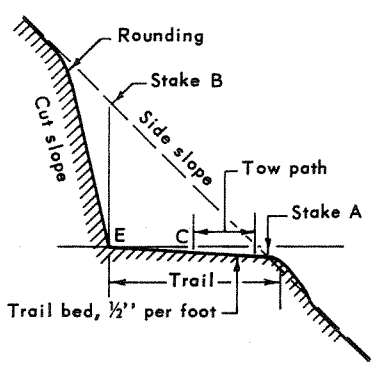
Trail Construction

A raw cut through a woodland is not a trail. A trail should look as though it has always been there; an integral part of the landscape.

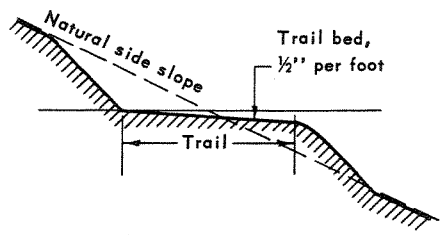
Probably the most crucial step in constructing a trail is to line out the entire path from start to finish. To do this (see sketch 1), place stake "A" at the trail grade where the cut section begins. Stake "B" is then placed at the inside edge of the trail floor. The distance between the stakes depends on the steepness of the land.

On one to one slopes or slopes of steeper grades, the width on solid earth for an eight foot trail should be six and a half feet (see sketch 1); as the cross slopes approach in three to one slopes, the width on solid approaches four feet (see sketch 2). Where no slope exists, line out in accordance with sketch 3.

Once you have lined-out the entire trail, you can begin to clear the area of only those trees which absolutely must be sacrificed for the minimum recommended trail width. Stakes should be well-placed so that there is no question when the trail is cleared and excavated. This is particularly important on curves.



SKETCH NO. 1
A good cross section in heavy cut



SKETCH NO. 2
For easy slopes

SKETCH NO. 3
For flat ground

Excavation

A narrow tow path about 18 inches wide is worked out at the base of the cut along line "A" and excavated back to "C". This path then establishes the line for excavation of the remainder of the trail and its grade. If alterations need to be made, less time is lost than if the entire trail were graded. The next step is to excavate to the full width.

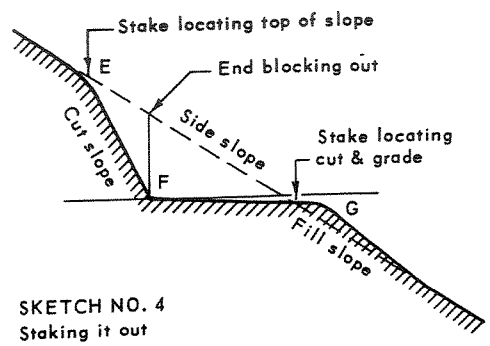
The slope of the banks must then be treated. The top of the slope, point "E" (sketch 4) should be marked or staked on the ground and the slope cut straight from "E" to "F". The slope is then finished with fill and feathered down onto the natural grade.

There are two primary objects in sloping of trail and truck banks: (1) *It is a particular aid to the control of erosion* in that it establishes slopes that are more nearly natural, thus enabling growths of various types to catch quickly and cover the new cut and fill surfaces; (2) *It eliminates materially the possibility of having the trail narrowed by earth loosened through the action of frost and rain water.*

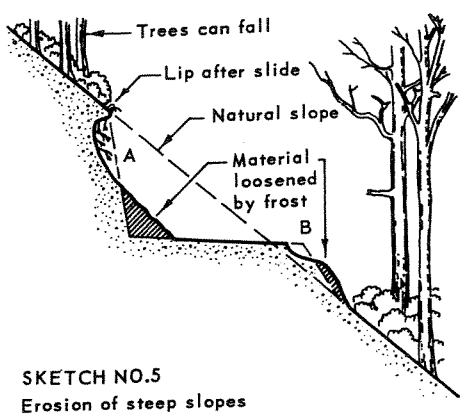
United States Department of the Interior, National Park Service
THE PARK PRACTICE PROGRAM
National Society of Park Resources • National Recreation and Park Association

DATE	October 1975	PLATE	1023 B
INDEX	B-3113	CONTROL	S-1458-B

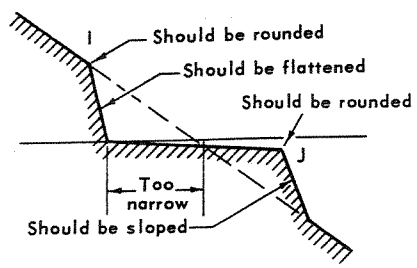
TRAIL CONSTRUCTION
CONTRIBUTED BY
Guy E. Arthur
U.S. Dept. of the Interior



