

A-04 Preventing Soil Erosion on Trails

Unless you live on table-top level land, you will have the potential for erosion from water runoff on your trails for foot traffic, moving equipment, and vehicles. Unless properly built, supported, and maintained, resulting erosion will degrade your soil. Trail maintenance is very important on homesteads.

Evolution of Homestead Trails

These become paths of necessity. They will follow the terrain even if it's not to the greatest advantage for managing runoff water. Think carefully about how the water will work with the trail to minimize erosion. But once established to the needs of the homestead, you have got to maintain the trails effectively.

Experience – Our original trail to the upper level pastures went straight up the hill along a fence line. As the soil compacted, erosion became quite a problem. To minimize this, the trail was relocated along the other fence line where the slope was more gradual for part of the rise. This left a steeper slope with a grade toward the runoff creek. Erosion, however, continued.

The remedial action was to install waterbars mostly as described below. We added shallow runoff ditches from the low ends of the waterbars that has since effectively channeled the rain water toward the runoff creek. Thus far, this has worked well and erosion has basically stopped. Nevertheless, when clearing the humus soil that flows down from the upper part of the creek, this is backfilled by hand where needed.

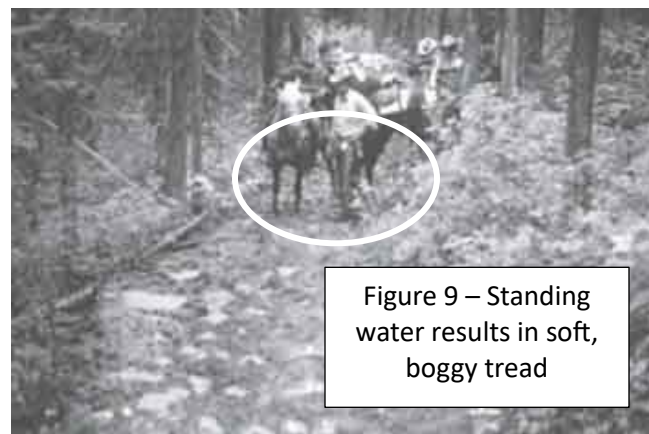
The following information is verbatim from the U.S. Forest Service on managing water on trails. Anyone who has hiked on trails in public parks has likely encountered these methods, even when not aware. They know what they're advising based on a lot of experience.



Trail Construction and Maintenance

Surface Water Control

Diverting surface water off the trail should be near the top of your list of priorities. Running water erodes tread and support structures, and can even lead to loss of the trail itself. Standing water often results in soft, boggy tread or failure of the tread and support structures. (Figure 9) Water is wonderful stuff—just keep it off the trail. Your job is to keep that water *off, Off, OFF* the tread! Treads are where people, animals, and vehicles pass over designated paths.



The very best drainage designs are those built into new construction. These include frequent grade reversals and outsloping the entire tread. The classic mark of good drainage is that it's self-maintaining, requiring minimal care.

Sheet Flow

When rain falls on hillsides, after the plants have all gotten a drink, the water continues to flow down the hill in dispersed sheets—called *sheet flow* (figure 10). All the design elements for a rolling contour trail—building the trail into the sideslope, maintaining sustainable grades, adding frequent grade reversals, and outsloped tread—let water continue to sheet across the trail where it will do little damage.

