EROSION AND SEDIMENTATION CONTROL

HANDBOOK FOR CONSTRUCTION SITES

Nova Scotia
Department of the Environment

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from top to bottom

Hydroseeding of a major highway.

A Temporary sedimentation basin — refer to Factsheet 2.10.

Berm consisting of straw bales and crushed rock placed in front of drainage works during major highway construction.

Close-up of a newly-sodded grassed waterway — refer to Factsheet 2.3.

All photos in this handbook were taken in the province of Nova Scotia.

PART I

INTRODUCTION

1.1 BACKGROUND

Soil is subject to natural weathering and erosion. Natural, or geologic, erosion by water, wind and ice has been occurring at a relatively slow rate since the Earth was formed. Excepting some cases of shore and stream channel erosion, natural erosion occurs slowly, shaping the landscape century by century, maintaining an environmental balance.

Construction activities and large earth-moving projects accelerate erosion dramatically, mainly by exposing large areas of soil to rain and running water. If this runoff is not properly treated, the result is often serious siltation of nearby watercourses. The consequences are degradation or destruction of fish and wildlife habitat, and water being less useful for fresh water supplies, navigation and recreation. For a more detailed explanation, see Appendix A.

Because all Nova Scotia watercourses, including rivers, lakes, ponds, and marshes, are protected by law for public use and enjoyment, the Nova Scotia Department of the Environment recognized the need to prepare an erosion and sedimentation control handbook as part of its educational program to promote protection of the environment.

This handbook is intended to aid in the design and construction of appropriate erosion and siltation control measures to prevent sedimentation of local watercourses. It should be used by persons with practical experience and technical training in this area. As each site and project differs in soil, topographic and climatic conditions, this handbook is not designed to provide precise instructions for every construction scenario.

1.2 PHYSICAL PROCESSES AND CAUSES OF EROSION

Because natural or geologic erosion of the Earth's crust takes place gradually over thousands of years, the process is not readily obvious. However, geologic norms of erosion provide guidelines for limits of practical erosion control measures and a basis for measuring the acceleration of soil erosion. Man's activities can speed up the natural erosion process considerably through the removal of soil in a matter of days or weeks. Inevitably, this affects the natural environment around the site. For example, a nearby river that is normally clear may suddenly turn a muddy-brown colour soon after a rainstorm passes over a construction area, as tonnes of soil are eroded by the rain and washed into the river.

Figure 1:
Sediment-laden water flowing into a river from a construction site during a heavy rainfall.

Erosion is primarily influenced by four factors: climate, soil type, topography, and vegetation. Soil erosion problems can differ from place to place because of the variability of each factor, and the relationship of one factor with another. Controlling erosion can be accomplished through understanding the nature of the relationships. Climate and soil conditions obviously cannot be controlled by man; however, proper planning can sometimes permit avoidance of construction on highly erodible soils and under adverse weather conditions. It is easier and more effective to manipulate vegetative cover and topographic conditions through erosion control practices like the ones presented in this handbook. For a more detailed discussion on the processes and causes of erosion, refer to Appendix B.

Figure 2:
A housing development where vegetation has been completely stripped, exposing bare soil to rainfall erosion on a long, steep slope.

1.3 EFFECTIVENESS OF EROSION AND SEDIMENTATION CONTROLS

Extensive use of mathematical soil loss prediction models throughout North America has resulted in recognized values assigned to rainfall, soil erodibility and topographic factors, for different areas and soils. When multiplied, these factor values provide an estimate of the annual soil loss from a site, and when combined with an erosion control factor, they can predict the relative reduction in the estimated annual soil loss. An erosion control factor of 1.0 means no erosion controls are used, such as when clearing or grubbing a site results in removal of all vegetation and the root zone, leaving the soil without protection against rainfall and runoff. Measures such as the use of certain types and rates of mulches, and methods of revegetation are assigned factor values less than 1.0.

For example, if an erosion control factor of 0.01 was assigned to the baseline, or completely undisturbed, condition of a construction site, and a factor of 1.0 was assigned to the disturbed construction site condition, the predicted annual erosion losses would be 100 times greater from the construction site. However, the predicted losses could be decreased to an acceptable level by implementing common erosion control measures.

This example, although more simplified than actual soil loss prediction techniques, nonetheless illustrates the relative merits that erosion and sedimentation controls implemented on construction sites could achieve. The factor values have not been rated to Nova Scotian conditions.

PART 2

EROSION AND SEDIMENTATION CONTROL ON CONSTRUCTION PROJECTS

A very important first step in reducing sedimentation of receiving water bodies is to develop a plan for controlling erosion before any earth-moving equipment disturbs a construction site. This plan is an integral part of the total site development plan and prescribes all the steps necessary, including scheduling, to assure erosion and sediment control during all phases of construction.

A knowledge of factors affecting erosion, as explained in Appendix B, provides the basis for technical erosion and sediment control principles. These principles can be utilized by the project planner in the design stage or readily implemented by a construction foreman in the field. Practical combinations of the five principles outlined on the following pages should be utilized to the maximum extent possible on all construction projects.

2.1 ACCEPTED PRINCIPLES AND PRACTICES FOR REDUCING EROSION AND SEDIMENTATION

1. FIT THE ACTIVITY TO THE TOPOGRAPHY, SOILS, WATERWAYS, AND NATURAL VEGETATION OF A SITE.

a) Costs for erosion control and maintenance can be minimized if a site is selected for a specific activity rather than attempting to modify the site to conform to the proposed activity.

b) Detailed planning will assure that roadways, buildings and other permanent features related to the activity conform to the natural characteristics of the site.

- Locate large graded areas on the most level portion of the site.
- Avoid areas subject to flooding and make every effort to preserve all features of natural channels. **Note that any channel alterations require a permit from the Department of the Environment.**
- Areas of steep slopes, erodible soils and soils with severe limitations for the intended uses should not be utilized without first overcoming the limitations through sound engineering practices.
- Limit the length and steepness of the designed slopes to reduce runoff volumes and velocities. Long, steep slopes should be broken by benching, terracing or constructing diversion structures.

2. EXPOSE THE SMALLEST PRACTICAL AREA OF LAND FOR THE SHORTEST POSSIBLE TIME.

a) Earth changes and the removal of natural vegetation leave an area susceptible to erosion and sedimentation; the larger the disturbed area and the longer it is left unstabilized, the more serious the problem becomes.
   - Plan the phases or stages of development so that only the areas which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch.

b) Complete grading as soon as possible after it is begun. Then, immediately after grading is complete, establish permanent vegetation and surface cover such as gravel, and erosion controls in the area.
   - Revegetate the slopes as work progresses — for example, as cut slopes are made, or as fill slopes are brought up to grade. This process is known as staged seeding.
   - Minimize grading of large or critical areas during the season of maximum erosion potential.

3. APPLY "SOIL EROSION" CONTROL PRACTICES AS A FIRST LINE OF DEFENSE AGAINST ON-SITE DAMAGE.

a) Applying erosion control practices on a site will prevent excessive sediment from being produced.
   - Keep soil covered as much as possible with temporary or permanent vegetation or with various mulch materials. Even project materials such as brush, logs and chippings can serve as mulch and help to control erosion.
   - Use special grading methods such as roughening a slope on the contour or tracking with a cleated dozer.
   - Roll and compact soil to make it less erodible.
   - Incorporate other practices such as diversion structures to divert surface runoff from exposed soils, and grade stabilization structures to control surface water.

b) Effective erosion control and sediment reduction depends upon judicious selection of conservation practices, adequate design, accurate installation in a timely fashion, and sufficient maintenance to ensure the intended results.

c) Prevent "gross" erosion in the form of gullies.

d) **When erosion is not adequately controlled, sediment control is more difficult and expensive.**

4. APPLY "SEDIMENT CONTROL" PRACTICES AS A PERIMETER PROTECTION TO PREVENT OFF-SITE DAMAGE.

a) The second line of defence is to control runoff and prevent sediment from getting off-site. Generally, this is done by either filtering runoff as it flows through an area or impounding the sediment-laden runoff for a period of time so that the soil particles settle out.
   - Berms, sedimentation basins, sediment traps, and vegetative filters are some examples of practices used to control sediment and protect watercourses.
   - Vegetative and structural sediment control measures can be classified as either temporary or permanent depending on whether or not they will remain in use after development is complete.

b) **The best way to control sediment, however, is to prevent erosion at its source.**

5. IMPLEMENT A THOROUGH MAINTENANCE AND FOLLOW-UP OPERATION.

This fifth principle is vital to the success of the four others. A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices. These practices must be maintained just as construction equipment must be maintained, and materials checked and inventoried.

- Start a routine "end of day check" to make sure that all control practices are working properly.
- Check the weather forecast daily and be prepared if rain is predicted.
- Throughout construction keep an adequate inventory on hand of materials such as straw bales, polyethylene, gravel, or rock riprap, and scout the area for other sources of useful materials like hay, bark or sawdust for mulching.

Usually these five principles are integrated into an overall plan of vegetative and structural measures and management techniques aimed at preventing erosion and controlling sediment, as demonstrated by the flow chart, Figure 3. In most cases, a combination of limited grading, limited time of exposure and a judicious selection of erosion control practices and sediment trapping facilities will prove to be the most practical method of controlling erosion and the associated production and transport of sediment.

PREPARE EROSION AND SEDIMENTATION CONTROL PLAN

Consists of a written document and drawings based on accepted principles and practices for reducing erosion and sedimentation.

- Carry out a thorough soils analysis
- Fit the activity to the natural site features, particularly waterways
- Include a stormwater management plan
- Expose the smallest area for the shortest practical time
- Plan for erosion control materials and the time to apply them
- Plan the location for sedimentation control measures
- Prepare for contingencies — maintenance is very important

IMPLEMENT TEMPORARY EROSION AND SEDIMENTATION CONTROLS DURING CONSTRUCTION

SURFACE STABILIZATION (TEMPORARY)

VEGETATIVE (1.5)	**NON-VEGETATIVE**
BUFFER STRIPS	RIPRAP (1.1)
MULCHING	GABION BASKETS (1.2)
HYDROSEEDING	GEOTEXTILE FILTER FABRIC (1.3)
MATTING (1.4)	MATTING (1.4)

DRAINAGE CONTROL (TEMPORARY)

CHANNELS (DITCHES) (2.1)(2.2)	GRADING PRACTICES (1.0)	SEDIMENTATION PONDS (2.10) (TEMPORARY/ PERMANENT)
CHECK DAMS		**FILTER BARRIERS**
BRUSH (2.7A)		STRAW (2.8)
ROCK (2.7B)		FILTER FABRIC (2.9)

IMPLEMENT MAINTENANCE PROGRAM THROUGHOUT CONSTRUCTION

DAILY ROUTINE CHECKS **REPAIRS** **REPLACEMENTS** **INVENTORY OF CONTROL MATERIALS**

PERMANENT EROSION CONTROL FOR FINISHED SITE

SURFACE STABILIZATION (PERMANENT)

VEGETATIVE (1.5)	**NON-VEGETATIVE**
SEEDING	RIPRAP (1.1)
SODDING	GABION BASKETS (1.2)
MATTING (1.4)	GRAVELLING
	PAVING

DRAINAGE CONTROL (PERMANENT)

CHANNELS (DITCHES) (2.1)(2.2)	STORM DRAIN OUTLET PROTECTION (2.4)	**CHECK DAMS** ROCK (2.7B)
BERMS, TERRACES, FINAL GRADING (1.0)	SEEPAGE DRAINS (2.6)	EARTH SODDED (2.7E)
GRASSED WATERWAYS (2.3)	CHUTES AND DOWNDRAINS (2.5)	GABIONS (2.7C)
		WOODEN PLANKS (2.7D)
		SANDBAGS (2.7F)
SEDIMENTATION PONDS (2.10)		

MAINTAIN PERMANENT EROSION CONTROL

MAINTENANCE PROGRAM

ROUTINE CHECKS **REPAIRS** **REPLACEMENTS** **INVENTORY OF CONTROL MATERIALS**

FIGURE 3
STEPS TO FOLLOW IN PREPARING AN EROSION AND SEDIMENTATION CONTROL PROGRAM FOR CONSTRUCTION PROJECTS.

NOTE: NUMBERS IN BRACKETS REFER TO FACTSHEETS, SECTION 2.3

2.2 GUIDELINES FOR PREPARING EROSION AND SEDIMENTATION CONTROL PLANS

Undertakings involving land disturbance that could result in siltation of watercourses may require environmental assessment and be subject to the provisions of the **Environmental Assessment Act** and the **Environmental Protection Act.** Highway, utility, pipeline construction, and other linear developments, residential subdivision and industrial parks developments, and mining exploration and development are all capable of causing gross sediment pollution if not properly planned and constructed. As such, they are typical undertakings assessed under the Acts and require an erosion and sedimentation control plan in order to be approved.

An acceptable plan usually consists of two parts:

1. A narrative report describing the project (including the scheduling or phasing of major construction activities), and explaining the methods, techniques, and procedures (including maintenance of control measures) to be followed.
2. A map (or several maps of the same scale) or a base map with overlays, depicting the topography and natural features of the area, the limits for clearing and grading, existing and anticipated erosion problems, and the location of suitable control measures. The map should be an integral part of any site plan, grading plan or construction drawings.

Conservation practices for erosion and sediment control should meet or exceed guidelines and specifications contained in this handbook. Practices for which guidelines and specifications are not contained in the handbook may be approved for inclusion in the plan, based upon their merits as proposed for use in individual circumstances.

Even within a regional area, the conservation practices needed to control accelerated erosion and sedimentation vary from site to site. The degree of slope, nature and types of soil, drainage characteristics, proximity to property boundaries and watercourses, acreage disturbed, amount of cut and fill, and other factors all have a direct bearing on what combination of conservation practices will result in an adequate erosion and sedimentation control plan.

Great care must be taken in selecting the right control measure for each erosion site. Although erosion problems often share similar symptoms, their causes may differ significantly. For this reason, it is wise to avoid a blanket approach to correction, but to undertake, instead, a thorough site investigation. This will help to determine the exact nature of the problem and how to correct it. For example, erosion along a drainage ditch may be the result of high stream flow velocity, unstable bank conditions, concentrated overland runoff, or any combination of these. Unless the actual causes of a problem are adequately determined, the applied remedial measure may fail to correct it, and may even aggravate it.

The selection, design and implementation of effective erosion and/ or sediment control measures requires a clear identification of the existing problems, as well as the objectives of the control efforts. It is important to avoid an indiscriminate choice of measures, but rather to select those that appropriately meet the specific objectives required in correcting the specific problem causes.

A broad classification of erosion and sediment problems such as that presented below provides a basis for considering categories of problems and control strategies.

Problem Type	Erosion Problem	Sediment Problem
I	X	—
II	X	X
III	—	X

An **erosion** problem exists where damage attributable to erosion involves the direct loss of soil, which in turn can mean the loss of roadways, the undermining of structures, and other damage necessitating costly repair.

A **sediment** problem exists where there is damage associated with the deposition of eroded material at downstream locations; for example, clogging of culverts, filling of drainage ditches and stream channels, silting of ponds and reservoirs, and contamination of downstream waters by sediment-borne pollutants.

Problem Type I involves an erosion problem but no sediment problem. Such a situation may occur where locally-eroded sediments, even in substantial quantities, are transported and deposited relatively short distances downslope or within the construction boundaries, but do not move into a waterway system.

Problem Type II involves both an erosion problem and a sediment problem. This type of situation can result from substantial material being eroded and transported into downstream ditches and stream channels.

Problem Type III involves a sediment problem only. This type of situation may occur when the direct loss of soil is insufficient to create local damage at the erosion source, but the accumulated sediment transported downstream creates depositional or water quality problems.

Recognizing the wide variations from one site to another, the following elements should be considered in the development of plan documents:

1. **A general statement of the project** (included in the narrative)
   - Brief description of the overall project
   - Date that project is to begin and expected date that final stabilization will be completed
   - The phasing (or staging) of land-disturbing activities and site stabilization to minimize the extent of exposed areas
   - Brief description of erosion control program
   - Brief description of sediment control program
   - Brief description of stormwater management program

2. **The topographic features** (shown on the map, which should also include map scale and north arrow)
   - The location of the project relative to highways, property boundaries, buildings, water supplies, and other identifiable landmarks or significant features
   - Contours at an interval and scale that will adequately describe the area prior to, and following, construction
   - Critical environmental areas located within, or in proximity of, the project areas, such as streams, lakes, ponds, wetland areas, drainage ditches, flood plains, and wells
   - Nature and extent of existing vegetation

3. **Information on the soils** (presented in the narrative and shown on the map)
   - Adequate description of each soil, including type, texture, slope, depth, drainage, and structure (as described in the Nova Scotia Soil Survey Reports)
   - Surface area of each soil

   Soils data is readily available in areas for which modern soil surveys are either completed or in progress. In the absence of a soil survey, a mechanical analysis of the soil should be made to the depth of the planned disturbance. Alternatively, an on-site evaluation should be made by a qualified soil scientist.

4. **The stormwater management program** (described in the narrative and the location of facilities shown on the map)
   - The amount of runoff from the project area and the upstream watershed; runoff-producing factors considered and methods of calculation
   - Brief analysis of problems posed by storm runoff on downstream areas
   - Analysis of local drainage factors which may contribute to on-site or off-site problems
   - Brief description of the permanent measures and facilities

designed to cope with the problem(s) (References such as the Province of Nova Scotia — Municipality of the County of Halifax Storm Drainage Design Criteria Manual (March 1982) may be used for design purposes, in addition to the factsheets in this handbook.)

5. **The proposed alteration of the area** (shown on the map)
   - Boundary limits and acreage of the project
   - Limits of clearing and grading
   - Areas of cuts and fills and proposed side slopes
   - Location for roads (including stream crossings), buildings, storm sewers, and other structures
   - Location and protection of stockpiles of excess fill or topsoil

6. **The temporary erosion and sedimentation control measures (vegetative and mechanical) to be used during active construction** (included in the narrative and shown on the map)
   - Purpose
   - Types of measures and facilities (refer to factsheets Section 2.3), and expected length of service
   - Location of measures and facilities
   - Dimensional details of the facilities
   - Design considerations and calculations (if applicable)

7. **The permanent erosion and sedimentation control measures for long-term protection** (included in the narrative and shown on the map)
   - Purpose
   - Types of measures and facilities (refer to factsheets Section 2.3)
   - Location of measures and facilities
   - Dimensional details of facilities
   - Design considerations and calculations (if applicable)
   - Landscaping or vegetative details such as seeding, sodding or mulching

8. **The maintenance program for the control facilities** (described in the narrative)
   - Inspection program, including frequency and schedule
   - Resodding or reseeding of vegetated areas
   - Repair or reconstruction of damaged structural measures
   - Method and frequency of removal and disposal of sediment from the control facilities or the project area
   - Method for disposing of temporary structural measures after they have served their purposes

2.3 FACTSHEETS

The following section of the handbook details a number of erosion and sedimentation control measures which may be useful in a variety of circumstances on construction projects. The factsheets provided may be used in preparing erosion and sedimentation control plans before development takes place or in applying some measures to an existing problem under field conditions.