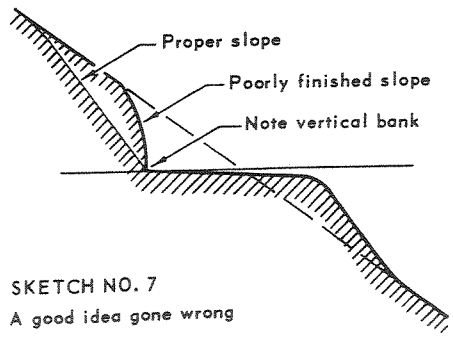
SKETCH NO. 4
Staking it out



SKETCH NO.5
Erosion of steep slopes



SKETCH NO. 6
Poor work.
See sketches Nos. 7 & 8.



SKETCH NO. 7
A good idea gone wrong

(Sketch 5 shows the action of frost on a poorly constructed trail.) The combined action of water and frost at "A" loosens the material which drops to the trail, in some cases to such an extent that the trail is impassible.

Sketch 6 illustrates a section of a poorly finished trail. The filled edge at "J" will soon be washed down the hillside by storm water leaving the narrow bed of the trail on solid ground. In this case the builder did not go far enough into the side slope to get the required amount of trail floor on solid earth. Earth should never be finished to corners as at "I" and "J" but should be rounded over to meet the existing grade above and below the trail. Cut slopes should never be finished as shown in sketch 7.

Sketch 8 illustrates an ideal trail section, well finished, with banks and trail bed properly sloped and corners of cuts and fills properly rounded.

The question of how far to cut back a slope (or bank) is often a problem. Where the cross slope is easy the bank may be taken back on a 2 to 1 slope, that is, two feet back for each foot in height. A 1½ to 1 slope is good, and a 1 to 1 slope is about as steep as earth will lie on a slope. The 1 to 1 slope should be regarded as a maximum slope to give a bank except in the situations where it would be necessary to grade 30 or 40 feet up a steep bank to get this 1 to 1 slope. This would require removing too much established growth. Such situations should be solved by the staking of the top of the cut bank to get the best solution possible.

TO KEEP THE SLOPE UNIFORM

It is sometimes difficult to keep a slope uniform when the bank varies in height. If the slope is to be 2 to 1, measure the height of the bank, then measure back twice this distance from the vertical face of the cut, and set your slope stake. These stakes should be set from five to ten feet apart to maintain a smooth, uniform slope.

WALL CONSTRUCTION

A natural slope is preferable to wall construction on trails where an earth slope can be made. A slope is a more natural condition and will cover over with a natural growth. However, walls are necessary in many situations. Great care should be taken in their erection. Generally one must depend on the stone that is available nearby for this construction. Nevertheless, it is worthwhile to go to some trouble in selecting stone that is adaptable. Stones should not be laid up in a haphazard way as they are handed to the builder; they should be selected to fit the position in the wall that they are to occupy and should be rejected if not of the right shape and size.

To assure solid construction and good appearance the following rule should be followed in the selection and setting of rock: Start the construction with proportionately large rock at the bottom of the wall; grade the size to smaller rock in the center section and again increase the size toward the top of the wall. The top course of the wall should be of rock sufficiently large to be solid.

The following method of wall construction has been used with good results:

1. The outside edge of the base of the wall is carefully staked on the alignment.

2. Batter boards are set at intervals along this line at the proper slope. It has been found advisable to allow about two inches of clearance between the batter board and the wall surface. Care should be taken in placing the batter boards to see that the top of the wall is located sufficiently far out to give the proper width of trail when finished.

3. After the batter boards are set, excavation is started. Wherever possible, walls should be built on rock base; however, if rock is not present, excavation should be made to solid earth, and below the frost line, before any wall construction is begun. *Never build walls on filled earth bases.*

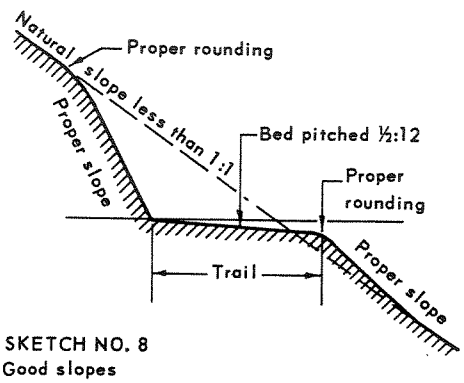
4. Where the trail is built of earth-fill back of the rock wall, the wall should be built to the following dimensions: The base of the wall should approximately equal one-half of the height. The front face of the wall should be battered 3" to the foot in all cases. The back of the wall should be built in steps starting at the bottom and finishing at the last stone course with a width of wall at least 18". (See Sketch 9)

5. Particular care should be given to locating the beginning and ending of the wall. Wherever possible the wall should begin and end in some natural formation leaving no sharp ends exposed above the natural surface. Where this is not possible, arrangements should be made for planting to obliterate the ends of the wall, as in sketch 10.