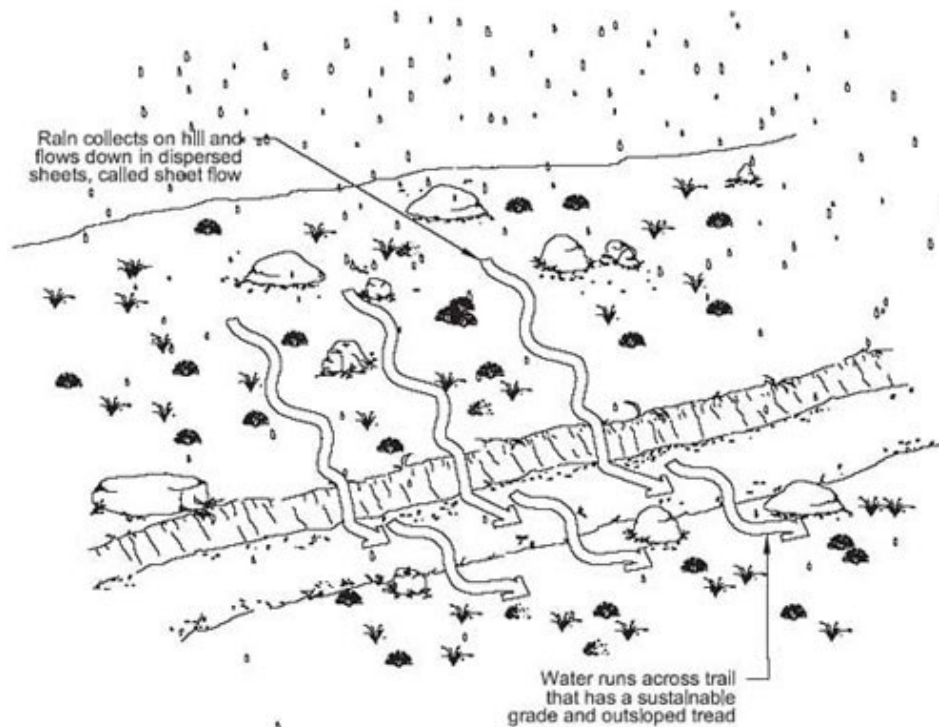


Figure 10 – Design elements for a rolling contour trail let water sheet across the trail. Sheet flow prevents water from being channeled down the trail, where it could cause erosion.

Grade Reversals

Sometimes, grade reversals are called grade dips, terrain dips, Coweta dips, or swales. For less confusion, let's call them *grade reversals*. The basic idea is to use a reversal in grade to keep water moving across the trail. Grade reversals are designed and built into *new trails*.

A trail with grade reversals and outslotted tread encourages water to continue sheeting across the trail—not down it. The beauty of grade reversals is that they are the most unobtrusive of all drainage features if they are constructed with smooth transitions. Grade reversals require very little maintenance.

Grade reversals take advantage of natural dips in terrain (figure 11). The grade of the trail is reversed for about 3 to 5 meters (10 to 15 feet), then "rolled" back over to resume the descent. Grade reversals should be placed frequently, about every 20 to 50 feet (6 to 15 meters). A trail that lies lightly on the land will take advantage of natural dips and draws for grade reversals. The trail user's experience is enhanced by

providing an up-and-down motion as the trail curves up and around large trees (figure 12) or winds around boulders.



Figure 11 – Grade reversals are much more effective than waterbars and require less maintenance. Grade reversals with outsloped tread are the drainage structure of choice.



Figure 12 – Grade reversal by curving the trail around trees and rocks.

Draining Water Off Existing Trails

Water will always find the path of least resistance—most likely your trail! Gullies form as water eats away the tread material on steep trails. Puddles sit in low-lying areas that leave water nowhere to go. When water starts destroying your trail, users start skirting around the damage. The trail becomes wider or multiple new trails are formed.

Getting water off the trail takes more than digging a drainage ditch. Find out where the water is coming from, then find a way to move it off the trail.

When a crew takes a swipe at the berm with a shovel or kicks a hole through it—that's useless drainage control. These small openings are rapidly plugged by floating debris or the mud-mooshing effect of passing traffic. The erosion lives on.

Knicks

Puddles that form in flat areas on existing trails may cause several kinds of tread damage. Traffic going around puddles widens the trail (and eventually the puddle.) Standing water usually weakens the tread and the backslopes. Water can cause a bog to develop if the soils are right. Traffic on the soft lower edge of the puddle can lead to *step-throughs*, where users step through the edge of the trail, breaking it down. Step-throughs are one of the causes of tread creep.

The *knick* is an effective outsloping drain. Knicks are constructed into *existing trails* (figure 13). For a knick to be effective, the trail tread must have lower ground next to it so the water has a place to drain. A knick is a shaved down semicircle about 10 feet (3 meters) long that is outsloped about 15 percent in the center (figure 14). Knicks are smooth and subtle and should be unnoticeable to users.



Figure 13 – Knicks constructed into existing trails will drain puddles from flat areas.

