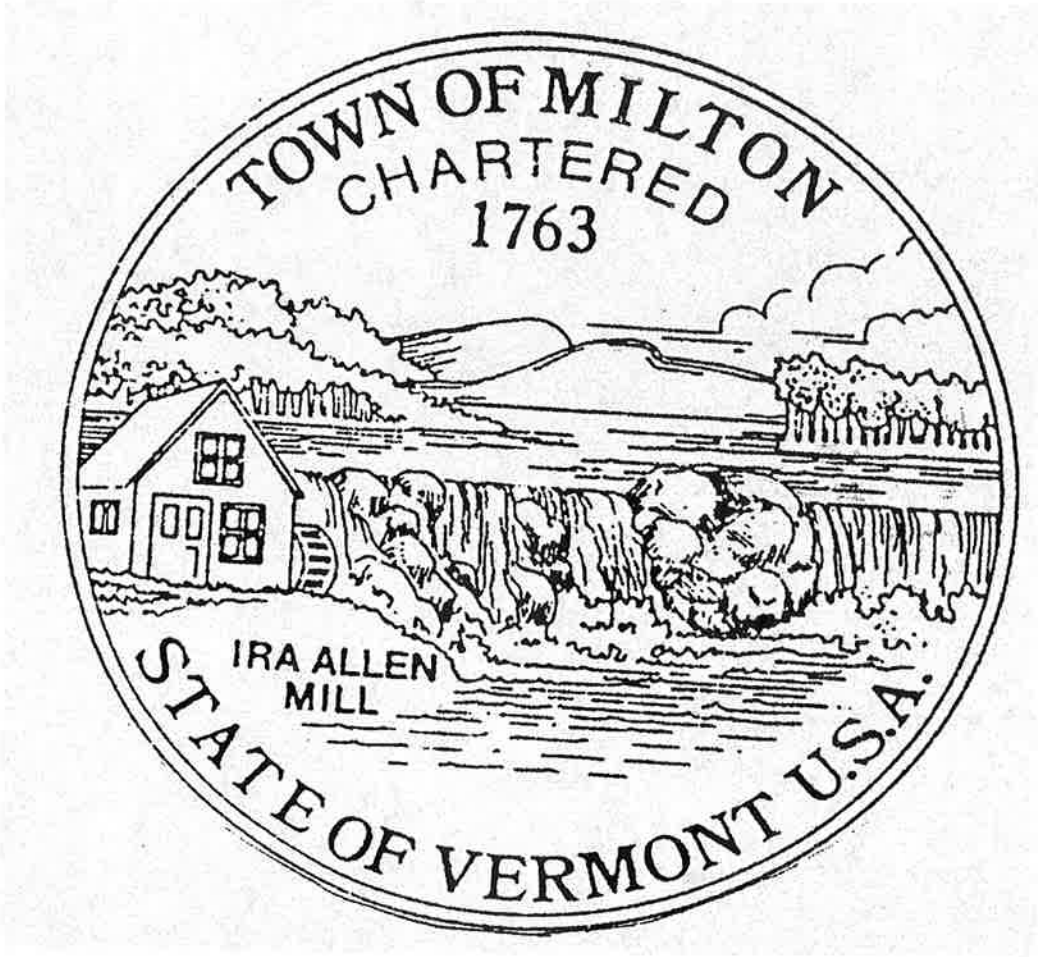
TOWN
of
MILTON, VERMONT



BEST MANAGEMENT PRACTICES
for
EROSION & SEDIMENT CONTROL

September 2002

Acknowledgements
Maine Department of Transportation, E&S C BMP, Vermont Geological Survey Handbook for E&SC on Construction Sites, and Soil Conservation Service, E&S C Manual

PREFACE

The Town of Milton Erosion and Sediment Control Best Management Practices shall become effective upon adoption of the Town of Milton Public Works Specifications by the Select Board. These Best Management Practices are guidelines for controlling erosion and sediment within the Town of Milton. These Best Management Practices are practices - not regulations - and are to work in conjunction with State of Vermont, Agency of Natural Resources, Erosion and Sediment Control Rules and Regulations.