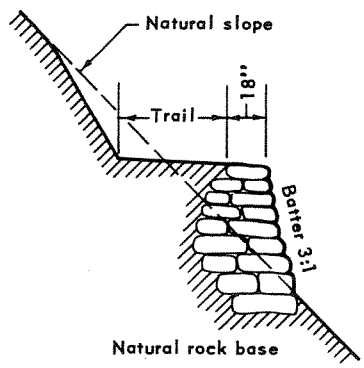
Sketch 11 is a typical walled section where the entire trail width is obtained without going into the side slope and creating a large scar. This is particularly useful on very steep cross slopes and in places where outcroppings of rock must be avoided.

Sketch 12 indicates a treatment that is practical when the trail is over an old railroad or road grade on which walls have been built that must be obliterated. This method creates an opportunity for the disposal of waste rock after blasting operations since it can be placed below the existing wall and covered with earth which will soon grow over and present a natural appearance. In new trail construction it is sometimes necessary to use this method for the disposal of scrap rock from blasting operations.

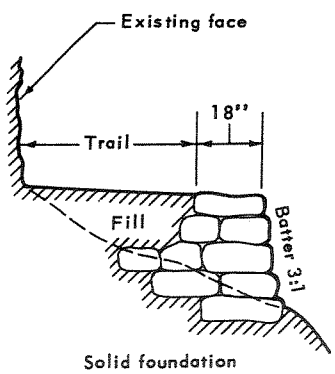
Sketch 13 illustrates a type of wall used where it is necessary to drop below the line of the trail to find firm foundations for wall construction. The slope between the top of the wall and the trail grade is built similar to the fill slope on the trail in ordinary circumstances. Care should be taken to leave a small ditch for drainage above the wall.



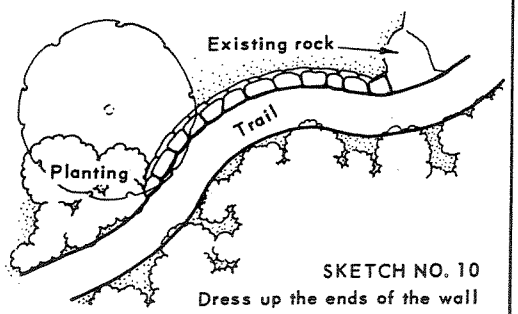
SKETCH NO. 8
Good slopes



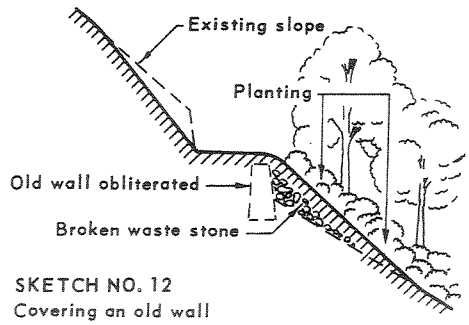
SKETCH NO. 9
Retaining wall



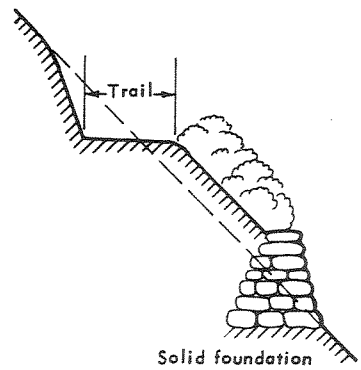
SKETCH NO. 11
Under a cliff



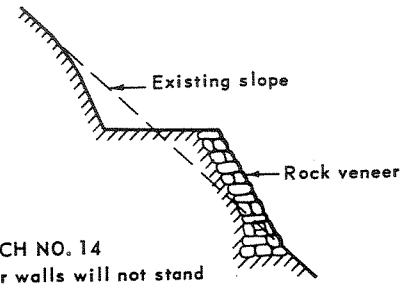
SKETCH NO. 10
Dress up the ends of the wall