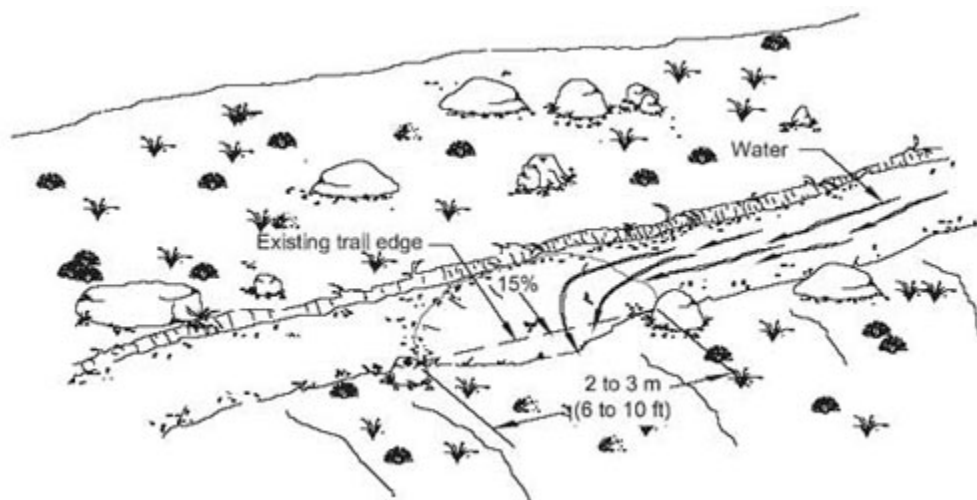


Figure 14 – A knick is a semicircle cut into the tread, about 10 feet (3 meters) long and outsloped 15 percent in the center.

If terrain prevents such outsloping, the next best solution is to cut a *puddle drain* at least 24 inches (600 millimeters) wide, extending across the entire width of the tread. Dig the drain deep enough to ensure that the water will flow off the tread. Feather the edges of the drain into the tread so trail users don't trip. Plant rocks or other large stationary object (guide structures) along the lower edge of the of the tread to

keep traffic in the center. In a really long puddle, construct several drains at what appear to be the deepest spots.

Rolling Grade Dips

Another way to force water off *existing trails* is to use a *rolling grade dip*. A rolling grade dip is used on steeper sections of a trail. It works well to drain water off the lower edge of contour trails. A rolling grade dip builds on the knick design. A rolling grade dip is a knick with a long ramp about 15 feet (4½ meters) built on its downhill side (figure 15). For example, if a trail is descending at a 7 percent grade, a rolling grade dip includes:

- A short climb of 10 to 20 feet (3 to 5 meters) at 3 percent
- A return to the descent (figure 16).

Water running down the trail cannot climb over the short rise and will run off the outsloped tread at the bottom of the knick. The beauty of this structure is that there is nothing to rot or be dislodged. Maintenance is simple.

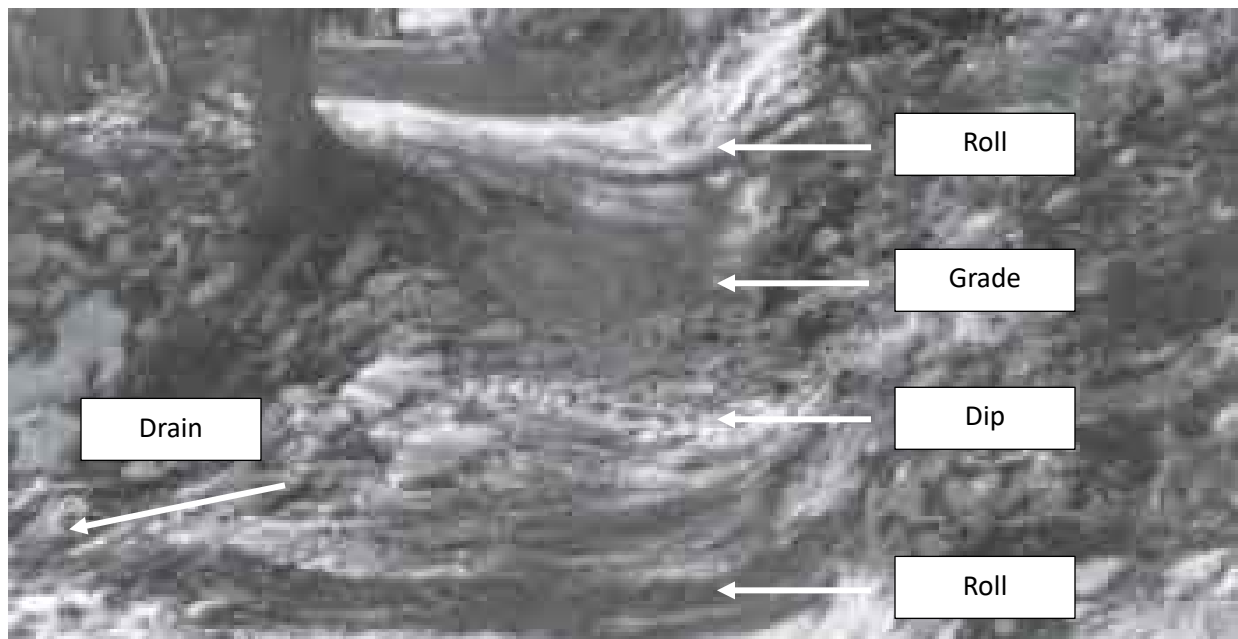


Figure 15 – Rolling grade dips direct water off steeper sections on existing trails.

