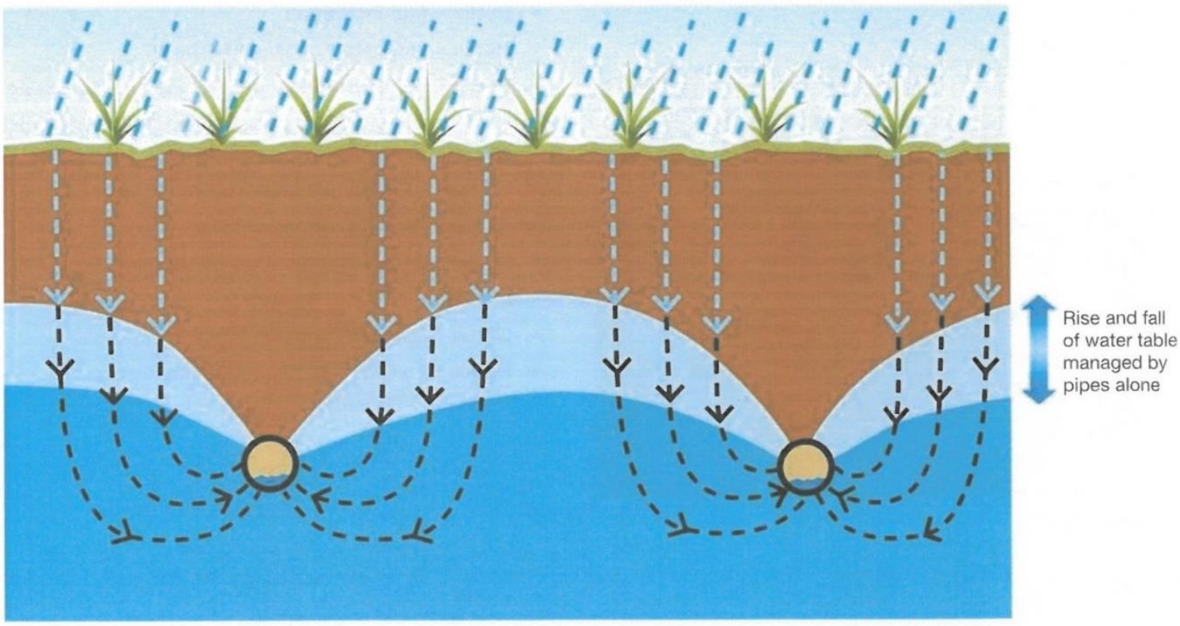


Figure 2. Water table control on permeable soils

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

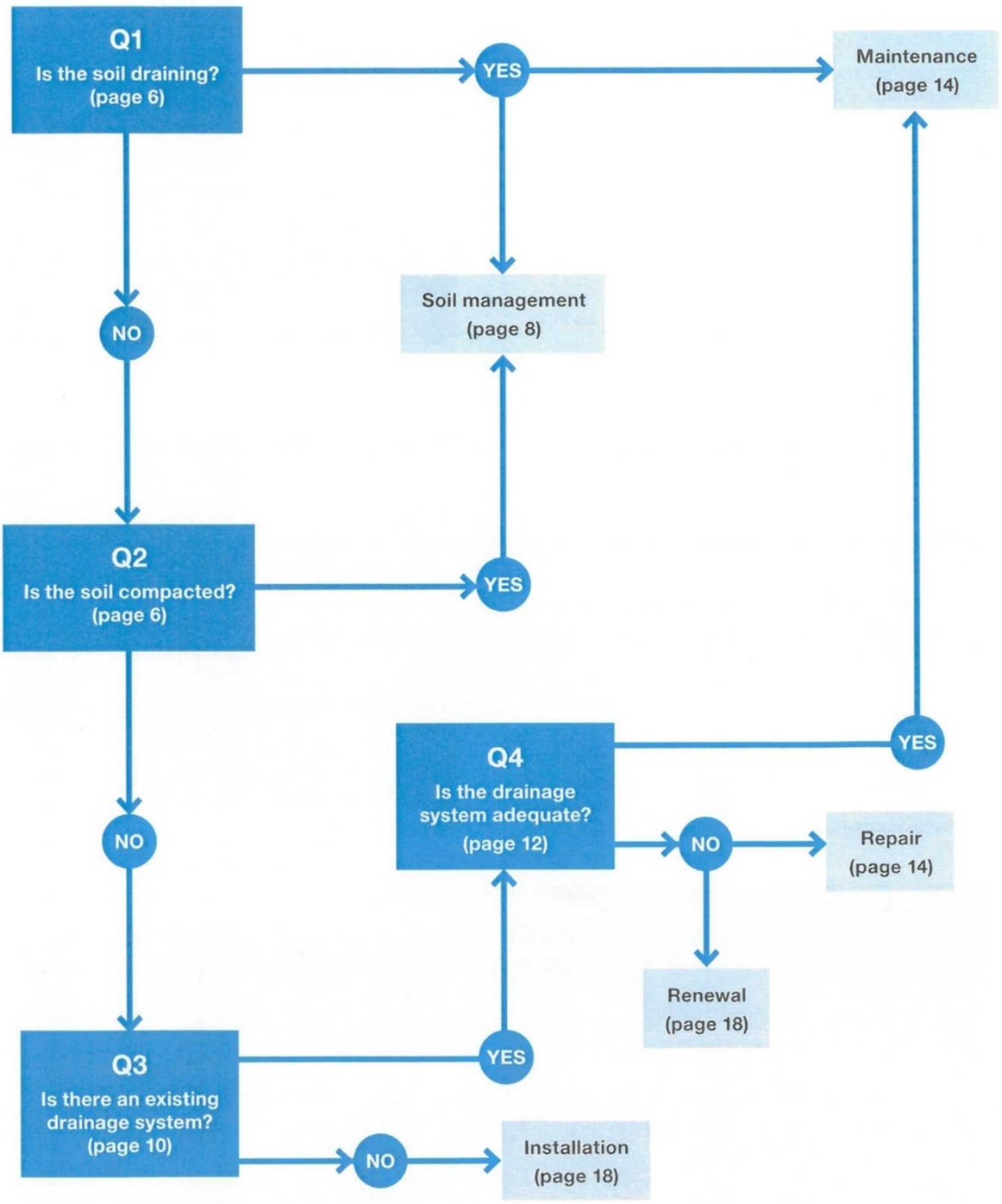
- Better traction
- Fewer cultivation passes
- Reduced draught forces
- Reduced wear and tear
- Fewer wet areas to avoid

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)
Soil management
(page 8)
NO
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

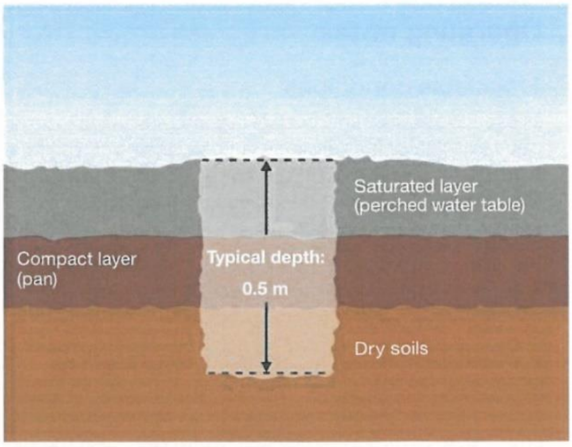


Figure 9. Soil inspection pit extending below the compacted layer

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.

