Gatwick Airport Northern Runway Project

Environmental Statement
Appendix 5.3.2: Code of Construction Practice Annex 4 - Soil Management Strategy

Book 5

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1 Introduction and Overview

1.1 Introduction

1.1.1 This SMS forms Annex 4 of **ES Appendix 5.3.2: Code of Construction Practice** (Doc Ref. 5.3) of the Environmental Statement (ES) prepared on behalf of Gatwick Airport Limited (GAL) for the proposal to make best use of Gatwick Airport's existing runways and infrastructure (referred to within this report as 'the Project').

1.1.2 The purpose of this Soils Management Strategy (SMS) is to describe the methodology and control measures to be adopted during the construction of the Project. Detailed soil management plans would be developed in general accordance with the principles in this strategy, prior to the commencement of construction.

1.1.3 The development of this SMS is based on recognised best practice guidance provided in the Department for Environment, Food & Rural Affairs (Defra) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (Defra, 2009) and the Institute of Quarrying (IQ) Good Practice Guide for Handling Soils in Mineral Workings (IQ, 2021).

1.1.4 The objectives of the procedures set out in this SMS have been developed to ensure, wherever practicable:

- the conservation of soil resources;
- the avoidance of damage to soil structures;
- the maintenance of soil drainage; and
- the reinstatement of the soil profile to its former condition (as near as possible).

2 Management and Supervision of the Soil Handling Process

2.1 Management and Supervision

2.1.1 GAL would ensure that there would be a designated person responsible for supervising and monitoring the implementation of the procedures set out below. This is in accordance with requirements set out in 'Toolbox Talk 2' of the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (Defra, 2009).

2.1.2 GAL would also ensure that there is a clear point of contact for each landowner/occupier. The Landowner/occupier shall be directed to this contact if they have questions regarding the ongoing works associated with the Project, or if they have any questions regarding how the works are affecting the day-to-day operations of their business.

3 Baseline Geology, Soils and Agricultural Land Classification

3.1 Published Information

3.1.1 The distribution of the main soil types taken from the published soils information and site survey work has been identified in **ES Chapter 19: Agricultural Land use and Recreation** (Doc Ref. 5.1), **ES Appendix 19.6.1: Published Agricultural Land Classification Data** (Doc Ref. 5.3) and **ES Appendix 19.6.2: Soil Survey Results** (Doc Ref. 5.3).

3.1.2 Geological information is provided by the British Geological Society (BGS) Internet Portal and on published geological maps. The 1:50,000 BGS sheet covering the area around Gatwick (Sheet 302 Horsham) identifies that the local bedrock is the Weald Clay. This is a stiff, grey mudstone weathering to a brownish grey clay at the surface. There are bands of clay ironstone within it, but these produce the same kinds of soils as the main mass of mudstone.

3.1.3 Of more consequence in affecting the nature of the soils is the presence or absence of superficial drift. This includes patches of river terrace deposits. Published information on the soils (see below) indicates that much of the Weald Clay in the area is covered by superficial drift, which is too thin to be shown as a separate feature on the geological maps. This is possibly derived, at least partly, from the river terrace materials.

3.1.4 The geological map (Sheet 302 Horsham) also identifies an area of river alluvium along the course of the River Mole and its tributaries.

3.1.5 At the extreme south east of the map are the underlying deposits of the Upper Tunbridge Wells Sand, which forms part of the higher ground (the High Weald) to the south and east of Crawley.

3.1.6 There is no detailed soil map for the area and so the only published source of information is Sheet 6 (South East England) of the 1:250,000 scale National Soil Map. ES Figure 19.6.1 (Doc Ref. 5.2) provides an extract from the published National Soil Map. It shows geographic groupings of soils called

Soil Associations within the study area, usually related to specific parent materials. Within each Association there are likely to be several more tightly defined soil types known as Soil Series.

3.1.7 The National Soil Map shows a close correlation with the geology around the existing airport, though with simplification for reasons of scale. There can be a considerable range in the kinds of soils within a particular Association, usually because of local variations in the character and thickness of the superficial drifts, including some not shown on the geological map because they are too thin.

3.1.8 The relationship between geology and soils, including the geology, Association Code, Association Name and a brief description is provided in the Table 3.1.1 below.

Table 3.1.1: Relationship between geology and soils

Geology	Soil Association Code	Soil Association Name	Brief Description
Weald Clay (with thin superficial drift and patches of thicker drift)	711e and 711i	WICKHAM 1 and WICKHAM 5	Poorly drained clayey soils with slightly more loamy surface horizons and patches of more sandy but poorly drained soils on river terrace deposits
Weald Clay (with little or no superficial drift)	712b	DENCHWORTH	Poorly drained clayey soils
River Terrace Deposits	841d	SHABBINGTON	Poorly drained sandy soils
Alluvium	813d	FLADBURY 3	Poorly drained clayey soils
Upper Tunbridge Wells Sand	572i	CURTISDEN	Poorly and imperfectly drained silty and fine sandy soils

3.2 Site Survey Results

3.2.1 The survey work carried out to inform ES Chapter 19: Agricultural Land use and Recreation (Doc Ref. 5.1) and reported in ES Appendix 19.6.2: Soil Survey Results (Doc Ref. 5.3) included detailed ALC soil survey work.

3.2.2 The density of auger boring data was collected at a standard interval of 100m spacings, supplemented by soil pit records and observations taken during archaeological excavation works within the surveyed areas. ALC survey work has been undertaken for the following areas within the Project site:

- areas affected by elements of the Project where soils and agricultural land would be permanently lost; and
- construction areas where soils would be temporarily disturbed during the construction of the Project.

3.2.3 There are additional land parcels identified as potential areas for environmental mitigation that also comprise agricultural land. However, these have not been included within the detailed ALC survey, as the soil resources within these areas would remain in situ to facilitate the implementation of the environmental mitigation measures and the quality of the land within these areas would be retained.

3.2.4 The areas of surveyed land identified above were found to comprise lower quality Subgrade 3b (moderate quality) Agricultural Land Classification (ALC) land, which is not classified as Best and Most Versatile (BMV) agricultural land.

3.2.5 The survey work to the north-west and north of Gatwick close to Longbridge Roundabout identified soils typical of the Denchworth soil associations. Profiles typically comprise approximately 25 centimetres (cm) of heavy clay loam topsoil overlying slowly permeable and mottled clay subsoils at a depth of 20 to 25 cm.

3.2.6 The surveyed land within the ownership of Gatwick to the east of the railway identified soils typical of the Wickham Soil Association. Profiles typically comprise a dark brown medium to heavy clay loam topsoil to a thickness of approximately 25 cm overlying a thin mottled heavy clay loam upper subsoil horizon and a slowly permeable mottled clay horizon at a depth of 30 to 40 cm.

4 Soil Resource Availability and Suitability

4.1 Topsoil Resources

4.1.1 The survey work carried out by GAL and Defra identified a single topsoil unit, which will be considered when developing proposals for soil stripping in construction areas where soils would be reinstated following construction. These areas include:

- construction compound north of South Terminal roundabout;
- Pentagon Field, following the placement of spoil materials; and
- construction area to the north of Longbridge roundabout.

4.1.2 Based on the survey work undertaken, there is a single topsoil soil unit present that would be stripped across the construction areas which comprises a thickness of approximately 250 millimetres (mm) of predominantly heavy clay loam/silty clay loam textures.

5 Soil Stripping Methods

5.1 Soil Stripping operation

5.1.1 Soil stripping operations would be carried out by the appointed contractor in accordance with Good Practice Guide for Handling Soils in Mineral Workings (IQ, 2021). Soils guidance sheets A-I are provided in Annex 1 of this SMS. Soil stripping is likely to comprise one of the following methods:

- Soil stripping with excavators and dump trucks (Sheet A, Annex 1);
- Soil stripping with excavators and dump trucks – Windrow Practice (Sheet E, Annex 1); or
- Soil Stripping with bulldozers and dump trucks – Modified Practice (Sheet I, Annex 1).

5.1.2 For each of the identified works area where soils are to be stripped, stored and restored, a SMS would be produced and approved by the relevant Local Planning Authority (LPA). The SMS would include the following information:

- the proposed thickness of soil strip within the individual soil units that exist in the area;
- the location of the soil storage areas; and
- haul route locations.

5.1.3 The sequence of soil stripping operations would be as follows:

- Existing vegetation on the area to be stripped and the storage mound locations to be cleared, if considered necessary, using an appropriate procedure depending on site conditions at the time.
- If present, invasive vegetation should be treated in accordance with the appropriate legislation and guidance for that species.
- If the vegetation is arable stubble no removal would be necessary.
- If grassland, this would be sprayed with a total herbicide and soil stripping would not begin before it has died off. Treatment for other vegetation would be decided pending site and weather conditions at the time.
- The appointed supervisor would monitor and ensure the handling method is implemented correctly. Haul routes to and from the stripping zones would be established clearly in advance, to ensure that excessive trafficking of subsoils is reduced, as far as possible.

6 Methods for Soil Storage

6.1 Soil Storage

6.1.1 Soils would be moved directly from the area being stripped to areas that have been identified as topsoil storage areas. The soils would be stored as close as possible to the area from which they have been stripped. Plans to identify the location of these soil stores and haul routes to access them would be included in the SMS developed for each individual work area and approved by the relevant LPA.

6.1.2 The locations of storage areas would be planned within the detailed SMS to ensure that the potential for damage to the soil storage heaps and/or contamination of the heaps with foreign construction materials is limited, as far as possible. All storage bunds intended to remain in situ for more than 3 months or over the winter period would be seeded and managed to control weeds as necessary.

6.1.3 Stripped soils would be moved to the storage locations by dump trucks running only on pre-determined marked routes which minimise trafficking over exposed subsoil.

6.1.4 At the storage locations, the mound construction is likely to follow the methodologies set out in either:

- Building Soil Storage Mounds with excavators and dump trucks (Sheet B, Annex 1); or
- Building Soil Storage Mounds with bulldozers and dump trucks (Sheet G, Annex 1).

6.1.5 The storage mounds would not exceed 3 m in height for topsoil and 5 m for subsoils and would be located and constructed so that there would be no loss of soil, as far as possible, into any adjacent hedgerows or ditches.

6.1.6 Storage mounds would be constructed by loose tipping of the delivered soil followed by shaping with an excavator or dozer to form a level surface at the top of the mound and uniform gradients down the side as shown above.

6.1.7 Once completed, the storage mounds would be sown in the first autumn with an appropriate grass seed mixture and managed to control weeds as necessary.

6.1.8 Soil would be removed from the storage mounds by the method described in Excavation of Soil Storage Mounds with Excavators and Dump Trucks (Sheet C, Annex 1). This is illustrated in Figure C.3 of Sheet C, Annex 1 of this SMS.

6.1.9 Alternatively, soil removal can also be carried out by an excavator located on the storage mound i.e. a reverse of the mound construction procedure described above. This method is illustrated in Figure C.1 and C.2 of Sheet C, Annex 1 of this SMS.

7 Method for Soil Placement

7.1 Soil Placement

7.1.1 Soil placement operations would be carried out in accordance with one of the following methodologies:

- Soil Replacement with excavators and dump trucks (Sheet D, Annex 1); or
- Soil replacement with bulldozers and dump trucks – Windrow Practice (Sheet H, Annex 1).

7.1.2 Following the removal of construction materials and any construction surfacing, the topsoil would be re-spread over the exposed subsoil in pre-loosened strips. Where necessary, loosening of the subsoil would be undertaken in accordance with soil decompaction by excavator bucket (Sheet N, Annex 1) in advance of topsoil being replaced within an area.

8 Soil Handling and Consistency Tests

8.1 General

8.1.1 The following methodology for determining whether soil handling can take place would apply equally to the soil stripping and storage mound construction and the removal of soil from storage mounds and its re-spreading. Three forms of assessment would be employed based on:

- seasonal considerations;
- ground and weather conditions; and
- soil moisture and consistency tests.

8.1.2 Examples of the forms of assessment that would be employed are provided below and these methods are intended to ensure that soils are handled only in a sufficiently dry and friable condition.

8.2 Seasonal Considerations

8.2.1 As a general principle, soil handling would not take place during the months of November to March inclusive. Soil handling taking place during the months of April to October inclusive would be subject to the requirements of ground and weather conditions and/or soil moisture and consistency tests as set out below.

8.3 Ground and Weather Conditions

8.3.1 Irrespective of the results of soil moisture and consistency tests, soil handling operations would not be undertaken, or would be curtailed or suspended under the following conditions:

- When there is surface ponding, or the ground is frozen or covered in snow.
- If there is light rain or drizzle, handling would proceed for up to four hours unless the soils are already in too moist a state.
- If there is light rain, handling would cease if the rain has not stopped in 15 minutes and would not restart until the soil moisture/consistency criteria can be met.
- If there is heavy rain, soil handling would stop immediately and would not re-start until the ground has had at least a full dry day or the soil moisture/consistency criteria can be met.

8.4 Soil Moisture and Consistency Tests

8.4.1 The handling guidance as determined by the soil moisture state as set out in Table 8.4.1 would be followed as necessary.

Table 8.4.1: Soil Moisture Guidance Criteria

Soil Moisture State	Handling Guidance
If the soil sample is wet, films of water are visible on the surfaces of grains and aggregates and/or when a soil sample is squeezed in the hand, and it readily deforms into a cohesive “ball”.	No handling
Peds (structures) break up/crumble readily when squeezed in the hand rather than forming into a ball.	Handling OK
If the sample is moist, there is a slight dampness when squeezed between the fingers, but it does not significantly change colour (darken) on further wetting	No handling by dozers but may be handled by tracked excavators if consistence test is passed
If the sample is dry and brittle it would look dry and change colour (darken) if water is added	Handling OK if consistence test is passed

8.4.2 The handling guidance as determined by soil consistency tests set out in Table 8.4.2 and Table 8.4.3 would be followed as necessary. They require a sample of soil to be manipulated and, at first, an attempt made to mould it into a ball.

Table 8.4.2: Soil Consistency Tests (Attempt to form a ball of soil)

Soil Consistency	Handling Guidance
Impossible because the soil is too hard (dry)	Handling OK
Impossible because the soil is too loose (dry)	Handling OK
Impossible because the soil is too loose (wet)	Handling not OK
Possible	Attempt to roll the ball into a thread of 3mm diameter on a flat non-adhesive surface using light pressure from the flat of the hand.

Table 8.4.3: Soil Consistency Tests (Soil Thread test)

Soil Consistency	Handling Guidance
Impossible to form a thread; the soil crumbles or disintegrates	Handling OK
Possible to form a thread	No handling, but seek advice from a professional soil scientist if this situation continues.

9 Drainage

9.1 Drainage considerations

9.1.1 During the soil stripping, existing drainage features would be recorded including the type, depth, size, angle, and conditions. Temporary drainage would be installed within the site area, to intercept existing field drains and ditches to maintain the integrity of the existing field-drainage system during construction. Temporary drainage measures would be implemented for works areas where necessary and the installation would be monitored by a suitably qualified person (as outlined in Section 2 of this SMS). Such measures would also assist in reducing the potential for wet areas to form during the works, thereby reducing the impact on soil structure and fertility.

9.1.2 Land drainage systems would therefore be maintained during construction and reinstated on completion of construction to ensure that the drainage system is operationally effective. The implementation of the permanent replacement drainage system would be monitored by a suitably qualified person (as outlined in Section 2 of this SMS).

10 Aftercare and Handover

10.1 Aftercare considerations

10.1.1 The aftercare period is the period following soil restoration during which steps are taken to enable the pre-working land use to be re-established. Three months prior to the commencement of the aftercare period, appropriate aftercare implementation measures for the individual works areas would be identified. These would include:

- cultivations to be undertaken, which would depend on the soil type and site conditions;
- seed mixture to be used for initial grass establishment; and
- soil samples would be taken from the bunds to be used in the restoration of the area to determine nutrient levels and inform proposals for lime and fertiliser applications.

10.1.2 At the end of the first year of aftercare there would be an on-site review to monitor:

- the physical soil characteristics of the restored land;
- identify any additional cultivations required;
- identify any further remedial measures that are required;
- collect samples to check soil nutrient levels and inform lime and fertiliser requirement; and
- effectiveness of reinstated drainage.

10.1.3 This review would enable the aftercare management requirements to be set for the following year, if necessary.

10.1.4 Where appropriate, the land would be handed back to the owner at the earliest opportunity following the implementation of the aftercare plan, which are to be set out in the individual SMSs for approval by the relevant LPAs.

10.2 References

Defra (2009) Construction Code of Practice for the Sustainable Use of Soils on Construction Sites.

IQ (2021) Good Practice Guide for Handling Soils in Mineral Workings.

10.3 Glossary

Table 10.3.1: Glossary of Terms

Term	Description
ALC	Agricultural Land Classification
BGS	British Geological Society
BMV	Best and Most Versatile
cm	Centimeter
ES	Environmental Statement
GAL	Gatwick Airport Limited
IQ	Institute of Quarrying

Term	Description
LPA	Local Planning Authority
LPA	Local Planning Authority
mm	Millimeter
SMS	Soils Management Strategy

Annex 1

Good Practice Guide for Handling Soils in Mineral Workings (Sheets A – I)

IQ

The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

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The information in this publication is general guidance on the best practices and approaches to soils guidance.
Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Methodology

- Sheet A -

Soil Stripping with Excavators and Dump Trucks – Sequential Bed/Strip Practice

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Preface

The purpose of Sheet A of the updated guidance is to provide a model method of best practice where excavators and dump trucks are to be used to strip soil using the sequential 'bed'/strip by strip practice.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974, and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

In this soil handling option, back-acting excavators are used to lift the soil resources and load them into dump trucks for the direct transport to the area being restored or to storage until needed.

The stripping practice involves the sequential separation and removal of the individual layers of soil identified in the Soil Resource & Management Plan (SRMP). It takes the form of advancing vertical slices through the soil profile as successive strips across the soil being removed. Hence the practice is often referred to as the 'Strip' or 'Bed' method.

