

Harvesting Best Management Practice Manual



Environmental Section
Buchanan Renewables
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1. Why best management practices

When forestry and plantation products are harvested using heavy equipment that can disturb soil, runoff carrying sediment may occur. This sediment-laden runoff is called 'non-point source pollution' if it gets into rivers, streams, lakes, ponds or wetlands. Other types of non-point source pollution include lubricants leaks, fertilizer and pesticide applications.

The basic principle behind best management practices (BMPs) is to minimise the overland spread and volume of water carrying sediment and nutrients that

- Impact wetlands and water bodies, which can ruin natural habitats for wildlife, and has the potential to irreversibly change local ecosystems.
- Impact drinking water supplies making water undrinkable for many villages who rely on creeks and rivers as their sole supply of water
- Impact fish/amphibian/reptile habitats, many of which villages have worked to ensure are sustained for food needs.
- Deplete soil nutrients creating sterile areas in which vegetation (including food and tree crops) will not grow. This effectively defeats our goal of sustainable harvesting.

BMPs also prevent rutting and will preserve access for future activities. They will also improve the looks of the harvesting process which is important for company public image.

Correct usage of the BMP will not only allow us to work to good environmental guidelines, but will assist us in working efficiently and ensure that the long-term sustainability goals that we all strive to achieve are maintained.

2. Planning

Planning is one of the most important BMPs, and the first to consider. This planning phase is a requirement under the Buchanan Renewable harvest management plan (BR HMP) process. Planning ahead can save time in the future once the job begins. Good planning will highlight any possible problems prior to them occurring and can result in the most efficient use of machinery, and reduce wear and down time.

Locate landings, access roads and skid roads to avoid steep slopes, wetlands, vernal pools, and stream crossings. It may be more cost effective and efficient to longer skid trails to avoid these situations. Avoiding them will also mean less possibility of erosion. Consider alternatives such as obtaining permission to access the neighbouring property to avoid such situations.

Planning not only means you will have access to the plantation, but also when the plantation has been felled can be accessed with ease for further development.

Timing is one of the most important BMPs. Operating within the dry season, when the ground is dry is an excellent way to reduce erosion.

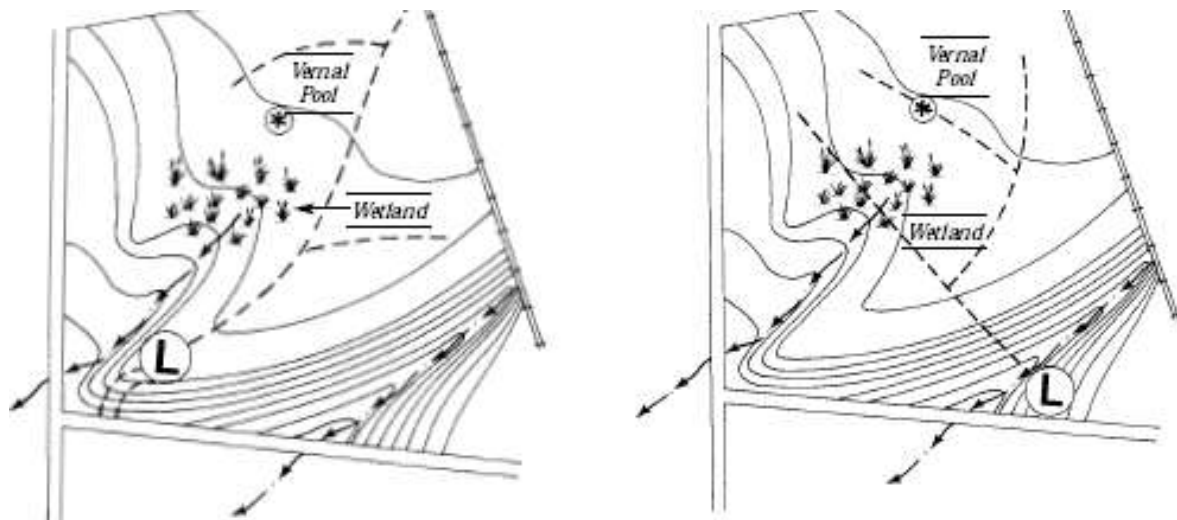


Figure 1. Topographic map of felling area. Left a well planned operation, avoiding sensitive areas. Right skid trails in conflict with such areas.

A harvest management plan must be completed prior to felling and must include a description of erosion control measures to be used. The HMP map should also show the proposed location of all truck roads, principle skid roads, streams and wetland crossings, as well as the general location of appropriate erosion control measures, such as Riparian Management Zones (RMZs).

