GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 1:

Soil Stripping with Excavators and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

v04/00

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

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SHEET 1 SOIL STRIPPING WITH EXCAVATORS & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where excavators and dump trucks are to be used to strip soil. This Guidance Sheet comprises 6 pages of text, 3 figures and a user response form.

The model method may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses back-acting excavators in combination with dump trucks (articulated or rigid bodied). An excavator is used to strip soil and load it into dump trucks for transportation to replacement areas or to storage.

The soil handling method can affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through trafficking, the effects of which increases with increasing soil wetness.

The advantage of this model method, if correctly carried out, is that it should avoid severe deformation of the soil as trafficking is minimised. Consequently, there should be no need for decompaction treatment during the operation.

The key operational points to ensure avoidance of severe soil deformation are as follows:

(i) To minimise compaction:

- the dump trucks must only operate on the 'basal'/non-soil layer, and their wheels must not on any circumstances run on to the soil layer(s).
- the excavator should only 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 maximum operating efficiency.
- if compaction is caused then measures are required to treat it (see Sheets 18 & 19).

(ii) To minimise soil wetness and re-wetting:

- the soil layers should have a moisture content below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]
- 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 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.

The Stripping Operation:

1.1 The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance.

1.2 Soil stripping operations should not start until the required soil moisture levels are reached (as determined by the agreed method), and should be suspended as soon as the water content returns to these levels. Prior to work commencing a Meteorological Office forecast should be obtained which gives reasonable confidence of soil stripping proceeding without interruptions from rainfall events. If significant rainfall occurs during operations, the stripping must be suspended, and where the soil profile has been disturbed it should be removed to base level. Stripping must not restart unless the weather forecast is expected to be dry for at least a full day.

1.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fail.

1.4 The operation should follow a detailed stripping plan showing soil units to be stripped, 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 ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

1.5 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. This is often referred to as the 'bed or strip system'. The system involves the progressive stripping of the soil in strips (Figure 1.1). Where there is a gradient to the site, the main axis of the soil strips should be along the main axis of the slope.

1.6 The haul routes and soil storage areas must be defined, and should be stripped first in a similar manner.

1.7 The excavator is only to work on the topsoil layer; the dump trucks are only to travel on the basal/formation layer.

1.8 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. Generally a bucket with teeth is preferable to one without. The dump trucks draw alongside the exposed soil profile, standing and travelling only on the basal layer (Figure 1.2).

1.9 The initial strip width and axis should be demarcated. Strip width is determined by the length of the excavator boom less the stand-off to operate; typically about 3-4m. Effective boom length can also reduce with profile depths greater than 1m; at 1.5m effective reach of standard boom may result in 2m wide strips.

1.10 Topsoil should be recovered to the full width of the strip without contamination 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 full thickness of the topsoil horizon should be stripped progressively along the strip before subsoil horizons are started (Figure 1.2).

1.11 The upper subsoil in the current strip is 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. The process is to be repeated for the lower subsoil and any other lower layer to be recovered as a soil material (Figure 1.3).

1.12 On completion of the strip, the procedures are repeated sequentially for each subsequent strip until the area is completely stripped.

1.13 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.

1.14 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.

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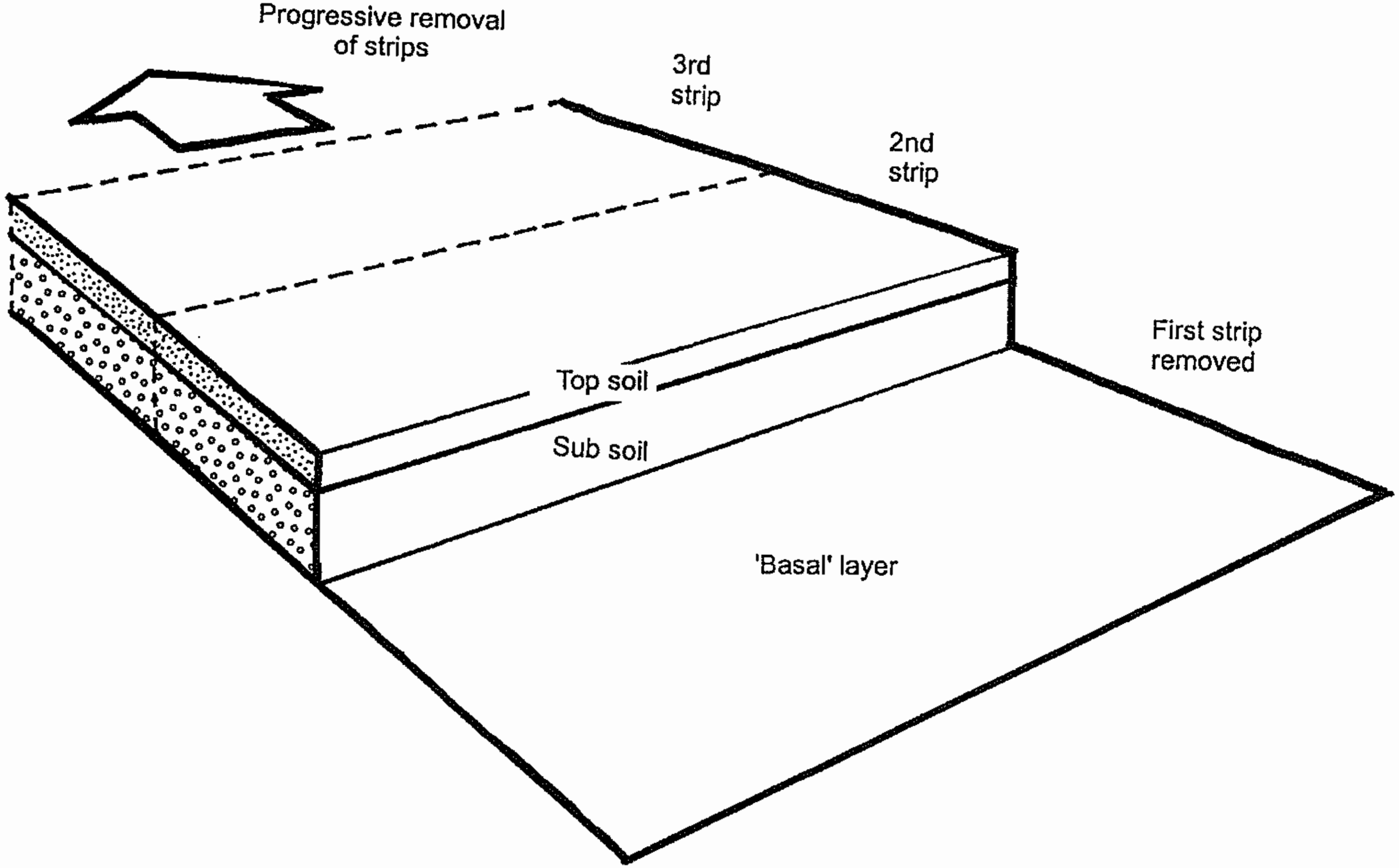

Figure 1.1 Soil stripping with excavators and dump trucks: The bed system

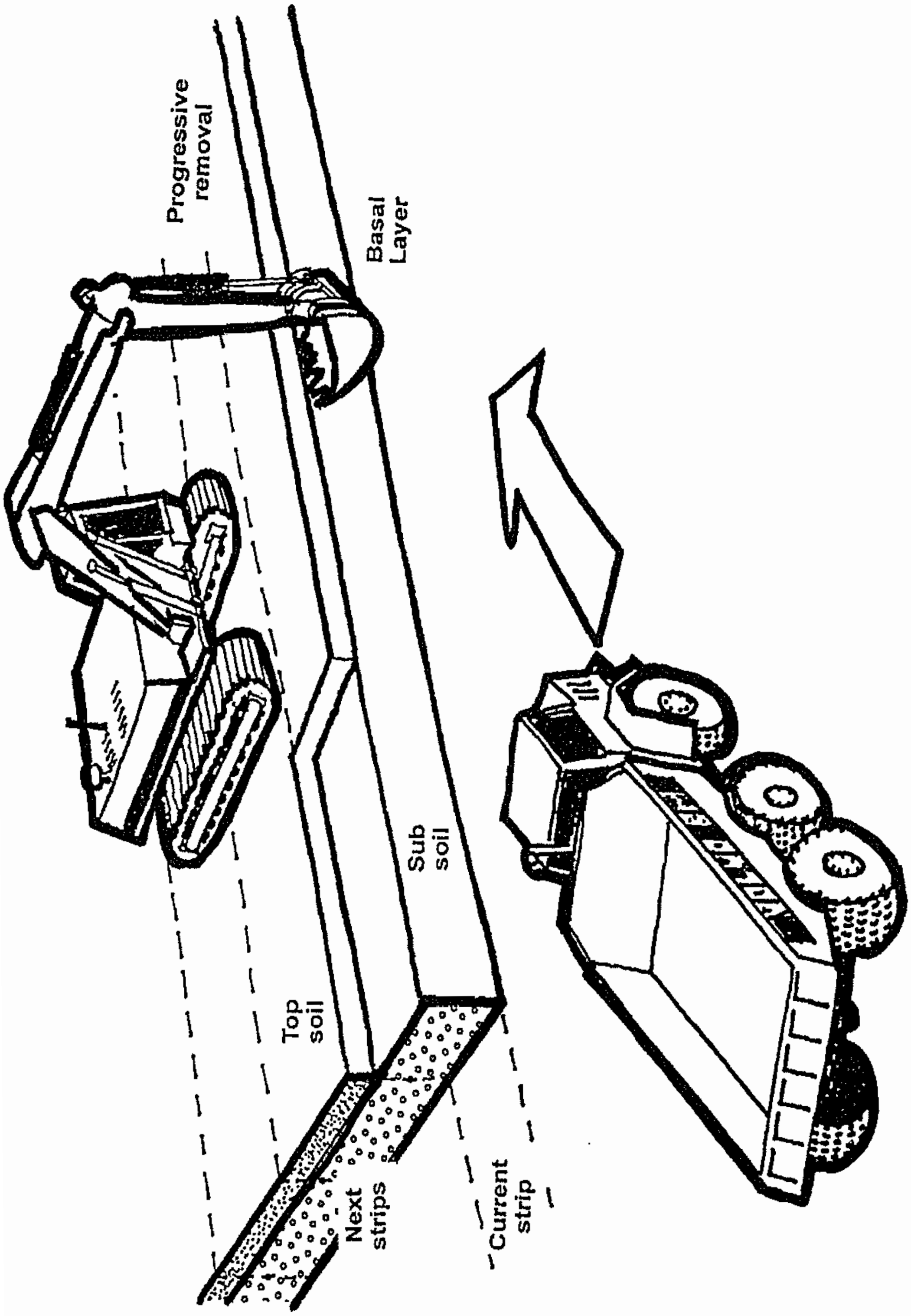

Figure 1.2 Stripping with excavators and dump trucks: Removal of top soil from a strip

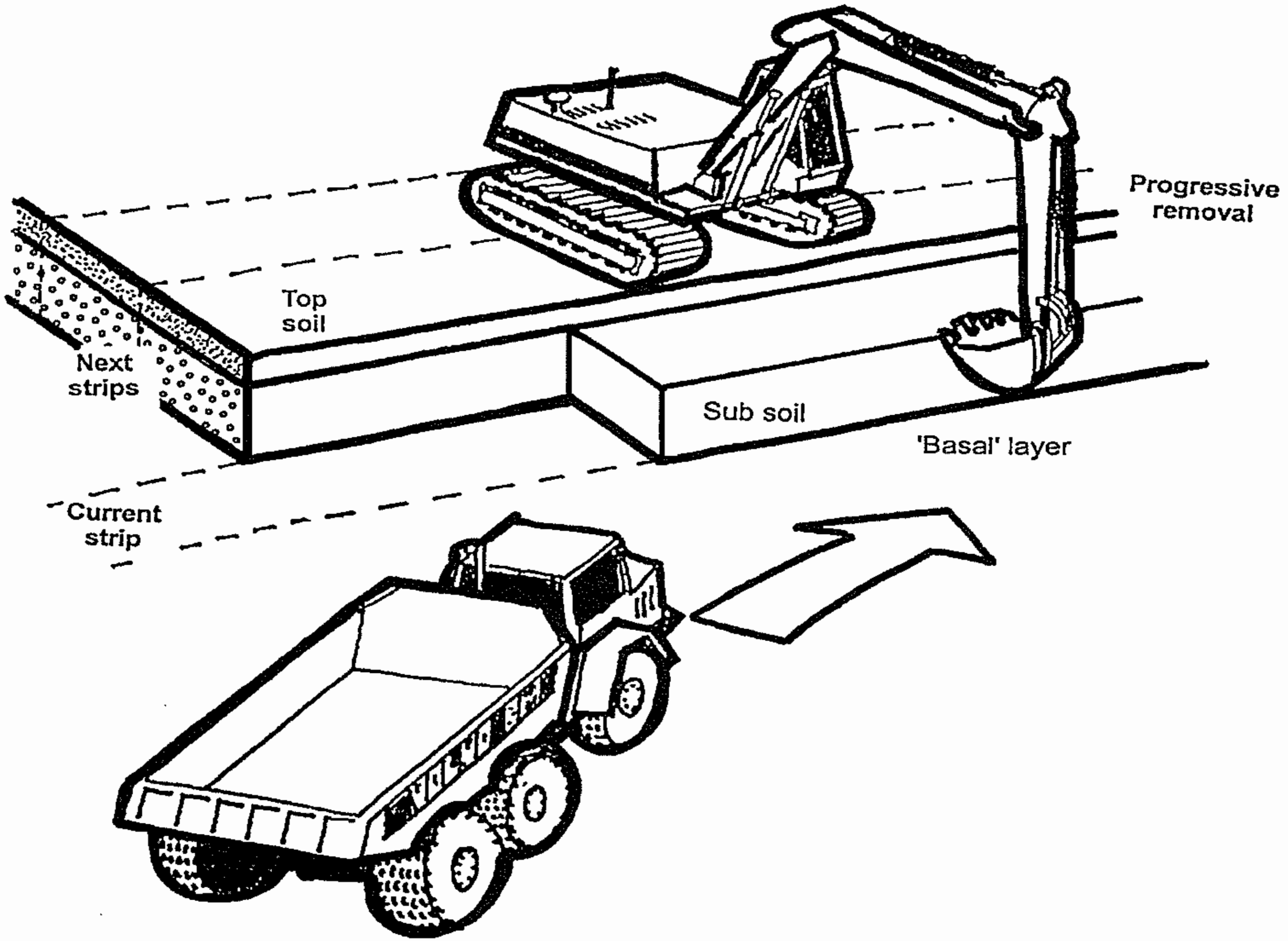

Figure 1.3 Stripping with excavators and dump trucks: Removal of sub soil from a strip

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SHEET 1

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 2:

Building Soil Storage Mounds with Excavators and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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April 2000

MAFF Ministry of Agriculture Fisheries and Food

SHEET 2 BUILDING SOIL STORAGE MOUNDS WITH EXCAVATORS & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where excavators and dump trucks are to be used to build soil storage mounds. This Guidance Sheet comprises 5 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses back-acting excavators to build the storage mound in combination with dump trucks (articulated or rigid bodied) to transport the soil.

The soil handling method can affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through trafficking, the effects of which increases with increasing soil wetness.

The advantage of this model method, if correctly carried out, is that it should minimise severe deformation of the soil as trafficking is minimised. However, compaction due to trafficking will be unavoidable in mounds where the height of the mound exceeds the effective reach of the excavator boom and the trucks have to travel on mounded soil. Such compaction will need treatment during the excavation operation (see Sheets 3 and 18).

The key operational points to minimise the degree and extent of severe soil compaction (and for the effective treatment of compaction) are as follows:

(i) To minimise 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 maximum operating efficiency.
- single-tier mounds are preferred to 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. Sheets 3 & 18]

(ii) 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.

The Storage Operation

2.1 The mounds should be sited on dry ground, not in hollows and should not disrupt local surface drainage. 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.

2.2 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails; haul routes must be maintained.

2.3 The operation should follow a detailed soil stripping/storage plan showing soil units to be stripped and stored, haul routes and the phasing of vehicle movements. The soil units should be defined within the site with information to distinguish types and layers, with information about ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

2.4 Remove topsoil and subsoil to basal layer from the haul routes, footprint of the storage mound and any other operating area in advance; adopting the practices outlined in Sheet 1. These soils should be stored in their respective mounds.

2.5 The dump trucks must only travel within the haul route and operational areas. The trucks should enter the storage area, reverse and back-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. The excavator operates by standing on the mound (Figure 2.1). The excavator bucket can be used to shape and firm 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.

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

2.7 Without the trucks rising onto the soil mound, the maximum possible height is related to the boom reach of the excavator (typically 3-4m).

2.8 To raise the mound higher, the trucks will have to travel on the upper surface of the mounded soils. In this case the mound should be raised to its maximum height (Figure 2.2). 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.

2.9 Any exposed edges/surfaces should be shaped using the excavator bucket 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 excavator bucket to promote the shedding of rain.

2.10 Work should stop in wet conditions 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.

Operational Variations

2.11 If front loading machines are to be used to excavate multi-tier mounds (Sheet 3), then the compacted inter-tier layer must be sequentially decompacted at the building stage by the method described in Sheet 18.

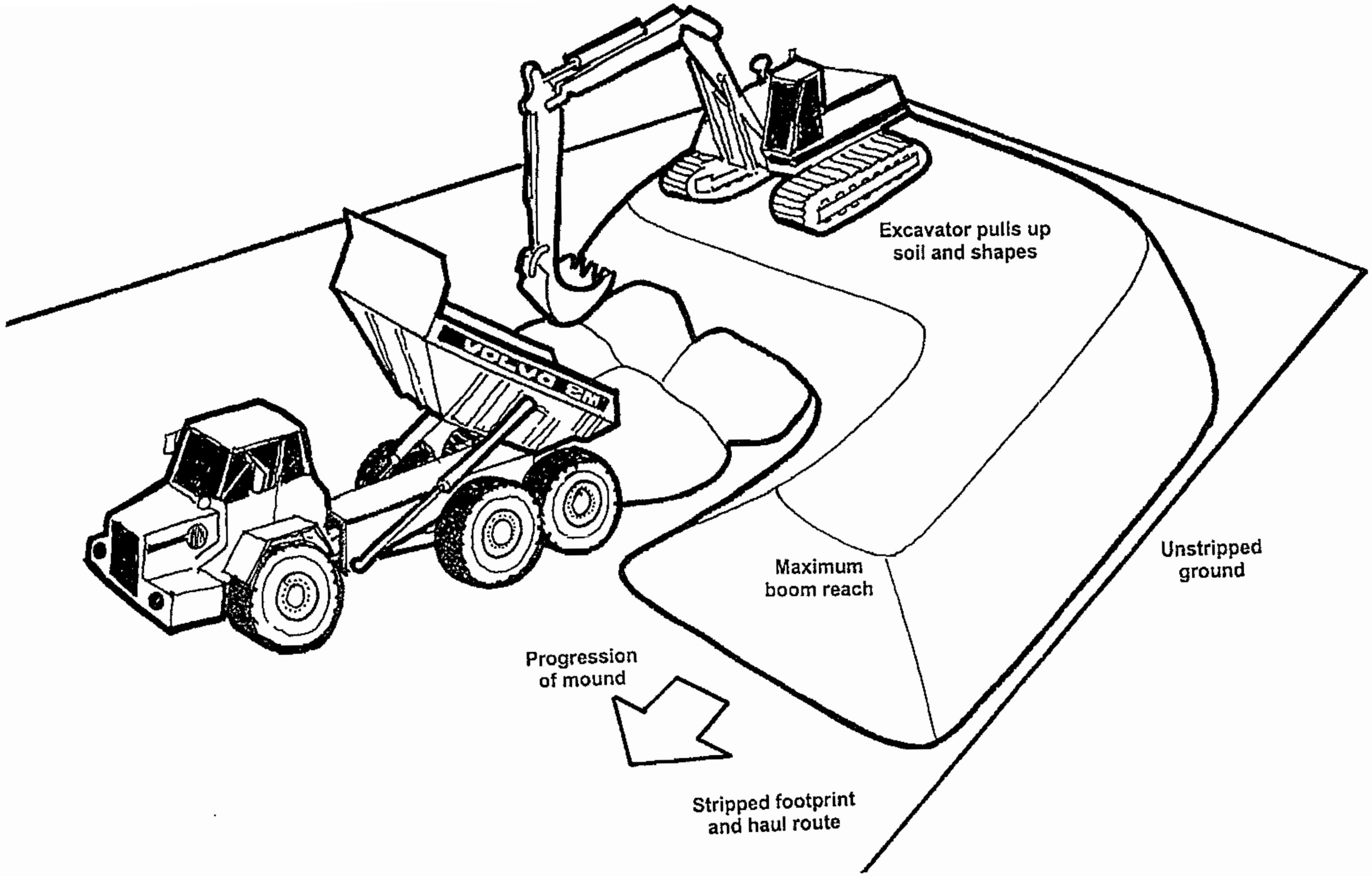

Figure 2.1 Soil storage mound construction with excavators and dump trucks: Single tier mound

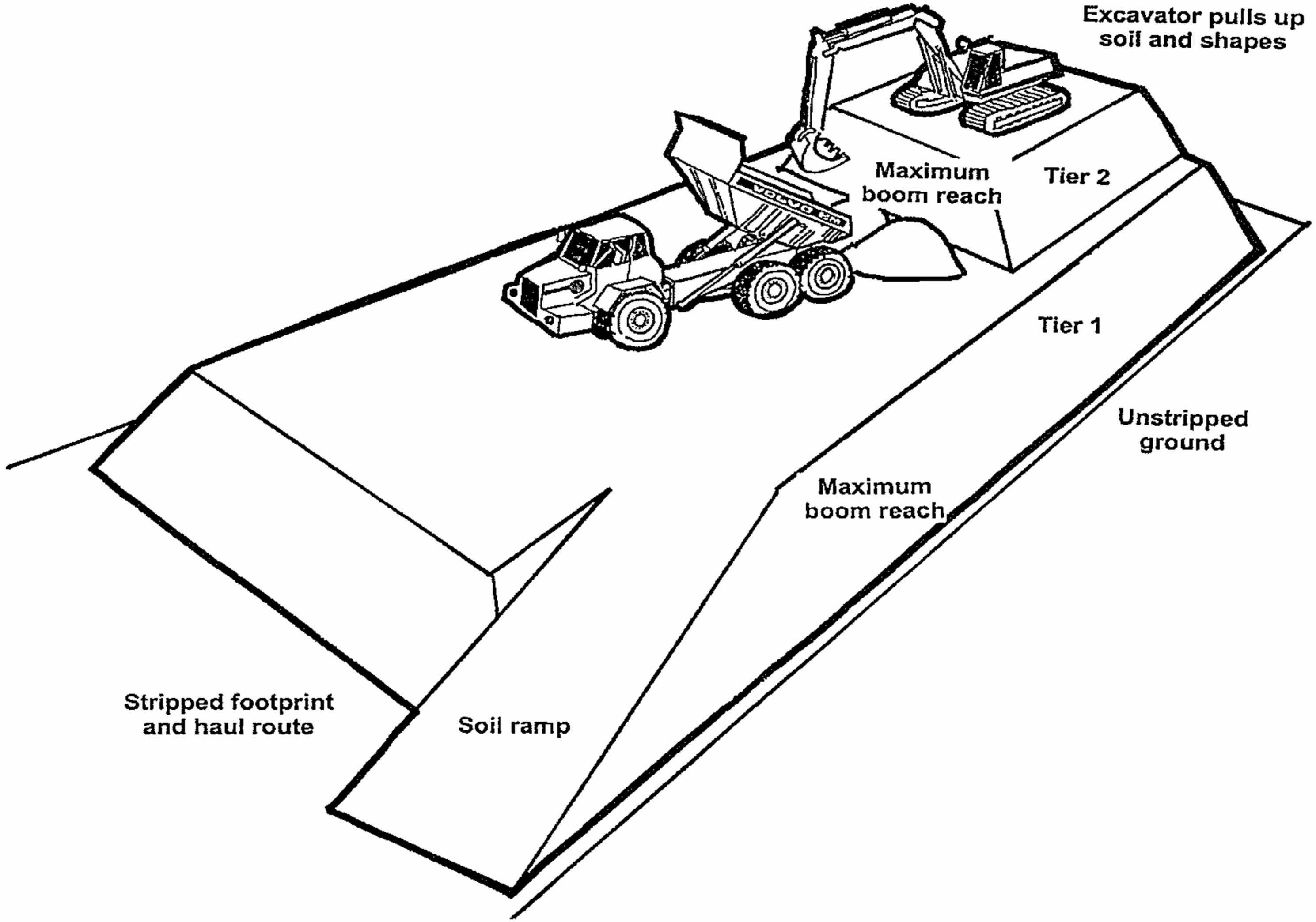

Figure 2.2 Soil storage mound construction with excavators and dump trucks: Multi-tier mound

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 3:

Excavation of Soil Storage Mounds with Excavators and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

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The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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SHEET 3 EXCAVATION OF SOIL STORAGE MOUNDS WITH EXCAVATORS & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where excavators and dump trucks are used to excavate soil storage mounds. This Guidance Sheet comprises 4 pages of text, 3 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses back-acting excavators to load the soil in to dump trucks (articulated or rigid bodied) for transport to the replacement areas.

The soil handling method can affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through trafficking, the effects of which increases with increasing soil wetness.

The advantage of this model method, if correctly carried out, is that it should avoid severe deformation of the soil as trafficking is minimised. However, where the soil has been stored in multi-tier mounds there will be a need for decompaction treatment during the excavation operation (see below and Sheet 18).