On site earth disturbances of equal to or greater than one acre require a detailed erosion and sediment plan to be submitted following State of Vermont, Agency of Natural Resources, Erosion and Sediment Control Rules and Regulations and meeting Town Of Milton Public Works Specifications.

On site earth disturbances of less than one acre are strongly recommended to use these BMPs where applicable to reduce and eliminate on site erosion.

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I. INTRODUCTION

A. WHY THIS MANUAL?

This manual has been written in response to water quality laws, regulations and the recognized need to accomplish erosion and sedimentation control with consistency and focus. The object is to provide guidance to the Town of Milton Public Works Department personnel, developers, contractors and outside consultants for incorporating Best Management Practices (BMPs) for Erosion and Sedimentation Control into design, construction and maintenance activities. The guidance provided in this manual will serve as a basis for the Developer's / Contractor's Erosion and Sedimentation Control Plan.

The BMPs are structured in the following format:

- A text describing "What is it?", "When and where to use it", and "What to consider" when selecting the BMP.
- When appropriate, Design Standards will be included in the narrative;
- When appropriate, a Standard Detail for the BMP will follow the narrative.

The BMPs included in this manual were developed after careful review of existing State of Vermont Erosion and Sedimentation Control Manual, BMP Manuals from other states and standards from other agencies and municipalities. This manual provides a compilation of structural and non-structural BMPs that have been found to work when properly selected, designed and installed.

This BMP Manual **is not** a specification. It **is** a guide to the Best Management Practices for Erosion and Sedimentation Control. It is a dynamic document that will change as new practices, new laws, and new technologies are developed. One of the goals of the Public Works Department is to "insure development meets the social, economic, and environmental needs of the public." Minimal impact to water quality certainly is important to the people of Milton and the State of Vermont.

It is the Public Work Department's goal that this document remains current by reviewing and incorporating new ideas, at a minimum, on an annual basis. As you gain experience in applying the practices put forth in this manual, you will undoubtedly find ways to accomplish the intended goals in a more effective manner. Ideas should be submitted to the Town Engineer, whenever they arise, for review.

To summarize, the purpose of the BMP manual is to keep Milton's waters clean.

B. GUIDELINES FOR SENSITIVE WATER BODIES

Sensitive water bodies need to have additional erosion controls beyond the standard practices used in their watersheds. The primary difference for a project in the watershed of one or more sensitive water bodies will be that the project must use a combination of BMPs to protect the resource, and one of the BMPs must be an erosion control BMP versus a sedimentation BMP. A combination of BMPs will minimize the risk of water quality impacts. If one BMP fails, another should provide additional protection.

In some sensitive watersheds, the Town Engineer may specify which BMPs will be used on the project and may provide specific guidance regarding timing and phasing of exposed soils.

C. STORMWATER MANAGEMENT PLANNING

The Town of Milton Public Works Department has set minimum standards for stormwater management that will be met on every project. The State of Vermont, Agency of Natural Resources is in the process of setting new stormwater management policies and rules in place. These Best Management Practices are to complement the existing policies and rules and the new policies and rules when in place. While some BMPs address short term erosion and sedimentation controls, other BMPs address long term controls that treat and manage stormwater for many years. Both short and long term controls must be considered in selecting appropriate BMPs for every project.

D. THE EROSION PROCESS

In order to prevent erosion, or to control it effectively when it does occur, it is important to understand the four sequential processes involved: raindrop impact, sheet flow, rill/gully formation, and stream flow.

Raindrop Erosion- Raindrop erosion occurs when rain drops fall and their impact dislodges soil particles and splashes them into the air. The dislodged soil particles can then be easily transported great distances by the flow of surface runoff.

Sheet Erosion- Sheet erosion occurs when the action of raindrop splash and runoff remove a layer of exposed surface soil. The water moves as broad sheets over the land and is not confined to small depressions.

