Mineral Lands Division Information Resource

Erosion and Sediment Control (sheet 1 of 11)

1. INTRODUCTION

This document is provided for informational purposes only as a description of practices that may be adopted by those parties involved in exploration or quarry development intending to minimize or control the effects of erosion and sedimentation. **The practices described in this document do not modify regulatory requirements that apply to an activity being undertaken**, such as those requirements that are set out in the Environmental Guidelines for Mineral and Quarry Materials Exploration, the terms and conditions of an exploration approval, quarry permit, or quarry lease, or other regulatory document or in applicable legislation or regulations.

2. BACKGROUND

Erosion is defined as the mechanical detachment of sediment (clay, silt, sand, or gravel) from its place or origin and subsequent transportation by moving water or wind. Since erosion by water is more typically the concern with respect to disturbed exploration sites, erosion by wind will not be addressed here.

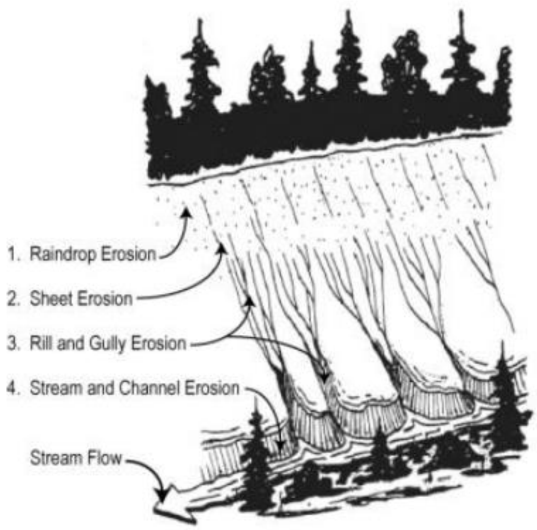
Eroded material is carried either in suspension or bounced along the bottom by saltation. Where the moving water is forced to slow down, for example, by entering a pool or pond, energy is dissipated from the system and deposition of sediment occurs. Deposition rates vary greatly based on flow velocity, topography, and the size of the particles. For example, in a low-energy environment, course sand settles in a matter of seconds whereas clay-sized particles settle out over many days.

While erosion is a natural occurrence, disruption or removal of the protective ground cover consisting of topsoil and vegetation can produce an increase in erosion rates on the order of 10 to 20 times. The intensification of erosion caused by disruption or removal of the ground cover can result in a number of undesirable environmental impacts. Increases in turbidity of aquatic habitats decreases oxygen and light availability and causes decreased feeding rates and increased stress and respiration rates in fish, which can cause mortality in local populations. Deposition of sediment can partially or completely bury spawning beds and smother incubating eggs. Harmful substances such as oils and heavy metals can be attached to transported sediment and introduced into aquatic habitats.

In the context of exploration: disruption of the ground cover occurs inadvertently due to ATV and heavy equipment traffic; removal of the ground cover is inherent to trenching and test pitting and to grubbing, stripping, and excavating as may be needed to prepare access trails, drill sites, laydown areas, or campsites.

In the context of quarrying, removal of the ground cover is inherent to the extraction of quarry materials and to general site development.

Types of water erosion, increasing in intensity and effect, are described in Figure 1.



Types of Water Erosion	
Raindrop Splash Erosion	The impact of falling droplets of rain mechanically dislodges soil particles causing them to be carried away by runoff.
Sheet Erosion	Before concentrating into small channels. Raindrop splash and runoff moves as broad sheets over the land and removes layers of exposed soil.
Rill and Gully Erosion	As runoff concentrates in rivulets, it cuts grooves called rills. If the flow of water is sufficient, rills will develop into gullies.
Stream and Channel Erosion	Large volumes of fast-flowing water in unprotected channels will cause stream bank and stream bottom instability, scouring and removal of significant portions of the stream or channel banks and stream bottoms.

Figure 1. *Types of water erosion.* (source: Handbook for Mineral and Coal Exploration in British Columbia, 2008/9 edition).

3. EROSION CONTROL

Exposed sediment is vulnerable to erosion. **Erosion control** aims to prevent erosion at the source by reducing the amount of sediment exposed. By contrast, **sediment control** is an “after-the-fact” approach which attempts to intercept sediment already having been eroded and now in transport. This section reviews methods of erosion control.

