Forest roads and tracks

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Revision History

Date	Version	Comments
19.08.11	1.0	First issue

1 Purpose

Without suitable access, many woodlands can not be managed economically. This guidance note provides an introduction to the planning and construction of access tracks and surfaced haulage roads in woodland, and aims to define the minimum appropriate standards for their construction, repair and maintenance, in England.

1.1 Introduction

The guidance has been drawn together in consultation with Forestry Commission civil engineers who have provided the specifications and practical advice. However, it is not a comprehensive forest engineering guide.

The guidance details standards that are considered to be reasonable and are based upon good practice. The diagrams within this guidance show how tracks and roads should and should not be constructed. However, in certain circumstances it might be neither possible nor realistic to achieve them. The figures and tables give information that will help with decision making and work specifications. They are not available in other publications.

This guidance note forms part of a suite of information to be utilised woodland owners, managers and contractors creating access infrastructure, and by applicants and administrators of the England Woodland Grant Scheme when handling applications for Woodfuel WIG.

2 Background

Apart from the initial investment in woodland establishment or a woodland purchase, access infrastructure represents the single greatest capital expense by the owner, with surfaced roads costing in the order of five times that of extraction tracks. It is therefore essential to establish the need for, and timing of access infrastructure.

To avoid being reactive to situations a sound, up to date management plan for the woodland should already be in place. Through this plan, it will be possible to properly consider all relevant factors affecting the woodland, including identification of inadequately accessed areas and the timing of timber production, and therefore, provide an opportunity to reduce costs when planning access infrastructure needs.

2.1 Appraisal process

The aspiration in any woodland should be to implement the most effective and economic combination of surfaced and unsurfaced tracks to ensure sustainable forest management. An appraisal process will assist in determining an appropriate balance of track types, but as a guide, the minimum roading requirement should only be that which;

- Is sufficient to facilitate safe access and egress to and from the public highway;
- Has appropriate timber stacking, loading and turning provision;
- Has the appropriate track based infrastructure required to be used for timber extraction.

2.2 Planning and design

As part of the appraisal process, consideration must be given to the woodland environment (habitats, topography, soil type, tree species etc), harvesting systems (forwarder, harvester, motor manual, skidding etc), nature conservation, recreational use and landscape, as these will all have a material bearing on where access infrastructure is located, and on the type and timing of construction.

The management plan will have much of this information contained within it, so route planning for access infrastructure should be able to be well planned, and well timed, achieving an optimum road and track density at a minimum cost.

An Economic Appraisal may also be used in an attempt to minimise the costs of extraction from stump to the public highway, whilst providing the optimum road and track infrastructure to serve a particular woodland site. See Appendix 1.

2.3 Construction and maintenance

Woodland access infrastructure should generally be planned as a permanent facility for the management of woodland, and so it's construction should be looked at as a long term investment covering several silvicultural interventions, if not a whole rotation.

Construction is normally planned to fit in with the timing of the timber harvesting programme and will be undertaken when local seasonal conditions provide the best working conditions, i.e. avoid very wet conditions.

Remember: Poor design or construction can result in inadequate access being created, cause significant environmental damage, and result in high repair and maintenance costs, or even legal problems.

Well planned and properly constructed tracks will have minimal impact on the environment but will still need to be maintained in order to sustain the productivity of the woodland and maximise the life span of the investment.

Whole Life Costing is a methodology that justifies an extra initial expenditure on key elements of the access specification in order to sustain a longer lifespan.

3 Route selection

Route selection is an essential part of your planning process and must follow a logical sequence in order to minimise time, effort and expense in survey, design and construction.

The final route selected will be a compromise of a variety of conflicting constraints and restrictions but ultimately will also need to balance the management needs of the woodland versus the cost of the investment.

Spending extra time and care at the route selection stage should reduce future harvesting and operating costs, and create less environmental damage.

3.1 Initial scoping

Undertake a map based desk study, utilising local site knowledge and information in your management plan about what work you propose to undertake in the woodland, and where there are constraints that have to be worked around or incorporated.

Possible restrictions could be:

- The woodland type being managed, and the management systems being used.
- Access off the public highway.
- Agreements with third parties to cross their land.
- Restraints imposed or consents required by Regulatory bodies.
- Environmental, such as slope, water courses and service way-leaves.
- Landscape implications of the route line.
- Sites important for archaeology and nature conservation.
- Public access, public rights of way, or public views.

Through the desk study, these restrictions will give rise to a route corridor that can be broadly plotted on the map, within which the access route is best located, and which is most worthy of more detailed study.

3.2 Field survey

Now you need to get to know the woodland and the terrain in those optimum areas identified during scoping, by walking the route thoroughly. Keep an open mind about what you find and look for opportunities to keep access infrastructure simple. Remember, it may be more cost effective to go around an issue rather than through it.

The reconnaissance should be carried out to gain information on:

- terrain conditions and topography that could give rise to unstable road sections;
- indications of sub-grade (soil) material, rock outcrops, marshy ground and soft soil, and potential sources of rock or other suitable construction materials;
- areas for disposal of surplus material, either adjacent to the survey line, or in tips off –site;
- the location water courses and other wet areas;
- important features such as old walls or buildings, veteran trees etc.;
- landscape issues that might arise as a result of the preferred route;
- the location of important areas of wildlife habitat.

Figure 1 shows some of the key considerations at the field survey stage.

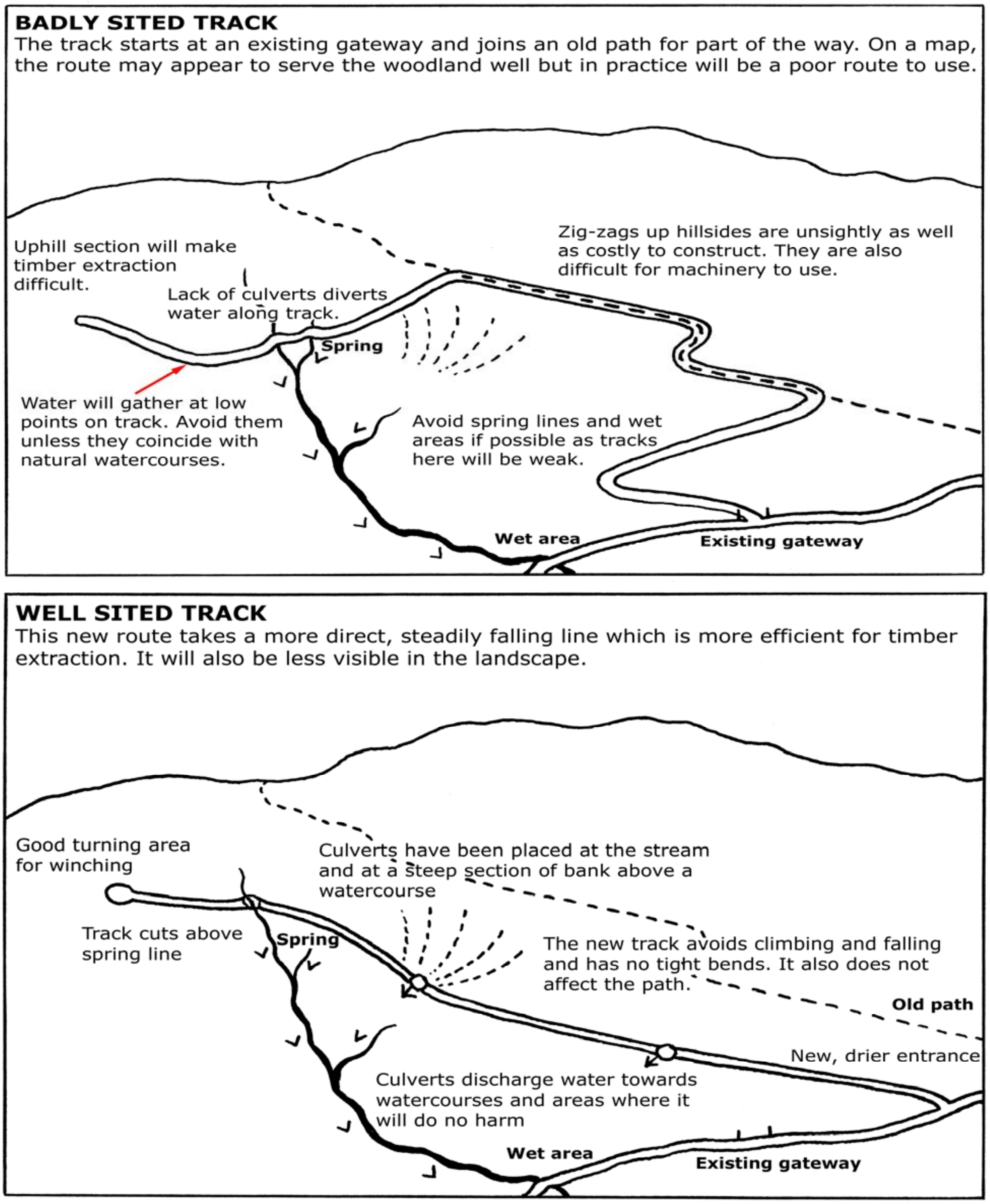
Points to consider:

- The track should reach the areas of woodland most in need of access, but avoid unnecessary travel up and down slopes, and should avoid hairpin bends, especially on steep slopes.
- The track should avoid wet areas, and be planned in accordance with the current Forest and Water Guidelines (4th Edition).
- The track should seek a safe place to connect to the public highway, reducing the potential for conflict with the Planning Authority.
- Avoid siting your track along existing paths and rides simply because they are there. They may be suitable for timber extraction and modern machinery, but you

may be removing significant biodiversity from the ride. Going through the woodland is generally more environmentally sustainable.

- When planning the direction and felled width of the road line, an East – West alignment will be good for wildlife and conservation values but will have a problem with lack of sunshine and wind to keep it dry, unlike North – South alignments.

Figure 1: View of a sloping woodland where the ground is not freely drained



3.3 Identifying the route

The information gathered from the desk study and the field survey will allow a more detailed route selection to be formed. The depth of study needed will differ from site to site depending on the scale of the work proposed, and the complexity of the site.

Once all the information available is reviewed you will be able to identify the actual route to be cleared, and be able to demark it on the ground. From the route selection process the detailed survey undertaken will have also identified:

- what permissions and consents will be required, and who from;
- which sections of track are to be surfaced for vehicular use, and which will be for timber extraction purposes;
- the locations of access facilities such as turning and loading points, harvesting ramps, main culverts and other water crossings.

3.4 Appearance in the landscape

Try to avoid positioning tracks on prominent un-wooded slopes. Follow the land form and avoid long straight routes, especially along external boundaries. The ability to work to both sides of the road is obviously more efficient and would require less roading.

Consider additional planting to conceal tracks across open ground in sensitive areas, and where they work across open land to provide access to woodlands.

In exposed woodlands with unstable crops, cutting a track line will increase the risk of windblow. If a crop is too unstable to thin, avoid cutting a track through it.

3.5 Maps and drawings

Maps should be produced to an appropriate scale to detail where the route line will run. Maps must also indicate clearly where the route will be surfaced for vehicles or a track for forestry equipment and show where culverts will be sited.

Cross sectional drawings should be undertaken showing gradients and crossfalls. For intricate sites, or sites containing bridges or access off public roads, it will be necessary to produce larger scale drawings. The scale should be sufficient to show clearly the necessary detail and measurements.

Examples of technical drawings are located at the end of this guidance note.

4 Legislative issues and best practice

Once the requirement for access infrastructure has been established, there will normally be a need to consult various authorities, and obtain permissions or consents.

4.1 Local planning system

(Town and Country Planning (General Permitted Development) Order 1995)

The Town and Country Planning legislation considers the formation, alteration and maintenance of a private way (road or track), for the purposes of forestry, to be 'permitted development'. Therefore, these operations, including obtaining minerals locally, are not normally subject to full planning consultation.

However, in England and Wales, before any such work starts, the developer must apply to the local planning authority for a determination as to whether the work is in fact permitted development. You must submit a description of the work involved, including the materials to be used, a plan of route of the track, together with a fee to your local authority.

Many Local Authorities do have standard 'determination' proforma, usually available via a link from their website. The authority must respond within 28 days, and where they approve the work they will often grant a "General Development Order".

NB: There may be regional variations between councils and planning authorities.

However, if the track joins or runs within 25 metres of a classified public highway, or if the site is particularly sensitive, such as in a national park or an Area of Outstanding Natural Beauty (AONB), the development is not 'permitted' and a full planning consultation will be required. If a full planning consultation is required, allow a minimum of a further 8 weeks for the Planning Authority to come to a decision.

It is sensible to submit your proposals to the local authority early.

4.1.1 Highways / Roads authority

Consultation is always required with the highway / roads authority when an access is constructed off a classified public highway. It is always advantageous to consult early, as the highway authority will need time to research and advise on the optimum positioning of the junction, and ensure that the location is safe in terms of visibility for other highway users.

Prospective developers need to submit a description of the work involved, including the type of materials to be used, with a plan showing the route of the track, to the local authority, together with a fee.

4.2 Water management and protection

Consultation with the Environment Agency (England and Wales) is necessary where there is likely to be interference with a watercourse during construction, use or maintenance of a forest track or road.

Water Resources Act 1991 – Any works in, over or under a main river require the prior consent of the Environment Agency under the Section 109 of the Water Resources Act 1991. In the context of forest tracks, construction or replacement of both bridges and culverts will require formal consent (a Main River is defined as a watercourse shown as such on a main river map).

Land Drainage Act 1991 – The installation of a culvert or alteration affecting the flow of an ordinary watercourse requires the prior consent of the Environment Agency under Section 23 of the Land Drainage Act 1991. In the context of forest tracks only culverts will require formal consent. Clear span bridges do not fall under the legislation. (An ordinary watercourse is any watercourse not defined as Main River. There is no de minimus to this definition).

Where a proposed forestry track or road crosses a number of minor watercourses, requiring a single assessment of flood risk, then a single consent application and fee should be submitted, and single consent issued covering a number of similar structures. This process will be the same as any other consent application and will be determined within 2 months.

4.3 Environmental Impact Assessment (Forestry) Regulations

(Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999)

The Forestry Commission (FC) is responsible for administering the EIA regulations in respect of forest roads and quarries. The Regulations apply equally to both grant aided and non-grant aided projects. Applications for grant funding are automatically assessed by the FC, and there is a 'Determination Form' for those developers who do not seek grant support. There is no fee for an EIA opinion.

Applicants must always seek an opinion from the FC on new forest roads and quarry projects. It is up to FC to determine if the work is a relevant project under the Regulations, or not. If a relevant project is identified, the FC then decides whether consent is required. Developers may be asked to provide additional information in order for the FC to make a decision.

Existing tracks should only form part of the EIA process if there is to be significant surface vegetation removed as part of restoration, and where an existing track formation is being stoned as part of the process.

If the FC decision is that no consent is required, the decision lasts for 5 years. However, when construction starts on a new road or track, any deviation in the route, for example, due to unexpected ground conditions, will require a further EIA opinion.

If the FC decides that proposals will have a significant effect on the environment then, under these Regulations, the proposer must obtain the FC's consent for the work. This will include submitting an Environmental Statement as part of the application for consent.

4.4 Tree felling

(Forestry Act 1967 as amended)

Subsection 9(4) of the Forestry Act says that the requirement for a felling licence does not apply to any felling that is immediately required for the purpose of carrying out development authorised by planning permission or deemed to be granted (permitted development).

However, for all other tree felling, Forestry Commission approval must be granted. It is an offence to fell trees without a licence if an exemption does not apply. The Forestry Commission will issue a Felling Licence where it is satisfied that the proposals meet forestry standards.

If you propose to carry out felling or thinning as part of a grant scheme application, then you will get a Felling Licence Certificate with your approved contract. After any felling you must comply with the restocking conditions of the licence.

4.5 Habitat Regulations

Since 1994 it has been an offence, under the Habitats Regulations, to deliberately kill or cause significant disturbance to a protected species, or to deliberately destroy their eggs. It has also been an offence to 'damage or destroy a breeding site or resting place' used by them (such as a bat roost in a tree or a dormouse nest on the woodland floor).

Recently a number of changes were made to Habitats Regulations that increase the legal protection given to protected species in England. These changes are intended to reinforce implementation of the European Habitats Directive across the UK.

There are several species covered by the regulations that are found in woodland, and the amendment therefore has implications for how woodlands are managed and forestry operations carried out.

Woodland managers need to consider the presence of protected species and follow good practice guidance to avoid committing an offence. Management practices may need to be modified or rescheduled to a less sensitive time of year, and where this is not possible or adequate, operators may need to apply for a licence to comply with the law.

A suite of guidance has been developed to support woodland owners and managers in England.

4.6 Best practice

There are many other areas of legislation and regulation that may need to be considered when undertaking civil engineering operations within woodlands, but which are equally relevant for wider sustainable forest management.

Bio-security is particularly important at this time, as the forest industry deals with a number of plant health issues. Civil engineering operations, involving the movement of soil and use of heavy machines and lorries within woodland, could lead to the movement of tree pests and diseases around the country. Woodland managers and contractors need to be aware of what Bio-security measures need to be in place where they are working, and adhere to best practice guidelines.

There is a wealth of Best Practice guidance published by the Forestry Commission and other organisations on all manner of topics to support and advise woodland owners and managers, for example, the FC Guidelines on Soil, Water, Archaeology, Landscape, Conservation and Heathland.

5 Design and layout of access

The design and layout of the access to be created, and its technical specification, will be greatly influenced by the immediate site characteristics on the route that you select and by the use of the access you propose. In general terms:

- Surfaced forest roads need to be designed to a more detailed specification than tracks in order to be safe and effective for use by lorries travelling at low speed (15 mph), and they should therefore be designed by a civil engineer.
- It is also recommend an engineer be used for designing the construction of timber transfer and turning points, large culverts and any other major watercourse crossing.

- Harvesting tracks will require less surfacing materials and a lower specification of finish, but must still have a sound Formation, compacted and freely draining, in order to survive a series of harvesting operations.