The factsheets are prepared under two broad categories of Surface Stabilization and Drainage Control. They are as detailed as possible in order that they may apply to various types of construction projects, and they are also cross referenced to make the user aware that more than one remedial measure is usually required for a thorough erosion and sedimentation control effort.

These factsheets may not encompass every possible situation. Nor do they represent an accurate-in-every-detail description of every construction scenario, because each site and project differs in soil, topographic and climatic conditions. Rather, they are general guidelines that, when combined with practical experience and technical training, can effectively aid engineers and other construction experts in project design and construction.

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
GRADING PRACTICES

PURPOSE

- To provide sites more suitable for buildings, facilities and other land uses
- To improve surface drainage and to conduct the runoff water in a controlled manner to a stable surface or subsurface outlet
- To limit the length and steepness of slopes in order to reduce runoff volumes and velocities

CONDITIONS WHERE APPLICABLE

- Where grading to planned elevations is practical for the purposes stated above

ADVANTAGES

- Divert water away from buildings
- Prevent standing water and soil saturation detrimental to structures and to lot users
- Provide for disposal of water from lots
- Provide grades for safe and convenient access to and around buildings and lots for their use and maintenance

DESIGN CONSIDERATIONS

During development, some exposure of bare earth and some grading work are inevitable; however, they can be minimized by careful planning and scheduling.

Complete regrading work as early during the job as possible, and stabilize the bare earth by mulching, seeding to grasses, etc. Keep cuts and fills on as flat a slope as possible, and if the slope is steeper than 2 horizontal to 1 vertical (2:1), consider a retaining wall or cribbing as an alternative. A 3:1 slope is about the steepest on which tractors and maintnance equipment can operate efficiently. In erodible soils, consider lower cuts and fills of 3:1 and 4:1. In all cases, round the top and toe of the slope to blend with the adjacent ground.

Grading of terraces in a subdivision.

In order to protect adjoining property from erosion, sliding or settlement, do not make cuts too close to property lines. Place fill so that there is no danger of sliding or washing onto adjoining property. Do not locate fills adjacent to a stream bank, unless they are protected by riprap.

As a general recommendation, the edge of a cut or fill should be at least as far horizontally from property lines as the vertical height of the cut or fill, for heights up to 6 m (20 ft.); the edge of cuts or fills higher than 6 m (20 ft.) should be placed at least 6 m (20 ft.) from property lines.

Polyethylene liner used to protect a temporary diversion ditch.

Seeps or springs encountered during construction will require proper drainage control.

Use terraces to form a series of diversions down a slope or to change a steep slope to a series of smaller slopes. Terraces may have the added advantages of inducing infiltration of surface water and trapping some sediment.

Make provisions to safely conduct surface runoff to storm drains or protected outlets via diversion ditches, or chutes and downdrains, in order to ensure that runoff will not flow over or down the graded slope.

DESIGN STEPS

1. Design retaining walls, diversions and seepage drains if required. Cut and fill slopes of more than 9.1 m (30 ft.), but less than 12.2 m (40 ft.) in vertical height should be terraced at approximately mid-height. Cut and fill slopes with a vertical height greater than 12.2 m (40 ft.) should be terraced at approximately equal vertical intervals about 6 m (20 ft.) apart. Unusual soil stability conditions may require closer terrace intervals to assure vegetative establishment and maintenance.

2. Terraces should be not less than 1.5 m (5 ft.) wide. Provide additional width as needed for equipment travel, vegetative establishment and maintenance. Terraces should have a minimum grade of one percent if vegetated or one-half percent if paved, a 10:1 lateral slope towards the toe of the upper bank, and should convey water to an acceptable outlet.

3. Topsoil can be spread on a slope if the exposed soils are not suitable for establishing vegetation. The topsoil should be firmly bonded to the existing soils to prevent slips. Bonding can be improved by scarifying the slope before placing topsoil. Depth should be not less than 100 mm (4 in.).

4. Benches are flat areas on sloping land. They may be placed on or near the contour and made wide enough to accommodate a house and lot. It is absolutely essential that the soil be properly compacted.

Benches consist of part cut and part fill. On steep slopes, fill areas may slip when wet. Sliding potential may be reduced by careful planning for the disposal of runoff water from the building and lot. By sloping the bench to drain toward the cut area, water from the buildings and lots will drain into storm sewers, reducing the chance of fills becoming saturated and unstable.

When properly planned and installed, benches can materially reduce runoff and erosion hazards by slowing down the velocity of water and by providing increased water absorption. They are most effective when constructed on steep slopes.

IMPLEMENTATION STEPS

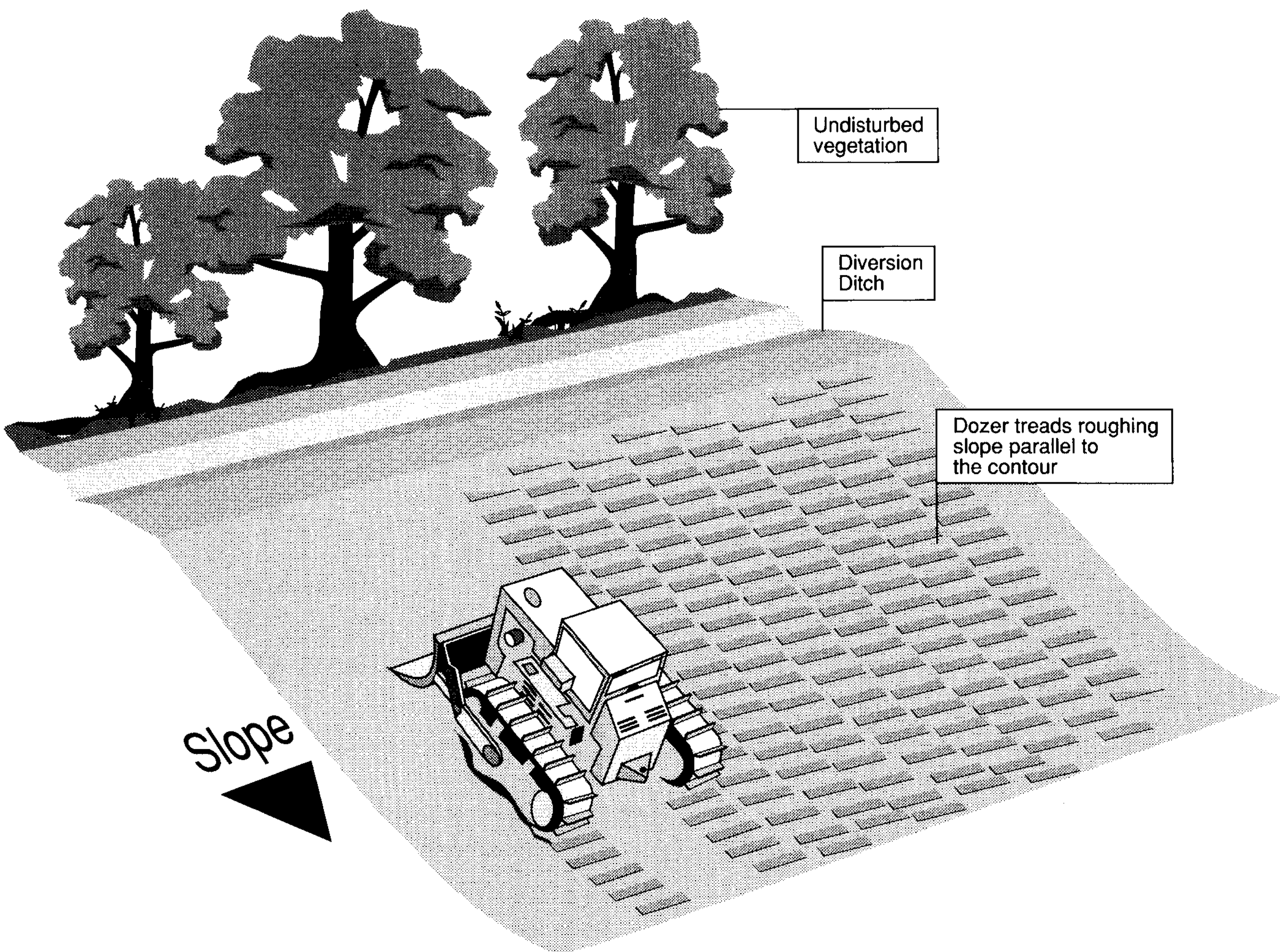
1. Rough finished slope surfaces with track vehicles, parallel to the contour, to help establish vegetation.
2. Clear trees, stumps, roots, brush, sod, and debris from land to be cut and filled.
3. Apply fill in such a way that it does not encroach on natural watercourses or constructed channels, **unless a permit has been obtained from the Nova Scotia Department of the Environment**. No work can commence until this permit has been acquired.
4. Grading should be done in such a way as to avoid diverting water onto the property of another landowner without the expressed consent of the landowner.
5. During grading operations, exercise the necessary measures for dust control.

MAINTENANCE

Regrade if serious gullying occurs before a vegetative cover begins to establish.

CROSS REFERENCES

- Factsheet 1.4 Temporary Matting
- Factsheet 1.5 Vegetative Linings & Buffer Strips
- Factsheet 2.1 Diversion Ditch
- Factsheet 2.5 Chutes & Downdrains
- Factsheet 2.6 Seepage Drains



Unvegetated slopes should be temporarily scarified to minimize runoff velocities.

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
RIPRAP LINING

PURPOSE

- To provide flexible, inexpensive bank protection in situations where vegetation alone is inadequate to prevent erosion

CONDITIONS WHERE APPLICABLE

- Where erosion is caused by surface runoff or subsurface seepage
- On streambanks and stream bends with erodible soils
- In areas where submergence lasts continuously for more than a few days (e.g., situations where vegetation alone provides inadequate control)

Note: Work along the banks of a watercourse may require a permit, so consult the Nova Scotia Department of the Environment for advice.

ADVANTAGES

- Tolerates some lateral seepage if a filter fabric is used underneath
- Provides a flexible lining
- Provides a rough surface that dissipates stream's force, therefore minimizing the erosion problem
- Provides immediate protection
- May be co-established with vegetation for a more natural appearance
- Adjusts to minor shifts and movement of a streambank
- Easy to apply
- Minor repairs made easily
- Relatively inexpensive when stone is readily available
- Can be placed during winter months on streambanks because trucks are able to be driven on frozen ground to the erosion site

DISADVANTAGES

- If not properly feathered in, will cause a shift in the erosion problem up or downstream (in streambank applications)
- High initial cost if stone must be hauled any distance
- Should be placed on a well-graded slope no steeper than 2:1
- Very expensive for a large-scale application

Riprap used on steep embankment.

DESIGN CONSIDERATIONS

The ability of riprap to resist erosive forces depends on water velocity and the interrelation of the size, shape, weight, and gradation of the stone, the side slopes, roughness, shape, and alignment of the channel, and the thickness of the riprap layer.

The type of stone applied depends on what is most available (quarried stone, field stone, rubble).

The stone should be of a blocky, angular shape, rather than elongated, and should be sized of a mixed gradation so that smaller stones fill the voids between the larger ones. A layer of filter stone may be required depending on the type of underlying soil and the size of protective riprap above.

DESIGN STEPS

1. Select a stable slope for the soil.
2. Determine if a seepage drain is required.
3. Select the stone size.
   - Use stream flow velocity (assuming a graded channel Manning's roughness of 0.030) to determine suitable stone size.

Stream Flow Velocity	Mean Stone Diameter
m/sec. (ft./sec.)	mm (in.)
less than 2.0 (6.6)	80 - 110 (3 - 4)
2.0 - 2.5 (6.6 - 8.2)	110 - 180 (4 - 7)
2.5 - 3.0 (8.2 - 9.8)	180 - 220 (7 - 8.5)
3.0 - 3.5 (9.8 - 11.5)	220 - 330 (8.5 - 13)

   Velocities greater than 3.5 m (11.5 ft.)/sec. require a more extensive design for streambank protection and should not be attempted without the aid of a soils engineer or other person experienced in the design and installation of erosion and sediment control measures.

   - Riprap should be applied at a thickness of at least 1.5 times the maximum stone size and not less than 300 mm (1 ft.) thick.

4. Select the filter material, either a geotextile or layer of filter stone, from manufacturer's literature or technical references.

Riprap, sod and crushed stone used to stabilize stream bank after installation of a pipe line.

5. Locate the riprap on the channel bank.
   - Riprap design on stream channel bends or meanders should not be attempted without the aid of a soils engineer or other person experienced in the design and installation of erosion and sediment control measures.
   - On straight channel sections the riprap should protect the bank toe beneath the channel bottom and extend to the top of the bank or at least 600 mm (2 ft.) above the channel design flow water level.

- The riprap should not be placed in a manner that would constrict the channel width.

IMPLEMENTATION STEPS

1. Prepare the site (after consultation with the Nova Scotia Department of the Environment).
   - Clear the area of debris.
   - Grade the banks to the recommended slope.
   - Dig out the toe trench.
   - Install any seepage drains required.
2. Place the riprap.
   - Lay out the filter fabric, if it is being used, or the layer of filter stone.
   - Riprap can be placed by hand or by machine (backhoe, etc.). (Be sure that the stone is not dropped from such a height that it will damage the filter fabric.)
   - Riprap should be placed to its full thickness in one operation.
   - Blend or "feather" the ends of the riprap section into the upstream and downstream banks so the ends do not protrude into the stream and cause eddying and further bank erosion.
   - If installed under winter conditions, the riprap should be carefully placed and/or contained to prevent it from spilling over the ice.
3. Complete the installation.
   - A vegetative lining should be used on any areas that were graded but not riprapped.

MAINTENANCE

Once in place, riprap lining requires little upkeep. However, any displacement of stone should be repaired immediately.

CROSS REFERENCES

- Factsheet 1.3 Geotextile Filter Fabric
- Factsheet 1.5 Vegetative Linings & Buffer Strips
- Factsheet 2.6 Seepage Drains

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
GABION BASKET LINING

PURPOSE

- To protect streambanks from severe erosive action of stream flow
- To provide retaining wall support for an unstable soil bank

Note that before a gabion basket lining may be used to line a watercourse, a permit must be obtained from the Nova Scotia Department of the Environment.

CONDITIONS WHERE APPLICABLE

- Where the flattest possible bank slope is steeper than the recommended slope
- Where slumping is being caused by either seepage or stream flow undercutting
- Where stone of sufficient size is not available for an adequate loose riprap lining.

ADVANTAGES

- Provides a dual purpose of bank protection and retaining wall support
- May be co-established with vegetation for further protection, stabilization and aesthetic properties
- Normal life span of 30 to 50 years
- Can be used for a wide range of bank lengths, heights and shapes
- Very little maintenance usually required

DISADVANTAGES

- Subject to rusting and deterioration unless the baskets are made of galvanized wire
- Relatively expensive when compared with vegetation and riprap linings

DESIGN CONSIDERATIONS

The gabion baskets are supplied in a variety of standard sizes and are normally joined together with wire ties.

To prevent toe failure along a streambank, a line of gabion baskets, built at the mean stream level, should be constructed to act as a protective apron.

The apron must be deep enough to protect against anticipated scour and may be formed with a gabion mattress.

A seepage drain should be installed if there is a seepage problem.

A filter fabric should be used if the existing bank material is not granular.

The lining must be blended into the bank at both up- and downstream ends.

DESIGN STEPS

The design of a gabion basket lining is sufficiently involved as to require the assistance of a soils engineer or other

Filling the gabion baskets with stone. Note that each successive layer is stepped back slightly.

person experienced in the design and installation of erosion control and siltation control measures.

IMPLEMENTATION STEPS

1. Prepare the site.
   - Clear debris from the area to be lined.
   - Grade or excavate the site as the design requires.
   - Install a seepage drain and filter fabric if required.

2. Place the gabion baskets.
   - Set the first row of empty gabion baskets in place with their lids open, and tie them together with connecting wire.
   - Fill the gabions with stone slightly larger than the mesh opening. (Filling by hand is desirable as dumping the stone in usually deforms the baskets.)
   - Fill the basket uniformly to prevent deformation of basket sides.
   - If the basket is deeper than 300 mm (1 ft.), fill it to a 300 mm (1 ft.) depth and then tie connecting wires to opposite sides of each cell of the basket to prevent deformation; continue this at 300 mm (1 ft.) intervals until the basket is filled.
   - When the baskets are full, close and tie down the lids.
   - Repeat for additional rows or layers.
   - Step the next one back and tie in properly.

3. Complete the installation.
   - Backfill any open spaces between the bank and the gabion baskets.
   - Cover backfill and any other unprotected areas with either a vegetative lining or a riprap lining.

4. Protect upstream and downstream.
   - Use loose rock riprap and/or vegetation at the ends of the gabion lining to "feather" it into the existing bank.

MAINTENANCE

Make periodic checks for undermining or erosion at locations where the gabion baskets meet the bank.

Any broken basket wire should be repaired immediately by wiring across the break.

CROSS REFERENCES

- Factsheet 1.3 Geotextile Filter Fabric
- Factsheet 1.5 Vegetative Linings & Buffer Strips
- Factsheet 2.6 Seepage Drains

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
GEOTEXTILE FILTER FABRIC

PURPOSE

- To serve as a soil stabilizer, allowing water to flow through the lining, while preventing underlying soil from being washed away

CONDITIONS WHERE APPLICABLE

- Under any flexible or rigid lining, especially when applied on highly erodible soils (e.g., sand)
- Beneath drop structures
- With riprap linings, check dams and siltation ponds

ADVANTAGES

- Eliminates many of the problems associated with installation of graded granular filters (e.g., segregation of material)

Geotextile used prior to riprap placement.

- Prevents possibility of undermining of the remedial measure leading to failure
- Easily installed
- Greater tensile strength than granular filters
- Relatively inexpensive measure where granular material is not accessible

DESIGN CONSIDERATIONS

The installation of fabrics to replace granular filter material may not be economical in small problem areas. Moreover, a filter fabric may not be required if the parent bank material has a good covering of granular material. If there is a seepage problem, a seepage drain should be installed in addition to the filter fabric.

If there is no granular material, installation of a filter fabric may be necessary to protect fine particles from erosive water action.

The choice of filter fabric depends on the type of soil present and the type of water action (surface or subsurface). Filter fabrics are classed according to their soil retention and water permeability characteristics.

DESIGN STEPS

1. Select the filter fabric.
   - Considering the many variables associated with geotextile selection (e.g., soils, hydraulic conditions, construction conditions and techniques), it is recommended that a person experienced in the design and installation of erosion and siltation control measures (e.g., a soils engineer or the manufacturer's representative) be consulted for advice on selection, geotextile design and installation information.

IMPLEMENTATION STEPS

1. Prepare the site.
   - Regrade or otherwise develop the bank according to the site and type of lining being applied.
2. Install the seepage drain if required.
3. Install the filter.
   - Lay the fabric by running up and down or across the slope (adjacent rolls of fabric should be overlapped a minimum of 300 mm (1 ft.).
   - If a seepage area is being covered, extend the material above the seepage limit.
   - Make sure the fabric is not pulled tight, to allow for stretching when cover is applied. (However, folds and wrinkles in the fabric should be avoided.)
   - Pins may be required to secure fabric on steep slopes.
   - When using a filter fabric under riprap, stones should not be dropped from a distance higher than 1 m (3.3 ft.).
   - Repair any rips or tears in the geotextile by placing a new piece of geotextile over the torn area, extending at least 1 m (3.3 ft.) beyond the rip or tear.
   - When installing the geotextile filter fabric, take care to lay or roll — not drag — it into place. This prevents silt and clay particles from smearing the geotextile and thus decreasing its filtering properties.