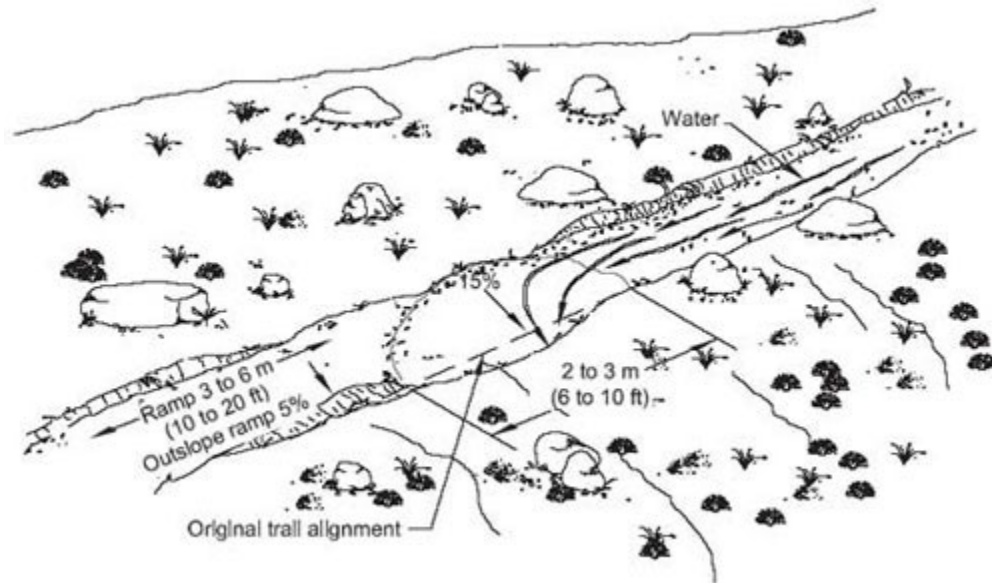
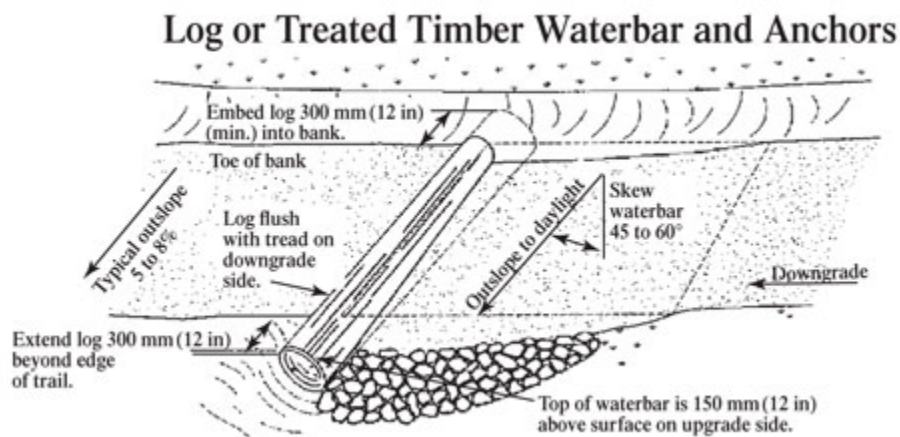


Figure 16 – A rolling grade dip builds on the knick design. It helps direct water off steeper sections of existing trails.

Rolling grade dips should be placed frequently enough to prevent water from building up enough volume and velocity to carry your tread's surface away. Rolling grade dips are pointless at the top of a grade. Mid-slope usually is the best location. The steeper the trail, the more rolling grade dips will be needed. Rolling grade dips should not be constructed where they might send sediment-laden water into live streams.

Waterbars

Waterbars are commonly used drainage structures. Make sure that waterbars are installed correctly and are in the right location. Water moving down the trail turns when it contacts the waterbar and, in theory, is directed off the lower edge of the trail (figure 17).