Key to establishing long standing and sustainable access will be:

- understanding site drainage needs and management of water;
- knowing the soils and geology on the site;
- using the appropriate construction methods and construction plant;
- creating consistent curves and gradients along which to operate.

5.1 Design criteria

At design stage, the main points which could influence the final geometry of a new track are set out below. Safety during construction and in subsequent use must always be considered.

Terrain restrictions will influence:

- The vertical and horizontal alignments and corner radiuses of the track.
- The felling widths required to allow the track to be engineered.
- Excavation and fill slopes, soil and rock side slopes, and therefore measures to maintain stability and mitigate bank erosion.
- The availability of borrow pits or roadside side slope excavation for construction materials.
- The carriageway pavement design – camber or crossfall.
- The drainage and ditch provision.
- The culvert and cross drain positions and approaches.
- The location of bridges – if required.

Harvesting methods and requirements will dictate:

- The need for, and future usage of a track.
- The volume and intensity of traffic to use the track.
- The timing of use - all year, or use restricted by season and / or climate.
- Harvesting facilities, such as access ramps and loading facilities.

Timber stacking areas should be designed into the route line at the outset, as they will have a localised impact on both the track surface (vehicles loading / unloading and turning), and on drainage and water quality during harvesting operations.

5.2 What do we mean by a track?

Different specifications of access route and infrastructure can be used and the choice (or combination of choices) will be dependant on the intended purpose of the access. Table 1 below describes the most relevant categories for woodlands.

Table 1: Description of tracks

Type of route	Purpose	Type of site	Notes
Light tracks	Provide access to ATVs or horses	On very sensitive sites or where only very small volumes of timber are being harvested.	Widths vary but generally quite narrow (c.2.0 – 2.5 metres wide). Horse routes need to avoid uphill extraction.
Tractor / Skidder Track	Allow working access for tractors and skidders, or light 4x4 vehicles	Small woodlands, or steeper sites where skidding or static winching are the most cost effective method of harvesting.	Sturdy track, wide enough for a tractor or light vehicle. Width of 3.0m – 3.5m, widening to 4.0m on bends with a minimum radius of 6.0m. Max. gradient 20%, but usually 10–15 %, with a cross fall of 5%, and lower gradients on bends.
Forwarder Tracks	Extracting large volumes of processed timber using purpose built forwarders or forestry tractors with timber trailers	Larger woodlands on terrain suitable for short-wood harvesting systems.	Heavier duty and wider than tractor tracks, with gentler bends. Running width of 4.0m. Bends, min. radius 8.0m with 5.0m running width. Max. gradient 20%, but usually 10–15%, with a cross fall of 5% and lower gradients on bends.
Forest Roads	Usually designed to carry 44 Tonne articulated lorries.	Large commercial woodland where it is more economic to bring lorries into the woodland than to extract timber to existing lorry roads.	Detailed specification to ensure good drainage and safe use. Stone is used to provide strength. Gradient not to exceed 10%. Running width 3.2m, wider on bends. Geometry and specification are critical.
Turning / stacking areas	To turn large vehicles within woodland, and may also be designed for timber stacking.	Essential for most small woodland. Could be positioned on the woodland edge.	Can be round or 'T' shaped depending upon the gradient, and should be built to the same standard as the track or road.
Transfer Points	A lay-by beside the public road. Timber stacked for collection by lorry. Avoids mud on public road.	Smaller woodlands or where it is not cost effective to bring lorries into the woodland. Steep sites are difficult.	These need to allow a lorry to park off the highway safely and should be long enough to provide enough space for timber to be stacked.

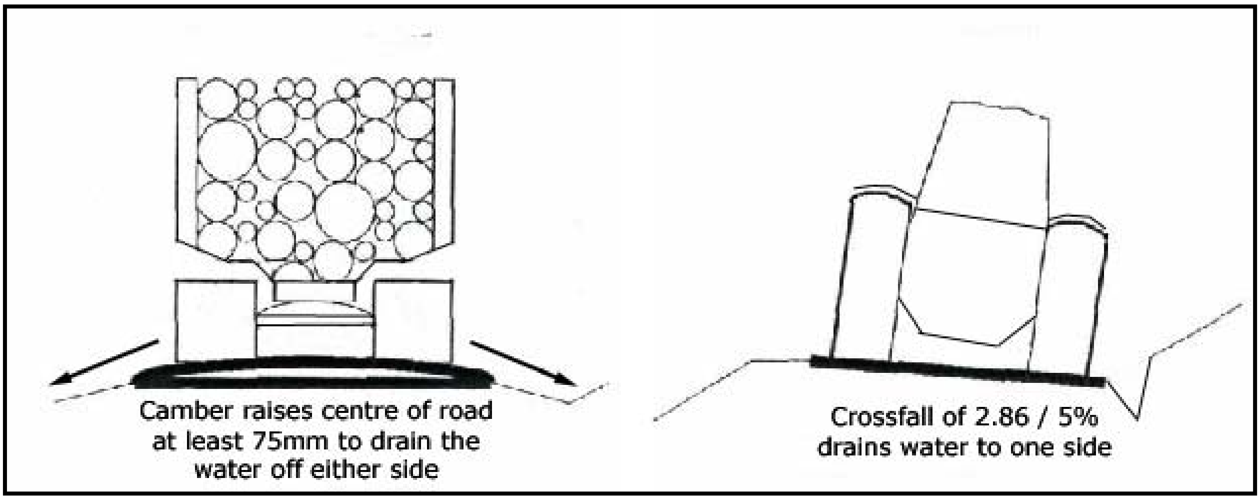
5.3 Drainage

Good drainage is fundamental to the strength of any across route, as a wet road or track will be weak, and will not provide a lasting solution to access needs. Therefore, all tracks and roads need to be designed to:

- prevent water collecting on the surface;
- keep water away from the running surface and prevent erosion by run-off.

Roads and tracks generally do this in different ways, and these are illustrated in Figure 2.

Figure 2: Road and Track profiles



Road profile **Track profile**

Both Camber and Crossfall, if properly formed and compacted, provide a track profile that will allow water to run off the running surface and into a drain network. Side slopes are usually the best place to build roads and tracks, as it is much easier to channel the water away using the slope, and the ground is much drier and firmer than on flatter areas.

5.4 Soils & geology

In addition to land form, the underlying geology will have a greatly influence the way in which a track needs to be built, and the overall strength it will have. The local geology will dictate whether local stone and aggregate material is available and can be obtained used for construction, or whether aggregates and / or recycled construction materials will have to be imported.

Freely draining slopes, such as shale banks, are often the driest and easiest places to construct tracks. However, on less well drained ground with poorer soils, construction will be more difficult, and some soils such as peat or clay will need particular techniques to be applied when creating tracks.

Simply adding more stone on top of a wet route is no substitute for drainage and can be an expensive mistake!

5.5 Using the right machinery

It is important to use a machine that can cope with the site conditions safely and produce a track cost-effectively. Table 2 indicates the suitability of the main different types of machinery.

Table 2: Choice of machinery

Type of machine	Specification	Advantages	Disadvantages	Comments
Wheeled excavator: JCB type machine for use in restricted access.	2.1m wide, front bucket 1.2 m3 Backacter with 180° degree rotation and variety of buckets.	Widely available, easy to transport, hourly rate low.	Unsuitable for soft ground. Unstable on slopes. Low power, therefore slow and unable to cope with larger stumps. No 360° rotation limits ability to lay culverts.	Only really suitable tracks on flat easy ground such as shale or sand, where the stumps are small and culverts are not needed.
Tracked excavator: Small 3–6 Tonne excavators.	1.5m wide. Fixed front blade. Back-acter with 360° rotation. Variety of buckets as for JCB.	Narrower, more precise than a JCB. Able to build narrow access routes on softer ground. More stable on slopes	Needs transported to site on a trailer. Similar outputs and power to JCB. Struggles with larger stumps.	For use in restricted access. An ideal machine for light tracks and paths.
6–12 tonne 360° excavator	2.1m wide. Fixed front blade. Back-acter with 360° rotation. Variety of buckets sizes	Greater power, higher outputs. Copes with large stumps. Stable on steep slopes and on wet ground.	Less available than JCB. Hourly rate more expensive. Needs transported by low loader.	Ideal machine for making tractor and forwarder tracks. Efficient and cost effective.
Larger excavator	2.7m wide. 360° Backacter only. Variety of bucket sizes.	Powerful and fast. Ideal for cutting forest roads. Easily copes with large stumps and harder rock.	Boom may be too big for cutting forwarder tracks. High hourly rate. Transport by low loader. Expensive for small jobs.	Widely available. Ideal for cutting forest roads but too large for working on tracks.
Bulldozer Various sizes	Front blade only	Ideal for formation work on very large roads and cuttings.	No Backacter means unable to lay culverts or grade batters. Push only. Action is clumsy leading to wide tracks.	Unsuitable for constructing tracks in woodlands.

Note: Breakers can be fitted to all of these machines (except bulldozers) for cutting through rock larger machines can cut harder rock.

The most common machine used for creation of woodland access is a 360° tracked excavator.

However, do not choose a machine solely on the basis of availability and low hourly costs, as a small machine may not be able to build a track to the right specification on your site conditions. Both the construction operation and the future use of the track may be unsafe. Furthermore, low outputs from smaller machines can result in slow progress and a higher overall cost than hiring an appropriate machine.

5.5.1 Choice of operator

All operators for the machines listed in Table 5 should be suitably qualified to use the machine, and have experience working on forest tracks. The current "industry standard" qualification is a CITB/CPCS licence. Checks should be made as to the competency of contractors and operators.

The building of forest roads and tracks is a very small part of the construction industry, and operators are not taught about working in woodlands when working towards their licences. Contractors unfamiliar with working in forestry may not be aware of the specification of forestry tracks, and may not know how they will be used for timber extraction.

Site conditions in woodlands are very different to construction sites, and even agricultural land drainage schemes. Woodlands present many unfamiliar problems and hazards to machine operators. Tree felling and extraction may need to take place during construction requiring co-operation and understanding between contractors. Tree stumps can destabilize machines, and operators need to know how to dig them up and incorporate them into the fill.

All these things point to using contractors with experience in forestry. If you are in doubt about a contractor's suitability for the job, ask to see an example of a woodland track that they have constructed.

6 Construction and materials

Methods of construction will vary according to the type of ground being worked. However, the requirements of the Construction (Design and Management) (CDM) Regulations apply to all but the smallest projects.

Construction in summer is usually easier, quicker and of better quality than winter working, but adequate time should be allowed for construction, particularly on peat. However, regardless of the site and underlying soil type, one should never be afraid to stop work if the weather gets really bad.

Guidance is given within this document for;

- Brown earth and shale
- Working on side slopes
- Thick clays
- Deep peat

However, there are many other soil types and situations to consider.

6.1 Clearing the route line

The first operation on site is usually to fell all trees and substantive vegetation within the width of the route line.

For new tracks, it is recommended that a cleared track line of 9m – 15m wide be created. Surfaced forest roads for timber haulage, and stacking and loading areas may need up to 25m width. Existing extraction tracks or roads being upgraded to cater for modern forestry equipment will also need to be widened to these dimensions.

The felled width is important for two reasons;

- To provide sufficient unhindered room in which to create the grade of track or road required, and its associated drainage;
- To allow the surface of the track, once constructed, direct sunlight and wind to encourage rapid drying of the running surface, and to assist melting snow and ice.

6.1.1 Felling trees and removing stumps

If the ground does not allow for felled timber within the track line to be extracted prior to access construction, then often the best method is for trees to be felled either up or down the slope, and for the branches to be sned out.

This allows the machine operator to move lop and top and logs far enough from the track line with the bucket to allow construction of the track formation to start. Timber extraction can then take place when the track is complete. For larger trees this may not be possible, and co-operation is needed between the harvesting contractor and the machine operator.

Avoid wiggling the route line around individual trees as this will make the track twisty. Trees retained within the route line are unlikely to survive if left close to excavations, as root damage is most certain to occur when creating the track Formation and drain, and compaction of the soil will adversely affect hydrology around the roots. See Figure 3.

As a rule of thumb, a minimum clearance of 2 metres should be left between the edge of the route line excavation, and the edge of the woodland, and ideally, no excavation should take place under the canopy of adjacent trees.

Additionally, root growth and overhanging branches from trees retained within the felled width will cause future problems for drains, and by overshadowing the running surface. This will allow water to persist on the running surface, causing damage, and branches may grow sufficiently to obstruct vehicles during future harvesting operations.

Additional areas may have to be felled where locations have been identified for borrow pits or small quarries.

The machine operator should not leave cut tree stumps in the ground along the track line as they will tend to poke up and, as stone settles, cause a hazard to future use of the track. Stumps should be dug out and cast side or upturned and placed back into the route line, and compacted down. See Figure 3.

Remember, once the running surface has been constructed, the edges can be landscaped with the stored top soil, and the remainder of the felled width will naturally infill, or can be planted to provide varied habitat. Scallops and glades at irregular intervals can provide variety and shaded areas for wildlife.

However, care must be taken to ensure that the vegetation does not become a cause of instability or landslips, or restrict sight distances. Any vegetation growing in this zone will need to be managed to maintain the sunlight and wind access and soil stability.

6.1.2 Working on side slopes

The excavating machine needs to establish a level platform to work on. The Formation cut should be done with a small bucket to help identify poor material and suitable materials for the Formation.

Loose, poor quality material, such as top soil should be pushed to one side. Good material from the cut should be used to fill under the running surface. Tree stumps must be dug out and inverted, making a hole for them if necessary, and the batter should also be cut at this stage but roughly.

Looking at Figure 3, in places where the topsoil is deeper you can move the track towards to bank in order to access more shale or cut the track a little deeper. Alternatively you may be able to "win" stone from other sections of track in order to metal sections where there is less.

6.2 Formation (Sub Grade) – the track base

The Formation or Sub Grade is the part of a track or road structure on which the running surface and associated drainage is established. The Formation specification applies to tracks, forest roads, passing bays, entrance points and loading and stacking bays. Getting the Formation right will greatly benefit the final track structure.

The minimum Formation width and depth will depend upon the composition and strength of the underlying soil material, the ground slope on which the road line lies, and the proposed track width – normally 3.4m.

Soil strength decreases as moisture content rises, with different soils having different strengths when wet.

For haulage roads, it is particularly important to assess the quality and quantity of Formation material available at an early stage to ensure you can construct a safe road, and inform if you need to import material.

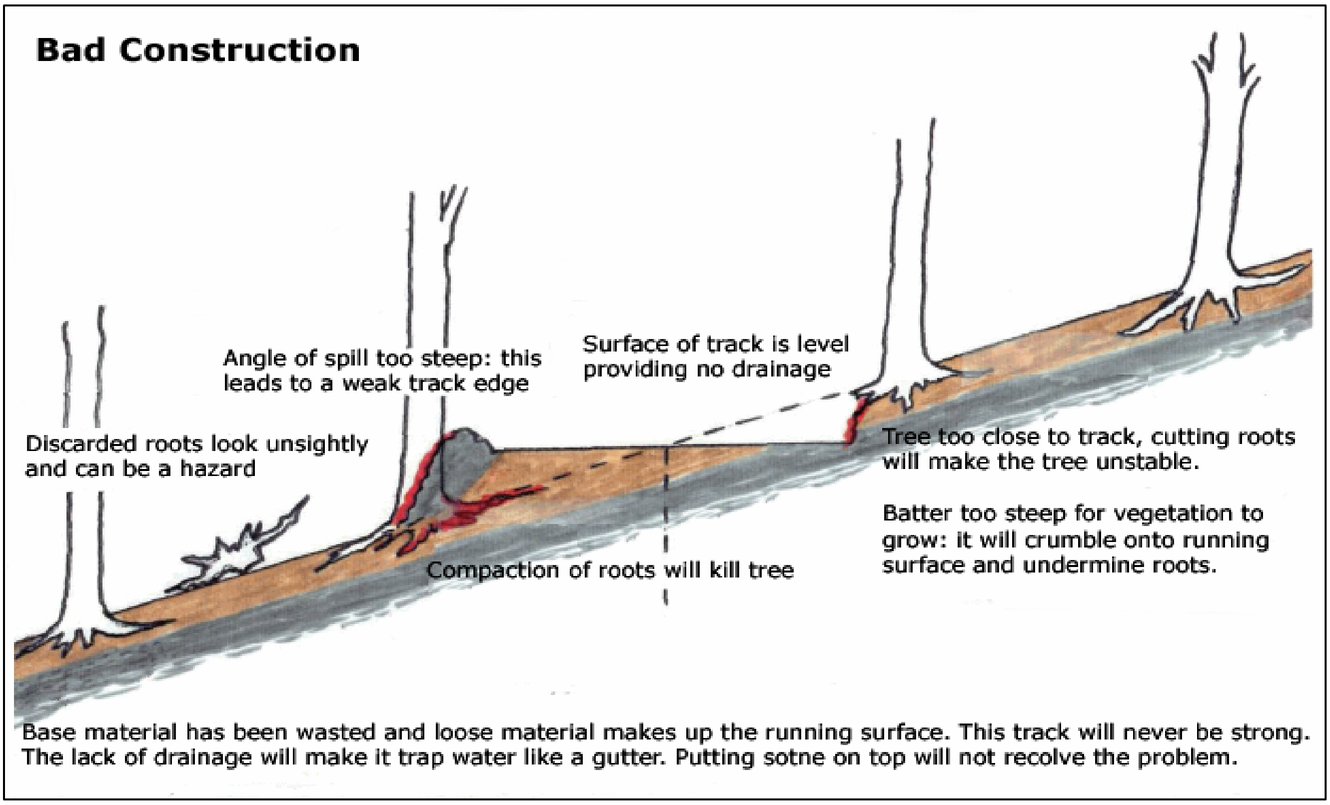
For more information on the strength of different soils, and how this directly affects the width of the Formation needed to carry an effective running surface, see Appendix 2. The running width will be somewhat narrower than the Formation width. See Figure 4.