Preserving the natural ground vegetation cover is the primary means to prevent erosion as ground vegetation cover protects the soil from rain and wind, binds the soil with roots, and absorbs water. The most fundamental erosion control practice is to limit disturbance of ground vegetation to the minimum necessary to carry out the work. In order to accomplish this, careful planning and focused field supervision are necessary.

In this document, ground vegetation and topsoil are referred to together as **“organic cover”.**

Where exploration activities require the removal of organic cover, the organic cover should be stockpiled so that once exploration work has been completed it can be re-spread back over the site without delay. If deeper excavations are taking place, it is important that the organic cover be stockpiled separately from deeper materials so that the organic cover remains accessible and does not get lost when backfilling deeper materials.

For quarrying, the stockpiling of organic cover is required and it must be stockpiled separately from other materials such as overburden.

For exploration, where the original organic cover is removed or rutted through, then exposed soils and sediments should covered at the first opportunity.

The following materials and methods are recommended (as applicable, depending on the situation) for covering exposed soils and sediments to limit erosion:

- **Corduroy or brush matting** (*recommended for exploration areas or trails still in use*).

- **Scattered timbers, brush, roots, stumps** (*recommended for areas that do not need to be travelled over or disturbed again*). For slopes, consideration should be given to orienting timbers parallel to contour so as to intercept and disperse flowing water rather than channeling it. Timbers may also be partially embedded in the ground to provide structure.

- **Scattered organic mulch such as hay, straw, woodchips, wood fiber, recycled paper fiber, or compost** (*recommended for areas that do not need to be travelled over or disturbed again and where timbers and brush are unavailable or insufficient or to be applied beneath them*). Organic mulches will mould to the ground surface, are biodegradable, and generally promote vegetation growth. As with any ground covering used for erosion control, organic mulches should be inspected regularly to ensure continued effectiveness, especially after heavy rainfall events. Important considerations when selecting an organic mulch include the following:

    - Straw is preferred over hay as it does not attract animals and there is significantly less potential to introduce an invasive plants species. One bale (92 cm x 46 cm x 36 cm) covers an area of approximately 20 m^2.

    - Wood chips are highly resistant to wind and water however do not readily allow plants beneath them to grow up through. Applications of nitrogen fertilizer will assist decomposition and re-vegetation.

    - Wood fibers and recycled paper fibers may be applied hydraulically.

For exploration access trails where ruts are just starting to form, the ground should be covered without delay with corduroy and brush matting to prevent deepening of the ruts.

Before the end of the exploration season, deeply rutted or pock-marked ground should be physically restored to its approximate original position and then covered with organic materials. If an excavator is available, physical restoration should be carried out by the excavator “retreating” from the exploration area while restoring the ground in its wake.

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Options for erosion control over large areas in particularly sensitive locations include rolled erosion control products and organic fiber rolls, described below. The manufacturer's instructions should be followed when using a rolled erosion control product or organic fiber rolls. When using the manufacturer's instructions, assume that the instructions represent minimum requirements under perfect conditions.

Rolled erosion control products are temporary degradable or permanent non-degradable "blankets" of material held together with netting and functioning similarly to an organic mulch. These products are supplied in a roll and are applicable to both flat and sloping profiles, including stockpiles. Erosion control benefits from these products are immediate and can last for several months to several years, depending on the specific product and site conditions. Rolled erosion control products fall into two categories: temporary degradable, consisting of straw, natural fibers, or coir (shredded coconut husks), and long-term non-degradable, consisting of synthetic fibers, nets, or wire mesh.

In order to be effective, rolled erosion control products must be well fastened to the target surface by fasteners which vary in configuration depending on the proposed use and include U-shaped metal staples, circle top pins, biodegradable stakes, and wooden stakes.

Organic fiber rolls are tubular rolls of organic fibers enclosed in a biodegradable netting. The rolls are installed parallel to contour on large slopes to control erosion by creating grade-breaks for natural runoff. When new, organic fiber rolls can act as a "filter" for course sediment and also as an effective method of sediment control by collecting waterborne sediment along the upslope edge of the roll. The rolls are designed for short-term erosion control with a functional life of about one to two years in low runoff flow conditions. In high water flow conditions, the height of the roll can be compromised by water overflowing the roll or erosion undermining the roll.