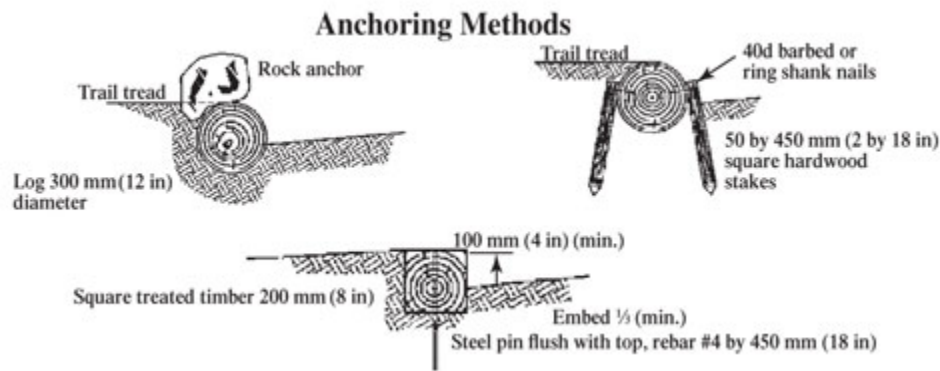


Figure 17 – Logs used for waterbars need to be peeled (or treated with preservative), extended at least 300 millimeters (12 inches) into the bank, staked or anchored, and mostly buried.

Dips Are In, Bars Are Out

For existing trails with water problems, we encourage the use of rolling grade dips or knicks instead of waterbars. Here's why. By design, water hits the waterbar and is turned. The water slows down and sediment drops in the drain.

Waterbars commonly fail when sediment fills the drain. Water tops the waterbar and continues down the tread. The waterbar becomes useless. You can build a good rolling grade dip quicker than you can install a waterbar, and a rolling grade dip works better.

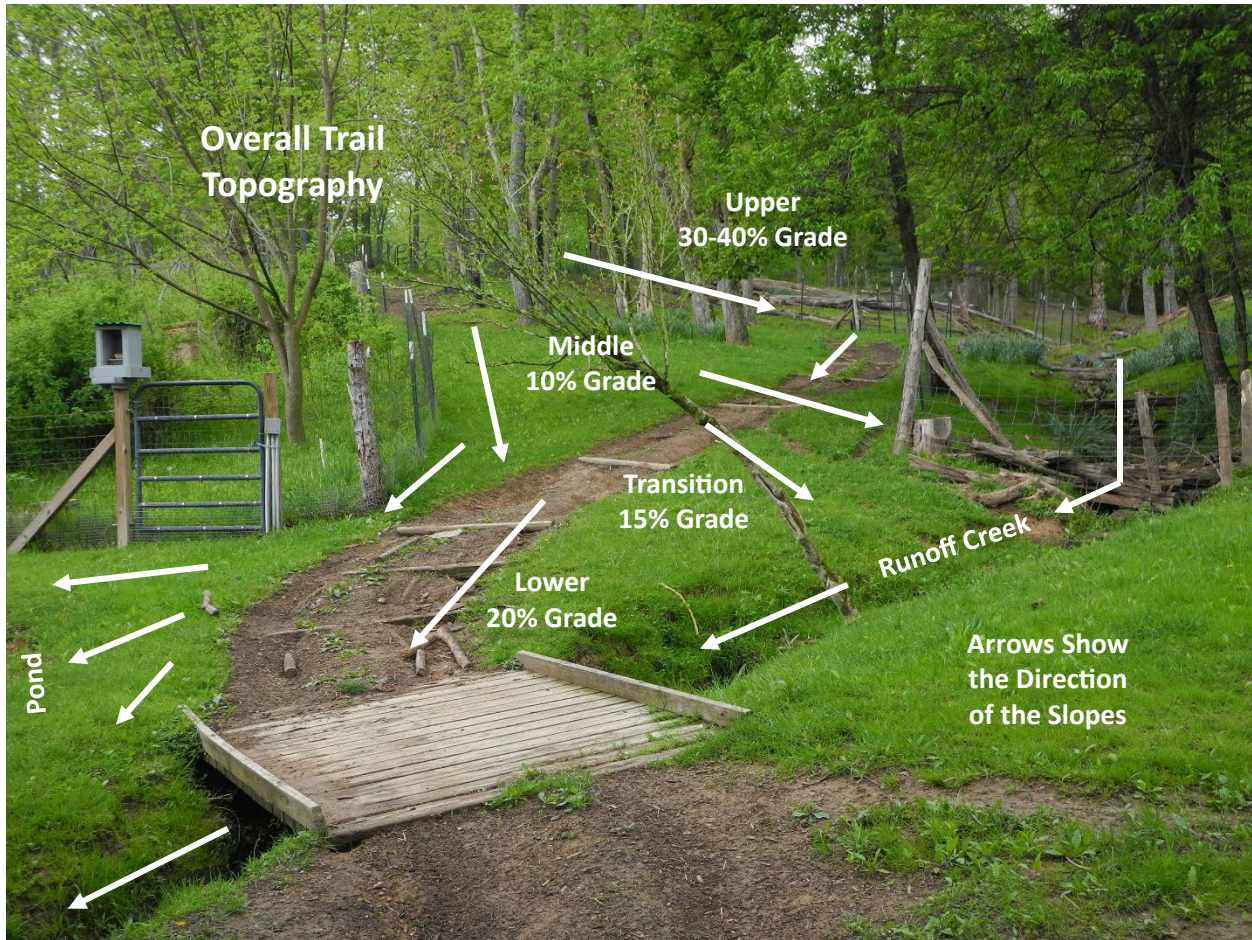
On grades of less than 5 percent, waterbars are less susceptible to clogging unless they serve a long reach of tread or are constructed in extremely erodible tread material. On steeper grades (10 to 15 percent), waterbars are prone to clogging if they are less than a 45-degree angle to the trail. Waterbars are mostly useless for grades steeper than 20 percent. At these grades a fine line exists between clogging the drain and eroding it (and the waterbar) away.