Operating on sustained slopes of 30% or more for a slope distance of 200 feet or greater requires the indication of the steep slope areas on the HMP map. Special care must be taken to prevent erosion from roads, skid roads, and trails by closely following erosion control practices such as water

bars to stabilise these areas during and after the felling operation. Specific measures to control erosion in these areas should be detailed in the plan.

No logging equipment may operate within these Riparian management zones except;

- To reduce environmental damage shown to be necessary in a statement within an approved HMP
- At an approved stream crossing
- On a pre-existing road
- In riparian management zones greater than 50 feet in width, beyond 50 feet from the water body. In this case, equipment can operate beyond 50 feet from the water body, as long as no principle skid road is located there, disturbance of the soil is minimised, and any disturbed soil is promptly stabilised.

Site managers will have a copy of the HMP on the job site, so that it can be referred to or inspected at any point.

3. Skid Trails

Skid Trails should be kept the minimum number possible, and should be implemented so that they use existing road structures or have the most direct route to the landing site, taking into account local topography. Multiple skid roads are not to be used within the same area without good reasoning. Should multiple skid roads within the same area be required, this should be documented in the HMP.

Skid trails should avoid waterbodies and wetland areas preserving RMZ zones and only entering RMZs at the designated crossing points.

On primary skid roads constructing a series of water bars at intervals along a road allows the volume of erosive water flowing down the road to be reduced. Without water bars, flooding, washouts, and accelerated road degradation can occur.

Water bar spacing locations should use common sense in their placement, since local terrain often prevents them from being located exactly where the guidelines below specify, however these guidelines are a requirement of BR harvest management and environmental practices.

Road Grade (%)	Approximate distance needed between water bars (Feet)
1	400
2	245
5	125
10	78
15	58
20	47
25	40
30	35
35	32
40+	29

The correct procedure for the installation of a water bar is;

1. Angle of the centre line of the road is roughly 30 degrees (i.e. not perpendicular)
2. Height of the berm and depth of the ditch is between 8-12"
3. Outflow for water from the ditch is open and extends beyond the edge of the skid road
4. Reinforce the berm with a log or similar material.
5. Make them deep to ensure that they last
6. Mulching or seeding the berm will reduce scouring or erosion to the berm and will ensure that it will last.

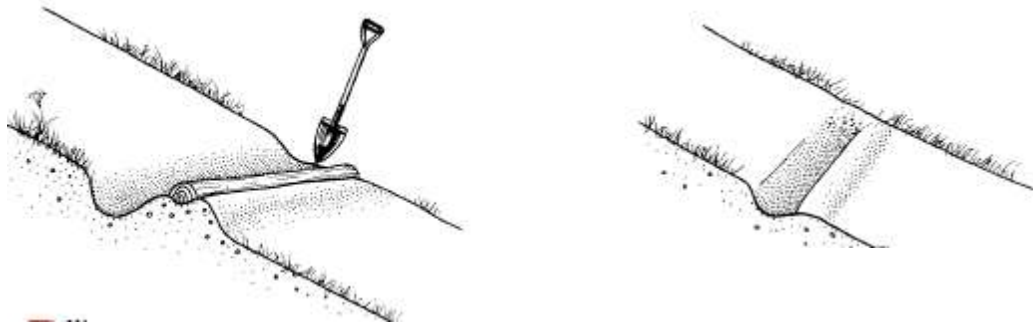


Figure 2. Two water bars; Left, Proper procedures as indicated. Right, incorrect procedures

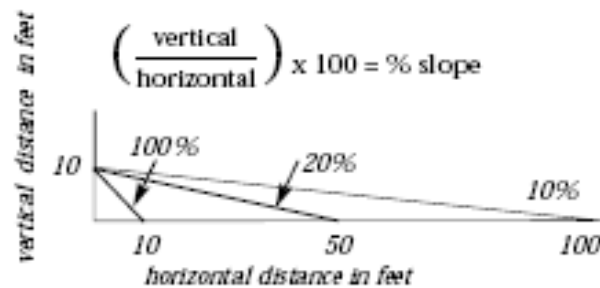


Figure 3. How to determine the slope of an area

Skidders should not be operated on slopes greater than 60%, unless special permission is given by BR management. In these cases, the production team must show that soils are stable and that measures will be used to minimize erosion during and following the operation.

Do not operate a machine in a wetland unless the ground is dry, or otherwise stable enough to support it. Identify the location of the wetland or stream crossings on the ground with clear identification methods (flags, hi-visibility tape etc) as well as on the map within the HMP.