Rill and Gully Erosion- Rill and Gully erosion occurs as runoff flows and concentrates in rivulets cutting several inches deep into the soil surface. These grooves are called rills, and in unrepaired rills or in other areas where a concentrated flow of water moves over the soil, gullies may develop.

Stream and Channel Erosion- Stream and channel erosion occur if the above processes are not controlled. Increases in volume and velocity of runoff from construction activities may cause long term, chronic erosion of the stream or channel banks and bottoms.

Wind Erosion- Wind mechanically erodes dry soils by winnowing fine particles from coarser ones.

E. CONSEQUENCES OF EROSION

- Increased export of sediment and pollutants to lakes, streams, rivers and coastal waters impairing and/or destroying aquatic habitats for fish and other aquatic organisms or wildlife.

- Often the environmental impacts from erosion and sedimentation are irreparable and penalties can be levied against the responsible party.

- It is often far less costly to plan for and prevent erosion than to repair damage once it has begun. Repairs are often very labor intensive and lead to large expenses for a project.

- As roadway shoulders and embankments erode and washouts around pipes and bridge abutments occur, bridges, slopes and guardrails become structurally unstable.

II. STANDARDS and COMMITMENTS

A. STANDARD EROSION AND SEDIMENT CONTROL PRACTICES

Erosion and sediment controls are a variety of temporary and permanent measures that prevent soil erosion and inhibit sediment transport in runoff. For both temporary and permanent practices, **erosion controls**, which prevent soil from being transported, are more desirable than **sediment controls**, which restrict the deposition of sediment already in transport. Many of the BMPs and standard details include common sense ideas that will reduce a project site's vulnerability to erosion, saving time and money while protecting adjacent resources and property.

To properly employ the various measures at our disposal consider the following when developing an effective erosion control plan:

1. Minimize impacts in Environmentally Sensitive Areas

As a first preventative measure one should minimize impact to areas that are considered environmentally sensitive by limiting the following construction activities:

Soil Disturbance -

- Within a watershed of any sensitive water body.
- Within 76 m of a lake, river, brook, or perennial or intermittent stream.
- Within 30 m of a wetland.

Stream Crossings -

- Construction areas which require crossing of, or construction adjacent to, any intermittent or perennial channel.

2. Timing and Sequencing the Work to Minimize Erosion Potential

Avoidance of sensitive areas is not always possible or practical. In those situations the time of year the project is built and sequencing of the various construction phases should be carefully reviewed to minimize the potential for adverse impacts. Freeze-thaw cycles will dislodge some soils and put them in suspension making them difficult to control during winter conditions. Frozen material cannot be placed directly in fills, so it requires temporary placement until it thaws, again creating a potential source of sedimentation. In addition, establishment of a permanent erosion resistant vegetative cover requires a full growing season. The following questions should be considered when planning advertisement and completion dates for contracts and when sequencing the work on the project:

Timing -

- Does the work **need** to be done during the winter season or can the project objective be achieved working in the usual construction season of May 15 to November 15?
- Is the potential for adverse impact increased when working in the winter season?
- Are the disturbed soils frost susceptible, giving rise to unstable slopes during the spring thaw?
- What are the resources nearby that will be negatively impacted in the event erosion occurs?
- Does the season of the work require costly erosion control measures that exceed what might be required in a more favorable season?

Sequencing -

- Is there a sequence of construction that will better protect adjacent property?
- Is there work in or adjacent to water bodies that should be done during a low flow period?

3. Keep Disturbed Areas Small

Put simply, the smaller the bare soil area subject to the forces of erosion, the less sediment there is available to be transported off-site.

Limit Bare Soil -

- Consider staged construction to limit the area of bare soil within a given time frame.
- On projects where the excavation is used to build the fills, plan the work such that the bare soil area is kept to a minimum. Use temporary mulch and seed and other BMPs as necessary to prevent erosion.