Most waterbars are not installed at the correct angle, are too short, and don't include a grade reversal. Poorly constructed and maintained waterbars become obstacles and disrupt the flow of the trail. The structure becomes a low hurdle for travelers, who walk around it, widening the trail.

A problem with wooden waterbars is that horses [or equipment] can kick them out. Rock, if available, is always more durable than wood (figure 18). Cyclists of all sorts hate waterbars because the exposed surface can be very slippery, leading to crashes when a wheel slides down the face of the waterbar. As the grade increases, the angle of the waterbar (and often the height of its face) is increased to prevent sedimentation, raising the crash-and-burn factor.

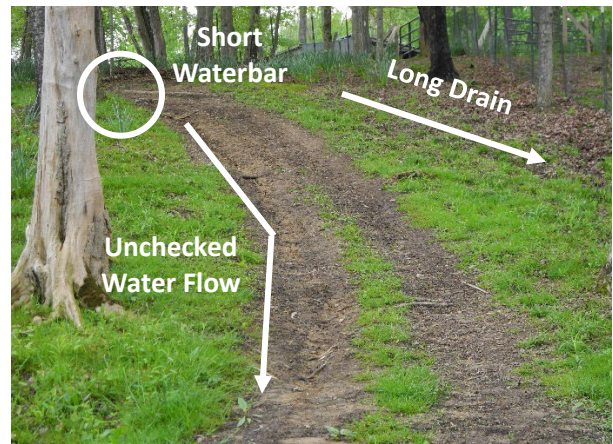
Experience: Failed Water Bars – We have an established trail to the upper level for equipment (tractor, ATV primarily, and tug mower). The trail varies from about a 20% grade to 10% grade to 30-40% grade from bottom to top. Being desperate for immediate help to limit erosion we installed several waterbars at angles to direct rainwater drainage to the adjacent runoff creek. This sort of worked for about a year and then failed miserably when we had a very muddy winter in the middle of sugaring season. Maple sap was coming in great quantities so the trail suffered badly. Sometimes it's give and take on a homestead.

This is typical of what happens when a trail must go where there's only one reasonable location.



Lower 20% Grade with Significant Erosion

The waterbars were too short and the drains were not deep enough to keep up with the water flow. When overtopped with sediment the trail became a significant problem. Logs made it passable.



Upper 30-40% Grade with Minimal Erosion

An upper waterbar was minimally too short but was helped with a long drain to the runoff creek that did not fill with sediment. When the waterbar filled, water had a free run down this muddy steep trail.

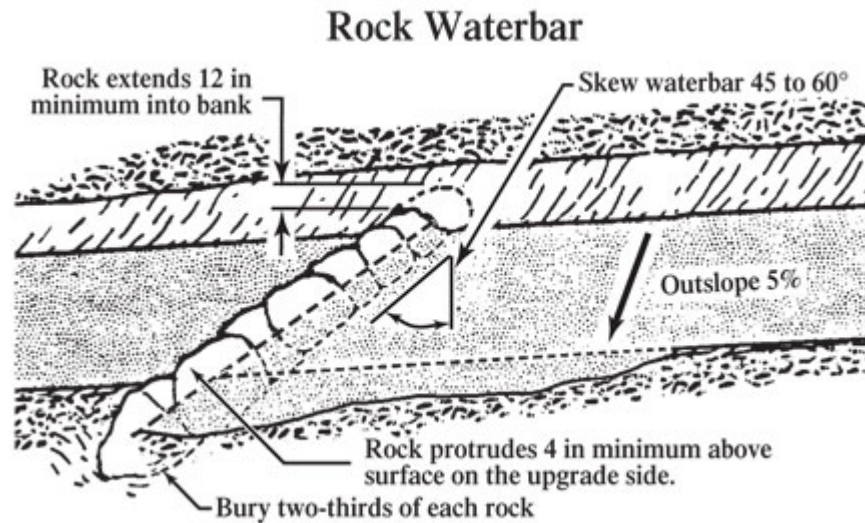


Figure 18 – Waterbars need to be constructed at a 45 to 60-degree Angle to the trail. Rock waterbars are more durable than wood.