The upper layer (topsoil) in the strip being removed is lifted first within the safe and efficient operational reach of the excavator boom (which defines the width of each strip). For each subsequent soil layer, if it is to be recovered, the process is repeated until the basal layer (usually overburden or the economic mineral layer) is reached. When the soil resource/ profile sequence within the strip is completely removed, the process is repeated on the abutting area to be stripped of soil. The method can also be adopted where only a single soil horizon is to be recovered.

Normally the excavator operates only from on the soil surface with the dump trucks travelling on the exposed lower non-soil layer. This the preferred operating mode of the excavator as there is a better recovery of the particular soil layer on handling. In some circumstances, such as where, i) the topsoil/ surface layer has a particularly low baring capacity and is prone to compaction (such as peat or organic soils), ii) a thin soil layer lies directly on the mineral layer, or iii) access is limited from the bottom of steep gradients, the excavator will need to operate from the exposed 'basal' mineral/overburden layer or a raised access strip.

Similarly, the normal operation of the dump trucks is on the exposed non-soil basal/overburden layer. In cases where the soil horizon has i) a particularly low baring capacity or ii) where there needs to be enhanced protection of potential archaeological features, the dump trucks may have to operate upon the topsoil which may have to be surcharged.

Advantages & Disadvantages

The advantages of this machinery combination and handling practice are:

i) When the excavator operates only from on the soil surface, compaction is largely confined to the top-soil (which is ultimately more easily treated) and potentially reducing the risk of severe compaction of the subsurface soil layers where the soil is to be directly placed without storage
ii) It is easier to see and react to localised changes in soil types and variation in horizon depth
iii) It is suited to the stripping of thin and 'patterned' soil layers
iv) It offers the most flexibility in respect of short soil drying periods and likely wet weather as it is less susceptible to stoppages due to soil rewetting as a transpiring vegetation cover can be retained later into the stripping programme. It is particularly suited to northerly and western, and upland locations, and particularly when there are uncertain weather patterns.

The disadvantages are:

i) It requires skill and discipline in its deployment, and a high level of supervision, being suited to experienced operators
ii) Without care the bed system may result in a greater mixing of soil horizons
iii) Steep gradient/complex topographies may limit the safe and practical deployment of this machinery combination and handling practice.

Suitability

The excavator-dump truck combination with the bed/ strip handling practice methodology is considered as 'best practice' by Natural England and the Welsh Government for agricultural soils and preferred for all soils. In particular, it is the most suitable of any of the methods available where:

i) The soil is prone to compaction and where decompaction treatments cannot be relied upon to be effective (this incudes peat)
ii) The intended after use, environmental and ecosystem services are dependent on

maintaining (as far as it is possible) the soil functional characteristics such as, porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This includes productive agricultural, horticultural and forestry land, but also some natural habitats, and where water storage/infiltration is of importance for risk of flooding. Where the soils are stored prior to replacement some remedial treatment may have to be relied upon.

ii) The bed/strip soil handling method is not suitable where an archaeological surface needs to be investigated as a whole. Subject to approval by the planning authority the method can be used with care where there is a 'watching brief' by an archaeologist, but may have to be abandoned for another approach where important artefacts are detected. However, trafficking may be restricted to the topsoil surface until the subsoil has been approved for removal and taken away.

iii) The placement of the stripped soils into stockpiles is likely to result in compression and compaction and may negate this particular benefit of the handling practice.

iv) As the benefit of the practice lies in the direct placement of the stripped soil it calls for the mineral extraction scheme to be organized to minimize the need for soils storage.

MODEL METHODOLOGY

A.1 Key operational points to minimise the risk of severe soil compaction and wet soil conditions are summarised in Boxes A.1 and A.2.

A.2 The timing of soil handling operations should only take place when the soils are in a 'dry and friable' condition (ie when it breaks and shatters when disturbed rather than smears and deforms) (see **Part One, Supplementary Note 4**). Prior to the start or recommencement of soil handling, they should be tested to confirm they are in suitably dry condition (see Box A.3).

Box A.1 - to minimise compaction:

- The dump trucks should normally only operate on the 'basal'/non-soil layer, and their wheels must not run on to the soil layer/s
- The excavator should normally operate on the topsoil layer
- The adoption of a bed/strip system avoids the need for the trucks to travel on the soil layers
- The machines are to only work when ground conditions enable their efficient operation
- Soils are to be in a 'dry' condition.

Box A.2 - to minimise soil wetness and re-wetting:

- The bed/strip system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents The soil profile within the active strip should be stripped to the basal layer before rainfall occurs and before stripping is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance
- The maintenance of a transpiting crop is important, and an appropriate cropping regime should be established for the year of soil stripping
- Before stripping, excess vegetation should be removed; in the case of grassland it should be cut or grazed short and arable crops should have been harvested.

A.3 Soil handling is not to take place during rain, sleet or snow and in these conditions should be prohibited due to unsafe machine operating conditions. Prior to commencing operations, a medium/long term weather forecast should be obtained which gives reasonable confidence of soil handling being completed without significant

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**).

Box A.5

In doing so, compaction by the excavator is largely restricted to the upper layer of soil, which is more easily treated after the soil has been relaid. The degree of topsoil compaction will depend on the machine's ground pressure, its mode of operation and soil wetness. Smaller wide tracked excavators may cause less compaction.

Box A.6

For hard/stony soils toothed buckets are needed. Where the mixing of soil layers at their interface is to be minimized, a bucket with a 'blade' is preferable where the soil is 'soft' and free of large stones or stone free. Where there is a watching archaeological brief, the use of bladed buckets will normally be required.

Similarly the choice of bucket type, whether it is a standard 'digging'/bulking or wide ditchingtype will depend on the soil strength and stoniness.

A.7 Unless specified in the SRMP, the excavator is only to work on the topsoil layer and the dump trucks are only to travel on the basal/formation layer (Box A.5).

A.8 Stripping is to be undertaken by the excavator standing on the surface of the topsoil and digging the topsoil to its maximum depth, and it loading into dump trucks. The dump trucks draw alongside the exposed soil profile, standing and travelling only on the basal layer (**Figure A.2**). The type of bucket to be used largely depends on the nature of the soil (Box A.6).

A.9 The initial strip width and axis should be demarcated. The strip width is determined by the length of the excavator boom less the stand-off to safely operate; typically, about 3-4m (Box A7). Excavators with long booms ('long reach') can be used, but may be more restricted by gradient limitations, and require skilled and experienced operators.

A.10 Topsoil should be recovered to the full width of the strip without mixing with the underlying subsoil (not more than 20% of the lower horizon should be exposed at the layer junction within the strip). The thickness and identification of the horizon junction must be verified before and during stripping. The full thickness of the topsoil horizon should be stripped progressively along the strip before the underlying subsoil horizon(s), if present, is to be started (**Figure A.2**).

A.11 The (upper) subsoil in the current strip is then to be stripped and monitored in the same manner. The final 25cm of the subsoil layer should be left as a step to protect the adjacent topsoil layer from local collapses. On completion, the process is to be repeated if there is a lower subsoil, and then any other lower layer to be recovered as a soil material (**Figure A.3**).

Box A.7 - Orientation of the Excavator

Usually the excavator is orientated and operates with its tracks at 90^{O} to the axis of the bed being stripped as this is the most stable position.

Whilst the reach of the boom and hence the width of the bed/strip can be significantly increased and the excavator traffickiing over the soil surface decreased by orientating it with the tracks parallel to the soil being stripped, this may affect the stability of the excavator, particularly on a gradient or where soils have a low bearing capacity. Hence its safe deployment needs to be checked before its adoption.

A.12 On completion of the strip, the procedures are repeated sequentially for each subsequent strip until the soil to be stripped is completely removed.

A.13 Where the soils are to be directly replaced (without storage in mounds), the initial strip of the upper horizons will have to be stored temporarily to

release the lowest layer and enable the sequential movement of materials. The stored initial soil material would normally be placed on the lower layer removed from the final strip at the end of the programme or on partially completed profiles if rain interrupted the operation.

A.14 Where the stripping operation is likely to be interrupted by rain, or there is likely to be over-night rain, remove any exposed subsoil down to the basal layer before suspending operations. Make provisions to protect base of current or next strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

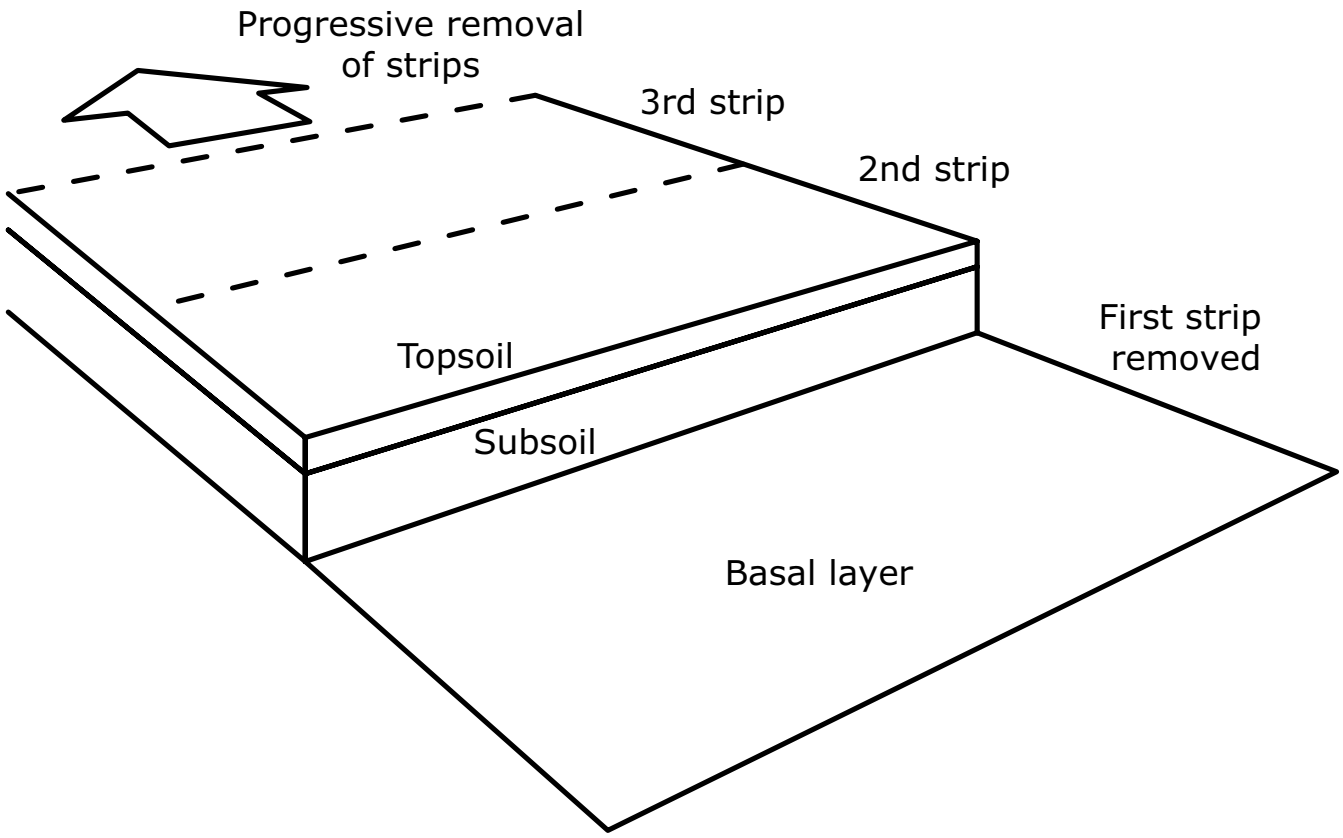

Figure A.1: Soil stripping with excavators and dump trucks: The bed system.

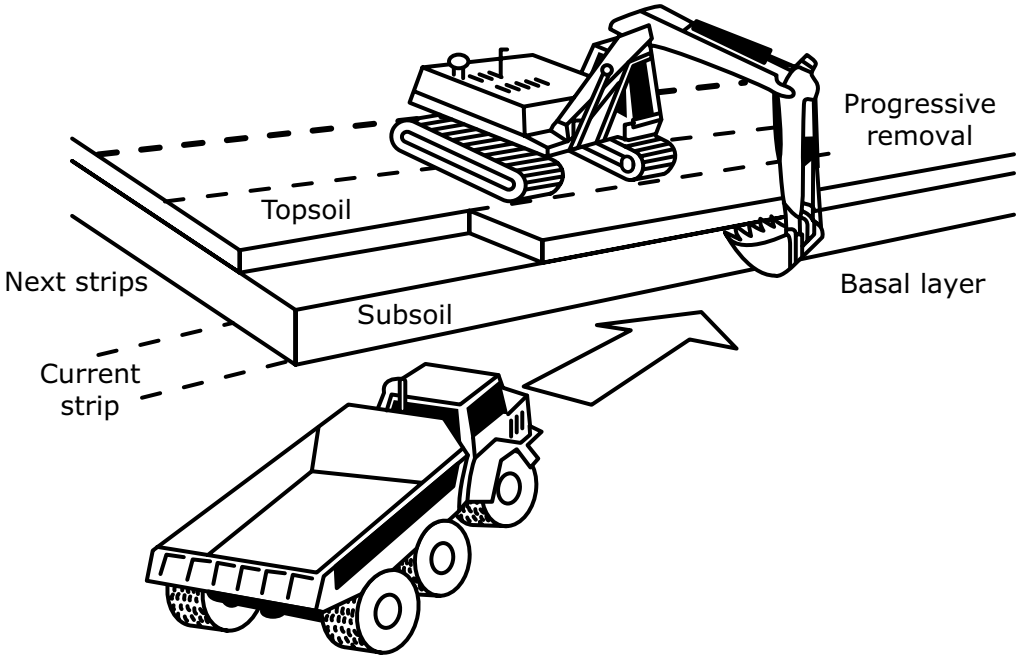

Figure A.2: Stripping with excavators and dump trucks: removal of topsoil from a strip.

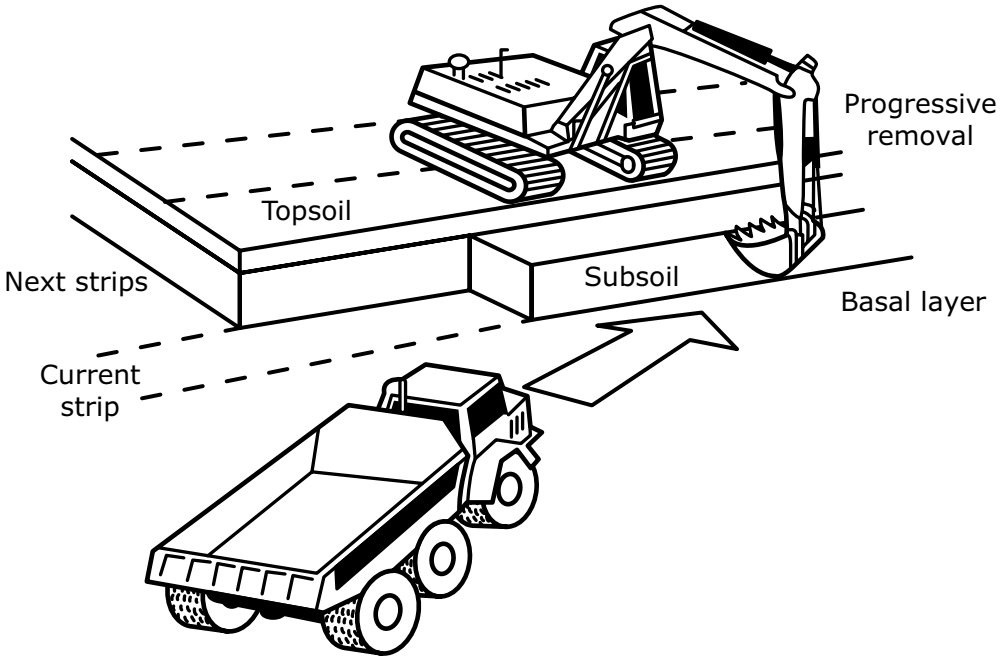

Figure A.3: Stripping with excavators and dump trucks: removal of subsoil from a strip.

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The information in this publication is general guidance on the best practices and approaches to soils guidance.
Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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For over 100 years the Institute of Quarrying has been supporting people working in the mineral extraction industry. It is the only international professional body for quarrying, construction materials and the related extractive and processing industries. IQ's focus is to be the global leader in standards for the sector, to push innovation and operational best practice, to support the industry in driving healthy, sustainable workplaces and to promote the positive impact of the industry and profession. Being a member of IQ means being part of a global community of industry professionals committed to sharing knowledge and improving industry standards.

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet B -

Building Soil Storage Mounds
with Excavators and Dump Trucks

Author: Dr R N Humphries CBiol CSci FRSB FBSSS FIQ
- Blakemere Consultants Ltd & Celtic Energy Ltd

Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

Version 1 | March 2021 | © Institute of Quarrying

Preface

The purpose of Sheet B of the guidance is to provide a model method of best practice where excavators and dump trucks are to be used to build soil storage mounds.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine perators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

This soil handling method uses back-acting excavators to build the storage mound in combination with dump trucks to transport the soil. Either the excavator sits on the basal layer and casts the tipped soil into a mound or it sits on the tipped soil and pulls it into a mound. The latter is preferred as it is easier to form the mound. In many cases low ground pressure bulldozers are used to grade and trim the finished mound.

Top- and subsoil(s) are to be stored in separate mounds or in clearly defined parts of mounds, in some circumstances where the topsoil can be easily recovered it may be laid over the subsoil.

The space available for storage in mineral workings is often limited and this determines the 'height' of mounds. For topsoil the preference is for 1 to 3m height in order to minimize the impact of storage on biological processes, whereas for subsoils where the biological activity is lower, subject to safe operations, mounds are often raised to heights of 3 to 5m depending on the resilience of the soils to compaction (see Part One & Supplementary Note 3).