Protect Existing Vegetation -

- Preserve as much natural vegetation as possible.
- Protect buffer strips of natural vegetation between construction activities and environmentally-sensitive areas.

Soil Erodibility -

- Identify the erodibility of the soil that must be disturbed and design controls to handle the potential (e.g.. clays are more erodable than sand).

4. Stabilize Disturbed Areas As Soon As Possible

Soil stabilization refers to measures which protect soil from the erosive forces of raindrop impact and flowing water. Applicable practices include temporary erosion control materials, vegetative establishment, mulching and the timely application of an aggregate base course on areas to be paved. Soil stablization measures should be selected as appropriate for the time of year, site conditions and estimated duration of use. Timely application of stablization measures is the best defense against erosion damage as it stops erosion before it starts. The goal should be to construct, finish, and permanently stabilize slopes and ditches instead of completing one operation at a time. Therefore, the following should be considered:

Mulching -

- Temporary Mulch applied at least weekly, and more often if weather forecasts or other conditions warrant it.

- Final Mulch should be accomplished within 1 week of slopes being brought to final grade.

Seeding -

- Final Seeding should be accomplished within a week after slopes are brought to final grade.

- In sensitive watersheds the final seeding should be completed as soon as practicable and within one week of completion of the grading of slopes.

Temporary Measures -

- Utilize temporary erosion and sedimentation control measures such as mulching, temporary erosion control blankets, check dams, and temporary berms or diversions

- Stabilize stockpiles or stabilize them with erosion control devices and sediment traps.

Permanent Measures -

- Install other permanent erosion control measures such as riprap downspouts, stone ditch protection, etc. as part of the slope or ditch construction.

- Protect existing vegetated areas as much as practicable.

- Establish a permanent vegetative cover.

Combination -

- Use a combination of the above.

5. Reduce Stormwater Runoff Over Disturbed Areas

Those areas that are currently being disturbed by construction activities, or those on which new vegetation has yet to become firmly established must be protected from runoff. Concentrated flows are particularly important to avoid or control as they cause rill, gully, and stream bed erosion.

Divert Runoff -

- Consider using temporary berms or diversion ditches along the top of slopes in conjunction with temporary slope drains or riprap downspouts to convey the water down the slope to a stabilized area. On long slopes consider using a diversion to reduce the slope length.

- Whenever a slope intersects underground seepage, install some means to collect the water, not allowing it to flow over the slope causing erosion and instability. This may be accomplished by underdrain or a diversion ditch.

Use Permanent Measures -

- Construct permanent ditches as early as possible in building the project. Install permanent erosion control and stabilization measures as the ditch is constructed. Channel runoff into the ditches and construct sedimentation devices as the work proceeds.

6. Protect Existing Stormwater Inlets and Culverts

Sediment-laden water from construction areas that enters new or existing catch basins or culverts can cause heavy sediment deposits in these systems. It is generally much more cost-efficient to prevent the sedimentation than to clean these systems.

Temporary Measures -

- Install filter barriers such as silt fence or hay bales around catch basins, inlets, and small culverts (but not in channelized flow). Protect larger culverts with stone checkdams and sediment traps.

- Sediment collected must be disposed of properly.

- In some cases, a temporary perforated riser may be necessary at the inlet of a culvert for use during the construction phase to allow sediment to settle out in a controlled manner.

- To function properly, these temporary structures need inspection and maintenance at least weekly and before, during and after storms that cause runoff. When construction is completed and upslope areas stabilized, they should be removed to avoid seriously obstructing the storm system.

Permanent Measures -

- Culvert inlets/outlets should be protected with riprap or other appropriate stabilization measures.

7. Keep Runoff Velocities as Low as Possible / Reduce Channelization

Since the amount of sediment and the distance it is transported is directly related to the velocity of the runoff, a number of measures may be considered to reduce the velocity of the runoff.

Short-Term Measures -

- Sediment Basins or Traps should be considered to slow runoff velocity and provide settling areas prior to discharging runoff into surface waters.