MAINTENANCE

Some fabrics should be protected from direct sunlight or excess heat.

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
TEMPORARY MATTING

PURPOSE

- To provide cover for the surface of slopes, or in channels or waterways (swales)
- To protect newly-seeded soil from eroding from raindrop splash or runoff

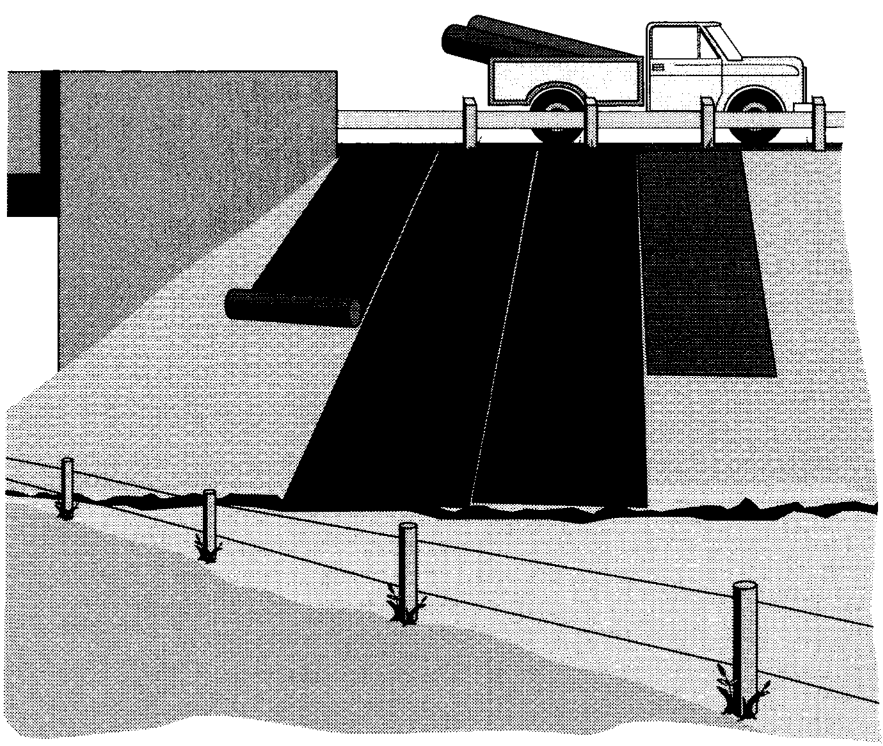
Examples of temporary matting include jute mat, glass fibre mat, woven paper mat, vegetative mat (commonly called erosion control blankets), all of which are available in rolls to cover large areas. They act as mulch to hold moisture in, and allow grass to grow through. In this way, they eventually help establish a permanent vegetative cover.

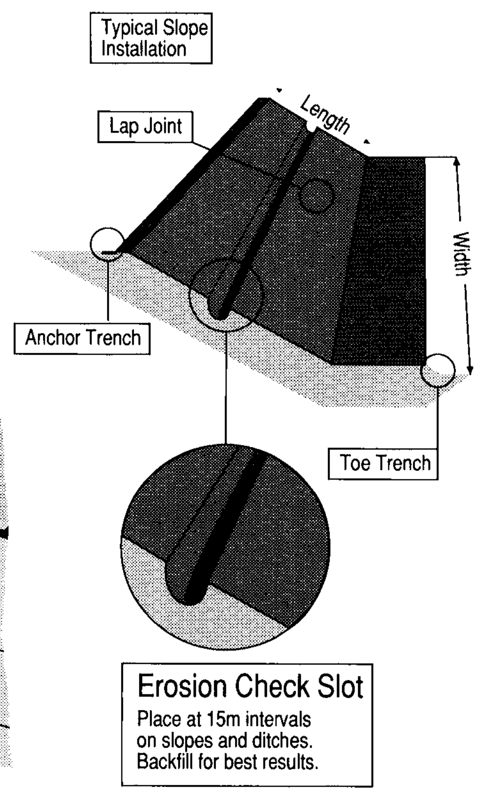
CONDITIONS WHERE APPLICABLE

- Where flow velocity is low
- On steep slopes and streambanks where erosion hazard is high and germination is likely to be low
- Where moving water is likely to wash out new vegetation (e.g., in diversion ditches, drainage ditches and grassed waterways)

ADVANTAGES

- Less expensive than other structural techniques
- Not subject to wind blow





- Good protection against surface runoff, allowing vegetation to get properly established
- Provides a reliable cover for overwinter protection of late season grading work
- Retains soil moisture which aids in vegetation establishment
- Easy to handle
- Fast protection for newly-topsoiled slopes or new ditches

DISADVANTAGES

- Labour intensive
- Expensive

DESIGN CONSIDERATIONS

- Size and slope of area to be covered
- Volume and velocity of flow that is to be conveyed through the area

DESIGN STEPS

1. Determine the area to be protected.
   - The matting should cover all areas that are to be graded and seeded.
2. Select the type of temporary matting to be used.
   - The selection of the mat is dependent upon the availability, as well as the length of time that temporary protection is required.

IMPLEMENTATION STEPS

1. Prepare the site and seedbed as required.
   - Put in place all engineering and structural requirements such as drains.
   - Provide a uniformly even ground surface by removing gullies, large roots and other obstructions.
2. Fertilize and seed the area as required.
   - Apply all of the fertilizer and seed immediately before the installation of the matting, except for jute matting, where half the seed is applied after the matting has been installed.
3. Install the matting.
   - In channels lay out the matting in the direction of the flow.
   - On steep slopes lay out the matting with its length extending from the top to the bottom of the slope.
   - Lay the matting out starting from the up-slope end of the site, with a minimum 100 mm (4 in.) overlap between mats laid side by side.
   - Using U-shaped wire staples, staple the upper edge of the matting into a 150 mm (6 in.) deep trench. Then backfill and firmly pack the trench.
   - If two mat lengths must be put end to end, the down-slope mat is stapled into a trench as previously outlined, then overlapped a minimum 100 mm (4 in.) by the up-slope length.
   - Place staples 450 mm (1.5 ft.) apart along overlaps and 600 mm (2 ft.) apart along outer edges, making sure the matting is smooth and in firm contact with the soil.
   - Additional staples may be required to secure the mat in depressions.
   - Make sure the matting is well anchored so it does not slip or wash out.
   - Any water that may accumulate underneath the fabric must be prevented from moving downward with sufficient velocity to cause erosion. On slopes more than 15.2 m (50 ft.) long there should be an erosion check slot at the

midpoint. On slopes and ditches more than 30.5 m (100 ft.) long there should be a check slot at 15.2 m (50 ft.) intervals. The check slots are trenches about 100 mm (4 in.) deep and 100 mm (4 in.) wide dug across the slope or ditch.

MAINTENANCE

Reseed and repair any matting that washes out.
In the second year, fertilizer may be applied again to facilitate thick growth.

CROSS REFERENCES

- Factsheet 1.0 Grading Practices
- Factsheet 2.3 Grassed Waterway
- Factsheet 2.6 Seepage Drains

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
SURFACE STABILIZATION

CONTROL MEASURE
VEGETATIVE LININGS AND BUFFER STRIPS
(STREAMBANK PROTECTION)

Before hydroseeding.

Six months after hydroseeding.

PURPOSE

- To provide a natural, self-regenerating cover, or lining, for protection of streambanks from erosive action of runoff (overland flow and open channel flow)

CONDITIONS WHERE APPLICABLE

- Where the bank can be adequately sloped
- Where stream flow velocities are less than 1-2 m (3.3-6.6 ft.)/sec.
- Where water flows are intermittent
- Where stream currents are offshore
- Where undercutting and/or lateral seepage are not causal factors
- As a temporary cover on large areas where final regrading has not been carried out and more substantial protection is to be installed
- Most economical where protection is required over an extensive bank area
- In conjunction with other linings such as riprap and gabion baskets

ADVANTAGES

- Relatively low cost compared to other types of linings, especially for covering large areas
- Provide a natural protective cover against erosive action of down-slope surface runoff on the bank
- Flexible, self-adjusting, permeable, and adaptable to changes
- Provide additional benefits of improved wildlife and fisheries habitat and aesthetic value
- Provide extra bank stabilization through the root system of shrub plantings

DISADVANTAGES

- Of little use where slope is too steep or where there is substantial seepage

- Establishment of vegetation by sodding is more expensive and harder to care for during initial stages
- Possibility of serious erosion while the vegetative cover is being established, especially if a temporary cover is not used
- Possible reduction of channel capacity or reduction of stream flow due to heavy shrub growth

DESIGN CONSIDERATIONS

The cover type and slope must be considered when selecting the width of buffer strips.

If undermining or lateral seepage activity is evident, vegetative protection may be ineffective unless seepage is controlled and toe protection is provided. Toe protection can easily be provided by installing riprap on the lower portion of the slope. The artificial toe should extend above the normal water level and preferably above the zone of lateral seepage.

Shrubs or small trees can be planted for aesthetic purposes, bank stabilization or wildlife enhancement.

Mulch should be applied to all exposed sites immediately after they have been seeded.

DESIGN STEPS

1. Select stable slope for soil.
   - The slope shall not be steeper than the angle of repose of the soil material. **Before grading or making alterations of the natural streambank, contact the Nova Scotia Department of the Environment for necessary permits.**
2. Determine if a seepage drain or other drainage control is required.
3. Select the width of the buffer strip; it should be wider for steeper slopes or areas exhibiting excessive runoff.
4. Select vegetation mixture (or sod).
   - The selection of buffer strip vegetation is dependent upon the site conditions and the intended use of the buffer strip.
   - Streambank vegetative linings usually contain a mixture of grasses and legumes, with the fast-growing grasses providing relatively quick protection while the slower legumes become established; for example:

MIXTURE**	SEEDING RATE	FERTILIZER AT SEEDING	FERTILIZATION AT 150 MM (6 IN.) HIGH
Permanent Cover:			
Kentucky-31 Tall Fescue	45 kg/ha (40 lbs./ac.)	10-50-0 @ 112 kg/ha (100 lbs./ac.)	15-15-15 @ 560 kg/ha (500 lbs./ac.)
		or	
		12-12-12 @ 560 kg/ha (500 lbs./ac.)	none
or			
Bird's-foot Trefoil and Creeping Red Fescue	13.5 kg/ha (12 lbs./ac.) and 20 kg/ha (18 lbs./ac.)	10-50-0 @ 112 kg/ha (100 lbs./ac.)	15-15-15 @ 560 kg/ha (500 lbs./ac.)
Temporary Cover:			
Fall Cereal Rye	67 kg/ha (59.6 lbs./ac.)	18-46-0 @ 112 kg/ha (100 lbs./ac.)	none

**Typical mixture used by the Nova Scotia Department of Transportation and Communications for roadside applications. For best results on a particular site, contact a professional landscape firm or seed company.

5. Select shrubbery to be used. The assistance of a Landscape Architect or other experienced person may be required.
6. Determine the required seeding season.
   - Spring seeding of grass-legume mixtures is preferred before mid-June.
   - The mixture can also be dormant-seeded (September); however, this approach may not allow sufficient time for ground cover to become established and the seed may be washed away by subsequent spring flooding.
   - Seeding between mid-July and late August should be avoided unless implementation can definitely include regular watering.
7. Select mulch for application after seeding. If spring seeding, mulch may not be necessary, as temperatures are not as extreme and the moisture content in the soil is usually sufficient for seed germination; however, mulch does protect the soil from the impact of rain drops.

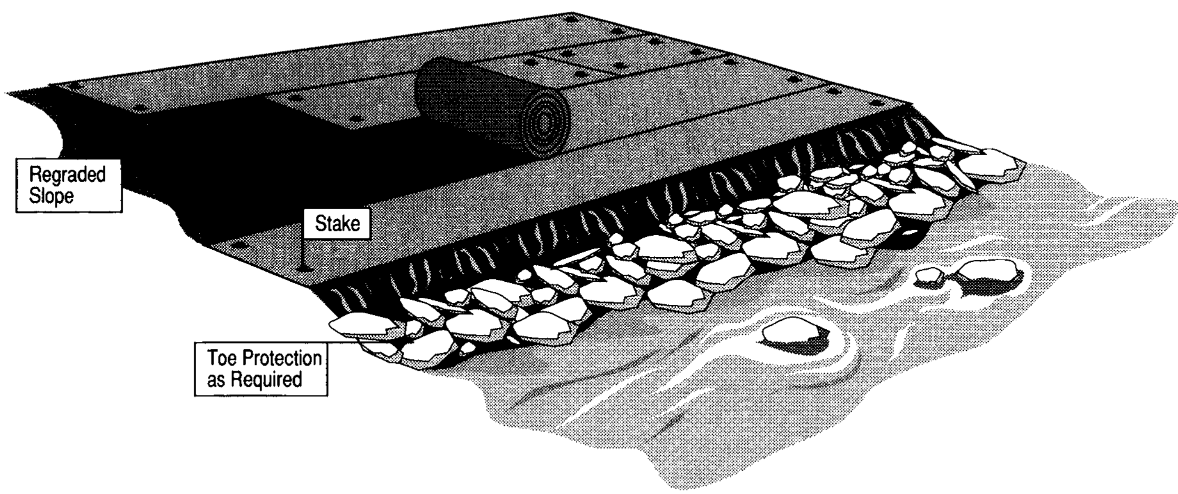
IMPLEMENTATION STEPS

1. Prepare the site (including the buffer strip) for seeding or sodding.
   - Clear the area of debris.
   - **Grade banks to the recommended slope and in accordance with conditions of the Nova Scotia Department of the Environment Permit.**
   - Install a seepage drain if required.
   - Apply the fertilizer as required.

1A. Prepare the site for shrub plantings.
   - Clear away excess debris by scalping or furrowing (removing a layer of sod 30-70 mm (1-3 in.) deep and 300-450 mm (12-18 in.) square).
   - On sloping sites scalping should be done with the sod turned downhill.
   - The planting pit must be large enough to accommodate roots without doubling them over; or, if the plant has a root ball, the pit diameter must be 300 mm (12 in.) larger than the ball.

2. Planting the shrub.
   - Plant by hand or machine.
   - Place the shrub into the pit.
   - The use of a fertilizer may be necessary, depending on soil conditions.
   - Backfill and pack soil firmly around the shrub to eliminate air pockets, forming a saucer shape to retain surface water.
   - Water the shrub. (Several water applications may be necessary, depending on the tree and site conditions.)
   - When used to enhance wildlife habitat, shrubs are usually more effective planted in clumps or blocks.

3. Apply the seed mixture, or sod.
   Seed mixture:
   - Apply the seed mixture uniformly on a firm, moist seedbed to a maximum of 5 mm (1/4 in.) on clay soil and 100 mm (1/2 in.) on sandy soil.
   - Hydro-seeding provides a rapid and efficient means of establishing vegetation, and is convenient for large areas and/or slopes too steep for wheeled equipment.
   - Conventional seeding equipment can be used on slopes of 3:1 or flatter.
   - Hand cyclone seeding is effective on small areas and where access is limited.



Sod:

- Roll out the sod horizontally across the slope with joints staggered, and hold it in place with stakes.
- Pack the sod well after placement.
- Apply water for several days after placement.

4. Apply the mulch immediately following seeding.
   - Straw may be used, for example, at 2.5-5 tonnes/ha (1-2 tons/ac.).
5. A temporary matting may be applied to protect the seeded area until the vegetation is established.
6. Fence or otherwise protect the seeded area until the vegetation is established.

MAINTENANCE

As soon as possible, reseed or resod areas that do not germinate.

Depending on the seed mixture, cut the area a few times to encourage thicker growth and discourage take-over by weeds.

Prune shrubs if necessary to prevent encroachment on the stream.

Replace any severely-damaged or dead shrubs, particularly if they become lodged in the stream or obstruct the flow.

Check mulched areas for damage, periodically and immediately after severe storms, until the desired purpose of the mulching is achieved. Repair any damaged areas as soon as discovered.

CROSS REFERENCES

- Factsheet 1.0 Grading Practices
- Factsheet 1.4 Temporary Matting

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
DIVERSION DITCH

PURPOSE

- To reduce slope lengths
- To break up concentration of runoff
- To move water to stable outlets at a non-erosive velocity
- To divert water away from cut or fill slopes, steeply sloping land, construction sites, buildings and residences, active gullies or other erodible areas, and low-lying areas, in order to prevent flooding
- To convey silted runoff to a vegetated area to disperse flow and filter silt

Diversion ditches apply only to overland runoff. **Note that any diversion of a natural watercourse requires a permit from the Nova Scotia Department of the Environment.**

CONDITIONS WHERE APPLICABLE

- Where runoff from higher areas is, or has potential for, damaging property, causing erosion, contributing to pollution, flooding, or interfering with the establishment of vegetation on lower areas
- Where surface and/or shallow subsurface flow is damaging sloping upland
- Where the length and steepness of the slope need to be reduced in order to lower runoff velocity, thereby keeping soil loss to a minimum
- Where a diversion dyke is not adequate

Diversions are only applicable below stabilized or protected areas. Avoid establishing diversion ditches on slopes greater than 15 percent. Diversions should be used with caution on soils subject to slippage. **Construction of diversions and outlets must be in compliance with provincial and municipal drainage and water control laws.**

ADVANTAGES

- Induces infiltration of surface water and removes some sediment
- An inexpensive alternative to terraces
- Reduces volume of water requiring silt removal

DISADVANTAGES

- Not feasible where access is difficult
- May require additional surface disruption
- May cause off-site property damage and therefore may require the purchase of additional property

DESIGN CONSIDERATIONS

The size of the diversion required depends on the amount of runoff to be diverted, the velocity of the runoff, the erodibility of the soil, and the slope of the area.

If the diversion is being used in conjunction with some form of outlet, the outlet should be constructed first.

Depending on the soil type, it may be necessary to cover the bottom and/or side slopes of the ditch with rock and then seed or use other types of stabilization.

Take care in locating the outlet so as not to create new problems of flooding, property damage, erosion, or killed vegetation.

Diversions are classified as follows:

Temporary
These diversions are installed as an interim measure to facilitate some phase of construction. They usually have a life expectancy of 1 year or less.

Permanent
These diversions are installed as an integral part of an overall water disposal system and will remain for protection of property.

DESIGN STEPS

1. Design the surface diversion.
   - The Halifax County Storm Drainage Design Criteria[1] may be used as a reference, and the design may require the assistance of a soils engineer or other person experienced in the design and installation of erosion control and siltation control measures.
2. Design the outlet.
   - If the diversion intersects another surface channel with the same bottom elevation, the two should join in such a manner that no unnecessary turbulence is created.
   - If the diversion intersects a surface channel with a lower bottom elevation, some type of drop structure is required.

IMPLEMENTATION STEPS

1. Install the outlet.
2. Install the diversion.
   - The diversion is installed similarly to a grassed waterway with the addition of a berm on the down-slope side.
3. Vegetate and/or protect the ditch with rock, asphalt or concrete. If a temporary diversion is being constructed, it may be adequate to line the diversion with polyethylene and construct a number of check dams within it. (see photo)

MAINTENANCE

Any bare or eroded areas should be revegetated.