In this soil handling option, the mounds are either built as one 'tier' or 'multi-tier' high. In the single tier only the excavator and if used the bulldozer traffic the tipped soil surface and usually the final surface. Whilst, in the multi-tier mounds it is also trafficked by loaded dump trucks.

Advantages & Disadvantages

Storage vs Direct Placement:

The advantages of storage are:

i) It gives flexibility in the operation of the mineral site

ii) Flexibility (i.e. weather and ground conditions) for when it is reused.

The disadvantages are:

i) There is an high risk of compaction of the soil material by stacking in the mound which later cannot be effectively treated

ii) There may be significant degradation of biological functions with long-term storage.

Single vs Multi-tier Mounds:

The advantage of multi-tier mounds is that they take less space.The disadvantages are:

i) With multi-tier mounds there is high risk of severe compaction of the soil material layers by repeated trafficking by laden dump trucks in the building of multi-tier mounds which later cannot be effectively treated

ii) There may be a longer delay in recovery of the soil's biological functions on replacement.

Suitability

Soil storage is less suitable where:

i) The subsoil(s) are significantly less resilient to compaction (such as silts and sandy clay loams) and when decompaction treatments cannot be relied upon to be effective because of a risk of soil wetness or operational limitations (such as the unavailability of effective decompaction tools) (see **Part One and Supplementary Notes 3 & 4**)

ii) The intended after use, environmental and ecosystem services are dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This usually includes the most productive agricultural, horticultural and forestry land, many types of natural habitats, and where water storage/infiltration is of importance for the risk of flooding

iii) The bed/strip practice using excavators is used (Sheet A) as the compaction caused can negate its benefit

iv) Multi-tier mounds are used, particularly where the intended after use, and the environment and ecosystem services are dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This usually includes the most productive agricultural and forestry land, many types of natural habitats, and where water storage/infiltration is of importance for the risk of flooding.

MODEL METHODOLOGY

B.1 Key operational points to minimize the risk of severe soil compaction and soil wetness are summarised in Boxes B.1 and B.2.

Box B.1 - To minimize compaction:

- strip in advance the soil to basal layer along haul routes and the operational footprint of the storage mound
- dump trucks are only to stand and travel on the basal layer (unless raising the next level in multi-tier mounds)
- the machines are to only work when ground or soil surface conditions enable their efficient operation
- single-tier mounds should be prioritised over multi-tier mounds as it avoids the need for trafficking on the soil being stored
- raise the soil using only the excavator and maximise the mound height before trucks allowed to access upper surface
- in the raising of multi-tier mounds, trafficking is to be confined to the upper surface of the lower tier. This layer will require decompaction on excavation of the mound.

B.2 The timing of the building of the soil storage mounds will be governed by the weather and soil conditions governing stripping (see **Sheets A, E, F, I**). Unless the soils are required to be kept in a wet state (eg peat), the mounds should be sited on dry ground, not in hollows and should not disrupt local surface drainage (Box B.3). Where necessary mounds should be protected from run-off/ponding by a cut-off ditch which is linked to appropriate water discharge facilities. Where the storage mound is in a hollow due to the removal of surface soils, measures should be undertaken to ensure that water is not able to pond within the storage area.

B.3 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.

Box B.2 - To minimize the wetting of soils:

- soil mounds to be built in dry/draining/drained locations and protect from run-off from adjacent areas
- raise the soil mound to maximum height progressively along the axis of the mound, and shape the mound as it is being built to shed water and seal exposed surfaces whenever stripping is suspended
- measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks.

Box B.3

Where soils such as peat need to be kept in a wet condition this may require storage in (bunded) cells where receiving rainfall cannot drain.

B.4 The operation should follow the detailed stripping/storage plan set out in the SRMP showing soil units to be stripped, haul routes and the phasing of vehicle movements. 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.

B.5 Adopting the practices outlined in **Sheet A**, where relevant, remove topsoil and subsoil to basal layer from the haul routes, footprint of the storage mound and any other operating area in advance. The soils should be stored in their respective mounds.

B.6 The dump trucks must only travel within the haul route and operational areas. Typically the trucks should enter the storage area, reverse and tip the soil load starting at the furthest point of the

mound from the point of access. The back- acting excavator pulls up the soil into a mound of the required dimensions (Box B.4). The excavator operates by standing on the mound (**Figure B.1**) or the stripped basal layer. The excavator bucket can be used to shape and firm the sides as the mound is progressively formed to promote the shedding of rain.

B.7 The process is repeated with the tipping of soil against the forming mound, and without the dump truck wheels traversing onto previously tipped material. The operation continues progressively along the main axis of the mound.

Box B.4 - Choice of Bucket Type

For hard /stony soils toothed buckets are needed. Where the mixing of soil layers at their interface is to be minimized, a bucket with a 'blade' is preferable where the soil is 'soft' and free of large stones or stone free. Where there is a watching archaeological brief, the use of bladed buckets will normally be required.

Similarly, the choice of bucket type, whether it is a standard 'digging'/bulking or wide ditching type will depend on the soil strength and stoniness.

B.8 Without the trucks rising onto the soil mound, the maximum possible height and width of the mound is related to the boom reach of the excavator (typically about 3-4m). Excavators with long booms ('long reach') can be used, but may be more restricted by gradient limitations, and require skilled and experienced operators.

B.9 To raise the mound higher, as a multi-tier mound, the trucks will have to travel on the upper surface of the mounded soils (first tier). In this case the mound should be raised to its maximum height (**Figure B.2**). A ramp will have to be provided for the trucks to rise onto the surface of the first tier, which should be capable of trafficking safely and without difficulty. The next tier would be formed repeating the process described above.

B.10 If further tiers are required, the process would be repeated. Any exposed edges/surfaces should be shaped using the excavator bucket on the onset of rain during the day, this should include any exposed incomplete surfaces. All surfaces should be shaped to shed water at the end of the day. The final outer surface should be progressively shaped using the excavator bucket or low ground pressure bulldozer to promote the shedding of rain.

B.11 Work should stop in wet conditions (Box B.5) with measures undertaken to shed water from the soil surfaces and to prevent ponding at the base of the mound and on the basal layer. At the start of each day ensure there is no ponding on the basal layers and operating areas.

Box B.5 - Rainfall Criteria

- 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, after rain has ceased, soil tests shall 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.

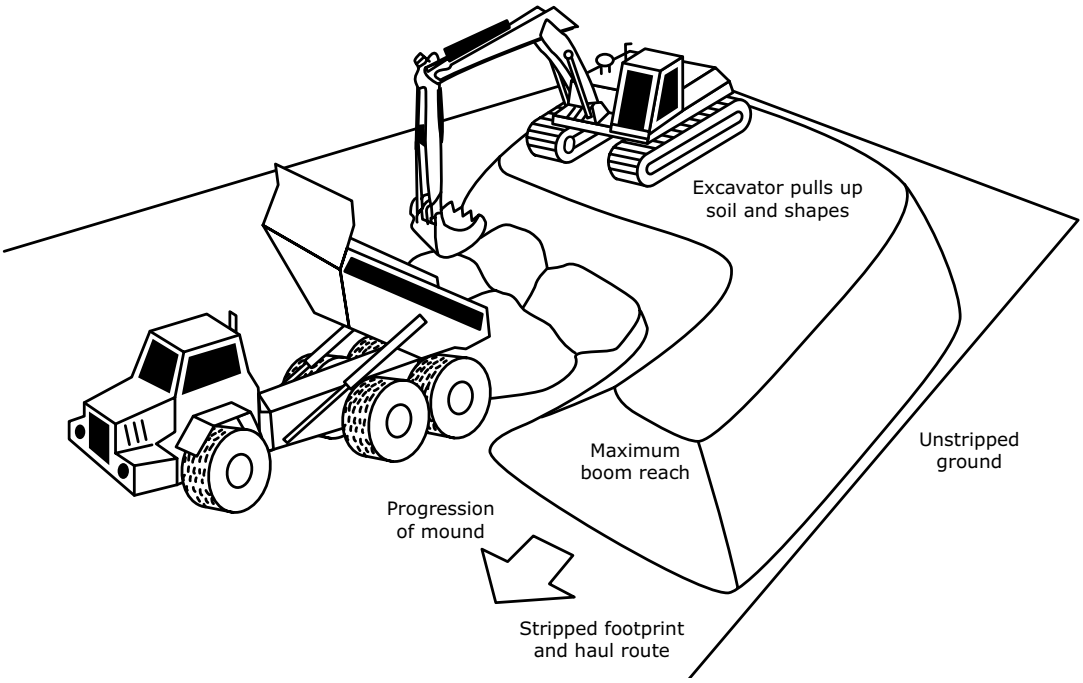

Figure B.1: Soil storage mound construction with excavators and dump trucks: Single tier mound.

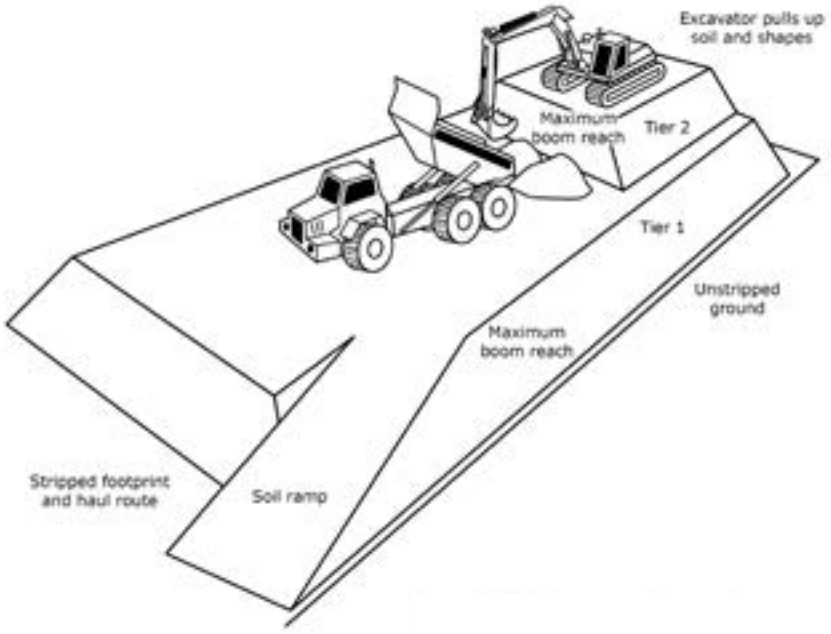

Figure B.2: Soil storage mound construction with excavators and dump trucks: Multi-tier mound.

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet C -

Excavation of Soil Storage Mounds
with Excavators and Dump Trucks

Author: Dr R N Humphries CBiol CSci FRSB FBSSS FIQ
- Blakemere Consultants Ltd & Celtic Energy Ltd

Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet C of the guidance is to provide a model method of best practice where excavators and dump trucks are to be used to recover soils from storage mounds.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

This soil handling method uses back-acting excavators and sometimes tracked shovels to recover soils from storage mounds in combination with dump trucks to transport the soil to the replacement area. Top- and subsoil may be stored in separate mounds or in clearly defined parts of the same mound, in some circumstances where the topsoil can be easily recovered it may be laid over the subsoil.

In this soil handling option the mounds are either built as single 'tier' or as 'multi-tiers'. In the single tier only the excavator, and if used the bulldozer, traffic the soil surface of the mound. In the multi-tier, the mound is also trafficked by loaded dump trucks.

The suitability, advantages and disadvantages are discussed in Sheet B and are predetermined here by the circumstances and the decision to store the soils. The removal of soils from the store can cause additional compaction. The advantage of this model method is that it should minimize additional severe compaction of the soil as trafficking is minimized. However, where the soil has been stored in multi-tier mounds it is likely to be a need for decompaction treatment of the interface between the tiers where the dump trucks have trafficked during the excavation and loading operation.

MODEL METHODOLOGY

C.1 The timing of excavation of the soil storage mounds will be governed by the weather and soil conditions governing stripping (see Sheet A). Key operational points to minimize the risk of severe soil compaction and soil wetness are summarised in Boxes C.1 and C.2.

C.2 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.

C.3 The trucks should enter the storage area and draw alongside the active excavation face. The

Box C.1 - To minimize compaction:

- The dump trucks should only operate on the 'basal'/non-soil layer, and their wheels must not on any circumstances run on to the soil in store
- The excavator should be the only machine to operate on the single tier soil mound
- The machines are to only work when ground conditions enable their efficient operation
- When excavating the multi-tier mounds, to avoid trafficking, a dozer can be used to push the upper tier down to the excavator avoiding the need for trucks trafficking on the mound otherwise excavate tier by tier starting with the uppermost with trafficking confined to the upper surface of the lower tier
- ff severe compaction has been caused then measures are required to treat it before it is loaded into the trucks by the excavator 'digging' over the affected layer (see below and Sheet N).

Box C.2 - To minimize soil wetness and rewetting:

- The mound should be shaped to shed water before rainfall occurs whenever removal is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks.

Box C.3 - Choice of Bucket Type

For hard /stony soils toothed buckets are needed. Where the mixing of soil layers at their interface is to be minimized, a bucket with a 'blade' is preferable where the soil is 'soft' and free of large stones or stone free.

Similarly, the choice of bucket type, whether it is a standard 'digging'/bulking or wide ditching type will depend on the soil strength and stoniness.

back-acting excavator is stand on top of the mound to load trucks (**Figure C.1**) using an appropriate bucket type (Box C.3). The mound is to be dug to the base before moving progressively back along its axis.

C.4 When excavating the multi-tier mounds, where possible, to avoid trafficking a low ground pressure bulldozer can be used to push the upper tier soil down to the excavator. This avoids the need for dump trucks trafficking on the mound. Otherwise excavate tier by tier starting with the uppermost with trafficking confined to the upper surface of the lower tier. Here the excavation should be at the same height of tiers as originally built so that the same surfaces are used for trafficking to build it are again used, so as to minimize further severe compaction (**Figure C.2**). Having removed the upper tier, the trafficked layer(s) must be decompacted. This can be achieved by progressively digging the surface, as described on Sheet N, in advance of loading the next layer. It is essential that the digging is effective and this needs to be checked before soil is loaded. The process is repeated for each soil tier.

C.5 Any exposed edges/surfaces should be shaped on the onset of rain during the day. All surfaces should be shaped to shed water at the end of each day.

C.6 Work should stop in wet conditions (Box C.4) with measures undertaken to prevent ponding at the base of the mound and on the basal layer. At the start of each day ensure there is no ponding on the basal layer and operating areas.

Operational Variation

C.7 Front loading tracked machines may be used to excavate single tier soil mounds provided that they only operate on the basal layer along with the dump trucks (**Figure C.3**).

Box C.4 - Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

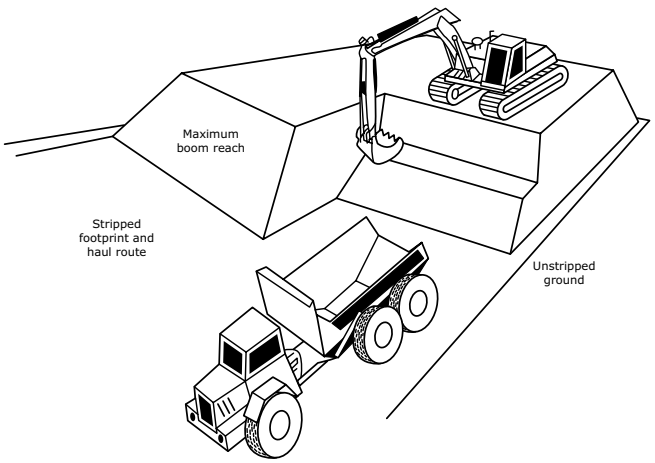

Figure C.1: Excavation of soil storage mounds with excavators and dump trucks: Single tier mounds.

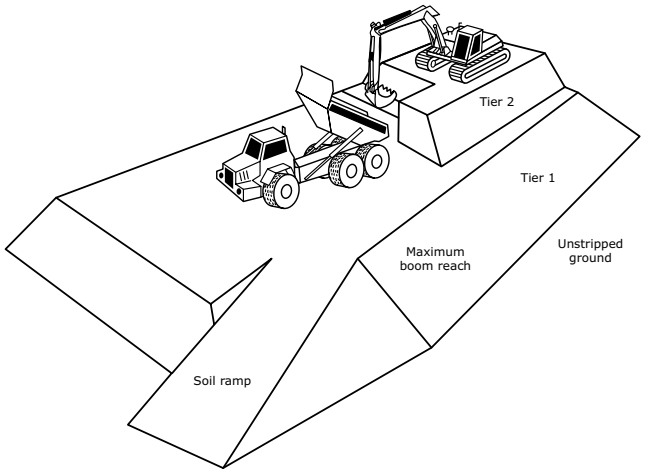

Figure C.2: Excavation of soil storage mounds with excavators and dump trucks: Multi tier mounds.

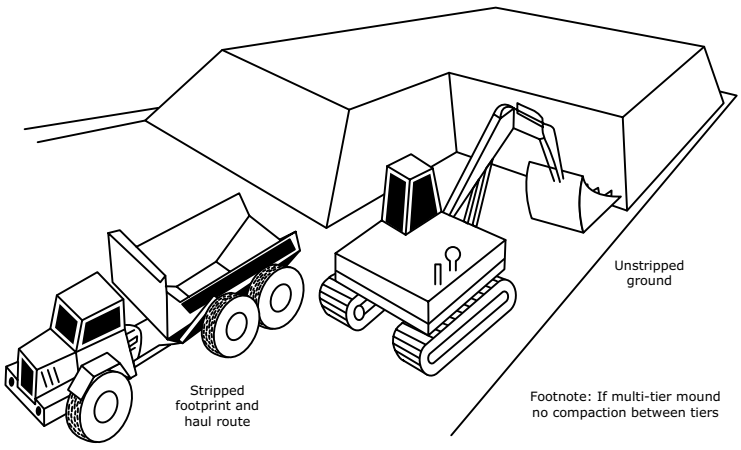

Figure C.3: Excavation of soil storage mounds with front loading shovels and dump trucks: Single and multi tier mounds.