The key operational points to ensure avoidance of severe soil deformation are as follows:

(i) To minimise compaction:

- the dump trucks must 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 only operate on the soil mound.
- the machines are to only work when ground conditions enable their maximum operating efficiency.
- when excavating the multi-tier mounds, excavate tier by tier starting with the uppermost, trafficking is to be confined to the upper surface of the next tier.
- if compaction has been caused then measures are required to treat it before it is loaded into the trucks (see below and Sheet 18).

(ii) To minimise soil wetness and rewetting:

- the mound should be shaped to shed water before rainfall occurs and whenever 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 Excavation Operation

3.1 The dump trucks are to travel only on haul routes and in operational area, and both must be maintained. In the case of single tier mounds they must only operate on the basal layer. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

3.2 The trucks should enter the storage area and draw alongside the active excavation face. If back-acting excavators are used, they will need to stand on top of the mound to load trucks (Figure 3.1). The mound is to be dug to the base before moving progressively back along its axis.

3.3 With multi-tier mounds, the soil should be excavated tier by tier starting with the uppermost tier. This will necessitate the running of the trucks on the stored soil. Excavation should be in the same height of tiers as originally built so that the same surfaces are used for trafficking to minimise further compaction (Figure 3.2). Having removed an upper tier the trafficked layer must be decompacted. This can be achieved by progressively digging the surface as described on Sheet 18 in advance of loading the next layer. It is essential that the digging is effective and this needs to be systematically tested before soil is loaded. The process is repeated for each soil tier.

3.4 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.

3.5 Work should stop in wet conditions 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 Variations

3.6 Front loading machines may be used to excavate single tier soil mounds provided that they only operate on the basal layer with the dump trucks (Figure 3.3).

3.7 Front loading machines are only to be used for multi-tier mounds if the compacted inter-tier layer has been decompacted at the building stage.

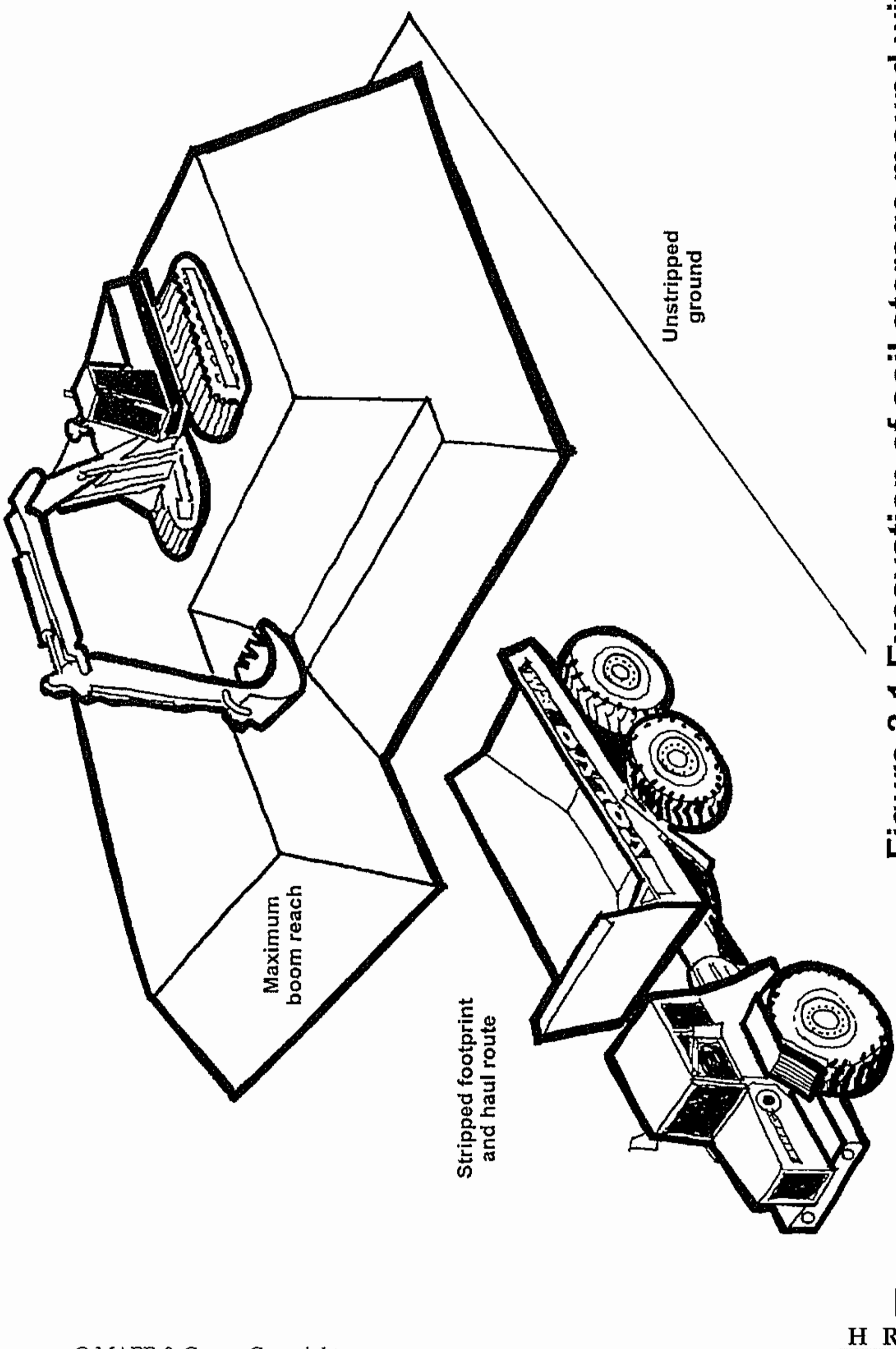

Figure 3.1 Excavation of soil storage mound with excavators and dump trucks: Single tier mound

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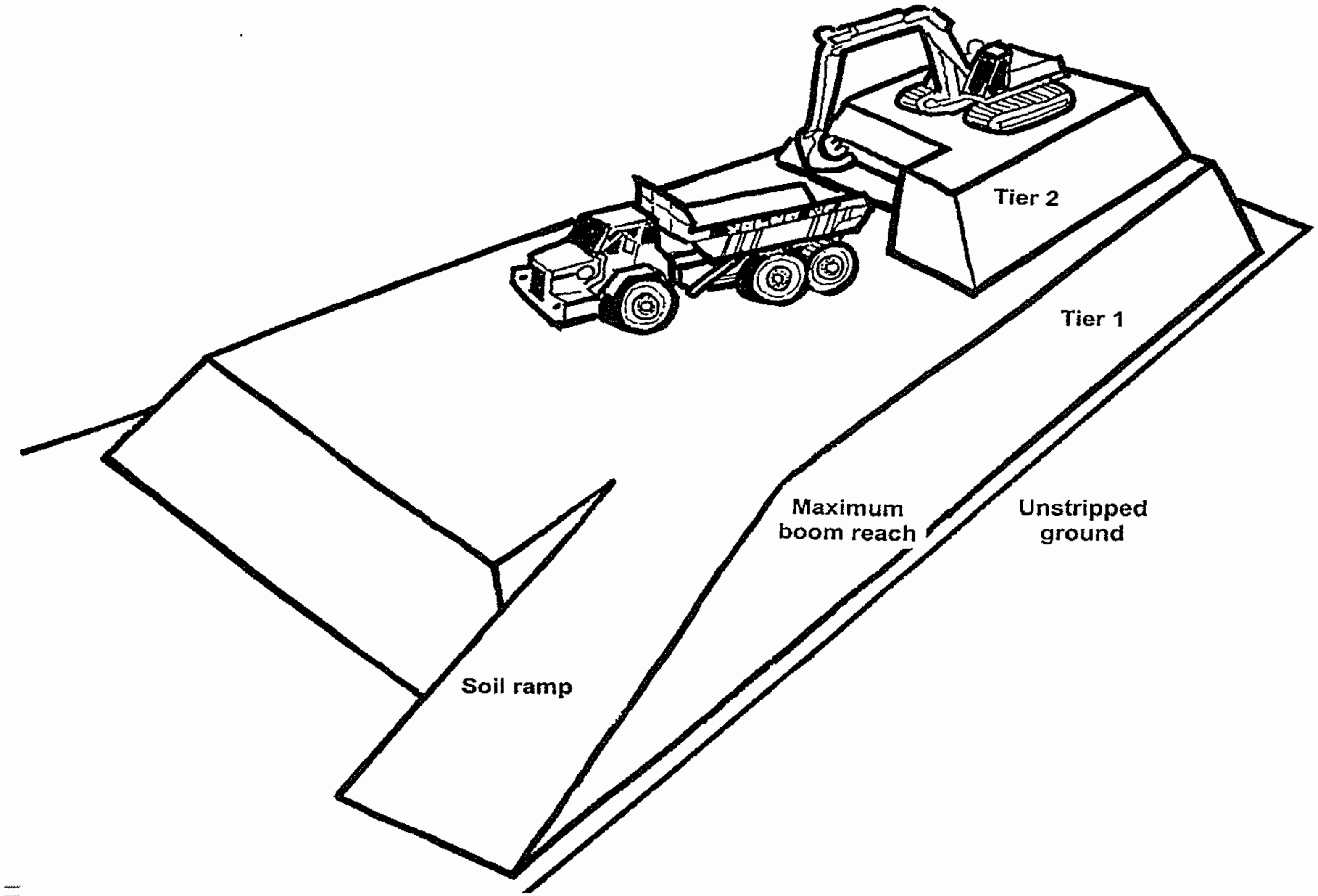

Figure 3.2 Excavation of soil storage mound with excavators and dump trucks: Multi-tier mounds

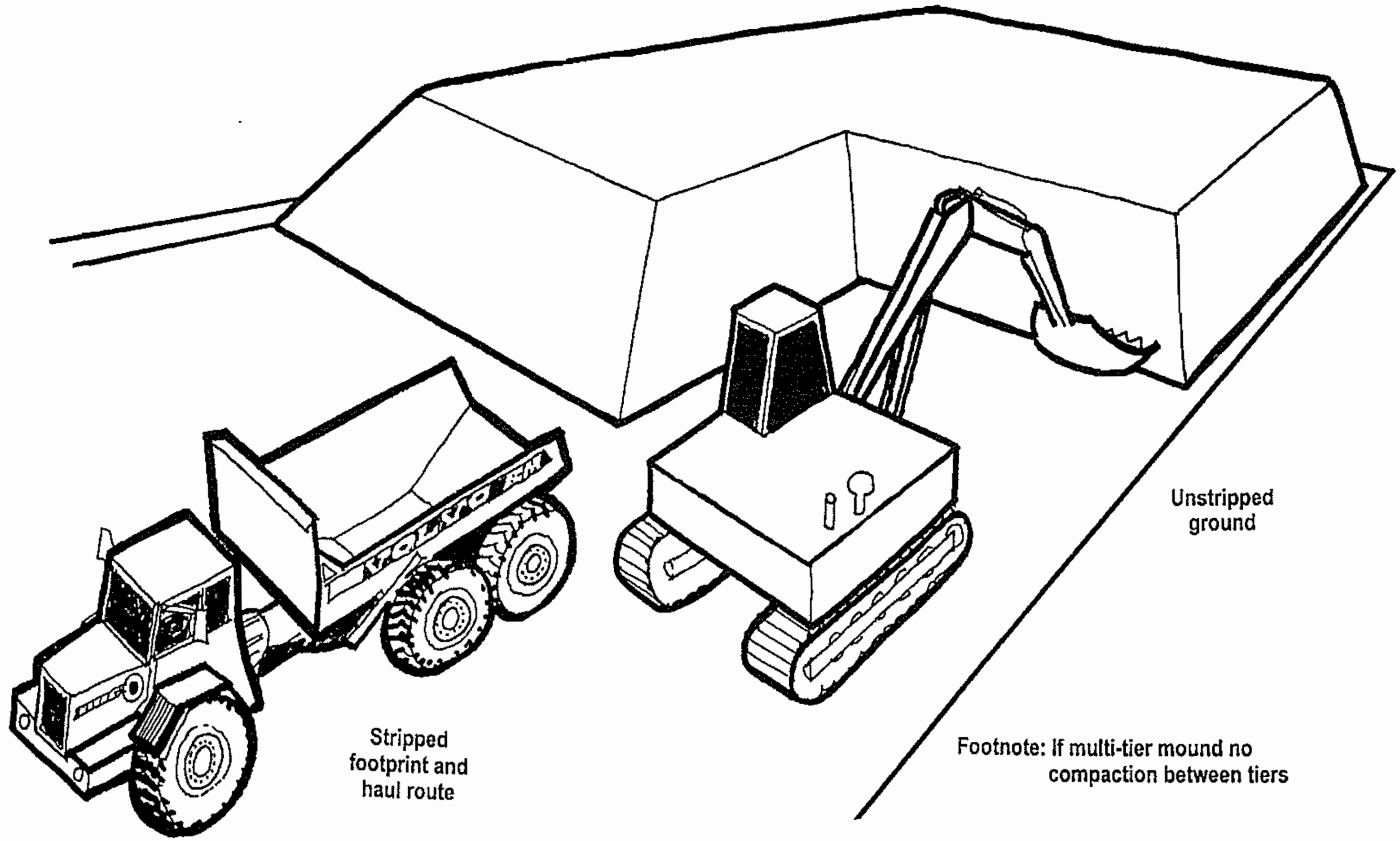

Figure 3.3 Excavation of soil storage mounds with front loading shovels and dump trucks: Single and multi-tier mounds

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SHEET 3

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 4:

Soil Replacement with Excavators and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

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MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

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SHEET 4 SOIL REPLACEMENT WITH EXCAVATOR & DUMP TRUCK

The purpose of this Guidance Sheet is to provide a model method for best practice where soils are to be replaced by excavators and dump trucks. This Guidance Sheet comprises 7 pages of text, 4 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses back-acting excavators in combination with dump trucks (articulated or rigid bodied). An excavator is used to spread the soil tipped from dump trucks used for transportation to replacement areas.

The soil handling method can affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through trafficking, the effects of which increases with increasing soil wetness.

The advantage of this model method, if correctly carried out, is that it should avoid severe deformation of the soil as trafficking is minimised. Consequently, there should normally be no need for decompaction treatment during the replacement operation, unless the soils are in a compacted state following stripping or storage. Where compaction occurs at replacement this will need treatment during the replacement process. Also where required, it will be necessary to integrate the removal of stones or damaging materials with the replacement process. Both decompaction and removal of materials are covered in separate Guidance Sheets (16-19).

The early installation of under drainage is strongly recommended. Where required this should either be undertaken sequentially during the replacement of the soils or in the early aftercare period. Until drains are installed it is recommended that the restored land is sown and managed as grassland.

The key operational points to ensure avoidance of severe soil deformation are as follows:

(i) To minimise compaction:

- the dump trucks must only operate on the 'basal'/non-soil layer, and their wheels must not on any circumstances run on to the soil layer(s).
- the excavator must only operate on the basal layer.
- the adoption of a bed/strip system avoids the need for the trucks and excavator to travel on the soil layers.
- the machines are to only work when ground conditions enable their maximum operating efficiency.
- if compaction has been caused, then measures are required to treat it (see Sheets 18 & 19).

(ii) To minimise soil wetness and rewetting:

- 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 to 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 Replacement Operation

4.1 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.

4.2 Prior to commencing operations a Meteorological Office forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events. 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 must not restart unless the weather forecast is expected to be dry for at least a full day.

4.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails.

4.4 The operation should follow a detailed replacement plan showing 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. Detailed daily records should be kept of operations undertaken (including the removal of stones and other damaging materials, and the results of any assessment of the need for additional decompaction and effectiveness of decompaction work undertaken), and site and soil conditions.

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

4.6 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'. The system involves the progressive sequential laying of the materials in strips across the area to be restored (Figure 4.1).

4.7 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 5-8m. Effective boom length can also reduce with profile heights greater than 1m; at 1.5m the effective reach of the standard boom may result in only 2m wide strips. A wide bucket with a blade and not teeth should be used to spread the soil.

4.8 Reverse dump truck up to edge of the current strip and tip the lowest layer (subsoil) soil, without the wheels riding onto the strip (Figure 4.1). 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 4.2). The excavator is to spread the tipped soil to full thickness by digging, and the pushing and

pulling action of bucket. 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 'slice' the blocks into smaller pieces (see Sheet 18) 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 4.3). Alternatively, decompaction by ripping should be undertaken once the strip is complete (see Sheet 19). Decompaction work must be completed before the next soil layer is placed.

4.9 Level boards and soil pits should be used to verify soil thickness in each strip and overall levels. Allowances (ie. a bulking factor) should be made for any settlement that may take place of the replaced loose soil.

4.10 Where stones are to be removed as part of the replacement process, normally the method described in Sheet 16 should be used once the strip is complete. An alternative method and one suited to removing potentially damaging materials (eg wire ropes) is described in Sheet 17. These operations must be completed before the next soil layer is placed.

4.11 On completion of the lowest (subsoil) layer, repeat the process spreading the next layer (subsoil/topsoil) (Figure 4.4). 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. The soil is to be spread by the excavator to full thickness by digging, and the pushing and pulling action of bucket described above, and undertaking any necessary decompaction work and removal of stones if using Sheets 16 to 19. Repeat the process progressively (left to right) along the strip and undertake any removal of damaging materials or decompaction. Level boards should be used to verify soil thickness in strip and overall levels.

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

4.13 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 clean.

4.14 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 only start part of a strip; this too must be completed.

4.15 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.

Operational Variations

4.16 When the replaced soil profiles reach about 0.6-1m in height it may not be possible to discharge the load from some dump trucks directly onto the previously placed 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 topsoil is minimised if the basal/ formation layer is kept to level and clean.

4.16 If the basal/formation layer is to be decompacted, before any soil material is placed, each strip is to be firstly decompacted before the subsoil layer is replaced using either methods described in Sheets 18 or 19. The basal layer must only be decompacted in the strip required for soil replacement, and must

only be prepared on the day of soil placement. During this process it may be necessary to use Sheets 16 or 17 for the removal of stones or damaging materials from the decompacted basal layer.

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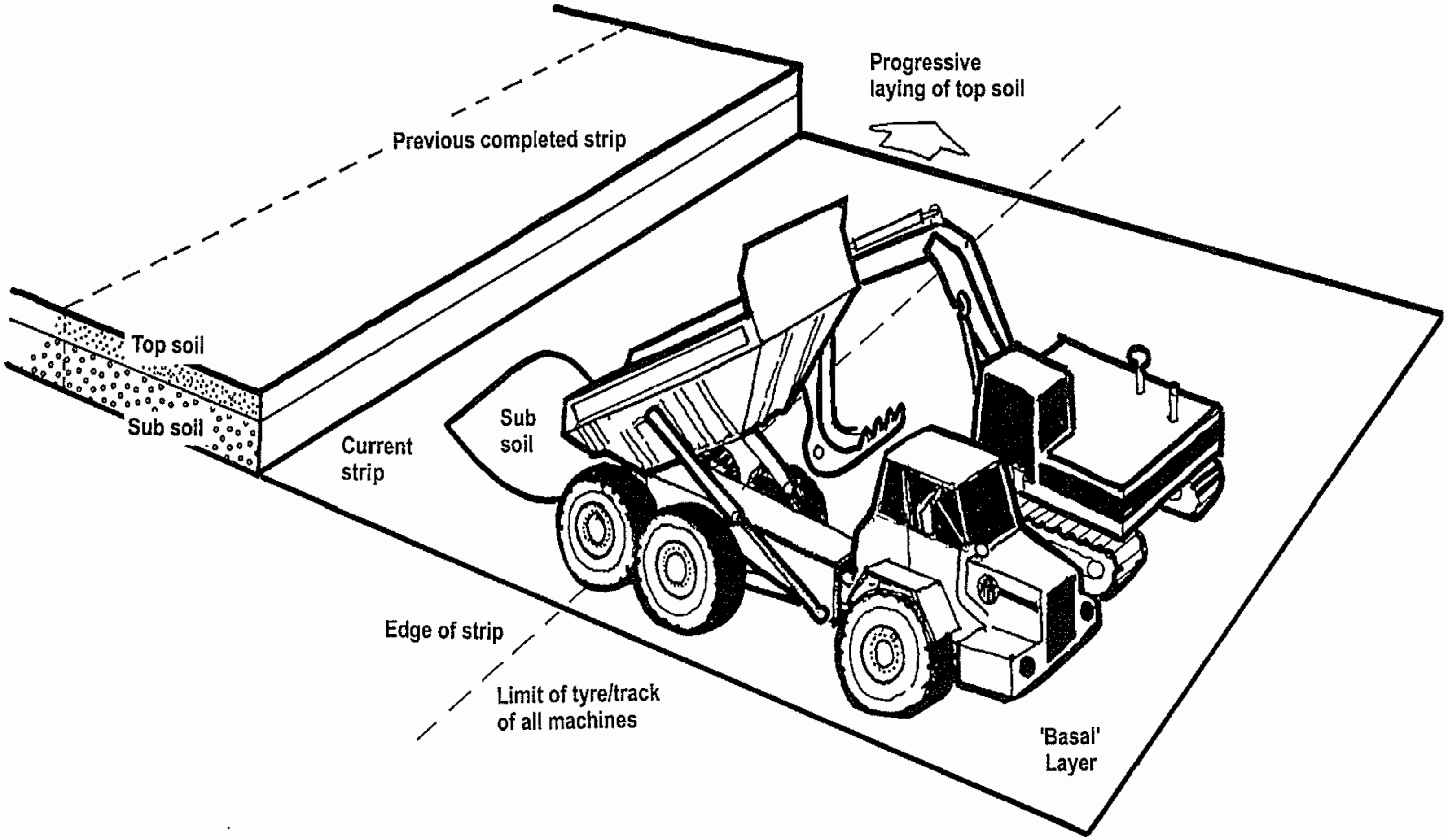
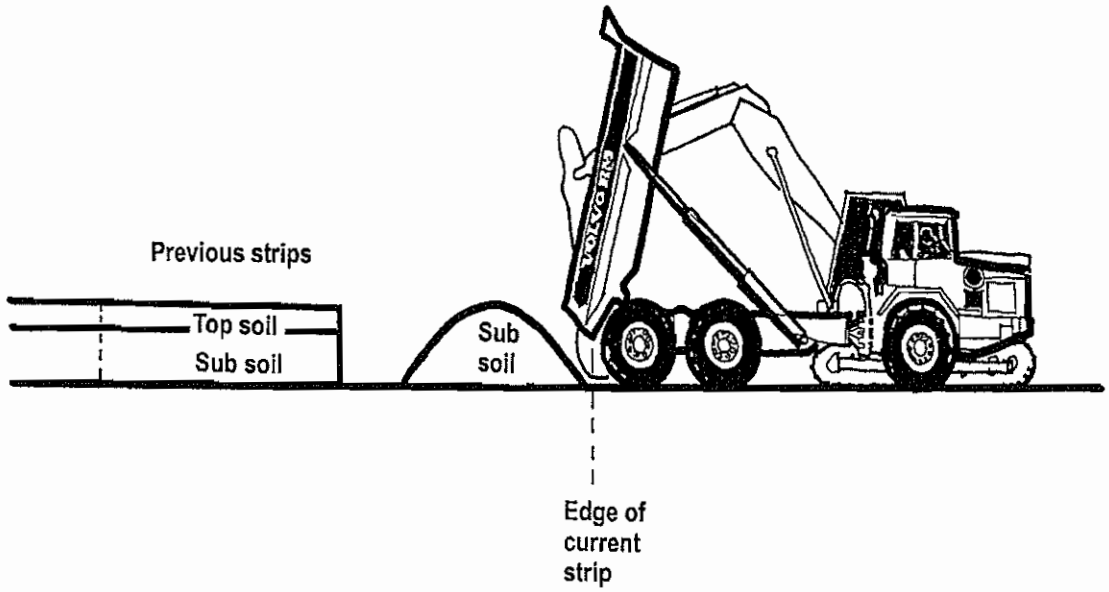