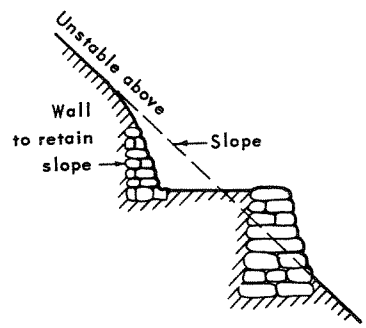
SKETCH NO. 12
Covering an old wall



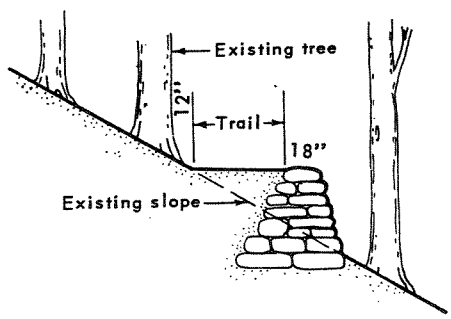
SKETCH NO. 13
A stopper for the toe



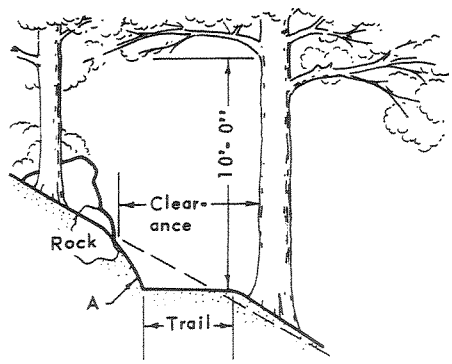
SKETCH NO. 14
Veneer walls will not stand



SKETCH NO. 15
Walls above the trail are not desirable



SKETCH NO. 16
Swing out around trees



SKETCH NO. 17
Clearance for trees

Sketch 14 indicates a type of wall that has been used in the past but is not practical and has been washed out or turned over by frost action. It is merely a rock veneer and cannot be depended upon to retain a fill where there is pressure against it.

Sketch 15 indicates a wall on the cut side of the trail serving to retain loose earth and rock above the trail floor. This may be justified in a few exceptional cases, but as a rule, wall construction above the bed of the trail should be avoided, as well as any laid-up job above a trail such as veneer construction to eliminate a hole in the upper bank where a stump has been removed. Where it is necessary to retain a bank above a trail it may be done by placing the rock in such a manner that it gives the appearance of a natural outcropping or formation. This area should be planted in a natural manner. The natural condition should prevail down to the trail edge.

Where trails pass close to large trees and the location is kept below the tree, the type of construction shown in Sketch 16 should be adopted. This will make it possible to build the trail to the proper grade and location without injury to the tree roots.

TRAIL WIDTH

A four foot width is desired for horse trails. This width should not be measured out to a sharp edge which is not substantial. It should be measured from the outside of the trail where the fill slope starts to round over, to a point just out from the base of the cut slope, allowing for rounding out at point "A". (See sketch 17)

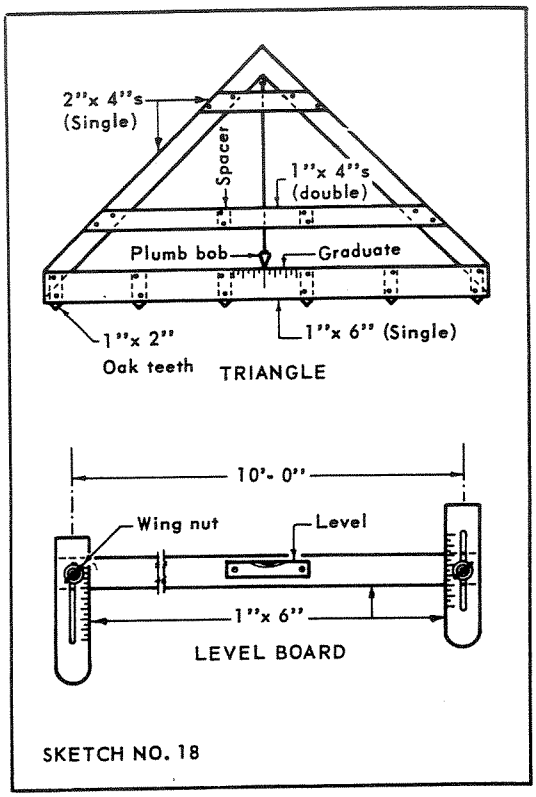
Where there is a wall on the lower side of the trail, the width should be measured from the inside of the wall. The top of the wall should not be included in the width of trail.

Where there is a steep dangerous bluff or drop-off below the trail, the trail bed should be widened to seven or eight feet, exclusive of wall width. On the normal trail there should be at least one foot clearance beyond each side of the trail to permit passage for pack animals. This distance may be increased where there is a dangerous condition below the trail. Tree branches that overhang the trail should be removed to permit passage of horseback riders. (See sketch 17)

TEMPLATES FOR GRADES

There are two kinds of templates which help in constructing trails, shown in Sketch 18. The triangular form is for grading trail surfaces. The bottom member is graduated, by actual trial, to give grades of 1/8, 1/4, 3/8, 1/2, 3/4, and 1 inch per foot. It may be made in any proportions, but the higher the triangle the wider the plumb bob will swing, and the easier the graduations can be read. The teeth on the bottom give a better check on the grade than a straight-edge can, since they cut into high places.