- Temporary Check Dams in ditches allow a certain amount of ponding of runoff which slows the velocity and allows sediment to deposit behind the dam. Regular inspection and maintenance of these measures is essential as sediment deposits can accumulate rapidly.

- Mulch and Erosion Control Blankets reduce raindrop impact, sheet, and rill erosion. They slow the velocity of runoff and promote infiltration.

Long-Term Measures -

- Vegetation reduces raindrop impact and sheet and rill erosion. It slows the velocity of runoff and promotes infiltration.

- Ditch Turnouts reduce concentrated flow and allow runoff to be spread out into natural buffer areas where sediment can be removed and infiltration increased.

Combinations -

- Sedimentation Basins outlettng into a Level Spreader.

- Check Dams and Sediment Traps.

- Hillside Diversion with a RipRap Downspout.

8. Retain Sediment On Site

As previously stated, natural erosion takes place slowly over time, whereas construction and maintenance activities can cause accelerated erosion. The goal of stormwater management planning is to limit erosion and sedimentation. Typically, stormwater flowing off a construction site does not look clean until 95% of the Total Suspended Solids (TSS) are removed.

It is, therefore, very important to consider the following:

Filter Barriers -

- Silt fence alone will not attain adequate TSS removal.

- Wood waste compost filter berms have been observed to attain better TSS removal than silt fence.

Containment or Limiting Measures -

- When working near water courses install erosion control measures to stabilize the disturbed areas immediately after soil disturbance.

- Maintain a vegetative buffer to the extent possible between disturbed areas and the sensitive resource.

- Erosion controls should be installed prior to any soil disturbance (stumping or grubbing) in the area.

9. Inspect and Maintain Erosion Control Measures / Correct Defects

Inspect BMPs -

- Periodic inspection of erosion control measures at least weekly and prior to, during and after storm events is a must. Inspection during storm events is desirable to see which areas need different or additional erosion control measures to improve the effectiveness of the Erosion Control Plan. Inspections should be conducted by qualified personnel with the authority to make changes to the Erosion Control Plan and immediately implement necessary changes.

Maintain BMPs -

- Erosion and Sediment Control measures may require repairs and removal of accumulated sediment to remain effective.

- Sediment removed during maintenance must be disposed of in an approved area.

- See individual BMPs for specific Maintenance Requirements of individual BMPs.

10. Remove Temporary Erosion and Sediment Control Measures

Temporary measures such as temporary check dams, sediment barriers, temporary slope drains, etc. must be removed when upslope disturbed areas have been permanently stabilized. If left on-site, temporary measures may seriously impair the normal function of the designed stormwater system and be an eyesore for years. Wood waste compost filter berms may not have to be removed. In most circumstances, they can be spread out, seeded, and left to decompose. Stone check dams may be able to be spread out and pressed into the ground surface. However silt fence must be removed from the site. Areas disturbed during the removal of these devices must be properly stabilized.

B. GUIDELINES FOR SENSITIVE WATER BODIES

Sensitive water bodies need to have additional erosion controls beyond the standard practices used in their watersheds. The primary difference for a project in the watershed of one resources will be that the project **must use a combination of BMPs to protect the resource, and one of the BMPs must be an erosion control BMP versus a sedimentation BMP.** A combination of BMPs will minimize the risk of water quality impacts. If one BMP fails, another should provide additional protection.

In some sensitive watersheds, the Town Engineer may specify which BMPs will be used on the project and may provide specific guidance regarding timing and phasing of exposed soils.