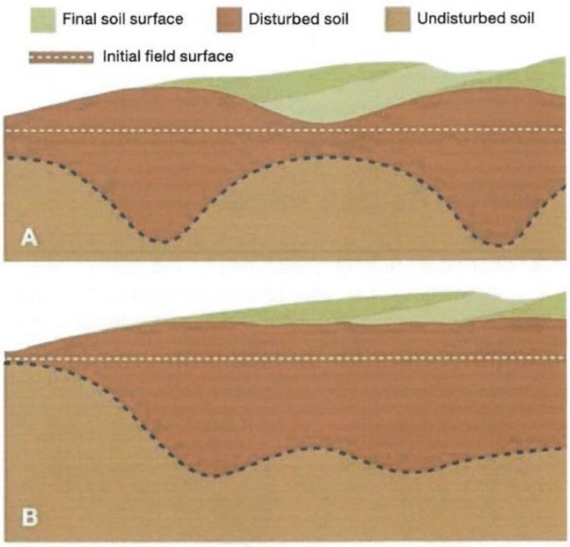


Figure 12. A is an example of tines set too wide and B shows tines correctly set

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**)

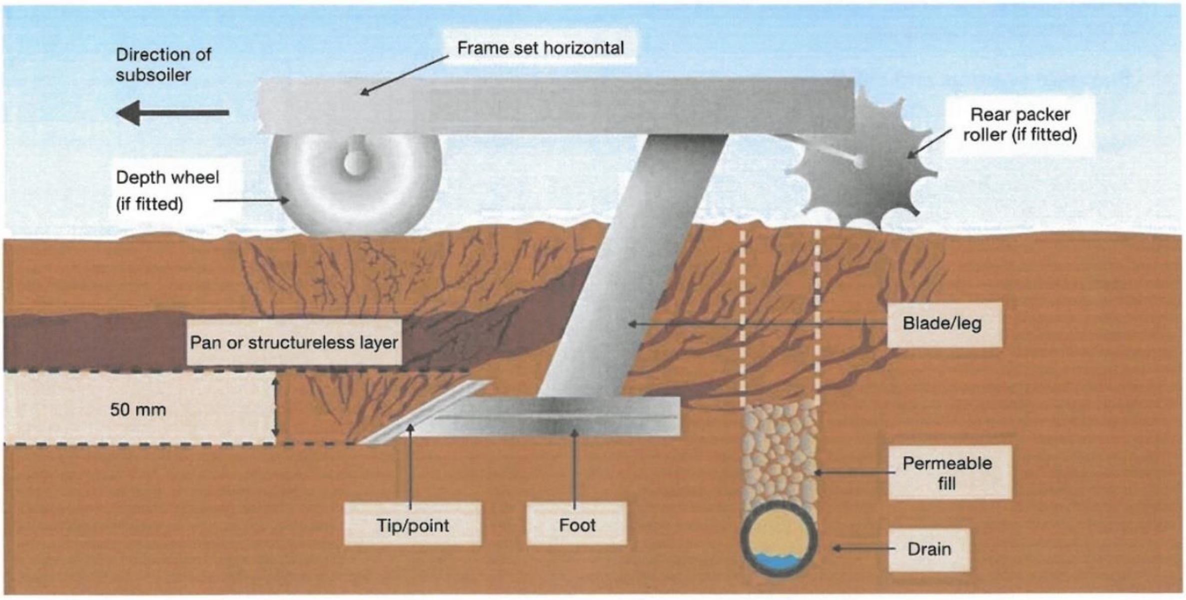


Figure 13. Subsoiler operation

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.

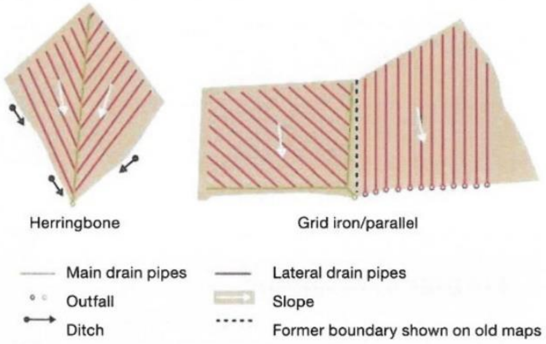


Figure 14. Typical drainage layouts

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.