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Newfoundland Labrador
Department of Industry, Energy and Technology

Erosion control on sections of access trail where the organic cover has been removed or rutted through, **or on prepared access roads**, can be assisted by the installation of **water bars**.

Water bars, in the form timbers or scrap lumber, should be placed across access trails located on sloped ground (Figures 2, 3). Water bars may even be constructed by embedding a line of cobbles or elongate stones across the path. The bars should be placed oblique to the trail with the downslope end of the bar extending beyond the edge of the trail to divert water out of the trail. The bars should be partially embedded in the ground along their length. Water bars provide a measure of erosion control by reducing the quantity of water flowing down the surface by periodically diverting it and also by reducing the flow velocity of the water thereby reducing its erosive ability. The ability of water bars to function depends on the depth of ruts and the overall depth of the access trail: if the trail has become too rutted, it will be difficult to place water bars to check the flow of water through the ruts; if the trail surface has become significantly lower than the adjacent ground surfaces, it will be difficult to embed the bars in such a way to divert water out of the trail.

Figure 2 (right). Installation of water bars. (source: British Columbia Ministry of Forests: Recreation Manual)

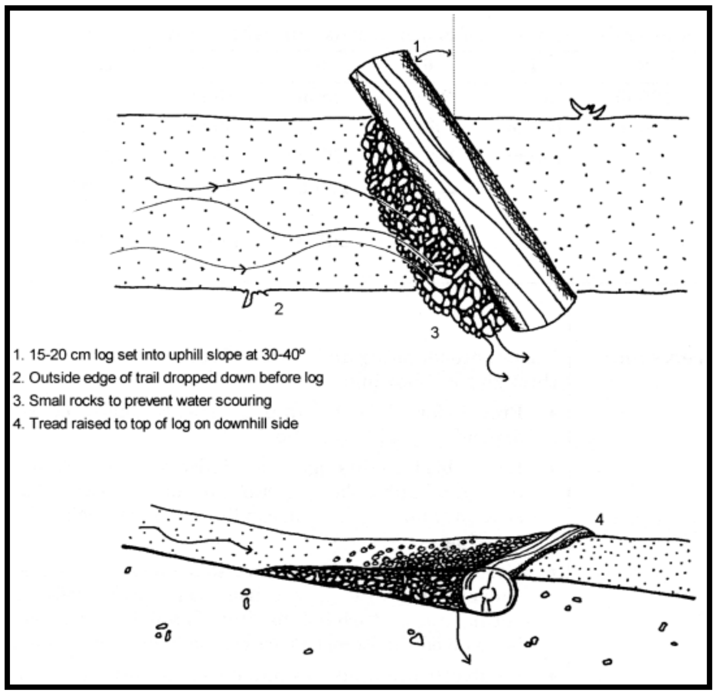
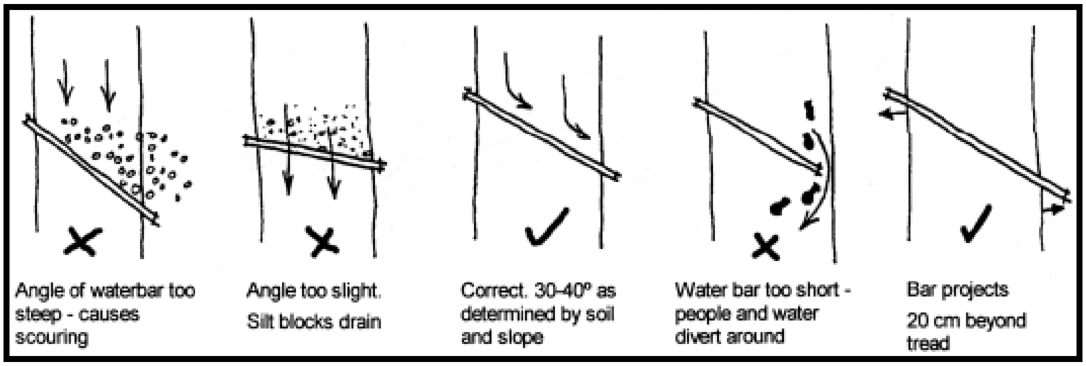