To provide further protection to these sensitive water resources, the following items must be addressed in the Erosion and Sedimentation Control Plan:

- Timing of projects to avoid winter construction whenever possible
- Phasing work to avoid large areas of disturbed soils
- Identification and mapping of areas of highly erodable soils
- Areas of steep slopes (1:2 or steeper)
- In-water work
- Cold water fisheries sensitivity to sedimentation
- Evaluate the use of long term stormwater treatment through the use of BMPs such as:
  - ❖ Ditch turnouts
  - ❖ Level lip spreaders
  - ❖ Vegetative buffers

Designs shall provide for long-term stabilization of the disturbed soils. For example, it may be necessary to protect a cold water fishery from thermal warming and long-term sedimentation problems. In this case riprap may be used to control the sedimentation problem and vegetation may be planted within the riprap to provide shading. In addition, the natural vegetation in the area should be protected from disturbance.

In summary, careful design and installation of temporary and permanent erosion and sedimentation control devices can protect and enhance the surrounding environment, while at the same time serve our project needs. This is the goal we should have on all projects with extra emphasis on projects in sensitive watersheds.

C. STORMWATER MANAGEMENT PLANNING

The Town of Milton Public Works Department has set minimum standards for stormwater management that will be met on every project. The State of Vermont, Agency of Natural Resources is in the process of setting new stormwater management policies and rules in place, these Best Management Practices are to complement the existing policies and rules and the new policies and rules when in place. While some BMPs address short term erosion and sedimentation controls, other BMPs address long term controls that treat and manage storm water for many years. Both short and long term controls must be considered in selecting appropriate BMPs for every project.

Short term controls are part of an Erosion and Sedimentation Control Plan for the construction and maintenance of projects. Long term controls are an integral part of the planning and design of a project. In order to assure that minimum stormwater management standards are met in the design phase of a project, the following elements must be incorporated provided they are feasible:

Waterways - Ditches, swales, and sideslopes will be designed for long-term stability with minimal maintenance. Use vegetated swales whenever feasible.

Points of Discharge - Discharge points will be designed to minimize potential erosion of the receiving channel/resource. Energy dissipation and ditch turnouts to buffers are encouraged wherever opportunities arise.

Culvert End Treatment - Use appropriate culvert inlet and outlet protection.

Cold Water Fishery - When discharging to a cold water fishery stream, take measures to avoid and minimize thermal effects such as providing for shading of channels and outlets, utilizing ditch turnouts and buffers, minimizing the amount of riprap, and minimizing the amount of clearing.

D. EROSION AND SEDIMENTATION CONTROL PLAN

When it is expected that the proposed work will disturb existing ground cover, either natural or manmade (i.e. paved areas), an Erosion and Sedimentation Control Plan will be prepared and kept on site. The plan will address the ten principles of erosion and sediment control discussed in Section A and will be tailored to match the intended work. This is a requirement for all Maintenance and Construction projects or activities. The Plan is effective until all permanent stabilization measures are in place. The following items should be addressed as a minimum:

(1) name of on-site person responsible for the implementation of the plan:

(2) emergency storm response procedures;

(3) proposed locations for use of silt fence and alternative erosion control devices such as wood waste filter berms;

(4) silt fence and silt curtain inspection frequency for removal of collected sediment, including how the sediment will be removed and where it will be disposed of;

(5) temporary mulching procedures for disturbed earth areas;

(6) temporary sediment control at the inlets and outlets of existing and proposed catch basins;

(7) dust control procedures for staging areas, stockpile areas, and on haul roads;

(8) stormwater runoff diversions, where needed, and their outlet locations;

(9) inspection and maintenance schedules for all soil erosion and water pollution control measures;

(10) the location of all sedimentation basins used for dewatering the cofferdams.