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The information in this publication is general guidance on the best practices and approaches to soils guidance.
Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet D -

Soil Replacement with Excavators and Dump Trucks
- Sequential Bed/Strip Practice

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Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet D of the guidance is to provide a model method of best practice where excavators and dump trucks are to be used to replace soil using the sequential 'bed'/strip by strip practice.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

In this soil handling option, back-acting excavators are used to replace the soil resources tipped from dump trucks at the area being restored.

The replacement practice involves the sequential building up of the individual layers of soil identified in the Soil Resource & Management Plan (SRMP) as vertical slices through the soil profile and advancing as successive strips. Hence, the practice is often referred to as the 'Strip' or 'Bed' method.

The lower layer (subsoil) is placed first within the safe and efficient operational reach of the excavator boom which defines the width of each strip. For each subsequent soil layer, the process is repeated until the top layer (usually topsoil) is placed. When the soil resource/profile sequence within the strip is completely replaced, the process is repeated on the next strip to be replaced with soil and until the whole receiving area is completed. The following guidance can also be adopted where only a single soil horizon is to be replaced.

Unlike the stripping and storage practices, the replacement of soils is usually in concert with other work to remediate soil conditions such as compaction (**Sheets N & O**) and removal of stones/non-soil debris (**Sheets L & M**) to facilitate the intended after use, soil functions, and environmental and ecosystem service provisions. These actions have their own practices which need to be integrated into this model methodology of soil handling. The need for these will have been specified in the SRMP and/or in soil replacement conditions attached to the planning consent, or as determined by the soil specialist during the soil stripping/storage/replacement operations.

Advantages & Disadvantages

The advantages of this machinery combination and handling practice are:

i) Provided the soils are not put into storage mounds, it is the most likely to result in soil profiles with the least compacted soils, which may not require remedial treatment or only minimal of action, as trafficking on the relayed soils is avoided
ii) It can be easier to create localised changes in soil types and variation in horizon depth
iii) It is suited both to the replacement of deep and uniform soils (including peat) as well as thin and 'patterned' soil layers
iv) It is more flexible and quicker in responding to stoppages and restarts due to wet weather
v) There is a greater certainty that a transpiring vegetation cover can be established during the soil replacement programme

The disadvantages are:

i) That it requires greater supervision, skill and discipline in its deployment, and is best suited to experienced operators
ii) Without good control and regular monitoring of soil layer depths, use of profile boards or machine fitted GPS it can be harder to gauge the rate of use of soil resource
iii) There is a risk of some soil 'loss' and mixing of soil horizons at the exposed edges of multi-layered soils as the profile is built up
iv) The bed system involving sequential remedial works may take longer to complete than other practices and machinery options
v) Steep gradient/complex topographies may limit the safe and practical deployment of this handling practice

Suitability

The excavator-dump truck combination with the bed/strip handling practice methodology is considered 'best practice' by Natural England and the Welsh Government for agricultural soils and preferable for all soils. In particular, it is the most suitable of any of the methods available where:

i) The soil is prone to compaction and where decompaction treatments cannot be relied upon to be effective
ii) The intended after use, environmental and ecosystem services are dependent on soils maintaining their functional characteristics such as, porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This includes productive agricultural, horticultural and forestry land, many types of natural habitats, and where water storage/infiltration is of importance for the risk of flooding. Where the soils are stored prior

to replacement some remedial treatment may have to be relied upon

iii) As the bed/strip method offers the most flexibility in respect of short soil drying periods and likely wet weather, and can be less prone to delays and stoppages, it is particularly suited the wetter geographical locations

iv) The full benefit of the practice for soils lies in their direct placement, this requires the mineral extraction scheme to be organized to minimize the need for soils storage.

MODEL METHODOLOGY

Basic Soil Replacement Operation

D.1 The following is the basic model methodology using excavators and dump trucks and the bed/strip practice. It is presented here, firstly without any remedial interventions to give clarity of the methodology. Further on the methodology is repeated to demonstrate how the interventions can be integrated in to the soil replacement process.

D.2 Key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in Boxes D.1 and D.2.

D.3 The timing of soil handling operations in England and Wales is set out in **Part One, Supplementary Note 4**. For directly placed soils this will use the in situ soil wetness protocol for soil stripping operations to determine the timing for soil replacement (Box D.3). For soil that has been stored, the relaying operation should be governed by the weather (rainfall) criteria set out in Box D.4. Here, the operation will generally need to be completed no later than the end of September unless the establishment of a satisfactory vegetation cover can be assured.

D.4 Soil handling is not to take place during rain, sleet or snow and in these conditions should be prohibited if unsafe for machine operations. Prior to commencing operations, a medium/long term weather forecast should be obtained which gives reasonable confidence of soil handling being completed without significant interruptions from rainfall events. The soil based criteria set out in Box D.4 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

Box D.1 - To minimise compaction:

- The dump trucks should only operate on the 'basal'/non-soil layer and not run on the replaced soil layer(s)
- The excavator must only operate on the basal layer
- The machines are to only work when ground conditions enable their efficient operation
- If compaction has been caused, then measures are required to treat it (see **Sheets N & O**).

Box D.2 - To minimise soil wetness and re-wetting:

- The bed/strip system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents. The soil profile within the active strip should be completed including the topsoil layer before rainfall occurs and before replacement is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be restored is to be protected from in-flow of water, ponding etc. Wet sites must be drained in advance. Before the operation starts the basal layer should be to level and clean.

D.5 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their efficient operation. The work should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. Otherwise the operation is to be suspended until suitable remedial measures can be put in place.

D.6 The operation should follow the detailed SRMP replacement plan showing the soil units to be replaced, haul routes and the phasing of vehicle movements. The soil units should be defined on the site with information to distinguish types and layers,

Box D.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 D.4 - Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

and thickness and conveyed to the operational supervisor/operator. 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. Detailed daily records should be kept of operations undertaken and site and soil conditions.

D.7 The excavator and dump trucks are only to stand, work and travel on the basal/formation layer.

D.8 The soil layers above the base/formation layer are to be replaced in sequential strips with the sub-soil layer(s) replaced first, followed by the topsoil layer, each layer being replaced to the specified thickness. The next strip is not to be started until the profile in the current strip is completed. This is often referred to as the 'bed' or 'strip' system which involves the progressive sequential laying of the soil in strips across the area to be restored (**Figure D.1**).

D.9 The initial strip width and axis is to be demarcated. The strip width is determined by excavator boom length less the stand-off to operate; typically, about 3-4m (Box D.5). Excavators with long booms ('long reach') can be used, but may be more restricted by gradient limitations, and require skilled and experienced operators.

D.10 The preferred type of bucket to place the soils is usually a digging/bulking bucket with an attached blade or a wide ditching bucket, but a toothed

bucket can be used.

D.11 Profile boards should be used to control soil horizon thickness in each strip and overall levels achieved verified using soil pits. Allowances (i.e. a bulking factor) should be made for any settlement that may take place of the replaced loose soil.

Box D.5 - Orientation of the Excavator

Usually, the excavator is orientated and operates with its tracks at 90° to the axis of the bed being stripped as this is the most stable position. Whilst the reach of the boom and hence the width of the bed/strip can be significantly increased by orientating it with the tracks parallel to edge of the soil being spread, this may affect the stability of the excavator, particularly on a gradient or where the basal layer has a low baring capacity. Hence, its safe deployment needs to be checked before its adoption.

D.12 The dump trucks reverse up to edge of the current strip and tip the lowest layer (subsoil) soil, without the wheels riding onto the strip (**Figure D.1**). The dump truck should not drive away until all the soil is deposited within the strip without spillage over the basal layer; this may require assistance from the excavator to 'dig away' some of the tipped soil (**Figure D.2**). The excavator is to spread the tipped soil to full thickness by digging, and using the pushing and pulling action of bucket.

D.13 Each load of soil should be spread following tipping before another is tipped. Should the spread soil comprise of large blocks (>300mm), normally these should be broken down by using the excavator bucket into smaller pieces before the next load is spread. The process is repeated until the strip is completely covered with the required depth of the soil layer (**Figure D.3**).

D.14 On completion of the lowest (subsoil) layer, repeat the process spreading the next layer (subsoil/ topsoil) (**Figure D.4**). Tip the soil by reversing to the outer edge of strip/soil previously laid, but without the truck wheels riding onto the already placed layer (see Box D.6 for deep soil profiles). The soil is to be spread by the excavator to full thickness by digging, and using the pushing and pulling action of bucket described above. Repeat the process progressively along the strip. Profile boards should be used to control the soil thickness in the strip and overall levels.

D.15 Where the profile is made up of further soil layers (subsoil/topsoil) the above process should be repeated on completion of the strip.

BOX D.6 - Soil Profiles Greater Than 1m Thickness

When the replaced soil profiles reach about 1m in height from the basal layer it may not be possible to discharge the load from smaller dump trucks directly onto the previously placed lower layers because of the height of the dump truck body. The preferred solution is to tip the soil against the partially completed profile as heaps without the dump trucks rising onto or reversing into the placed material. The soil material is then lifted by the excavator onto the profile. It is considered preferable to accept some limited soil losses rather than to contaminate the topsoil with overburden. The loss of top-soil is minimised if the basal/ formation layer is kept to level and clean.

D.16 On completion of topsoil layer, the processes outlined above should be repeated for the next strips until the area to be restored is completed. Before the operation starts the basal layer should be to level and cleared of any residual soil.

D.17 At the end of each day the current strip must be completed if rain is forecast. If during a day it is evident that a full strip cannot be completed, then complete the part of a strip that has been started.

D.18 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

Method with Integration of Remedial Actions

D.19 Usually there should be less of a need for remedial treatment during the replacement operation with this machinery combination and handling practice (unless the soils were compacted during stripping or storage). Where compaction occurs, treatment will need to be integrated into the replacement process as will the need for the removal of stones or non-soil debris. Both decompaction and the removal of materials are covered in **Sheets L to O**. Where required, the early installation of under drainage can either be integrated sequentially during the replacement of the soils or later during the aftercare period.

D.20 The placement of the stripped soils in storage is likely to result in compaction and negate this particular benefit of the handling practice. Box D.7 sets out some of the remedial options/combinations to facilitate decompaction, and where necessary, the removal of stones and non-soil debris for a final profile comprising a basal layer, subsoil and topsoil layers. Except for Option 3, these actions need to be undertaken sequentially as each soil strip is placed.

D.21 The following is the model methodology integrating the remedial interventions within the bed/strip handling practice.

D.22 The key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in the above Boxes 1 and 2.

D.23 Prior to commencing operations a weather forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events (Box D.4).

D.24 If significant rainfall occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to topsoil level. Replacement should not restart unless the weather forecast is expected to be dry for at least a full day and the soils are in a dry condition (Box D.3).

D.25 The operation should follow the detailed replacement plan in the SRMP showing the soil units to be replaced, haul routes and the phasing of vehicle movements. The soil units should be defined on the site with information to distinguish types and layers, and thickness and conveyed to the operational supervisor/operator. 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. Detailed daily records should be kept of operations undertaken and site and soil conditions (including the removal of stones and other non-soil debris that needs to be removed), and the results of the effectiveness of the work undertaken, and any need for additional remedial treatments.

Box D.7 - Integration of Decompaction & Stone/ Debris Removal

Option 1: is where the basal layer needs to be treated but is left until the subsoil is placed when both are decompacted together, followed by the decompaction of the topsoil and subsoil layers together (and basal layer) using tines that are long enough. This option is not suited to digging where the soil horizons would be mixed.

Option 2: is where each layer is treated separately by either tines or digging.

Option 3: is where the basal layer is treated or left untreated, followed by the placement of the subsoil and topsoil layers, which are to be decompacted by the use of tines. In the case of deep horizons this option can be limited by the capability of the machinery, the tines or bucket used. This option is not suited to digging where the soil horizons would be mixed.

D.26 The excavator and dump trucks are only to stand, work and travel on the basal/formation layer. Only where the remedial work involves the use of a bulldozer does machinery have to traffic the soil surface being treated, as the excavators work from the basal layer.

D.27 The soil layers above the base/formation layer are to be replaced in sequential strips with the subsoil layer(s) replaced first, followed by the topsoil

layer; each layer being replaced to the specified thickness. The next strip is not to be started until the profile in the current strip is completed. This is often referred to as the 'bed' or 'strip' system which involves the progressive sequential laying of the soil in strips across the area to be restored (**Figure D.1**).

D.28 The initial strip width and axis is to be demarcated. Strip width is determined by excavator boom length less the stand-off to operate; typically, about 3-4m (see Box D.5).

D.29 The preferred type of bucket to place the soils is usually a digging/bulking bucket with an attached blade or a wide ditching bucket. However, where a bucket is being used to decompact soils, it should be a 'digging' type and have teeth or a stone-rake type with multiple tines is to be used.

D.30 Where there is a requirement to treat compaction and/or remove stones/damaging materials in the basal layer, these need to be carried out along the demarcated strip prior to the first layer of soils being laid.

D.31 Decompaction of the basal layer can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the basal material, followed by the excavator using a stone-rake bucket (the stone to be loaded on a dump truck and removed (**Sheet L**).

D.32 Profile boards should be used to control soil horizon thickness in each strip and overall levels achieved verified using soil pits to verify. Allowances (i.e. a bulking factor) should be made for any settlement that may take place of the replaced loose soil.

D.33 On completion, the loaded dump trucks reverse up to edge of the current strip and tip the lowest layer subsoil without the wheels riding onto the strip (**Figure D.1**). The dump truck should not drive away until all the soil is deposited within the strip without spillage over the basal layer; this may require assistance from the excavator to 'dig away' some of the tipped soil (**Figure D.2**). The excavator is to spread the tipped soil to full thickness by digging, and using the pushing and pulling action of bucket.

D.34 Each load of soil should be spread following tipping before another is tipped. Should the spread soil comprise of large blocks (>300mm), normally these should be broken down by using the excavator bucket to break the blocks into smaller pieces before the next load is spread. The process is repeated from left to right until the strip is completely covered with the required depth of the soil layer (**Figure D.3**).

D.35 Where there is a requirement to treat compaction and/or remove stones/damaging materials in the subsoil layer, these need to be carried out along the demarcated strip prior to the next overlying layer of soils being laid. Decompaction can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the soil (particularly if it is wet), followed by the excavator using a stone-rake bucket (to be loaded on a dump truck and removed (**Sheet L**).

D.36 On completion of the lowest (subsoil) layer, repeat the process spreading the next layer (topsoil or upper subsoil) (**Figure D.4**). Where the profile is made up of further soil layers (subsoil/topsoil) the process outlined above should be repeated on completion of the strip. Tip the soil by reversing to the outer edge of strip/soil previously laid, but without the truck wheels riding onto the already placed layer (see Box D.6). The topsoil is to be spread by the excavator to full thickness by digging, and using the pushing and pulling action of bucket described above. Repeat the process progressively along the strip. Profile boards should be used and soil pits to verify soil thickness and overall levels in each strip.

D.37 Where there is a requirement to treat compaction in the topsoil layer within each strip as it is completed (see Box D.8), this can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). If required, stone removal may require prior ripping/digging to release them from the soil clods, followed by the excavator using a stone-rake bucket (the stone to be loaded on a dump truck

and removed) (**Sheet L**).

D.38 On completion of the topsoil layer the processes outlined above should be repeated for the next strips until the whole area to be restored is completed. Before the operation starts the basal layer should be to level and clean.
D.39 At the end of each day the current strip must be completed if rain is forecast. If during a day it is evident that a full strip cannot be completed, then complete the part of a strip that has been started.

Box D.8

It is important that the decompaction and any stone/debris is removed from the topsoil layer as each strip is completed. Leaving it until the entire area is soiled will mean that the equipment, and in particular where the dump trucks collecting stones, have to traffic the soil surface resulting in compaction of the topsoil and the underlying subsoil.

Decompaction might be undertaken from the topsoil surface once the placing of the soils is completed (see **Sheet O**). However, this only advisable where it is certain that it will be effective and no other earth-moving machinery is to traffic the replaced soil and that soil wetness and weather conditions are suitable (see **Part One, Supplementary Notes 3 & 4**).

D.40 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

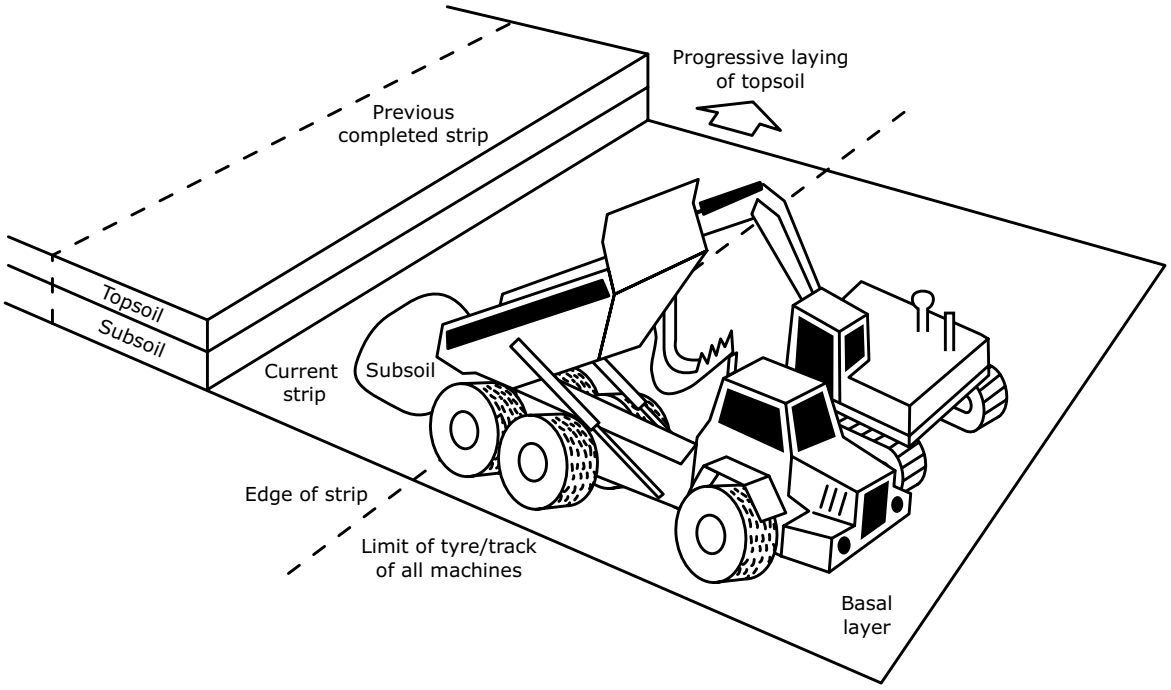

Figure D.1: Soil replacement with excavators and dump trucks: Subsoil layer.