Figure 3 (below). Installation of water bars [upslope to top]. (source: British Columbia Ministry of Forests: Recreation Manual)



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Re-vegetation is required for permanent erosion control. While re-vegetation will eventually occur naturally, the Department has documented many instances where mineral soil and till in the province, having become exposed in the course of mineral exploration, have remained largely barren of vegetation for periods of twenty years or more. For this reason, and for prompt erosion control, re-vegetation of exploration sites should be facilitated by one or more of the following practices: re-spreading the original organic cover (i.e., stockpiled topsoil and ground vegetation); scattering timbers, roots, stumps, and brush; applying an organic mulch (except for those such as wood chips that, unless applied thinly, may inhibit plant growth); and seeding, whether mechanically or hydraulically. Seeding is addressed below; the other practices are addressed above.

Note that replacing the original organic cover (i.e., topsoil and vegetation including remaining woody material) is more effective in re-vegetating disturbed ground than other methods.

Seeding functions as erosion control by binding the soil with roots and by slowing incoming rain and overland flow. Seeding is most effective when paired with the distribution of organic materials, whether organic cover, woody debris, or organic mulch. The distribution of organic materials will stabilize the soil before plants become established, provide shelter and microhabitats for sprouting seeds and young plants, and provide an organic base from which to grow and obtain nutrients.

The following seed mixture has been found effective for seeding alongside new highways in the province:

- annual rye grass
- Canada blue grass
- creeping red fescue (boreal)
- hard fescue
- tall fescue
- timothy grass
- white clover
- birdsfoot trefoil

This mixture works well for slope stabilization. Annual rye grows very quickly, sending out fibrous roots to bind the soil, preventing rill erosion. Annual rye grass is short-lived, lasting only one growing season, and doesn't self-seed in the province's climate. Slower growing, self-seeding fescue, bluegrass, clover, and trefoil can then become established within the protection of the rye grass, becoming further established over the next few years in the stable soil left by the rye. Once vegetation is in place, the ground has been stabilized and native colonizers rapidly move in. Initial native colonizers include goldenrod, pearly everlasting, fireweed, raspberry, northeastern wild rose, and alder.

The development of plant cover by seeding is not guaranteed and is limited by many factors, including soil compaction, nutrient levels, acidity, drainage, climate, weather events, and time of year. Soils should be not compacted and with an irregular surface to better hold seeds, promote run off infiltration, and provide microhabitats for growth. Fertilizer should be applied to provide nutrients where soils are lacking.

Perhaps the simplest seeding method is to harvest alder seeds by hand during late fall and let the wind blow the seeds across the surface to be covered. The seeds do not need fertilizing and are adapted to nutrient-deficient soils. Other seeds can also be spread by hand, however for systematic, even application seeds should be applied mechanically or hydraulically.

Mechanical seeding includes using a personal rotary seeder and ATV cyclone seeding. For most mineral exploration applications, hand-operated rotary seeders are recommended. They are cost effective and can seed areas at about a rate of one hectare an hour. Seed density and spreading rates can be easily calculated and controlled based on manufacturer's recommendations and fertilizer can be spread as well, although not at the same time due to density differences and mixing inconsistencies. ATV mounted cyclone spreaders distribute seeds in a very similar fashion, with the same advantages, but can cover much larger areas in shorter time, if required.

Hydraulic seeding uses water to deliver seed and fertilizers and when mulch is also delivered is referred to as **hydroseeding**. Hydraulic seeding is the most effective seeding method but still does not guarantee that the seeds will germinate and grow. Hydroseeding is the most expensive seeding technique and requires specialized equipment and good site access.

4. SEDIMENT CONTROL

Sediment control measures are necessary where there is a risk that sediment, or waterborne drill cuttings, may enter an open waterbody or watercourse. In determining whether sediment control measures are necessary, consider that waterborne sediment or drill cuttings can travel long distances should they intercept topography that forms a channel (even if it is dry), and thereby potentially be carried into an open waterbody or watercourse located some distance away.

Sediment control measures should be located at the base of slopes and as close to the source as possible.