CROSS REFERENCES

- Factsheet 1.1 Riprap Lining
- Factsheet 2.3 Grassed Waterway
- Factsheet 2.4 Storm Drain Outlet Protection

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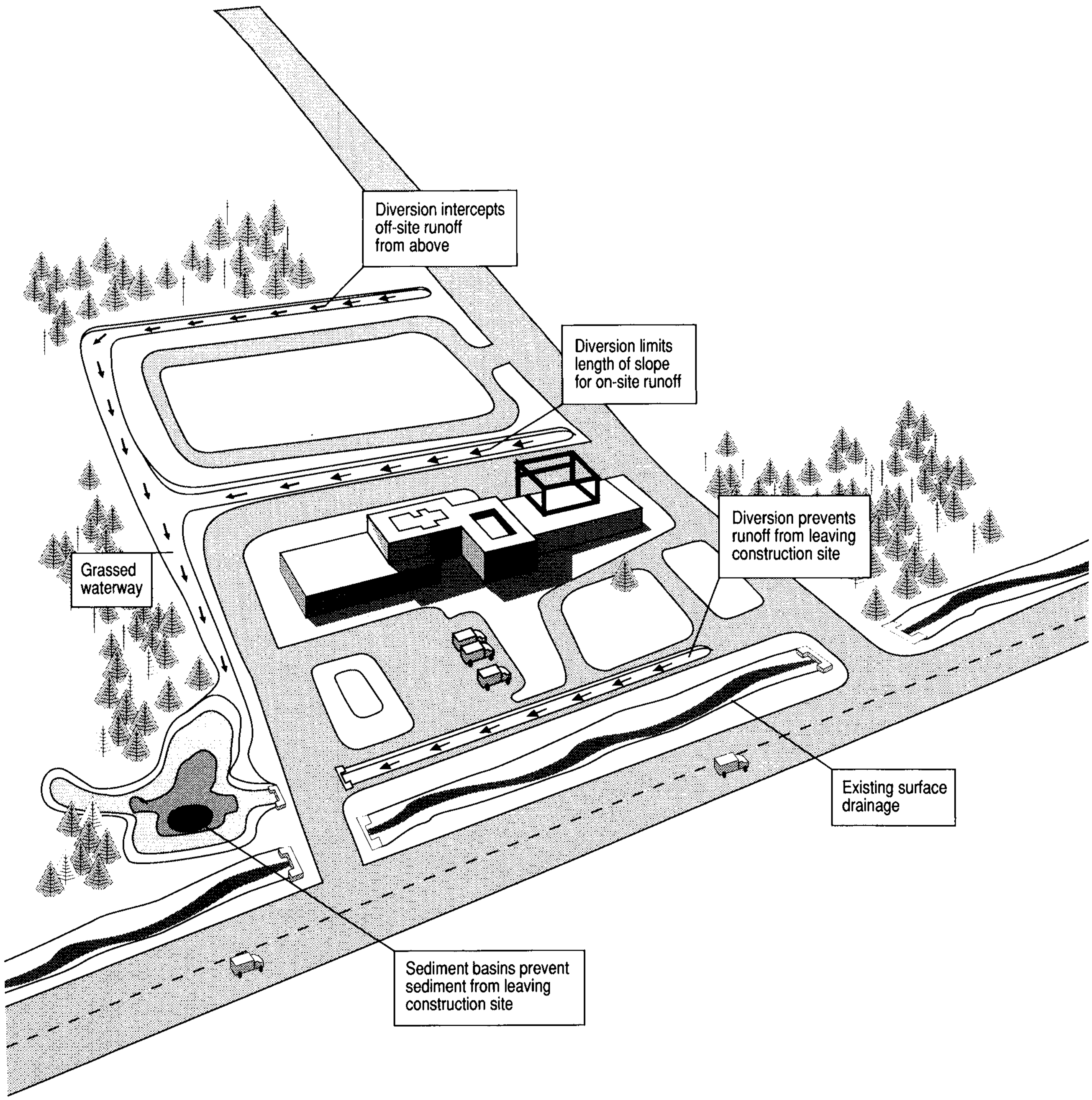
1. Province of Nova Scotia and Municipality of the County of Halifax Design Criteria Manual, March, 1982.

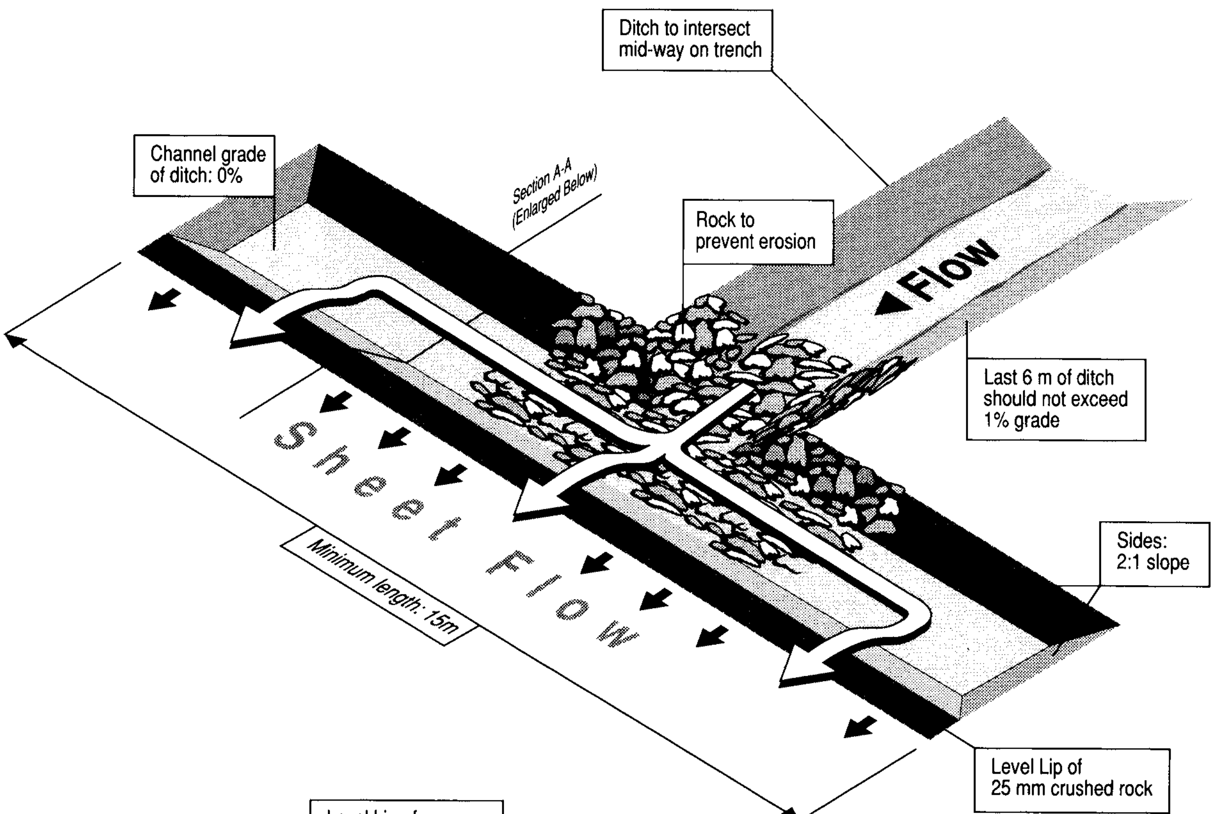

Diversion intercepts off-site runoff from above
Diversion limits length of slope for on-site runoff
Diversion prevents runoff from leaving construction site
Grassed waterway
Existing surface drainage
Sediment basins prevent sediment from leaving construction site

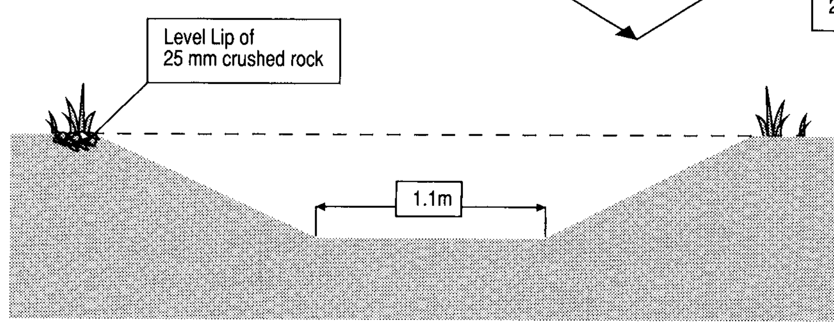
Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
DISPERSION DITCH





PURPOSE

- To convert a concentrated flow of storm runoff into sheet flow and to outlet it onto areas stabilized by existing vegetation without causing erosion

CONDITIONS WHERE APPLICABLE

- Where storm runoff is intercepted and diverted from graded areas onto undisturbed stabilized areas (e.g., at diversion outlets, etc.). This practice applies only in those situations where the ditch can be constructed on undisturbed soil and where the area directly below the lower lip is stabilized by existing vegetation. **The water must not be allowed to reconcentrate below the point of discharge.**

ADVANTAGES

- Inexpensive method of reducing erosive force of runoff
- Induces infiltration of surface water and removes some sediment

DESIGN CONSIDERATIONS

Take care to prevent off-site flooding or property damage.

Dispersion ditches should be constructed in undisturbed soil or properly compacted fill.

They should outlet to a level, vegetated surface in an undisturbed, stabilized area. The inlet should be located at a point equidistant from both ends of the ditch.

Dispersion ditches are not effective for large volumes of storm drainage.

IMPLEMENTATION STEPS

1. Excavate the ditch to a minimum length of 15 m (50 ft.), a minimum width of 1.1 m (3 ft. 6 in.) and a minimum depth of 750 mm (2 ft. 6 in.) to allow for the efficient removal of sediment.
2. Cover the bottom of the ditch and the side directly opposite the inlet with rock of sufficient size to prevent erosion.
3. Convey drainage flow to the ditch through a pipe or a ditch protected by rock.
4. Construct a level lip of 25 mm (1 in.) crushed rock, to ensure uniform spreading of storm runoff.

MAINTENANCE

Check regularly to ensure that the lower lip is level.

If the ditch is filled with sediment, it should be cleaned out or re-excavated.

CROSS REFERENCE

- Factsheet 2.1 Diversion Ditch

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
GRASSED WATERWAY

PURPOSE

- To convey stormwater at non-erosive velocities through inconspicuous mown grass channels to a safe discharge point

CONDITIONS WHERE APPLICABLE

Grassed waterways should not be used under continuous flow conditions or to replace a watercourse.
They can be used where runoff velocities will be fairly low.

ADVANTAGES

- Unobstrusive and fits well into rolling mown grass terrain; visually more acceptable than lined channels
- Reduces velocity, energy and erosive potential of runoff
- Cheap to construct and maintain
- Increases infiltration of runoff and availability of soil moisture to vegetation on site
- Removes some sediment from stormwater

DISADVANTAGES

- Space-consuming, in order to allow easy mechanized mowing with very shallow side slopes

DESIGN CONSIDERATIONS

Grass waterways are broad, shallow, gently-sloping channels lined with a dense, erosion-resistant turf of mown grass. They should be very carefully fitted into the grading plan for maximum effectiveness, visual unobtrusiveness and ease of mowing. Natural swales are preferable. Their function is to convey concentrated runoff from one point to another at safe velocities, but they are also used to intercept overland flow or sheet runoff on long slopes and to convey it to a safe discharge point. Grass waterways are intended to carry storm runoff only, and are dry at other times. If there is heavy or prolonged flow in the

waterway, grass alone cannot give adequate protection, in which case it is necessary to line the channel center with stone or concrete. A subsurface drain of crushed stone (French drain) under the center of the waterway will help prevent standing water from killing the grass.

Maximum storm runoff will determine the size of the waterway. Future development of paved areas may cause peak flows to exceed the channel capacity and necessitate channel enlargement or lining.

Careful sizing and design of grass channels is essential if they are to function effectively without erosion damage. The channel should be sodded if there is a need to use the waterway soon after it is constructed.

DESIGN STEPS

The Halifax County Storm Drainage Criteria[1] may be used as a reference to ensure channel capacity is equal to, or greater than, expected runoff.

IMPLEMENTATION STEPS

1. Prepare the seedbed by removing all obstructive debris, etc., and distributing and incorporating the necessary lime and fertilizer.
2. Make sure fill areas are well-compacted wherever they are crossed by a waterway. In these areas it is advisable to increase the channel capacity by about 10 percent to allow for settlement of the fill.
3. Until the turf becomes established it will be necessary either to: (i) divert runoff via an alternative route; (ii) line the channel with a temporary protective lining, and mulch the shoulders thoroughly; or (iii) lay sod over the channel. The latter will give good protection within a month if growing well, but a severe storm shortly after laying could damage both channel and sod. In view of the high cost of sodding, this may be an unacceptable risk. Sometimes it is recommended that sod be overlapped slightly to increase retardance and erosion resistance on steep slopes. It may be necessary to stake the sod to avoid washout.
4. If necessary, line the centre of the channel with rock or concrete.

MAINTENANCE

Mow as often as necessary to prevent encroachment by bushes and small trees.

CROSS REFERENCES

- Factsheet 1.0 Grading Practices
- Factsheet 1.4 Temporary Matting
- Factsheet 2.1 Diversion Ditch

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1. Province of Nova Scotia and Municipality of the County of Halifax Design Criteria Manual, March, 1982.

Nova Scotia
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EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
STORM DRAIN OUTLET PROTECTION

PURPOSE

- To convert pipe flow to channel flow
- To minimize scour and channel erosion by reducing velocity of flow before entering receiving channels below storm drain outlets

CONDITIONS WHERE APPLICABLE

- For storm drain outlets, road culverts, paved channel outlets, etc., particularly where the water discharges into existing streams or drainage systems
- At the outlet of chutes and downdrains

ADVANTAGES

- Prevents scour of the bottom of the channel immediately downstream from the outlet, thereby preventing undermining and failure of the structure
- Prevents streambank erosion downstream from the outlet
- Prevents fill embankment slippage and erosion

DISADVANTAGES

- None; almost always a necessity under the conditions mentioned above

DESIGN CONSIDERATIONS

The apron at the storm drain outlet should be constructed of concrete, gabion, asphalt, or riprap (according to the table below). Filter fabric may be required under riprap in areas with fine textured soils.

The apron should slope downstream at less than one percent or at the gradient of the existing channel. Side slopes should be 2:1 or flatter. There should be no overfall at the end of the apron.

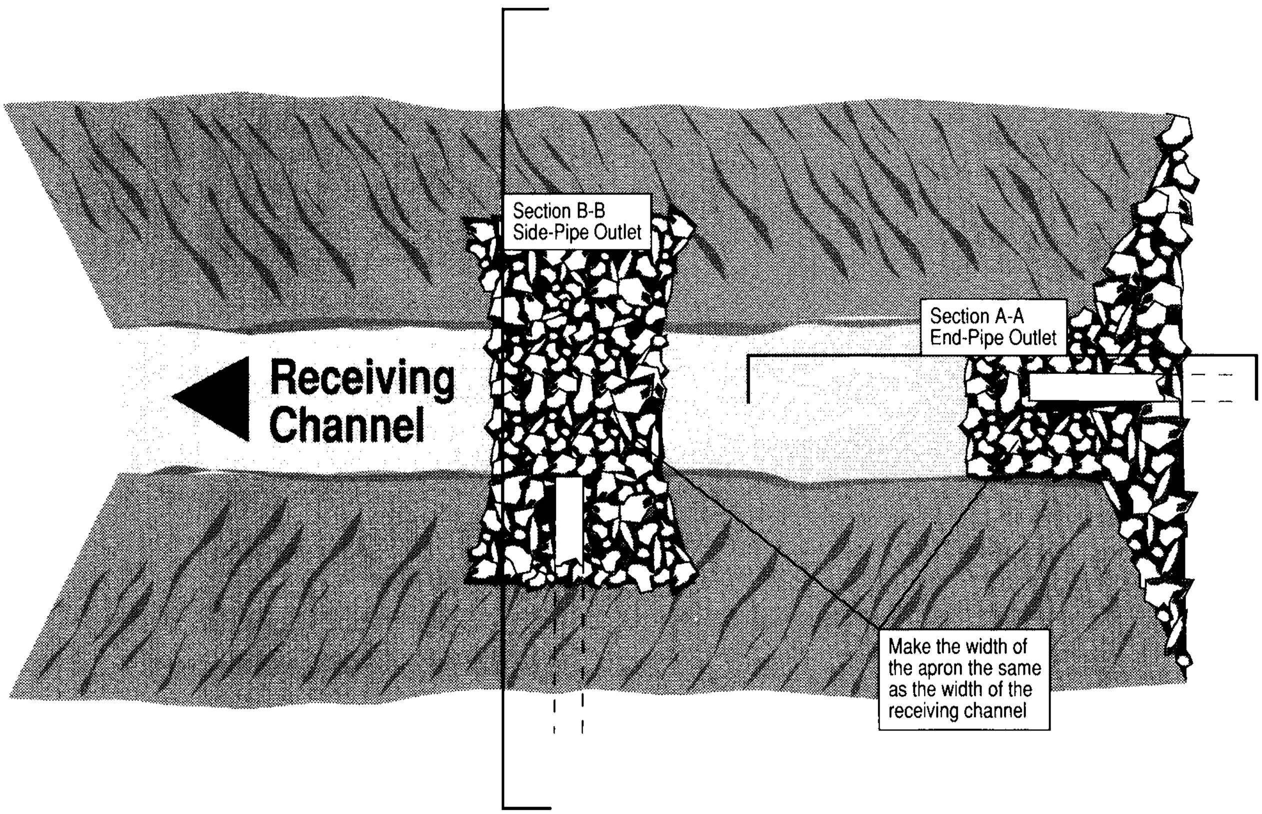
Depending on the configuration of the storm drain inlet, lateral protection may be required to prevent washout of the upstream embankment, and it is required in all cases for the downstream embankment. Riprap or other approved materials should be placed to the top of the pipe and a minimum of one pipe diameter on each side of the pipe (or pipes in the case of multiple pipe installations).

The top of the sidewall should extend at least 300 mm (1 ft.) above maximum tailwater.

If possible, pipes should be terminated at a point short of a watercourse so that adequate outlet protection can be placed to reduce erosive velocities before drainage reaches a stream. Construction in this manner would avoid the need for working in a stream, which requires approval from the Nova Scotia Department of the Environment.

Culvert Diameter	Length of Apron	Average Stone Size	Apron Thickness
up to 1.2 m (4 ft.)	6 pipe dia.	150 mm (6 in.)	300 mm (12 in.)
1.2-2.1 m (4-7 ft.)	8 pipe dia.	300 mm (12 in.)	450 mm (18 in.)
2.1-3 m (7-10 ft.)	10 pipe dia.	600 mm (24 in.)	750 mm (30 in.)

TOP VIEW



DESIGN STEPS

If a concrete headwall is to be constructed, contact a soils engineer or other person experienced in the design and installation of erosion and siltation control measures.