No machinery is allowed to operate in a vernal pool or area of conservation value (key habitat or cultural sites) at any time of the year. A RMZ must surround each vernal pool

No equipment may operate in RMZ except

- To reduce environmental damage shown to be necessary in a statement within an approved HMP
- At an approved stream crossing
- On a pre-existing road
- In RMZs greater than 50 feet in width, beyond 50 feet from the water body. In this case, equipment can operate beyond 50 feet from the water body, as long as no principle skid road is located there, disturbance of the soil is minimised, and any disturbed soil is promptly stabilised.

All principle skid roads will be stabilized whenever they are left inactive for one month or more, or whenever the production or environmental teams determine such work is necessary. All necessary and required erosion controls will be performed by the completion of the operation.

Monitor weather forecasts and plan ahead for severe storms. Most sediment enters a stream following a severe storm. Processed slash from the chippers or grass bales, are a good way to keep sediment from entering streams at crossings and water bars

Consider topography in the location of skid roads. Avoid steep slopes and follow the contours of the local surrounds where possible.

Choose skids roads partially on the basis of which trees and scrubland are best to damage. Every reasonable effort should be made to preserve advance regeneration of the areas worked in.

Roads and skid trails should be smoothed and repaired after felling and left in a stable condition to resist erosion, through the implementation of water bars, mulching and the use of planted grass lines¹ where necessary.

¹ See SOP on use of planted grass lines.

4. Truck Roads

Adequate drainage ditches, culverts and water bars will be provided, and runoff will be led into RMZ or grass impoundments to remove sediment.

Access roads from the chipper to a road should be mulched to enable soil stabilization

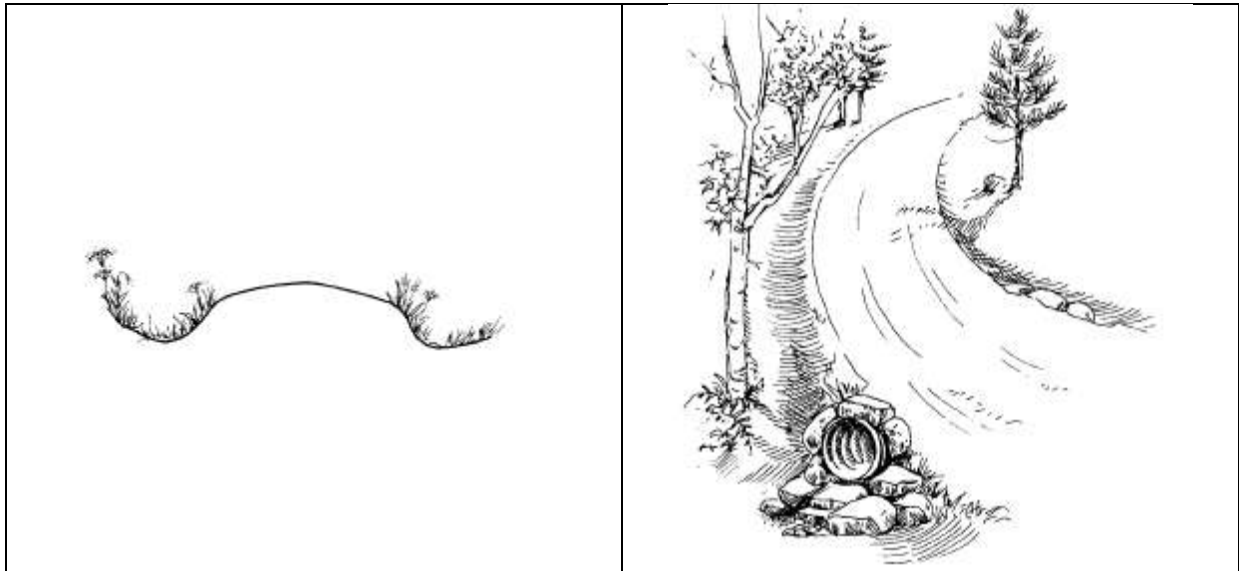


Figure 4. Road with proper crown and ditches in place, and occasional broad based dips, and culverts in use

