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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 H-

Soil Replacement with Bulldozers and Dump Trucks
- Windrow Practice

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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.

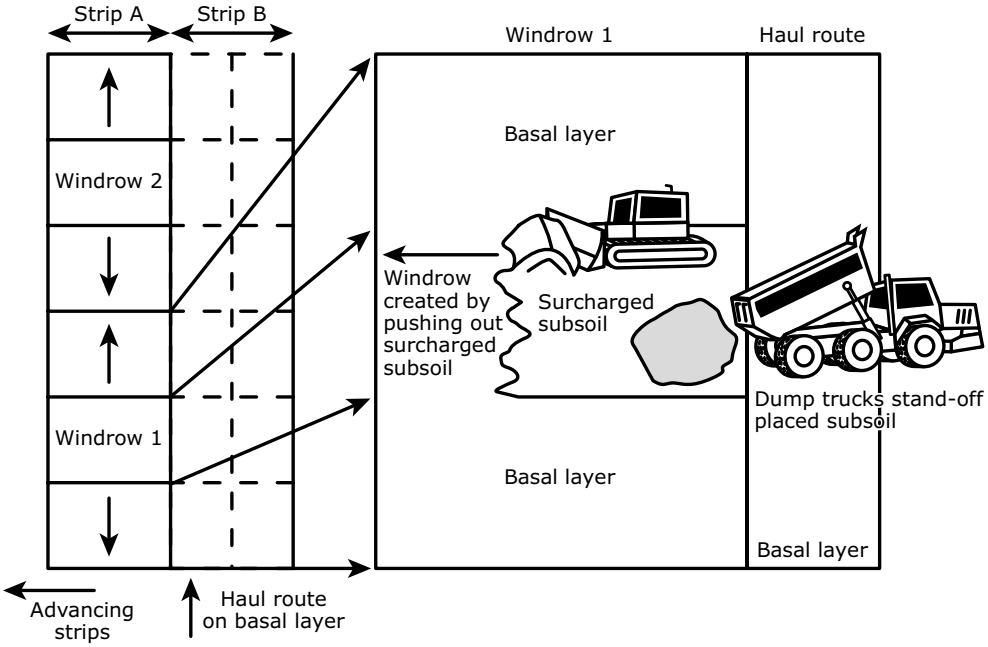

Figure H.1: Advance of subsoil surcharged windrow from dump trucks.

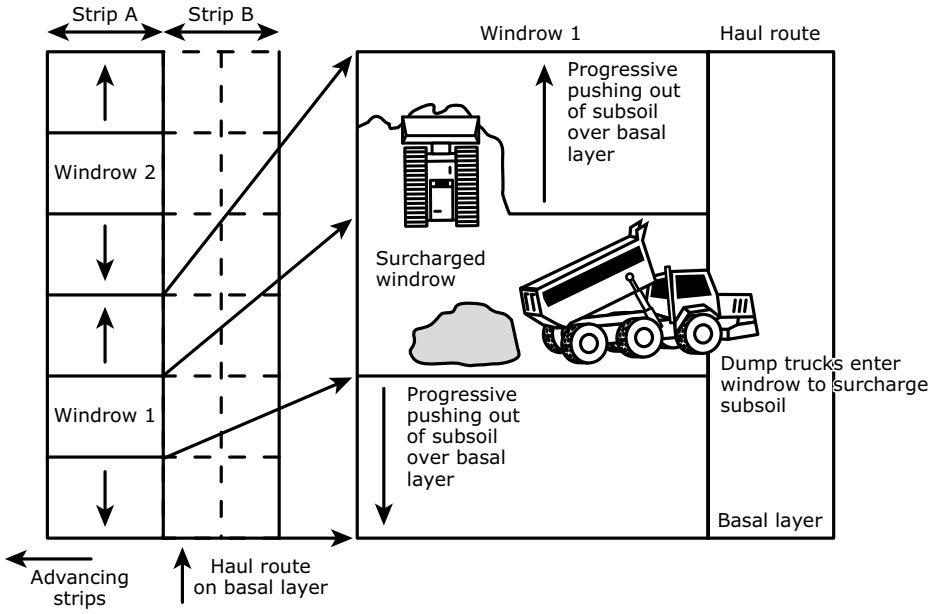

Figure H.2: Spreading of subsoil from surcharged windrow.