Figure 4.1 Soil replacement with excavators and dump trucks: Sub soil layer



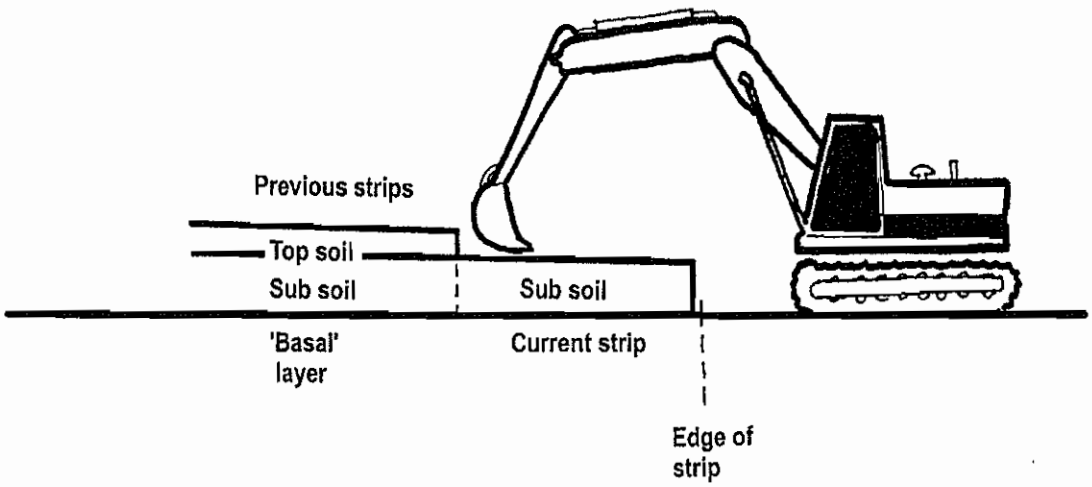


Figure 4.2 Soil replacement with excavators - dump trucks Sub soil layer

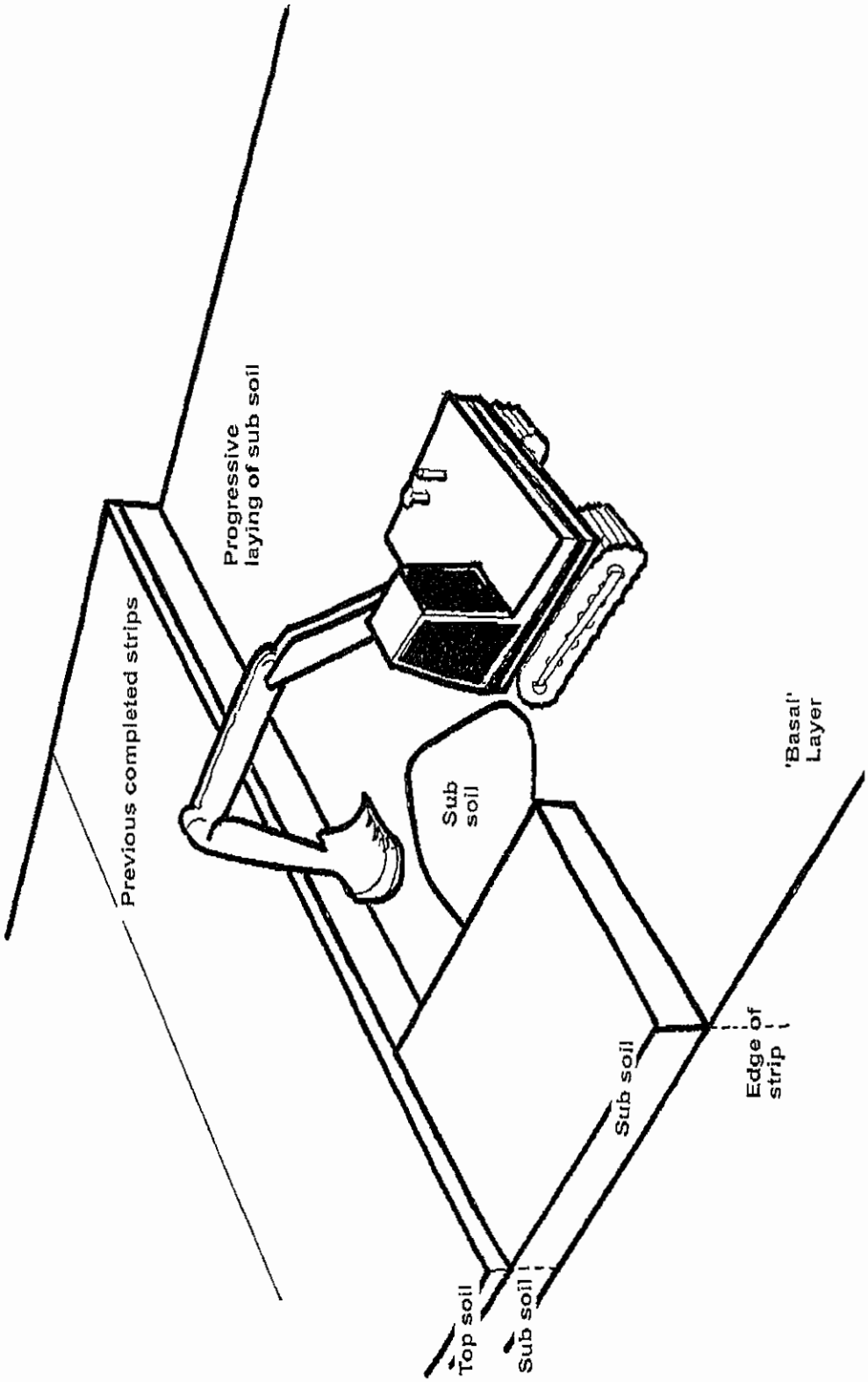
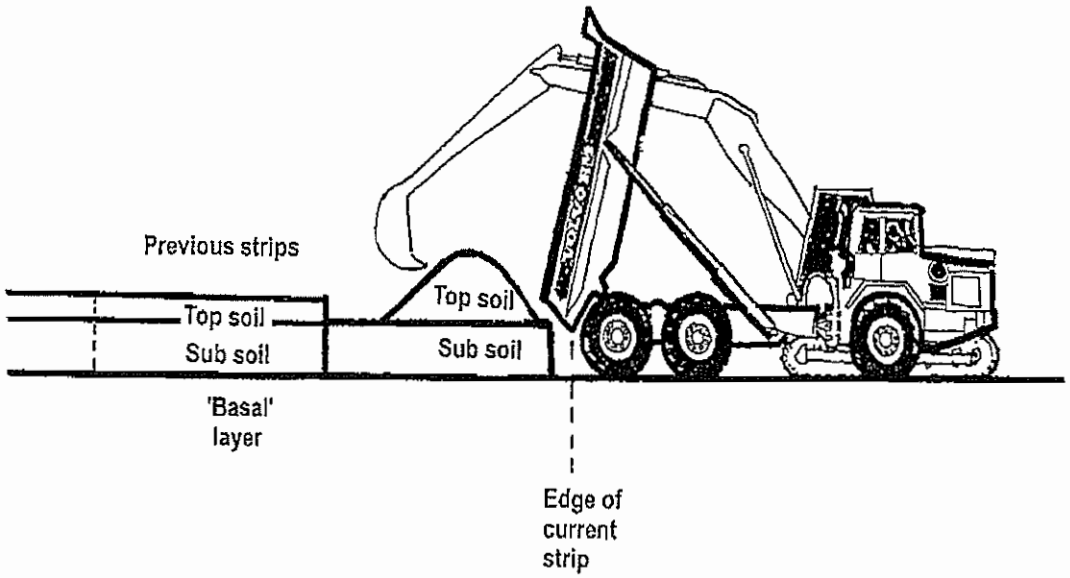


Figure 4.3 Soil replacement with excavators and dump trucks: Sub soil progressively laid



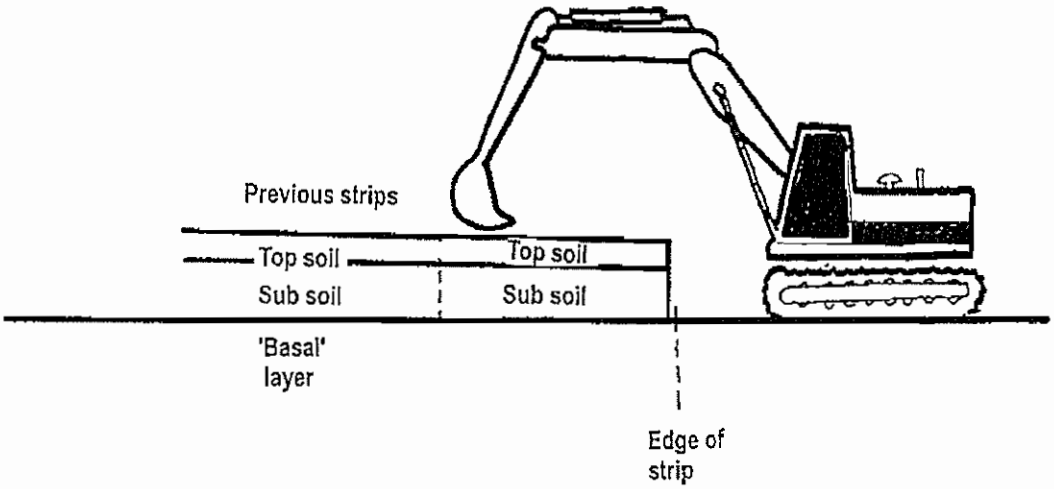


Figure 4.4 Soil replacement with excavators and dump trucks: Top soil layer

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SHEET 4

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Please copy and return to: M Stephen, Farming and Rural Conservation Agency, Rural Development Team, Government Buildings, Block C, Brooklands Avenue, Cambridge CB2 2BL, UK

GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 5:

Soil Stripping with Towed Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 5 SOIL STRIPPING WITH TOWED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where tracked bulldozers pulling scraper boxes are used to strip soil. This Guidance Sheet comprises 6 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked with cleats), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a tracked bulldozer pulling an earth scraper 'box' to strip and transport soils to the replacement areas or to storage. An auxiliary bulldozer may be required to assist in the lifting of soils and the management of the soils stripping area and haul routes.

The earth scraper soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This

is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by towed earth scrapers.

There are a number of key operational points during stripping to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- the adoption of an 'in-out' only at the end of strips minimises trafficking.

- the machines are to only work when ground conditions enable their maximum operating efficiency.

- the soils are to be picked up in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.

- the soil layers should have a moisture content of 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

(ii) To minimise soil wetness and rewetting:

- 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 earth scrapers.

- 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.

The Stripping Operation

5.1 The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance.

5.2 Soil stripping operations should not start until the required soil moisture levels are reached (as determined by the agreed method), and should be suspended as soon as the water content returns to these levels. Prior to work commencing a Meteorological Office forecast should be obtained which gives reasonable confidence of soil stripping proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the stripping must be suspended, and where the soil profile has been disturbed it should be removed to base level. Stripping must not restart unless the weather is expected to be dry for at least a full day.

5.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails.

5.4 The operation should follow a detailed stripping plan showing soil units to be stripped, 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 ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

5.5 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 layer. The next strip should not be started until the current strip is completely stripped to the basal layer. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential stripping of the materials in strips (Figure 5.1). Where there is a gradient to the site, the main axis of the soil strips should be along the main axis of the slope.

5.6 The haul routes and storage areas must be defined, and should be stripped first in a similar manner.

5.7 The scraper is only to travel and work on the soil layer when stripping soils, otherwise it is to travel only on the basal/formation layer. The scrapers are to enter the strip at the designated 'in' end and only exit the strip at the 'out' end (Figure 5.1). Where possible, the scrapers are to travel in the same tracks as previous passes. If a bulldozer is used to assist the scraper by pushing, this is the only other machine to operate on the soils to be stripped.

5.8 The initial strip width and axis is to be demarcated. The soil profile is to be stripped in strips of two to three machine widths (about 6-12m).

5.9 Starting at the furthest end of the strip (Figure 5.1), the soil layer is to be picked up in the thickest layer possible (not less than 150mm) over the shortest distance possible, whilst maintaining the operational efficiency of the bulldozer and scraper (using an auxiliary bulldozer to push if necessary).

5.10 Topsoil should be recovered to the full width of the strip without contamination 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 full thickness of the topsoil horizon should be stripped progressively along the strip before subsoil horizons are started.

5.11 The upper subsoil in the current strip is to be stripped and monitored in the same manner (Figure 5.2). The final 50cm of the subsoil layer should be left as a step to protect the adjacent topsoil horizon from local collapses. The process is to be repeated for the lower subsoil and any other lower layer to be recovered as a soil material.

5.12 On completion of the strip, the procedures are to be repeated sequentially for each subsequent strip until the area is completely stripped.

5.13 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 is forecast.

5.14 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.

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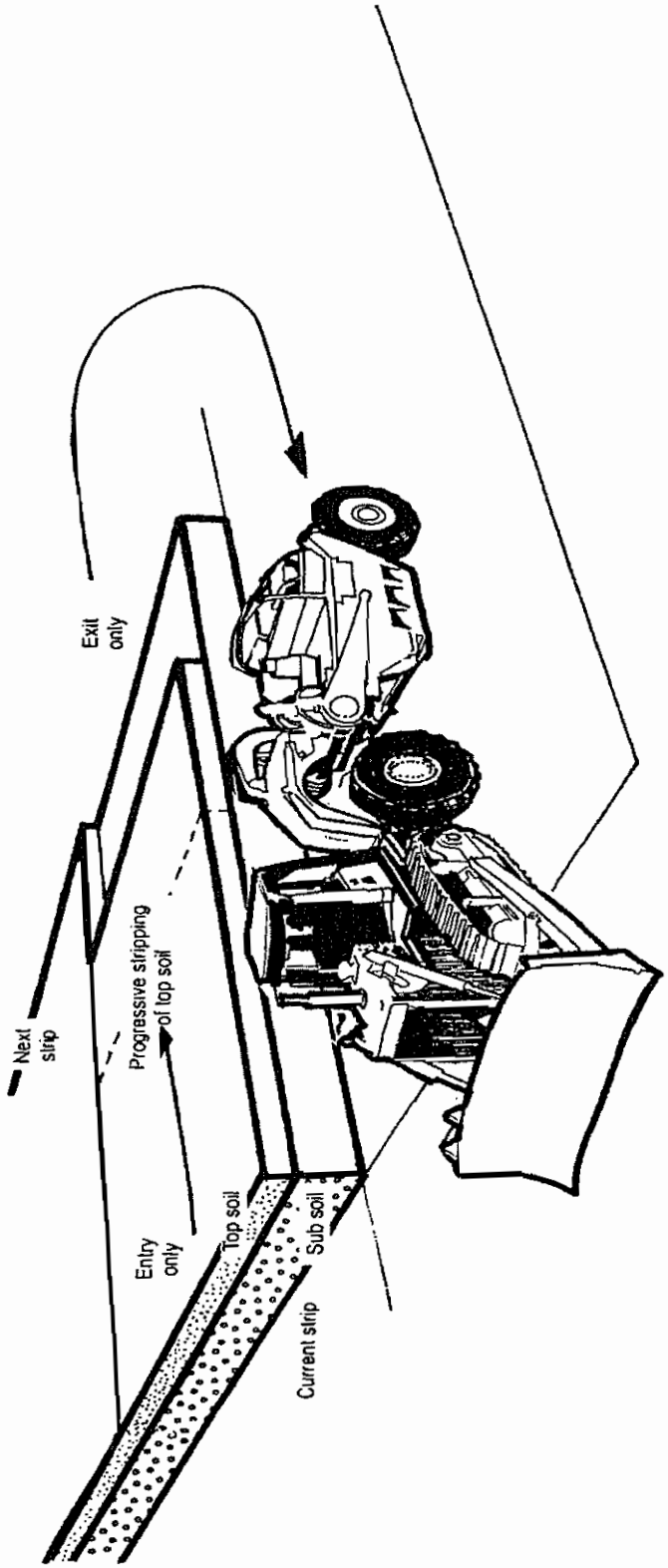

Figure 5.1 Soil stripping with towed earth scrapers: Top soil

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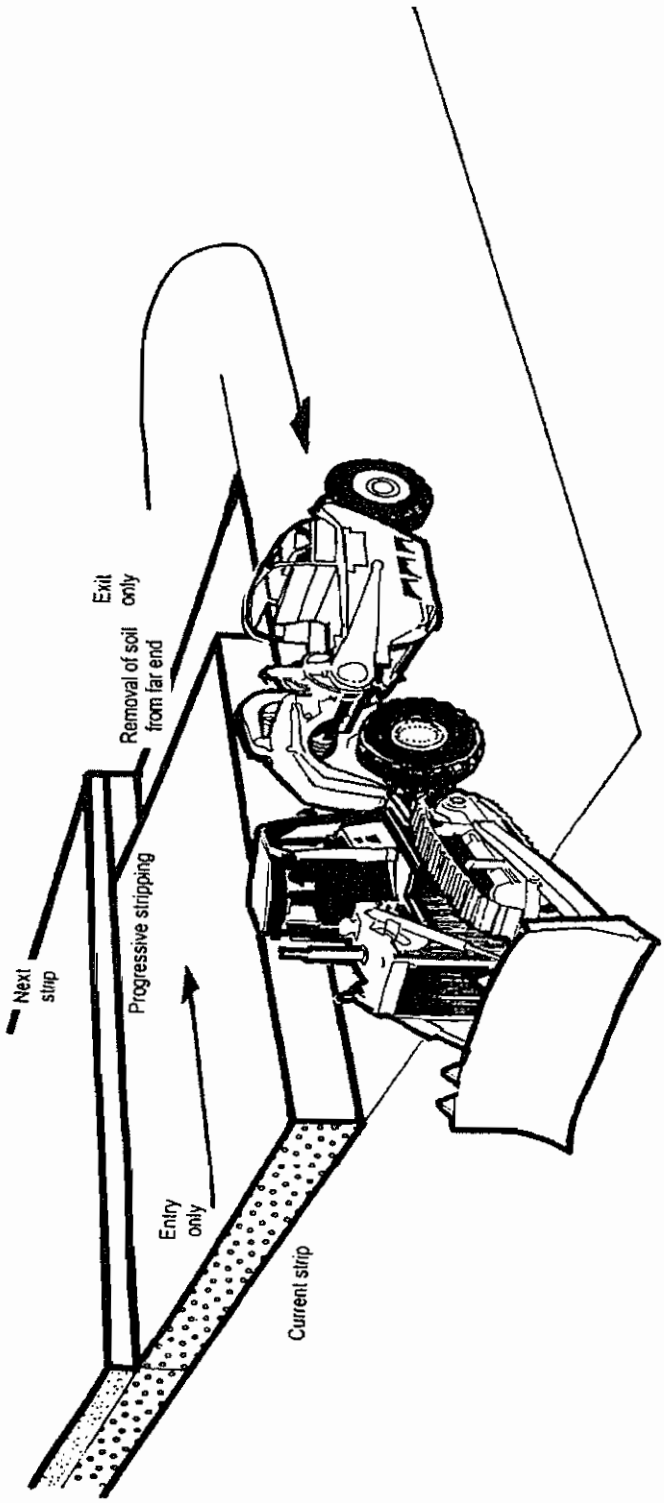

Figure 5.2 Soil stripping with towed earth scrapers: Sub soil

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SHEET 5

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 6:

Building Soil Storage Mounds with Towed Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

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The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 6 BUILDING SOIL STORAGE MOUNDS WITH TOWED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where bulldozer towed earth scrapers are used to build soil storage mounds. This Guidance Sheet comprises 4 pages of text, 1 figure and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a tracked bulldozer pulling an earth scraper 'box' to transport and place the soils into storage. An auxiliary bulldozer may be required to assist in the traction of the scraper unit in the building of the soil mound, and to shape the mound and maintain haul routes

The earth scraper soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by towed earth scrapers.

There are a number of key operational points during soil mound construction to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- strip in advance the soil to basal layer along haul routes and the operational footprint of the storage mound.
- the adoption of an 'in-out' only at the end of the mound minimises trafficking.
- the soils are to be released in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.
- the machines are to only work when ground or soil surface conditions enable their maximum operating efficiency.

(ii) 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 the earth scrapers.

The Storage Operation

6.1 The mounds should be sited on dry ground and not in hollows and should not disrupt local surface drainage. 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.

6.2 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails; haul routes must be maintained.

6.3 The operation should follow a detailed soil stripping/storage plan showing soil units to be stripped and stored, haul routes and the phasing of vehicle movements. Haul routes are required at both ends of the mound and along one side when building with earth scrapers; these should be retained for the excavation process. The soil units should be defined within the site with information to distinguish types and layers, and ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

6.4 Remove in advance topsoil and subsoil to overburden/basal layer from the haul routes and from the foot print of the storage mound and 'operating area' by adopting practices outlined in Sheet 5. The soils removed from the haul routes and foot print of the storage mounds should be stored in their respective mounds.

6.5 The scrapers must travel only along the haul route and in the operational area, and enter and leave the storage mound footprint by the 'in-out' designated routes. The soil should be released in as thick wedges as possible (300mm) over the shortest distance (starting at the far end of the mound) whilst maintaining operational efficiency of the earth scrapers (using the auxiliary bulldozer to push if necessary). The placement of soil should start at one side of the storage area building upwards and laterally along the axis of the mound; with the scraper travelling in the same tracks where possible (Figure 6.1).

6.6 Any exposed edges/surfaces should be shaped using a 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 a bulldozer blade to promote the shedding of rain.

6.7 Work should stop in wet conditions 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.

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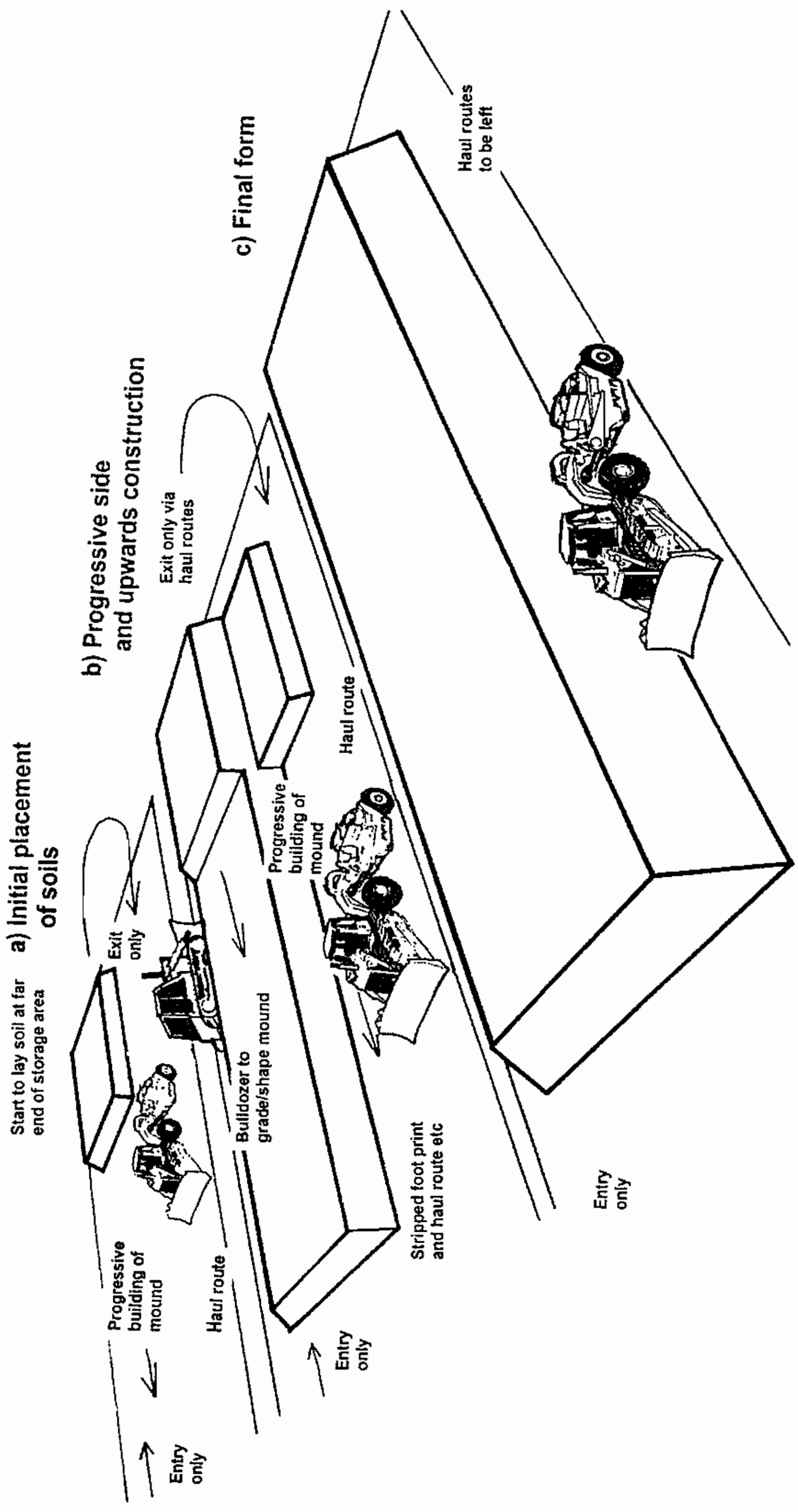

Figure 6.1 Storage mound construction with towed earth scrapers: Single and multi tier mounds

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SHEET 6

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 7:

Excavation of Soil Storage Mounds with Towed Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 7 EXCAVATION OF SOIL STORAGE MOUNDS WITH TOWED EARTH SCRAPER

The purpose of this Guidance Sheet is to provide a model method for best practice where bulldozer towed earth scrapers are used to excavate soil mounds. This Guidance Sheet comprises 3 pages of text, 1 figure and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a tracked bulldozer pulling an earth scraper 'box' to excavate the soils from the storage mound and transport to the replacement area. An auxiliary bulldozer may be required to assist in the traction of the scraper unit in the extraction of the soil, and to shape the mound and maintain haul routes

The earth scraper soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by towed earth scrapers.

There are a number of key operational points during soil mound excavation to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- the earth scrapers are to only travel and stand on the basal layer along haul routes and the operational footprint of the storage mound.
- the adoption of an 'in-out' only at the end of the mound minimises trafficking.
- the soils are to be picked up in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.
- the machines are to only work when ground or soil surface conditions enable their maximum operating efficiency.

(ii) To minimise the wetting of soils:

- extract the soil mound progressively along the axis of the mound, and shape the mound as it is being extracted 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 the earth scrapers.

The Excavation Operation

7.1 The scrapers must travel only along the haul route and in the operational area, and enter and leave the storage mound footprint by the 'in-out' designated routes. The retained haul routes at each end and alongside the soil mound will need to be used in the excavation and transport of soil by the scrapers. Haul routes must be maintained. Detailed daily records should be kept of operations, and site and soil conditions.

7.2 The soil should be lifted in as thick wedges as possible (300mm) over the shortest distance. The lifting of soil should start along the crest of the mound and preferably remove one side of the storage mound first (starting at the far end of the mound) with the scraper travelling in the same tracks where possible (Figure 7.1). The objective is to minimise the exposure of soil to rain events by progressively removing the mound along the axis. An auxiliary bulldozer may be required to push the scraper to maintain traction during mound removal, it is also used to shape and firm the mound.

7.3 Any exposed edges/surfaces should be shaped using a bulldozer blade on the onset of rain during the day. All surfaces should be shaped to shed water at the end of the day.

