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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: Model Methodology

- Sheet J -

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

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Preface

The purpose of Part Two, Sheet J 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 modified 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.

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 the past soil layers have been replaced in their entirety one by one. Firstly the subsoil, then the topsoil layer until the basal layer is covered. 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 and pushes out the soil from bunds tipped by the dump trucks along the advancing soil edge. This approach was described and illustrated in MAFF Sheet 15 https://webarchive.nationalarchives.gov.uk/ukgwa/20090318025517/http://www.defra.gov.uk/farm/environment/land-use/soilguid/sheet15.pdf. It is also similar to the bulldozer practice given in **Sheet H**, but without the formation of windrows and the need for the dump truck to traffic the surcharged soil. In this respect it is easier to operate than the windrow practice and likely to cause less compaction.

The following guidance can be adopted where only a single topsoil horizon is to be placed.

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 dry periods and likely wet weather as it is less susceptible to stoppages due to soil rewetting and a vegetation cover can be sequentially established.

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 out the soil. Hence, subsequent remedial treatments are likely to be relied upon
ii) It is not suited to the laying of thin and 'patterned' soil layers.

Suitability

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 **Table 7, 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 have been placed into storage stockpiles
iv) It is suited to northern and western, and upland locations, and particularly when there are uncertain weather patterns.

MODEL METHODOLOGY

Basic Replacement Operation
The following is the basic model methodology using bulldozers with dump trucks and the modified layer by layer practice. It is presented here, firstly without any remedial interventions to give clarity of the methodology. Further on the methodology is repeated with the interventions to demonstrate how integration is to be achieved.

Box J.1 - To minimize compaction:

- The dump trucks should only operate on the 'basal'/non-soil layer, and their wheels must not in any circumstances run on to the soil layer(s)
- The machines are to only work when ground conditions enable their efficient operation
- The soils are to be replaced by the bulldozer in as thick layer as possible whilst maintaining their operational efficiency
- The bulldozer should make the minimal number of passes over the soil as possible
- The soil layers are to be in 'dry' condition.

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

- 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 replaced is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance.

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

J.2 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 J.3). For soil that has been stored, the relaying operation should be governed by the

Box J.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.

weather (rainfall) criteria set out in Box J.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.

J.3 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 criteria set out in Box J.3 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

J.4 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.

Box J.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.

J.5 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 J.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.

J.6 Within each soil unit the soil layers above the base/formation layer are to be replaced using a bulldozer to spread the soil layer by layer in advancing strips/blocks until all the soil is replaced. The bulldozer is only to stand and work on the soil layer when replacing the soils, otherwise it is to travel only on the basal layer. The dump trucks in this practice only operate on the basal layer.

Box J.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.

J.7 Demarcate the width of the strip to be soiled and the width of the replaced soil strip is the effective push distance of the bulldozer (Box J.5). Profile boards should be used to control soil horizon thickness being replaced and overall levels achieved verified using soil pits.

J.7 The dump truck tips the soil load on the front of the advancing face and the bulldozer pushes out the tipped subsoil to its full and final thickness with the minimum distance and number of pushes (**Figures J.1 & J.2**). The procedure is repeated until the strip of the subsoil layer is replaced.

Box J.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.

J.8 On completion of the width of the subsoil strip/ block, the topsoil is tipped on its leading edge and pushed out to the final thickness with the minimum number of pushes (**Figure J.3**). This is repeated to advance topsoil coverage until the entire strip is soiled (see Box J.6 where soil profile is greater than 1m thickness).

J.9 Where the replacement operation is likely to be interrupted by rain, the topsoil layer should be placed before rain occurs and at the end of each day. Should this not be possible the subsoil layer is to be 'sealed' by a low ground pressure bulldozer tracking and 'blading' of 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.

Methodology with Remedial Actions

J.10 The following is the model methodology using bulldozers with dump trucks and the modified layer by layer practice with the remedial interventions to demonstrate how integration is to be achieved. The key operational points to minimize the risk of severe soil compaction and soil wetness are summarised in Boxes J.1 and J.2 above.

J.11 Usually there will be a need for decompaction treatment during the replacement operation with this methodology. The placement of the stripped soils in storage is likely to result in greater compaction. Where compaction occurs, treatment will need integrating into the replacement process as will any need for the removal of stones or non-soil debris. Both decompaction and removal of materials are covered in separate **Sheets L to O**.