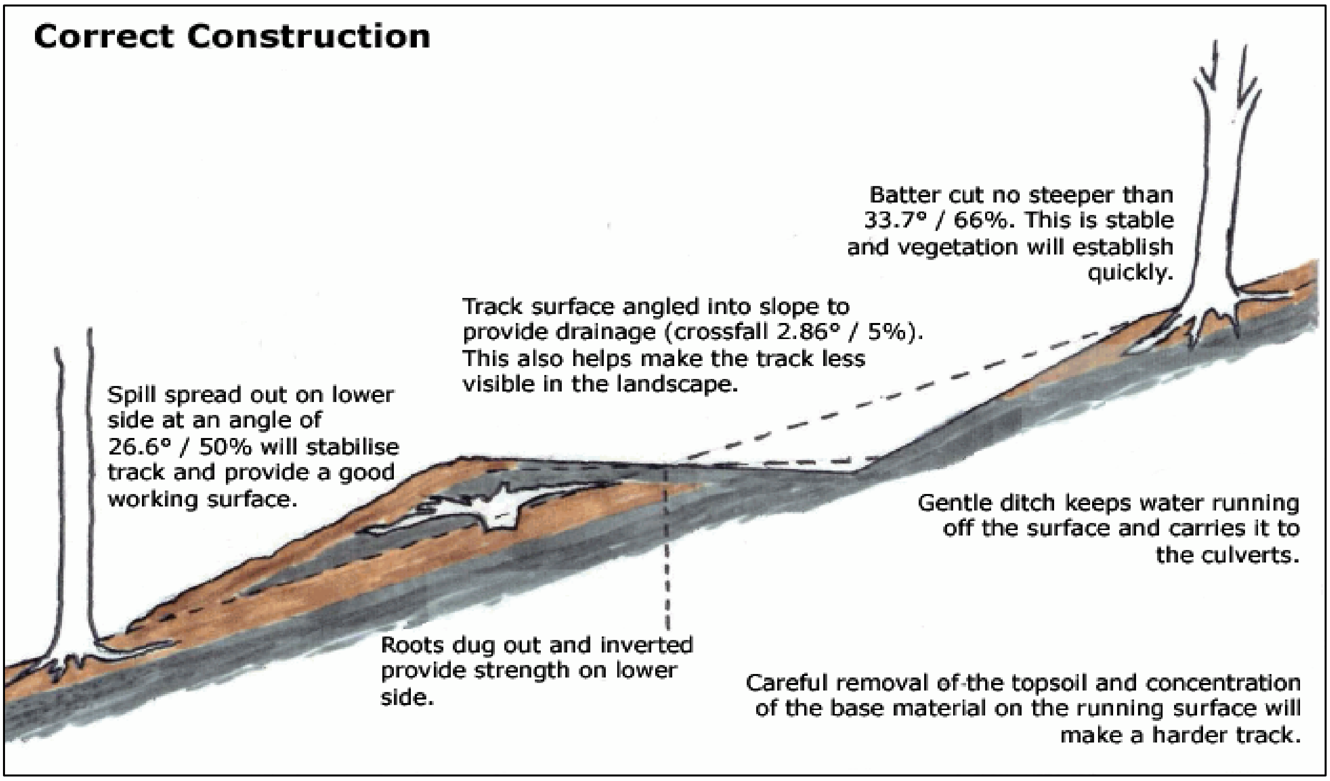
6.2.1 Soil management

Organic surface material and topsoil is not a good Formation material. It is usually better to remove topsoil, which is a valuable commodity, and store it onsite for landscaping later, after the construction is complete.

Remember, the structure of top soil is easily damaged, and it is important to handle and store top soil correctly so that it can be reused at a later date.

Figure 3: Cross sections of track built on a 30% cross slope





Technical diagrams showing cross sections of track profile on a range of slopes are shown in Appendix 7.

6.2.2 Creating the track Formation

Figure 3 shows good and bad practice for a track being cut on through brown earth overlying shale which is good enough to be used to make the running surface, and how to handle trees and stumps within the felling width.

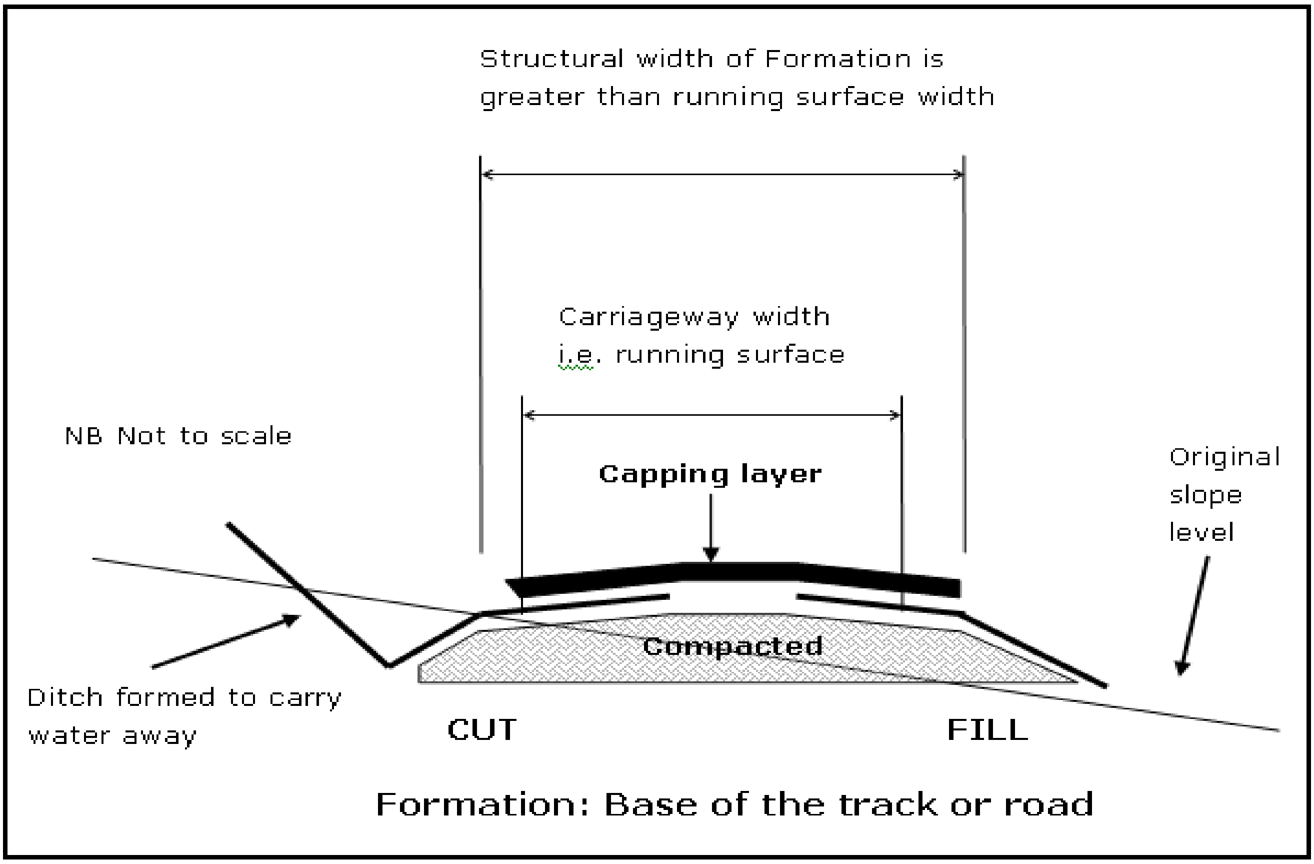
Wherever possible, the track should be founded on natural ground rather than on fill. By cutting further into the bank you increase the amount of Formation material available, and reduce the area to be filled. However, it may still be necessary to import additional stone to reinforce the Formation or to act as a Capping layer (see section 6.2.4).

Ideally, the Formation should be shaped to mirror the final running surface, as this will require less metalling. The profile of the Formation also provides a linear drain to catch water from the running surface. See Figure 4.

For a good quality Formation, compaction is essential. This will seal and strengthen the Formation, and help shed any water into the track side ditch. Rolling of the Formation is not always feasible, but movement of heavy construction machines can still achieve a certain amount of compaction.

A poorly constructed Formation will not provide the strength on which to place a running surface, or the drainage, and the track will quickly break up and fail.

Figure 4: Formation – the track base



6.2.3 Roadside drainage ditch

The prime function of the roadside drainage ditch is to carry away the surface water. See Figure 4. Ditches should be in place early in the construction process to ensure that the

Formation does not act as a drainage channel. Ideally, this will be undertaken during the excavation of the sub grade and the creation of the track Formation.

A 'V' shaped linear ditch should be constructed on the up-slope side of the track. Ditch side slopes should be at a stable angle. 'U' shaped ditches should be avoided because of the tendency of the sides to slump or erode.

The ditch should be positioned as not to undermine the edge of the track.

Following compaction and sealing of the Formation, any surface water coming off the camber or crossfall and into the ditch, and any intercepted sub-surface water coming off the uphill side of the road, should be diverted away from the Formation to the nearest culvert.

To be effective in keeping the ground water level low, the ditch must be at least 150mm below the formation level. This may also help to lower the ground water level to below the formation.

- Ditch gradients should be greater than 2% to ensure water flows, avoid siltation and minimise maintenance.
- Gradients of 2% - 6 % work well on all types of soil, but the distance between culverts may be a consideration on some soils on steeper slopes.
- Gradients steeper than 6% may need stone protection on some soils to minimise erosion.

In order to minimise pollution, a ditch should not lead directly into a significant watercourse. Instead, silt traps and ditch relief culverts should be installed (see section 6.3.1).

Care must be taken to ensure that the ditch creates neither an unacceptable safety hazard (to road vehicles, users, maintenance teams or forest workers), nor a major hindrance to harvesting operations.

Temporary drainage may occasionally be needed if there is a risk of inundation of the work area. Temporary measures will help to avoid damaging either the environment or the road structure in the short term, but must no become permanent solutions.

6.2.4 Batters and spills

In addition to creating a camber etc, on side slopes you need to design the angle of batters according to the strength of the underlying soil and sub soil material. Weaker ground needs to be graded to a gentler angle in order to provide a stable bank.

Batters that are too steep, or on poor or soft ground, will crumble or slip onto the running surface, making the track narrower and blocking the drainage. Figure 5 shows the appropriate angles for batters on different materials.

Once the formation cut has been made, a 2 metre wide bucket should be used to finish off the batters and spill to leave smooth slopes which will consolidate more quickly and tidily than rough faces. See Figure 5.

Figure 5: Angle of batters and spills

Rain water runs to the side of the running surface, which forms a shallow V shaped, self cleaning drain and flows along to the next culvert.

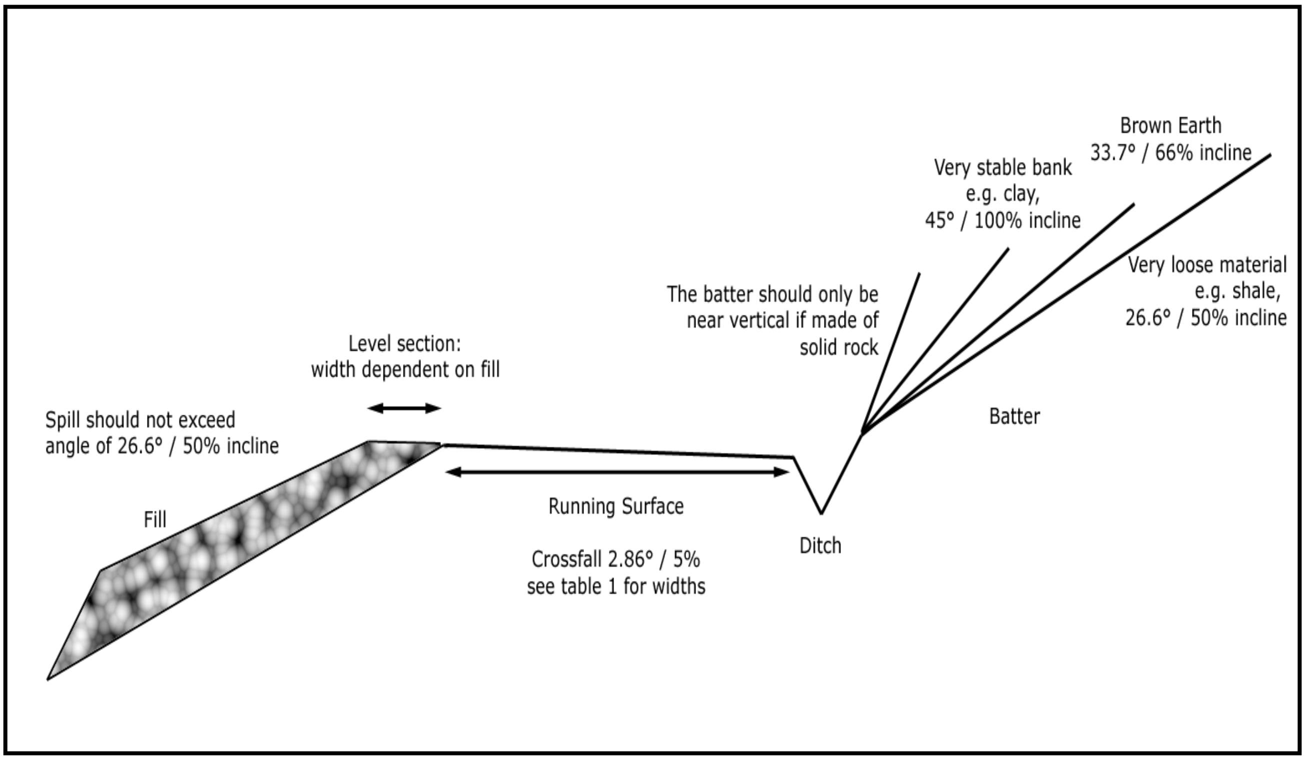


Figure 5 also illustrates that regardless of the base material, the gradient of the spill on the lower side should not exceed 1 in 2. This is in order to provide maximum stability to the lower side of the track and to allow access for timber extraction. Spill slopes and batters cut at a gentle angle will also vegetate more easily than steep faces which can remain as scars in the landscape for many years.

The cleared corridor will naturally infill with regeneration or through seeding and planting in time. Care must be taken to ensure that future vegetation does not become a cause of instability or landslips, block drains and ditches, or restrict sight distances. Any vegetation growing in this zone will need to be managed to maintain the sunlight and wind access.

6.2.5 Pavement (Capping layer)

Adding a Capping layer of crushed stone or recycled material on top of the Formation, for the full width of the running surface, will help protect the Formation from wear. See Figure 4.

The depth of the Capping layer can be regulated to meet the needs of the underlying soil type, and to ensure that camber or crossfall meet appropriate gradients, and that longitudinal gradients can be kept even.

On many track projects it is normal to construct the pavement in a single process, using, where possible, locally obtained material. Construction in a single layer protects the

Formation from possible damage caused by construction traffic running back and forth. However, a single layer construction does not allow for full compaction of the pavement by a vibrating roller where the pavement material is laid excessively deep.

If the pavement layer can be constructed in compacted layers of less than 250mm, without damage to the formation, a stronger road will result, for the same depth of material.

The pavement must be structurally sound over the total running width. By using a camber profile, it may be possible to reduce the depth of road stone needed on centreline, an area which is not normally subject to traffic, and therefore save on the quantity of material needed.

The ideal pavement is made from a 75 or 100 mm well-graded granular material. Sharp, angular material is better than rounded gravel, and will compact well, but poor quality materials are difficult to compact.

Saturated materials are impossible to compact properly. Strength will increase as the material drains and consolidates.

6.3 Water crossings

The definition of watercourse includes all channels for the passage of water, whether natural or man-made, including channels which would normally be dry, such as many forest drains.

Every effort should be made not to pollute watercourses with alien material, and where possible, any works should be carried out during the "dry" season, and not during the spawning season from October to March.

Available methods for crossing waterways are:

- Culvert - can be disruptive to aquatic life; high embankments a possibility
- Bridge - the preferred choice at most major stream and river crossings
- Vented causeway - overtopping may cause pollution problems and are liable to blockage
- Ford - high risk of pollution; probability of erosion if unpaved.

The Forestry Commissions Forests and Water Guidelines (4th Edition) should be consulted for information and guidance.

6.3.1 Culverts and Cross Drains

Roadside drains should not intercept large volumes of water from the ground above the running surface. Any watercourse or spring, however small, which is intercepted by a track or road line, should be culverted or bridged at that point.

Culverts for such drainage should be of a sufficient size and spacing to avoid overloading, blocking or washout, and should follow the original line of the watercourse. Tables 4 and 5 give guidance on pipe size and frequency of use.

It is essential to minimize the amount of water diverted along the track side ditch to prevent the volume of water building up in the ditch and damaging the running surface. A cut off culvert can be used to relieve build up of water in the ditch.

Always take care when siting additional culverts to avoid discharging water where it may cause problems downhill for you, your neighbours, or on a highway, as you will be liable!

Ditches on the upper side of the running surface should use cut off culverts to direct water to the lower side of the track a short distance before stream crossings, so as to prevent direct discharge. See Figure 6.

Roadside drains likely to carry high sediment loads must not be allowed to discharge directly into, and pollute a watercourse. Where appreciable sediment movement is unavoidable, water must instead be discharged into a buffer area of adequate size, or into a silt trap or catch pit that have been constructed to allow sediment to settle. Provision must be made for cleaning out and maintaining silt traps and catch pits.

Figure 6: A cut off culvert

Roadside drains should discharge to a buffer area so that any suspended sediment can be filtered out before the water reaches a steam.

Discharging water from a track side ditch directly into a standing crop of trees can lead to water-logging of the roots of trees. This could result in unstable soil conditions and potentially windblow of standing trees. It is important to judge where the water is discharged as much as where it is collected from.

As well as being effectively located, a culvert needs to be of the correct size (diameter) to cope with storm flows. The size will depend on the nature of the site as well as the area of land that the culvert will drain. A detailed map showing contours is needed to identify and measure the catchment area.