IMPLEMENTATION STEPS

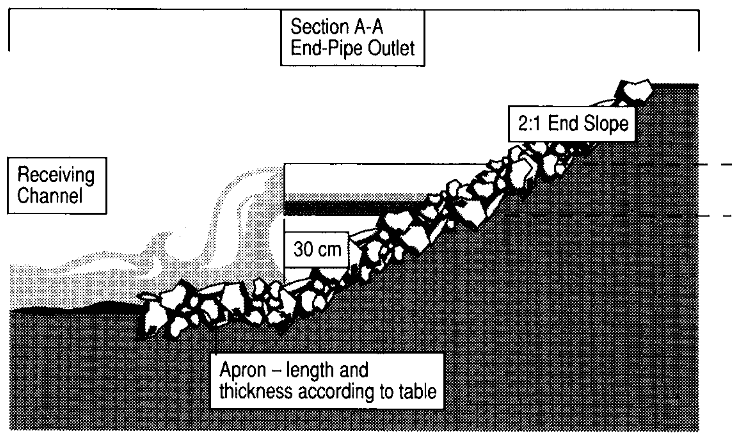
The apron should be constructed in periods of low or no flow.

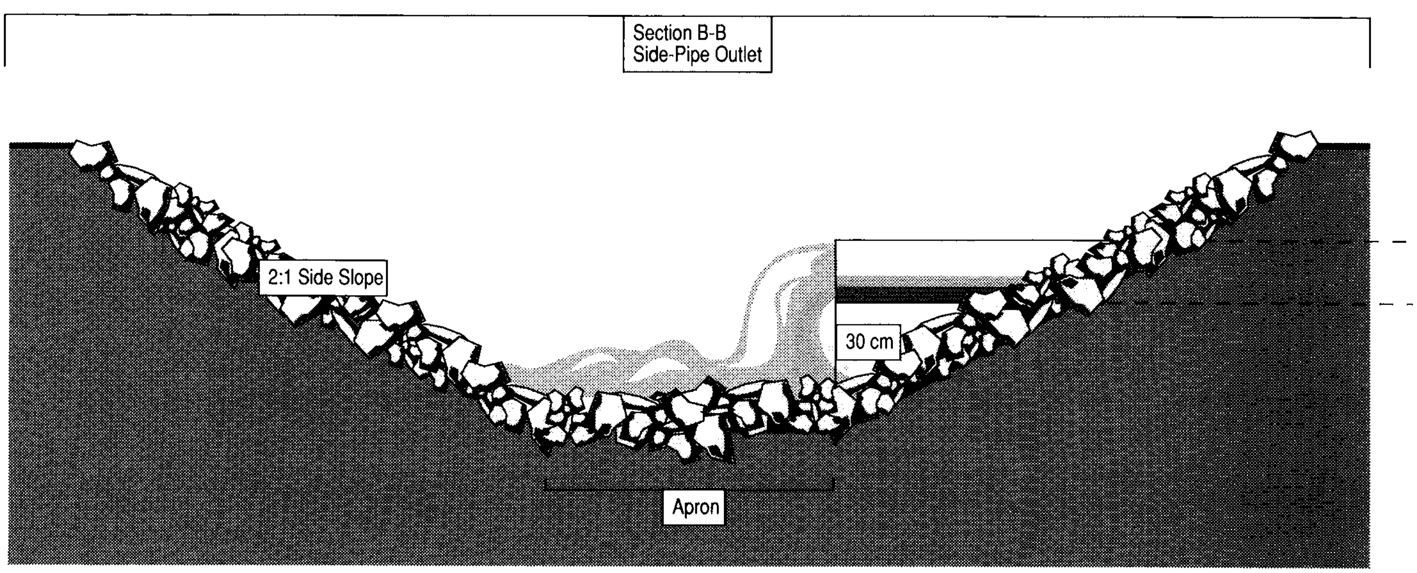
MAINTENANCE

Check the apron periodically to ensure no portions of it have been washed away. If so, they should be replaced immediately.

CROSS REFERENCES

- Factsheet 1.3 Geotextile Filter Fabric
- Factsheet 2.5 Chutes & Downdrains


Section A-A
End-Pipe Outlet
2:1 End Slope
Receiving Channel
30 cm
Apron – length and thickness according to table


Section B-B
Side-Pipe Outlet
2:1 Side Slope
30 cm
Apron

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EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
CHUTES AND DOWNDRAINS
(DROP STRUCTURES)

Good example of a corrugated steel pipe downdrain.

PURPOSE

- To conduct surface runoff down a cut or fill slope where it cannot be conveyed laterally in a satisfactory manner

CONDITIONS WHERE APPLICABLE

- Where distance of channel runoff conveyance would be too long
- Where soils are incapable of handling the expected runoff
- At the head of a gully
- Along a roadside
- In highway medians
- Where drainage ditches intersect a watercourse at different bottom elevations

ADVANTAGES

- Relatively simple to construct
- Protect against erosion in a short reach of ditch as opposed to protecting an entire length of ditch that is too steep
- Good erosion protection where space is limited (e.g., steep cuts and fills on highway rights-of-way)

DISADVANTAGES

- Require very regular maintenance inspection

DESIGN CONSIDERATIONS

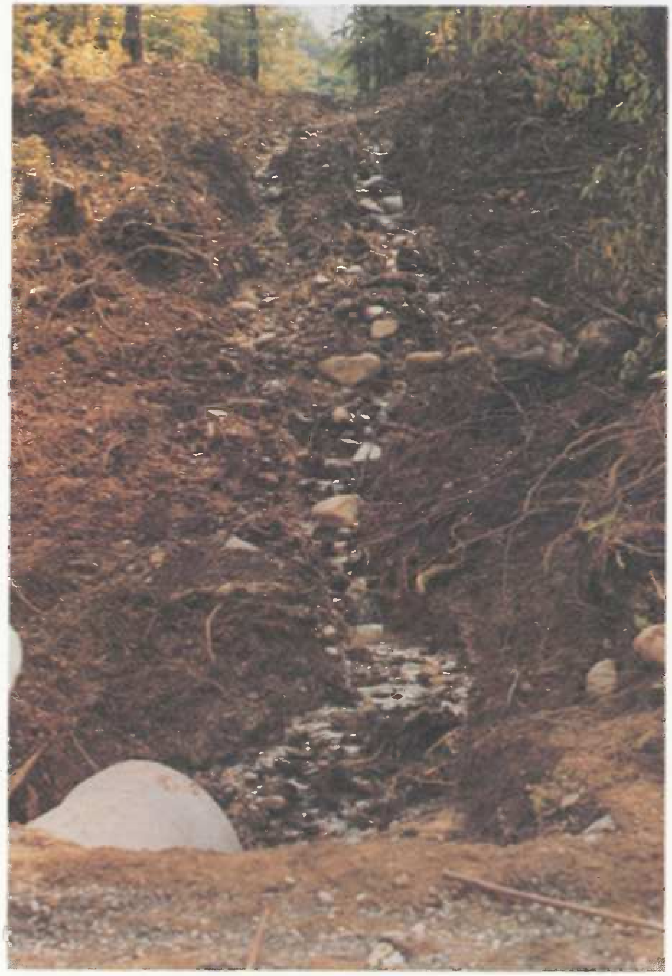
The type and size of structure depends on its location and the volume and velocity of water that it is to convey.

Site accessibility also has an effect on the type of drop structure selected.

When discharging into an open ditch, outlet protection must be provided.

DESIGN STEPS

Chutes, downdrains and drop structures are hydraulic designs which may be subject to frost displacement. Conse-



Good example of a riprap-lined chute. Before: an unstable and eroding slope.

After: a stable storm drainage easement.

quently, the assistance of a soils engineer or other person experienced in the design and installation of erosion control and siltation control measures is required.

The following are some examples of drop structures:

Chutes and Downdrains

Chutes and flexible downdrains are designed to convey water down a short, steep slope without causing erosion of the slope. Chutes are best used on cut slopes, whereas flexible downdrains are more appropriate on fill slopes. Chutes should be constructed of riprap, a gabion mattress lining, a concrete block system lining, concrete, asphalt, or corrugated steel pipe.

It is important to construct chutes so that the centre is lower than the sides and thereby contains the drainage within the chutes. Chutes must be large enough to convey whatever peak flows may occur during the period in which they are in use.

An apron should be constructed at the outlet of chutes and flexible downdrains. The apron should be of sufficient size to prevent erosion downstream from the outlet.

Subsurface Drains

Subsurface drains are concrete, synthetic or corrugated metal subsurface drainage structures with a vertical inlet. They convey drainage to a point that does not interfere with desired surface land use.

These structures may, or may not, have (1) a rodent/trash grate at the inlet or (2) an anti-vortex device.

In some instances, it may be necessary to install anti-seep collars.

Straw bales or a berm of crushed rock should be placed around the inlet during the construction period to prevent silting of the drainage structure.

The inlet of the horizontal section of the drop structure should be a minimum of 1 m (3.3 ft.) above the bottom of the structure.

Horizontal inlets should be partially covered to prevent the pipe from filling with sediment.

These structures may tie into existing subsurface drainage systems or discharge into surface drainage works.

IMPLEMENTATION STEPS

The implementation of a drop structure depends upon the type of structure. In all cases, assistance should be provided by a professional engineer or other experienced person.

MAINTENANCE

Chutes and downdrains require regular maintenance checks.

Repair any eroded spots immediately to prevent the entire structure from being washed out.

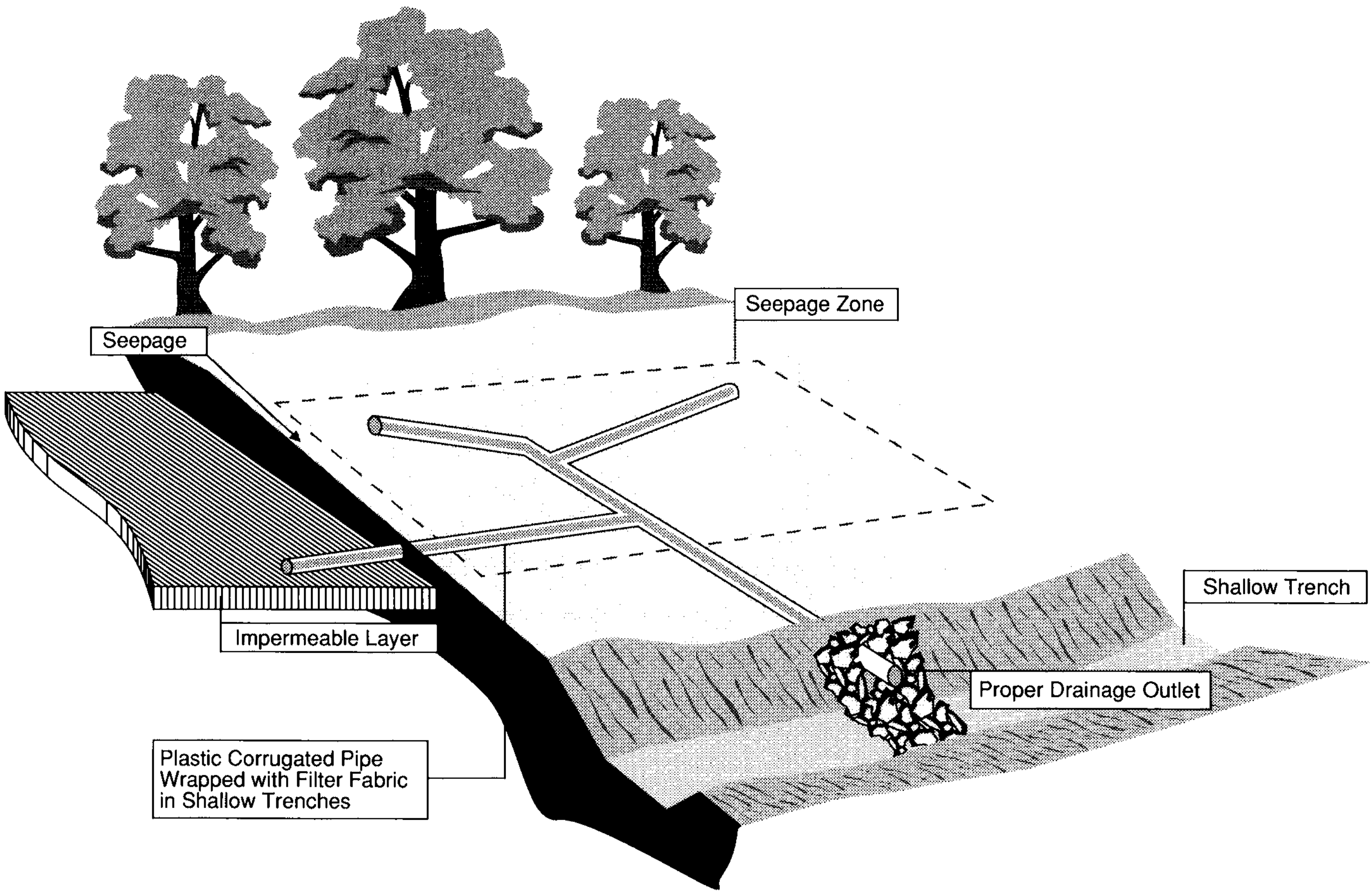
CROSS REFERENCE

- Factsheet 2.4 Storm Drain Outlet Protection

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
SEEPAGE DRAINS



Seepage Area Drain

PURPOSE

- To intercept and control groundwater seepage that causes bank stability problems

CONDITIONS WHERE APPLICABLE

- On banks and their toes where the seepage is causing sloughing and bank "mining"
- In conjunction with other bank stabilization measures

ADVANTAGES

- Prevent further gully development
- Stabilize streambanks, allowing proper installation of channel linings

DISADVANTAGES

- Difficult to install on steep banks and in large gullies

DESIGN CONSIDERATIONS

Seepage layer drains should be used to drain small areas, while seepage area drains should be used for larger sites.

In some instances it may be necessary to consider anti-seep collars on the drain pipe.

It is important to determine the type and cause of the seepage problem, for example, whether the seepage occurs above an impermeable layer or over a large portion of the bank area.

It is also important to determine the volume of seepage water to be drained and the accessibility of the seepage area in order to install the drain.

DESIGN STEPS

The selection and design of the seepage drain is dependent on the cause of the seepage problem, as well as the other remedial measures to be installed. For this reason, assistance of a soils engineer or other person experienced in the design and installation of erosion and siltation control measures is recommended.

IMPLEMENTATION STEPS

Seepage Area Drain

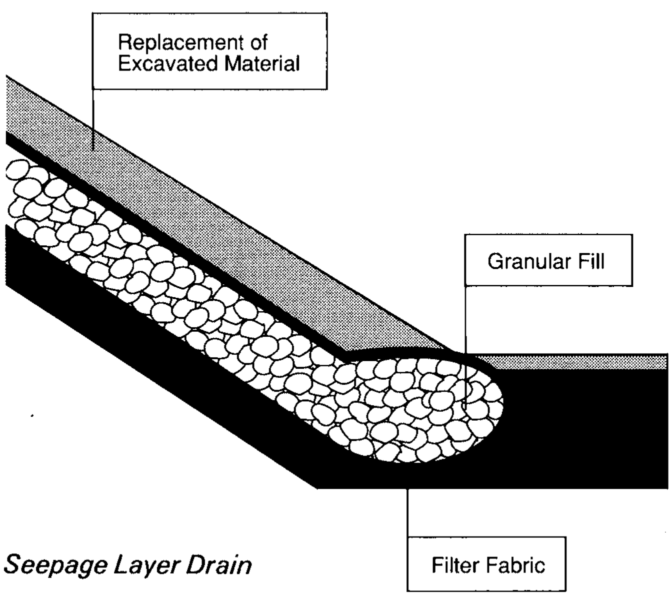
1. Prepare the site as designed.
2. Excavate the drain trenches.
3. Install the drain pipe.
4. Backfill the drain trenches.
5. Complete other designed remedial measure work.

Seepage Layer Drain

1. Prepare the site as designed.
2. Excavate the area by removing the soft and wet material.
3. Install a layer of granular fill.
4. Backfill the area with the dried-out, excavated material.
5. Complete other designed remedial measure work.

CROSS REFERENCES

- Factsheet 1.3 Geotextile Filter Fabric
- Factsheet 2.4 Storm Drain Outlet Protection



Seepage Layer Drain

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
CHECK DAMS
(GENERAL)

Check dams are also called sediment traps or silt traps.

PURPOSE

- To prevent erosion of gully or ditch bottoms: by slowing velocity of concentrated runoff; by collecting and holding moisture and soil in the bottom of the gullies, thereby facilitating the establishment of stabilizing vegetation
- To trap small amounts of sediment by reducing velocity
- To prevent silt (caused by sheet and rill erosion) from being deposited on lands downstream from those being developed

CONDITIONS WHERE APPLICABLE

Check dams must not be used in watercourses; they are only for ditches carrying storm drainage.

Permanent check dams can be used:
- In gully bottoms where channel gradient is too steep for a vegetative lining alone and where the channel is too large for practical installation of structural linings

Temporary check dams can be used:
- In gullies that have been regraded to aid in vegetation establishment
- Only in gullies that have drainage areas of less than 4 ha (10 ac.) and where water velocity is less than 2 m (6.5 ft.)/sec., or is intermittent

ADVANTAGES

- Make use of readily available materials; therefore, cost is minimal
- Carefully designed and located, most check dams can remain as permanent structures

DESIGN CONSIDERATIONS

Check dams are constructed, with slight variations in method, of various materials, depending on what is readily available and whether the check dam is to be permanent or temporary. Construction is labour intensive.

They must be carefully designed and constructed to avoid washouts.

They are limited to treating runoff from only small drainage areas, so consideration must be given to using these structures in conjunction with other drainage control measures.

Several check dams, not over 400 mm (1.3 ft.) high, are preferable to a few larger dams.

Locate check dams in the ditch or gully to reduce runoff velocities and maximize the sediment-trapping capacity.

DESIGN STEPS

Determine if the check dam is to be permanent or temporary and select the material. The type of check dam will be determined by the volume and velocity of the runoff and the required life expectancy of the dam.

The following are examples of permanent and temporary check dams:

Permanent:	Temporary:
Rock Dams	Rock Dams
Gabion Dams	Sandbag Dams
Plank or Slab Dams	Brush Dams
Sodded Earth Fill Dams	
Sandbag Dams	

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Make the centre of the check dam (i.e., the spillway) as broad and as nearly flat as possible.
3. Raise each end of the dam 450 mm (1.5 ft.) or more to protect the bank.
4. Set the wing walls of the check dam well back into the bank (keyed-in).
5. Make sure the dams are embedded below the channel surface to prevent undermining.
6. Place a protective apron at the foot of the check dam, extending it 1 m (3.3 ft.) beyond the main spillway and on both banks of the ditch. This will prevent the falling water from undermining the structure.
7. The number of dams will be determined by the slope of the ditch and the soil erodibility.
8. Determine the vegetative lining for the gully, if necessary.
9. If a notch spillway is being used it should be broad and shallow, rather than narrow and steep.
10. Excavate a small area just upstream of the check dam. This area will provide some capacity for trapping sediment.
11. Make sure the top of the check dam is as high as the base of the one upstream.