7.4 Work should stop in wet conditions 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.

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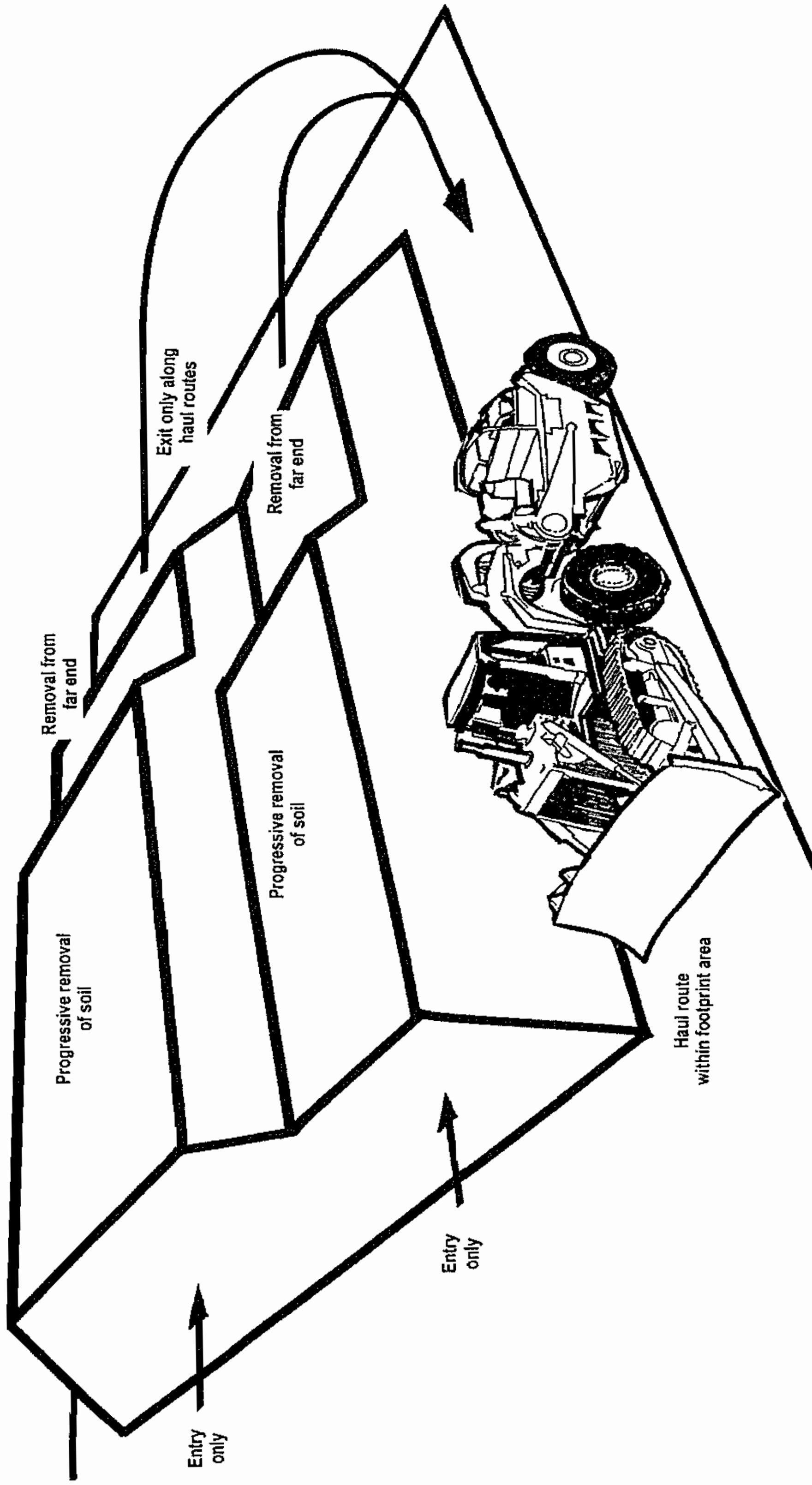

Figure 7.1 Excavation of soil storage mounds with towed earth scrapers: Single and multi tier mounds

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SHEET 7

Version: 04/00

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 8:

Soil Replacement with Towed Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

v04/00

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 8 SOIL REPLACEMENT WITH TOWED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where bulldozer towed earth scrapers are used to replace soils. This Guidance Sheet comprises 6 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a tracked bulldozer pulling an earth scraper 'box' to transport and lay the soils.

The earth scraper soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory

restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by towed earth scrapers.

The early installation of under drainage is strongly recommended. Where required this should either be undertaken sequentially during the replacement of the soils or in the early aftercare period. Until drains are installed it is recommended that the restored land is sown and managed as grassland.

There are a number of key operational points to minimise the degree and extent of severe soil deformation and for the effective treatment of the compaction:

(i) To minimise compaction and optimise decompaction:

- the adoption of an 'in-out' only at the end of strips minimises trafficking.
- the machines are to only work when ground conditions enable their maximum operating efficiency.
- the soils are to be relaid in as thick layer as possible whilst maintaining the operational efficiency of the scraper, using an auxiliary bulldozer to push if necessary.
- effective decompaction on soil replacement is a requisite of the earth scraper handling method (see Sheet 19).
- the soil layers should have a moisture content 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

(ii) To minimise soil rewetting and for effective decompaction:

- 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 replaced to 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 the earth scrapers.

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

The Replacement Operation

8.1 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.

8.2 Prior to commencing operations a Meteorological Office forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to topsoil level. Replacement must not restart unless the weather is expected to be dry for at least a full day.

8.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails. All haul routes should be maintained.

8.4 The operation should follow a detailed replacement plan showing 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. Detailed daily records should be kept of operations undertaken (including the removal of stones or other damaging materials, and the results of any assessment of the need for additional decompaction and effectiveness of decompaction work undertaken), and site and soil conditions.

8.5 The scrapers must travel only along the haul route and the basal/formation layer operational area, and enter and leave the strips receiving soil by the 'in-out' designated ends. When ever possible the scrapers should travel in the same tracks when laying soils as in previous passes.

8.6 The soil layers above the base/formation layer are to be replaced in sequential strips with the subsoil layer(s) to be replaced first, followed by the topsoil layer; each layer replaced to the specified thickness. The next strip is not to be started until the current strip is completed. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential laying of the materials in strips across the area to be restored (Figure 8.1).

8.7 The initial strip width and axis should be demarcated. Strip widths should be up to two machine widths (about 10m).

8.8 Start at the entry end of the strip with lowest soil layer (subsoil). Release the soil slowly and maximise the thickness of soil laid (eg 300mm) over the shortest distance possible, whilst maintaining their operational efficiency. The strip is to be completed and the soil placed to the required thickness by repeating the process progressively along the strip (Figure 8.1). Some final grading of the completed strip might be necessary. This should be minimised and carried out with the scraper or bulldozer, but not a grader.

8.9 Level boards and soil pits should be used to verify soil thickness in each strip and overall levels. Allowances (ie. bulking factor) should be made for any 'heave' that may take place when the replaced soil is decompacted.

8.10 The ripping strategy needs to be determined at the planning of operations and must take into account the thickness of soil layers, depth of recompaction and the effective depth of the ripping tool (Sheet 19), and the need for the removal of stones and other damaging materials (Sheet 17). These should be specified in the soil replacement plan. Decompaction and removal of materials should only take place when each specified soil layer is completed along the strip, and the work must be completed before the next layer of soil is placed.

8.11 On completion of the lowest layer (subsoil), including decompaction and removal of materials, repeat the process sequentially spreading the next layers (subsoil/topsoil) (Figure 8.2).

8.12 On completion of the topsoil layer, the above processes 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 clean.

8.13 At the end of each day the current strip must be complete 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.

8.14 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.

Operational Variation

8.15 If the basal/formation layer is to be decompacted, before any soil material is placed, each strip is to be firstly decompacted before the subsoil layer is replaced. Decompaction is dealt with in Sheet 19, which covers strategies, equipment and methods of operation. The basal layer must only be decompacted in the strip required for soil replacement, and must be prepared on the day of soil placement. During this process it may be necessary to use Sheet 17 for the removal of stones or damaging materials from the basal layer.

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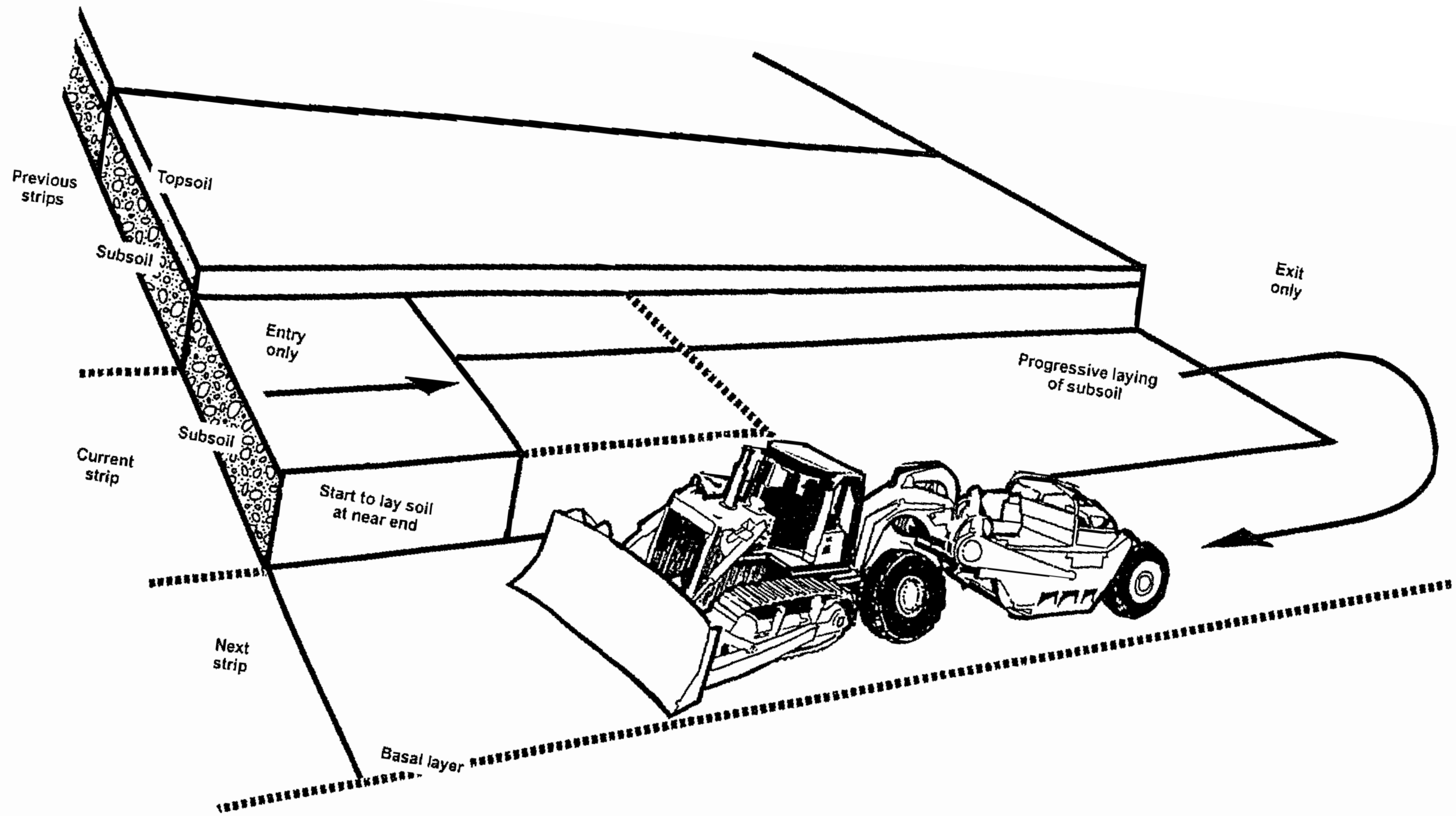

Figure 8.1 Soil replacement with towed earth scrapers: Sub soil

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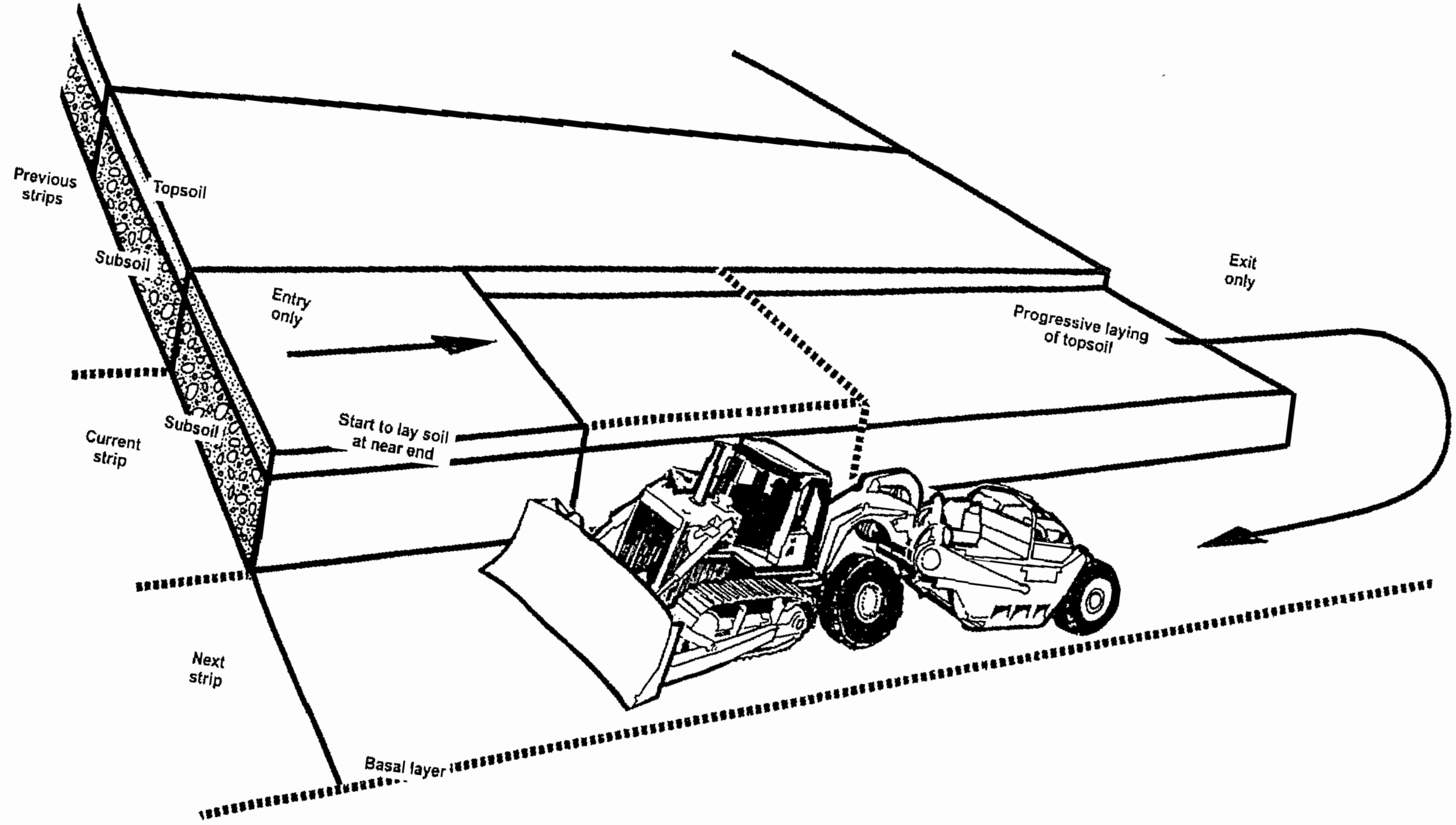

Figure 8.2 Soil replacement with towed earth scrapers: Top soil

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 9:

Soil Stripping with Self-Propelled Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

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MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 9 SOIL STRIPPING WITH SELF-PROPELLED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where self-propelled earth scrapers are used to strip soil. This Guidance Sheet comprises 6 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient, and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a self-propelled 'box' earth scraper to strip and transport soils to the replacement areas or to storage. An auxiliary bulldozer will be required to assist in the lifting of soils and the management of the soils stripping area and haul routes.

The self-propelled earth scraper soil handling method in particular can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated

trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by self-propelled earth scrapers.

There are a number of key operational points during stripping to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- the adoption of an 'in-out' only at the end of strips minimises trafficking.
- the machines are to only work when ground conditions enable their maximum operating efficiency.
- the soils are to be picked up in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.
- the soil layers should have a moisture content of 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

(ii) To minimise soil wetness and rewetting:

- 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 earth scrapers.

- 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.

The Stripping Operation

9.1 The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance.

9.2 Soil stripping operations should not start until the required soil moisture levels are reached (as determined by the agreed method), and should be suspended as soon as the water content returns to these levels. Prior to work commencing a Meteorological Office forecast should be obtained which gives reasonable confidence of soil stripping proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the stripping must be suspended, and where the soil profile has been disturbed it should be removed to base level. Stripping must not restart unless the weather is expected to be dry for at least a full day.

9.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails.

9.4 The operation should follow a detailed stripping plan showing soil units to be stripped, 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 ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

9.5 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 layer. The next strip should not be started until the current strip is completely stripped to the basal layer. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential stripping of the materials in strips (Figure 9.1). Where there is a gradient to the site, the main axis of the soil strips should be along the main axis of the slope.

9.6 The haul routes and storage areas must be defined, and should be stripped first in a similar manner.

9.7 The scraper is only to travel and work on the soil layer when stripping soils, otherwise it is to travel only on the basal/formation layer. The scrapers are to enter the strip at the designated 'in' end and only exit the strip at the 'out' end (Figure 9.1). Where possible, the scrapers are to travel in the same tracks as previous passes. If a bulldozer is used to assist the scraper by pushing, this is the only other machine to operate on the soils to be stripped.

9.8 The initial strip width and axis is to be demarcated. The soil profile is to be stripped in strips of two to three machine widths (about 6-12m).

9.9 Starting at the furthest end of the strip (Figure 9.1), the soil layer is to be picked up in the thickest layer possible (not less than 150mm) over the shortest distance possible, whilst maintaining the operational efficiency of the self-propelled scraper (using an auxiliary bulldozer to push if necessary).

9.10 Topsoil should be recovered to the full width of the strip without contamination 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 full thickness of the topsoil horizon should be stripped progressively along the strip before subsoil horizons are started.

9.11 The upper subsoil in the current strip is to be stripped and monitored in the same manner (Figure 9.2). The final 50cm of the subsoil layer should be left as a step to protect the adjacent topsoil horizon from local collapses. The process is to be repeated for the lower subsoil and any other lower layer to be recovered as a soil material.

9.12 On completion of the strip, the procedures are to be repeated sequentially for each subsequent strip until the area is completely stripped.

9.13 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 is forecast.

9.14 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.

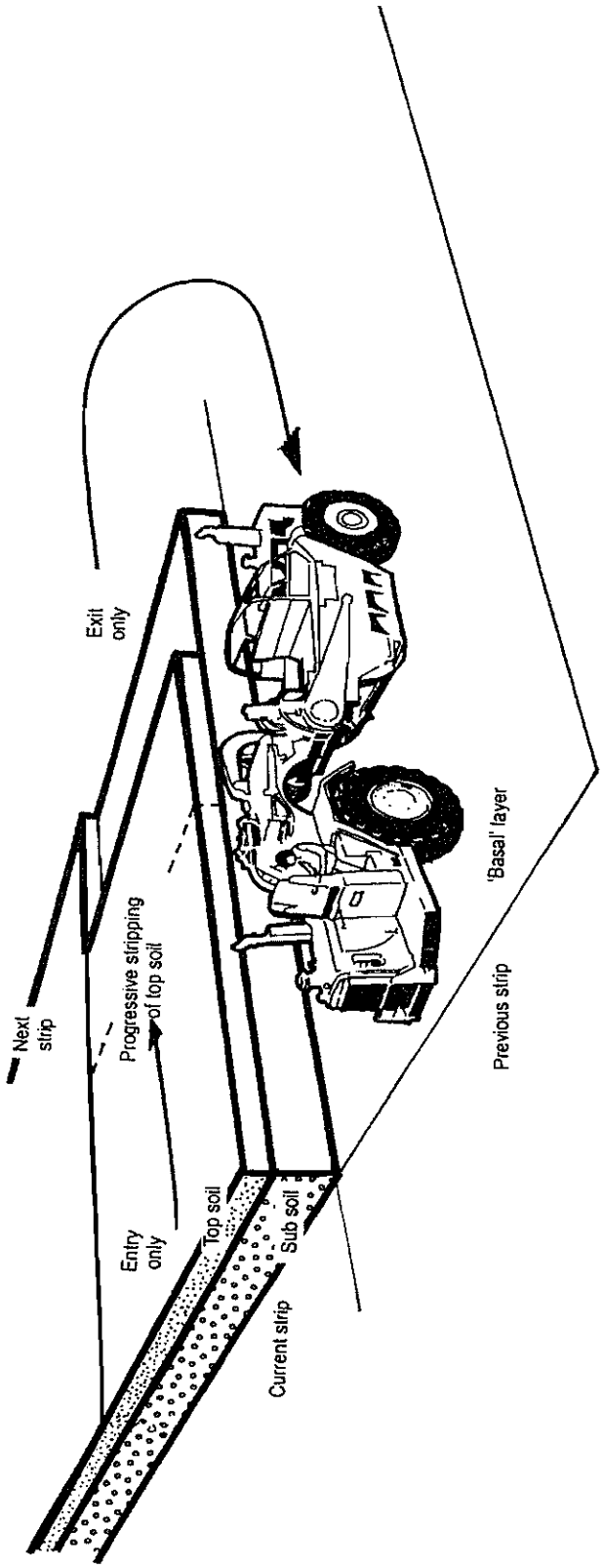

Figure 9.1 Soil stripping with self propelled scrapers: Top soil

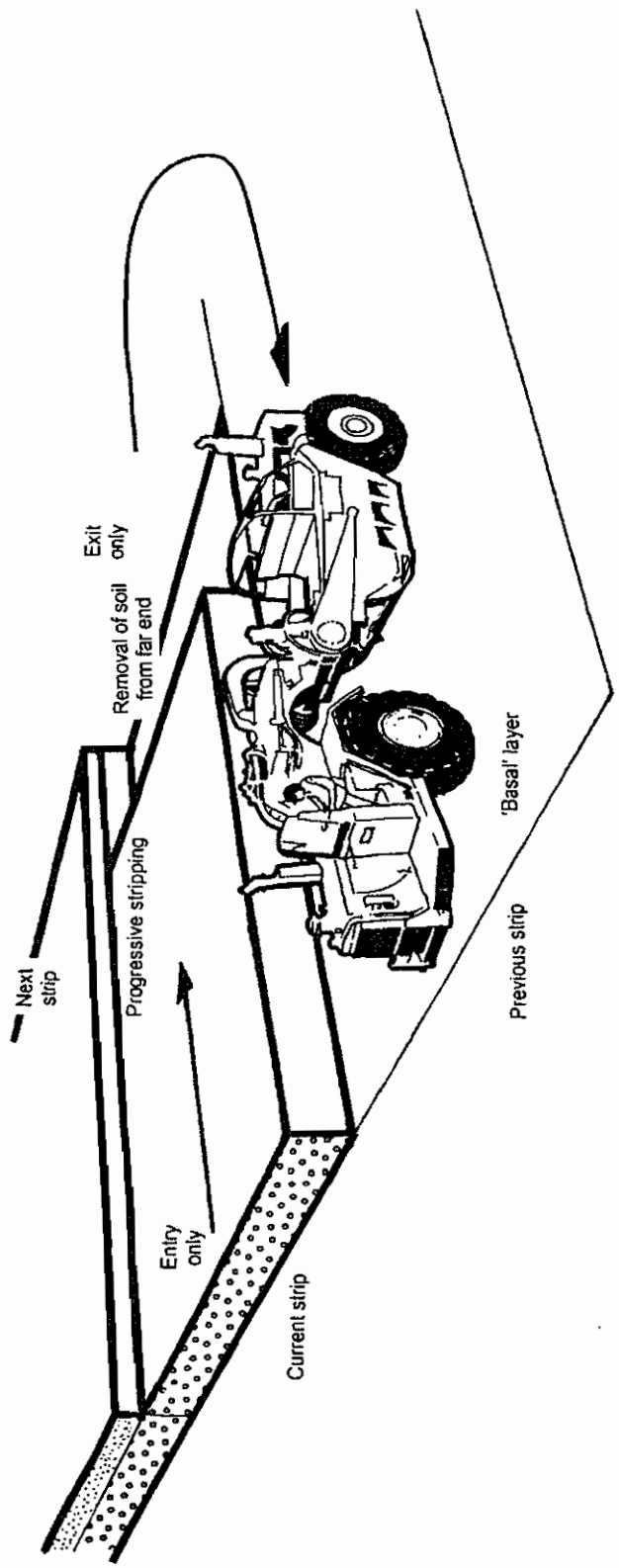

Figure 9.2 Soil stripping with self propelled scrapers: Sub soil

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 10:

Building Soil Storage Mounds with Self-Propelled Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 10 BUILDING SOIL STORAGE MOUNDS WITH SELF-PROPELLED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where self-propelled earth scrapers are used to build soil storage mounds. This Guidance Sheet comprises 4 pages of text, 1 figure and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient, and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a self-propelled 'box' earth scraper to transport and place the soils into storage. An auxiliary bulldozer will be required to assist in the traction of the scraper unit in the building of the soil mound, and to shape the mound and maintain haul routes.

The self-propelled earth scraper soil handling method in particular can significantly affect the agricultural quality of the restoration through severe soil deformation

(compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by self-propelled earth scrapers.

There are a number of key operational points during soil mound construction to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- strip in advance the soil to basal layer along haul routes and the operational footprint of the storage mound.
- the adoption of an 'in-out' only at the end of the mound minimises trafficking.
- the soils are to be released in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.
- the machines are to only work when ground or soil surface conditions enable their maximum operating efficiency.

(ii) 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 the earth scrapers.