6.3.2 The Talbot formula

The Talbot formula, shown in Table 3, is a useful starting point for calculating the diameter of culverts needed. However, it is important to understand that this is only a guide, and that local factors and knowledge will have a big effect on decision making.

It is now common for the Environment Agency to expect culverts to have a much greater safety margin as a result of changes in weather patterns, due to climate change.

Table 3: Talbot values

Catchment Area in ha	1.0	1.7	3.7	4.7	6.6	11.0	16.0	20.0	24.0	33.0	43.0	47.0
Pipe Dia. in mm	300	450	500	600	700	800	900	1000	1200	1300	1400	1500

Note: Culverts of 600mm and over need to have cut off culverts installed to the discharge ditch, as shown in Figure 6 above. Further guidance should be obtained from the Environment Agency or a qualified Civil or Agricultural Engineer.

This is especially important in mountainous areas, on steep or recently felled areas, or areas where thin or saturated soil overlies impermeable bedrock, such as granite, and where water will be able to shed very quickly. Springs and drains may exist which can greatly increase the volume of water at wet times of the year, and may even bring in water from outside the catchment area.

If in doubt, specify a larger diameter of pipe as the extra cost is minimal compared to rebuilding a washed out culvert and track. Also, remember that small pipes tend to block up more easily with debris, so it is better to have one large pipe than 2 smaller ones.

6.3.3 Spacing of ditch relief culverts

Culverts should be provided at all the low points along road and track sections, and at sufficient frequency to relieve the trackside ditch of excessive water. If a significant amount of water is allowed to remain in the track side ditch, it will begin to saturate the Formation, weakening the running surface and resulting in expensive repairs.

Table 4 should serve as a guide to the maximum spacing between culverts:

Table 4: Culvert spacing

Ditch Gradient	**Culvert Spacing (m)**	
%	Normal conditions. Cross slope of the ground < 15%	Very wet or steep conditions. Cross slope of the ground > 15 %
<4	200	100
5	160	80
6	130	65
7	115	55
8	100	45
9	90	40
10	80	35
11	70	30
12	65	25

6.3.4 Types of pipe for culverts

In addition to the size and number of culverts needed, you will also need to decide what type of pipe to use. Table 3 sets out the relative merits of the most commonly used pipes in forest and woodland settings.

Table 5: Pipes types for culverts

Type of pipe	Advantages	Disadvantages	Comments
Corrugated steel, galvanised, "Helcor/Armco" pipes	Cheap and strong. Sections can be bolted together to form longer lengths by using collars	Must order correct length. If pipes are cut the ends rust. Pipes liable to corrode, especially if laid poorly, especially in acidic water	Cost effective, and durable if correctly installed. Do not use in acid rock areas.
Twin wall plastic	Light and easy to carry and simple to join together. Easily cut to length as required. Will not corrode in acidic water.	A bit more expensive than galvanised pipes at larger diameters. Not quite as strong.	Easiest pipe to work with. Ideal for most forestry use, especially in smaller sizes.
Concrete pipe	Very cheap and strong	Very heavy. Only comes in 1m lengths. Push fit joints will come apart easily. Installation is difficult. Pipes over 60cm dia. must be concreted in.	Not recommended for forestry use
Perforated plastic land drainage pipe	Spare lengths often found left over from land drainage jobs.	Weak. Too floppy to lay at correct angle. Bends tend to trap debris	Not suitable for culverts. Do not be tempted to use this type of pipe.

6.3.5 Culvert installation

Having planned the location, size and type of pipe that is to be used, you then need to install the culvert or cross drain pipe properly.

For pipes to work efficiently, and to last - to cope effectively with storm flows and the weight of forestry operations crossing them, they must be installed in line with the manufactures recommendations.

The installation of pipes for culverts and cross drains is set out in Figures 7 and 8.

Figure 7: Installation of a culvert, cross sectional view

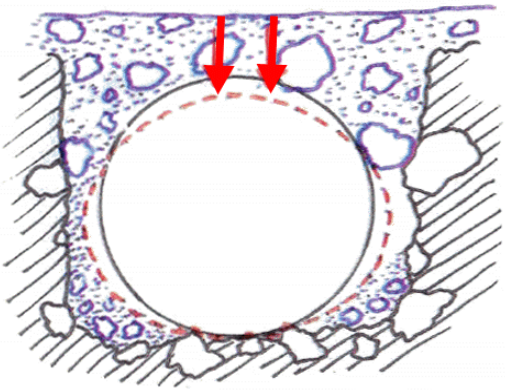
BAD CONSTRUCTION

Plastic and Helcor pipes have limited strength and must be supported well.

Poor installation leads to collapse after very limited use.

Thin layer of poor material will not spread load from passing vehicles. This will lead to abrason and deformation of the pipe and early failure.

Loose backfill will not support pipe and will allow it to deform on loading.



Trench too narrow to allow proper backfilling. Larger stones get stuck leaving cavities below where the pipe is unsupported.

Unprepared bed will not support the pipe well. If material is soft, the pipe will deform on loading. Rocks will penetrate the pipe leading to premature collapse.

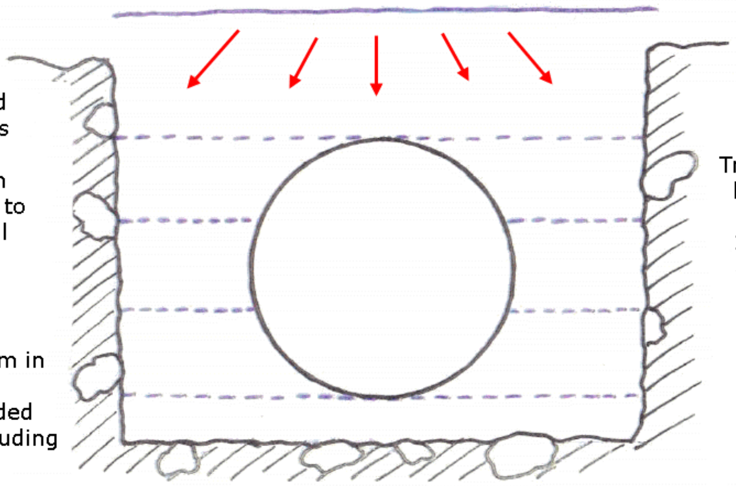
CORRECT CONSTRUCTION

A well installed pipe will maintain in shape and strength for many years.

A thick layer of good stone is needed above the pipe to spread the load. See manufacturer's guidance. For Helcor pipes, allow at least 30cm of stone. For plastic pipes, allow at least 45cm of stone.

Fill trench with good stone (MOT type 2 is ideal). Fill in 15cm layers, firming down between each layer to ensure that it is well packed.

On pipes over 100cm in diameter, special techniques are needed to install pipes, including the use of props.



Trench is wide enough to backfill pipe. Cut trench wide to allow at least 30cm between pipe and side of trench to give enough space to compress stone.

The pipe needs to lie on a firm bed of selected material (the ideal would be 10cm of MOT type 1 stone).

Figure 7 shows the difference between a pipe badly installed and correctly installed.

The trench the culvert pipe is to be laid into should be excavated perpendicular to the road line. For an existing watercourse, it may be necessary to divert water flow to enable the pipe to be installed well, as it is easier to install a pipe in dry conditions that in wet. In such circumstances, this may allow some straightening of existing watercourses.

The trench should be of sufficient depth to accommodate the pipe and to allow a minimum compacted depth of backfill over the pipe, as specified by the manufacturer. The larger the pipe diameter becomes, the greater the depth of backfill that will be required.

Catchpits should be provided at the pipe inlet to intercept suspended material. These must be at least 300mm below the pipe inlet invert, and large enough to contain the expected amount of material. The size will need to be reviewed with experience.

The bed of the trench should be flat and smooth, and excavated on natural ground, not on fill as this could lead to serious scouring and soil erosion. There must be a gentle gradient to let water flow through the pipe to the lower side.

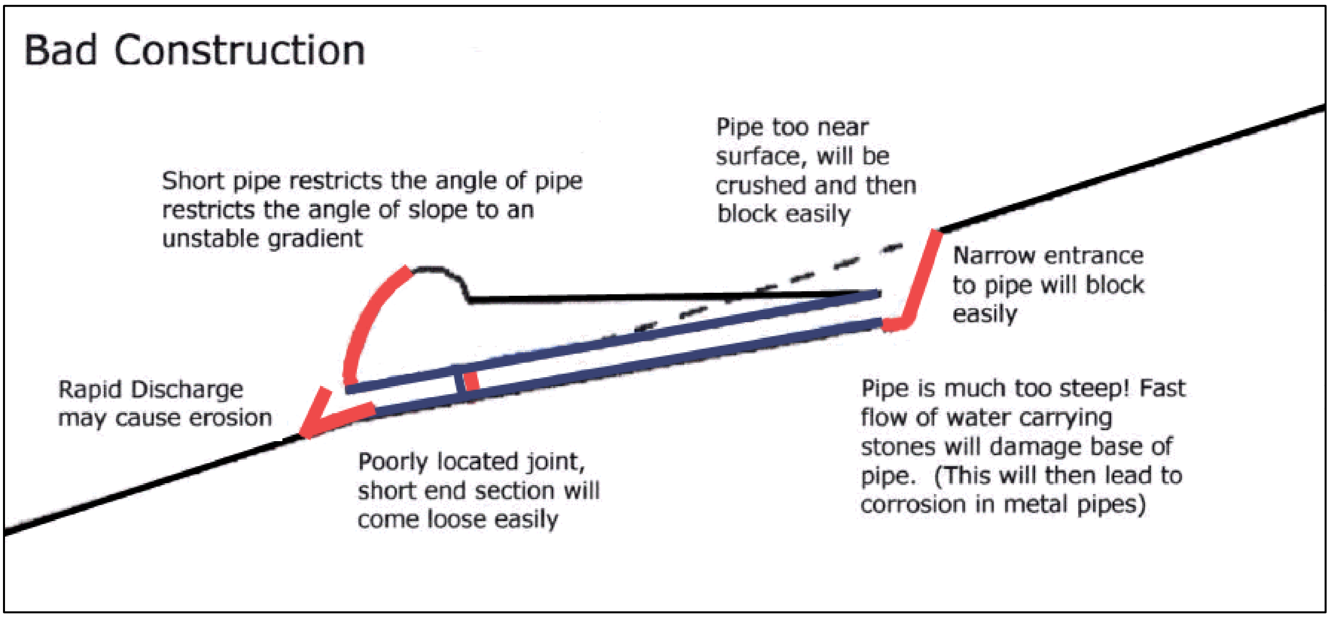
A layer of selected stone material, which is free from sharp stones that might damage the pipe, should be compacted on the base of the trench before laying the pipe, and can be regulated to ensure the required gradient is achieved.

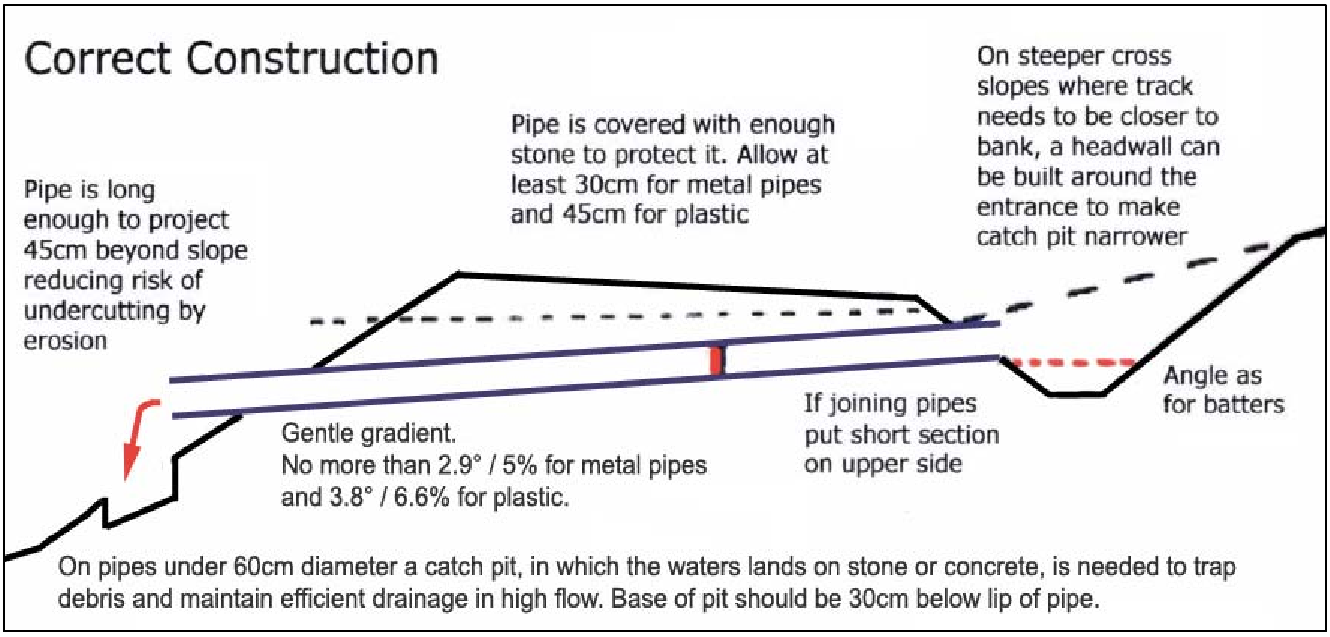
The width of the trench should be kept as narrow as possible for the diameter of pipe being laid, but you should have at least 300 mm clearance on wither side to allow for compacting of backfill material. For larger pipe diameters, it will be necessary to reinforce the trench sides to prevent them from collapsing.

Backfill material should be free from sharp stones that could damage the pipe. Backfill is laid in 150 mm layers on both sides at the same time, and thoroughly compacted, taking care not to float the pipe.

Thin walled flexible pipes rely upon well-compacted backfill for their strength, and larger diameter pipes should be braced during installation to ensure the final shape is as designed.

Figure 8: Construction of a cross-drain culvert, longitudinal section





The above sketches are indicative of good and bad methods of installing a pipe; however in a larger watercourse, culvert location should be chosen so as not to impede the passage of fish. In certain cases a bridge may be required.

NB: The example given for correct construction would not be applicable where passage is required for fish, in this instance the culvert pipe must be laid flush with the riverbed.

Remember: Sub-standard or poorly located culverts are the most common cause for tracks to wash out. Culverts should therefore be designed by an engineer and installed by experienced operators.

6.3.6 Head and tail walls

All culvert pipes will need protecting around the inlet and outlet, where the pipe goes under the track. A number of simple techniques can be applied, depending on the culvert diameter.

- Construction of a sandbag collar, placed around the neck of the pipe and up to track level.
- Construction of a masonry collar, where larger stones are placed around the neck of the pipe;
- Construction of masonry headwall, where larger stones or blocks are cemented together to form a wall around the neck of the pipe

For larger diameter pipes, it may be necessary to also construct 'wing walls' around the catch pit, or to retain the upper slope. In these cases it is likely that the walls constructed will need to be supported by concrete footings (foundations) of at least 200mm thick.

6.3.7 Bridges, fords and causeways

A bridge should almost certainly be the preferred option where the span over a watercourse is greater than 2 metres. Occasionally, it may be worth considering for spans as low as 1.2 m, as bespoke bridge construction could be a more cost effective or long term solution to crossing streams and rivers.

Bridge design should includes full schematic / engineering drawings and be fully costed before agreeing then.

Vented causeways (also known as Irish bridges) and fords are not to be recommended for forestry use. Although cheap, they are liable to be a source of pollution, both during construction and when in use, and can be dangerous in time of flood. They can also be the cause of scouring downstream.

6.4 To stone or not to stone a track

The Formation and Capping layer will normally be enough to allow harvesting operations to take place, and for timber to be extracted from the woodland to a loading point. The main reasons for applying additional layers of stone material are;

- To improve the strength of the track Formation in particular locations;
- To aid repair of damaged areas in an existing track Formation;
- To improve the quality of the surface, and thereby increase the variety uses the track can be subjected to.

Adding layers of road surfacing will only usually be undertaken for those sections of track where haulage lorries or other such heavy vehicles require access. The route selection process will have identified how much of the track needs to be of sufficient specification to carry heavy haulage vehicles.

However, the quality of the surfacing material used will define the running quality of the road surface, and ultimately determine the type of use it gets. Choice and treatment of surfacing material is therefore very important.

If access is needed throughout the year for heavy machinery, you may need to put on extra stone to help form a strong running surface. However, this adds greatly to the cost of the track, and can normally only be justified where access for machinery is essential all year round, or where the ground conditions are very poor.

Where you are widening or reinstating an existing track, you will be able to reincorporate existing stone materials from the previous track structure as part of the Formation. This may help strengthen the formation and result in less stone having to be supplied for capping and or surfacing layers.

Bringing in stone is very expensive, and different types and sizes of stone have different structural properties. If you think that you need to import stone, consult an engineer, as costly mistakes can be made by bringing in the wrong material.

An awareness of the environmental implications of importing stone is also needed. For example, using an acidic stone in a sensitive base-rich area may adversely affect the native vegetation.

6.4.1 Tracks and roads on thick clay

Thick clay is one of the most difficult types of ground on which to construct access routes.

Never use wheeled machinery for formation work on clay as it may sink and create huge ruts. A tracked excavator is essential, but only the minimum of cutting should take place, (but you must still remove stumps). Remember that you are not expecting to win stone from lower down as with shale. Instead, once the formation cut is made, you will need to bring in high quality stone to make the Formation and the running surface strong, and prevent the rain penetrating to the clay underneath.

Stone needs to be carefully specified and laid in layers. The first needs to be fine to "blind" the clay, before larger material is added to build strength. A finer top layer is then needed to seal the surface well. ''Blinding" the clay will prevent larger stones penetrating into the clay which would weaken the road and lead to rutting. Consider the use of a geo-fabric as a separation layer.