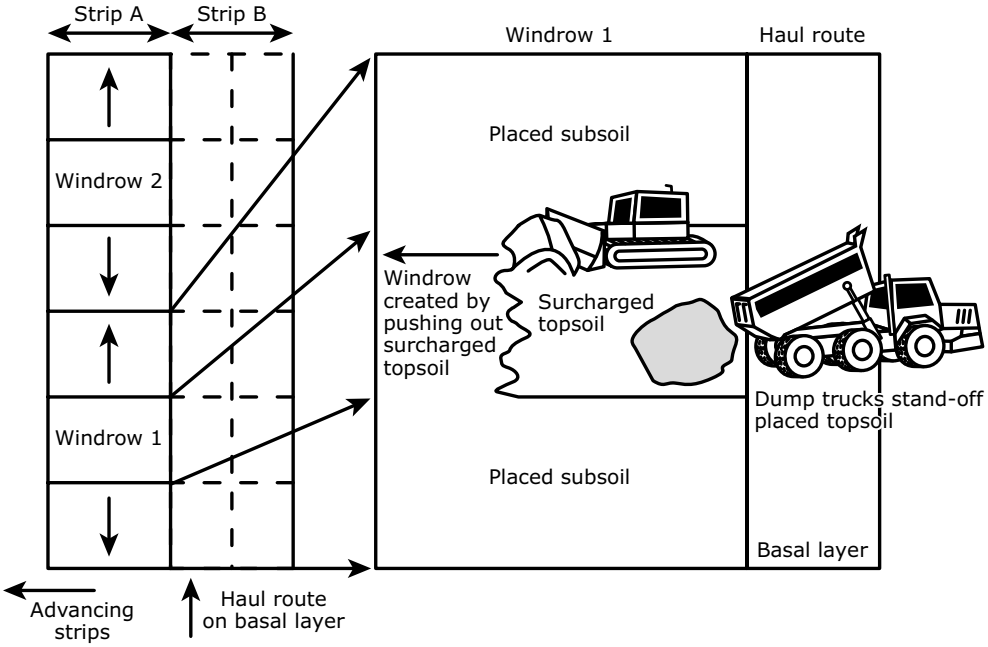

Figure H.3: Advance of topsoil surcharged windrow from dump trucks.

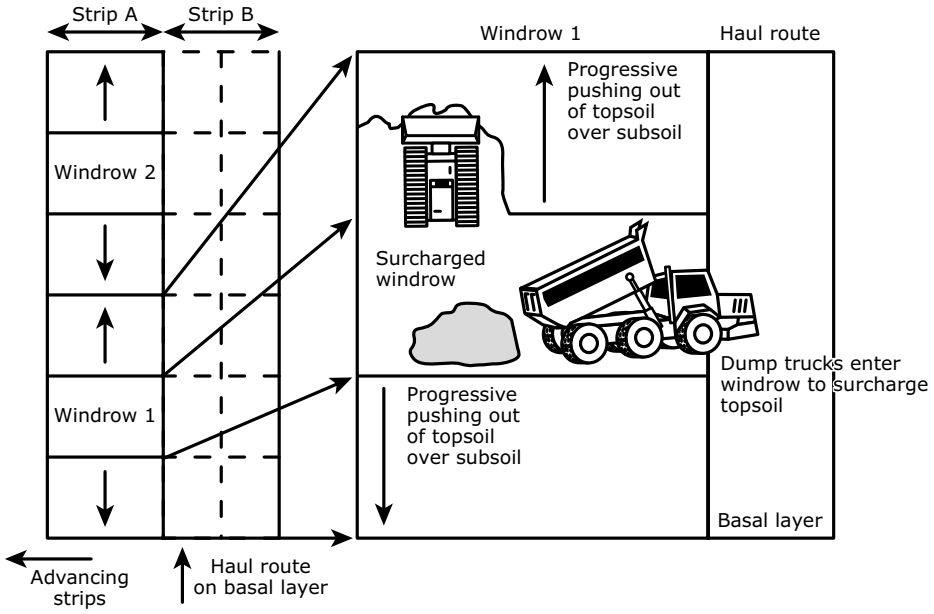

Figure H.4: Spreading of topsoil from surcharged windrow.