IMPLEMENTATION STEPS

The implementation steps for each type of check dam are given in the individual factsheets.

MAINTENANCE

Tips on maintenance for each type of check dam are given in the individual factsheets.
If the check dams are permanent, consideration must be given to allowing access to the structure for any necessary repairs.

CROSS REFERENCES

- Factsheet 1.4 Temporary Matting
- Factsheet 1.5 Vegetative Linings & Buffer Strips

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EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
BRUSH DAM

CONDITIONS WHERE APPLICABLE

Brush dams may not be used in a natural watercourse. However, they can be used in gullies with small drainage areas, low runoff velocity and soil conditions that permit the driving of necessary anchoring stakes

ADVANTAGES

- Inexpensive and easily constructed
- Material readily available at or near site

DISADVANTAGES

- May be aesthetically unacceptable
- Under continuous flow conditions brush may eventually rot
- Limited to relatively low flows

DESIGN CONSIDERATIONS

The kind chosen for a particular site depends on the amount of brush available and the size of gully to be controlled.

Regardless of the type used, it is important that the centre of the dam be kept lower than the ends to allow water to flow over the dam rather than around it.

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.

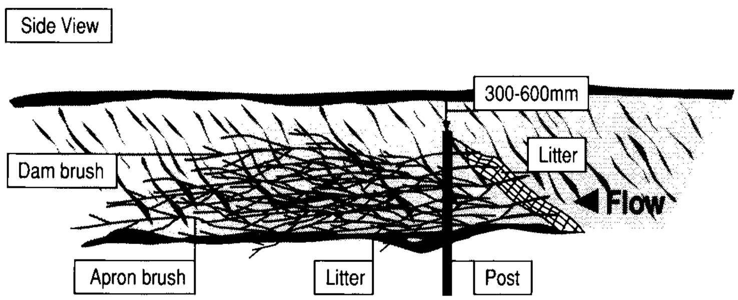
IMPLEMENTATION STEPS

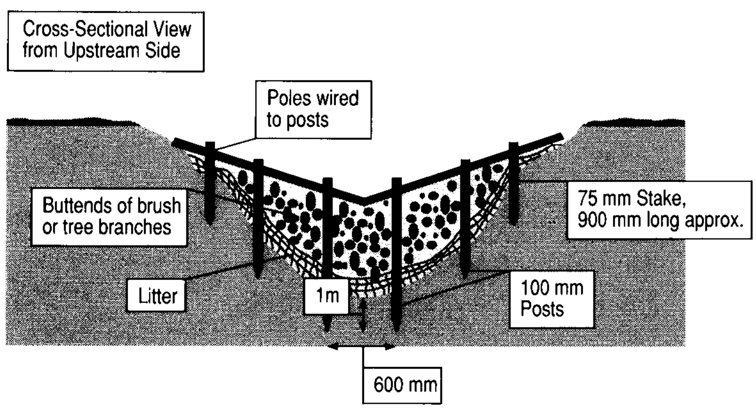
1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.
3. Construct the dam.
   - Drive 100 mm (4 in.) diameter wooden posts into the bottom of the ditch or gully. The center posts should be set about 600 mm (2 ft.) apart and driven in about 900 mm-1 m (3-3 1/2 ft.). The tops of the center posts should be about 300 mm to 600 mm (1-2 ft.) below the top of the gully banks.
   - Place a 150 mm (6 in.) layer of litter between the posts and on the gully bottom and sides, extending downstream from the posts for about 1.8 m (6 ft.). Litter consists of twigs, straw, etc.
   - Place the brush, with the longer, straighter limbs used for an apron, in a layer across the bottom. The shorter dam brush would then be layered on top of the apron brush, and tramped. The butt ends of the brush are placed upstream between the posts. Usually, the gully can be almost filled with brush, and when the cross poles are placed, the brush will be forced down into a compact mass.
   - Place the cross poles on the upstream side of the posts. One or two men should stand on these poles to compress the brush properly while the poles are being wired to the posts and stakes with no. 9 galvanized wire.
   - Place a layer of litter against the upstream face of the dam, and carefully pack it into the openings between the butt ends of the brush.

4. The sides of the ditch should be stabilized by means of sodding, seeding, mulching, or gravelling immediately after construction.

MAINTENANCE

Remove any build-up of silt on the upstream side of the dam.
Repair or revegetate any washed-out or eroded areas.





EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
ROCK DAM

CONDITIONS WHERE APPLICABLE

Rock dams may not be used in a natural watercourse. However, they may be used in gullies of low to moderate (1-8°) slope, having a small drainage area, and where a source of suitable rock is available.

ADVANTAGES

- Flexibility and weight constantly hold dam in contact with gully bottom
- Easy to construct, depending on location
- Materials normally are readily available

DISADVANTAGES

- Requires frequent inspection and maintenance

DESIGN CONSIDERATIONS

Size of stone used should be directly proportional to the anticipated velocity of runoff to be treated. If 25-50 mm (1-2 in.) rock is used it is necessary to protect the centre and back side of the dam with 100 mm (4 in.) rock. If larger rock is available, a gradation of stone size should be used with none smaller than 100-150 mm (4-6 in.)

If only large stone is available, it is necessary to place filter fabric under the stone to prevent the finer soil particles from washing away.

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.
Several check dams, rather than one or two, will likely be required.

IMPLEMENTATION STEPS

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.
3. Construct the dam.
   - Excavate across the gully or ditch to a depth of 250 mm (10 in.).
   - If only large rocks are available, lay them in rows across the gully or ditch with sufficient overlays to produce a shingle effect.
   - Keep the centre of the dam lower than the sides.
   - Construct a stone apron if necessary from below the spillway to a

point 1 m (3.3 ft.) downstream. The apron should also protect the banks of the ditch. If runoff velocities are low and a dam is to be constructed of 25-50 mm (1-2 in.) rock, an apron is not needed.

- Construct the next dam.

4. The sides of the ditch should be stabilized by means of sodding, seeding, mulching, or gravelling immediately after construction.

MAINTENANCE

Replace any displaced stone and remove any build-up of silt from the upstream side of the dam.

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
GABION BASKET DAM

A properly installed series of gabion check dams. Note also the effectiveness of hydroseeding and lining the ditch with rock to achieve maximum erosion control.

CONDITIONS WHERE APPLICABLE

Gabion basket dams may not be used in natural watercourses. However, they can be used in gullies or ditches of moderate (8-12°) slope, having a small- to medium-sized drainage area, and where a source of suitable rock is available.

ADVANTAGES

- Can be used where only small rock is available
- More durable than other check dams
- Flexibility and weight constantly hold dam in contact with ditch bottom
- Resistant to vandalism
- More resistant to damage by fairly high velocities than other types of check dams

DISADVANTAGES

- More expensive than other types of check dams

DESIGN CONSIDERATIONS

Gabion baskets are the most permanent type of check dam. They come in a variety of standard sizes and are normally held together with wire ties.

Although stone reduces water velocity, even small stones are not very efficient at trapping sediment. The trapping efficiency of stone can be improved by placing a layer of straw in the bottom of the gabion to assist in the filtering action.

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.

IMPLEMENTATION STEPS

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.
3. Construct the dam.
   - Set the bottom of the wire baskets approximately 300 mm (12 in.) below the bottom of the ditch.
   - Fill the wire baskets with rock and a layer of straw, and wire shut.
   - Place a rock apron just downstream of the baskets and extend it to a point 1 m (3.3 ft.) from the gabion.
4. Stabilize the sides of the ditch by sodding, seeding, mulching, or gravelling immediately after construction.

MAINTENANCE

Repair any broken wire.
Remove any build-up of silt from the upstream side of the dam.

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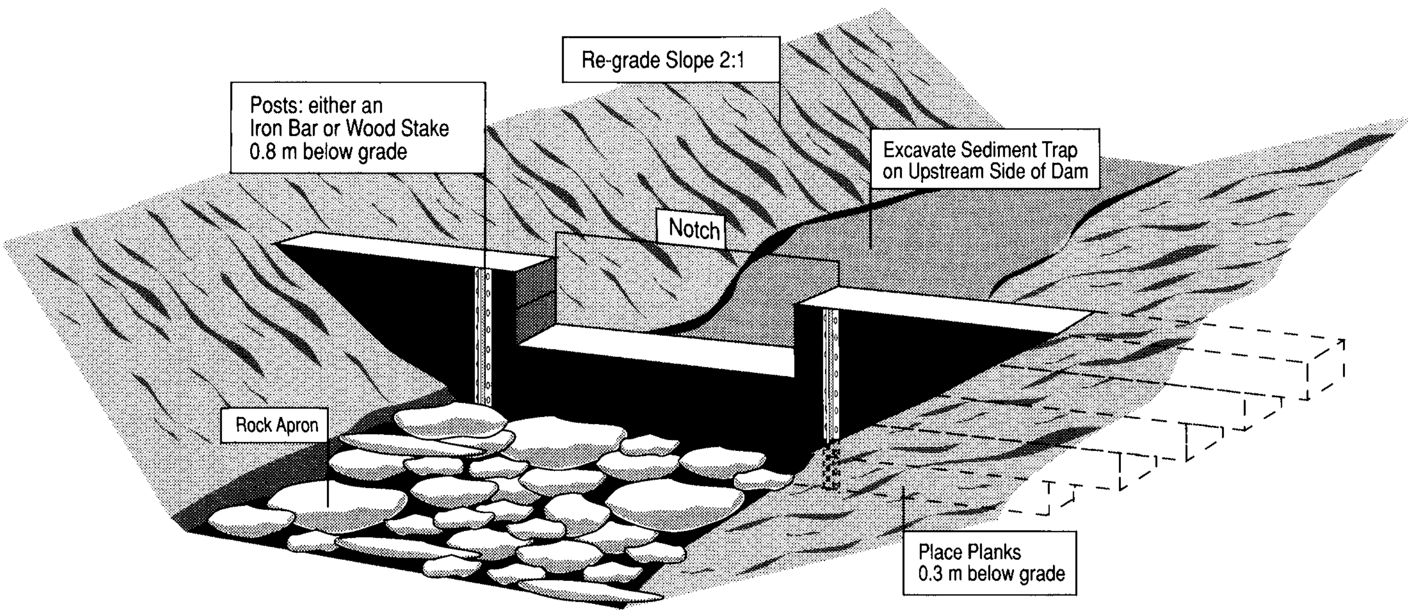
EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
PLANK DAM



CONDITIONS WHERE APPLICABLE

Plank dams may not be used in a natural watercourse.
They can be used:

- In gullies with small- to medium-sized drainage areas
- When a durable check dam is needed

ADVANTAGES

- Inexpensive (given availability of materials)
- Easily constructed
- Heavy board, slabs or railroad ties can be used instead of planks

DISADVANTAGES

- Planks may rot if submerged conditions prevail

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.

IMPLEMENTATION STEPS

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.
3. Build the dam.
   - Set the posts in a straight row across the gully to a depth of approximately 1 m (3.3 ft.).
   - Set the posts immediately on each side of the spillway.
   - Dig a narrow trench along the upstream side 300 mm (1 ft.) deep and wide enough to permit placing the bottom plank and a thin layer of straw or grass as a seal. Then backfill with well-packed earth.
   - Nail planks to posts with the ends of the planks set well into the banks.
   - Cut in the spillway notch.
4. Install the apron.
   - Use either rock or brush to form the apron.
   - Excavate an area of at least 450 mm (1.5 ft.) beyond each side of the notch spillway ends and downstream at least twice the effective height of the dam to a depth of 50-70 mm (2-3 in.).
   - Where brush is used, lay it in the area with the cut ends upstream.
   - Place long pieces in the bottom and shorter pieces on top, similar to the way shingles are laid.
   - Anchor the brush with short stakes.
   - If rock is being used, fill the area with large rock up to the original gully bottom level.
5. Stabilize the sides of the ditch by sodding, seeding, mulching, or gravelling immediately after construction.

MAINTENANCE

Once installed, a plank dam requires only a minimum of routine maintenance.
Repair any damage to the apron.
Remove any build-up of silt from the upstream side of the dam.

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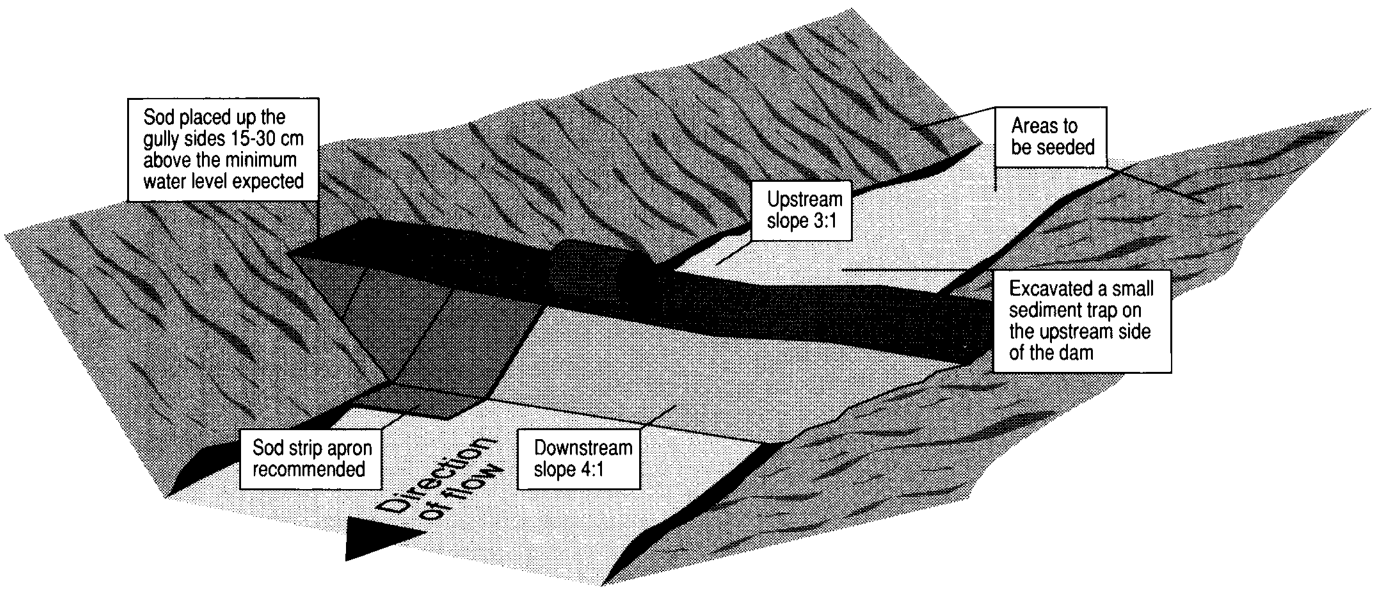
EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
SODDED EARTH FILL DAM



CONDITIONS WHERE APPLICABLE

Earth fill dams may not be used in a natural watercourse. However, they can be used in small- or medium-sized gullies (1-1.7 m or 3.3-5.6 ft.) and a channel grade that is relatively flat (3:1).

ADVANTAGES

- Gives a quick covering, especially when using grasses which spread by stolons or rootstocks
- Effective means of establishing vegetation in areas where runoff would wash out newly-established vegetation
- Can be more cost-effective than other structures in instances where runoff is not excessive and good soil is available

DISADVANTAGES

- May require a longer time than other structures to provide complete stabilization of the ditch

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.

IMPLEMENTATION STEPS

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.

3. Build the dam.
   - Pack the fill well and avoid heights greater than 500 mm (1.6 ft.).
   - Make sure that the top of the fill is low in the centre and gradually curves upward to meet the gully sides in order to provide the necessary spillway capacity.
   - Avoid side slopes of the dam in excess of 3:1 on the upstream side and 4:1 on the downstream side. (See sketch.)
   - Sod earth fills parallel to the flow and on the downstream side of the dam.
4. Vegetate the ditch.

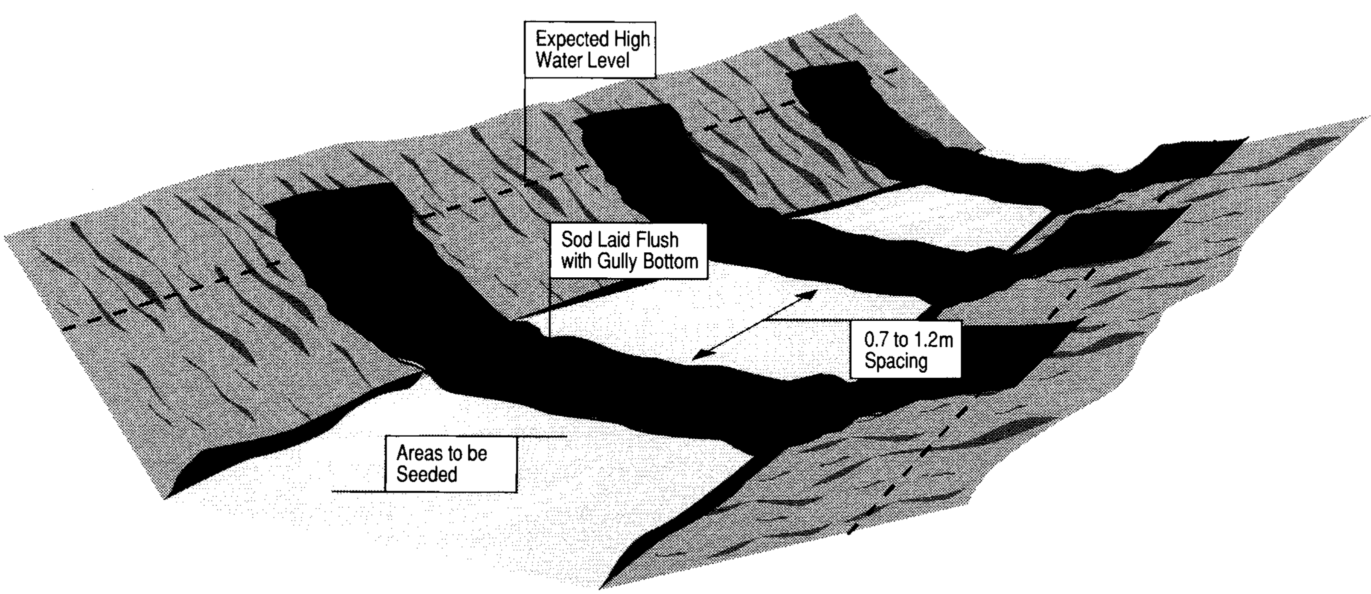
Alternative Dam

Sod Strip Check

- Lay sod strips, approximately 300 mm (1 ft.) wide, in a shallow trench of the same width.
- Make sure that the strips are flush or slightly below the bed of the gully.
- Extend the strips up the gully side at least 150 mm (6 in.) above the expected high water levels.
- Space the strips 700 mm-1.2 m (2.3-3.9 ft.) apart; the distance can vary depending on the spreading characteristics of the sod used.
- Contour sod strips can be used where vegetation is difficult to establish due to the steepness of the slope.

MAINTENANCE

Repair and revegetate any eroded or washed-out areas.
Remove any build-up of silt from the upstream side of the dam.