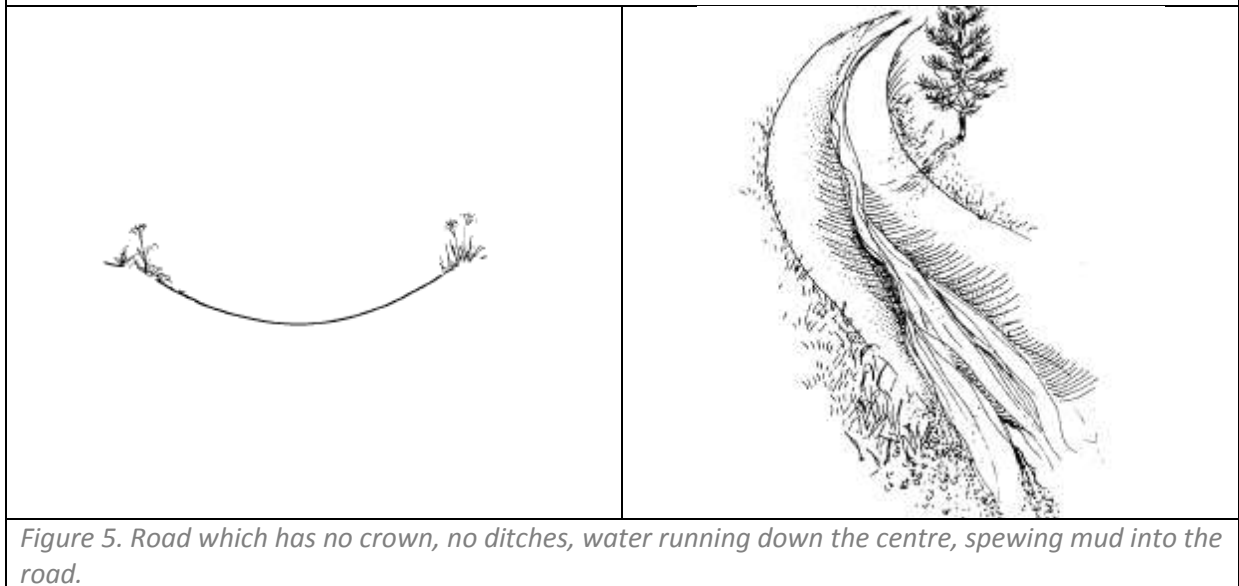


Figure 5. Road which has no crown, no ditches, water running down the centre, spewing mud into the road.

When culverts are used, the harvest management plan must state its diameter, based on the culvert sizing table below²;

Area above pipe (acres)	Pipe diameter (inches)	
	Type I	Type II
1	8	8
5	12	12
10	15	18
15	18	24
20	24	24
25	24	24
30	24	30
35	30	30
40	30	30
45	30	30
50	30	36
75	36	36
100	48	36
150	48	48
200	60	48

Broad based clips can be installed by a bulldozer, and are easier to maintain than culverts, since they do not have to be cleaned out. They also cannot be broken down by off-road vehicles. They are effective at moving surface water off the road and into adjacent ditches or the plantation floor. The recommended spacing is;

Road Grade (%)	Approx distance between dips (ft)
1	500
2	300
5	180
10	140

Open top culverts can also be used to move water off the road surface. Recommended spacing is

Road Grade (%)	Approx distance between culverts (ft)
1	400
2	245
5	125
10	78
15	58
20	47

² Type I terrain is forested and rolling with slopes between 5% and 10%. Type II terrain is forested and hilly, with slopes between 10 and 36%. Culvert diameters are based on the 25-year storm.

Landings

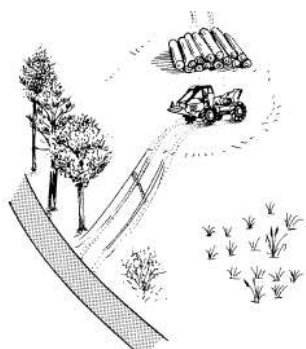
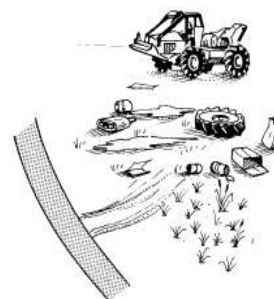


Figure 6. An example of a good landing described within this section

Figure 7. An example of an improper landing



All unnatural debris such as can, papers, discarded tires, metal parts and other junk must be raved. Woody debris will be placed neatly to improve and promote rapid decay.

Soil will be stabilized and if necessary seeded with cover crops or local grasses.

The location of the landing will be on gentle sloping or level ground with good drainage, to avoid ponding of water. Whenever possible, place the landing out of sight of public ways, curving the access road to break line-of-sight from the public way. The landing should also be made as close as possible to the main road system to avoid the need for further access roads for trucks to be built.

Set the landing at least 100 feet from water bodies and wetlands. If the landing must be closer than 100 feet to a water body or wetland, use appropriate soil stabilisation and silt traps.

The landing should be set away from all residential areas where possible, to avoid noise and dust pollutions.

Locate diversions such as water bars and broad based dips on the truck roads leading out of the landing, to prevent the flow of accumulated water and sediment from the landing out into the public way.