The Storage Operation

10.1 The mounds should be sited on dry ground and not in hollows and should not disrupt local surface drainage. 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.

10.2 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails; haul routes must be maintained.

10.3 The operation should follow a detailed soil stripping/storage plan showing soil units to be stripped and stored, haul routes and the phasing of vehicle movements. Haul routes are required at both ends of the mound and along one side when building with earth scrapers; these should be retained for the excavation process. The soil units should be defined within the site with information to distinguish types and layers, and ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

10.4 Remove in advance topsoil and subsoil to overburden/basal layer from the haul routes and from the foot print of the storage mound and 'operating area' by adopting practices outlined in Sheet 9. The soils removed from the haul routes and foot print of the storage mounds should be stored in their respective mounds.

10.5 The scrapers must travel only along the haul route and in the operational area, and enter and leave the storage mound footprint by the 'in-out' designated routes. The soil should be released in as thick wedges as possible (300mm) over the shortest distance (starting at the far end of the mound) whilst maintaining operational efficiency of the earth scrapers (using the auxiliary bulldozer to push if necessary). The placement of soil should start at one side of the storage area building upwards and laterally along the axis of the mound; with the scraper travelling in the same tracks where possible (Figure 10.1).

10.6 Any exposed edges/surfaces should be shaped using a 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 a bulldozer blade to promote the shedding of rain.

10.7 Work should stop in wet conditions 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.

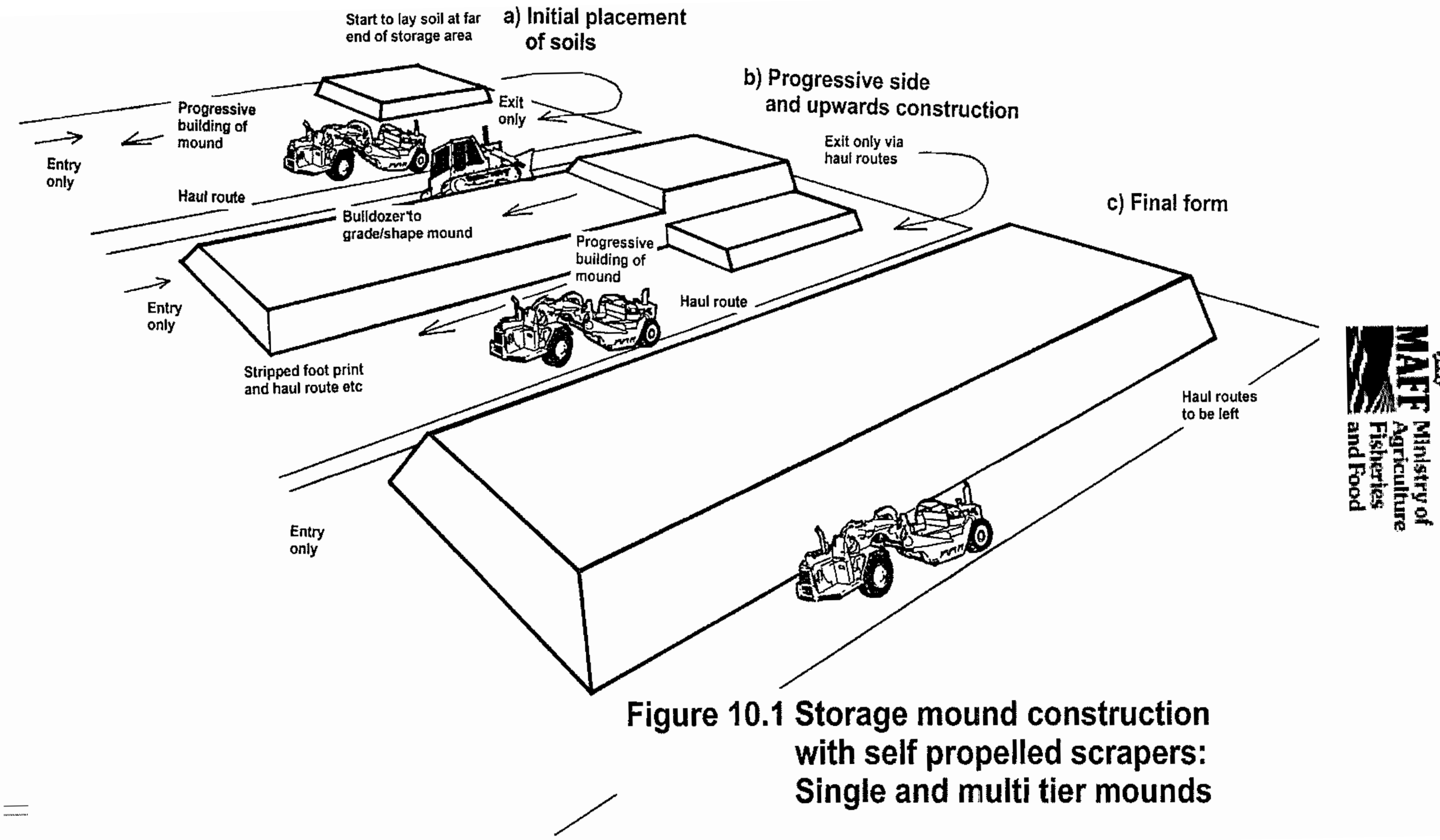

Figure 10.1 Storage mound construction with self propelled scrapers: Single and multi tier mounds

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SHEET 10

Version: 04/00

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 11:

Excavation of Soil Storage Mounds with Self-Propelled Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

v04/00

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 11 EXCAVATION OF SOIL STORAGE MOUNDS WITH SELF-PROPELLED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where self-propelled earth scrapers are used to excavate soil mounds. This Guidance Sheet comprises 3 pages of text, 1 figure and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient, and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a self-propelled 'box' earth scraper to excavate the soils from the storage mound and transport to the replacement area. An auxiliary bulldozer may be required to assist in the traction of the scraper unit in the extraction of the soil, and to shape the mound and maintain haul routes

The self-propelled earth scraper soil handling method in particular can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by self-propelled earth scrapers.

There are a number of key operational points during soil mound excavation to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- the earth scrapers are to only travel and stand on the basal layer along haul routes and the operational footprint of the storage mound.
- the adoption of an 'in-out' only at the end of the mound minimises trafficking.
- the soils are to be picked up in as thick layer as possible whilst maintaining their operational efficiency, using an auxiliary bulldozer to push if necessary.
- the machines are to only work when ground or soil surface conditions enable their maximum operating efficiency.

(ii) To minimise the wetting of soils:

- extract the soil mound progressively along the axis of the mound, and shape the mound as it is being extracted 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 the earth scrapers.

The Excavation Operation

11.1 The scrapers must travel only along the haul route and in the operational area, and enter and leave the storage mound footprint by the 'in-out' designated routes. The retained haul routes at each end and alongside the soil mound will need to be used in the excavation and transport of soil by the scrapers. Haul routes must be maintained. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

11.2 The soil should be lifted in as thick wedges as possible (300mm) over the shortest distance. The lifting of soil should start along the crest of the mound and preferably remove one side of the storage mound first (starting at the far end of the mound) with the scraper travelling in the same tracks where possible (Figure 11.1). The objective is to minimise the exposure of soil to rain events by progressively removing the mound along the axis. An auxiliary bulldozer may be required to push to maintain traction during mound removal, it is also used to shape and firm the mound.

11.3 Any exposed edges/surfaces should be shaped using a bulldozer blade on the onset of rain during the day. All surfaces should be shaped to shed water at the end of the day.

11.4 Work should stop in wet conditions 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.

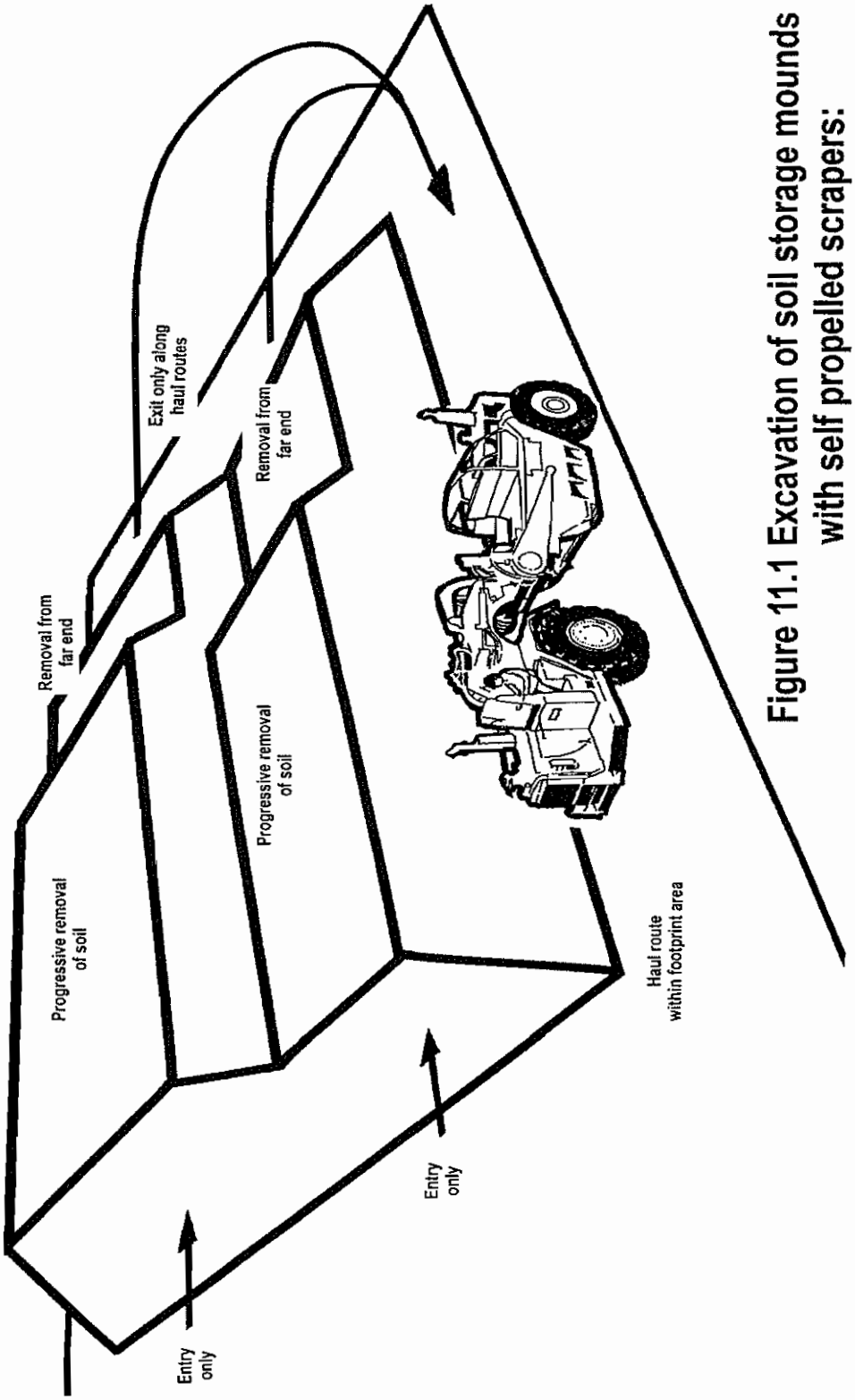

Figure 11.1 Excavation of soil storage mounds with self propelled scrapers: Single and multi tier mounds

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SHEET 11

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 12:

Soil Replacement with Self-Propelled Earth Scrapers

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

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MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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**MPG7 (November 1996, paragraph 3).

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SHEET 12 SOIL REPLACEMENT WITH SELF-PROPELLED EARTH SCRAPERS

The purpose of this Guidance Sheet is to provide a model method for best practice where self-propelled earth scrapers are used to replace soils. This Guidance Sheet comprises 6 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient, and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a self-propelled 'box' earth scraper to transport and lay the soils.

The self-propelled earth scraper soil handling method in particular can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated

trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by self-propelled earth scrapers.

The early installation of under drainage is strongly recommended. Where required this should either be undertaken sequentially during the replacement of the soils or in the early aftercare period. Until drains are installed it is recommended that the restored land is sown and managed as grassland.

There are a number of key operational points to minimise the degree and extent of severe soil deformation and for the effective treatment of the compaction:

(i) To minimise compaction and optimise decompaction:

- the adoption of an 'in-out' only at the end of strips minimises trafficking.
- the machines are to only work when ground conditions enable their maximum operating efficiency.
- the soils are to be relaid in as thick layer as possible whilst maintaining the operational efficiency of the scraper, using an auxiliary bulldozer to push if necessary.
- effective decompaction on soil replacement is a requisite of the earth scraper handling method (see Sheet 19).
- the soil layers should have a moisture content 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

(ii) To minimise soil rewetting and for effective decompaction:

- 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 replaced to 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 the earth scrapers.

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

The Replacement Operation

12.1 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.

12.2 Prior to commencing operations a Meteorological Office forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to topsoil level. Replacement must not restart unless the weather is expected to be dry for at least a full day.

12.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails. All haul routes should be maintained.

12.4 The operation should follow a detailed replacement plan showing 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. Detailed daily records should be kept of operations undertaken (including the removal of stones and other damaging materials, and the results of any assessment of the need for additional decompaction and the effectiveness of decompaction work undertaken), and site and soil conditions.

12.5 The scrapers must travel only along the haul route and the basal/formation layer operational area, and enter and leave the strips receiving soil by the 'in-out' designated ends. When ever possible the scrapers should travel in the same tracks when laying soils as in previous passes.

12.6 The soil layers above the base/formation layer are to be replaced in sequential strips with the subsoil layer(s) to be replaced first, followed by the topsoil layer; each layer replaced to the specified thickness. The next strip is not to be started until the current strip is completed. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential laying of the materials in strips across the area to be restored (Figure 12.1).

12.7 The initial strip width and axis should be demarcated. Strip widths should be up to two machine widths (about 10m).

12.8 Start at the entry end of the strip with lowest soil layer (subsoil). Release the soil slowly and maximise the thickness of soil laid (eg 300mm) over the shortest distance possible, whilst maintaining their operational efficiency. The strip is to be completed and the soil placed to the required thickness by repeating the process progressively along the strip (Figure 12.1). Some final grading of the completed strip might be necessary. This should be minimised and carried out with the scraper or bulldozer, but not a grader.

12.9 Level boards and soil pits should be used to verify soil thickness in each strip and overall levels. Allowances (ie. bulking factor) should be made for any 'heave' that may take place when the replaced soil is decompacted.

12.10 The ripping strategy needs to be determined at the planning of operations and must take into account the thickness of soil layers, depth of recompaction and the effective depth of the ripping tool (Sheet 19), and the need for the removal of stones and other damaging materials (Sheet 17). These should be specified in the soil replacement plan. Decompaction and removal of materials should only take place when each specified soil layer is completed along the strip, and the work must be completed before the next layer of soil is placed.

12.11 On completion of the lowest layer (subsoil), including decompaction and removal of materials, repeat the process sequentially spreading the next layers (subsoil/topsoil) (Figure 12.2).

12.12 On completion of the topsoil layer, the above processes 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 clean.

12.13 At the end of each day the current strip must be complete 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.

12.14 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.

Operational Variation

12.15 If the basal/formation layer is to be decompacted, before any soil material is placed, each strip is to be firstly decompacted before the subsoil layer is replaced. Decompaction is dealt with in Sheet 19, which covers strategies, equipment and methods of operation. The basal layer must only be decompacted in the strip required for soil replacement, and must be prepared on the day of soil placement. During this process it may be necessary to use Sheet 17 for the removal of stones or damaging materials from the basal layer.

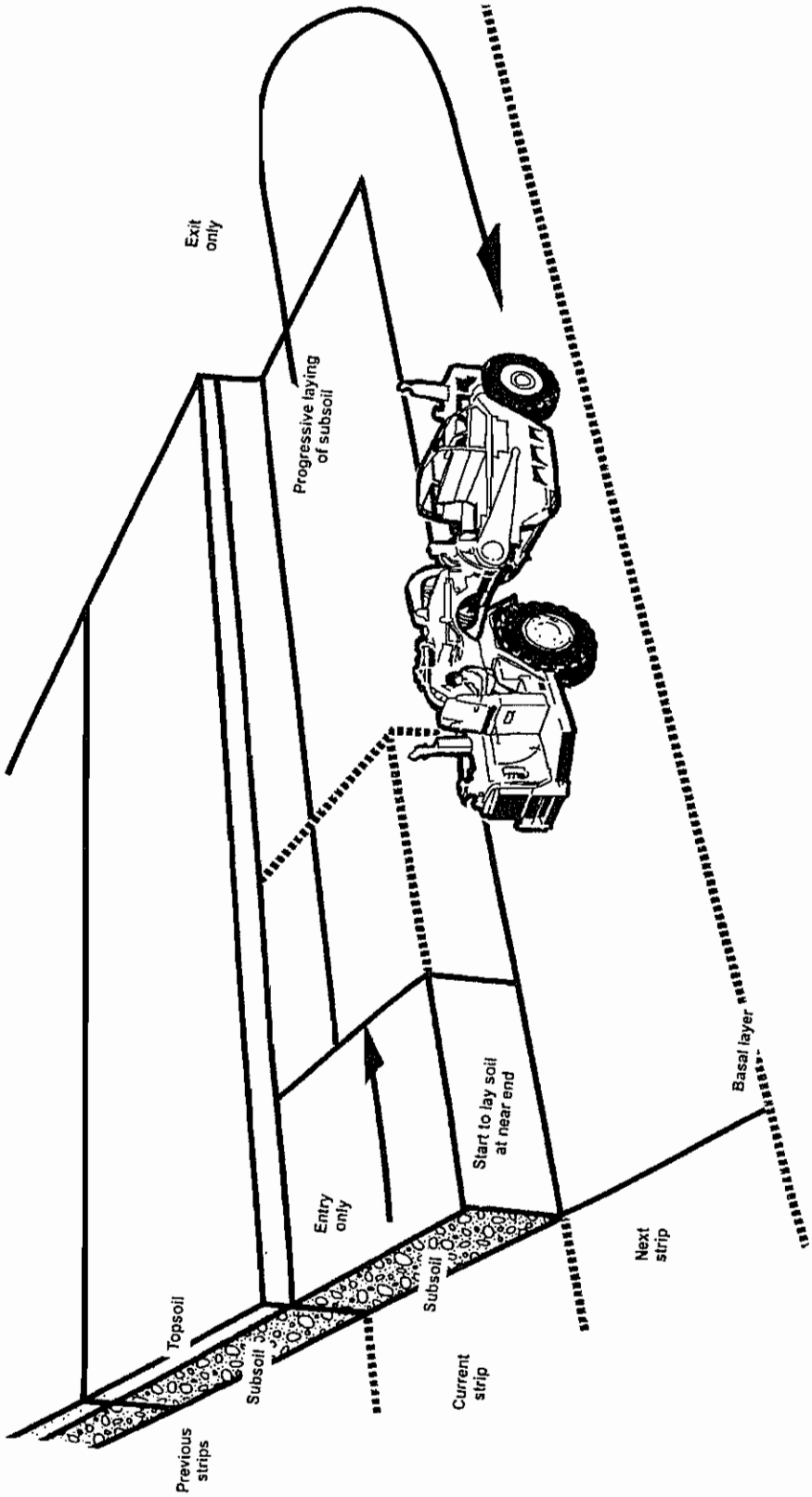

Figure 12.1 Soil replacement with self propelled scrapers: Sub soil

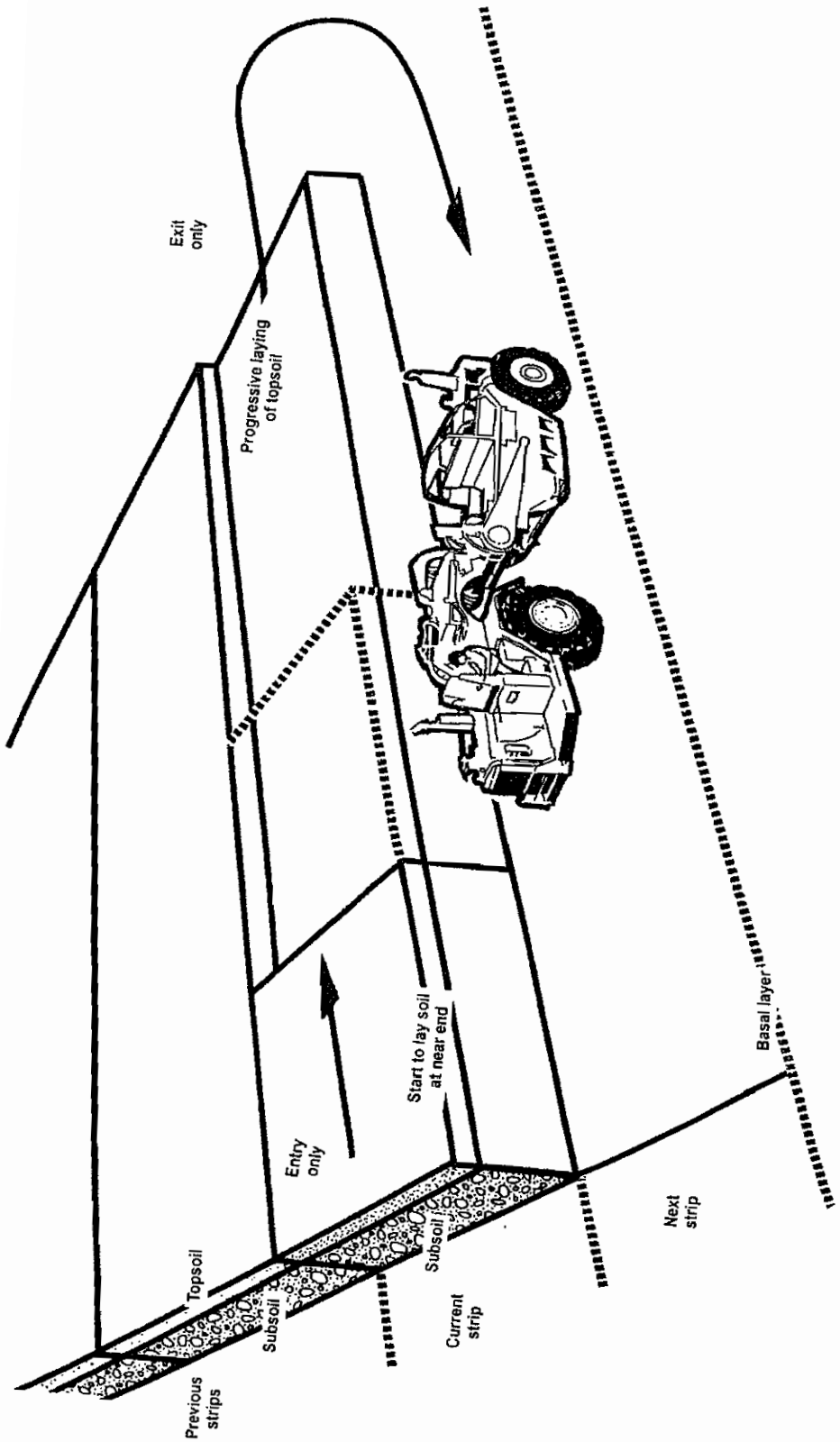

Figure 12.2 Soil replacement with self propelled scrapers: Top soil

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SHEET 12

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 13:

Soil Stripping with Bulldozers and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 13 SOIL STRIPPING WITH BULLDOZERS & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where bulldozers, excavators and dump trucks are used to strip soils. This Guidance Sheet comprises 6 pages of text, 4 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a bulldozer to strip the soils, an excavator to load the soil into dump trucks, and the trucks transport it to storage or to the replacement area.

The bulldozer soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during stripping, the building of soil mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration

there is a need for effective decompaction treatment during the replacement operation (see Sheets 15 & 19). Decompaction treatment is an obligate requirement when soils are handled by bulldozers.

There are a number of key operational points during stripping to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise compaction:

- the dump trucks must only operate on the 'basal'/non-soil layer, and their wheels must not in any circumstances run on to the soil layer(s).
- the adoption of a bed/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 maximum operating efficiency.
- the soils are to be stripped by the bulldozer in as thick layer as possible whilst maintaining their operational efficiency.
- effective decompaction on soil replacement is a requisite of the bulldozer handling method (see Sheet 19).

(ii) To minimise the wetness of the soil and re-wetting of the soil:

- the soil layers should have a moisture content of 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

- 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 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.

The Stripping Operation

13.1 The area to be stripped is to be protected from in-flow of water, ponding etc. Wet sites should be drained in advance.

13.2 Soil stripping operations should not start until the required soil moisture levels are reached (as determined by the agreed method), and should be suspended as soon as the water content returns to these levels. Prior to work commencing a Meteorological Office forecast should be obtained which gives reasonable confidence of soil stripping proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the stripping must be suspended, and where the soil profile has been disturbed it

should be removed to base level. Stripping must not restart unless the weather is expected to be dry for at least a full day.

13.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails.

13.4 The operation should follow a detailed stripping plan showing soil units to be stripped, 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 ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

13.5 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 layer. The next strip should not be started until the current strip is completely stripped to the basal layer. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential stripping of the materials in strips (Figure 13.1). Where there is a gradient to the site, the main axis of the soil strips should be along the main axis of the slope.

13.6 The haul routes and storage areas must be defined, and should be stripped first in a similar manner.

13.7 The bulldozer is only to stand and work on the soil layer 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 excavator is only to stand and work on the mounded soil when loading the dump truck, otherwise it is to travel on the basal layer (Figure 13.1).

13.8 Demarcate an initial strip width of about 20m and divide the strip into 20m long segments.

13.9 The topsoil layer is to be pushed up in the thickest layer possible (eg 150-200mm thick), whilst maintaining operational efficiency of the bulldozer, to form a low mound (1-2m high) along the edge of the exposed soil profile (face). The soil nearest the exposed face should be pushed up first, progressively working to the back of the strip (Figure 13.2). The procedure is repeated in each successive segment until the strip is completed.