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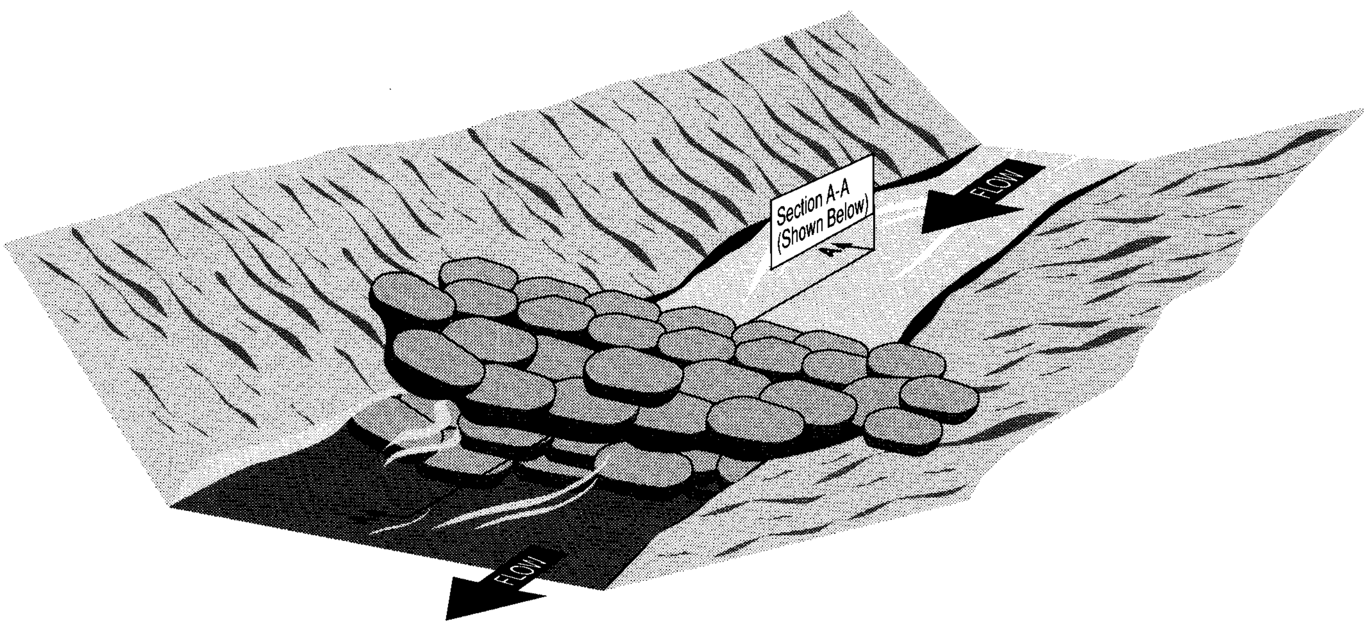
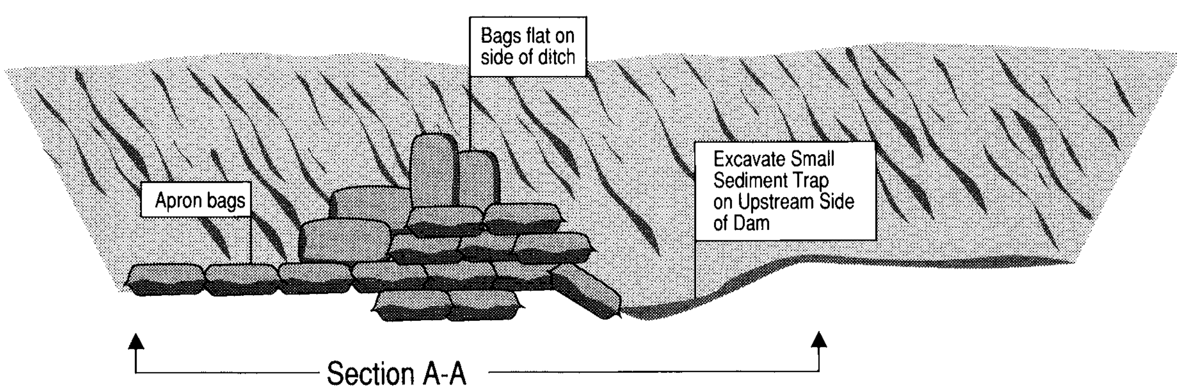
EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
SANDBAG DAM





CONDITIONS WHERE APPLICABLE

Sandbag dams may not be used in natural watercourses. However, they can be used in gullies with small drainage areas and low runoff velocity.

ADVANTAGES

- Inexpensive
- Easy to construct
- Good alternative where rock is unavailable

DISADVANTAGES

- Effective only when placed in ditches that have relatively low volumes of runoff

DESIGN CONSIDERATIONS

The main design consideration is the volume and velocity of the flow.

DESIGN STEPS

Follow the design steps listed in Check Dams — General, Factsheet 2.7.

IMPLEMENTATION STEPS

1. If the side slopes of the ditch are steep, regrade to a more stable slope.
2. Excavate the sides of the channel to allow the dam to be keyed-in.
3. Excavate across the gully or ditch to a depth of 250 mm (10 in.).
4. Lay sandbags in a row across the gully and at least two bags high. The bags should be overlapped so as to produce a shingle effect.
5. Place sandbags as an apron below the spillway and extended at least 1 m (3.3 ft.) downstream.
6. Stabilize the sides of the ditch by sodding, seeding, mulching, or gravelling immediately after construction.

MAINTENANCE

Remove any build-up of silt from the upstream side of the dam.
Repair any wash-outs and replace any bags that have become displaced.

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EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
STRAW FILTER BARRIER

CONDITIONS WHERE APPLICABLE

Straw barriers may not be used in a natural watercourse. They are a short-term measure and are effective only when treating runoff from very small drainage areas for a short time. Therefore, their cost-effectiveness is questionable under some uses. Burlap or geotextile filters would be suitable substitutes.

Straw barriers can be used:

- When normal flows are minimal or where conditions exist for runoff from infrequent, high-intensity rainfall
- In shallow ditches or swales
- Along the side of waterways or property boundaries during construction of other measures
- In drainage areas of less than 1 ha (2.5 ac.)

ADVANTAGES

- Low cost
- An effective preventative control measure against sedimentation from rainfall, while constructing more elaborate erosion control structures and/or allowing vegetation to establish

DISADVANTAGES

- Must be cleaned out, repaired, and replaced regularly to maintain effectiveness

Roadway being built over a brook. Straw barrier intercepts sheet flow, diverting it to a temporary siltation pond (out of view) on valley floor, thereby greatly reducing gullying of the road embankment.

DESIGN CONSIDERATIONS

Straw filter barriers are designed to allow water to flow through, not over, the barrier; therefore, if properly installed and maintained, they require no apron.

The bales plug up with sediment very quickly and require constant surveillance and close attention to maintenance. If the bales are not replaced when plugged with sediment, a rock apron must be constructed on the downslope side of the barrier.

Straw bales used to filter sediment near the edge of a lake — here, one small lot is being developed.

The maximum life is approximately 3 months, or considerably less under wetter conditions and successive storms.

IMPLEMENTATION STEPS

Experience has shown that straw barriers placed on various kinds of construction projects in Nova Scotia and elsewhere have had high rates of failure because of improper installation and use. When improperly placed, undercutting and end flow occurs, which actually increases the amount of sediment eroded and transported by runoff.

1. If the barrier is used in a ditch or swale, and the side slopes of the ditch are steep, regrade to a more stable slope. Excavate the sides of the ditch to allow the bales to be keyed-in. Refer to the design steps listed in Check Dams — General, Factsheet 2.7.

2. Excavate the trench.
   - Excavate a trench the width of a straw bale and the length of the proposed barrier to a minimum depth of 100-150 mm (4-6 in.) below the surface.

3. Place the straw bales.
   - Place the bales on their sides and tightly together in the trench. (If the bales have been tied with non-degradable twine, they should be placed on the flat.)
   - Drive two sturdy wooden or steel stakes through each bale, deep enough to anchor them securely. Drive the first stake in each bale toward the previously laid bale to force the bales together.
   - Wedge loose straw between any cracks or other openings and scatter loose straw over the soil on the uphill side of the barrier. Subsequent movement of the loose straw tends to seal any undetected openings in the barrier.
4. Backfill
   - Backfill and lightly compact the excavated soil up to a depth of 100 mm (4 in.) against the up-slope side of the barrier.
   - Backfill and compact the excavated soil to ground level on the down-slope side.
5. Dig a sediment trap on the upslope side of the barrier.

Here, the straw bales are covered with crushed stone and used as a berm to filter runoff from a large construction area before it flows off the site into a storm sewer.

MAINTENANCE

The barrier should be checked regularly and replaced, if necessary, after each rainstorm. It should be replaced if the bales become clogged with silt. (Wet bales are very heavy.)

Remove the buildup of sediment from the upslope side of the barrier.

The barrier can normally be removed after other measures have been completed and control is well established.

Nova Scotia
Department of the Environment

EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

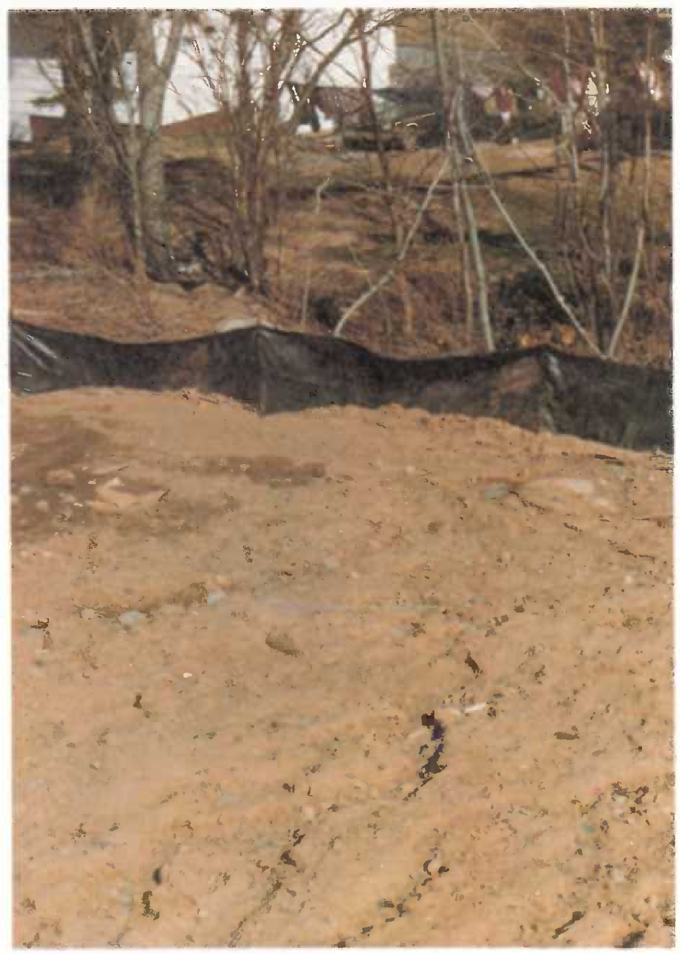
CONTROL MEASURE
FILTER FABRIC BARRIER
(GEOTEXTILE)

CONDITIONS WHERE APPLICABLE

This type of temporary barrier is commonly referred to as a silt fence. Its use should be limited to situations in which only sheet or overland flows are expected. Filter barriers may not be used in a natural watercourse. These barriers are not effective when continuous flow and/or moderate to high velocities can be expected.

The barrier can be used:

- To surround a disturbed work site, where it should be installed just upslope from the area to be protected, in order to prevent silt from being conveyed to an adjacent property or watercourse
- Along the contour of exposed slopes (maximum steepness 2:1)



ADVANTAGES

- Stronger and more flexible than straw barriers
- Higher filtering capacity than straw barriers
- Easily and quickly installed, and repositioned
- Reuseable

DISADVANTAGES

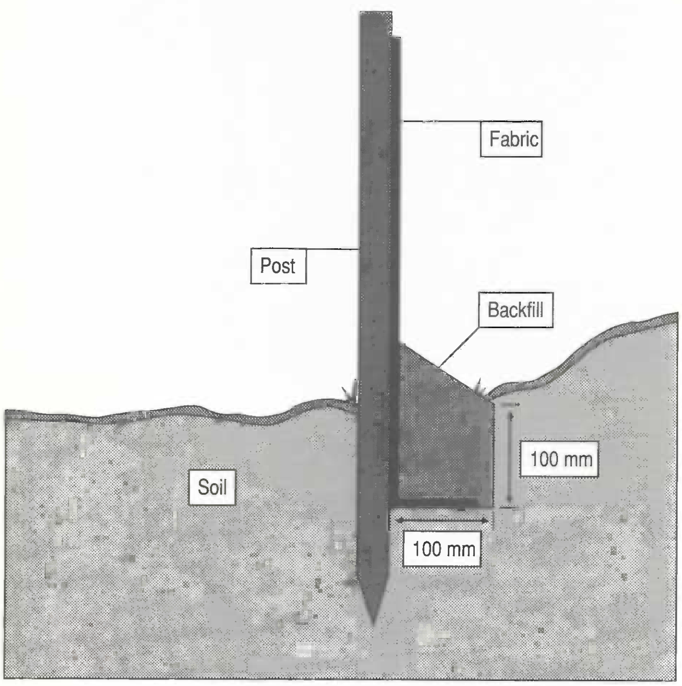
- Must be cleaned out at regular intervals to maintain effectiveness

DESIGN CONSIDERATIONS

The barrier is designed to allow water to flow through it; thus, no apron is required.

IMPLEMENTATION STEPS

1. Filter barriers should be located so they are protected from damage by heavy equipment.
2. If the barrier is to be constructed across a wide ditch or swale carrying low flow, ensure that the ends of the filter are keyed-in to the sides of the ditch to prevent end flow. If the side



slopes of the ditch are steep, regrade to a more stable slope. For further information, see Factsheet 2.7, Check Dams — General.

3. Excavate the trench.
   - Excavate a 100 mm (4 in.) by 100 mm (4 in.) trench in a crescent shape across the flow path, with ends pointing upslope.
4. Set wood stakes supplied by the manufacturer.
   - Drive sturdy, 50 mm (2 in.) square wood stakes, spaced 1 m (3.3 ft.) apart, securely into the ground along the downslope side of the trench.
     Note: If the ground is hard, a pick or steel bar will be needed.
5. Install the filter barrier.
   - The filter fabric should be in a continuous roll and cut to its desired length. (Avoiding seams improves the strength and efficiency of the barrier.)
   - Staple the filter fabric to the upstream side of the stakes, extending the bottom 200 mm (8 in.) into the trench.
   - The filter barrier should not exceed 900 mm (36 in.) in height.
6. Backfill.
   - Backfill and compact the soil in the trench over the filter fabric.
7. Vegetate exposed soil immediately.

MAINTENANCE

Clean out accumulated sediment at regular intervals and after severe rainstorms, and promptly repair the barrier if undercutting or end flow has occurred.

The barrier can be removed once other construction work has been completed and the area is stabilized.

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EROSION AND SEDIMENT CONTROL FACTSHEET

CATEGORY
DRAINAGE CONTROL

CONTROL MEASURE
SILTATION PONDS

These are also referred to as sedimentation ponds or basins, and are not to be confused with silt traps. (For information on silt traps refer to Factsheet 2.7.)

PURPOSE

- To intercept and retain sediment-laden runoff so that sediment may settle out, thereby reducing the amount of sediment leaving the disturbed area, and protecting drainage ways, properties and watercourses below the pond from excessive sedimentation

CONDITIONS WHERE APPLICABLE

Generally, siltation ponds are used as a "last resort" to treat runoff which has already become silt-laden. **They do not solve erosion problems.** Natural watercourses must not be considered for the location of siltation ponds.

They can be used:

- Where physical conditions or land ownership restrictions on a disturbed site preclude the installation of erosion control measures to adequately control runoff, erosion and sedimentation
- Below construction operations which expose critical areas to soil erosion

Siltation ponds remain in effect until the disturbed area is protected against erosion by permanent stabilization.

There are three types of siltation ponds that may be installed: expedient, temporary or permanent.

Expedient siltation ponds should be designed for a few days' use and should provide for a small amount of storage. They can quickly be constructed with a bulldozer or backhoe.

Temporary siltation ponds have a life span of a few months to a few years and provide much more storage than expedient ones.

Permanent siltation ponds serve a function after construction is completed. These ponds may act as a flood-proofing measure or provide recreational opportunities. For detailed information regarding permanent siltation ponds, refer to "Design of Sedimentation Basins") Transportation Research Board, 1980) or other references.

ADVANTAGES

- Eroded topsoil may be reclaimed
- Improves watercourse quality, particularly when used in conjunction with other erosion and sedimentation control practices
- Useful in areas where slope stabilization is either not possible or ineffective, or where volume of water to be treated is high

DISADVANTAGES

- More costly than slope stabilization

DESIGN CONSIDERATIONS

A primary consideration is the location of the siltation pond and the available land area. The volume of the siltation pond must be at least 190 m^3 (1/16 ac.-ft.) for every hectare (acre) under construction. The efficiency of sediment trapping is dependent upon watershed soil type. Clay and silt particles do not settle quickly once they are suspended in water. Watersheds that contain soils high in clay and silt require large ponds to capture the soil that has been eroded.

The average basin length should be at least twice the average width, in order to increase the amount of time in which settling may occur. The average basin depth should be at least 1.2 m (4 ft.) to lessen the frequency of clean out.

It should be located and designed for easy clean out by large mechanized equipment. It is necessary to provide space to put material that has been removed from the pond, so that it does not wash into nearby watercourses.

Determine if a pipe, weir or drop inlet spillway is to be used. In some instances, it may be necessary to use filter fabric on spillways.

The size and cost of sedimentation ponds can be greatly reduced by preventing off-site drainage from entering the construction site (cross reference — Diversion Ditch Factsheet 2.1). The effectiveness of a pond can be increased by diverting non-turbid storm water around it. Therefore do not locate a siltation pond in a stream, lake, natural pond or swamp.

It is recommended that sedimentation basins not be built in series.

DESIGN STEPS

The design of siltation ponds requires the assistance of a soils engineer or other person experienced in the design and installation of erosion and siltation control measures.

1. Determine the area of land that will drain to the siltation pond. Minimize that area to the extent possible.
2. The Rational Method can be used to determine runoff.
3. Protect the weir spillway with riprap.
4. Place the riprap just downstream of the pond outlet to prevent scour.

IMPLEMENTATION STEPS

Siltation ponds should be installed before any grubbing of the construction site occurs.

MAINTENANCE

Inspect the sedimentation basin periodically while construction operations are going on in its immediate vicinity, so that any damage by equipment or by erosion can be detected and repaired immediately. After each rain inspect the basin for erosion damage or for the need for cleanout.

Remove the accumulated material when the sediment level comes within a foot or so of the spillway crest or when the pond is about 2/3 full. If the basin has a dewatering system, it might be well to wait until the sediment dries before starting cleanout. However, if rain is forecast, the cleanout should be done without delay, even if a dragline must be brought in for the cleaning.

Place the removed sediment where it cannot re-enter the basin or the stream below.

When temporary siltation ponds are no longer needed for siltation control, the site should be levelled and revegetated.