Are waterbars ever useful? Sure. Wood or rock waterbars are useful on foot and stock trails where a tripping hazard is acceptable, especially at grades less than 5 percent. Also consider reinforced or armored grade dips where you don't have much soil to work with and in areas with occasional downpours.

A variation from the traditional waterbar is the *waterbar with riprap tray*. The riprap tray is built with rock placed in an excavated trench. The tops of the rocks are flush with the existing tread surface, so they're not an obstacle to traffic. Use *rectangular rocks*, chunkers, butted together, not overlapped. Start with your heaviest rock at the downhill side—that's your *keystone*. Lay rock in from there until you tie into the bank. Bury two-thirds of each rock at a 45 to 60-degree angle to the trail.

Add a retainer bar of rock angled in the opposite direction from the waterbar. The downhill edge of the retainer bar is at an angle so it nearly touches the downhill edge of the waterbar (figure 19). Fill the space between the waterbar and retainer with compacted tread material.

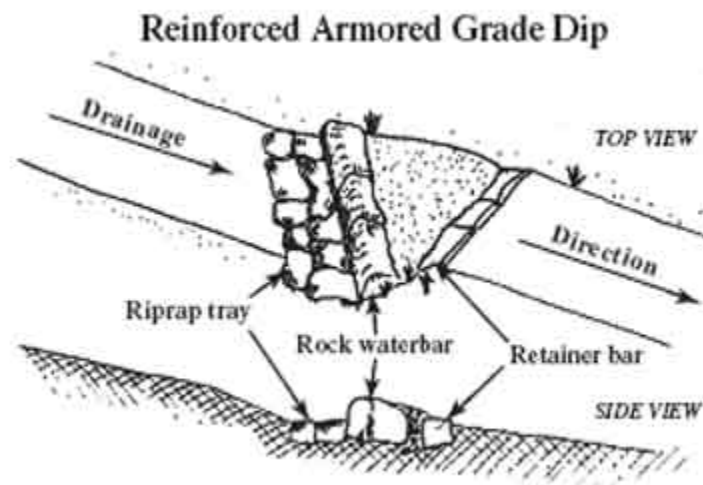


Figure 19 – A waterbar with a riprap tray.

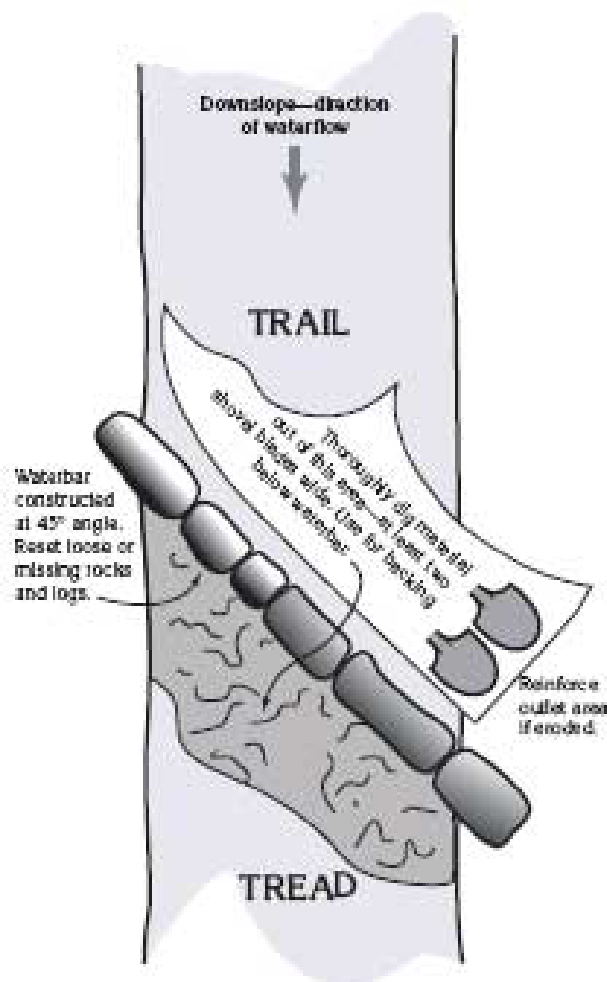
Maintaining the Drain

The number one enemy of simple drains is sediment, especially at waterbars. If the drain clogs, the water you are trying to get rid of either continues eroding its way down the tread, or just sits there in a puddle.