Check hoses and fittings regularly to prevent leaks of lubricants and hydraulic oil from machines. Should any spillages of lubricants, hydraulic fluids or fuels, immediate clean up should be carried out with the appropriate spill equipment. In the event of slow leaks whilst a machine is parked overnight or for extended periods, place an oil-absorbent mat to catch the leak.

5. Silt fence installation and Riparian management zones

a. Silt fence

Silt fences are intended to be used to retain sediment from small disturbed areas by reducing the speed of overland flow. The rule of thumb for placement down gradients of disturbed areas such as landings generally is to use 100 feet of silt fence for every ¼ acre of disturbed area.

Proper installation of silt fence involves

- Drive posts spaced 4-6 feet apart
- Fence height should be 2 ½ feet.
- Attach a continuous length of fabric to the posts. Attach the posts down gradient from the fabric, so water and sediment do not pull the fabric from the posts
- Bury several inches of the fabric in the ground to anchor it preventing flow beneath it
- Backfill the base of the fabric with compacted soil or crushed stone.

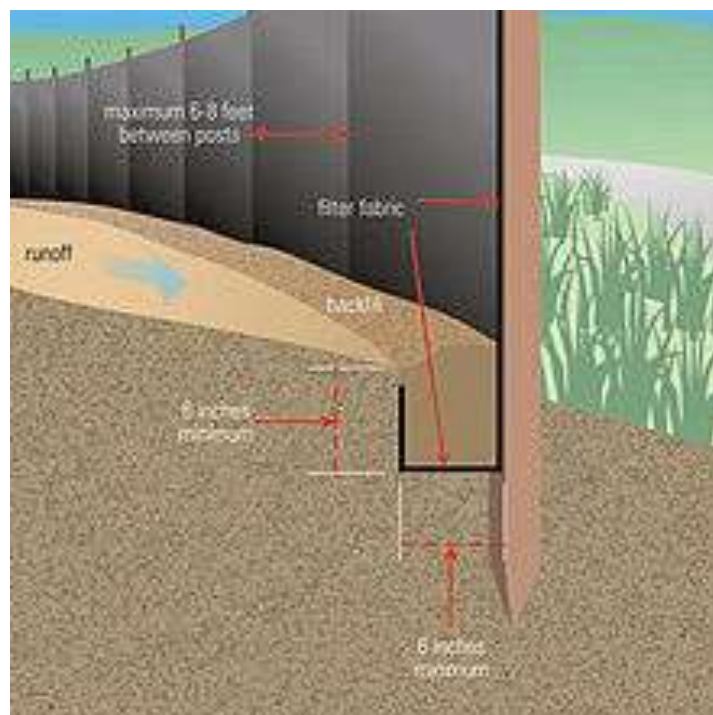
Beware of undercutting of silt fence due to improper burying of the fabric

Do not install silt fences across streams, ditches or waterways

Inspect fence periodically and after each rainfall, replacing worn fabric and accumulated sediment deposits immediately.

Remove all fence materials and unstable sediment after the drainage area is stabilized.

The design life of a silt fence is 6 months or less. Do not leave the fence in place as permanent erosion control structure, as it may act as a barrier to amphibian and reptile life.



b. Riparian management zones (RMZs)

It is the purpose of RMZs is to;

- Slow the movement of overland flow of water, thus enabling transported sediment to be left behind, ensuring that water quality is maintained.
- Provide an opportunity for vegetation to take up nutrients that may otherwise flow into the water body
- Provide shade to the adjacent water body, preventing warming of the water and thus injury to aquatic and riparian wildlife habitat.
- Protect bank stability and prevent erosion.
- Maintains wildlife habitats and wildlife corridors.

It is important not to disturb the floor within RMZs, to permit the filtration of overland flow through ground vegetation and forest floor debris. It is likewise important to retain at least 50% of the overstory basal area, to provide the important shade function to the adjacent water body.

RMZs are required along all water bodies and vernal pools. No more than 50% of the basal area may be cut at any one time, and a waiting period of 5 years must elapse before another cut is made. The residual stand will be composed of healthy growing trees well distributed over the area. Exceptions to this standard may be made by BR management if it is shown that a heavier cut is necessary to protect the stream, bank or water quality. This decision and supporting documentation will be included in the HMP.