Common sources of sediment-laden water in the mineral exploration industry are: drill discharge waters (high flow), bedrock (e.g., trench bottom) cleaning discharge waters (high flow), as well as excavation, drill site, and stockpile runoff (low flow).

Sediment control is intended to supplement effective erosion control and does not provide an effective replacement for erosion control. Sediment control methods include sediment fences, sediment retention ponds, and berms.

Sediment fences consist of permeable geotextile fabric anchored by posts into the ground for the purpose of collecting sediment (Figure 4), and are also known as silt screens, silt fences, and filter fences. Note, however, that filtration is only a secondary function of sediment fences and decreases rapidly with time as filtered particles clog the medium. Sediment fences function primarily by causing pooling of sediment-laden water thereby producing a low energy environment that allows waterborne sediment to settle out of the water column.

If configured and installed correctly, sediment fencing is an effective method of sediment control. However, sediment fencing should only be used as a temporary measure and does not provide effective erosion control. If installed incorrectly sediment fencing may actually contribute to additional erosion, for instance, by water undercutting the fence. To ensure the effectiveness of sediment fencing, installed fencing must be regularly inspected and accumulated sediment removed. The life cycle of a sediment fence is estimated to be one year, and maintenance should include annual removal and replacement if the need for sediment control remains.

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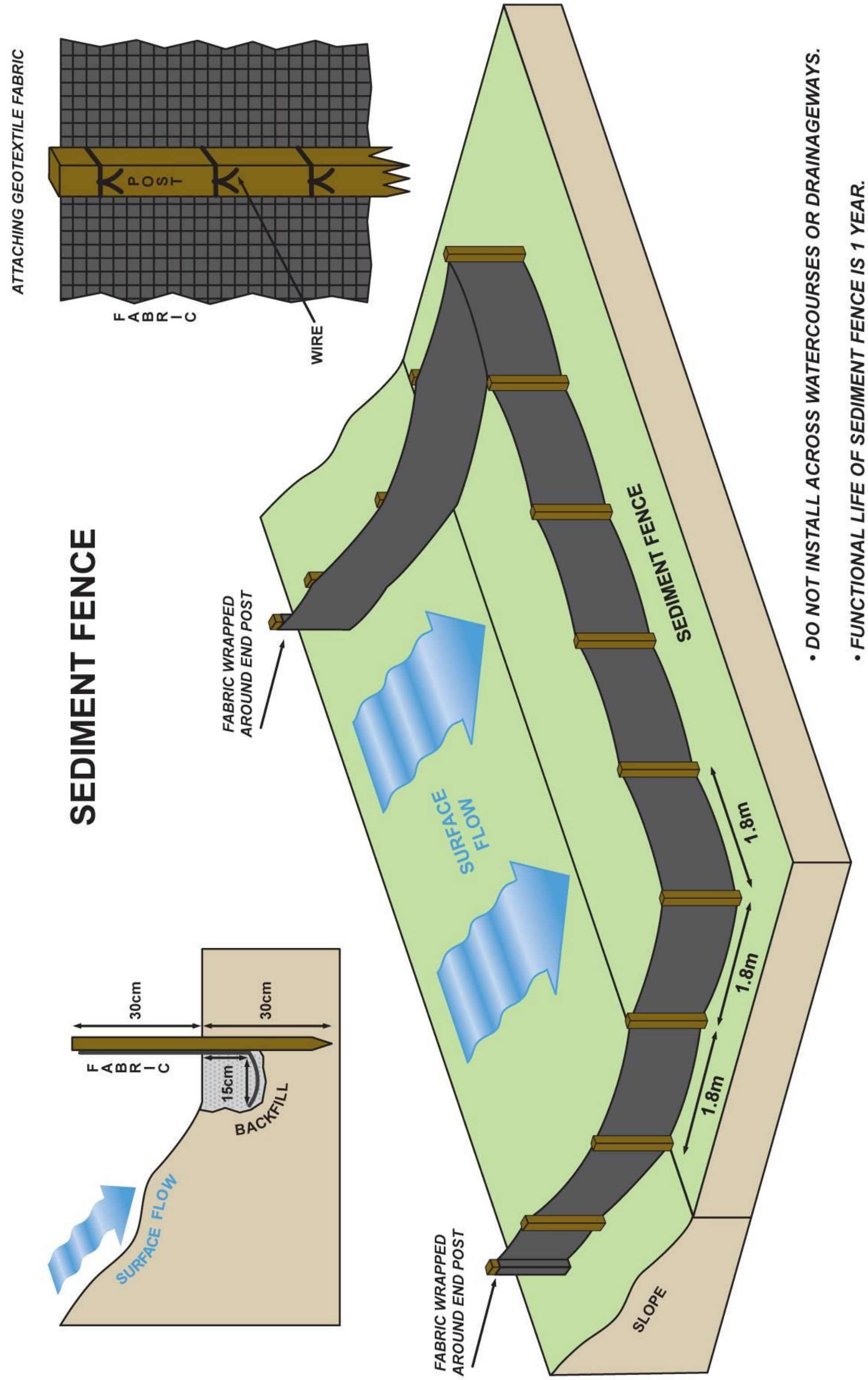