6.4.2 Tracks and roads over deep peat

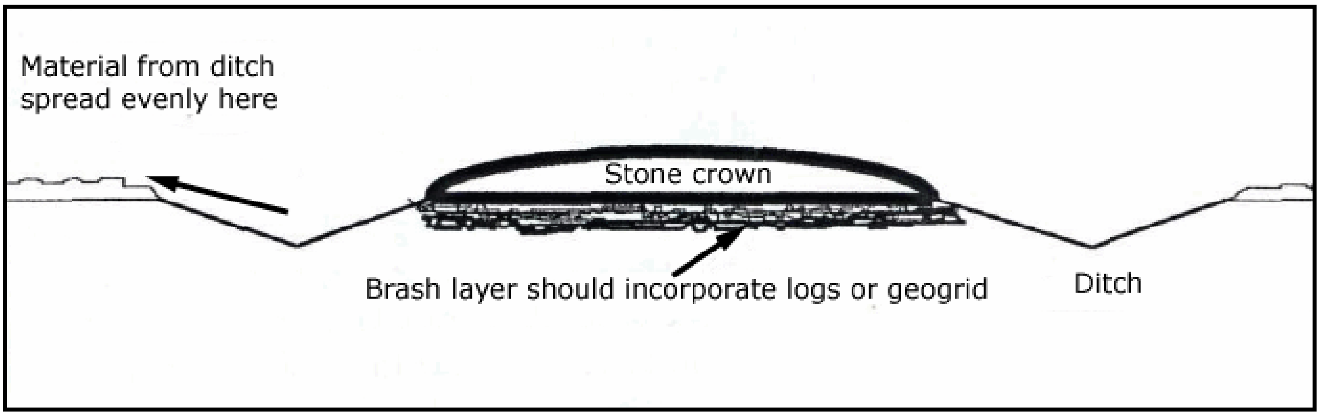
Deep peat is usually level and therefore a track should be built in a similar way to a forest road, with a crown that drains water both ways. This will make the track more stable.

Utilizing vegetation and brash will help to reduce the amount of stone needed (see table 4). Sitka Spruce brash is ideal for this, particularly if long tops are laid across the track in what is often called "corduroy" style. Large amounts of fresh, springy brash are needed in order to establish a thick mat as it will compress down to a remarkably thin layer. For example: A 2 metre pile of fresh, loose brash will compress to form a mat as thin as 30cm thick.

If cutting a new road line through a crop, incorporate all the brash from the trees felled to make the formation cut, as well as the upturned root plates of trees.

Figure 9 shows how a road or track over peat needs to sit on top of the peat like a stable raft.

Figure 9 - Track over deep peat



Consult with an engineer for best designs for tracks over peat.

6.4.3 Timber haulage roads

Forest roads are very well built sections of forest track, with several layers of well compacted surfacing applied to give a safe and consistent running surface for timber lorries. For issues that need considering when constructing forest roads, see Appendix 3

It should also be remembered that forest roads are very different to the public highway. Not only is the forest road normally single lane, but edges and verges are often soft and may not be safe for large or heavy vehicles.

Traction on forest roads can often be much less than on public roads, particularly in wet conditions, and they are subject to more irregularities than many public roads, such as potholes, ruts, sharp stones and general roughness.

Manoeuvring for large vehicles on forest roads can also be very awkward, but design standards take this into account. The design criteria are based on slow moving timber haulage traffic. 15mph should be regarded as the maximum safe speed.

Therefore, the width of the Formation, and the running surface laid on top are critical to safe use of the road by hauliers. On straight sections, the normal running width should be around 3.4 m. A greater running width is required on forest road corners. Appendix 3 gives information on running surface widths required.

Where possible, the design of the forest road and track network should encourage harvesting machines and harvesting activities to be kept off the surfaced carriageway. The harvesting infrastructure required, such as timber stacking and loading points, ramps etc, should be constructed at the same time as the road, as this will reduce overall costs.

6.4.4 Surfacing forest roads

Surfacing material is, at least to some extent, a sacrificial material in the sense that it will be lost (worn away) over the years. This should be considered when choosing the surfacing materials and designing the road thickness.

Despite the knowledge that it will need to be replaced, the surfacing material should be durable and of a quality that will enable it to be shaped and properly compacted.

The ideal material is MOT Type 1, well-graded, granular material. There should be sufficient silt to clay fraction to facilitate sealing. When laid on top of the Capping layer and compacted, the initial surfacing thickness should be at least 100 mm.

However, depending on the underlying soil type and the strength of the Formation, you may need to consider greater depths of surfacing materials. See Appendix 2.

Importing material for surfacing is expensive. However, this cost is almost always worthwhile compared to using an unsatisfactory, locally worked material when all the attendant costs, including increased maintenance, are considered.

6.4.5 Depth of stone needed for surfacing

Table 6 gives some guidance about the depth of stone that might be needed for year round access on different types of ground.

Table 6: Depth of stone needed

Type of ground	**Recommended depth of stone** (for running surface)	**Useful tips**
Firm Shale	No need to bring in stone, self metalling.	Shale can wash out easily so avoid steep gradients and bends.
Brown earth, and weaker shales	Up to 300mm stone. About 200mm if a geo-fabric is used.	If good stone can be dug on site, compare the cost of digging it to buying it in.
Thick Clay	Up to 450 mm of good quality stone is essential in order to make a strong running surface. About 250mm if a geo-fabric is used	After formation, "Blind" clay with fine stone before adding coarser stone to build strength.
Deep Peat Specialist construction techniques required. Consult an engineer.	If lying directly on peat, you may need 600-1000mm of stone.	Reduce the depth of stone needed to 300 – 500mm by laying slate waste, (100mm size), or geogrid on top of vegetation and/or brash mat.

Commonly used grades of road stone are:

- MOT type 1 37mm diameter down to dust
- MOT type 2 18mm diameter down to dust

Membrane – the use of a Geogrid material is preferred on peat, is recommended on heavy clay soils, and may be used in other localised situations where appropriate – for example, where there is water logging or site sensitivity.

The membrane is rolled out over the full width of the running surface prior to pavement materials being added and compacted. The manufacturer's guidelines should be followed to ensure that the correct sized stone used, preventing the membrane from being punctured or torn.

Great care should be taken when considering using material from old mine workings, as these can be very toxic and result in pollution of the local vegetation and watercourses.

In sensitive landscapes, avoid importing types of stone that will look out of place, such as white limestone.

6.5 Roadside harvesting facilities

For forest roads to function satisfactorily, they must be supported by facilities such as turning points, passing points, timber stacking and loading areas, timber landing areas, ramps and of course, access to the public highway.

6.5.1 Turn-rounds

Turn-rounds need to be provided at or very near the end of the part of the track accessible by haulage lorries, optimising the distance that extracted timber has to travel between stump and public highway.

For small woodlands, given the expense associated with surfaced forest roads, this will normally be just inside the woodland entrance, with a cheaper extraction track network bringing timber from stump to that location.

However, on long lengths of forest road where there are no junctions or other turning facilities, additional turn-rounds are useful at about 1km intervals.

Where possible, turn-rounds should be situated on level ground, for example, at the top or bottom of slopes. It is preferable to reverse turn into the bank side of the road, and not over the (weaker) edge, and preferable to reverse turn onto the driver's side to avoid blind spots.

Where possible, the turn-round should be positioned to be used empty – only for turning, as this function can be compromised by stacking timber next to it.

However, by designing the turn-around to cater for harvesting equipment working off the road line, it will permit timber to be stacked next to the turn-round ready for loading. This can be achieved by increasing the felled width of the route line next to where turn-rounds will be located, but needs a larger area of flat ground in the process.

However, for large volumes of timber, using a turn-round for stacking timber is not recommended as the effectiveness of the turn-round for its prime purpose will be limited.

The normal turn-round configurations are:

- 'T' shaped (see Figure 4.4 at the end of this section)
- 20m 'U' turn
- Circular turn-rounds are possible down to 11m radius, but 25m transitions are required both in and out. There is a tendency for this type of turn-round to get clogged with mud and brash during harvesting operations.

Turn-rounds need to be built to the same specifications as that for surfaced roads, using the same materials. However, dimensions for turn-rounds are greater than that for forest roads.

See Appendix 4 for diagrams of styles of turn around.

6.5.2 Passing Bay

Normal width forest roads do not permit vehicles to pass on the carriageway, so where a significant length of forest road is to be constructed, consideration should be given to providing passing bays, where deemed necessary.

Because it is difficult for articulated lorries or lorries with trailers to reverse any distance, passing places should be situated where the last and next appropriate passing bay can still be seen. This will prevent drivers meeting between passing locations.

Passing bays need to be built to the same specifications as that for surfaced roads, using the same materials.

6.5.3 Loading and stacking areas

Careful planning allows stacking areas to be off the road line and away from turn-rounds, so do not interfere with vehicle movements. However, lack of space often results in the timber stacks projecting into the carriageway, with obvious safety implications.

Well-planned facilities can keep harvesting machines and timber conversion operations off the carriageway, limiting damage to the road surface, and minimise, if not avoid, the necessity for repairs.

Lack of facilities may lead to conversion on the carriageway, resulting in the deposition of brash and chippings on the surface, and interruption of traffic. NB: Conversion and stacking bays are often the most neglected feature associated with timber extraction and roads adjacent to these areas are the most likely to require emergency repairs.

Stacking bays can often be created on the down - side of the road using surplus excavated material from the road construction. However, care will need to be taken to ensure that the bay is capable of taking vehicle loading.

Double width bays are useful in certain circumstances for both stacking and loading.

Stacking areas should be located where the road gradient is not too steep, as fully laden lorries can have difficulty moving off.

6.5.4 Sky-line and hi-lead timber landing areas

Space is a major design criterion for landing cable extracted timber. The felled width of the track should be designed and planned to allow sufficient space for landing, conversion and stacking (as required).

Wherever possible, skyline landings should be located off the track line itself, as the site can become very congested with timber. The design of the landing area should allow room for timber collection by forwarder or lorry, and therefore attempt to ensure that the forest track can be kept clean and clear, permitting the uninterrupted passage of vehicles.

6.5.5 Ramps and tracks

Mineral ramps are often necessary to allow harvesting machines access to and from extraction tracks or roadside facilities such as timber stacking areas. Heavy harvesting machinery should avoid travelling on surfaced forest roads whenever possible to prevent unnecessary damage.

Ramps and tracks should join the track or road at an acute angle to avoid severe manoeuvres scouring and eroding the surface.

Other points to note are:

- Ditch crossings must be constructed in a manner that limits the possibility of becoming blocked. Pipes should not be less than 300 mm in diameter
- Care must be taken with ramps coming down onto the track or forest road, to minimise any flow of water and material such as soil onto the road. Cut-off grips across the ramp can be used to reduce the water (and mud) flow. Additionally, they often need silt traps to avoid pollution and contamination of the roadside ditch or other watercourses
- It is sometimes useful to have a shakedown zone adjacent to the road. Stoning the first 25m of track with clean stone, in the range 100 – 200 mm, may help to shake off the soil and mud and avoid detrimental contamination of the road surface
- Grips and shakedown zones require maintenance!
- Log ramps over ditches are not recommended. Water flow is restricted and soil is easily stopped between the logs, causing water to be held up
- Ditch crossings at track and road summits have least effect on the roadside drainage.

6.6 Access to the public highway

The junction of the forest road or track and the public highway will be the most trafficked part of the access infrastructure for the woodland.

The junction has to provide safe entry and exit to the woodland entrance for heavy and slow timber lorries, and so it is no surprise that the local planning authority have a regulatory role in approving its placement and aspects of the construction specification. See section 4.1.

The apron of the junction has to be constructed to a high standard in order to provide the stability needed by fully laden lorries turning.

Most local highways/roads authorities will require some bituminous material to be laid in the immediate vicinity of a public road. Such work should be carried out to their required specification.

Particular care will be required with visibility splays from the forest road onto the public road. Many local highways / roads authorities will specify the minimum requirements that have to be met. The maintenance of such splays should be of importance in order to protect those using the woodland entrance and the public highway.

On a busy public road, it is undesirable for a lorry turning left (whether into or out of the access) to have to cross the public road centreline. Infilling the turning corner will help the lorry turn into or out of the junction. A possible layout for a 90° junction with a ‘major’ public road is shown in Appendix 6.

One-way skewed accesses can be used to reduce earthworks or to divert traffic in a chosen direction. An example is shown at Figure 4.7 at the end of this section.

6.6.1 Bituminous macadam surfacing

Bituminous macadam surfacing is an expensive alternative to mineral surfacing of a forest road. As with mineral surfacing, it would be used when wanting to increase the pavement strength and provide a running surface for haulage lorries.

In most situations, it will be cheaper to increase the depth of metalling need to strengthen the pavement, and therefore blacktop normally overlooked for the majority of forest roads.

Compared to water bound materials, maintenance of and repairs to bituminous materials are both more difficult and more expensive. However, over any given period of time, a well-constructed bituminous road should require less maintenance than a water bound road.

There are some instances where blacktop has justifiable uses:

- to increase the pavement strength;
- unavoidably steep gradients where it is necessary to increase the traction for lorries;
- areas where dust suppression is required, for example, adjacent to property;
- where ice and snow is cleared by mechanical means or salt application ;
- at the junction with the public road. As required by the local highways/roads authority.

If Bituminous macadam is to be used in a forestry setting, advice should be sought from a qualified civil engineer to ensure that the correct system or specification is used.

Care should be taken to ensure that the underlying Formation material is:

- non - frost susceptible to a depth of 450mm;
- of adequate strength and in good condition;
- correctly shaped and fully compacted.

6.6.2 Bituminous surface dressing

Using Bitumin as a surface dressing will not add to the pavement strength as it is simply a thin layer applied to the surface of an existing pavement. The main reasons for its use would be to:

- increase the traction;
- reduce water ingress into the pavement;
- dust suppression.

Bitumin surface dressing on water bound roads can easily fail in frosty weather.

Vibrating rollers should not be used on surface dressing as the chippings may be pushed in

Again, advice should be sought from a qualified civil engineer to ensure that the correct system or specification is used. Correct advice will help to minimise this risk.

6.6.3 Road planing

Road planing can be a useful and cheap surfacing material where available, but does not add to the pavement strength.

The main use for the material is as dust suppression and for avoiding the migration of other surface materials. They can be used thickly at bridges to stiffen approaches and to reduce potholes.

On sensitive sites it is undesirable because it has the potential to leach toxins into the surrounding soils, damage vegetation and pollute watercourses.

Road planing is viewed by some authorities as controlled waste, regardless of the fact that an end use is planned. Advice may be necessary from the local Environment Agency or planning authority on storage (if required) and conditions of use.

7 Contract specification

Understanding what is required to construct a sustainable track within woodland is key to being able to draw up a specification the contractor should follow.

A typical specification should detail:

- Is the track is to be constructed from new / upgraded from existing
- What is the route line the track is to follow
- Consents required / obtained, and where they apply
- Felled width required for clearing the route line
- Width and depth of the Formation – basic / stoned etc
- The use (Tractor/Forwarder/Haulage), and therefore, the type of running surface
- Width of the running surface and radius of corners
- Gradient (between 2% and 20%) and crossfall (between 4.5% and 8%)
- Stone type and depth
- Using a Geotextile membrane, with alternative stone type and depth
- Number of cross drains, their construction, location and diameter and placement.

8 Maintenance and aftercare

8.1.1 Road maintenance

All waterbound tracks lose material over time due to attrition. This loss happens because of weathering as well by the harvesting and haulage of timber.

The correct profile on a track made of good material will shed water efficiently and vehicles will experience a smooth ride. However, sudden changes in camber, adverse camber on bends, differential settlement of the wheel-tracks, deep potholes and ruts are all hazards that may emerge and need to be repaired.

Recarpetting will be necessary from time to time to replace lost material and ensure a smooth running surface.

Maintenance should be carefully planned and programmed in order to maximise effectiveness. The frequency of routine road maintenance should be determined by need and not necessarily by time span.

Take care to limit the loss of expensive pavement stone during maintenance operations.

Herbicide spraying is an effective means of keeping down grasses and non-established woody growth, but it must be undertaken with care and adherence to safety precautions.

Flail mowing can be effective for grasses and small diameter woody growth. A heavy-duty flail mounted on a tractor can clear the vegetation off the carriageway. Given suitable access conditions, this combination can also control vegetation in the ditch and (to a certain extent) on the batter slope.

The limitations on maintenance of harvesting tracks mean that they may well suffer from vegetation growth and water damage. This should not be allowed to progress to the point that the road is in danger of being lost.

8.1.2 Road repair

Routine road maintenance is not always sufficient to keep a road in the condition necessary for the required use. Other repairs are commonly needed because of:

- harvesting damage;
- pavement failure;
- surface failure;
- loss of material.

Harvesting damage can often be minimised or even avoided by good planning and use of the site. However, where damage does occur, for any reason, often the only effective solution will involve additional stone.

Pavement failure is often deep-seated, and may be due to failure in the foundation or structure of the road. This is often associated with excess water causing saturation of the material which has failed. Excavation of the poor material is likely to be the only long-term solution.

In such cases, improvement of the drainage may well be sufficient to reduce the moisture content of the various levels. Reshaping and sealing the Pavement will then prevent the further ingress of water. However, new material may also be required.

Surface failure can be the result of soft material or the breakdown of the surfacing material under repeated load – heavy vehicles travelling back and forth. It is associated with shallow rutting, potholing and an increase in surface fines. There is also some evidence to show that super-single tyres can increase the stresses in the surface layers leading to an increase in surface failure.

In such cases, grading and rolling can easily bring back the track surface profile, but new material may also be required.

8.1.3 Ditch and culvert maintenance

The purpose of ditch maintenance is not so much to have a clean ditch, but to ensure that there is a reasonably free flow of water. In some instances, a clean ditch can increase water velocity to the extent that damage ensues.

Much ditch maintenance is carried out by excavator or by hand, although, on sections of forest road it can be possible to use the grader when road maintenance is occurring.