J.12 Box J.7 sets out some of the remedial options/ combinations to facilitate removal of stones and decompaction.

J.13 Prior to work commencing a weather forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events (see Box J.4).

J.14 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 J.3).

J.15 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.

J.16 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.

J.17 Within each soil unit the soil layers above the base/formation layer are to be replaced layer by layer in advancing strips until all the soil is replaced. The haul routes and storage areas must be defined and should be replaced last in a similar manner.

J .18 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.

J.19 Only the bulldozer is to stand and work on the soil layer when replacing the soils, otherwise it is to travel on the basal layer.

J.20 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 prior to the first 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, 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.

J.21 On completion of the remedial work, the subsoil is spread with the bulldozer pushing out the soil, tipped at the edge of the treated basal layer to cover it to the required depth (**Figures J.1 & J.2**). The dump trucks should avoid reversing onto the treated basal layer to minimize severe recompaction of the basal layer.

J.22 On completion of the subsoil placement and 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 (**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.

J.23 On completion of the subsoil remediation works the topsoil replacement begins. The dump truck tip the topsoil on to the advancing edge of the subsoiled strip (see also Box J.6) for the bulldozer to pushes out to its final thickness with the minimum distance and number of pushes (**Figure J.3**). The procedure is repeated across the area to be soiled until it is completed.

J.24 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.

J.25 Whilst remedial treatment is generally limited to the bulldozer option (**Sheets M & O**), because of the risk of further compaction from the excavator and dump truck option (**Sheets L & N**), it is possible to arrange for the operations so that there is minimal trafficking and the retreating excavator treats any compacted areas.

J.26 There is also the option of ripping with bulldozer tines (**Sheet O**) to treat compaction in the top- and subsoil layers together (Box J.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.

J.27 On completion of the replacement of the full soil profile in the strip, the next is formed with the process being repeated until the area to be soiled has been completed.

J.28 Where the replacement operation is likely to be interrupted by rain or there is likely to be overnight rain, the exposed subsoil and topsoil layers are 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.

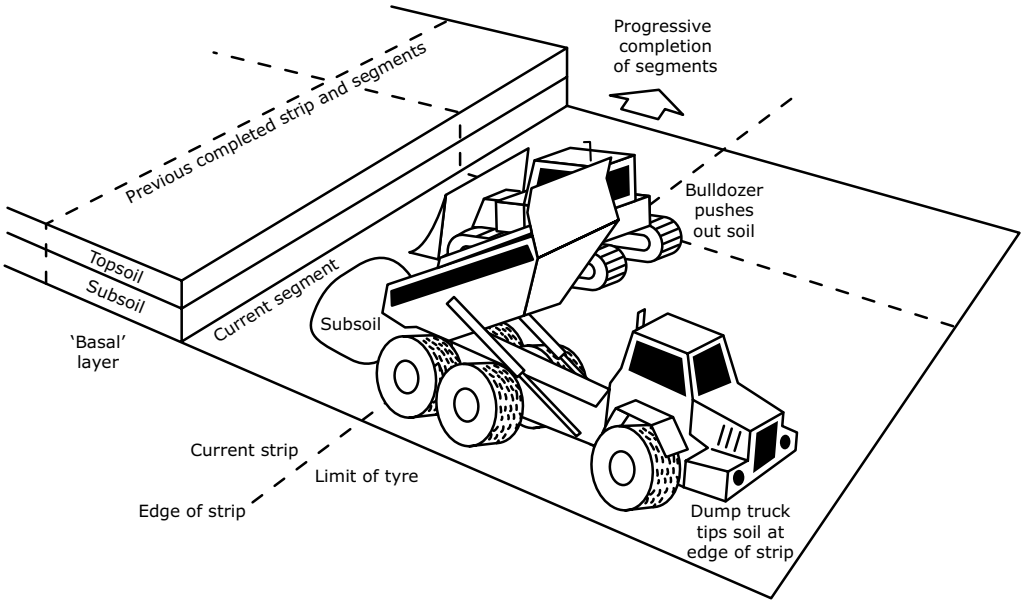
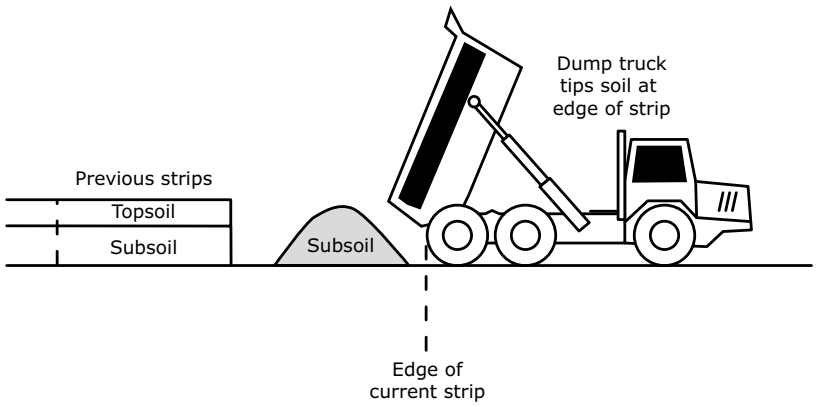