CROSS REFERENCES

- Factsheet 1.1 Riprap Lining
- Factsheet 1.3 Geotextile Filter Fabric
- Factsheet 1.4 Temporary Matting
- Factsheet 2.1 Diversion Ditch
- Factsheet 2.4 Storm Drain Outlet Protection

GLOSSARY

ACRE-FOOT (ac.-ft.)
The volume of water that will cover 1 acre to a depth of 1 foot.

AESTHETIC
Pleasing to look at.

ANGLE OF REPOSE
The angle between the horizontal and the maximum slope, that a soil assumes through natural processes.

APRON
A floor or lining that protects a surface from erosion by dissipating the energy of a direct flow of water; it is placed at the bottom, or toe, of a slope, chute or spillway, or at the outlet of a culvert.

BANK "MINING"
Bank material washed out along a horizontal layer by groundwater seepage above an impermeable layer, causing slumping of the upper bank material.

BENCHING
A technique of grading or placement of fill to create a series of level benches or 'steps' on a slope. Benches reduce the effective slope length and also serve to trap sediment.

BERM
A ridge that breaks the continuity of a slope.

BORROW AREA
A source of earth fill material used in the construction of embankments or other earth fill structures.

BUFFER STRIP
Usually a strip of permanent vegetation left beside streambanks to retard the flow of runoff water that causes deposition of transported material, and to protect the banks. It could also be a vegetative strip, particularly of trees or bushes, left between the construction project and adjacent property.

CHECK DAM
A small dam constructed in a gully, ditch, or other similar place to decrease water velocity (by reducing the channel gradient), minimize scour erosion and promote accumulation of sediment.

CONDUIT
Any channel intended for conveyance of water, whether open or closed (like a culvert).

CONTOUR
(1) An imaginary line on the surface of the earth connecting points of the same elevation.
(2) A line drawn on a map connecting points of the same elevation.

CYCLONE SEEDER
A hand-turned or tractor-drawn seeder that broadcasts seed onto the seedbed by a rotary motion that slings the seed outward from the seeder.

DEPOSITION
The accumulation of material which settles or is dropped due to slower movement of the transporting agent, water.

DISPERSION DITCH
A ditch that converts a concentrated flow of runoff into sheet flow and outlets it onto areas stabilized by existing vegetation, thus helping to prevent erosion.

DRAIN (NOUN)
(1) A buried pipe or other conduit (subsurface drain).
(2) A ditch or channel (open drain) for carrying off surface water or groundwater.

DRAIN (VERB)
(1) To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or internal flow.
(2) To lose water (from the soil) by percolation.

DRAINAGE
(1) The removal of excess surface water or ground water from land by means of surface or subsurface drains.
(2) Soil characteristics that affect natural drainage.

DRAINAGE AREA (WATERSHED)
All land and water area from which runoff may run to a common (design) point.

DROP INLET SPILLWAY
An overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

DROP SPILLWAY
An overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

DROP STRUCTURE
A structure for dropping water to a lower level and dissipating its surplus energy; a fall. The drop may be vertical or inclined.

ERODIBLE
Susceptible to erosion.

EROSION
Detachment of soil particles by erosive agents, principally water, wind, ice, and gravity.

EROSIVE
Having sufficient velocity to cause erosion. Refers to wind or water. Not to be confused with 'erodible' as a quality of soil.

FILTER FABRIC (GEOTEXTILES)
A synthetic material of woven or non-woven (plastic) description. Its purpose is to allow water to filter through while retaining fine soil particles and preventing them from being washed away.

GABION MATTRESS
A thin gabion (flexible woven-wire basket), usually 150 to 230 mm (6 to 9 in.) thick, filled with rock and used to line channels or stream banks for erosion control.

GRADE
(1) The slope of a road, channel, or natural ground.
(2) The finished surface of a roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction, like paving or laying a conduit.
(3) To finish the surface of a roadbed, top of embankment or bottom of excavation.

GRADIENT
Change of elevation per unit length; slope.

GULLY/GULLYING (GULLY EROSION)
Erosion of soil caused by concentrated runoff which forms a deeply-cut channel in the land surface.

HECTARE (ha.)
A measure of the area of a land surface equal to 2.47 acres.

HYDRO-SEEDING
Mechanical application by spraying onto the surface of the soil a specially-mixed slurry of turf-establishing materials, consisting of water, seed, fertilizer, and short-fibre wood or paper mulch.

INLET
(1) A surface connection to a closed drain.
(2) A structure at the entrance end of a conduit.
(3) The upstream end of any structure through which water may flow.

JUTE
A coarsely woven material of jute yarn which can be used to control soil erosion.

LAND-DISTURBING ACTIVITY
Any land change which may result in soil erosion, including, but not limited to, clearing, grubbing, grading, excavating, transporting, and filling of land.

LITTER
Fine-textured vegetative material such as straw or forest litter.

MEAN STREAM LEVEL
The average or normal water level in a stream.

MULCH
A natural or artificial layer of plant residue or other materials covering the surface of the soil to protect and enhance certain characteristics, such as retention of soil moisture and protection against the impact of raindrops.

OUTLET
The point at which water discharges from a conduit, channel, stream, or drainage area.

PIPING
The removal of soil through subsurface flow channels or "pipes" developed by seepage water.

POLLUTION
A detrimental alteration or variation of the physical, chemical, biological, or aesthetic properties of the environment (including the water resources), which will render, or is likely to render, the waters harmful to public health, or less useful to man, animals, birds, or aquatic life.

RILL/RILLING
(RILL EROSION)
A small channel, not more than thirty centimetres (one foot) deep, cut into the surface of the soil by runoff.

RIPRAP
Large rock, cobbles, or boulders placed on earth surfaces for protection of the soil against the erosive action of water.

RUNOFF
The portion of precipitation on a drainage area that is not absorbed into the ground but is discharged into streams. Components of runoff include overland flow (sheet flow), open channel flow and groundwater flow.

SCARIFY
To abrade, scratch, modify, or break the surface of the soil.

SCOURING
Erosion of the bed or banks of a channel, usually localized around an obstruction or structure in a channel or at the outlet of a conduit, due to an increase in the water velocity around the obstruction or discharging from the conduit.

SEDIMENTATION
Transportation and deposition of soil particles that become detached through erosion.

SEEPAGE
Water escaping through, or emerging from, the ground; usually considered to occur along an extensive line or surface, as contrasted with a spring, where the water emerges from a localized spot.

SHEET EROSION
Soil erosion caused by sheet flow (overland flow), which is water flowing in a thin layer over the soil surface.

SIDE SLOPE
The slope of the sides of a watercourse or embankment; the steepness of a grade or hill. It is expressed as a ratio or percentage. It is customary to name the horizontal distance first; for example, 2 to 1, or frequently, 2:1 (200 percent), meaning a horizontal distance of 2 units to 1 unit vertical distance. When expressed in degrees, it is the angle of the slope from the horizontal plane, with a 90 deg. slope being vertical (maximum), and 45 deg. being a 1:1 slope.

SILTATION
See also SEDIMENTATION. Denotes sediment pollution of a watercourse.

SLOUGHING
Slow crumble and falling away of a portion of the bank into the stream, occurring when the soil structure is weakened by water seeping through the bank.

SLUMPING
Sudden collapse or sliding of a portion of the bank into the stream, occurring when underlying support is inadequate and/or the soil structure is weakened by water seeping through the bank.

SOIL PERMEABILITY
The ability of soil to allow water or air to move through it.

STABILIZATION
The process of establishing an enduring soil cover of vegetation and/or mulch or other ground cover in combination with installing temporary or permanent structures for the purpose of minimizing soil erosion.

TAILWATER
The water in the channel immediately downstream from a structure.

TERRACING
An erosion control technique that involves constructing an embankment or combination of an embankment and channel across a slope at a suitable spacing to divert or store surface runoff instead of permitting it to flow uninterrupted down the slope.

TOPOGRAPHY
The configuration of the Earth's surface, including the shape and position of its natural and man-made features.

TOPSOIL
The upper layer of soil, containing organic matter and suited for plant survival and growth.

TRASH RACK
A grill, grate or structural device used to prevent debris from entering a spillway, conduit or other hydraulic structure.

TURBIDITY
(TURBID WATER)
Condition of water when it becomes cloudy due to sediment moving in suspension in the water.

UNDERCUTTING (UNDERMINING)

(1) Erosion along the toe of a streambank due to concentrated channel flow (e.g., at the bend in a stream or around an obstruction), creating an overhanging or vertical bank.

(2) Loss of soil from under an embankment, slope, streambank, or structure due to concentrated flow resulting in scouring.

WATERSHED

See DRAINAGE AREA.

APPENDIX A

EFFECTS OF SEDIMENTATION ON THE ENVIRONMENT

Sedimentation is the process of transportation and deposition of detached soil particles. Sediment is estimated to be the largest single water pollutant by volume — at least 700 times that of sewage. Turbidity caused by excessive sediment in water destroys the aesthetic attractions of lakes and streams, thereby spoiling recreational activities like swimming and fishing. Sedimentation of lakes reduces mean depth and volume and provides substrates for nuisance aquatic plants. It can also affect the quality of drinking water. Deterioration of the quality of a municipal water supply for long periods eventually necessitates sophisticated and expensive water purification treatment. If a river is used for hydro-electric purposes, increased sediment loads may damage turbines.

Other pollutants — namely, dissolved nutrients, dissolved salts, heavy metals, pest control products, bacteria, and fertilizers — are often attached to eroded soil particles. When deposited in lakes or rivers, they can kill fish, wildlife and waterfowl, and can become a serious health threat to man.

One of the most serious environmental effects of siltation is the destruction of fish and fish habitat. Fish can withstand high turbidity for short periods, but such conditions may induce an added physiological stress which makes fish susceptible to infection by disease-causing micro-organisms.

Figure A-1:
Aerial view of siltation to a water supply lake due to upstream construction activities.

Figures A-2 and A-3
High concentration of sediment pumped out of a construction project into a stream smothered this small fish in minutes. Larger 6 in. trout suffocated soon after.

High turbidity levels reduce light penetration and inhibit photosynthesis, thereby affecting the food chain and dissolved oxygen content. Streams that fill with sediment have fewer suitable habitats for fish and provide less shelter. Eventually, populations of sport fish like salmon and trout decline and less desirable species proliferate. Decline of fish stocks in turn affects the natural food chain of waterfowl, small mammals and furbearing animals.

Some of the most prominent types of sediment-producing activities are farming, forestry operations, highway construction, urban development, and other mass grading projects. One main reason for excessive erosion and transport of sediment is that the peak of land clearing often coincides with a heavy rainfall season. Studies have indicated that successive changes in land use within a watershed are accompanied by changes in sediment yield. For example, sediment yields can vary from 38 tonnes per square kilometre per year (100 tons per square mile per year) from forested areas to 304 tonnes per square kilometre per year (800 tons per square mile per year) from agricultural lands, and in excess of 38,000 tonnes per square kilometre per year (100,000 tons per square mile per year) from exposed construction areas.

APPENDIX B

EROSION AND SEDIMENTATION PROCESSES

GEOLOGIC AND ACCELERATED RATES OF EROSION & SEDIMENTATION

Soil erosion is the gradual wearing away of the land surface by water, wind, ice and gravity. The transportation, deposition and accumulation of soil is known as sedimentation.

The natural or geologic erosion of the Earth's crust takes place gradually, over thousands or millions of years and is, therefore, not readily discernible. However, geologic norms of erosion provide guidelines for limits of practical erosion control measures, and a basis for measuring the acceleration of soil erosion.

Man's activities can speed up the natural erosion and sedimentation processes considerably through the rapid removal of soil in a matter of days or weeks.

Figure B-1:
A stable, natural stream environment. Geologic erosion is unnoticeable.

Figure B-2:
Accelerated erosion of a large construction area upstream caused a dramatic build-up of sediment in this stream in a few weeks.

SHEET, RILL AND GULLY EROSION

Sheet erosion is caused by raindrop impact and splash, and refers to the removal of a fairly uniform layer of soil by shallow sheets of water without the development of conspicuous channels. Sheet erosion is often unobserved, but may be evidenced by the accumulation of freshly-eroded material at the foot of slopes.

Rill erosion is the creation of conspicuous shallow channels due to the detachment and removal of soil by running water as the sheet flow becomes concentrated. While sheet erosion is not greatly influenced by slope steepness or location on a slope, rill erosion results primarily from the effects of runoff, and is greatly influenced by slope and flow rate. For the purpose of implementing erosion controls, sheet and rill erosion are usually considered and treated as one, rather than two separate processes.

Gully erosion occurs as overland flow in rills combines into increasingly larger channels. It involves more significant erosion than does rill erosion. Therefore, heavy equipment, specially designed structures or the costly import of new material are required to replace the eroded soil and to control or repair gullies and their tributary rivulets.

Figure B-3:
Sheet and rill erosion occurring on an exposed highway embankment quickly filling in the drainage ditch with sediment.

Figures B-4 and B-5:
The advancement of gully erosion at a landfill site over a two month period. For scale, notice the man standing in the gully in the photograph, on the right.

PHYSICAL PROCESSES AND CAUSES OF EROSION

Erosion is influenced primarily by four factors: climate, soil type, topography, and vegetation. Soil erosion is often difficult to control because of the variability of each factor, and the complex inter-relationships among them. Controlling erosion can be accomplished through understanding the nature of the relationships or by deriving some suitable method of rating the factors in order of importance.

CLIMATIC FACTORS

Rainfall is the major climatic factor which contributes to erosion. It causes erosion in two ways: by raindrop impact, and by runoff. The capacity of raindrops to detach soil particles upon impact is a function of the size and velocity of each drop and the rainfall intensity. For example, fine mist falls at about 25 mm (1 in.) per second, whereas the velocity of larger drops approaches 9.0 m per second (30 ft. per second) ——— like miniature bombs! The rainfall intensity and energy is important when comparing the erosive capacity of a short duration thunderstorm containing large drops, and a fine drizzle occurring over a longer period of time.

The second phase of erosion caused by rainfall occurs as runoff begins and rills begin to form. Runoff occurs when the rate of rainfall exceeds the combined infiltration capacity of the soil and surface water detention. When raindrops strike the bare soil surface, a slurry quickly develops. As rain water infiltrates the soil, clay particles are washed below the surface, thereby sealing the surface. This sealing process usually occurs within minutes of the beginning of an average rainfall, and even more quickly during heavy rainfalls.

The sealing process causes sheet flow to develop. Although sheet flow can transport suspended particles, it has little capacity to detach soil particles. The erosiveness of runoff increases with an increase in water velocity which occurs as the water flows downslope. The velocity of flow also increases with the amount of runoff and the concentration of runoff in rills. As the velocity increases, greater volumes of sediment and larger soil particles are transported. Freezing and thawing can be a cause of gully enlargement, especially when slumping occurs after spring thaw. Material that has accumulated in gullies due to slumping and other causes is usually transported from the gully during periods of spring runoff or heavy rainfall.

Although the amount and intensity of rainfall are critical parameters affecting erosion, the seasonal distribution is often more critical. The season of heaviest erosion is characterized by a combination of the most unstable ground condition and the most intensive rainfall. In areas like Nova Scotia, this occurs in the spring and fall, which are also busy construction periods. The amount of soil erosion depends on the soil moisture conditions and condition of the construction site at the time of intensive rainfall.

SOIL FACTORS

The rate of soil erosion may be influenced by landslope, rainstorm characteristics, cover, and soil management, but even with all factors being equal, some soils erode more readily than others. Complex interactions among a number of physical and chemical properties of the soil can affect its infiltration capacity, as well as the resistance of soil particles to detachment and transport. No single parameter is capable of predicting a soil's resistance to rainfall and runoff.

Soil erodibility tends to increase with a greater content of silt and very fine sand, and decrease with a greater content of coarse sand, clay and organic matter. Clay particles have a low erodibility because they are difficult to detach, but once they do become detached, they are easily transported and remain in suspension a long time, thereby prolonging environmental problems. Coarse sands, on the other hand, are easily detached, but have a low erodibility because they are difficult to transport. Except for clay soils, a higher percentage of organic matter in soil tends to increase infiltration rates and soil permeability, thus decreasing erodibility.

TOPOGRAPHIC FACTORS: SLOPE LENGTH AND STEEPNESS

The length and steepness of slopes affect the velocity of runoff water, and therefore are the principal surface features affecting erosion on a site. For practical field work, the combined effects of length and steepness should be considered. The slope shape is important to consider too because natural slopes may consist of convex, straight, and concave sections — all of which erode at different rates. Concave slopes are those that flatten towards the toe, or lower end, where the eroded soil particles become deposited, whereas convex slopes become steeper at the toe.

Depending on their size and velocity, raindrops can splash soil particles as far as 1.5 m (4.9 ft.) away. On a level surface of bare earth, soil particles splashed away from one area are normally replaced by soil particles splashed away from an adjacent area. On a slope, however, raindrop splash on bare earth simply displaces soil by transporting it downhill, without the accompanying replacement that occurs on level ground. The steeper the slope, the greater the amount of soil transported downhill. If rainfall is accompanied by strong wind blowing in the downhill direction, the amount of soil displaced increases even further.

The slope length is defined as the distance from the point of origin of overland flow to the point where either the slope gradient decreases and thus causes deposition, or the runoff water enters a well-defined channel. Sediment that is not ultimately deposited in a stream will not have significant environmental effects but could cause serious damage to property adjacent to the construction site.

VEGETATION AND SURFACE COVER

Accelerated soil erosion on construction sites is generally caused by the removal of a protective vegetative cover. Consequently, artificial aids then become necessary to replace the natural controls.

There are several ways that a vegetative cover can affect soil erosion:

1. A vegetative canopy of trees, bushes and grass intercepts rainfall, greatly reducing the impact force of rain drops. It is also effective in reducing the amount of water that reaches the soil, because some of the rainwater intercepted on the leaves of trees or blades of grass evaporates before dropping onto the soil, or reaches the soil in the form of smaller droplets. The type of vegetation and the amount of cover it provides will have different effects. A dense cover will reduce erosion by exposing less soil to direct rainfall. For this reason, short sod grasses are more effective in reducing splash erosion than taller shrubs or weeds. Effective soil protection can also be obtained during construction by using mulches to cover exposed soil or by simply leaving all or strategic parts of a site under natural cover for the greatest amount of time possible.

Figures B-6 and B-7:
The same site, viewed from opposite directions, shows a long, steep slope mulched to prevent sheet and rill erosion.

2. Vegetation reduces the velocity of overland runoff and tends to disperse it so that it does not concentrate. As the velocity is reduced, soil particles in transport are redeposited or filtered among the vegetation.
3. Vegetation prevents puddling and sealing of the soil surface, thereby maintaining infiltration.
4. The roots of plants increase the stability of soil granules, improve soil structure, and add to the organic matter content of the soil.

It is important to remember that the effectiveness of a vegetative canopy can change between seasons of the year, and even frequently between storms. Even without changes in the canopy, different amounts of raindrop interception can occur. An open canopy of tall vegetation may intercept more than 90 percent of the raindrops if a high wind drives them in at an angle, while the same canopy may intercept less than 50 percent of the drops if they fall vertically.

Figures B-8 and B-9:
A subdivision street which has been grubbed, but not developed for several months, has been completely covered with straw mulch. The closeup view shows that although some of the straw has been blown away, it has been very effective in keeping this erodible soil on the construction site.

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