Where the ditch abuts a forest road, care must be taken to ensure that no damage is done to the road structure during ditch maintenance.

During ditch maintenance, it is essential that the culverts are:

- not damaged by ditch maintenance operations;
- examined to ensure that they are sound and free flowing;
- cleaned out if required (particularly the entrance point);
- that the associated sump is also cleared out.

Although much of the necessary work can be done with the excavator bucket, there is often a need for some manual work. This is obviously true of the cleaning out of culverts. Care must be taken to ensure that culverts are examined to ensure work is carried out adequately to allow water flow.

The sump to any culvert should be sized to accord with the maintenance regime and the capacity of the local soils and track material to erode. Any excavated material should either be removed or placed in a stable position away from the ditch.

Where a culvert has been damaged and water flow through it is restricted, it must be replaced. This will involve excavating a trench to remove the existing culvert pipe and replace with a new one, as per Section 6.3.5.

The removed pipe should be disposed of as per manufacturer's guidance, and excess minerals either reused, if suitable, or cast aside and spread locally.

8.1.4 Weather effects

Although frost, snow, ice and rain are often the most commonly considered weather effects, dust control can also be very important.

Water damage is common. It should be dealt with as early as possible to try to prevent serious damage ensuing.

Frost, snow and ice must be treated with extreme care. Reduced traction will mean increased hazard.

Salt should not be used in an effort to remove snow or ice. Not only will rapid thawing render the surface loose, saturated and weak, but salt is deliquescent to some extent and will continue to attract moisture from the atmosphere. Drying out of the track thus becomes a very slow process. Salt will also damage adjacent vegetation.

Coarse grit should be used to improve traction. It will bed into snow and ice, and when the weather improves will be removed by traffic.

In warmer, drier weather, dust control can be a problem with water-bound road surfacing materials. As the surface dries out, fine material ceases to be bound in and can be removed by the effect of wind or the passage of a vehicle. Loss of fines not only affects the integrity of the road in that the surface may become loose due to lack of binding, but may represent a nuisance or even a health risk. This will depend on the situation.

9 Useful references

- Forest and Water Guidelines (4th Edition)
- Forest Research TCB Technical Note 27/98 – Access track construction in small woodlands

Appendix 1: Economic appraisal

Economic appraisal is a scientific equation used to minimise the total costs of extraction of timber from stump to the public road, and to provide an optimum road / track configuration for a particular woodland. In theory, the minimum infrastructure cost occurs when the total roading cost approximately equals the extraction cost. See Figure 10.

The relevant equations for optimum road density and optimum spacing that result from this principle are:

Road density, $x = \sqrt{\frac{k.h.V}{R}}$ m/ha   spacing, $S = \sqrt{\frac{2.R.ni.wf}{h.V.ei}}$ km

Where,

ei	=	extraction inefficiency, taken as
		1.30 for extraction using wheeled vehicles
		1.10 for extraction using cable crane
h	=	extraction costs pence / m^3 / 100m
k	=	(0.25 . ni . ei) / wf
ni	=	network inefficiency due to junctions, terrain limitations etc., taken as
		1.35 in flat terrain
		1.40 in hilly terrain capable of being worked by wheeled vehicles
R	=	combined cost of initial construction and the capitalised cost of annual maintenance expressed as £ / m
V	=	discounted vol. m^3 / ha (i.e. average volume discounted back to time of first thinning)
wf	=	working factor relating to the use of the road, taken as
		1.0 for extracting from one side of the road only
		2.0 for extracting from both sides of road

The ability to work to both sides of the road is obviously more efficient and would require less roading.

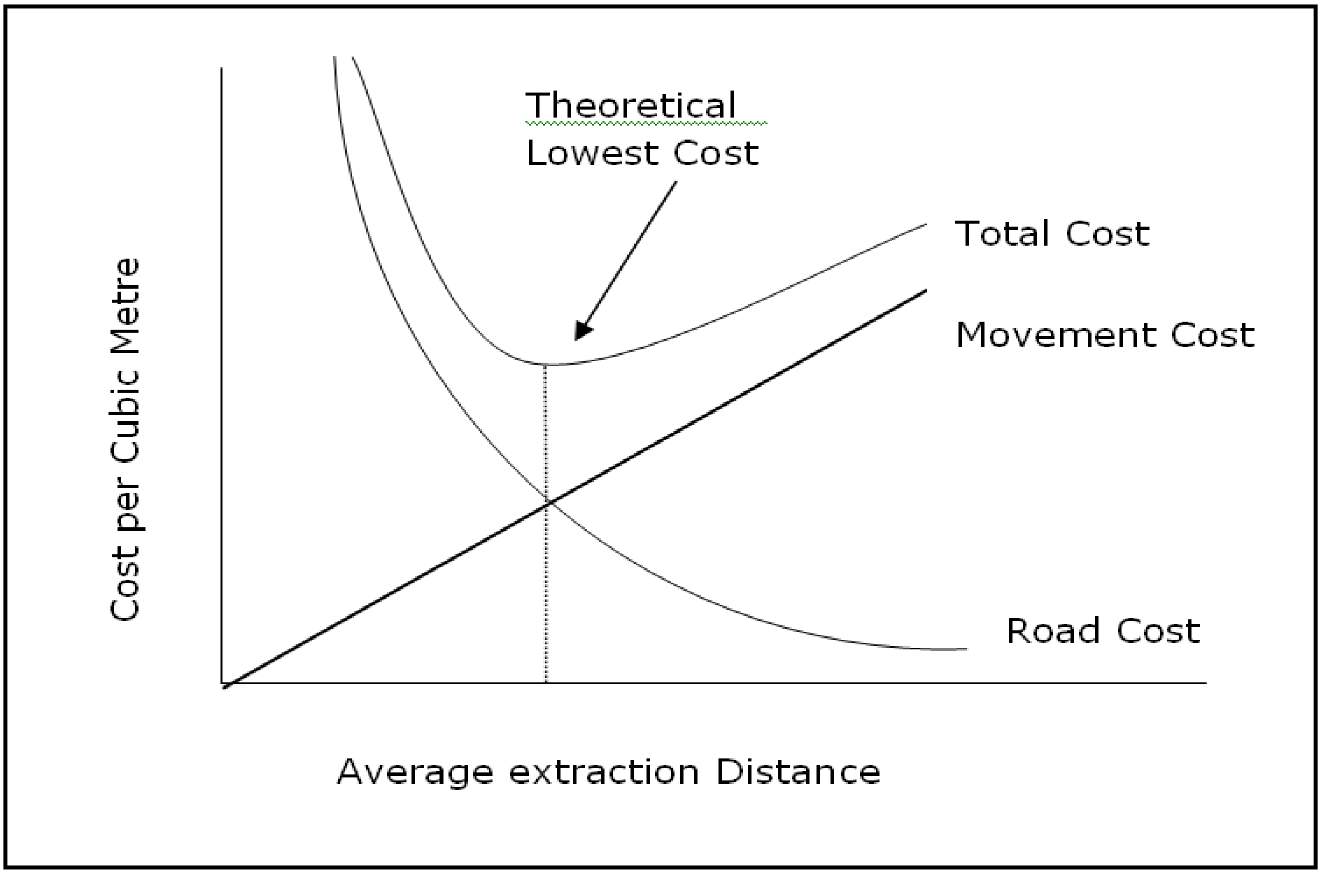
Although there is a theoretical optimum road density and minimum cost, a balance has to be struck in any particular location. More road length increases the roading cost but reduces the extraction cost by cutting down the distance from stump to roadside.

Good forest roads cost more than tracks, but they should be usable throughout a greater part of the year.

The choice of harvesting system could have a limiting effect upon the spacing of roads.

The appraisal is usually taken over a complete crop rotation, and normally assumes the road to have no residual value.

Figure 10



The positioning of a road can also be appraised to some extent. In steep terrain, uphill extraction will obviously be more expensive than downhill. A reasonable approximation might be to site the road so that the ratio of extraction distance uphill to downhill is the same as the ratio of extraction costs downhill to uphill. For example, in a simple situation, this means that for a rectangular plantation with boundaries and road perpendicular to the slope

$$\frac{Dup}{Ddown} = \frac{Vup}{Vdown} = \frac{hdown}{hup}$$

where 'D' = distance, and 'V' and 'h' are as defined in the table above.

A further appraisal may be required to ascertain the optimum timing of the provision of facilities in relation to the timing of harvesting. Computer appraisal programmes, such as FIAP, can be used to optimise timing of activities.
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Appendix 2: Soil strength, Formation width and Pavement thickness

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road subgrades and base courses. The CBR test is fully described in BS 1377: Soils for civil engineering purposes: Part 4, Compaction related tests.

The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. The harder the surface material, the higher the CBR rating, but moisture in the soil can have a significant effect on soil strength.

The following table which follows gives an indication of the variations of CBR which are possible at different moisture contents:

Table 7 - CBR

	CBR (California bearing ratio)	
	Position of Water Table	
Soil Type	>600mm below formation	<600mm below formation
Heavy clay	2 – 3	1 – 2
Silty clay	5	3
Sandy clay	6 – 7	4 – 5
Silt	2	1
Sand (poorly graded)	20	10
Sand (well graded)	40	15
Well graded sandy gravel	60	20

Formation width and Pavement thickness are a function of many factors including:

- sub-grade strength
- variation expected in moisture content
- pavement and surface material quality
- number of axle loadings, and their intensity

The Pavement width must be structurally sound over the total running width. By having a designed thickness of Pavement, it allows material quantities (locally won and imported) to be assessed and costed, and a Bill of Quantities to be formed.

The final use of the running surface will dictate what materials are actually applied on the ground. NB - harvesting track will have a more robust surface than a haulage road, but they should be constructed to the same thickness of Pavement in order to have the right strength.

The following table gives an indication of the total thickness of pavement that will be required for the various CBR values.

Table 8

Typical material (but see previous table)	CBR (%)	Minimum Formation Width (mm)	Pavement Thickness (mm)
Peat, silt	<2	6000	>850 (consider excavation)
Silty clay	2	5500	700
Heavy clay	3	5400	550
Sandy clay	4	5400	475
Saturated sand	7	5400	325
Fine sand	10	5400	250
Graded sandy gravel	20	5400	150
Rock	250+	5400	Min. 100 to allow grading of surface

Notes to Table

- The minimum Formation width has been calculated based on a running width of 3400mm, plus 1.5 times the Pavement thickness on each side, with an overriding minimum of 5400mm.
- The minimum Formation width will need to be increased to allow for a topside ditch on sloping ground, an embankment, or for safety reasons e.g. to keep the traffic away from a large drop down an embankment or into a ditch.
- Sub-grade strength often varies extensively under the Formation of a new road. Subsequent drying out of the sub-grade and pavement often increases the strength.
- It may be impracticable to drain fibrous material (peat) and some clay soils successfully.
- Pavement thickness can often only be assessed by using site based, competent judgement.
- The minimum depth of construction to obtain the desired strength should be used.
- The Pavement material needs to be of appropriate strength for the depth below surface. Lower layers can often be constructed using a low quality locally won material.
- The top 100mm of pavement must be of a durable stone that will not readily break down under the wheel loading. It must also be suitable for grading and rolling.
- Surfacing may need a binder / sealer of fines or cohesive material.

Appendix 3: Gradients, alignments and curves

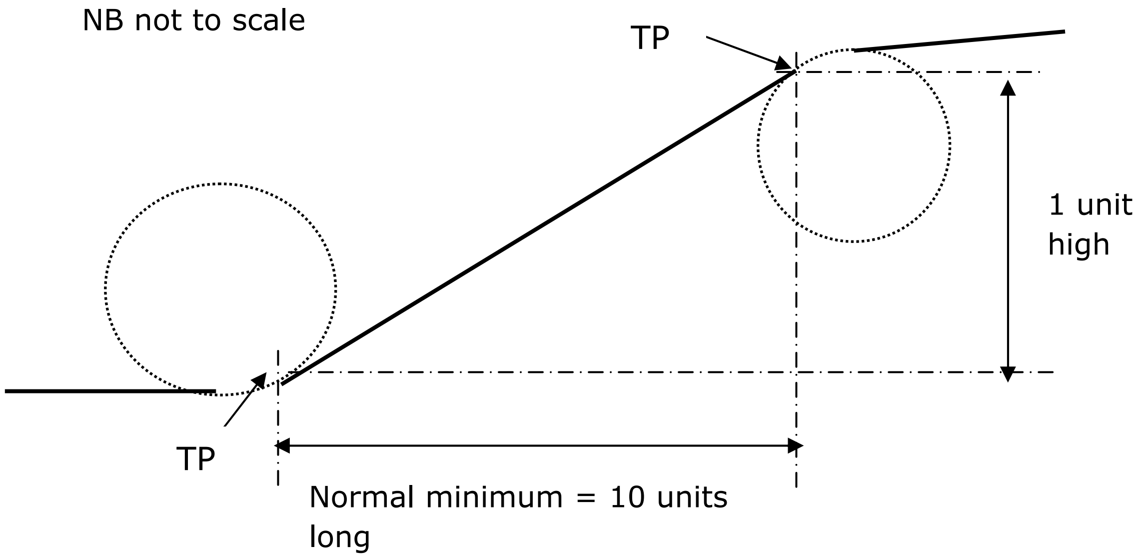
Measuring Gradient

Forest roads are normally constructed of water-bound macadam. This form of construction has limitations for traction, particularly under wet or frozen conditions.

- Where possible, gradients should be maintained within the range of 3-7% to avoid both flat gradient effects (e.g. potholing) and steep climbs. Given the normal methods of setting out a forest road, an accuracy tolerance of 0.5% is considered reasonable.
- The nominal maximum gradient should be 10% on straights or horizontal curves that do not require road widening.

Gradient should be measured between tangent points (TP) as shown schematically below.

Method of Measuring Gradient



Experience has shown that short lengths (< 200m) of steeper gradient (≤ 12.5%) within an overall gradient of 10%, can be accommodated on water-bound surfaces in good conditions. However, this relaxation must be used with caution, and only where it can be safely accommodated within the prevailing geometry.

It is difficult for lorries to move off from rest on a steep gradient. Where possible, stacking bay and turn-round locations should be planned for points where the gradient is no steeper than 5%, or where the gradient can be slackened over a short length to ease loading, increase stability when manoeuvring and aid traction.

A bituminous surface will allow lorries to negotiate much steeper gradients (~ 16%), but such a surfacing is expensive both to construct and to maintain. However, in some circumstances this could save considerable road building costs.

To facilitate ease of movement from rest, wherever possible, the approach gradients to junctions should be limited to 5%.

Vertical alignment – minimum gradient

Water-bound macadam gives rise to problems of surface water disposal.

Standing water on the surface rapidly leads to saturation, a reduction in Pavement strength, and the formation of potholes.

Roads constructed with a longitudinal gradient will always shed water better than roads that are essentially level. This is especially important in the bottom of sag curves. Such lengths should be kept to a minimum.

The recommended minimum longitudinal gradient is 2%.

Horizontal alignment

NB: The following recommendations are based upon the normal 16.5m length articulated vehicle permitted under the Road Vehicle (Construction and Use) Regulations 1986.

In general, a rigid vehicle (even with drawbar trailer) will perform most manoeuvres within the space required by a large articulated vehicle.

The design width for new construction and upgrading will be 3.4m on a straight carriageway.

This width will have a tolerance of 0.2m resulting in an actual minimum width of 3.2m.

- The tolerance quoted above has been introduced to take account of the normal construction methods used for forest roads. Every effort should be made to achieve the nominal design width.
- The widths quoted above refer to running surface. This width does not include any berm, safety margin or side slope of any description.

Horizontal curves

Circular curves will normally be used for horizontal bends. The recommendations which follow are based upon the outside radius, this being the line normally followed by the outside front wheel of an articulated vehicle.

To allow for trailer wheel cut-in, bends will normally be widened on the inside, as shown in Figure 11 below. Because of the assumed low vehicle speed, transition curves will not normally be provided.

Straight transition lengths are normally used to gain the additional width. See Figure 1. If widening on the outside of the bend is unavoidable, these transition lengths should be increased by 10m.

Table 9 below shows the recommended widths and gradients for horizontal curves. Intermediate values for distance, gradient and radius can be obtained from by interpolation.

There is no need to widen curves of radius 90m or greater, or where the deflection angle is less than 15°.

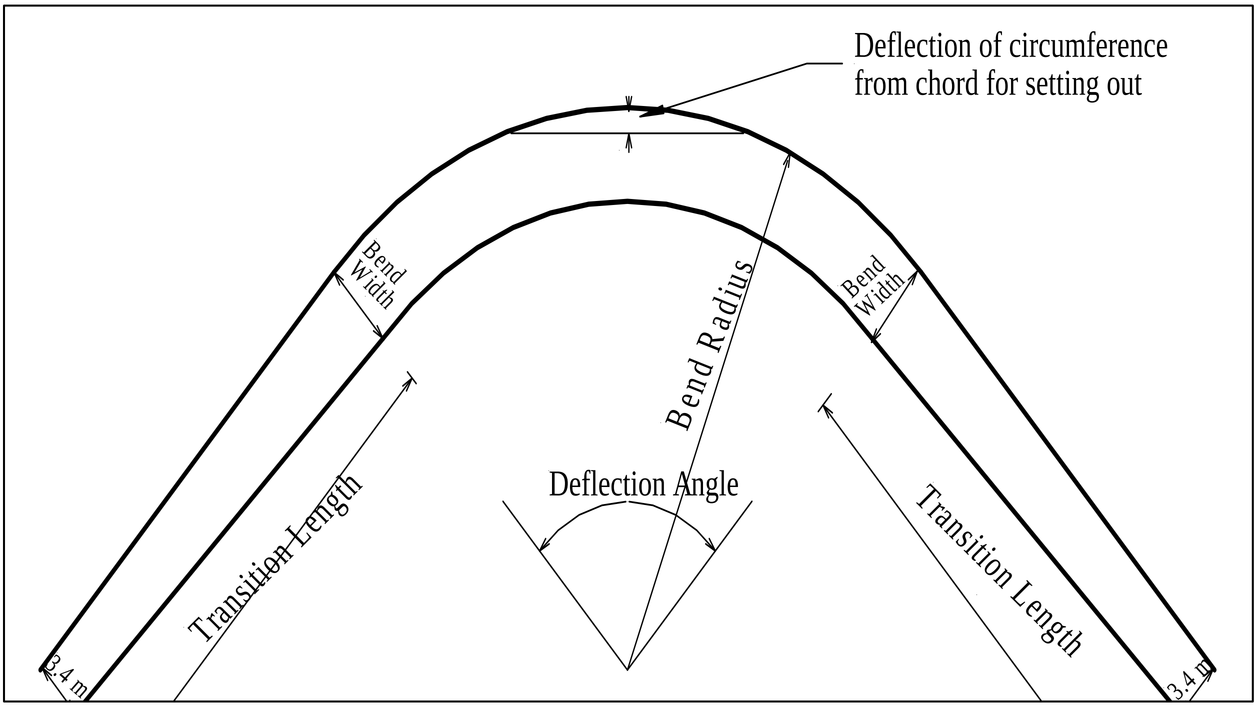
It must be noted that bends below 45m radius cannot be safely negotiated at 15mph (25 km/hr) by articulated vehicles.