Figure J.1: Soil replacement with bulldozer and dump truck using modified layer by layer method: Subsoil.



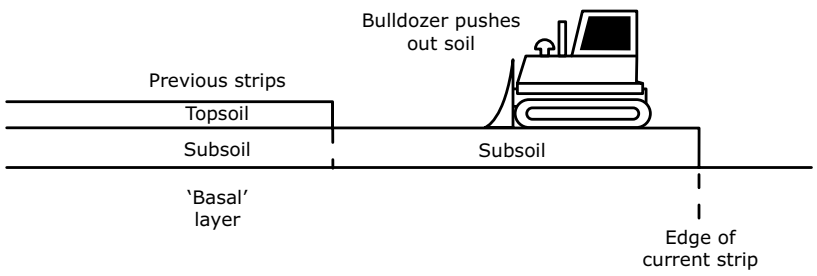


Figure J.2: Soil replacement with bulldozers and dump trucks using modified layer by layer method: Subsoil.

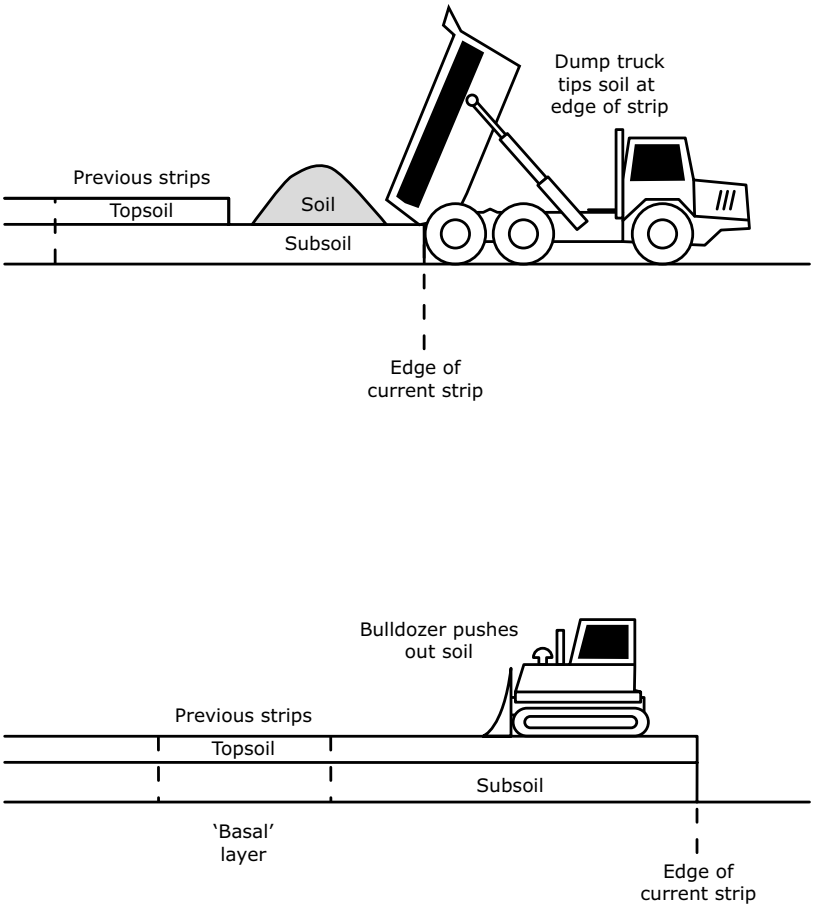


Figure J.3: Soil replacement with bulldozers and dump trucks using modified layer by layer method: Topsoil.