The best drains are self-cleaning; that is, the flow of water washes sediment out of the drain, keeping it clean. In the real world most drains collect debris and sediment that must be removed or the drain will stop working. Because it may be a long time between maintenance visits, the drain needs to handle annual high-volume runoff without failing (figure 20).

The best cure for a waterbar that forces the water to turn too abruptly is to rebuild the structure into a rolling or armored grade dip.

Figure 20 – The key to waterbar maintenance is to ensure that sediment will not clog the drain before the next scheduled maintenance. Embed rocks or logs a little deeper, cover them with soil, and you will have a reinforced waterbar.



Walking in the Rain

A lot of learning takes place when you slosh over a wet trail in a downpour and watch what the water is doing and how your drains and structures are holding up. Figure out where the water is coming from and where it's going. Think about soil type, slope, distance of flow, and volume of water before deciding your course of action.

Relocating Problem Sections of a Trail

If you've tried various drainage methods and water is still tearing up your trail, it's time to think seriously about rerouting the problem sections. Reroutes are short sections of newly constructed trail. This is your chance to incorporate all the good design features of a rolling contour trail that encourages water to sheet across the trail. Remember the good stuff:

- Locating the new section of trail on a sideslope
- Keeping the trail grade less than half the grade of the hillside
- Building with a full bench cut to create a solid, durable tread
- Constructing plenty of grade reversals
- Outsloping the tread
- Compacting the entire trail tread

Completed Trail Remediation

Overall

Although we wanted to use a rolling grade dip in the center section of the trail, an abundance of tree roots made this impossible. The compromise was a large number of water bars combined with ditch direction and sheet flow. The compacted soil required hand digging and breakdown of hardpan chunks. As the trail was built, this was watered at the end of each day to soften the soil for boot stomping.

Water Bars

The existing short waterbars were replaced with 8-foot bars positioned to work best with the slope of the trail and hillside. The water bars are anchored with 18-inch rebar. From the low end of each water bar 6 x 6-inch trenches were dug to the best location for drainage away from the trail toward the runoff creek or runoff pond. At the fence, all ditches were extended for unrestricted flow to the runoff creek.

Sheet Flow

This was graded toward the runoff creek in the transition area between the initial rise at the bridge to the steeper upper major rise. This almost flat area was graded under the bottom edge of the fence for unrestricted flow to the runoff creek. At the bridge, the sheet flow is toward the runoff pond.

Heavy Rain Tests

Two sessions have shown almost no soil erosion and no ponding of runoff at the water bars or ditches.

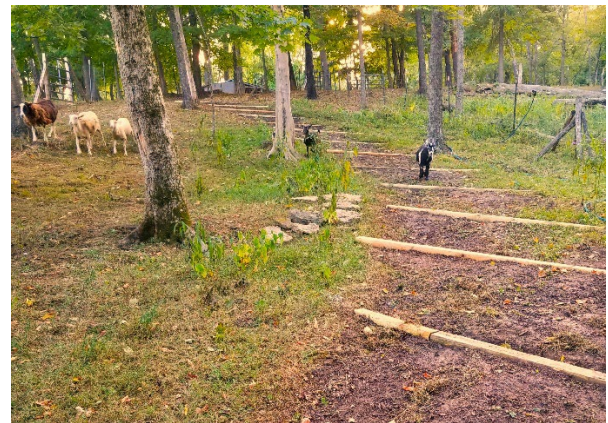
Ongoing Maintenance

Minor erosion will be inevitable necessitating annual clearing of soil from the water bar ditches. This will be returned to the trail. As wood chips are available, these will supplement low spots and ease transition across the water bars with the ATV, tug, tractor, bicycles, and toboggan sleds.



Lower 20% Grade with Sheet Flow

The lower part near the bridge sheet flows to the left to the runoff pond. Above that in the center area the sheet flow is to the right into the runoff creek. Ditch direction as needed.



Upper 30-40% Grade with Ditch Flow

All water bars are directed to a main ditch that flows to the right and downhill into the runoff creek. As the slope increased to 30-40% grade the number of water bars increased and are closer together.