Table 9: Horizontal curve recommended widths and gradients

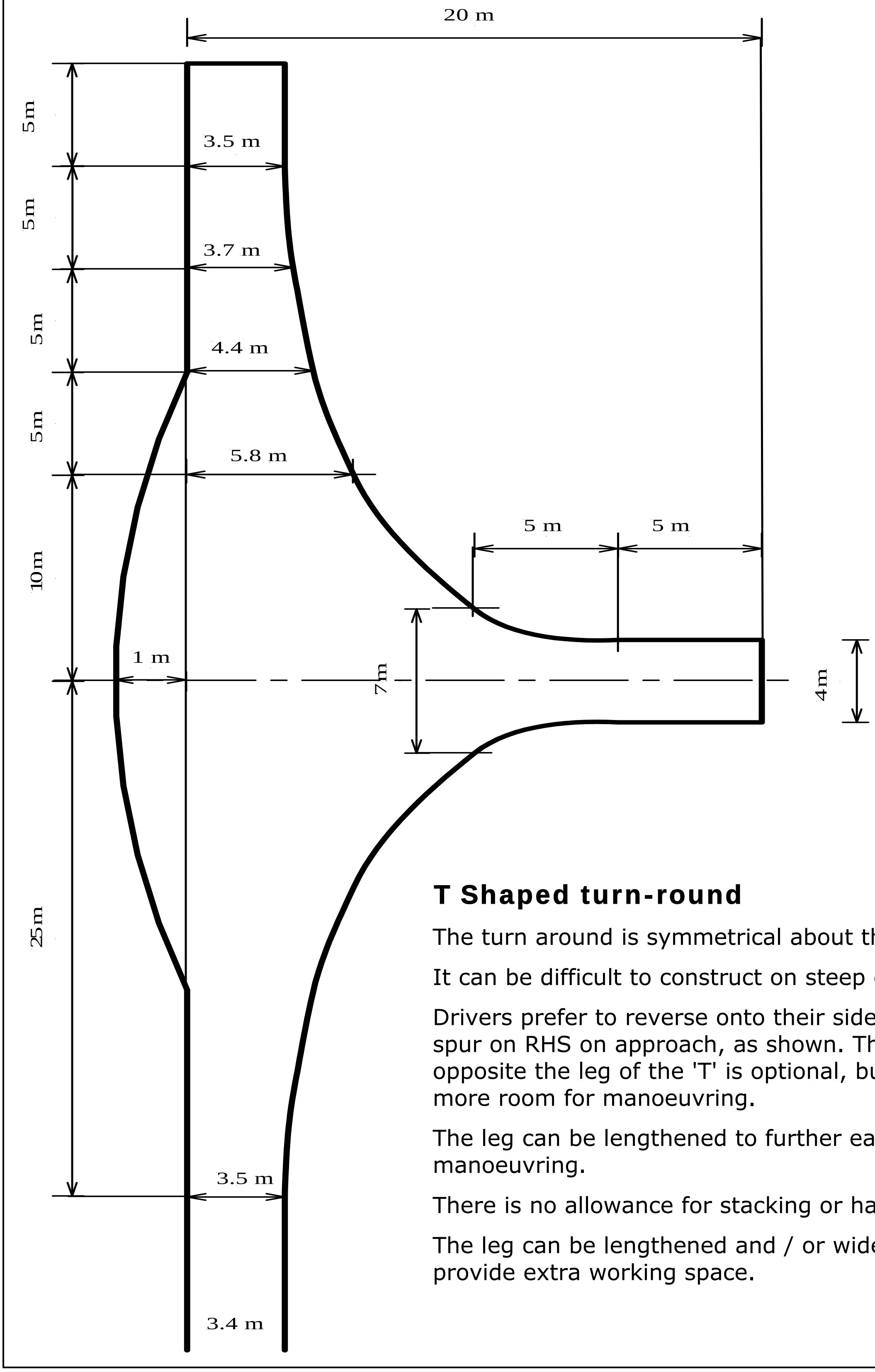
Deflection of circle. From chord of length for setting out (m)			Outside Radius	Minimum widths for maximum Angle of deflection (°)				Transition Straight Length	Maximum desirable gradient on outside radius
15m	20m	30m		15	45	90	180	**	**
				Running surface width					
m	m	m	m	m	m	m	m	m	%
0.3	0.6	1.3	90	3.4	3.4	3.4	3.4	-	10
0.5	0.8	1.9	60	3.4	3.8	4.0	4.0	20	8
0.6	1.1	2.6	45	3.4	4.0	4.5	4.5	20	7
1.0	1.7	4.0	30*	3.4	4.4	5.0	5.1	25	6.5
1.2	2.1	5.0	25		4.6	5.1	5.3	30	5
1.5	2.7	6.8	20		4.9	5.6	5.9	30	4.5
2.0	3.8		15			6.3	7.0	40	4
			10***				10.0	40	5 on diagonal

* Preferred minimum radius
** Figures based on experience
*** Absolute minimum hairpin

Figure 11



Appendix 4: Diagrams for a T Shaped turn-round



T Shaped turn-round

The turn around is symmetrical about the spur leg.

It can be difficult to construct on steep cross-falls.

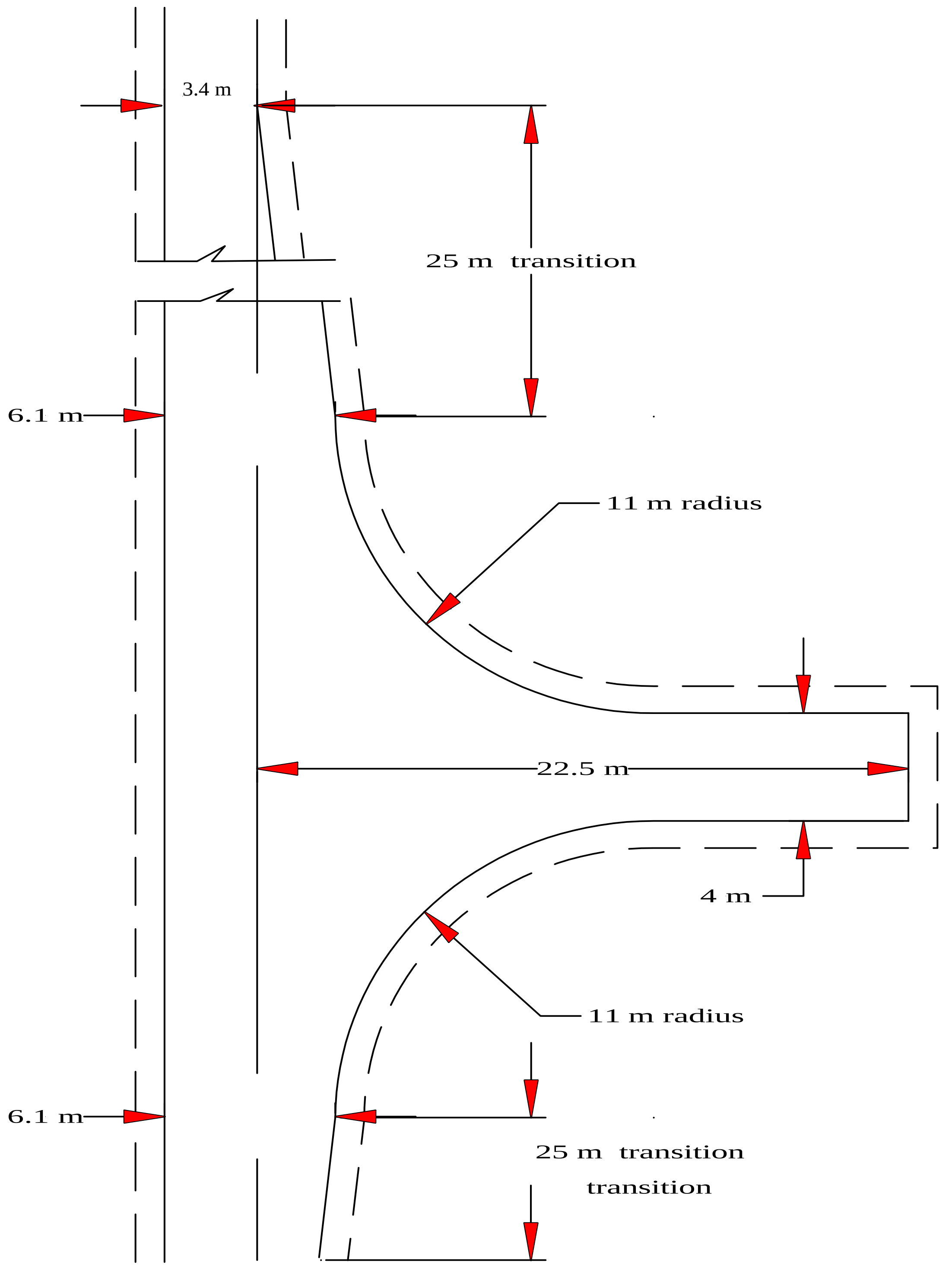
Drivers prefer to reverse onto their side, i.e. with spur on RHS on approach, as shown. The widening opposite the leg of the 'T' is optional, but this allows more room for manoeuvring.

The leg can be lengthened to further ease manoeuvring.

There is no allowance for stacking or harvesting.

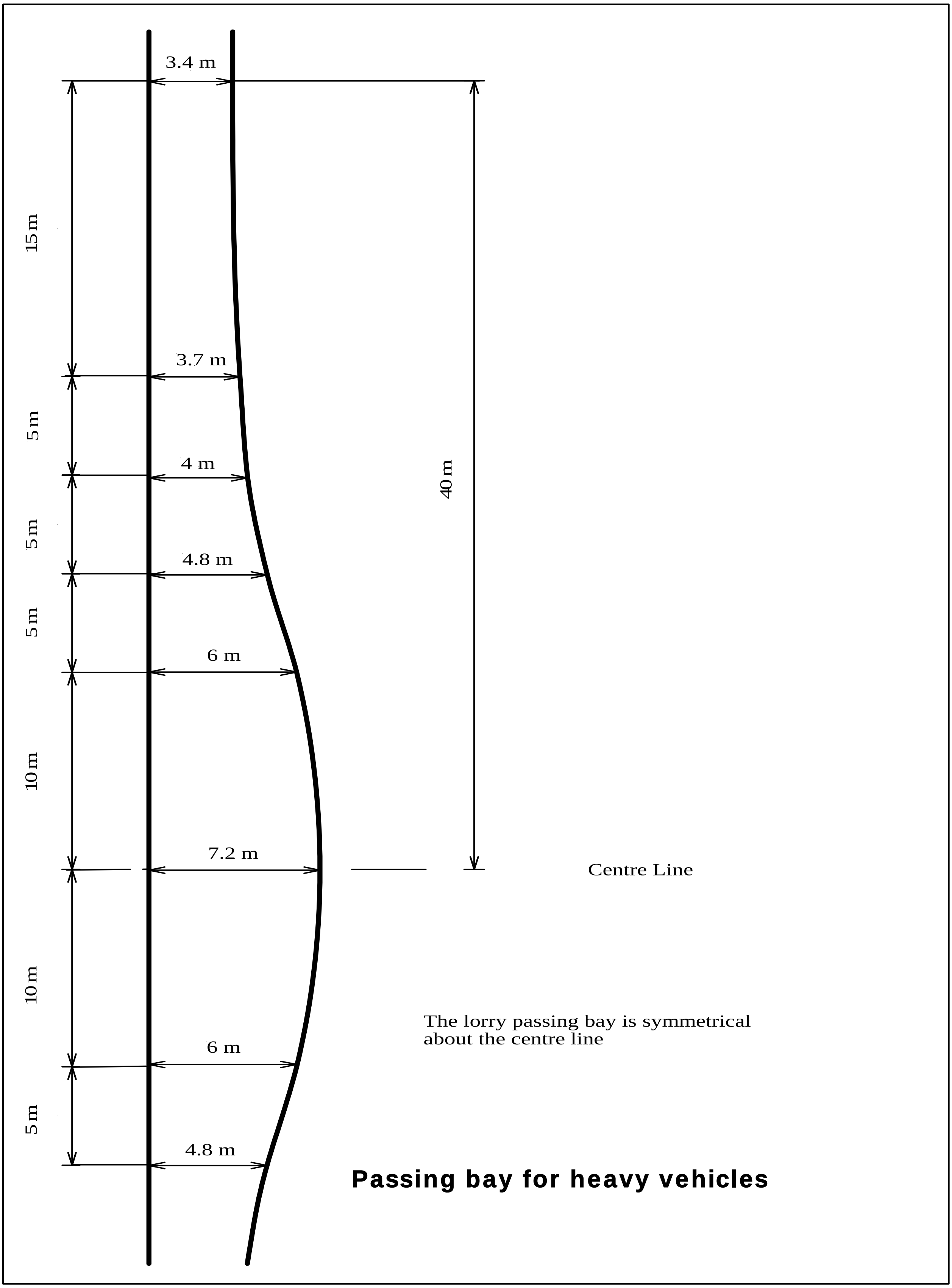
The leg can be lengthened and / or widened to provide extra working space.

Alternative diagram: T Shaped turn-round.

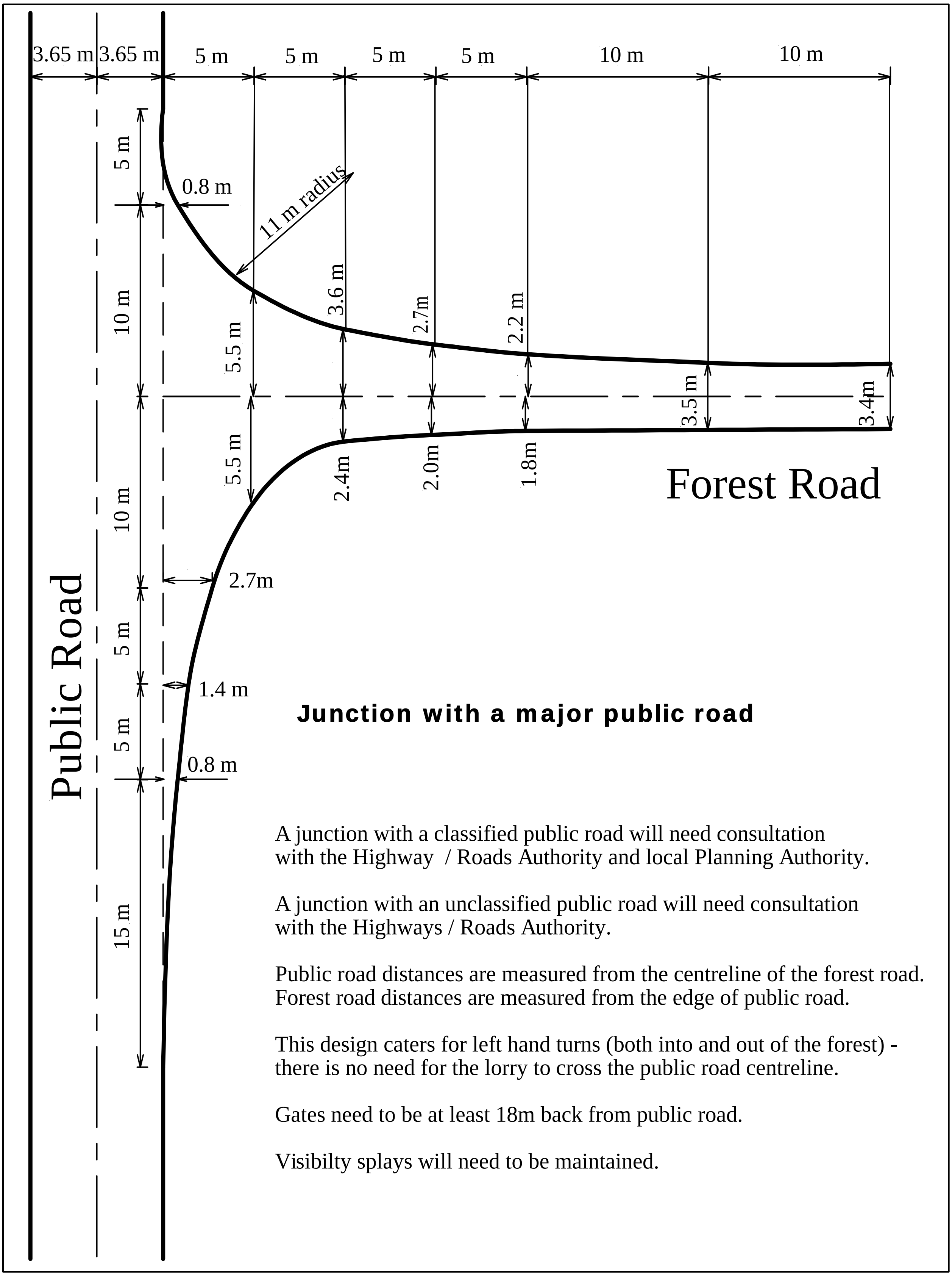


T Shaped turn-round

Appendix 5: Diagram for a passing bay



Appendix 6: Diagram for access to the public highway



Junction with a major public road

A junction with a classified public road will need consultation with the Highway / Roads Authority and local Planning Authority.