The level is used for length-wise grades on the surface, and for getting grades on walls and on the floor of culverts. A small level is screwed to the board near the top. The legs have slots in them which run on bolts in the board, and these legs may be graduated in inches. The bolts in the board must be a definite distance apart, such as 10 feet. If the grade desired is 1/4" per foot, and the bolts are 10 feet apart, one leg must be 10 × 1/4"or 2-1/2" longer than the other. The board will be level when the desired grade is reached.



SKETCH NO. 18

STREAM CROSSINGS

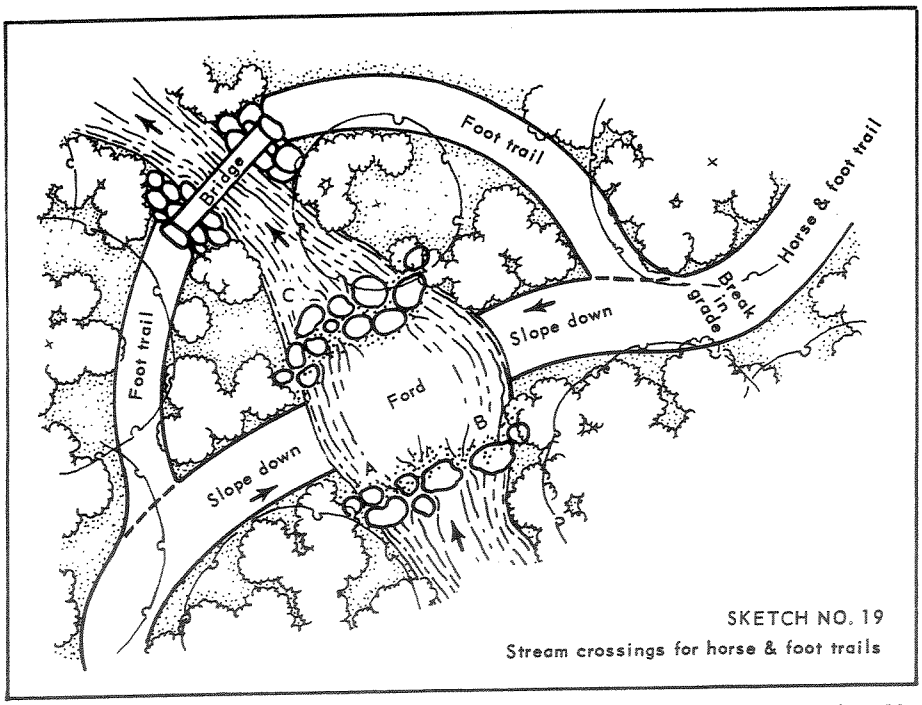
Care should be taken in the development of fords to see that as little damage as possible is effected by the entrance of the trail to the stream at either side.

Visitors will stop at stream crossings, which should be made as attractive as possible. Horse bridges are recommended at stream crossings only where the stream is of such size that it will be dangerous for a horse to cross at high water and where the construction of the ford would mar the surrounding area. The ford crossing is preferable because it is more natural and permanent and offers facilities for watering horses. The trail grade should dip at the ford to prevent water from flowing down the trail when the stream is in flood; however, this grade should not pitch sharply up or down at the approach or when leaving the ford, but should gradually rise to the normal grade.

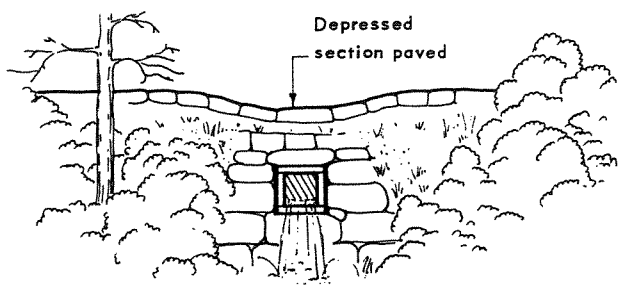
At ford crossings, if the current is swift, the stream should be slowed and widened to prevent washing out the ford. (See sketch 19.) This may be done by removing the obstructions above the proposed ford that tend to force the water into narrow channels or divert the water in the wrong direction. Thus in sketch 19, "A" may be a group of boulders that force the water between it and another boulder at "B".

In most cases it is necessary to build up the lower edge of the ford to make the trail crossing more nearly level. This should be done by placing weathered boulders at the edge of the ford at "C" in a natural manner and not in a definite wall. This slows the water so that gravel is deposited and any fill that is made will not be washed out. These stones, when properly selected will serve as stepping stones for pedestrian traffic except on the occasions when the water is exceptionally high.