Figure 4. *Sediment fence installation.*

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Sediment retention ponds consist of earthen basins excavated to collect runoff waters (e.g., drilling discharge waters) and allow the settling and deposition of waterborne sediment. Sediment retention ponds function similarly to sediment fences in that they provide a low energy environment for sediment to settle out of the water column. Sediment retention ponds can hold water indefinitely and sediment will naturally filter out of the runoff as the water drains into the ground. Typically in the exploration industry a sediment retention pond is only required for a relatively short period of time and consists of a small, temporary hole dug with an excavator. Sediment retention ponds must be constructed large enough that they do not overflow during use, and depending on sediment load and duration of use, accumulated sediment may need to be removed on occasion. When a retention pond overflows it is no longer able to capture clays and finer silts and in such a scenario a flocculent product or filtration may be required. Sediment retention ponds must be inspected and maintained regularly (suggest weekly and after large water flow events).

For high runoff volumes, whether due to large drainage areas (e.g., a large trench) or high precipitation or discharge rates (e.g., drill discharge waters), excavated sediment retention ponds are most appropriate. Such ponds are commonly referred to in the exploration industry as **sump pits**. Sediment retention ponds may even take the form of a tapered ditch, for example, excavated at the downslope end a trench.

For low runoff volumes, sediment retention ponds may consist of a shallow basin created by earthen berms. Without the support of the surrounding ground as in the case of dug ponds, ponds constructed of berms could be prone to sudden failure accompanied by the release of captured sediment, which is why they not be used for high flow applications.

Sediment retention ponds are an easy, inexpensive, and effective way to control waterborne sediment.

When a sediment retention pond created by excavation (whether to dig a hole or obtain material for a berm) is no longer required, it must be rehabilitated as per the requirements for trenches and other excavations.

5. SPECIAL CASE: CHANNELIZED RUNOFF

As illustrated in Figure 1, ongoing sheet erosion will eventually transition into rill and gully erosion which will eventually transition into stream and channel erosion. Channelized runoff can also occur as flow of water through rutted ground, particularly in boggy areas. Channelized runoff presents a unique challenge for erosion and sediment control and as such is considered a special case that is to be avoided if possible. Channelized runoff of significant volume or velocity cannot be contained by placing sediment fences or earthen berms across the channel because the water will inevitably (and possibly very quickly) flow around, over, or under the barrier. Where channelized erosive runoff occurs, the flow velocity should "checked" by some kind of permeable obstacle and the runoff diverted by channeling the water into a well vegetated or rocky dispersion / filtration zone.

Flow velocity may be decreased by check dams, which typically consist of gravel dams placed in ditches, however ditches and sources of clean gravel are not typical features of mineral exploration projects.

Bundles of timbers and brush placed longitudinally in a channel should have a similar effect as gravel check dams, especially when placed end to end. Bundles of timbers and brush have the added advantage that, where placed in access trail ruts, they can be driven over without inhibiting their function.

Channelized flow may be diverted by digging drainage channels to divert flow into well vegetated or rocky ground. Waterbars constructed with parallel lengths of lumber, or even timber, would similarly assist in diverting flow. Waterbars are embedded obliquely across the trail and extend into the surrounding, undisturbed ground (Figures 2 and 3).