13.10 Topsoil should be recovered to the full width of the segment without contamination with subsoil (not more than 20% of the lower horizon should be exposed at the layer junction within the strip). This will necessitate some trafficking of the bulldozer on the adjacent strip to be able to mound the entire topsoil within the segment. The thickness and identification of the horizon junction must be verified before and during stripping. The full thickness of the topsoil horizon should normally be stripped progressively along the segments in the active strip before subsoil horizons are started (Figure 13.2). The full topsoil horizon should be stripped along the length of the active strip before the subsoil horizons are started.

13.11 The upper subsoil in the current strip is to be stripped and monitored in the same manner. The final 50cm of the subsoil layer should be left as a step to protect the adjacent topsoil horizon from local collapses. The process is to be repeated for the lower subsoil and any other lower layer to be recovered as a soil material (Figure 13.3).

13.12 With each successive lower layer taken the bulldozer must only work within the segment and not operate across the boundary of the next strip. This will initially result in a 'stand-off' (shelf) at the back of the strip to accommodate the bulldozer. Before the next layer is stripped, the soil layer in this shelf is to

be mounded at the exposed side of the next segment for loading by the excavator into the trucks (Figure 13.4).

13.13 On completion of the strip, the procedures are repeated sequentially for each subsequent strip until the area is completely stripped.

13.14 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.

13.15 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.

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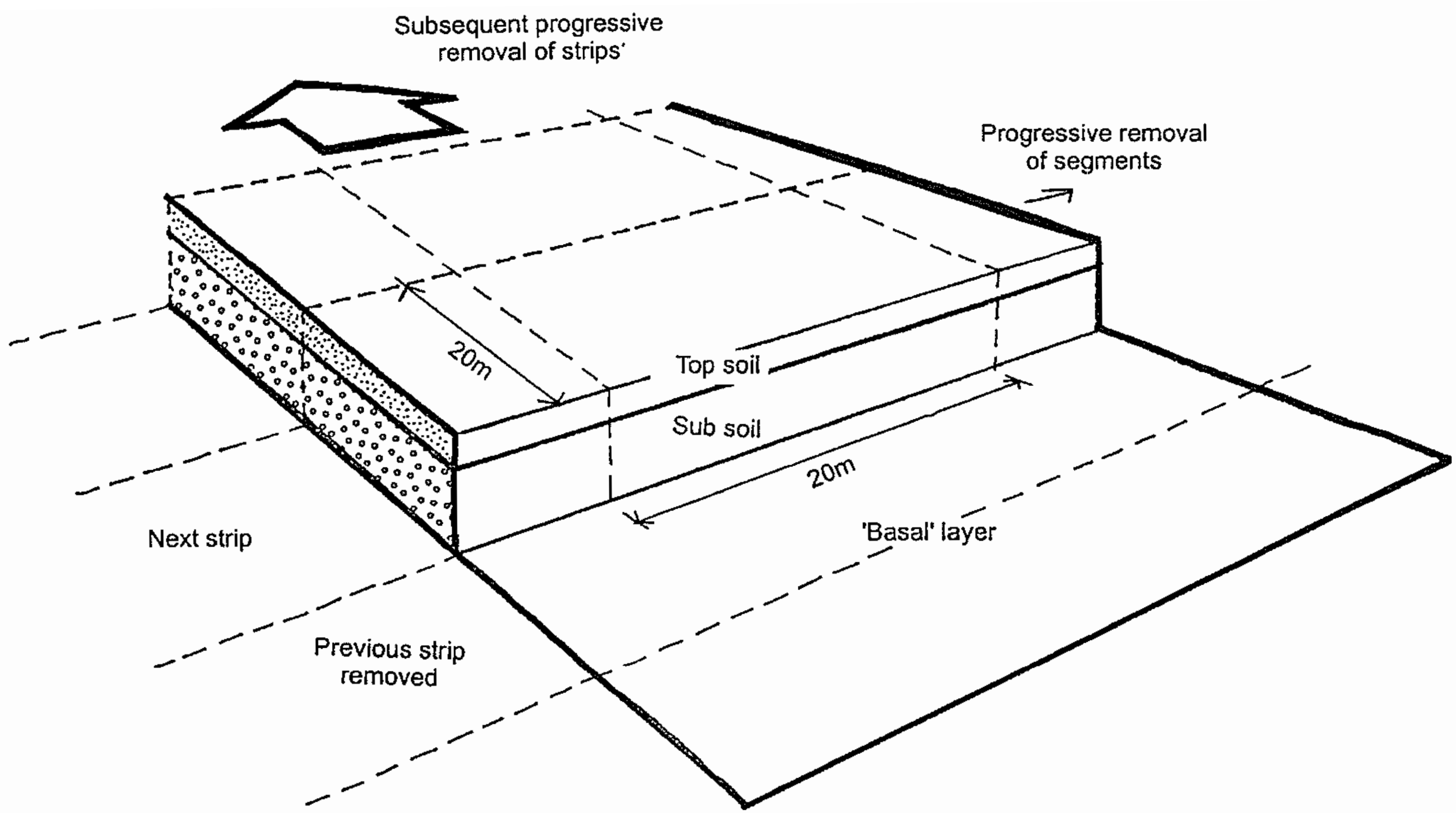

Figure 13.1 Soil stripping with bulldozers and dump trucks: The bed and segment system

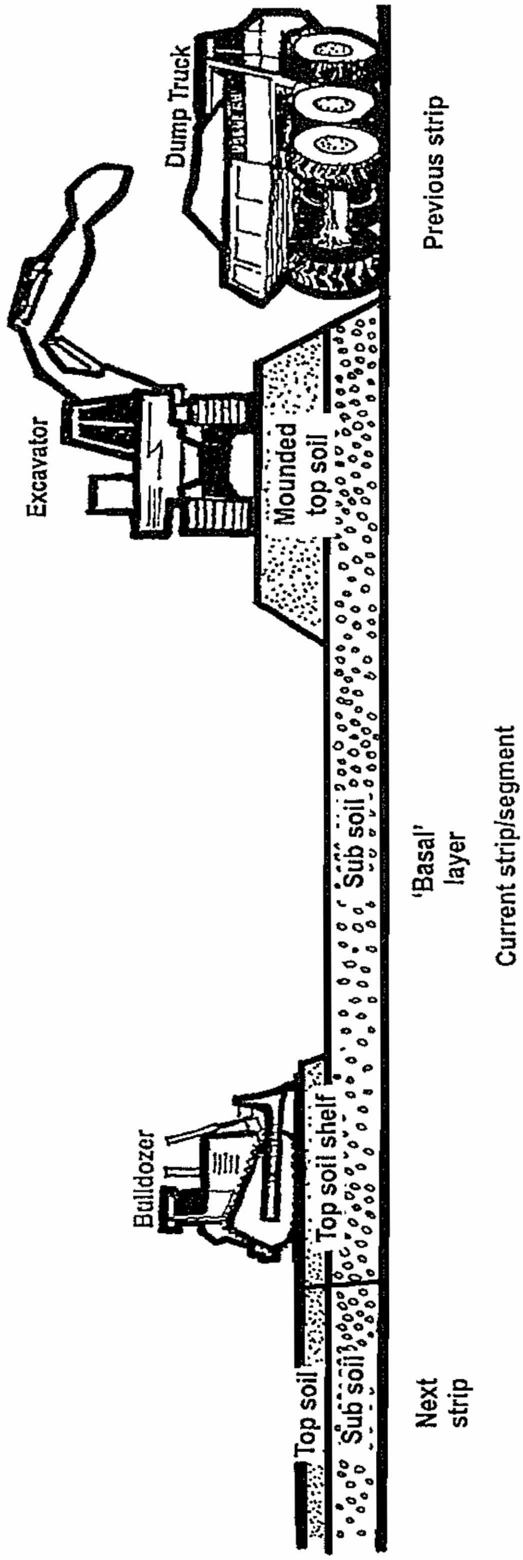

Figure 13.2 Soil stripping with bulldozers and dump trucks: Top soil

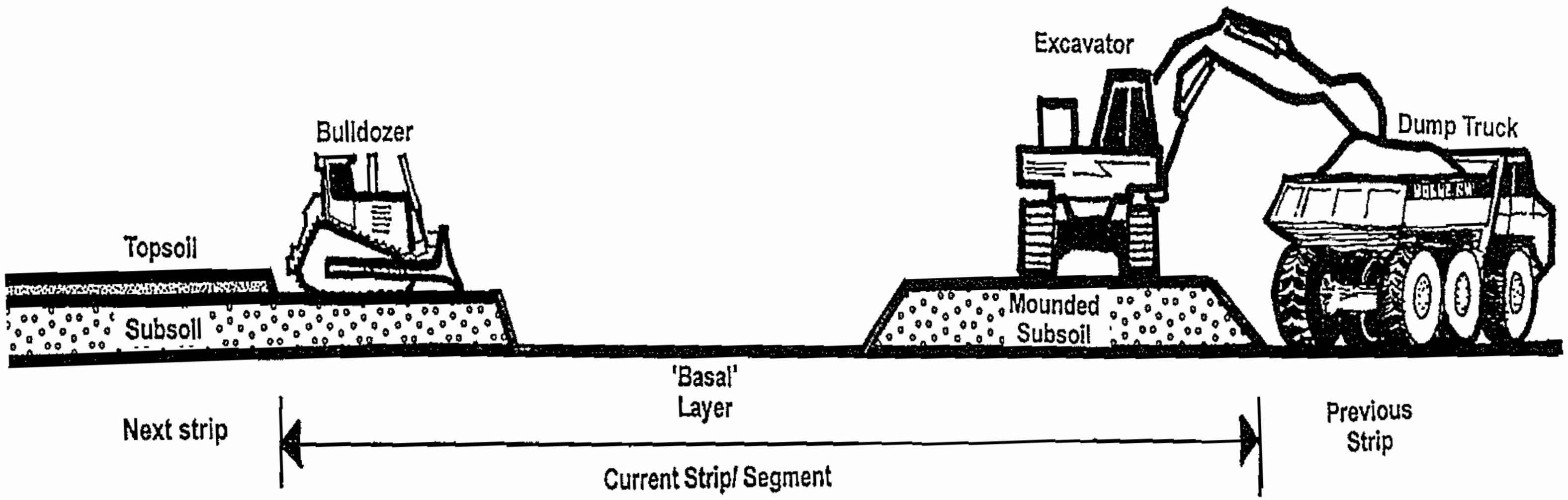

Figure 13.3 Soil stripping with bulldozers-dump trucks: Subsoil

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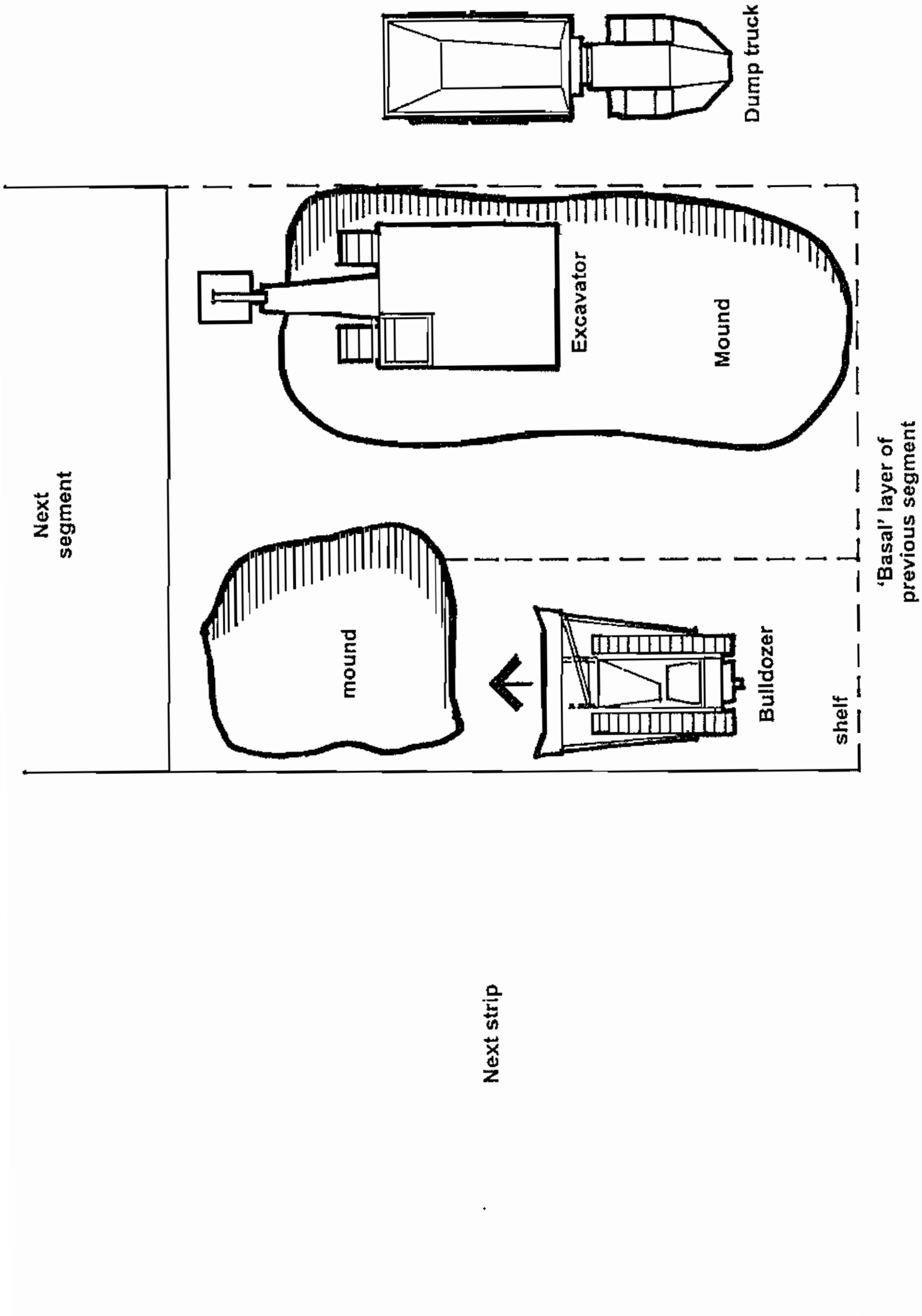

Figure 13.4 Soil stripping with bulldozers and dump trucks: The removal of soil along top soil and sub soil shelves

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 14:

Building Soil Storage Mounds with Bulldozers and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK. The art work was by R Shenton of H J Banks & Co.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 14 BUILDING SOIL STORAGE MOUNDS WITH BULLDOZERS & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where bulldozers and dump trucks are used to build soil storage mounds. This Guidance Sheet comprises 4 pages of text, 2 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a tracked bulldozer to push the soil into and shape the mound, and dump trucks to transport the soils. The bulldozer may also be required to maintain haul routes.

The bulldozer soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during

stripping, the building of soil mounds, and on replacement; the effects of which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheets 15 & 19). Decompaction treatment is an obligate requirement when soils are handled by bulldozers.

There are a number of key operational points during stripping to minimise the degree and extent of severe soil deformation, and to aid the effective treatment of the compaction on replacement:

(i) To minimise 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 operational efficiency.
- the machines are to only work when ground or soil surface conditions enable their maximum operating efficiency.
- the dump trucks must only operate on the 'basal'/non-soil layer, and their wheels must not in any circumstances run on to the tipped soil.

(ii) 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.

The Storage Operation

14.1 The mounds should be sited on dry ground and not in hollows and should not disrupt local surface drainage. 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.

14.2 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails; haul routes must be maintained.

14.3 The operation should follow a detailed soil stripping/storage plan showing soil units to be stripped and stored, haul routes and the phasing of vehicle movements. The soil units should be defined within the site with information to distinguish types and layers, and ranges of thickness. Detailed daily records should be kept of operations undertaken, and site and soil conditions.

14.4 Remove in advance topsoil and subsoil to overburden/basal layer from the haul routes and from the foot print of the storage mound and 'operating area' by adopting practices outlined in Sheet 13. The soils removed from the haul routes and foot print of the storage mound should be stored in their respective mounds.

14.5 The dump trucks must only travel within the haul route and operational area. The trucks should enter the storage area, reverse and back-tip the soil load starting at the furthest point of the mound from the point of access. The bulldozer pushes the soil into a mound of the required dimensions (Figure 14.1). 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.

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

14.7 Without the trucks rising onto the soil mound, the maximum possible height of a mound raised by bulldozer is in the order of 4-6m.

14.8 To raise the mound higher, the trucks will have to travel on the upper surface of the mounded soils. In this case the mound should be raised to its maximum height (Figure 14.2). 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.

14.9 Any exposed edges/surfaces should be shaped using the excavator bucket 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.

14.10 Work should stop in wet conditions 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.

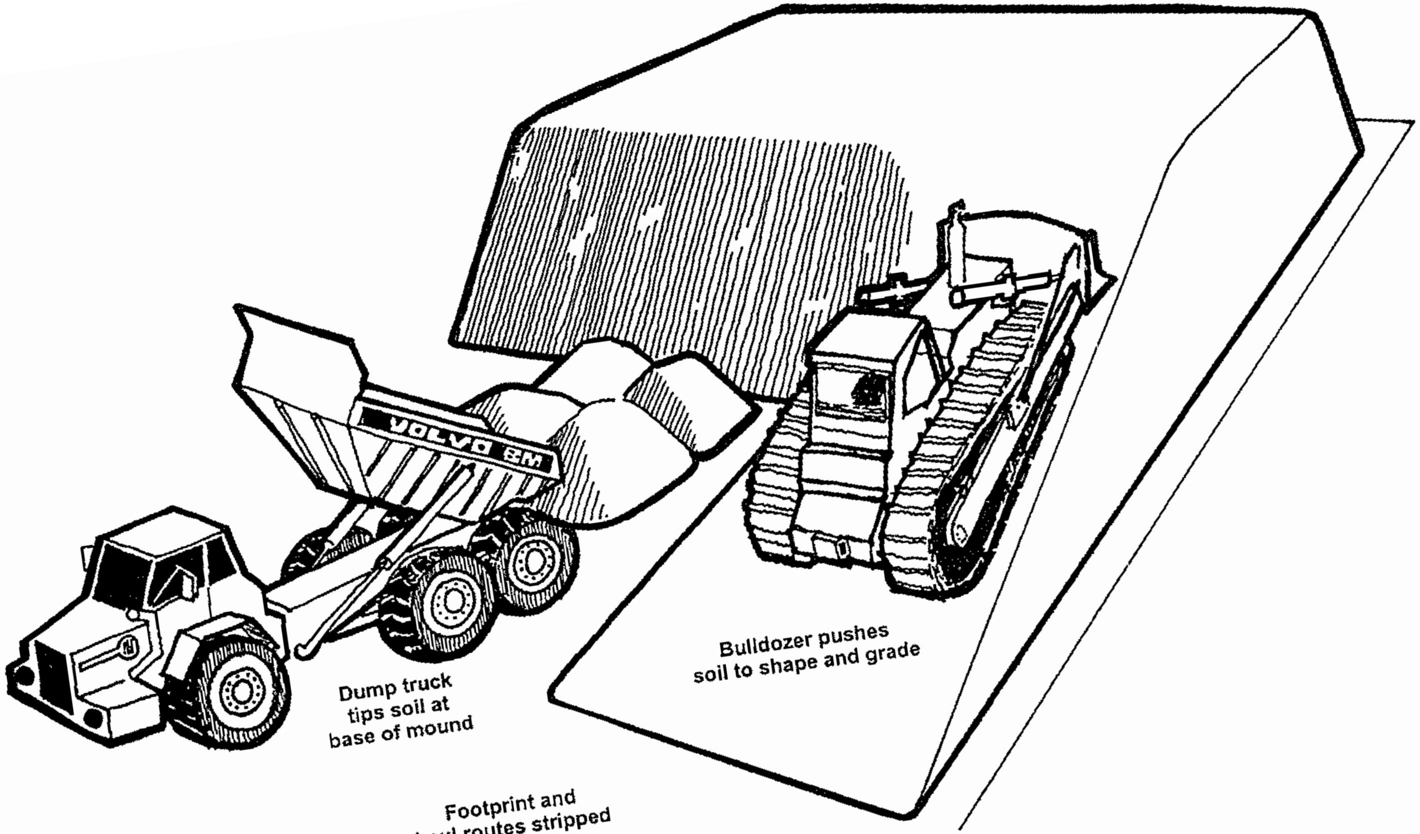

Figure 14.1 Soil storage mound construction with bulldozers and dump trucks: Single tier mound

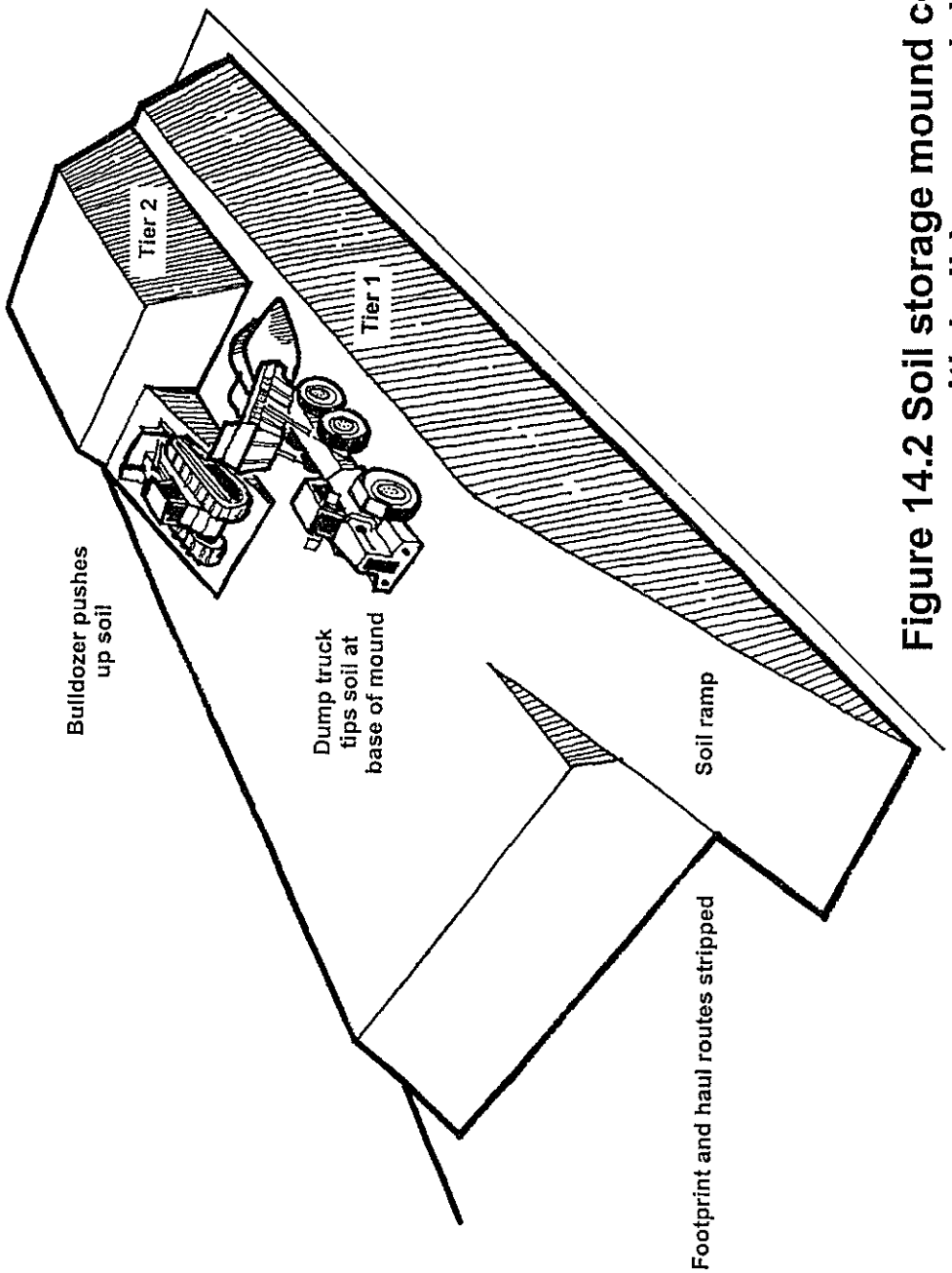

Figure 14.2 Soil storage mound construction with bulldozers and dump trucks: Multi-tier mounds

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SHEET 14

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 15:

Soil Replacement with Bulldozers and Dump Trucks

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 15 SOIL REPLACEMENT WITH BULLDOZER & DUMP TRUCKS

The purpose of this Guidance Sheet is to provide a model method for best practice where the soils are replaced using bulldozers and dump trucks. This Guidance Sheet comprises 6 pages of text, 3 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a bulldozer to replace the soils and dump trucks transport it to the replacement area. If the soil is from store an excavator will be required to load the trucks.

The bulldozer soil handling method can significantly affect the agricultural quality of the restoration through severe soil deformation (compression and smearing). This is primarily caused through unavoidable repeated trafficking over the soils during the lifting and the building and excavating mounds, and on replacement; the effects of

which increases with increasing soil wetness. Consequently, for satisfactory restoration there is a need for effective decompaction treatment during the replacement operation (see Sheet 19). Decompaction treatment is an obligate requirement when soils are handled by bulldozers and dump trucks.

The early installation of under drainage is strongly recommended. Where required this should either be undertaken sequentially during the replacement of the soils or in the early aftercare period. Until drains are installed it is recommended that the restored land is sown and managed as grassland.