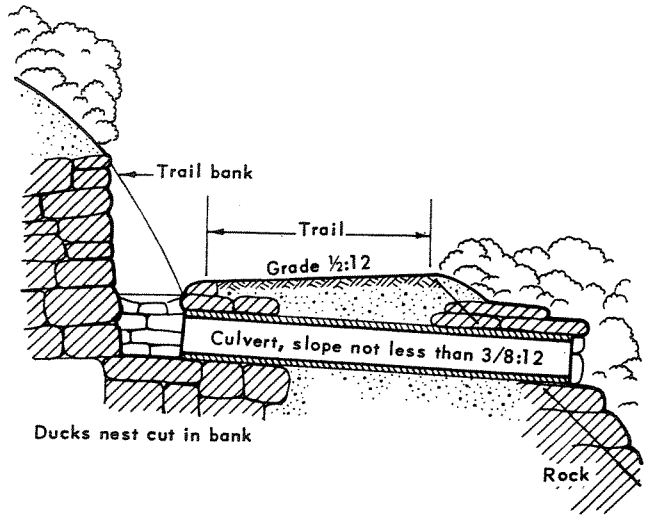
Where foot logs are used they should be placed below the ford, adjacent to it and close enough that they can be easily seen and used by passing pedestrians. In construction of foot bridges, any natural formation that is available should be used to make the structure fit into the surrounding country. In the absence of these natural formations, abutments should be built of native stone to appear as nearly natural as possible.



SKETCH NO. 19
Stream crossings for horse & foot trails



SKETCH NO. 20



SKETCH NO. 21
Drainage to inside of trail

DRAINAGE

No factor in trail construction is more important than proper drainage, and many sections of good trail are damaged and destroyed by erosion which could have been prevented. All drainage should be planned far ahead of construction. The method of carrying surface water off of each trail section should be determined in advance, along with the location, type, size, and construction details of all drainage structures.

Three general drainage conditions are encountered in trail construction: Sheet Water, Water Concentrating in Natural Basins, and Water in Natural Channels.

Sheet Water. Where water comes to a level section of the trail from an uphill slope it does not concentrate in drainage channels, but flows across in a sheet. In rare cases it is permissible to concentrate sheet water by cutting screened ditches across the hillside, with an open ditch bringing the water to a culvert under the trail. *The approved practice is to tilt the trail bed* so as to carry sheet water across the surface with the least concentration, and thus with the least danger of erosion.

Water Concentrating in Natural Basins. Since we like variety in foot trails, they go uphill and downhill, crossing ridges which shed water, and hollows which collect it. These hollows may concentrate water from a considerable area of watershed. The bottoms of these hollows, touching the trail, may be flat and wide, or steep and narrow. This topography calls for drainage structures, and the shape and area of a hollow determine their location, type and size.

Surface water should not be forced to concentrate in channels to a greater extent than it does naturally. To compel it to back up behind culverts in new locations is to invite destructive erosion and unsightly ditches. Several small culverts should be used rather than one large one. And the trail should be raised enough to impound a rush of storm water until it can flow through the culverts, without cutting new channels in the drainage basin, or across the trail.

In gullies, nature has already determined the type of structure to be employed, a culvert big enough to carry all the water that comes down. The gully has already established a temporary balance between the scour of the stream and its bed. This balance should not be disturbed, so the floor of the culvert should be at the level of the gully bed. Then the elevation of the trail, compared with the elevation of the gully bed, may dictate a wide, shallow culvert, or a deep, narrow one. But the wider the culvert the easier it will take water, and the less danger there will be of destructive cutting on the discharge side.

In many places where a small culvert seems to be needed it would be better to build a low-water crossing, which is merely a depressed section of the trail paved with flat stones.

Side Drainage Combined with Trail Surface Drainage. Sometimes it is necessary to drain a trail surface to the inside, against a bank, providing a catch basin, or "duck's nest", at the end of the culvert. The amount of water shedding off the trail, as compared with the amount coming from the side, may be large or small. Draining a surface in this way should be avoided, but where it is necessary, the side ditches should be paved with flat stones, to prevent undermining of the slope. (See sketch 21)

The only particular requirement for this type of culvert is to carry the catch basin well into the bank, even channelling into the slope to keep it away from traffic. The back wall of the catch basin should be carried far enough up the slope of the stable, and all danger of erosion around it should be foreseen and prevented.

Water in National Channels. Established channels determine the location of culverts, and the amount of water to be served can be estimated with reasonable accuracy. Any depression, even one coming from a small spring, is the established drainage channel in that area. This can be proved by the absence of erosion, and the presence of cover on nearby surfaces. The amount of run-off at flood stage can be estimated by lines of drift left by high water, scouring at the bases of trees, root

systems exposed by scouring, fresh surfaces on rocks below old stain-bands, shrubbery tilted down hill, and other signs.