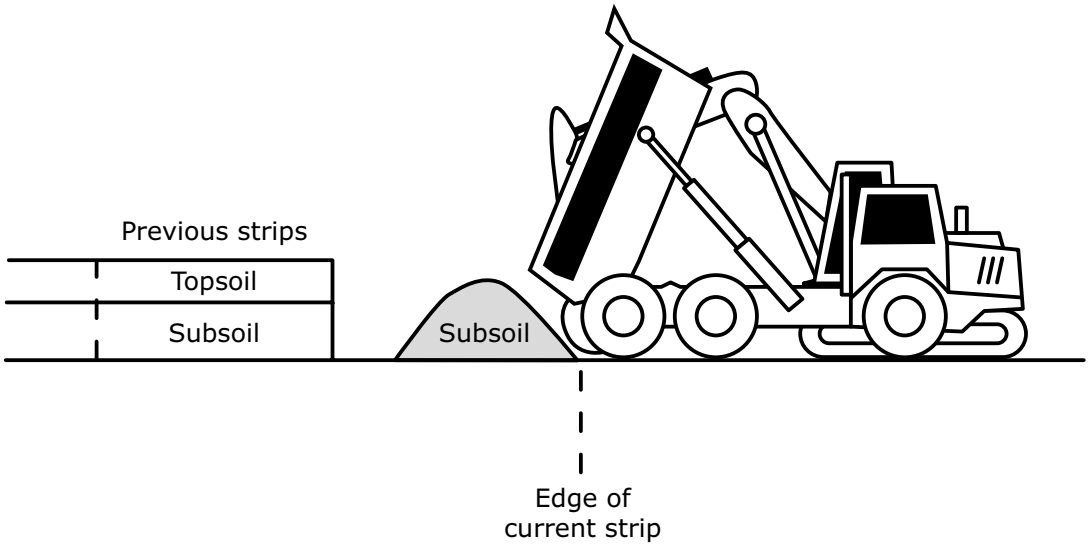

Figure D.2a: Soil replacement with excavators - dump trucks: Subsoil layer.

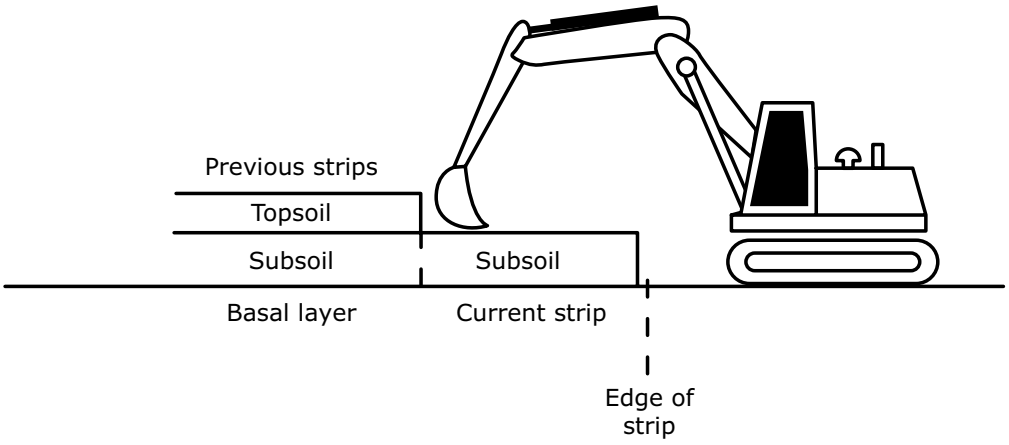

Figure D.2b: Soil replacement with excavators - dump trucks: Subsoil layer.

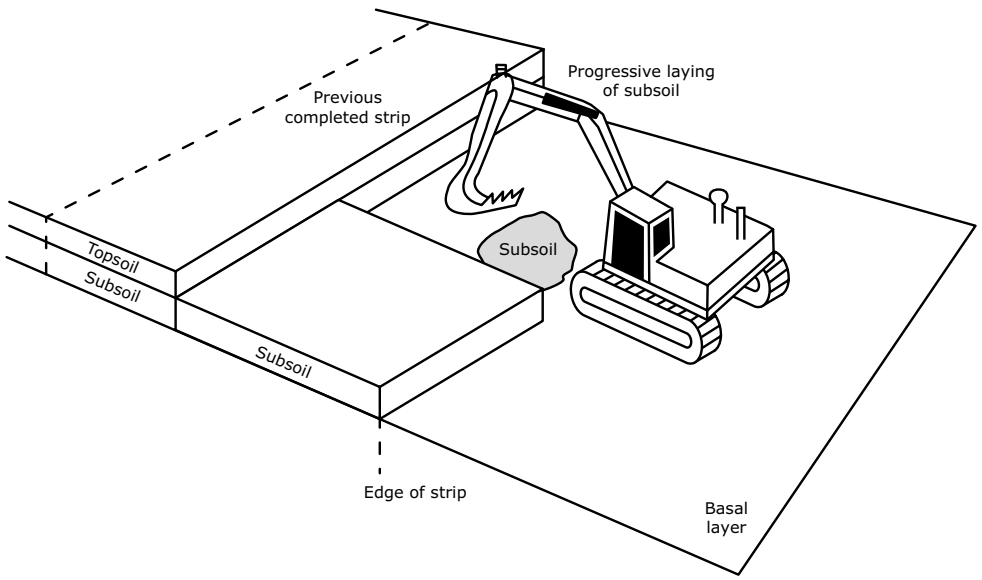

Figure D.3: Soil replacement with excavators and dump trucks: Subsoil progressively laid.

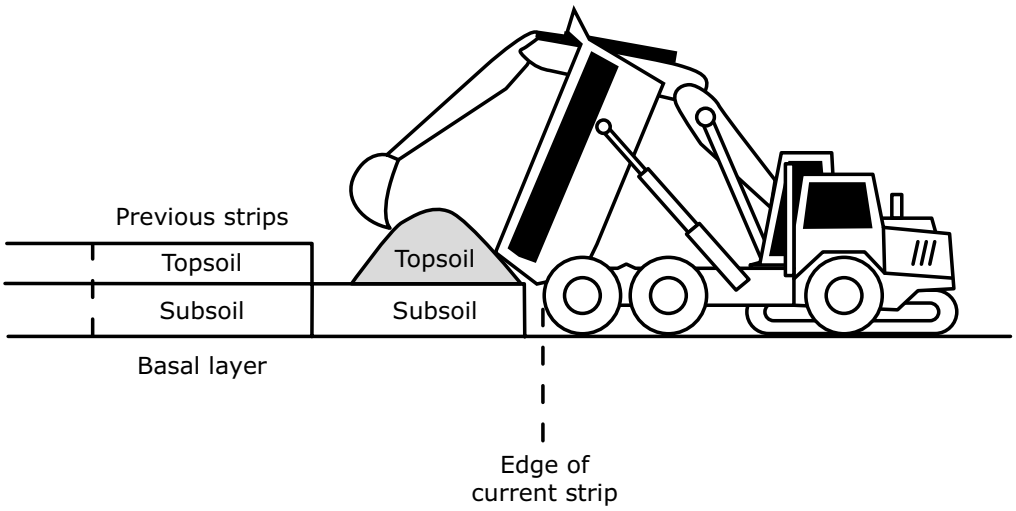

Figure D.4a: Soil replacement with excavators - dump trucks: Topsoil layer.

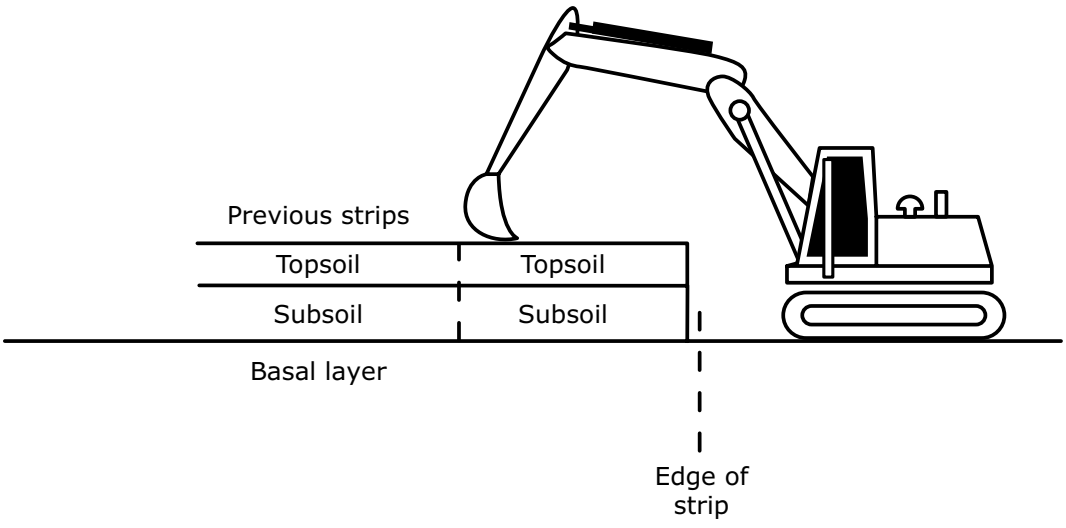

Figure D.4b: Soil replacement with excavators - dump trucks: Topsoil layer.

IQ

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PART TWO: Model Methodology

- Sheet E -

Soil Stripping with Excavators and Dump Trucks
- Windrow Practice

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Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet E of the guidance is to provide a model method of best practice where excavators and dump trucks are to be used to strip soil using the windrow practice.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

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The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

In this soil handling option, back-acting excavators are used to lift the soil resources gathered in 'windrows' and load them into dump trucks for the direct transport to an area being restored or to storage until needed.

The windrow stripping practice, sometimes referred to as the 'peninsular' method, involves the sequential separation and removal of the individual layers of soil identified in the Soil Resource & Management Plan (SRMP). The area to be stripped is divided into spaced parallel strips (windrows) where the soil between them is pulled from each side onto the strip acting as temporary repositories. The safe and efficient operational reach of the excavator boom defines the width between the windrows. The topsoil on the retreating surcharged windrows is then loaded systematically into the dump trucks by the excavator retreating towards the loading point on the haul route. On completing the removal of the topsoil, the exposed subsoil layer(s) is then recovered by the same procedure. The practice of stripping all the top-soil layer before starting the lower soil layers should be avoided as it increases the risk of rainfall events causing longer stoppages. The following guidance can also be adopted where only a single surface soil horizon is to be stripped.

Advantages & Disadvantages

The advantages of this machinery combination and handling practice are that:

i) It is a relatively simple operation to undertake and can be quicker than the bed/strip practice
ii) It can result a lower risk of severe compaction than the soil layer by layer practice, provided the soil is in a dry condition
iii) If the soil horizons are stripped sequentially for each windrow, it offers flexibility in respect of short soil drying periods and likely wet weather as it is less susceptible to stoppages due to soil rewetting as a transpiring vegetation cover can be retained later into the stripping programme. Hence, it can be suited to northern and western, and upland locations, and particularly when there are uncertain weather patterns.

The disadvantages are:

i) Its beneficial effect is dependent on all the soil horizons being stripped as windrows, which may make it a slower more involved operation than the soil layer by layer practice
ii) It requires skill and discipline, and a high level of supervision in its deployment, being suited to experienced operators
iii) Whilst it can result in less soil compaction than other methods, it is likely some will be caused by the excavator moving on the soil during the formation of and operation of the windrows, and hence, there may be reliance on subsequent remedial treatment
iv) Steep gradient/complex topographies may limit the safe and practical deployment of this machinery combination and handling practice.

Suitability

As the methodology involves the excavator operating on each layer of soils to form the successive windrows, there is a risk that compaction can occur and the likely reliance on remedial treatment with this practice. Hence, it is considered to be a less suitable practice than the bed/strip practice for minimizing the risk of soil compaction. The full benefit of the practice lies in the direct placement of the stripped soil and therefore requires the mineral extraction scheme to be organized to provide for this and minimize the need for soils storage.

Whilst it is not considered to be the 'best practice', the windrow practice may be acceptable in circumstances such as where there is a medium to high soil resilience to compaction (see **Table 7**, **Part One**) or the best available where:

i) The soil profile in each designated windrow is stripped sequentially to the basal layer before progressing to the next
ii) The dump trucks do not run on the in situ and the windrowed soils
iii) It is used to recover a single surface soil layer
iv) The intended after use, and environmental

and ecosystem services are less dependent on maintaining their full functional characteristics such as porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This may include the less productive agricultural and forestry land, many types of natural habitats, and where water storage/ infiltration is of lesser importance for the risk of flooding. Where the soils are stored prior to replacement, effective remedial treatment may have to be relied upon

v) It is not suitable for soils with a low bearing capacity such as peat or organic soils, or soils having a high water table

vi) It is often considered to be the most suitable of the soil stripping practices available for important archaeological sites (see Box E.1).

Box E.1

Stripping soils in windrows with an excavator is often the preferred practice when archaeological investigations and recording (as opposed to trial pit/trench sampling and 'watching briefs') are required as part of a planning consent. However, there may be a need for a deviation from normal good practice for soils with the excavator and dump trucks trafficking over the topsoil layer used as the haul route, and in some cases the surcharging of the topsoil for further protection of the archaeological feature. In these cases compaction of the topsoil will result and remedial treatment will have to be relied upon.

MODEL METHODOLOGY

E.1 Key operational points to minimize the risk of severe soil compaction and soil wetness are summarised in Boxes E.2 and E.3.

Box E.2 - To minimize compaction:

- The dump trucks should normally only operate on the 'basal'/non-soil layer, and their wheels must not run on to the soil layer(s)
- The excavator only operates on the windrow with the dump trucks only travelling on the basal layer
- The machines are to only work when ground conditions enable their efficient operation
- The topsoil to be surcharged on the windrow as a thick layer as possible whilst maintaining the safe operation
- The soil layers are to be in 'dry' condition.

Box E.3 - To minimize the wetness of the soil and re-wetting of the soil:

- The progressive windrow system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents. The soil profile within the active windrowed strip should be removed to the basal layer before rainfall occurs and before stripping is suspended
- Measures are required to protect the exposed face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance
- The maintenance of a transpiring crop is important, and an appropriate cropping regime should be established for the year of soil stripping
- Before stripping, excess vegetation should be removed; in the case of grassland it should be cut or grazed short and arable crops should have been harvested.

E.2 The timing of soil handling operations should only take place when the soils are in a 'dry and friable' condition (ie when it breaks and shatters when disturbed rather than smears and deforms) (see **Part One, Supplementary Note 4**). Prior to the start or recommencement of soil handling they should be tested to confirm they are in suitably dry condition (see Box E.4).

E.3 Soil handling is not to take place during rain, sleet or snow and in these conditions should be prohibited due to unsafe machine operating conditions. Prior to commencing operations, a medium/long term weather forecast should be obtained which gives reasonable confidence of soil handling being completed without significant interruptions from rainfall events. The soil based criteria set out in Box E.5 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

E.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.

E.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. 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.

E.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. To protect the subsoil from becoming wet during changes in the weather, the next windrowed topsoil strip should not be started

Box E.4 - 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.

until the subsoil under lying the strip is completely stripped to the basal layer (**Figure E.1**). Stripping is to be undertaken by the excavator standing within the windrow strip and loading the surcharged soil layer into dump trucks.

Box E.5 - Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

Box E.6 - Choice of Bucket Type

For hard /stony soils toothed buckets are needed. Where the mixing of soil layers at their interface is to be minimized, a bucket with a 'blade' is preferable where the soil is 'soft' and free of large stones or particularly stony stone free.

Similarly, the choice of bucket type, whether it is a standard 'digging'/bulking or wide ditching type will depend on the soil strength and stoniness.

Bladed buckets will be required for soil stripping involving archaeological investigation. Where there is a watching archaeological brief, the use of bladed buckets will normally be required.

E.7 The type of bucket to be used largely depends on the nature of the soil (Box E.6).

E.8 Demarcate the windrow topsoil strips to be surcharged; the width of the soil strip to be recovered between the windrows is determined by the effective and safe excavator boom radius from the edge of each windrow; typically, about 3-4m (Box E7). Excavators with long booms ('long reach') can be used, but may be more restricted by gradient

Box E.7 - Orientation of the Excavator

Usually, the excavator is orientated and operates with its tracks at 90^{o} to the axis of the bed being stripped as this is the most stable position.

Whilst the reach of the boom and hence the width of the bed/strip can be significantly increased and the excavator trafficking over the soil surface decreased by orientating it with the tracks parallel to edge of the soil being stripped, this may affect the stability of the excavator, particularly on a gradient or where soils have a low baring capacity. Hence, its safe deployment needs to be checked before its adoption.

limitations, and require skilled and experienced operators.