The RMZ will extend at least 50 feet back from the bank. The actual width of the RMZ to be left is measured along the slope and can be seen in the table below

Slope %	Width of RMZ from Bank (feet)
0-10	50
10-20	57
20-30	68
30-40	78
40-50	88
50+	Harvesting is not advised due to the high potential for erosion and sediment transport

The Width of the RMZ is to be defined as in the table above except in for streams greater in width than 30 feet bank to bank, ponds 10 acres or larger in area, designated scenic rivers and along outstanding resource waters and their tributaries (excluding vernal pools), RMZs will be of variable width, depending on slope as described in the following table:

Slope (%)	RMZ Width (feet)
0	50
10	90
20	130
30	170
40	210
50	250
60	290
70	330
80	370

No equipment may operate in the RMZ except;

- To reduce environmental damage shown to be necessary in a statement in the HMP.
- At an approved stream crossing
- On a pre-existing road
- In RMZs greater than 50 feet from the water body, as long as no principle skid road is located there, and disturbance of the plantation floor is minimized, with any disturbed soil promptly stabilised.

Cut trees and forestry slash will be removed out of the RMZ, with no slash remaining within 25 feet of any flowing brook, stream, river or any lake, pond or water supply.

A no cut buffer of 15 feet will be enforced within the RMZ areas

Soil compaction and rutting should be avoided within 200 feet of a stream, and special harvesting practices employed to ensure this does not occur, thus preserving the important habitat characteristics and wildlife habitats in the riparian corridor.

6. Stream Crossings

Stream crossings represent one of the principle ways that sediment can enter a water body. They do however prove necessary for a majority of cases.

When a crossing is essential, existing old crossings will be rehabilitated and used, providing that it can be shown that this will cause less disturbance than constructing a new corridor.

Temporary crossing structures will be removed at the end of the operation and the site will be stabilised.

The installation of permanent stream crossings and the construction of permanent roads involving fill through wetland resource areas requires the approval from BR Management.

The rehabilitation, new construction and stabilisation of stream crossings will be done to the standards defined below;

Banks	Stream bed	Acceptable crossing method
Shallow (less than 1ft in height)	Rocky	Ford with stabilised approaches, Culvert, bridge Corduroy
	Soft	Corduroy, bridge Corduroy with culvert
Steep (greater than 1ft in height)	Rocky	Corduroy, Culvert Bridge
	Soft	Corduroy, Culvert Bridge

All crossing are to be made at right angles to the channel

When crossing involves fill or other closed or semi closed structures which will obstruct flow, they will be designed to accommodate at least the 25-year storm (see culvert sizing on page 8).

All banks and approaches to stream crossings will be stabilised during and at the end of operation.

All stream crossing will be accurately mapped and labelled on the map within the HMP and on the ground with suitable materials (i.e. flags or hi-visibility tape).

Within 1000ft upstream of a public water supply, measured along the course of a stream, all stream crossings must use a temporary bridge.

Steep or undercut banks will be avoided to minimize erosion, and the approach to the crossing should be level for roughly 50 feet on both sides.

a. Crossing options

i. Corduroy or poled ford

Place logs in a stream parallel to the direction of flow. Logs should be large enough to keep the skidder out of the water, and should be level with the stream banks. Place one or several culverts in amongst the logs to permit the streamflow through the ford, and prevent damming. Ductile iron culverts or pieces of gas pipeline can withstand great impact and support heavy logging equipment without collapsing.

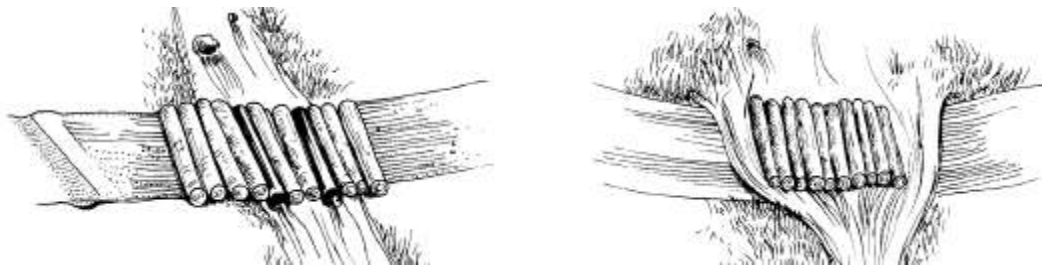
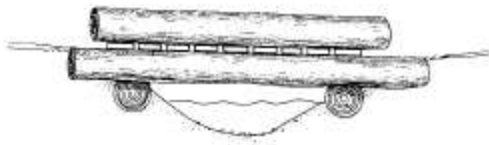


Figure 8. Poled Fords; The diagram on the left shows a properly constructed example. The example on the right shows a bad example, with dammed up water and flooding the approach.