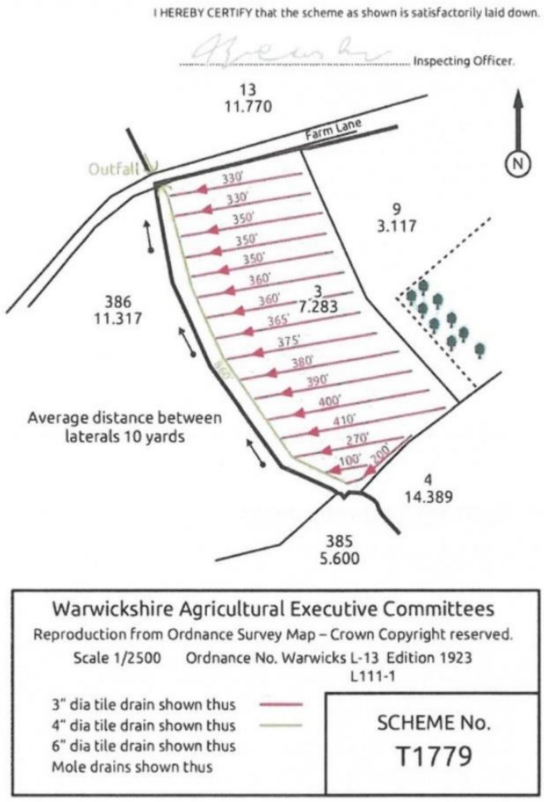


Figure 15. Example final drainage plan

Standard symbols and colours

Plastic pipes

Diameter mm	Colour
60 mmØ	Red
80 mmØ	Purple
100, 110, 125 mmØ	Green*
160 mm, 170 mmØ	Blue*
200, 225 mmØ	Yellow*
Over 225 mmØ	Black

*Indicate diameter

Open ditch

Outfall (in pipe colour)

Pipe drains with permeable fill

Pipe drains (new)

Pipe drains (existing)

Inspection chambers (in outlet pipe colour)

or

Pipe inlet chambers

Culverts (include reference No.)

③

Subsoiling

S

Moling

M

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

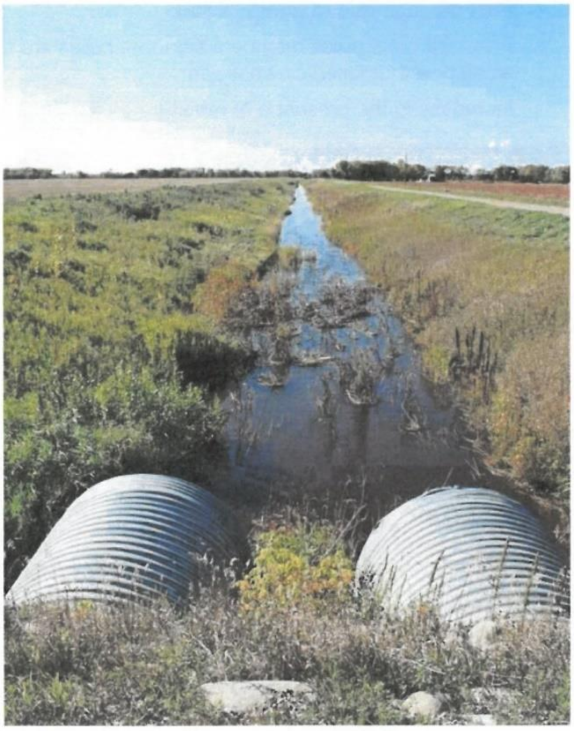


Figure 16. Drainage ditch

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.