E.9 The excavator is only to stand and work on the soil layers when stripping soils, otherwise it is to travel only on the basal/formation layer. The dump trucks are only to operate on the basal/formation layer. The exception is where it is stipulated that they are to traffic the topsoil for the protection of underlying archaeological features (see above Box E.1).

E.10 The top-soil layer is to be pulled up in the thickest layer possible onto the surcharged strip (**Figures E.1 & E.2**). It should be recovered to the full width of the segment being stripped without mixing with the underlying subsoil (not more than 20% of the lower horizon should be exposed at the layer junction within the strip). The thickness and identification of the horizon junction must be verified before and during stripping. The full thickness of the topsoil horizon should be stripped progressively before the underlying subsoil horizon(s), if present, is to be started. On completion of the topsoil windrow and its removal, the above procedures are repeated sequentially for each underlying soil horizon until the area is completely stripped of soil to the basal layer (**Figures E.3 & E.4**).

E.11 Where the soils are to be directly placed without storage in mounds, the initial strip of the upper horizons will have to be stored temporarily to

release the lowest layer and enable the sequential movement of materials.
The stored initial soil material would be placed on the lower layer removed from the final strip at the end of the programme or on partially completed profiles if rain were forecast.

E.12 When the stripping operation is likely to be interrupted by rain or there is likely to be overnight rain remove any exposed subsoil down to the basal layer before suspending operations. Make provisions to protect base of current or next strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

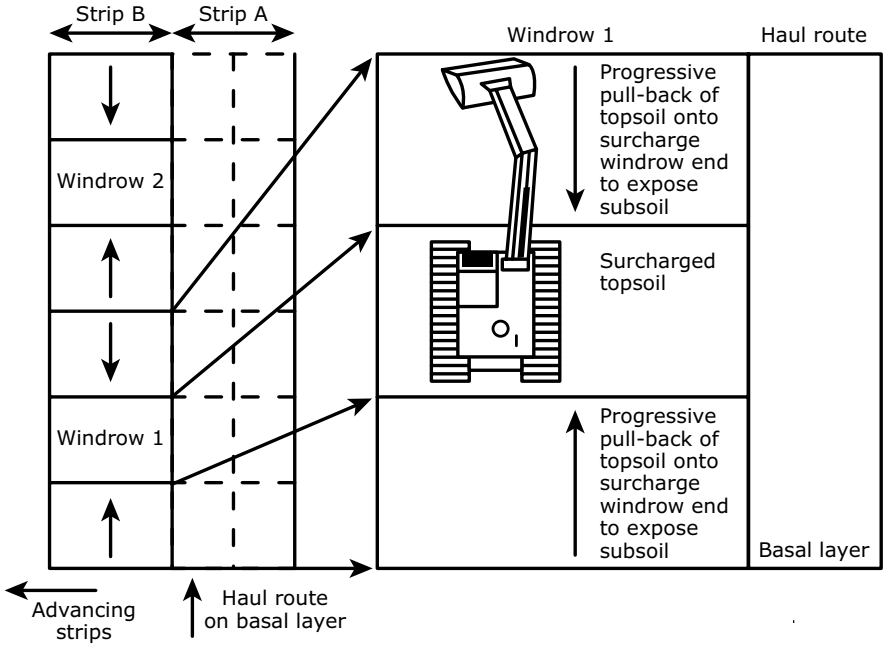

Figure E.1: Surcharging of windrow with topsoil.

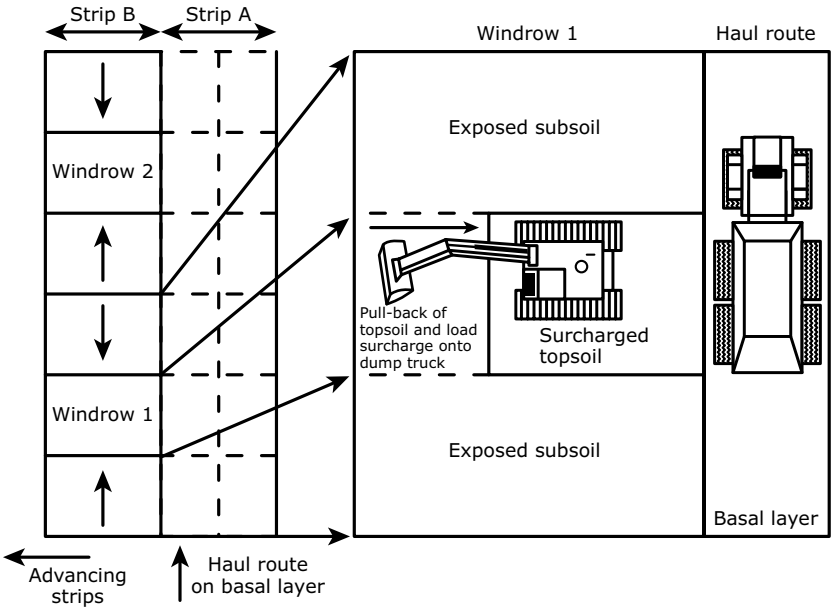

Figure E.2: Retreat of topsoil, surcharged windrow and loading of dump trucks.

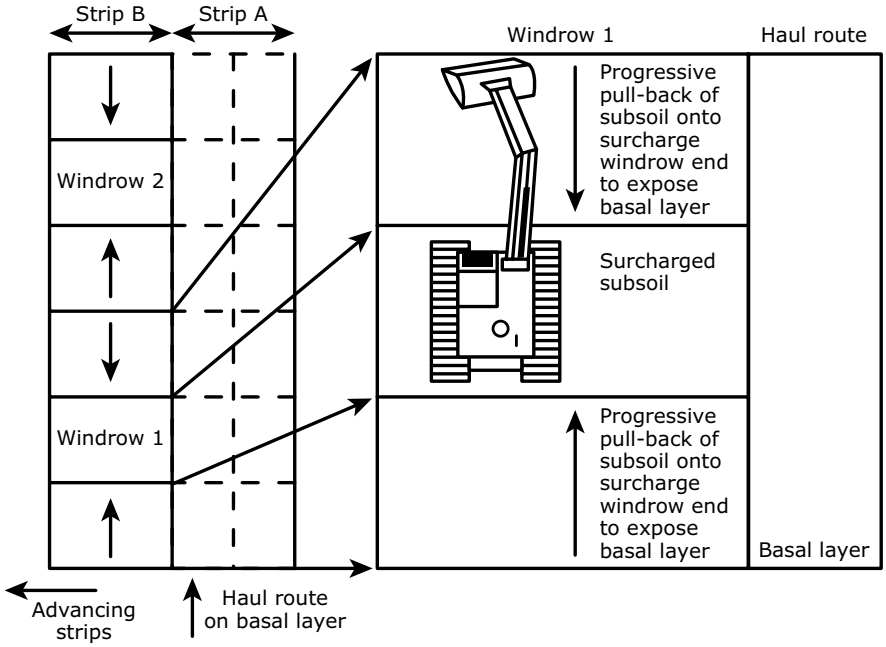

Figure E.3: Surcharging of windrow with subsoil.

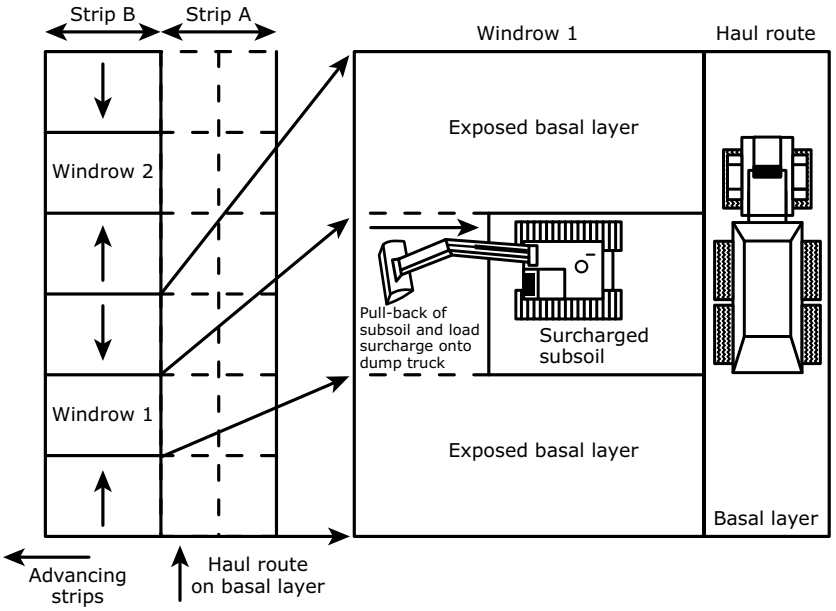

Figure E.4: Retreat of subsoil surcharged windrow and loading of dump trucks.

IQ

The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

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Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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For over 100 years the Institute of Quarrying has been supporting people working in the mineral extraction industry. It is the only international professional body for quarrying, construction materials and the related extractive and processing industries. IQ's focus is to be the global leader in standards for the sector, to push innovation and operational best practice, to support the industry in driving healthy, sustainable workplaces and to promote the positive impact of the industry and profession. Being a member of IQ means being part of a global community of industry professionals committed to sharing knowledge and improving industry standards.

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet G -

Building Soil Storage Mounds
with Bulldozers and Dump Trucks

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Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet G of the guidance is to provide a model method of best practice where bulldozers and dump trucks are used to build soil storage mounds.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular, those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

This soil handling method uses low ground pressure bulldozers to build the storage mound in combination with dump trucks to transport the soil. Top- and subsoil(s) are to be stored in separate mounds or in clearly defined parts of mounds, in some circumstances where the topsoil can be easily recovered it may be laid over the subsoil.

The space available for storage in mineral workings is often limited and this determines the 'height' of mounds. For topsoil, the preference is for 1 to 3m height in order to minimize the impact of storage on biological processes, whereas for subsoils where the biological activity is lower, subject to safe operations, mounds are often raised to heights of 3 to 5m depending on the resilience of the soils to compaction (see **Part One & Supplementary Note 3**).

In this soil handling option, the mounds are either built as one 'tier' or 'multi-tier' high. In the single tier only the bulldozer traffic the soil surface and usually the final surface. In the multi-tier, the mound is also trafficked by loaded dump trucks.

Advantages & Disadvantages
Storage vs Direct Placement:
The advantages of storage are:

i) It gives flexibility in the operation of the mineral site
ii) Flexibility (i.e., weather and ground conditions) when it is reused.

The disadvantages are:

i) There is a high risk of compaction of the soil material by stacking in the mound which later cannot be effectively treated
ii) There may be significant degradation of biological functions with long-term storage.

Single vs Multi-tier Mounds:
The advantage of multi-tier mounds is that they take less space. The disadvantages are:

i) With multi-tier mounds there is high risk of severe compaction of the soil material layers by repeated trafficking by laden dump trucks in the building of multi-tier mounds which later cannot be effectively treated
ii) There may be a longer delay in recovery of the soil's biological functions on replacement.

Suitability
Soil storage is less suitable where:

i) The subsoil(s) are significantly less resilient to compaction (such as silts and sandy clay loams) and when decompaction treatments cannot be relied upon to be effective because of a risk of soil wetness operational limitations (such as the unavailability of effective decompaction tools) (see **Part One and Supplementary Notes 3 & 4**)
ii) The intended after use, and environmental and ecosystem services are dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This usually includes the most productive agricultural, horticultural and forestry land, many types of natural habitats, and where water storage/infiltration is of importance for the risk of flooding
iii) The bed/strip practice using excavators is used (**Sheet A**) as the compaction caused can negate its benefit
iv) Multi-tier mounds are used, particularly where the intended after use, and the environment and ecosystem services are dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This usually includes the most productive agricultural and forestry land, many types of natural habitats, and where water storage/infiltration is not of importance for the risk of flooding.

MODEL METHODOLOGY

G.1 Key operational points to minimize the risk of severe soil compaction and soil wetness are summarised in Boxes G.1 and G.2.

Box G.1 - To minimize compaction:

- Strip in advance the soil to basal layer along haul routes and the operational footprint of the storage mound
- The soils are to be pushed by the bulldozer to form the mound in as thick layers as possible whilst maintaining their efficient operation
- The machines are to only work when ground or soil surface conditions enable their efficient operation
- The dump trucks should only operate on the 'basal'/non-soil layer, and their wheels must not in any circumstances run on to the tipped soil
- In the raising of multi-tier mounds, trafficking is to be confined to the upper surface of the lower tier. This layer will require decompaction on excavation of the mound.

Box G.2 - To minimise the wetting of soils:

- Site soil mounds in dry locations and protect from run-off from adjacent areas. Drain if a wet location
- Raise the soil mound to maximum height progressively along the axis of the mound and shape the mound as it is being built to shed water and whenever stripping is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks.

G.2 The timing of the building of the soil storage mounds will be governed by the weather and soil conditions governing stripping (see **Sheets A, E, F, I**). The mounds should be sited on dry ground and not in hollows and should not disrupt local surface drainage (Box G.3). Where necessary mounds should be protected from run-off/ponding by a cut-off ditch which is linked to appropriate water discharge facilities.Where the storage mound is in a hollow due to the removal of surface soils, measures should be undertaken to ensure that water is not able to pond within the storage area.

G.3 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.

Box G.3

Where soils such as peat need to be kept in a wet condition this may require storage in bunded cells where receiving rainfall cannot drain. Here, the use of bulldozers is not appropriate for handling peat, and excavators and dump trucks are to be used (**Sheets A – D**).

G.4 The operation should follow the detailed stripping/storage plan set out in the SRMP showing soil units to be stripped, haul routes and the phasing of vehicle movements. 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.

G.5 Adopting the practices outlined in **Sheets A**, F or I, where relevant, remove topsoil and subsoil to basal layer from the haul routes, footprint of the storage mound and any other operating area in advance. The soils should be stored in their respective mounds.

G.6 The dump trucks must only travel within the haul route and operational areas. The trucks should enter the storage area, reverse and tip the soil load starting at the furthest point of the mound from the point of access.

G.7 The low ground pressure bulldozer pushes the soil into a mound of the required dimensions (**Figure G.1**). The bulldozer is used to shape the sides as the mound is progressively formed to promote the shedding of rain, particularly at the end of each day, but also on the onset of rain during the day. This should include any exposed incomplete surfaces.

G.8 The process is repeated with the tipping of soil against the forming mound, and without the dump truck wheels traversing onto previously tipped material. The operation continues progressively along the main axis of the mound. Without the trucks rising onto the soil mound, the typical height of a mound raised by bulldozer is in the order of 4-6m.

G.9 Work should stop in wet conditions (Box G.4) with measures undertaken to shed water from the soil surfaces and to prevent ponding at the base of the mound and on the basal layer. At the start of each day ensure there is no ponding on the basal layers and operating areas.

Box G.4 - Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

G.10 To raise the mound higher, the trucks will have to travel on the upper surface of the mounded soils, or long reach excavators used to cast-up the soil. In this case the mound should be raised to its maximum height (**Figure G.2**). A ramp will have to be provided for the trucks to rise onto the surface of the first tier, which should be capable of trafficking without difficulty. The next tier would be formed repeating the process described above. If further tiers are required, the process would be repeated again.

G.11 Any exposed edges/surfaces should be shaped using the bulldozer blade on the onset of rain during the day. All surfaces should be shaped to shed water at the end of the day. The final outer surface should be progressively shaped using the bulldozer blade to promote the shedding of rain.

G.12 Work should stop in wet conditions (Box G.4) with measures undertaken to prevent ponding at the base of the mound and on the basal layer. At the start of each day ensure there is no ponding on the basal layers and operating areas.

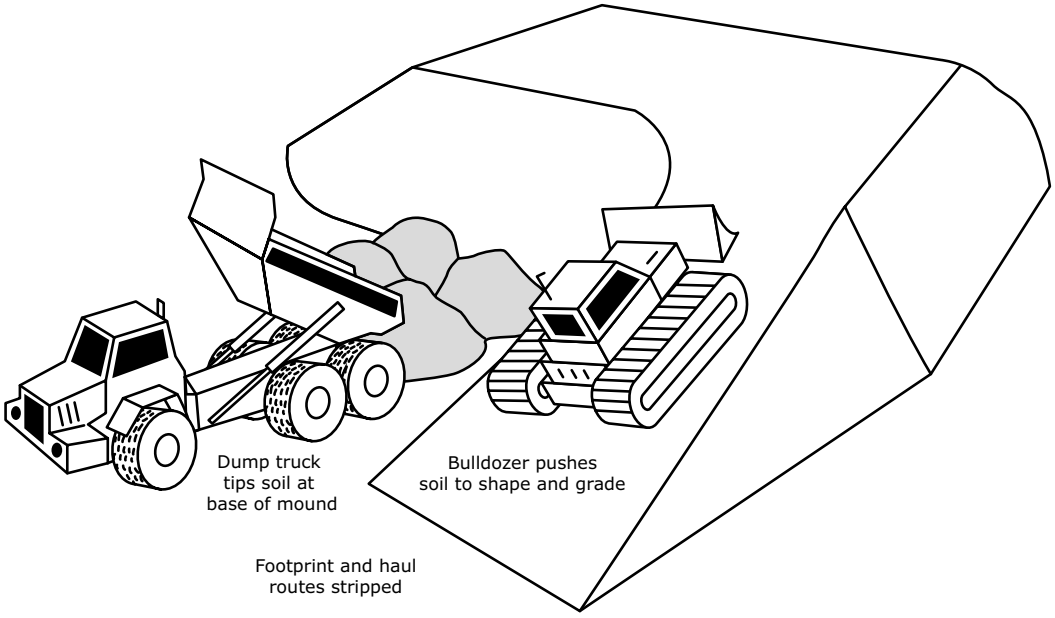

Figure G.1: Soil storage mound construction with bulldozer and dump trucks: Single tier mound.