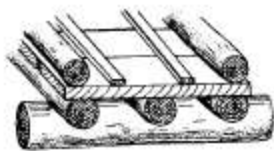
ii. Bridge

From the standpoint of water quality, it is most advisable to use a bridge to keep the machine and hitch completely out of the water. This means that lubricant and fuel will not wash into the stream water, and sediment will not be dragged into the stream on the tires and hitch. Also the banks will remain intact, and their disturbance will not represent another source of sediment. There are two ways to bridge a stream:

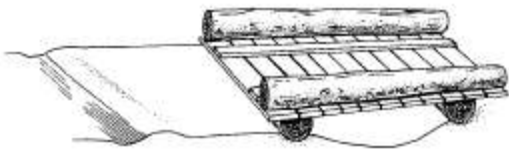
- 1) Skidder bridge constructed on site



3-6 stout logs used as stringers across the stream



4-inch planks used as decking, bumper logs added to the sides to keep the hitch from falling into the stream



Straight approach to line up hitch with sill or log abutments to improve stability, anchor the bridge in place, and elevate it above the level of the bank

Figure 9. Skidder bridge

2) Re-usable temporary skidder bridge

There are many different designs possible, including the recommended one below.

The construction is built of 2 independent sections, each 5 feet wide, 20 ft long and 7 inches thick, constructed of laminated timber, bolted together with a chain on one end which facilitates skidding into place. Sections are skidded into place from the landing, and located side by side at the crossing. At the end of the operation the pieces can be skidded back to the landing, and moved to another site. It is important to stabilise the approaches while installing and removing portable or temporary skidder bridges

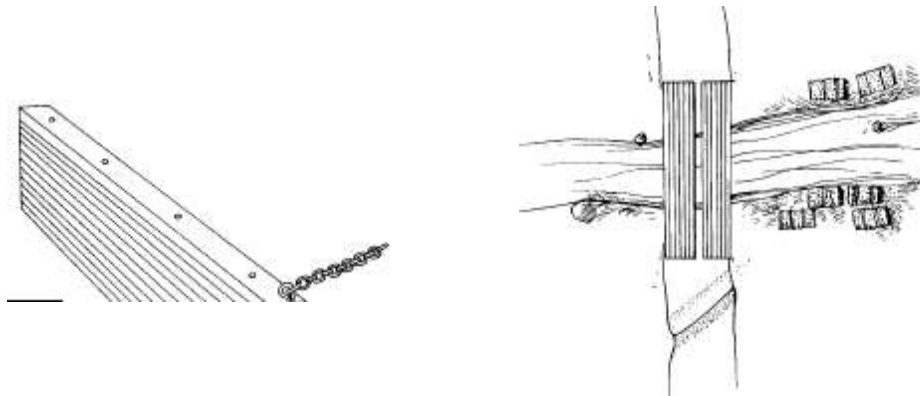


Figure 10. Reusable temporary skidder bridge

iii. Culverts

For the culvert sizing guide refer sizing table on page 8.

For all stream crossings it is important to stabilise the approaches to a stream crossing both during and after the operation. Unstable approaches are one the primary ways that sediment can enter the stream. Although water bars are generally installed at the end of a felling operations, it is advisable to install one directly uphill from the crossing to prevent water moving down a skid road from reaching a stream. The water bar will need to be occasionally reinforced during the job. The approach can be corduroyed with poles to prevent rutting and the churning of soil.

7. Wetlands

Although wetlands act as filters, this function may be compromised by excessive pollution loads, which in turn may cause wetlands to become sources of non-point source pollution, and impair other functions. Thus it is important to keep sediment out of wetlands, so as to not impair their function as filters. Runoff from roads, skid trails, and landings should not be directed into wetlands.

Wetlands that will be crossed or lie adjacent to any harvesting activity will be accurately shown and labelled on the harvest management plan. The location of the crossing must be identified on the ground using suitable materials.

All roads through wetland areas are temporary

Wetlands will not be operated in unless dry or otherwise stable, and after showing that silvaculture techniques are present to avoid significant environmental damage.

Isolated vegetated wetlands are areas that are generally saturated by ground water or covered by surface water long enough to produce hydric soil conditions and which, under normal circumstances, support wetland plant communities. Isolated wetlands have many of the same characteristics as bordering vegetative wetlands, Except that they do not border on a pond, lake or stream and are therefore not usually defined as wetland resource areas. Isolated wetlands may perform some important water quality functions, and may provide wildlife habitat. In order to maintain their ability to perform these functions it is suggested that all normal RMZ functions are applied to these isolated wetlands.

8. Vernal Pools

A vernal pool is a confined basin depression which, at least in most years, holds water for at least two continuous months and which is free of adult fish populations. These areas provide essential breeding habitat for a variety of amphibian species. RMZs with a boundary of 50 feet are to be setup around the vernal pools. Where the slopes within the RMZ are 30% or greater then the RMZ will extend to 100 feet, or to the point beyond 50 feet from the pool where a break in topography reduces to less than 30%.