The culvert must be large enough to carry flood water. And its floor must be at the level of the channel bed. These two factors determine the size and shape of the structure. Where there is any choice, the culvert should be wide, rather than deep.

If the drained slopes are bare, and erosion is to be retarded until cover grows, a catch basin can be built at the intake end of the culvert with dry walls built high enough to form an impounding basin behind them, where the flood water can deposit its silt before seeping into the culvert. But in such a case special care must be taken to protect the culvert with wing walls, so that impounded water will not find a passage along the walls of the structure and eventually wash out the trail.

Types of Culverts. Preferably all culverts should be made of stone using dry or mortar joints as prescribed by plans, general instructions or local conditions. The ends of the walls should be flared, as a usual practice, to hold the fill above and to prevent scouring by flood water. Care should be taken to keep the inside surfaces uniform and smooth to prevent debris from catching. A culvert should extend a foot or two beyond the edge of the trail on each side, and the trail widened to the head walls of the culvert. The bottom of the culvert should slope not less than ⅜" per foot.

Blind Drains. These are not as desirable as they might be. At first they carry water very well, but there is always the likelihood that their surfaces will clog with silt, so that they will not continue to function. Their worst fault is that they remain frozen in the spring after the trail surface has begun to thaw. At the time when the trail surface is least able to carry traffic and withstand erosion, the frozen drain will not take water.

WATERBREAKS

A waterbreak should be extended far enough into the bank on the upper side of the trail to prevent water from cutting around it. It may be necessary to cut a trench into the bank to accomplish this, tamping the dirt back afterward. Both ends should be anchored behind rocks or trees, or firmly staked in place.

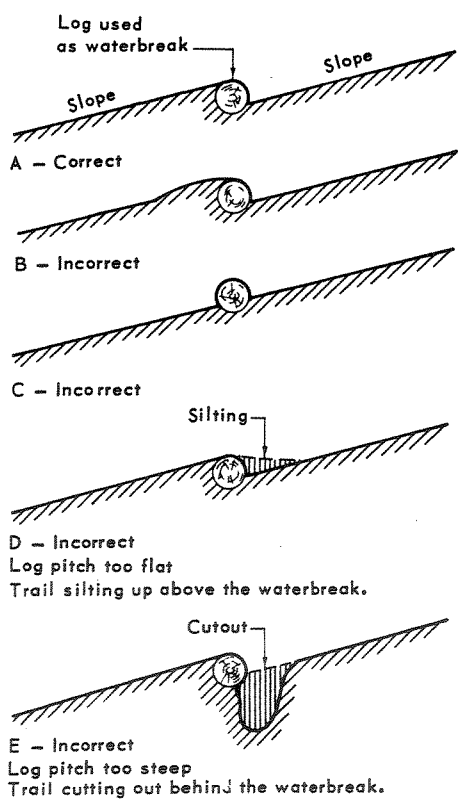
The pitch of a waterbreak, or the angle at which it lies across the trail, is very important. A definite relation between the slope of the trail, and the pitch of the waterbreak, must be established by experience in each location. This relation depends upon the nature of the soil, and may vary greatly on different sections of the trail. On one section there may be a stiff clay which does not wash. On another stretch there may be alluvial soil, which will wash badly.

As one of two extremes, take a section in tough clay on a flat slope. Here there is very little danger of washing, and the breaker can lie on a steep ditch carrying off all of the water quickly. If it were laid on a flatter pitch, there would be danger of depositing silt behind the breaker, and putting it out of use, as in sketch 22, Figure D.

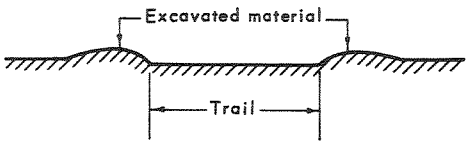
For the other extreme, consider a section in alluvial soil on a steep slope. Washing will occur here on the slightest incline, so the breaker must lie almost straight across the road. If it is given a more pronounced pitch the water will hit the breaker, turn off across the trail, and wash a cross-ditch as in Figure E. The breaker log will be washed out, and the water will go on down the trail, making an additional load for the next breaker to carry off.

The spacing of breakers cannot be determined by any rule, but there are three particular locations where they shold be placed: (1) Where there is a depression or wash, the breaker should be set below; (2) On sharp curves, the breaker should be set at the up-hill entrance of the curve; and (3) At changes in the trail grade, the breaker should be set just above the break in grade.