BMP SELECTION MATRIX

BMPs

	Erosion Control	Sediment Control	Pollutant Control	Stabilizer	Energy Dissipater	Thermal Pollution Control	Water Channeling	Prevention
Mulch	X			X		X		
Seeding	X			X		X		
Erosion Control Blankets	X			X				
Trees, Shrubs, Vines and Ground Cover	X		X	X		X		
Ditch / Swale protection	X		X	X		X	X	
Culvert Inlet Protection	X			X			X	
Culvert Outlet Protection	X			X			X	
Sediment Barriers / Filter Berms		X						
Check Dams	X	X			X			
Stabilized Construction Entrance	X		X	X				X
Dust Control								X
Storm Drain Inlet Protection		X						
Temporary Slope Drain	X						X	X
Riprap Downspout	X			X			X	X
Hillside Diversions							X	X
Sediment Trap and Basins		X	X					
Slope Stabilization	X			X		X		
Boom Supported Floating Silt Fence		X						
Temporary Stream Crossings								X
Temporary Stream Diversion								X
Sandbag Cofferdam		X			X		X	
Cofferdam Sedimentation Basin		X						
Buffer Areas	X		X	X	X	X		
Vegetated Swale	X		X				X	
Level Spreader	X		X		X			
Road Ditch Turnout	X		X	X	X		X	

METRIC TO IMPERIAL UNITS CONVERSION FACTORS

Metric Unit	Abbreviation	Multiplier		Imperial Unit
hectare	(ha)	2.47	=	acres
square meter	(m^2)	1.196	=	square yard
square meter	(m^2)	10.764	=	square foot
millimeter	(mm)	0.0394	=	inch
millimeter	(mm)	0.0033	=	feet
meter	(m)	3.28	=	feet
meter	(m)	1.094	=	yard
cubic meter	(m^3)	1.3	=	cubic yard
cubic meter	(m^3)	35.31	=	cubic foot
liter	(l)	0.264	=	gallon
kiloPascal	(kPa)	0.145	=	pounds per square inch
cubic meter per second	(m^3/s)	35.31	=	cubic feet per second

Example; 10 hectares = 24.7 acres
(10 X 2.47 = 24.7)

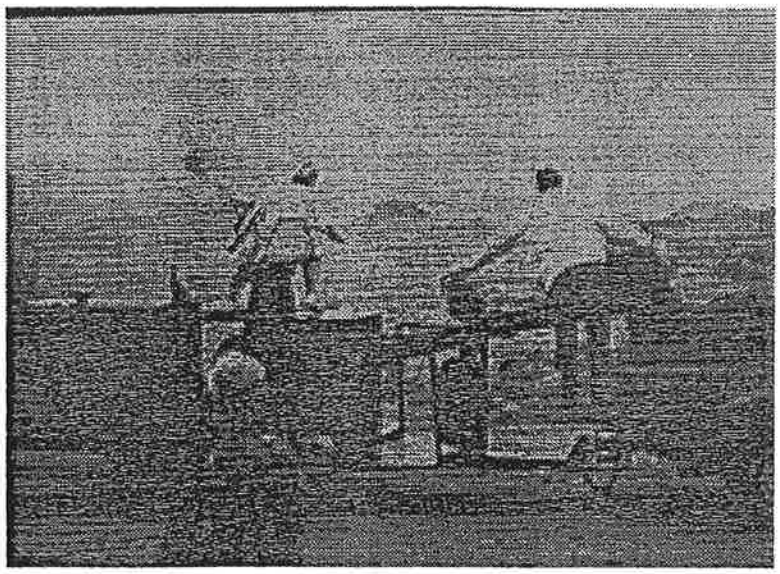
Note: One hectare is 10,000 square meters.

Note: Slopes in the Metric System (SI) are given as RISE : RUN.

1. MULCHING

What Is It?

Mulching is the application of hay, straw, wood waste compost/bark mulch, crushed stone, or cellulose fiber on disturbed surfaces to prevent erosion. It protects soils from rain impacts and rill erosion. As a temporary cover it can aid in the growth of vegetation by conserving moisture and providing protection against extreme heat and cold. Long term mulch cover usually consists of materials that resist decomposition such as wood waste compost, bark mulch, or crushed stone. Long term mulch is often used on soil surfaces where vegetative stabilization is either impractical or difficult to establish. Cellulose Fiber, hay and straw mulch can be applied with or without seeding.