A junction with an unclassified public road will need consultation with the Highways / Roads Authority.

Public road distances are measured from the centreline of the forest road.
Forest road distances are measured from the edge of public road.

This design caters for left hand turns (both into and out of the forest) - there is no need for the lorry to cross the public road centreline.

Gates need to be at least 18m back from public road.

Visibilty splays will need to be maintained.

Alternative diagram: Access to the public highway.

Skewed junction for a minor public road

Consultation is required with the Highway / Roads Authority (and local Planning Authority if road classified).

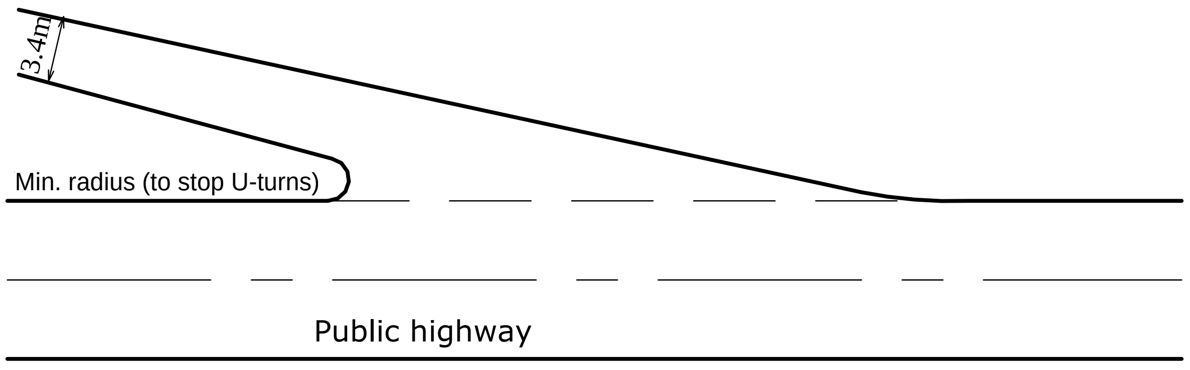
Reducing the junction angle reduces the earthworks, but increases the interface, (hence possible increase in surface treatment and longer ditch piping).

Increasing junction angle reduces the need for carriageway support.

Set forest road gate 18m back from edge of public highway.

Keep gradient to 5% on approach to forest road gate.

Visibility splays will need to be maintained.



Appendix 7: Cross section diagrams of track profile on slopes

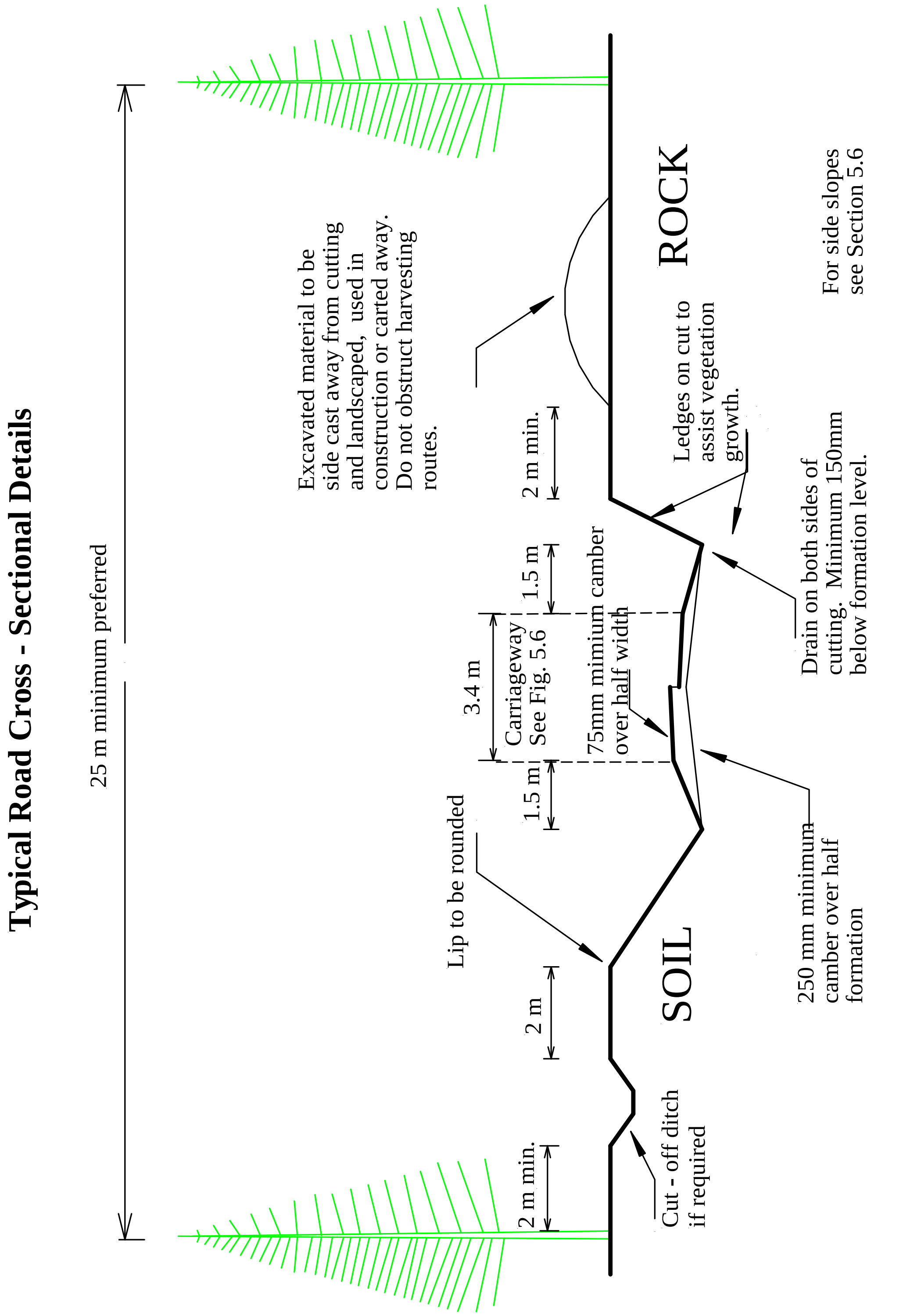


Figure 5.1 Cutting in Soil or Rock

Typical Road Cross - Sectional Details

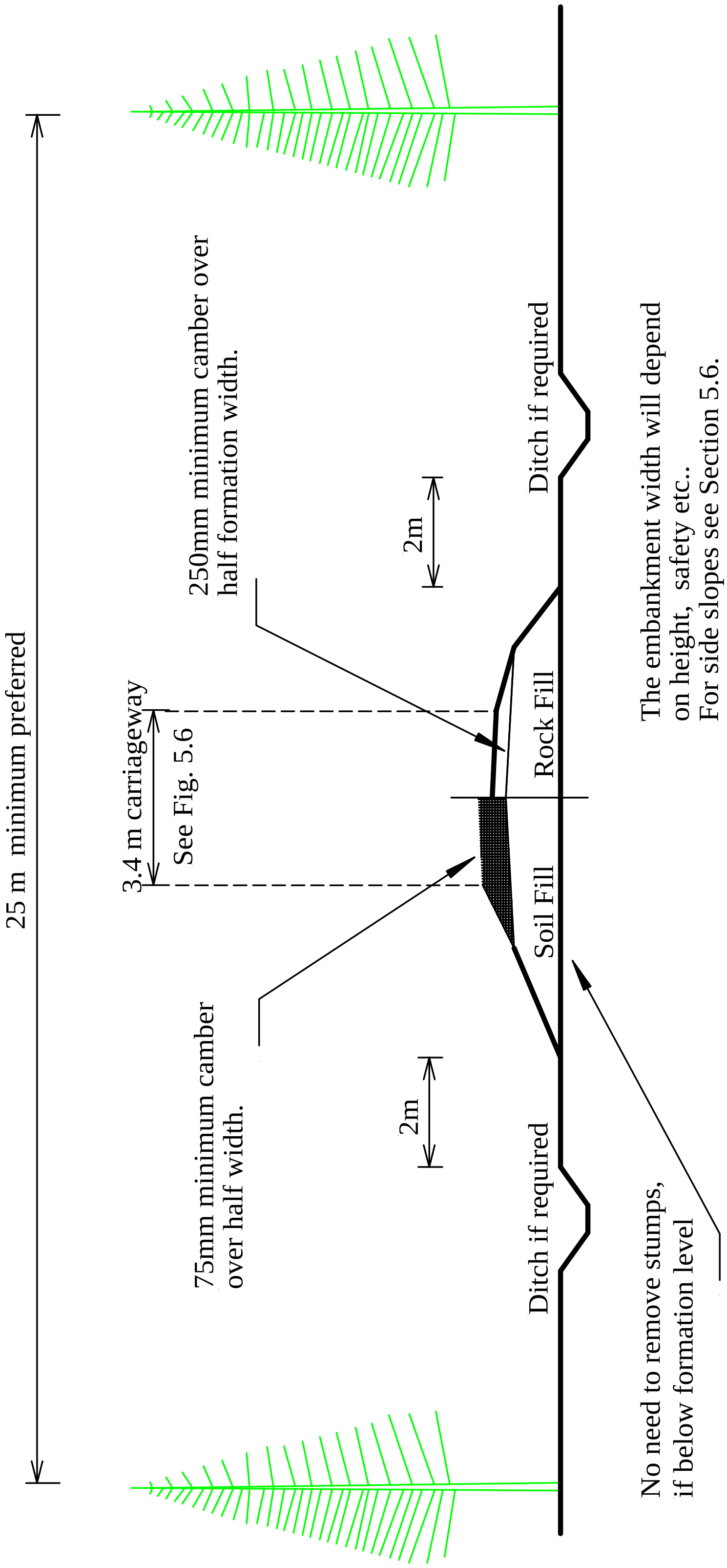


Figure 5.2 Embankment on Good Foundation

Typical Road Cross - Sectional Details

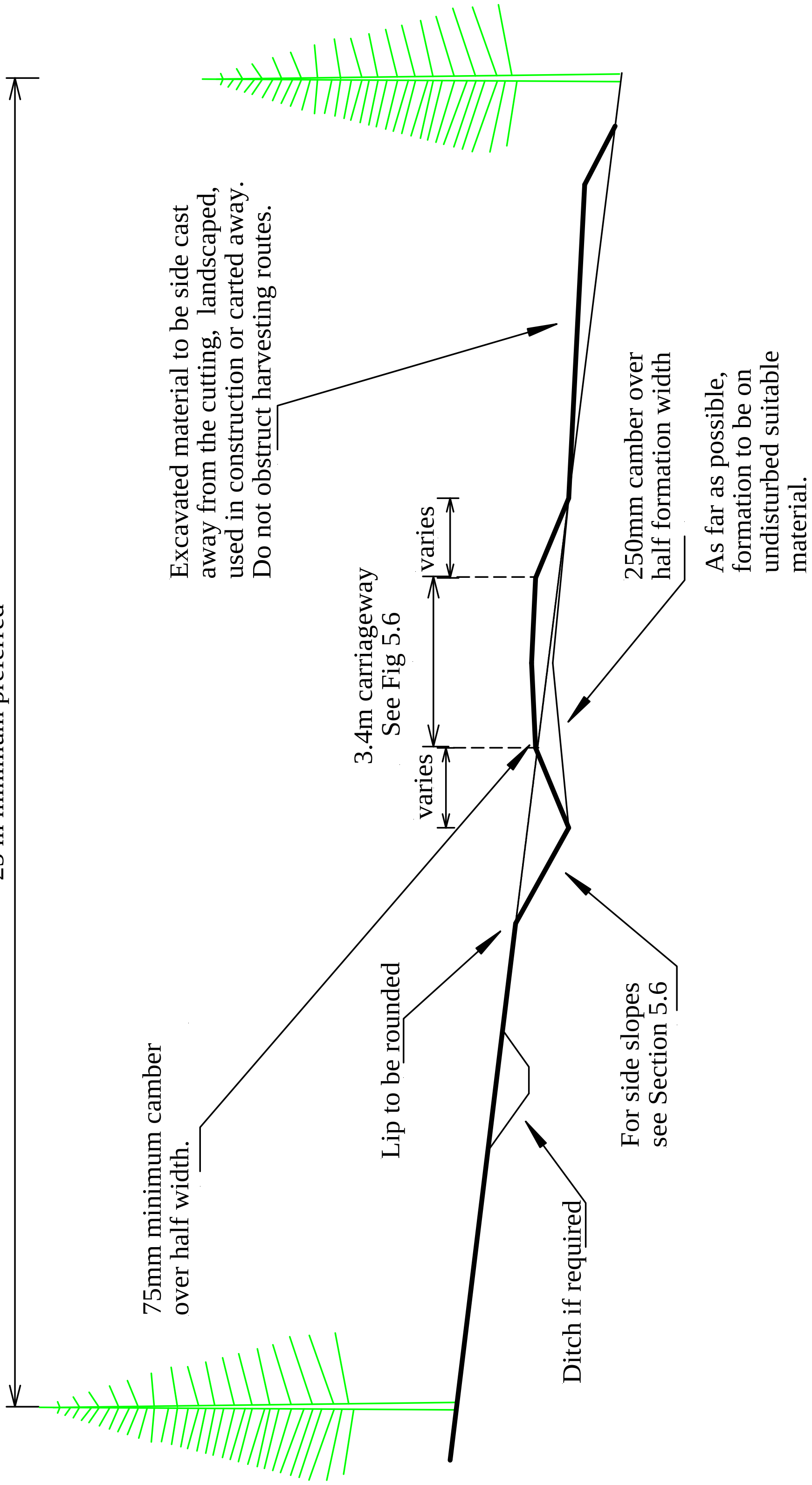


Figure 5.3 Cross Fall up to 10 Degrees

Typical Road Cross - Sectional Details

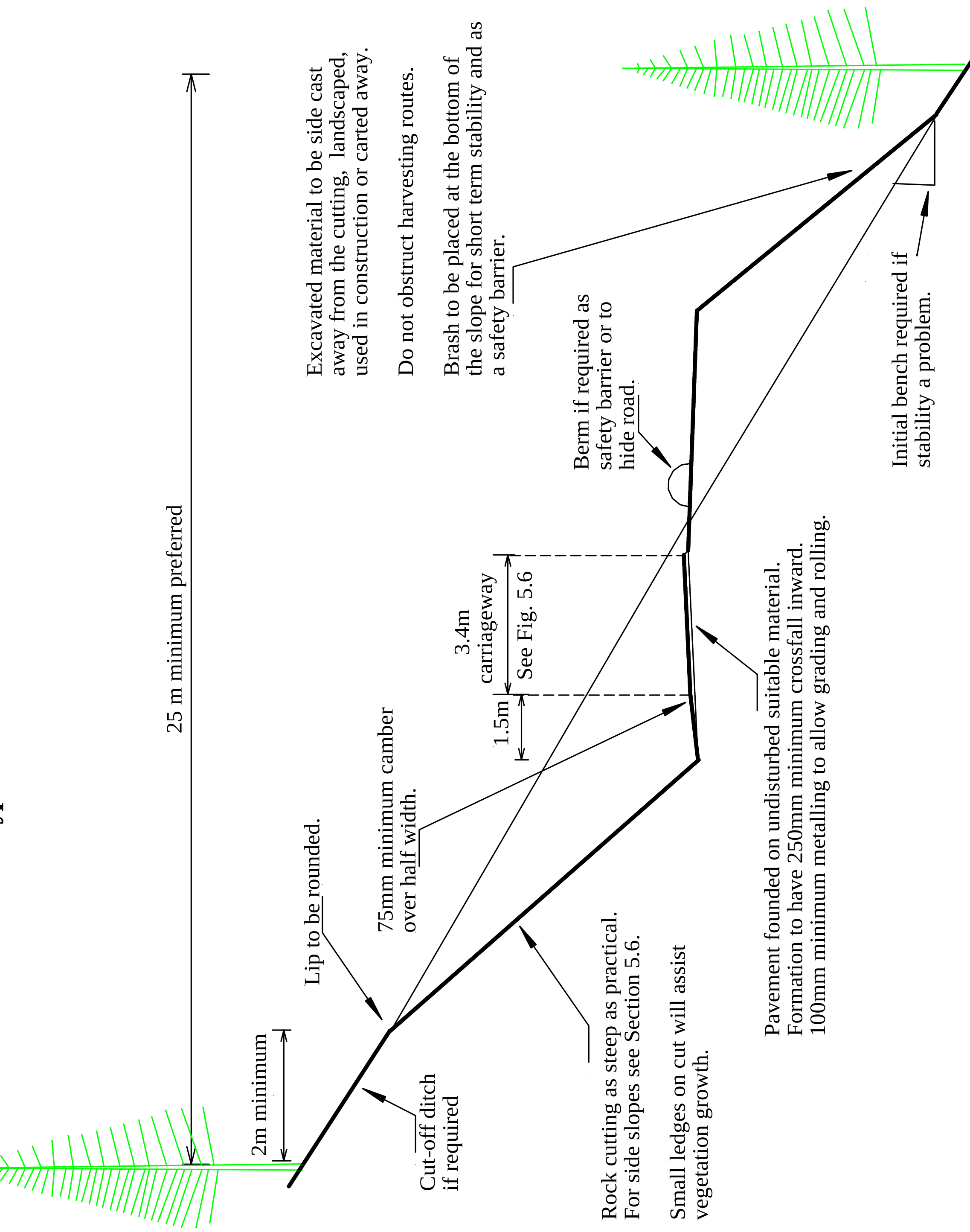


Figure 5.5 Rock Ledge Cut into Steep Cross Fall