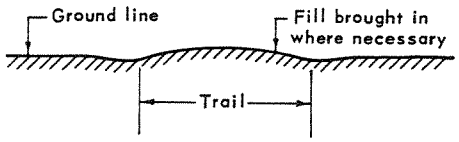
No harm is done if some excess water goes over a breaker that is carrying a full load off to the side. It is better to set them so that this occurs in heavy downpours, than to pitch the breakers so that excessive scouring occurs alongside the logs. If careful study is given to the behavior of breakers in different soils, and on different slopes, it will be possible to reach a reasonable balance between scouring, as one extreme, and silting up, as the other.



SKETCH NO. 22
Waterbreaks

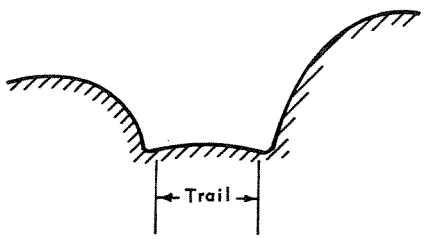


A – Incorrect method

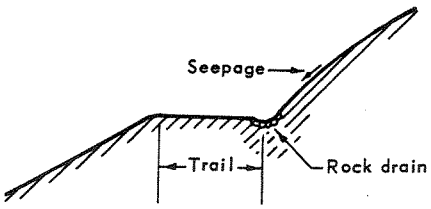


B – Correct method
Excavated material removed

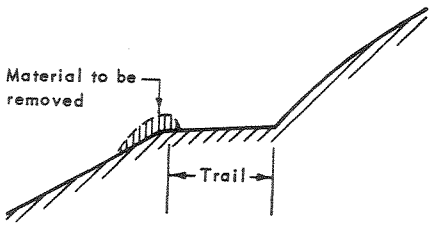
SKETCH NO. 23
Wrong & right construction on flat sections



A – Trail in "through cut" to be avoided



B – Rock drain correct method for seepage in cut bank



C – Correct method of "daylighting"

SKETCH NO. 24
Trails on old road beds

In sketch 22, "A", "B", and "C" indicate three methods of setting breakers. "A" is the correct method with the grade below the breaker finishing flush with the top of the log. When setting it is better to fill rather full back of the breaker and then tamp the soil well to prevent settling and the consequent exposure of the breaker. The grade above and below the breaker should feather nicely into the grade of the trail and not leave a "bump" as shown in "B". When breakers are set in this manner they are secure and, since the grade at the lower side rides the breaker, these are not visible when one looks up the trail.

"C" indicates a method not desirable. It is not as secure, is more noticeable and forms a greater obstruction to stumble over.

The following are conditions, frequently encountered, that require careful study to secure proper drainage.

On ground where there is no appreciable cross slope, the trail is frequently built as shown in "A" of sketch 23. Turf is cut from the trail bed and raked off to the sides, making piles that confine water to the trail and wash it out. On such locations, the proper method of construction will usually be to work out shallow, rounded depressions, not ditches, at the sides, and the good soil from these excavations used to slightly raise the trail bed forming a dry, well drained trail bed in wet weather. In some cases it will be necessary to gather additional fill from another section to raise the trail bed. "B" in sketch 23 indicates the correct method of construction in this type of topography.

Water should be directed away from these drainage depressions wherever conditions will permit.

Sketch 24 indicates types of construction used when trails follow old road or railroad grades.

"A". This sketch indicates the method used in "through cut" sections. It is not a desirable solution, however, and should be avoided wherever possible.

"B". This shows a condition frequently encountered where there is a seepage of water for some distance from the bank above the trail which will keep the trail bed continually wet if the water is not disposed of satisfactorily. Here the trail bed is raised and the seepage caught in a rock fill which should extend along the trail for the distance that the seepage exists, and from there connect with one or more culverts.

Mounds of earth similar to those shown in "C" should be graded off, or "daylighted," when they exist on an old road location that is being converted into a trail or truck trail.

SECURING FIRM TRAIL BED

Trails should not be built on top of peat or leaf mould beds. When this condition is encountered as is the case many times when passing through heavy growths of Rhododendron, the entire depth of soft material should be excavated to make a solid bed that is well drained and will remain solid. The leaf mould and peat removed should be used as topsoil on other parts of the trail and for planting operations.

TRAIL FINISHING

The frequently asked question is how far to go on trail finishing. It is not practical to do such refined grading as will not stand up under the relatively small amount of maintenance that those trails will probably receive in the future. The best answer to this question is that trail finishing should be carried to such a point that *erosion will be discouraged* and *natural growth will be encouraged*. Such finishing can be justified from the practical standpoint. All trails will require occasional maintenance work in the future to keep them in good condition. *Finishing them so that this upkeep will be kept to a minimum* is one of the guiding factors in trail construction. When banks are not properly sloped, walls not well built, and drainage not properly provided, there will be a constant maintenance job necessary with the resulting increase in cost of upkeep.