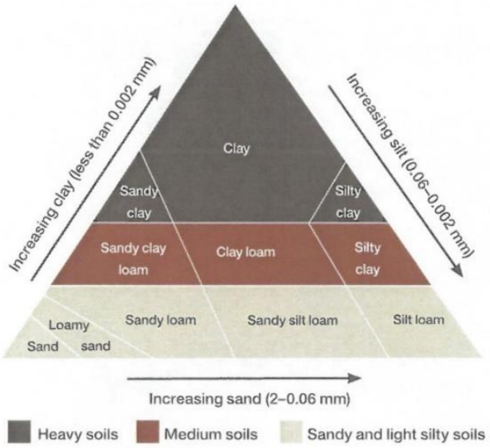


Figure 25. Soil texture classification
Source: Controlling soil erosion (Defra, 2005)

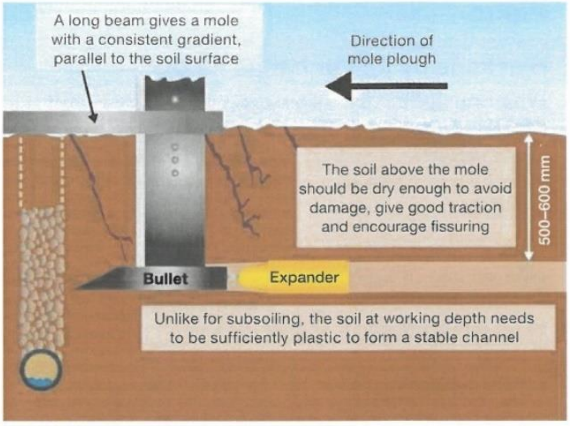


Figure 26. Appropriate conditions for forming mole drains

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.

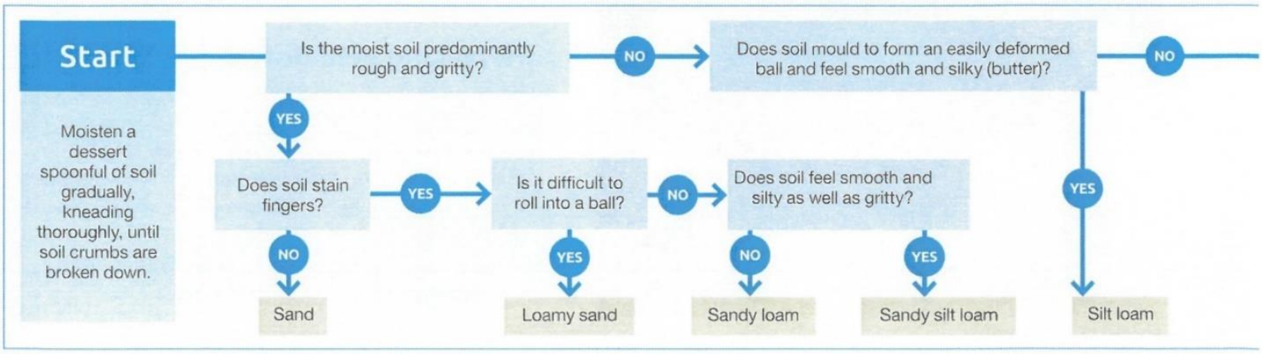


Figure 27. Appropriate conditions for forming mole drains
Source: Controlling soil erosion (Defra, 2005)

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.