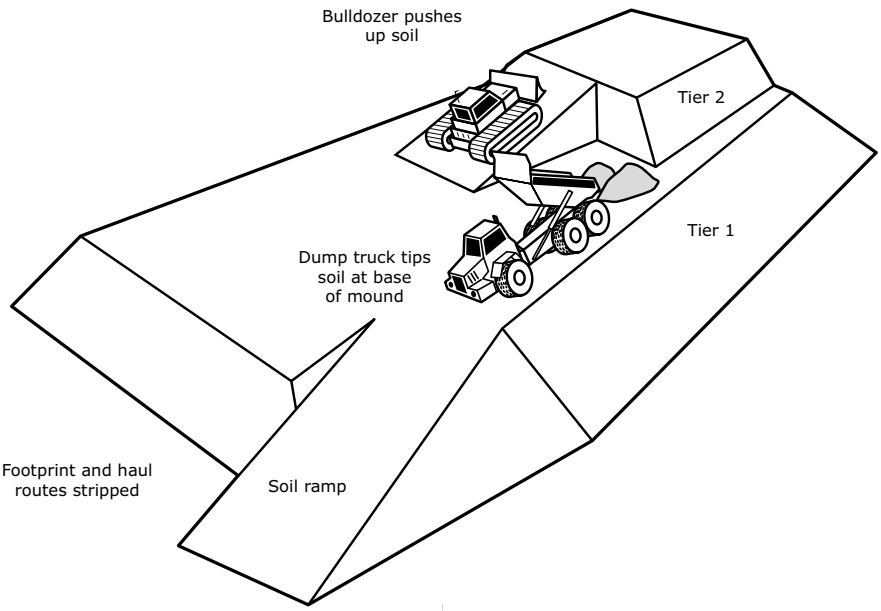

Figure G.2: Soil storage mound construction with bulldozers and dump trucks: Multi-tier mound..

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The information in this publication is general guidance on the best practices and approaches to soils guidance.
Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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For over 100 years the Institute of Quarrying has been supporting people working in the mineral extraction industry. It is the only international professional body for quarrying, construction materials and the related extractive and processing industries. IQ's focus is to be the global leader in standards for the sector, to push innovation and operational best practice, to support the industry in driving healthy, sustainable workplaces and to promote the positive impact of the industry and profession. Being a member of IQ means being part of a global community of industry professionals committed to sharing knowledge and improving industry standards.

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet H-

Soil Replacement with Bulldozers and Dump Trucks
- Windrow Practice

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Supporting artwork was provided by R Shelton (H J Banks & Co)
and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet H of the guidance is to provide a model method of best practice where bulldozers and dump trucks are to be used to replace soil using the windrow practice.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer’s specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

In this handling option, bulldozers are used to spread the replaced soil from series of linear surcharged strips (windrows). The windrow replacement practice is sometimes referred to as the 'peninsular' method.

It involves the sequential replacement of the individual layers of soil identified in the Soil Resource & Management Plan (SRMP). The method can be used for both top and subsoil.

The area to be replaced is divided into windrows from which excess soil is pushed out (from each side) over the adjacent unsoiled parts. The efficient operational distance of the bulldozers push and the safe height for the dump trucks to reverse and tip the soils defines the height of the surcharged windrow and the distance between the windrows. The following guidance can also be adopted where only a single soil horizon is to be replaced.

There is a hybrid excavator and bulldozer practice (see **Sheet K**) often referred to as a 'loose-tipping' method without the use of windrows where the subsoil(s) is replaced by the excavator method (**Sheet D**) with the topsoil then spread by bulldozer.

Advantages & Disadvantages
The advantages of this machinery combination and handling practice are:

i) It is a relatively simple operation to undertake and can be quicker than the excavator combination with the bed/strip practice
ii) If the practice is applied sequentially across the site, the windrow replacement practice can offer flexibility in respect of short dry periods and likely wet weather, operationally, it can be less prone to delays and stoppages in uncertain weather patterns.

The disadvantages are several:

i) There is risk of compaction of the replaced soil layers by repeated trafficking by the bulldozer and the loaded dump trucks as they enter and tip the soils on the windrows. Hence, remedial treatments are likely to be relied upon
ii) It can cause patterned ground due to uneven soil depths and where some areas are more compacted than others
iii) It is more difficult to create localised changes in soil types and variation in horizon depth over short distances.

Suitability
Whilst the method is not considered 'best practice', it may be acceptable in circumstances where:

i) The subsoil(s) have a high resilience to further compaction (see **Part One**) and when decompaction treatments can be more relied upon to be effective because of a low risk of soil wetness (low rainfall areas/prolonged dry conditions) or operational limitations (such as the availability of effective decompaction tools)
ii) The intended after use, and environmental and ecosystem services are less dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This may include low productivity agricultural and forestry land, some types of natural habitats, and where water storage/infiltration is of lesser importance for the risk of flooding. Where the soils are stored prior to replacement, effective remedial treatment may have to be relied upon
iii) It is suited to the placement of a single layer of topsoil rather than a series of soil layers
iv) The soils have been placed into storage stockpiles.

MODEL METHODOLOGY

Basic Soil Replacement Operation
H.1 The following is the basic model methodology using bulldozers with dump trucks and the windrow practice. It is presented here, firstly without any remedial interventions to give clarity of the methodology. The methodology is then repeated with interventions to demonstrate how integration is to be achieved.

H.2 Key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in Boxes H.1 and H.2.

Box H.1 - To minimize compaction:

- The dump trucks should only operate on the 'basal'/non-soil layer when not entering the windrows
- The machines are to only work when ground conditions enable their efficient operation
- The soils are to be spread by the bulldozer in as thick layer as possible whilst maintaining their efficient operation
- The bulldozer should make the minimal number of passes over the soil as possible
- The soil layers are to be in 'dry' condition

Box H.2 - To minimize the wetness of the soil and re-wetting of the soil:

- The windrow system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents. The soil profile within the active strip should be replaced to the topsoil surface layer before rainfall occurs and before replacement is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be restored is to be protected from in-flow of water, ponding etc. Wet sites must be drained in advance. Before the operation starts the basal layer should be to level and clean.

H.3 The timing of soil handling operations should only take place when the soils are in a 'dry and friable' condition (ie when it breaks and shatters when disturbed rather than smears and deforms) (see **Part One, Supplementary Note 4**). Prior to the start or recommencement of soil handling they should be tested to confirm they are in suitably dry condition (see Box H.3).

H.4 Soil handling (by any machinery combination and handling practice) is not to take place during rain, sleet or snow and in these conditions should be prohibited due to unsafe machine operating conditions. Prior to commencing operations a medium/long term weather forecast should be

Box H.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.

obtained which gives reasonable confidence of soil handling being completed without significant interruptions from rainfall events. The soil based criteria set out in Box H.4 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

Box H.4 - Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

H.5 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.

Box H.5

Whilst there can be a lower of a risk of compaction when using wide tracked ('low ground pressure' (LGP)) bulldozers, in some circumstances they may require to traffic the soil surface more than standard machines to achieve the same work rate, and therefore the advantage of their use may be less than anticipated. However, the risk of severe compaction and reliance on remedial treatments may be less with the use of LGP machines.

H.6 The operation should follow the detailed soil plan set out in the SRMP showing soil units to be replaced, haul routes and the phasing of vehicle movements. 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 replaced in a similar manner. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

Box H.6

As a general rule, a moving loaded dump truck can exert sufficient pressure to cause compaction of loose soil to a depth of 40 – 60cm depending on its wetness.

H.7 Either the process progresses across the site until there is a complete subsoil cover before topsoil is replaced or it is done in sections with the full profile being completed before another is started. The latter sequential approach has the advantage that a large expanse of subsoil is not exposed to wetting prior to top-soiling.

H.8 Profile boards should be used to control soil horizon thickness being replaced and overall levels achieved verified using soil pits.

Box H.7 - Integration of Decompaction & Stone/ Debris Removal

Option 1: is where the basal layer needs to be treated but is left until the subsoil is placed when both are decompacted together, followed by the decompaction of the topsoil and subsoil layers together (and basal layer) using tines that are long enough. This option is not suited to digging where the soil horizons would be mixed.

Option 2: is where each layer is treated separately by either tines or digging.

Option 3 is where the basal layer is treated or left untreated, followed by the placement of the subsoil and topsoil layers, which are to be decompacted by the use of tines. In the case of deep horizons this option can be limited by the capability of the machinery, the tines or bucket used. This option is not suited to digging where the soil horizons would be mixed.

H.9 The bulldozer is to work and travel on the soil layers (Box H.5). The dump trucks should avoid reversing onto the windrows until they have been surcharged sufficiently to buffer any underlying functional soil layer from compaction.

H.10 The area to be soiled is divided into a series of windrows on which the first loads of subsoil are pushed out by bulldozer to form the windrow of subsoil of 400 – 600mm thick (Box H.6). It is then surcharged with further subsoil being tipped by dump trucks reversing over the initial layer (**Figures H.1 – H.2**). The excess soil on the surcharged windrows is pushed out laterally by the bulldozer to cover the area between the windrows to the required depth.

H.11 On completion of the subsoil placement, the topsoil is replaced by the above procedure (**Figure H.3 & H.4**). The dump trucks should avoid reversing onto the windrows until they have been surcharged to buffer any underlying functional subsoil/basal layer from compaction (see Box H.6).

H.12 At the end of each day the current sector with soils being replaced must be completed if rain is forecast. If during a day it is evident that a full windrow cannot be completed, then that part must be completed to topsoil level.

H.13 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

Methodology with Remedial Actions

H.14 The following is the model methodology, using bulldozers with dump trucks for the windrow practice, with the remedial interventions to demonstrate how integration is to be achieved. The key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in the above Boxes H.1 and H.2.

H.15 Usually there will be a need for decompaction treatment during the replacement operation with this methodology. Where compaction occurs, treatment will need integrating into the replacement process as will any need for the removal of stones or non-soil debris within the replacement process. Both decompaction and removal of materials procedures are covered in separate **Sheets L to O**.

H.16 The placement of the stripped soils in storage is likely to have contributed to the compaction. Box H.7 sets out some of the remedial options/ combinations to facilitate decompaction, and where necessary, the removal of stones and non-soil debris for a final profile comprising a basal layer, subsoil and topsoil layers. Except for Option 3, these actions need to be undertaken sequentially as each soil strip is placed.

H.17 Prior to commencing operations a weather forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events (Box H.4).

H.18 If significant rainfall occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to the topsoil level. Replacement must not restart unless the weather forecast is expected to be dry for at least a full day and the soils are in a dry condition (see above Box H.3).

H.19 All machines must be in a safe and efficient working condition at all times. The machines are only to work when ground conditions enable their efficient operation. The work should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. Otherwise the operation is to be suspended until suitable remedial measures can be put in place.

H.20 The operation should follow the detailed replacement plan in the SRMP showing the soil units to be replaced, haul routes and the phasing of vehicle movements. The soil units should be defined on the site with information to distinguish types and layers, and thickness and conveyed to the operational supervisor/operator. 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. Detailed daily records should be kept of operations undertaken and site and soil conditions (including the removal of stones and other non-soil debris that needs to be removed), and the results of the effectiveness of the work undertaken, and any need for additional remedial treatments.

H.21 Profile boards should be used to control soil horizon thickness being replaced and overall levels achieved verified using soil pits. Allowances (ie. bulking factor) should be made for any 'heave' that may take place when the replaced soil is decompacted.

H.22 Only the bulldozer is to work and travel on the soil layers. The dump trucks should avoid reversing onto the windrows until they have been surcharged sufficiently to buffer any underlying functional soil layer from compaction (see above BOX H.6).

H.23 The area to be soiled is divided into a series of windrows. Where there is a requirement to treat compaction and/or remove stones/non-soil debris in the basal layer, these need to be carried out in the area to be soiled (including the windrows being formed).

H.24 Where there is a requirement to treat compaction and/or remove stones and non-soil debris in the basal layer, these need to be carried out in the area to receive the subsoil. Decompaction can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the soil, followed by the excavator using a stone-rake bucket (to be loaded on a dump truck and removed) (**Sheets L & M**). Where these treatments are deployed, to minimise additional compaction/recompaction, only the bulldozer need to work and traffic the basal layer and the soil surfaces, and the excavator and the dump truck being loaded with the recovered stones/debris stand and travel on the untreated basal layer.

H.25 On completion of the remedial work, the subsoil windrow is formed as described above with the bulldozer pushing out the excess sub-soil to cover the area to the required depth (**Figures H.1 & H.2**). The dump trucks should avoid reversing onto the windrows, particularly until they have been surcharged to buffer any underlying functional basal layer from compaction.

H.26 On completion of the subsoil placement, where there is a requirement to treat compaction and/or remove stones/non-soil debris in the subsoil layer, these need to be carried out prior to the topsoil being laid.

H.27 Where there is a requirement to treat compaction and/or remove stones and non-soil debris in the subsoil, these need to be carried out prior to the topsoil layer of soil being laid. Decompaction can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the subsoil, followed by the excavator using a stone-rake bucket (to be loaded on a dump truck and removed) (**Sheets L & M**). Where these treatments are deployed, to minimise additional compaction/recompaction, only the bulldozer need to work and traffic the subsoil layer, and the excavator and the dump truck being loaded with the recovered stones/debris stand and travel on the untreated basal layer.

H.28 The topsoil is replaced by the same windrow procedure as described above (see above H.10 & H.11) with the bulldozer pushing out the excess topsoil to cover the area to the required depth (**Figures H.3 & H.4**). The dump trucks should avoid reversing onto the windrows, particularly until they have been surcharged to buffer any underlying functional sub-soil layer from compaction (Box H.6).

H.29 Where there is a requirement to treat compaction and/or remove stones and non-soil debris in the topsoil, decompaction can by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the topsoil, followed by the excavator using a stone-rake bucket (to be loaded on a dump truck and removed) (**Sheets L & M**). Where these treatments are deployed, to minimise additional compaction/recompaction, only the bulldozer need to work and traffic the topsoil, and the excavator and the dump

truck being loaded with the recovered stones/debris stand and travel on the untreated basal layer.

H.30 In some circumstances decompaction can be undertaken from the top-soil surface once the placing of the soils is complete (Box H.7, Option 3). Here, stone and non-soil debris removal would be restricted to the topsoil layer.

However, this Option is only advisable where it is certain that it will be effective and will not compromise the achievement of the intended after use, soil functions, and environmental and ecosystem services.

H.31 At the end of each day the current soil placement must be completed if rain is forecast. If during a day it is evident that a full strip cannot be completed, then only start part of a strip; this too must be completed.

H.32 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

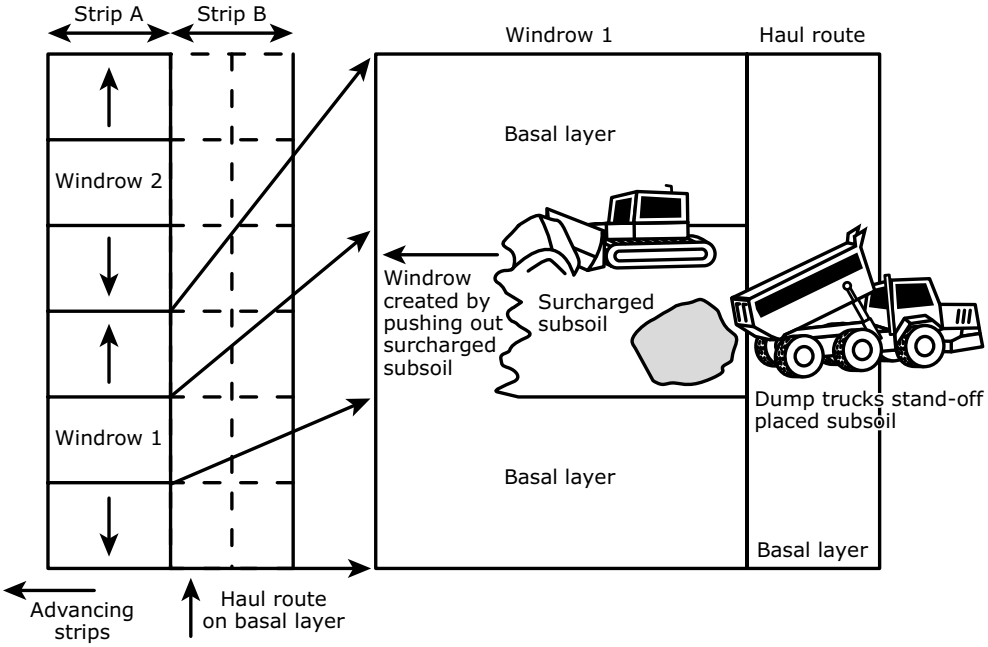

Figure H.1: Advance of subsoil surcharged windrow from dump trucks.

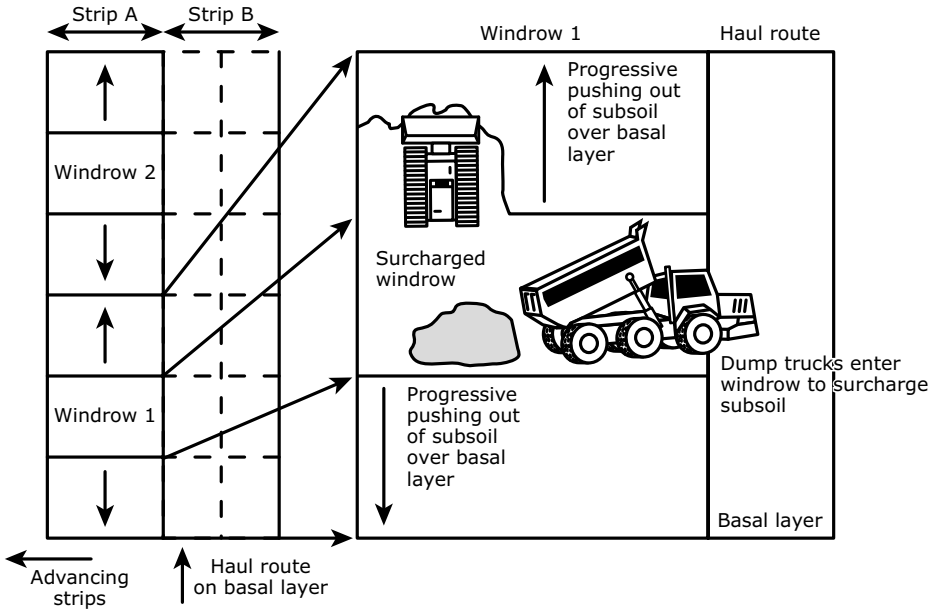

Figure H.2: Spreading of subsoil from surcharged windrow.