9. Liberian Wildlife

a. Rare & Endangered species

The Following list includes all mammals which occur in Liberia and are rated as Critically endangered, endangered or venerable in the IUCN Red List of threatened animals.

Common Name	Scientific Name
Chimpanzee	<i>Pan troglodytes</i>
Diana Monkey.	<i>Cercopithecus diana</i>
Liberian Mongoose	<i>Liberiictis kuhni</i>
Nimba Otter Shrew	<i>Micropotamogale lamottei</i>
Red Colobus	<i>Procolobus badius</i>
Aellen's Roundleaf Bat	<i>Hipposideros marisae</i>
African Elephant	<i>Loxodonta africana</i>
African Golden Cat	<i>Profelis aurata</i>
Jentink's Duiker	<i>Cephalophus jentinki</i>
Pygmy Hippopotamus	<i>Hexaprotodon liberiensis</i>
Sperm Whale	<i>Physeter catodon</i>
West African Manatee	<i>Trichechus senegalensis</i>
Zebra Duiker	<i>Cephalophus zebra</i>
Dwarf Crocodile	<i>Osteolaemus tetrapis</i>

For more information on these please refer to management for detailed

If these animals are known to exist in the proposed areas, then a review needs to be carried out to determine if the species will be effected in any manner. If an effect is found then operations will not be carried out within the area.

Local EPA should be informed of the presence of these species.

b. Other protected species

As well as the wildlife listed above, the following animals are fully protected within Liberia, under the national forestry law (2006). Buffer zones with a minimum of 50 feet will be setup around any area indentified as important habitats or recognised conservation areas. These sites will be shown within the HMP.

Liberian Name	Common Name
King Monkey	Black & White colobus
Red monkey	Red Colobus
Olive Colobus	Olive Colobus
Mona monkey	Mona Monkey
Lesser spot-nosed monkey	Lesser spot-nosed monkey
Sooty mangabey	Sooty mangabey
Lesser Galago	Lesser Galago
Elk Deer	Bongo
Bush Cow	Forest Buffalo
Black Back	Ogilby's Duiker
Yellow back	Yellow-backed duiker
Tricjy Jack	Royal Antelope
Water Deer	Water Chevrotain
Red Hog	Red river hog
Black Hog	Giant forest hog
Leopard	Leopard
Big Ant Bear	Giant Pangolin
Ant Bear	Long tailed pangolin
Ant bear	Tree pangolin
Alligator	Nile crocodile
Alligator	African slender-snouted crocodile
Boa constrictor	Rock python
Boa constrictor	Ball python
Boa constrictor	Boa constrictor
Green turtle	Green sea turtle
Sea turtle	Loggerhead sea turtle
Bare-headed Rockfowl	Bare-headed Rockfowl
Grey-necked Rockfowl	Grey-necked Rockfowl
Guineafowl	White-breasted guineafowl
All birds of prey	Ospreys, Falcons, Buzzards, Kestrels
All Hornbills	
All Turacos	
All Parrots	

10. Cultural Sites & Residential Areas

A Buffer zone with a minimum of 50 feet is to be established around all cultural sites and residential areas. This is to ensure that noise, dust and visual aspects are not affected.

A cultural site is defined as any sacred ground (worship sites, graves etc) or sites of tribal significance.

All cultural and residential sites should be included within the HMP.

11. Prescribed burning & Wildfires

The Burning of material should be avoided where possible, however should there be no alternative method of disposal or processing, then the following BMP should be followed.

- Do not conduct burns within 50 feet of a surface waterbody or wetland
- Avoid construction of firelines within 50 feet of a waterbody or wetland
- Locate firelines on contours as much as possible
- Avoid burning on steep slopes or highly erodible soils
- Revegetate and stabilize firelines and erosion prone areas with herbaceous cover

Avoid applying chemical fire retardants to wetlands

12. Before leaving the job

Pull temporary skidder bridges, and make sure that fords and other stream crossings are left in a stable, and free flowing condition

Remove all temporary structures (e.g. culverts, bridges) from wetland areas

Install appropriate water bars on skid trails, especially at the approach to the landing and stream crossings, steep slopes and erodible areas

Mulch the approaches to stream crossings, banks and steep sections of skid trails

Spread out any wood processing waste or slash over the felled area.

Remove all markers from around buffer zones and RMZs

Check for any spills or oil residues and carry out appropriate cleanup measures.

Remove any waste or other unnatural debris either through

- Returning it to a static BR Site for collection or disposal in keeping with company policy
- Collection by a licensed refuse collector, separating out hazardous waste stream in line with company policy
- Disposal at an EPA approved site.