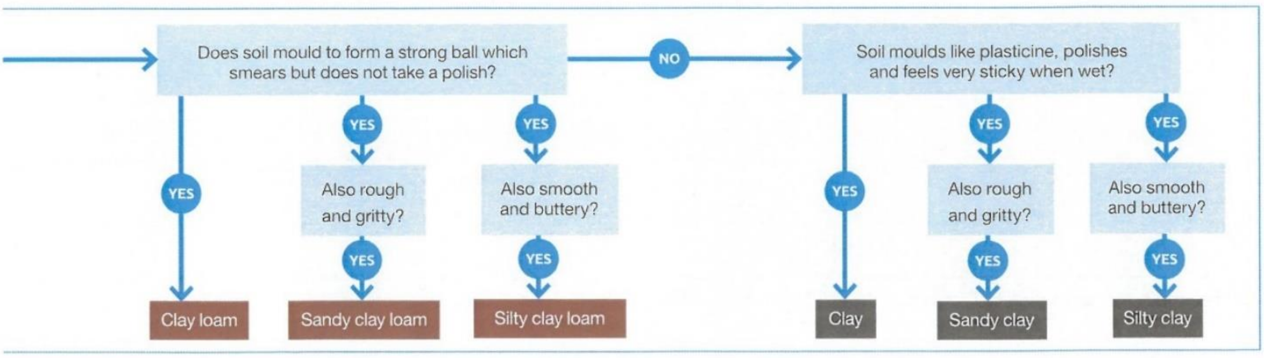
Moles less than 400 mm deep are liable to be damaged by tractors and animals during, or immediately after, rain and tend to be short-lived.

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

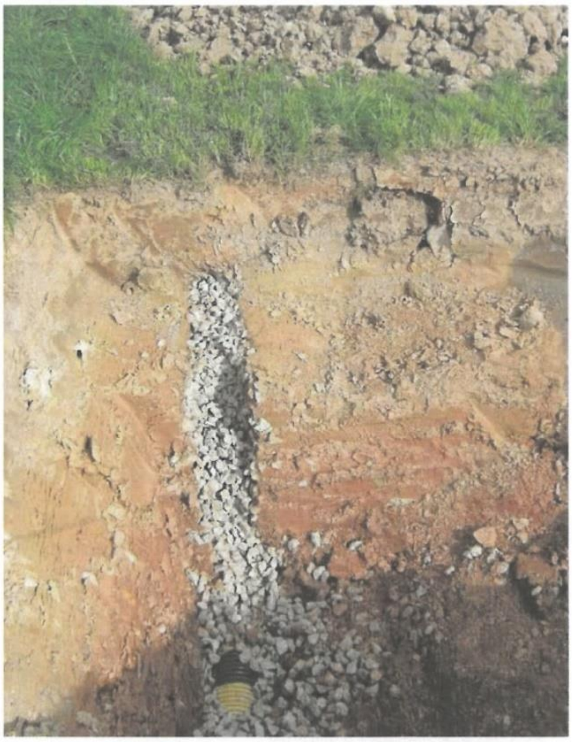


Figure 34. Permeable backfill in trench over drain

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.