There are a number of key operational points to minimise the degree and extent of severe soil deformation and for the effective treatment of the compaction:

(i) To minimise compaction and optimise decompaction:

- the dump trucks must only operate on the 'basal'/non-soil layer, and their wheels must not in any circumstances run on to the soil layer(s).
- the adoption of a bed/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 maximum operating efficiency.
- the soils are to be stripped by the bulldozer in as thick layer as possible whilst maintaining their operational efficiency.
- effective decompaction on soil replacement is a requisite of the bulldozer handling method (see Sheet 19).
- the soil layers should have a moisture content of 5% or greater below their lower plastic limit*. Moisture content should be assessed by oven

drying* of samples taken from representative locations and mid/lower points of each soil horizon. [*Or as required in the planning conditions.]

(ii) To minimise the re-wetting of the soil and maximising decompaction effectiveness:

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

The Replacement Operation

15.1 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.

15.2 Prior to commencing operations a Meteorological Office forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events. If significant rainfall is forecast or occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to topsoil level.

Replacement must not restart unless the weather is expected to be dry for at least a full day.

15.3 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their maximum operating efficiency. The operation should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. The operation is to be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails. All haul routes should be maintained.

15.4 The operation should follow a detailed replacement plan showing 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. Detailed daily records should be kept of operations undertaken (including the removal of stones and damaging materials, and the results of any assessment of the need for additional decompaction and the effectiveness of decompaction work undertaken), and site and soil conditions.

15.5 The dump trucks are only to stand, work and travel on the basal/formation layer. Only the bulldozer is to operate on the soil layers to spread the soil.

15.6 The soil layers above the base/formation layer are to be replaced in sequential strips with the subsoil layer(s) to be 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 current strip is completed. This is often referred to as the 'bed or strip system'. The system involves the progressive sequential laying of the materials in strips across the area to be restored (Figure 15.1).

15.7 Demarcate the initial strip width (15-20m) and axis, divide strip into 20m long segments. The haul routes should be clearly defined.

15.8 Reverse the dump truck to the edge of the current strip and tip the lowest layer (subsoil) soil at the edge of the strip. The bulldozer is used to spread the lower subsoil to full thickness, and in the thickest layers as possible from front to back of strip (Figure 15.2). This is undertaken progressively until the whole segment is complete, and then repeated in each segment until the strip is complete with the full depth of subsoil.

15.9 Level boards and soil pits should be used to verify soil thickness in each strip and overall levels. Allowance (ie. bulking factor) should be made for any 'heave' that may take place when the soil is decompacted.

15.10 The ripping strategy needs to be determined at the planning of operations and must take into account the thickness of soil layers, depth of recompaction and the effective depth of the ripping tool (Sheet 19), and the need for the removal of stones and other damaging materials (Sheet 17). These should be specified in the soil replacement plan. Decompaction and removal of materials should only take place when each specified soil layer is completed along the strip, and the work must be completed before the next layer of soil is placed.

15.11 On completion of the lowest layer (subsoil) across the whole strip, repeat the process sequentially spreading the next layers (subsoil/topsoil) (Figure 15.3). If the dump trucks have to rise on the already placed lower layers, this must be limited to the rear wheels only. The above decompaction operations must be arranged to treat the compacted strip margins.

15.12 On completion of the topsoil layer the above processes 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 clean.

15.13 At the end of each day the current strip/segment must be completed if rain is forecast. If during a day it is evident that a full strip cannot be completed, then ensure the current segment is completed.

15.14 At the end of each day, or during the day if interrupted by rain, make provisions to protect the base of the restored strip from ponding/run-off 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.

Operational Variation

15.15 If the basal/formation layer is to be decompacted, before any soil material is placed, each strip is to be firstly decompacted before the subsoil layer is replaced. Decompaction is dealt with in Sheet 19, which covers strategies, equipment and methods of operation. The basal layer must only be decompacted in the strip required for soil replacement, and must be prepared on the day of soil placement. During this process it may be necessary to use Sheet 17 for the removal of stones or damaging materials from the basal layer.

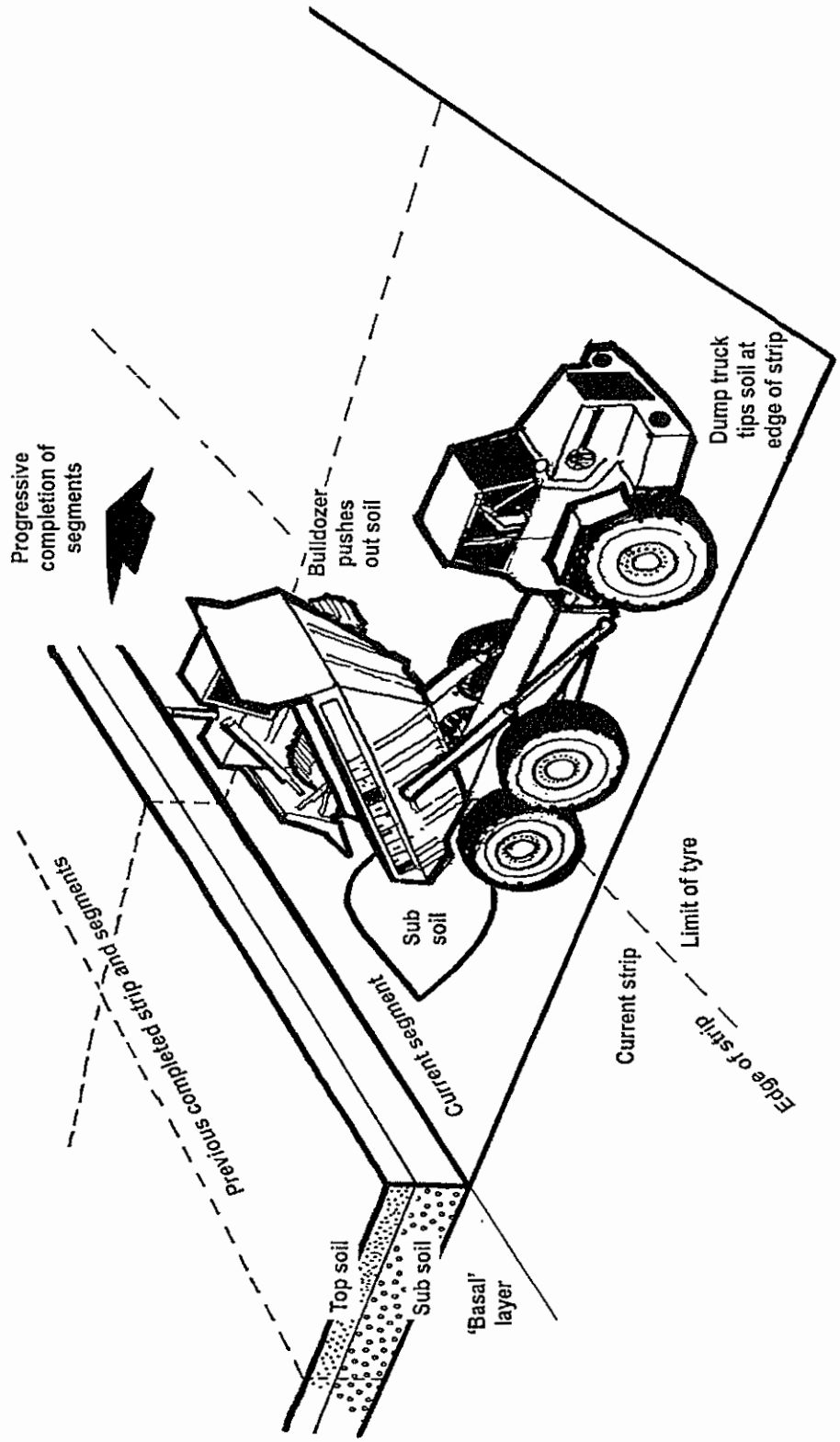
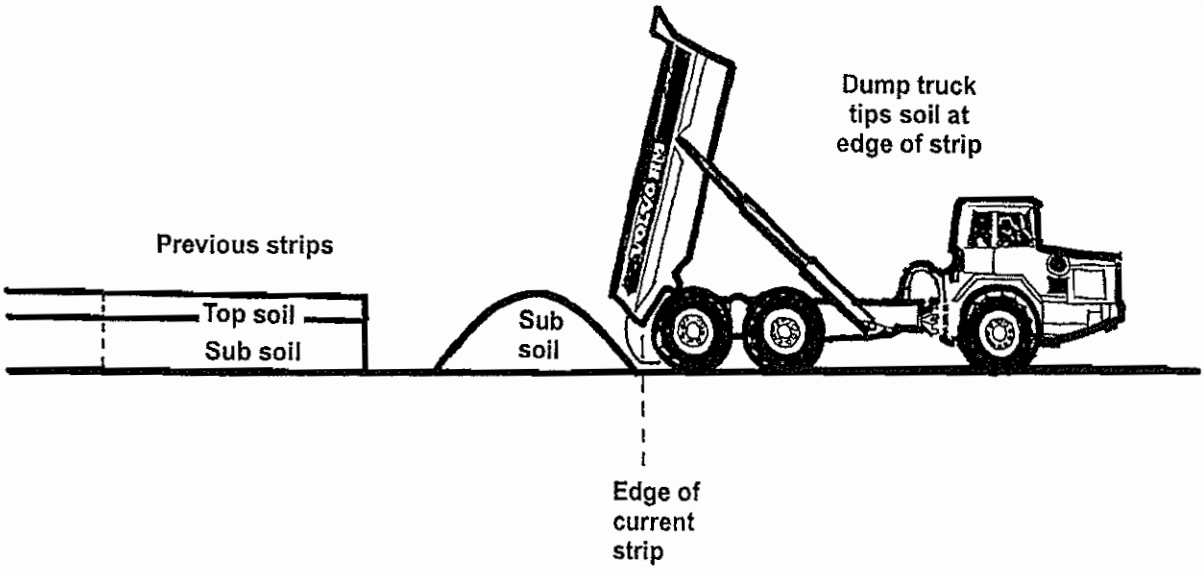


Figure 15.1 Soil replacement by bulldozers and dump trucks: Sub soil layer



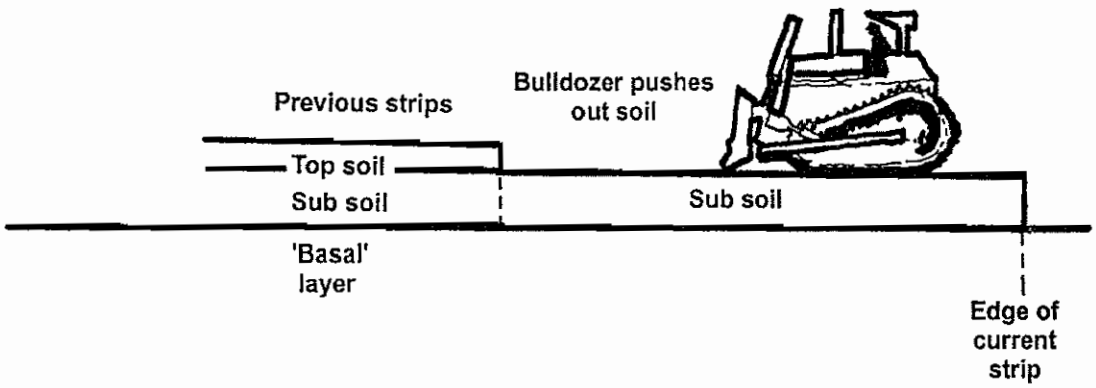
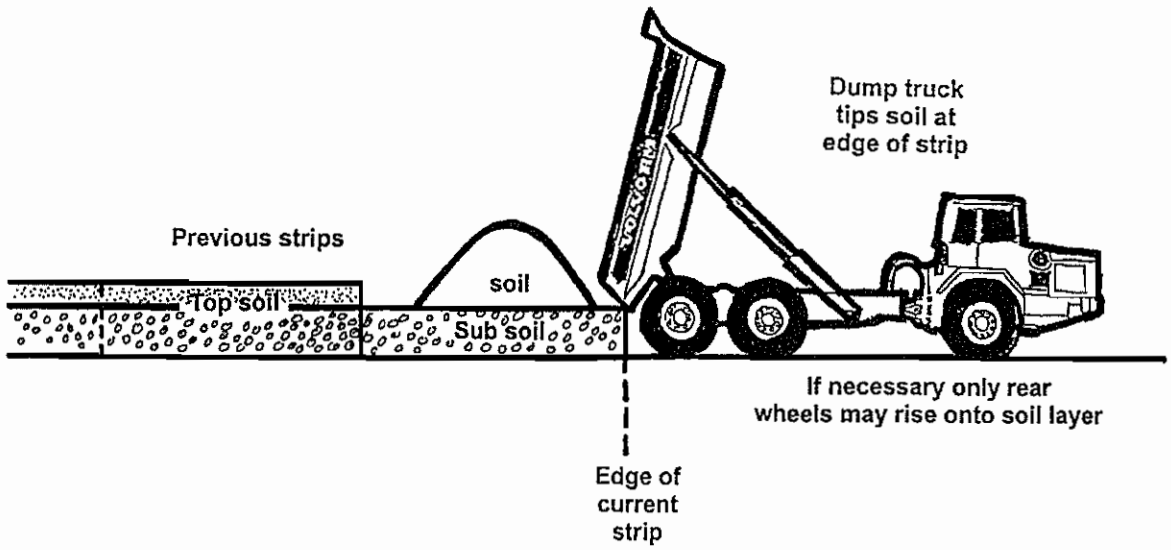


Figure 15.2 Soil replacement by bulldozers and dump trucks: Sub soil layer



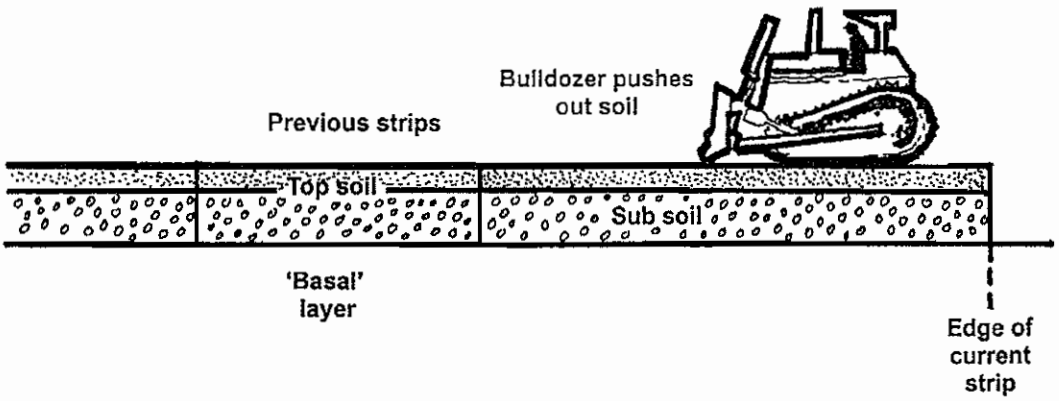


Figure 15.3 Soil replacement by bulldozers and dump trucks: Top soil layer

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MAFF Ministry of Agriculture Fisheries and Food

GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 16:

Release & Removal of Stones and Damaging Material from Excavator Replaced Soils

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

The Guide was written and prepared by Dr R N Humphries of Humphries Rowell Associates, Charnwood House, Loughborough, LE11 3NP, UK.

MAFF Ministry of Agriculture Fisheries and Food

SHEET 16 RELEASE & REMOVAL OF STONES AND DAMAGING MATERIAL FROM EXCAVATOR REPLACED SOILS

The purpose of this Guidance Sheet is to provide a model method for best practice where stones and/or potentially damaging materials are to be released from excavator replaced soils (see Sheet 4). This Guidance Sheet comprises 3 pages of text and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses a back-acting excavator to remove stones and damaging materials (eg. wire rope, concrete blocks) from replaced layers of soil or treated basal layers.

The occurrence of stones and materials can affect the agricultural quality of the restoration, largely through interfering with cultivations.

The advantage of this method, if correctly carried out, is that it should avoid additional deformation of the soil (compaction) as trafficking is avoided.

The key operational points to ensure avoidance of severe soil deformation are as follows:

(i) To minimise compaction:

- the excavator must only operate on the basal layer.
- the operation should only be carried out when the soils are below their plastic limit.
- the excavator is only to work when ground conditions enable maximum operating efficiency.
- if compaction is caused, then measures are required to treat it (see Sheet 18).

(ii) To minimise soil wetness and re-wetting:

- see Sheet 4.

The Release & Removal Operation

16.1 The removal of large stones (>150mm) from shallow depths of replaced soils (<300mm) is possible using an excavator fitted with a Geith Stone Rake Bucket (R) or similar. This is a slatted bucket with 'teeth' (150mm apart and about 300mm long). The same equipment can be used for the basal/formation layer provided it has been decompacted first, either by an excavator with a standard bucket (see Sheet 18) or ripping with tines (see Sheet 19). Where the stones to be removed are less than 150mm, but greater than 20mm, a specialist stone picking machine should be used. The use of such equipment is generally

only applicable to the topsoil layer. The removal of these smaller stones should be part of the cultivation phase for cropping, and is outside the scope of this document.

16.2 The effective removal of materials (wire rope, drums, tree roots, concrete lintels, etc) damaging to aftercare operations (eg. cultivation, under-drainage installation) is generally not effective with the above bucket method. This operation is best undertaken using ripping equipment and practices described in Sheets 17 and 19.

16.3 An excavator with a Geith type of bucket 'combs/rakes' the surface to a depth of up to about 200-250mm of each soil layer when it has been replaced to level along the strip, and before the next layer is placed. The combing action is used to release and windrow the stones, and the bucket is used to load them into a dump truck for disposal or utilisation elsewhere.

16.4 The combing action serves to level the soil surface and can also break up soil clods. Where the soil is of a very fine texture (clayey) and has a relatively high moisture content, it can be difficult to break down soil clods and release the stones. In these circumstances the stone rake bucket can be ineffective in releasing and removing stones.

16.5 Where required, in conjunction with the excavator-dump truck combination, the above is to be integrated into the procedures listed in Sheet 4.

16.6 Stone removal from the topsoil layer can be delayed until the whole area has been restored. If this option is adopted the use of the bucket method is not appropriate, and a tine cultivation method should be used followed by removal of the stones by hand or machine. In this situation, a final deep ripping of the soil profile is likely to be required on completion (see Sheet 19).

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SHEET 16

Version: 04/00

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 17:

Release & Removal of Stones and Damaging Material from Scraper & Bulldozer Replaced Soils

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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SHEET 17 RELEASE & REMOVAL OF STONES AND DAMAGING MATERIAL FROM SCRAPER & BULLDOZER REPLACED SOILS

The purpose of this Guidance Sheet is to provide a model method for best practice where stones and/or potentially damaging materials are to be released from earthscraper and bulldozer replaced soils (see Sheets 8, 12 and 15). This Guidance Sheet comprises 4 pages of text and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This soil handling method uses bulldozer-drawn tines to remove stones and damaging materials (eg. wire rope, concrete blocks) from replaced layers of soil or treated basal layers.

The occurrence of stones and materials can affect the agricultural quality of the restoration, largely through interfering with cultivations.

The method requires unavoidable repeated trafficking over each layer of soil to complete the operation, particularly compared to the removal of stone or materials by hand or machine. This is likely to result in the recompaction of the ripped soils and consequently, for satisfactory restoration, there is a need for effective decompaction treatment following the removal of the materials (see Sheet 19).

There are a number of key operational points to minimise the degree and extent of severe soil deformation (compaction and smearing):

- the adoption of an 'in - out' only at the end of strips to minimise trafficking.
- the machines are only to work when ground conditions enable their maximum operating efficiency.
- the soils should have a moisture content 5% or greater below their lower plastic limit.

The Release & Removal Operation

17.1 Ripping with tines can be used to release large stones (>150mm) and damaging materials (wire rope, tree roots, drums, concrete lintels etc) from replaced soils and basal/formation layers. Where stones to be removed are less than 150mm but greater than 20mm, a specialist stone picking machine should be used. The use of such equipment is generally only applicable to the topsoil layer. The removal of these smaller stones should be part of the cultivation phase for cropping, and is outside the scope of this document.

17.2 Where large stones and materials damaging to aftercare operations (eg. cultivations, under-drainage installation) are to be removed, the equipment and practices set out in Sheet 19 can be used and integrated into the procedures listed in Sheets 8, 12 and 15.

17.3 On completion of each soil layer (or as required), the strip is ripped (with over-lapping passes) to release the stones (Figure 19.4, Sheet 19). Generally, effective release is only achieved by cultivating the upper 300mm of the soil/basal layer.

17.4 Bulldozers with closely spaced (0.3-0.5m) 'stub' tines (400mm from tip to tool bar base) are often more effective in releasing stones than deep ripping equipment designed to alleviate severe compaction. Alternatively, high powered rubber-tyred tractors pulling heavy duty multi-tine cultivators can be effective (depending on soil texture and moisture content).

17.5 The released stones are usually collected by hand and loaded into tractor-drawn trailers travelling and standing on the basal/formation layer.

17.6 Stone removal from the topsoil layer can be delayed until the whole area has been restored. A shallower ripping (300mm) of the topsoil will be needed to achieve the operation. If this option is adopted, trafficking of the topsoil layer will take place during the collection of the stones. In this situation, the final deep ripping of the topsoil must be delayed until the stone removal operation is complete.

17.7 Where artefacts are to be removed, straight legged tines without wings (see Sheet 19) are the most suitable equipment; particularly in the case of basal/formation materials.

17.8 On completion of each soil/basal layer, the practice is to rip the entire layer placed (or intermediate layers if the thickness exceeds the effective depth of the tine) on a strip by strip basis. The tines are used to release and lift the artefacts to the surface, and drag them to the edge of the strip for collection and disposal. Any equipment/machinery used for the latter is only to travel and stand on the basal/formation layer.

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 18:

Soil Decompaction by Excavator Bucket

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling "Good Practice" to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 18 SOIL DECOMPACTION BY EXCAVATOR BUCKET

The purpose of this Guidance Sheet is to provide a model method for best practice where an excavator bucket is used to decompact soils and basal/formation layers. Excavators are most likely to be used for this purpose where soils are replaced by either excavator and dump truck or bulldozer and dump truck combinations. This Guidance Sheet comprises 3 pages of text and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

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This decompaction method uses an excavator (back-acting type) with a bucket to dig the soil layers to relieve compaction and smearing.

The advantage of this model method, if correctly carried out, is that it should result in the complete lateral decompaction of the soil layer. However the method is limited to relatively shallow depths due to practicalities and bucket size. There is no advantage

of this method over the use of tines (Sheet 19) in respect of soil water content, the soil must be dry enough to shatter.

There are a number of key operational points:

- the excavator is only to stand on and work from the basal/formation layer.
- the moisture content of the soils should be at least 5% below their plastic limit, or greater than this if so advised.

The Decompaction Operation

18.1 The excavator is only to stand on and work from the basal/formation layer.

18.2 The bucket is to be of a type with teeth.

18.3 Where the soil layer to be decompacted is up to about 0.5m thick the following procedure can be adopted. The excavator is to decompact the specified layer by systematically digging along a working face from the back to the front of the strip, working in sections. The digging is to be a cutting action, with the bucket down to the full depth of the layer to be decompacted, and through a scooping motion the soil material is lifted and re-deposited. It is essential each successive bucket 'dig' overlaps with the former both to the back and side of the dig. Finally, the bucket edge can be used to lightly grade the finished surface.

18.4 Where the soil layer is deeper than the capability of the bucket (about 0.5m), a 'double-digging' approach is needed. The process is to systematically work its way along the strip, and the next layer of soil is not to be laid until this operation is complete. The method is particularly time consuming and the method described in 18.5 below is recommended.

18.5 The alternative for deep profiles to be decompacted by this method is to place the layer in several layers, each up to 0.5m in thickness, and to sequentially decompact each layer as described in 18.3 above. The next layer is to be placed on the decompacted strip, but only when the former layer has been laid and decompacted along the entire length of the strip. The process is repeated until the soil horizon is replaced to the required thickness and has been 'dug over'.

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SHEET 18

Version: 04/00

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GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 19:

Soil Decompaction by Bulldozer Drawn Tines

Issued by the Farming and Rural Conservation Agency, Cambridge

April 2000

MAFF Ministry of Agriculture Fisheries and Food

MAFF FOREWORD

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*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

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MAFF Ministry of Agriculture Fisheries and Food

SHEET 19 SOIL DECOMPACTION BY BULLDOZER DRAWN TINES

The purpose of this Guidance Sheet is to provide a model method for best practice where tines are used to decompact soils and basal/formation layers. Tines are most likely to be used for this purpose where soils are replaced by either earth scrapers (towed and self-propelled types) or bulldozers and dump truck combinations. The tines should be drawn by tracked bulldozer and not by wheeled tractor or grader machines. This Guidance Sheet comprises 9 pages of text, 5 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This decompaction method uses a tracked bulldozer to draw tines through the soil layers to relieve compaction and smearing. For this method of decompaction to be effective, there are a number of requirements to be met, in particular the

soil should be in a dry enough condition to be able to shatter and the use of effective equipment.

There are a number of key operational points to maximise the effectiveness of the decompaction treatment:

(i) To maximise decompaction:

- the moisture content of the soils should be at least 5% below their plastic limit, or greater than this if so advised.
- the ripping pattern must be overlapping passes and recompaction at depth must be treated in the ripping strategy.
- the tines should be sufficiently closely spaced to ensure that full lateral decompaction is achieved with overlapping passes.
- the use of winged straight tines is recommended.
- the tine length and width must be compatible with the proposed depth of decompaction, and allow for soil 'heave'.
- tine and wings must have wear plates and be in good operating condition. Worn and deformed tools must not be used.
- the towing unit must be capable of pulling the tine combination in an operationally efficient manner, without undue weaving and track slippage.

(ii) To minimise rewetting:

- ripping should not be undertaken if significant rainfall is forecast.
- where the soil profile is partly raised to ground level, the uppermost soil layer should be left in an unripped state. Where the subsoil layer has been ripped, but the topsoil not placed, it should be sealed by blading with a bulldozer. On resumption of operations, the upper and lower layers will required decompacting.