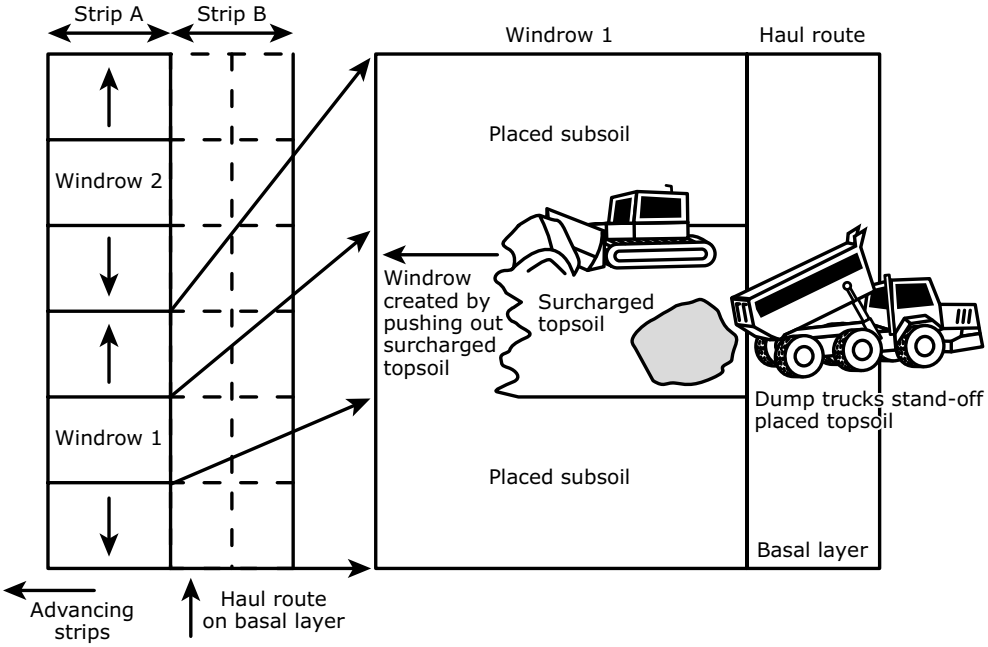

Figure H.3: Advance of topsoil surcharged windrow from dump trucks.

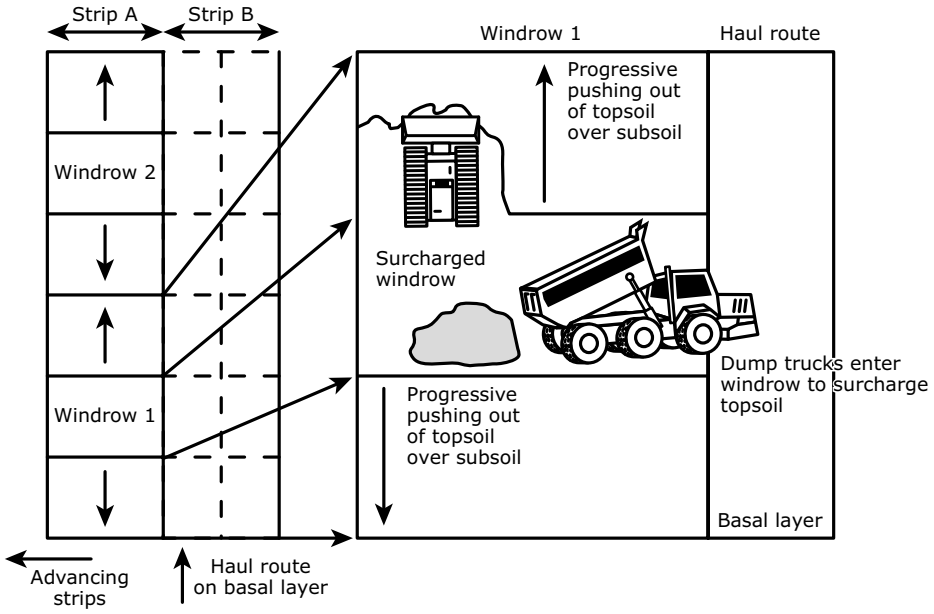

Figure H.4: Spreading of topsoil from surcharged windrow.

IQ

The Institute of Quarrying

Good Practice Guide for Handling Soils in Mineral Workings

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

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The information in this publication is general guidance on the best practices and approaches to soils guidance.
Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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For over 100 years the Institute of Quarrying has been supporting people working in the mineral extraction industry. It is the only international professional body for quarrying, construction materials and the related extractive and processing industries. IQ's focus is to be the global leader in standards for the sector, to push innovation and operational best practice, to support the industry in driving healthy, sustainable workplaces and to promote the positive impact of the industry and profession. Being a member of IQ means being part of a global community of industry professionals committed to sharing knowledge and improving industry standards.

GOOD PRACTICE GUIDE FOR HANDLING SOILS

In Mineral Workings

PART TWO: Model Methodology

- Sheet I -

Soil Stripping with Bulldozers and Dump Trucks
- Modified Layer by Layer Practice

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and D Fisher (Blue Room Graphics Ltd).

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Preface

The purpose of Sheet I of the guidance is to provide a model method of best practice where bulldozers and dump trucks are to be used to strip soil using a modified soil layer by layer practice.

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

i) Avoiding conditions when soils are wet/ plastic during handling
ii) The minimisation of soil compaction caused by trafficking and soil wetness
iii) Using appropriate remedial treatments where these are necessary
iv) Minimising soil loss, and mixing of soil layers or different soil types.

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

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Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations, The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer’s specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

Introduction

In the past soil layers have been stripped in their entirety one by one. Firstly the topsoil, then the subsoil layers by layer until the basal layer is exposed. The method deployed across the entire area is now discredited because of the likely severe compaction caused by the trafficking of the machines over much of the exposed soil surfaces. However, by restricting the extent of the ongoing process to blocks or wide bands of soil, to enable the dump trucks to travel on the basal layer, there may be instances where this 'modified' layer by layer approach can be deployed.

In this practice, only the bulldozer works on the exposed soil layers to form soil bunds along the exposed edge for loading by an excavator (usually) standing on the mound. This approach was described and illustrated in MAFF Sheet 13 https://webarchive.nationalarchives.gov.uk/20090318025435/http://www.defra.gov.uk/farm/environment/land-use/soilguid/sheet13.pdf.

It is also similar to the bulldozer practice described in **Sheet F**, but without the formation of windrows and the need for the excavator to traffic the surcharged soil to recover and load it into the dump trucks. In this respect it is easier to operate than the windrow practice and likely to cause less compaction.

The following modified guidance can also be adopted where only a single soil horizon is to be stripped.

Advantages & Disadvantages
The advantages of the modified handling practice are:

i) It is very simple to administer requiring little supervision and skill
ii) It can be quicker than both the excavator combination with the bed/strip and windrow practices
iii) It offers flexibility in respect of short soil drying periods and likely wet weather as it is l ess susceptible to stoppages due to soil rewetting as a transpiring vegetation cover can be retained later into the stripping programme. It is particularly suited to northerly and western, and upland locations, and particularly when there are uncertain weather patterns.

The disadvantages of the modified handling practice are:

i) There is risk of compaction of the top- and subsoil layers by the repeated trafficking of the bulldozer, even if a low ground pressure machine is used, as it pushes soil to the windrows. Hence, subsequent remedial treatments are likely to be relied upon
ii) It is slow react to localised changes in soil types and variation in horizon depth, and can result in the mixing of soil horizons
iii) It is not suited to the stripping of thin and 'patterned' soil layers, and cleanly exposing the top-sub-soil interface.

Suitability
Neither the unmodified or modified practice are suitable for sites requiring archaeological investigations and reporting, or for 'watching briefs' during soil stripping.

The layer by layer handling practice, without modification, is not advisable for the conservation of soil resources and functioning. Whilst the modified method is not considered 'best practice', it may be acceptable in circumstances where:

i) The subsoil(s) have a high resilience to further compaction (see **Part One**) and when decompaction treatments can be more relied upon to be effective because of a low risk of soil wetness (low rainfall areas/prolonged dry conditions) or operational limitations (such as the availability of effective decompaction tools)
ii) The intended after use, and environmental and ecosystem services are less dependent on maintaining functional characteristics such as soil porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This may include low productivity agricultural and forestry land, some types of natural

habitats, and where water storage/infiltration is of lesser importance for the risk of flooding. Where the soils are stored prior to replacement, effective remedial treatment may have to be relied upon

iii) The soils are placed into storage stockpiles.

MODEL METHODOLOGY

I.1 Key operational points to minimise the risk of severe soil compaction and soil wetness with the modified layer by layer practice are summarised in Boxes I.1 and I.2.

Box I.1 - To minimise compaction:

- The dump trucks should normally only operate on the basal layer, and their wheels must not in any circumstances run on to the soil layer(s)
- The adoption of the strip by strip system minimises the need for the trucks to travel on the soil layers
- The machines are to only work when ground conditions enable their efficient operation
- The soils are to be stripped by the bulldozer in as thick layer as possible whilst maintaining their efficient operation
- The bulldozer should make the minimal number of passes over the soil as possible
- The soil layers are to be in 'dry' condition.

Box I.2 - To minimize the wetness of the soil and re-wetting of the soil:

- The modified strip by strip system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents. The soil profile within the active strip should be stripped to the basal layer before rainfall occurs and before stripping is suspended.
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance
- The maintenance of a transpiring crop is important, and an appropriate cropping regime should be established for the year of soil stripping
- Before stripping, excess vegetation should be removed; in the case of grassland it should be cut or grazed short and arable crops should have been harvested.

I.2 The timing of soil handling operations should only take place when the soils are in a 'dry and friable' condition (ie when it breaks and shatters when disturbed rather than smears and deforms) (see **Part One, Supplementary Note 4**). Prior to the start or recommencement of soil handling, they should be tested to confirm they are in suitably dry condition (see Box I.3).

I.3 Soil handling (by any machinery combination and handling practice) is not to take place during rain, sleet or snow and in these conditions should be prohibited due to unsafe machine operating conditions. Prior to commencing operations a medium/long term weather forecast should be obtained which gives reasonable confidence of soil handling being completed without significant interruptions from rainfall events. The soil based criteria set out in BOX I.4 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.
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.

I.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. 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.

I.6 Demarcate an initial width of the 'strip' of soils to be recovered as the modified layer by layer practice.

Box I.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 I.4 – Rainfall Criteria:

- 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, after rain has ceased, soil tests shall 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.

Box I.5

Whilst there can be a lower of a risk of compaction when using wide tracked ('low ground pressure' (LGP)) bulldozers, in some circumstances they may require to traffic the soil surface more than standard machines to achieve the same work rate, and therefore the advantage of their use may be less than anticipated. However, the risk of severe compaction and reliance on remedial treatments may be less with the use of LGP machines.

This is the effective push distance of the bulldozer to bund the soil at the edge of the strip (Box I.5).

I.7 Within each soil unit the soil layers above the base/formation layer are to be stripped layer by layer in the retreating strips/blocks until all the soil is removed (**Figure I.1**).

I.8 The bulldozer is only to stand and work on the soil layer when stripping soils and the excavator on the resulting soil mound, otherwise they are to travel only on the basal/formation layer. The dump trucks are to operate only on the basal layer (**Figure I.2**).

I.9 The topsoil is to be pushed towards the retreating edge and heaped for the excavator to load onto the dump trucks (**Figure I.2**). The topsoil should be recovered to the full width of the segment without mixing with subsoil (not more than 20% of the lower horizon should be exposed at the layer junction within the strip). The thickness and identification of the horizon junction must be verified before and

during stripping. The procedure is repeated until all of the topsoil has been removed.

I.10 The above procedure is then repeated for the sub-soil until all the soil layer has been recovered, and then any subsequent lower layer to be recovered until the basal layer is fully exposed (**Figure I.3**).

I.11 Where the soils are to be directly replaced without storage in mounds, the initial strip of the upper horizons will have to be stored temporarily to release the lowest layer and enable the sequential movement of materials. The stored initial soil material would be placed on the lower layer removed from the final strip at the end of the programme or on partially completed profiles if rain was forecast.

I.12 Where the stripping operation is likely to be interrupted by rain or there is likely to be overnight rain, the soil layer is to be ‘sealed’ by the bulldozer tracking and ‘blading’ the exposed surface. Make provisions to protect base of current or next strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.

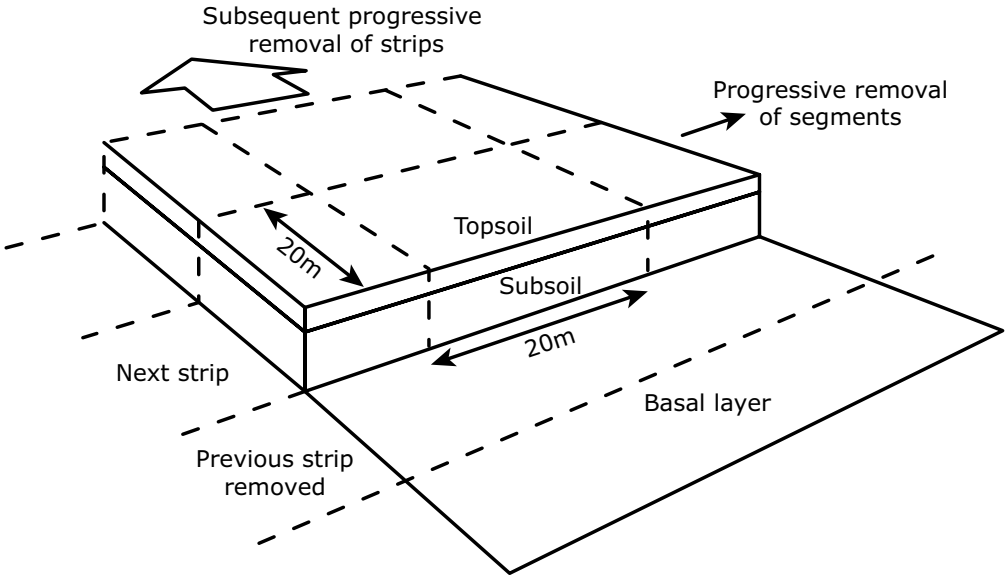

Figure I.1: Soil stripping with bulldozers and dump trucks using modified layer by layer practice.

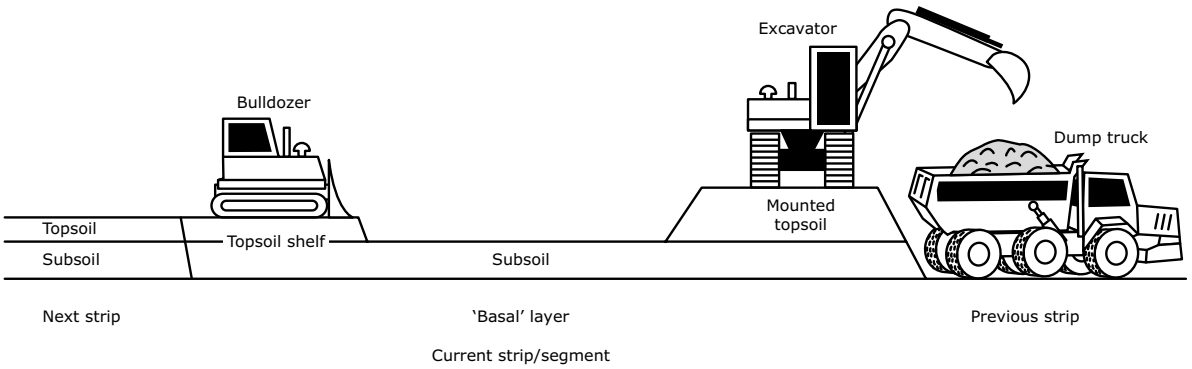

Figure I.2: Soil stripping with bulldozers and dump trucks using modified layer by layer method: Topsoil.

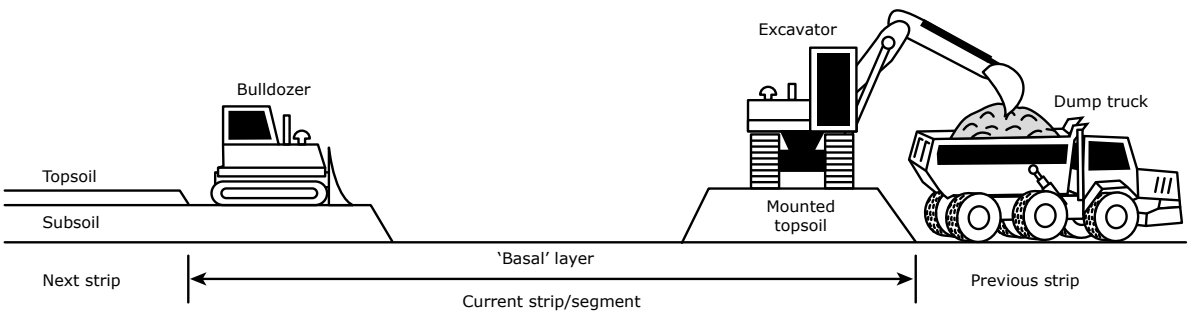

Figure I.3: Soil stripping with bulldozers and dump trucksn using modified layer by layer method: Subsoil.