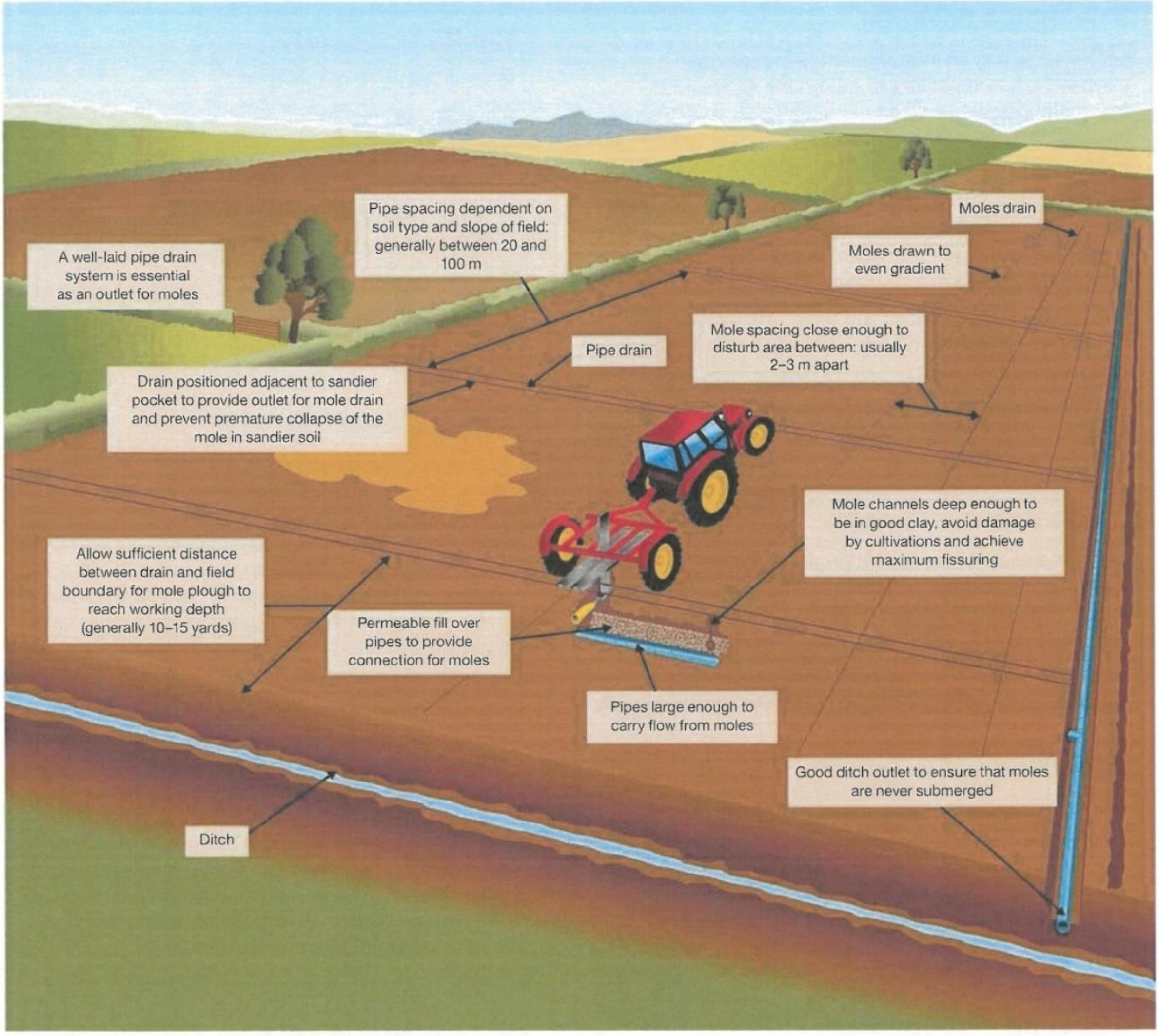


Figure 35. Layout of piped drainage and mole drains

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.

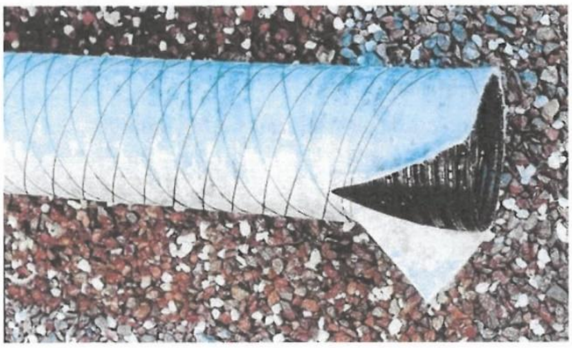


Figure 39. Single-wall pipe wrapped in geotextile

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:

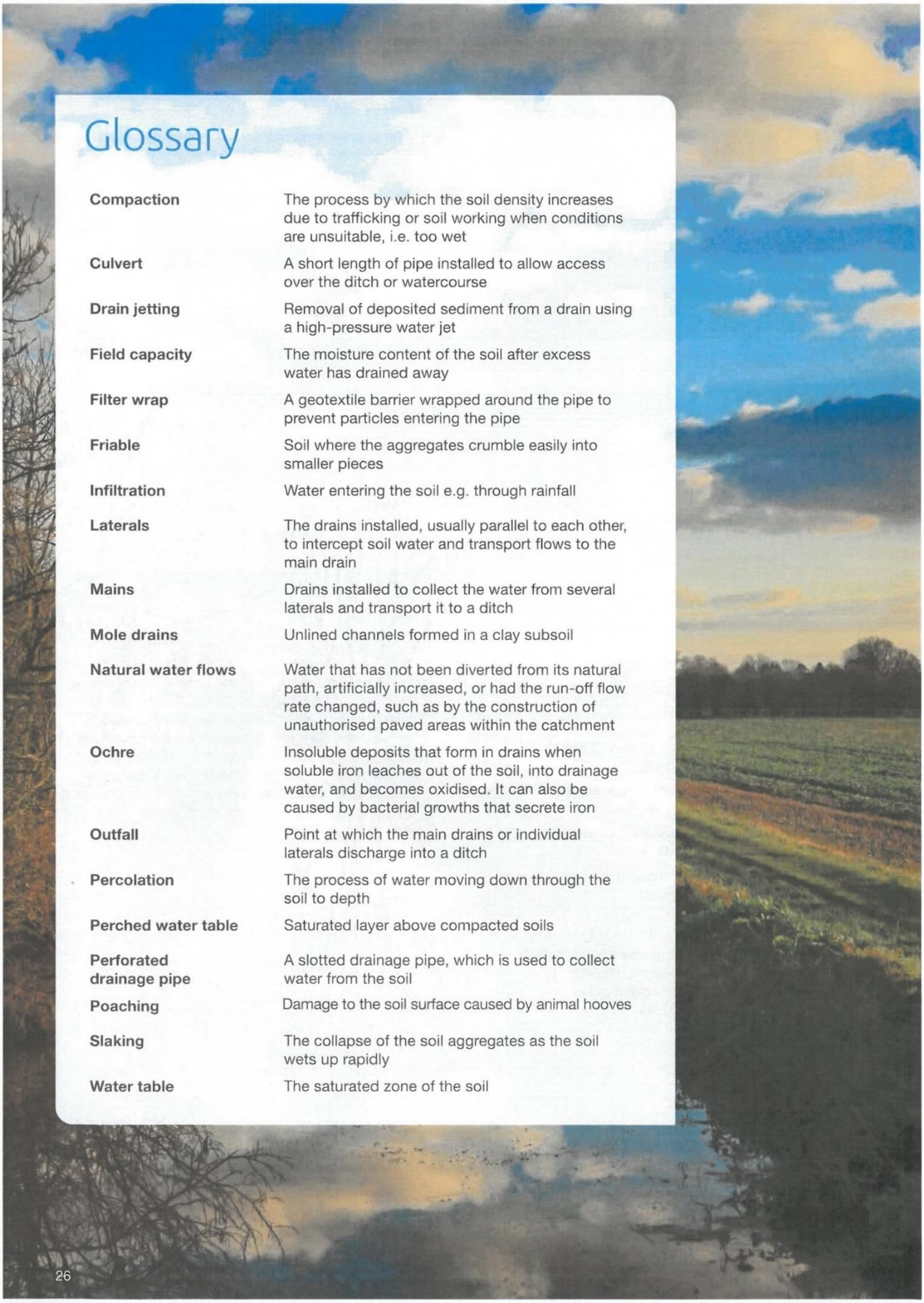
- The change from maize to grass silage has produced a higher dry matter yield and greater forage value from four cuts
- The change to Italian rye-grass resulted in an increase in forage value
- Cultivation savings:
  - Moving to grass, the cultivation savings were £105/ha/year
  - The average annual 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

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

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**
- Listen to our **podcasts**
- Visit **farm events and agricultural shows**
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APPENDIX SMP6

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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