Ripping Strategies

Ripping to decompact soils is an integral part of the soil replacement procedures using towed or self-propelled earth scrapers or bulldozer-dump truck combinations. The primary aim of the ripping strategy is to ensure that there is no significant compaction within the soil profile which might impede root growth or drainage. There are two basic ripping strategies that can be used. These are; when the soil profile is ripped sequentially as the soil layers are built up, or when it is ripped only after the profile is complete. Each have their own limitations and the selection should be matched to the soil profile in question and the specification of the equipment to be used. It may not be possible to treat deep compaction, or even compaction at moderate depth, once the profile has been completed, hence it is essential that the correct strategy is adopted. In some circumstances it may be necessary to adopt a combination of both strategies to achieve satisfactory results.

(i) Sequential ripping of each layer before next is placed (Figure 19.1a):

- appropriate when profile/horizon thickness exceeds the effective depth of the tine or capacity of the towing unit being used; a number of sequential rips are required, each layer ripped before the next is placed.
- the depth of subsequent sequential ripping must relieve any recompaction of the lower layers following the placement of the new overlying layer or other surface operations.
- appropriate where stones and/or damaging materials are to be released and removed from sub-surface horizons.
- has to be carried out during the replacement operations.
- the final surface layer ripping can be delayed (as with (ii) deep ripping approach) until all strips complete and works finished.

(ii) Single deep ripping on completion of profile (Figure 19.1b):

- appropriate when profile thickness is equivalent to or less than the effective depth of tine and capabilities of towing unit.
- appropriate where stones and/or damaging materials are absent or need not be removed from sub-surface horizons.
- appropriate where artefacts or stones need only to be removed from surface topsoil layer, where a shallower surface cultivation would be carried out prior to final ripping.
- appropriate where sequential ripping has been undertaken and there is still recompaction at depth.
- final ripping can be delayed until all strips and final works complete, or later in aftercare period.

Equipment

19.1 Crawler-tracked tractor units of a minimum 300hp are required. [Expect 30hp/leg or shank on multiple tine beam cultivator to 750mm depth and 100hp/tine three leg or shank to 750mm depth.]

19.2 There are two types of ripping units: i) frame-mounted on tractor unit and usually hydraulic operated, and ii) mounted on towed trailers/tool carriers and either cable or hydraulic operated. Control mechanisms have to be matched between tractor unit and tool carriers.

19.3 There are two types of tines: straight leg and curved leg. The former is the most commonly used and is the principal tool for decompaction. Straight tines are to be used where there are obstructions or the soils/formation layer is excessively stony. Curved tines are typically used, in combination with straight tines, and set to operate at shallower depth for the purpose of reducing the 'drag' resistance of the following straight tines. Often the straight tine is operated in a raked mode (about 10 degrees backwards from the foot) rather than in an upright stance to promote decompaction by uplift and also to reduce drag.

19.4 Straight tines (leg) should have a wedge foot (Figure 19.2) at the base to reduce drag, aid penetration and assist with the upward displacement of the soil and shattering effect.

19.5 There are two forms of straight tines, those with and those without wings (Figure 19.2). Wings of 250-400mm total span (outer tip to outer tip) are welded either side of the tine leg or foot at angle 20-30 degrees. This is to promote upward displacement and lateral shatter, but also has the effect of significantly increasing drag. Straight tines without wings will require either more overlapping passes or closer spaced tines (the latter will increase drag).

19.6 There are two critical dimensions which determine the potential effectiveness of the tines, these are tine length (which determines the potential depth of decompaction) and tine thickness (which determines the potential amount of heave and therefore shatter and decompaction). The achievement of the potential of the ripping tools is dependent on the moisture content of the soil/formation material (it must be dry enough to shatter otherwise the soil material simply deform around the tool).

19.7 The length of the tine is the most common limiting dimension of the tool. The length of the tine from the heal of the foot to the base of the tool bar/carrier

less 200/250mm or 30%, whichever is the lesser, is the potential maximum effective ripping depth of the tine (Figure 19.3). The deduction allows for upward displacement of the soil as the tool is drawn through the profile. Without this allowance the soil heave will rise to or above the tool bar and increase drag and reduce the decompaction achieved (Figure 19.3). The most commonly used tines have maximum effective depths of about 500-700mm. Whilst longer tines can be provided these may cause problems with mobility of the tractor unit. One exception is the British Coal specification SIMBA MK IV Ripper with 1.2m carrier borne tines which has a potential effective depth of 900-1000mm.

19.8 The width of the tine (front to back) co-determines the potential effective ripping/ decompaction depth, with a ratio of 5 times the width of the tine (Figure 19.2). Typically the width of the tine is 300-400mm, giving a potential effective depth of 1500-2000mm and operationally is not usually a limiting factor. The thickness and width of the tine used is usually determined by other factors, the mechanical stresses imposed by the work undertaken (ie its strength) and the slot dimensions in the tool bar carrier.

19.9 The thickness of the tine (typically 40-80mm) contributes significantly to its strength but also to drag. The tine should have a welded wear plate on the leading edge to reduce wear, as should the leading edge of the attached wings (Figure 19.2).

19.10 The minimum number of tines must be two, each following the mid point of the tracks of the tractor unit (Figure 19.4). Generally, the most common configuration is three with a tine central to the tractor unit. The tines may be arranged in a straight line or as a triangle with the central tine leading to reduce drag. The tines may or may not have wings, often the central tine may be without wings to reduce drag. Three winged tines are the preferred

configuration. However, straight tines are more appropriate where there are significant artefacts/obstructions, and where soils are excessively stony.

19.11 Mixed combinations of curved tines leading straight tines (as a double beam configuration) are an alternative and can potentially achieve more effective lateral shatter.

Decompaction Operations

19.12 Ripping to decompact materials must only to be undertaken when the soils are dry enough to shatter and must be suspended before the soil become plastic. Ripping should only be undertaken in dry weather and is to be suspended when the tractor unit looses traction/weaves under normal operating conditions. If the soils are inherently wet consideration should be given to deep ripping later following the establishment of a crop to dry out the upper horizons; this may require several successive years of treatment to progressively decompact the profile.

19.13 The tines are to be drawn through the basal/formation or soil layer at the required depth according to the decompaction strategy and capability of the equipment and towing equipment. The tines are to be drawn at sufficient and constant speed, and at their optimum angle (rake) to achieve maximum heave with the least drag, and without track slippage or the tractor unit weaving.

19.14 The ripping is only to be undertaken both ways along one axis and at an orientation to promote down-slope drainage, but never cross-wise or across slope. Where ripping is in one direction, as down slope on steep gradients, the machinery is to travel back only on unripped ground.

19.15 The ripping must achieve the required depth in the first pass without the heave rising above the base of the tool bar (Figure 19.3), the tine is to enter to its full depth on the first pass and all subsequent passes. The area should not be ripped to a shallow depth first and then re-ripped to a greater depth. However, this may be unavoidable in the first pass in order to 'break' ground and reduce resistance to be able to achieve the required penetration. Headlands are to be ripped first to enable quick and full penetration; this is essential at the base of slopes. Ripping must extend into and out of sides of ditches.

19.16 Where the final profile thickness is equivalent to or less than the effective depth of the tine, the ripping operation can be undertaken after all the horizon(s) have been laid (Figure 19.1b), except where it is necessary for stones or artefacts to be removed.

19.17 Where the profile thickness exceeds the effective depth of the tine, the profile must be ripped in a sequence of successive layers. The ripping is to be undertaken sequentially following the placement of each layer and before the next layer can be laid. This usually takes place after the placement of each horizon (ie lower subsoil, upper subsoil and topsoil) (Figure 19.1a). If the proposed horizon thickness exceeds the effective depth of the ripper tine, then the soil horizon needs to be laid in sub-layers, with each of these being ripped before the next is laid.

19.18 In the ripping of successive replaced horizons/layers, allowance must be given to recompaction caused in the lower layers by the laying and spreading of the soil by scrapers or bulldozer. The allowance necessary depends on the soil type and moisture content. For scrapers, recompaction to 400mm should be allowed for in specifying the thickness of the next layer of soil to be placed and decompacted. A minimum of 300mm should be allowed for bulldozers with standard or narrow tracks. The recompacted soil layer must be

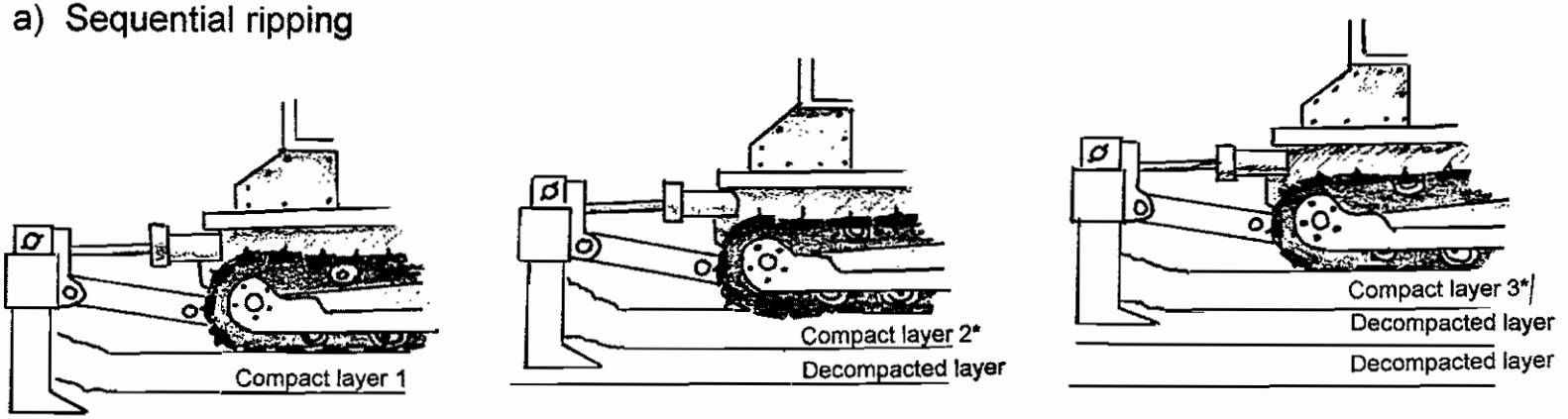
decompacted along with the thickness of the new layer laid. This requires the depth of decompaction of the next layer to include the thickness of the recompacted soil layers. The thickness of the new layer that can be laid over the recompacted layer(s) will be governed by the potential effective depth of the tine. Hence, after the laying and decompaction of the first soil layer, subsequent soil layers will have to be laid at shallower thickness (Figure 19.3).

19.19 The final decompaction of the topsoil layer should be to the full effective depth of the tine.

19.20 In carrying out the ripping operation, each successive pass is to overlap, with the tine on the ripped side bisecting the pass of the outer and central tine of the previous pass (Figure 19.4). Where full depth or lateral consistency of decompaction is not achieved, the overlap should be increased by further bi-section.

19.21 The degree and consistency of loosened soil must be checked as the ripping is taking place, especially across the junctions between strips (the latter may require inspection by pits). Routine qualitative assessment can be made with a 15mm diameter steel probe with blunt convex end. The probe is pressed in soils at 150mm intervals along a number of transects across the line of ripping, and the depth to penetration and feel of resistance recorded (Figure 19.5). Alternatively soil penetrometers may be used. Both methods should only be used in conjunction with a method of on-site 'calibration' of compactness; this is essential as soil water content and stoniness have a major influence on interpretation.

a) Sequential ripping



*ripping depth to include recompaction in lower layers

b) Final deep rip

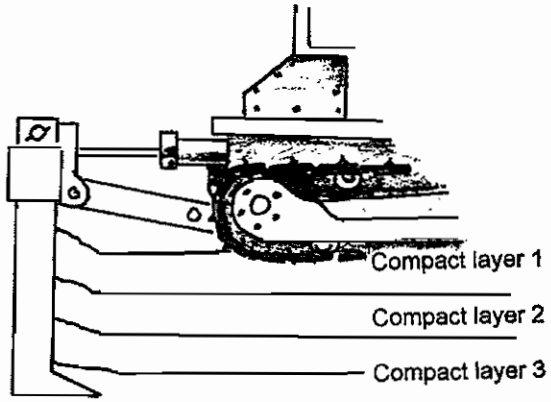


Figure 19.1 Decompaction by bulldozer drawn tines

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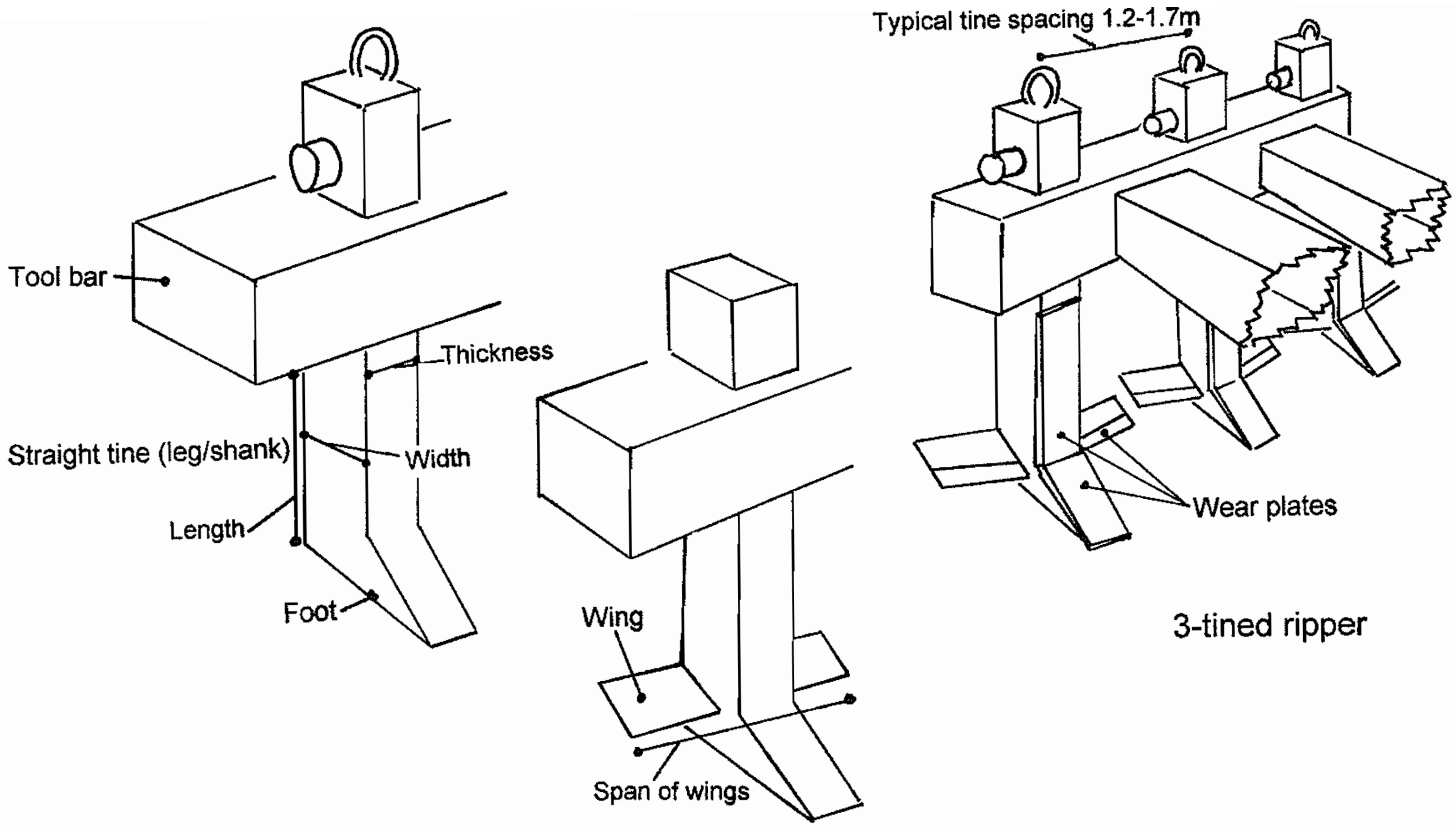
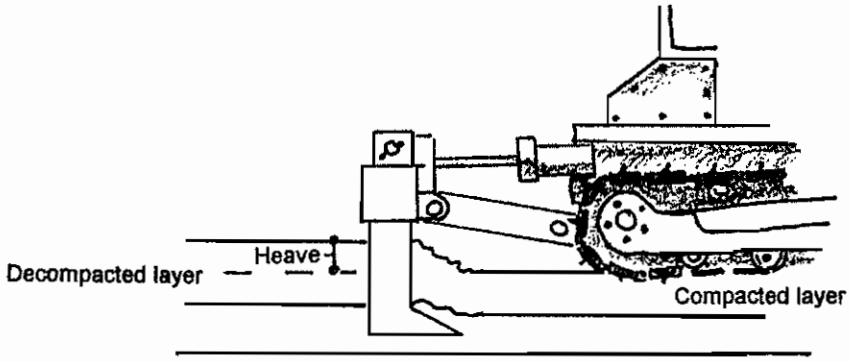
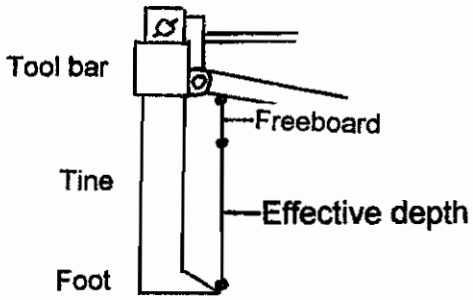


Figure 19.2 Features and critical dimensions of bulldozer drawn tines



Heave = freeboard required below tool bar



Calculation of effective depth of tine of 300mm width & 900mm in length below tool bar:

i) potential maximum depth of decompaction is 1500mm with tine of 300mm width and 900mm with tine of 900mm length
ii) potential effective operating depth for first soil layer is 900 - 200 (freeboard) = 700mm
iii) potential effective operating depth subsequent soil layer is 900 - (200 + 300 [eg depth of recompacted lower material]) = 400mm

Figure 19.3 Effective decompaction depth by tines

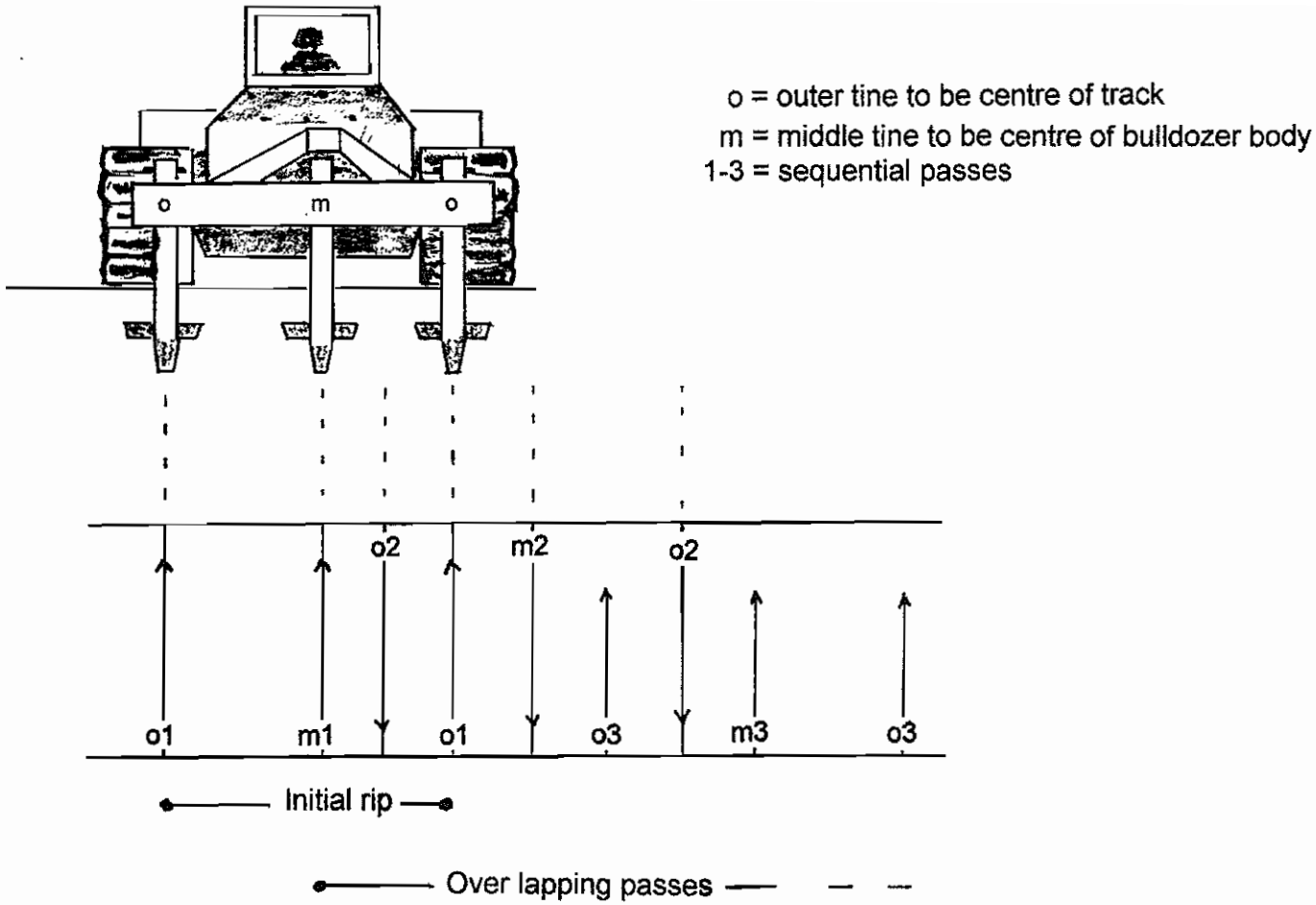


Figure 19.4 Decompaction by overlapping passes of bulldozer drawn tines

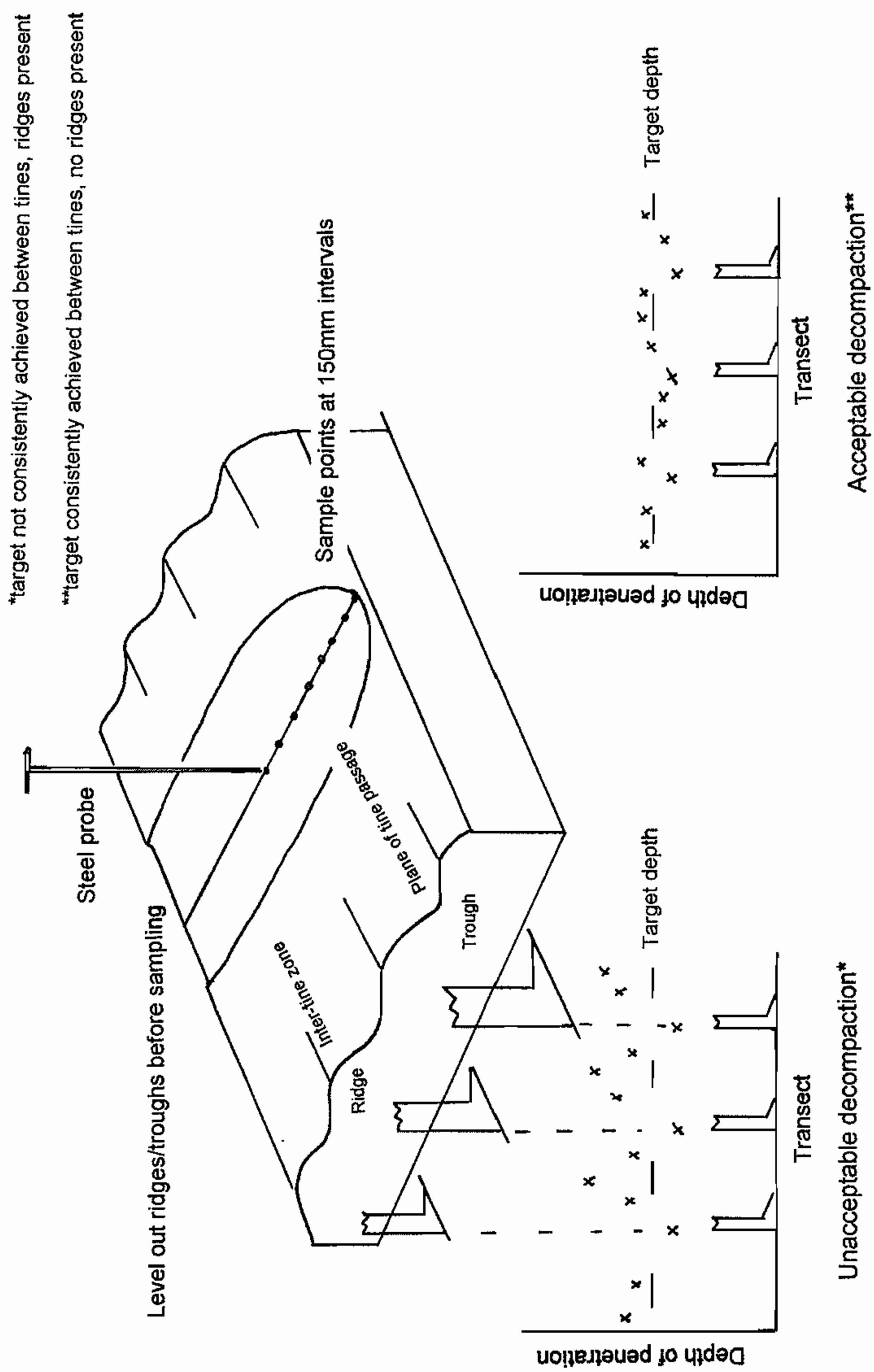


Figure 19.5 Assesment of decompaction achieved

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