When and Where to Use It:

This method of erosion control is used on any area subject to erosion, or which has unfavorable conditions for plant establishment and growth. Areas that cannot be seeded within the growing season are thickly mulched to provide temporary protection to the soil surface. An organic mulch other than wood fiber alone is used, and the area is seeded as soon as seeding dates permit. Permanent mulch is particularly valuable in stabilizing chronic erosion areas subject to heavy foot or light vehicle traffic. Mulch is also used in conjunction with tree, shrub, vine and ground cover plantings. Light mulches such as hay or straw are used to cover seeded areas the same day as seeding occurs. Mulches are not used in channels where there is concentrated flow. Mulch is applied within one week of completed grading and prior to storm events. However, in some sensitive watersheds it may be required daily

What to Consider:

General Considerations:

- **VTRANS STANDARD SPECIFICATION** Section 755.06 has information on construction requirements for mulch. Table 1.1 is a guide to mulch materials that includes application rates and depth cover.

Short-term Mulch Considerations:

- Temporary mulches are applied to cover 100% of exposed soils.
- Hay and straw mulch are not effective in areas of concentrated flows.
- Hay and straw mulch need to be anchored or tacked on slopes greater than 1:2 and/or where wind can move the mulch. Cellulose Fiber Mulch should be anchored on slopes greater than 1:3. The use of commercial tactifiers, hydro mulch, or paper mulch needs to be applied at a rate of 29 kg/1000 m^2. Mulch can also be anchored by using a mulch netting. The netting is stapled to the soil surface according to manufacturer's recommendations.

  Another, more labor intensive measure is the peg and twine method. This method can make future mowing very difficult. Divide areas into blocks approximately 1 m^2. Drive 4-6 pegs per block to within 50-75 mm of soil surface. Secure mulch to surface by stretching twine between pegs in criss-cross pattern on each block. Secure around each peg with two or more turns. Drive pegs flush with soil where mowing is planned.

Long-term Mulch Considerations:

- Permanent mulches should be applied to cover 100% of exposed soils. However, where seed is applied to establish vegetation, hay or straw mulch should be applied to cover 95 % of exposed soils.
- Under special circumstances crushed stone may be used as a permanent mulch when called for on plans. A geotextile filtercloth may be placed between the ground and the stone to prevent germination of weeds or other undesirable vegetation. Do not use filtercloth on slopes steeper than 1:4. Gravel and stone should be 6 mm to 60 mm in size and applied at a rate of 81 m^3 per 1000 m^2. Gravel and stone should be washed before being placed in sensitive areas.
- Wood chips, wood waste compost, or crushed stone are not used on slopes steeper than 1:2. Application of permanent mulch should be a minimum of 100 mm in depth.

Table 1.1 Guide to Mulch Materials

Mulch Material	Application per 93 m2	Rates per Acre	Depth of Application or Area Covered per unit	Remarks
Hay or Straw	32 -41 kg, (2 bales)	1365-1820 kg (90-100 bales)	95-100% coverage of surface	Do not use where mulch is to be maintained for more than 3 months. Subject to wind blowing unless kept moist or tied down. Hay can be moist but not wet.
Green Wood Chips or Shavings	209 - 420 kg	9090-18180 kg	50-150 mm	Has about the same use and application as sawdust. Resistant to wind blowing. Can be used on critical areas if protected from washing. Decomposes rapidly.[1]
Wood Excelsior	40 kg (1 bale)	1820 kg	95-100% surface coverage	Effective for erosion control. Tiedown usually not required. Decomposes rapidly. Subject to some windblowing. Packaged in 40 kg bales. Extra nitrogen fertilizer may be required.
Sawdust, Green or Composted	2.4-14.2 m3	–	25 - 175 mm	Effective as a mulch around ornamentals, small fruits, and other nurserystock. Resistant to wind blowing.[1]
Wood Waste Compost/Bark Mulch	9.2 m3		100 mm minimum	Resistant to windblowing. Can be left for long periods of time. Vegetation may eventually grow on top of mulch. Decomposes slowly. See Landscape Section for Specific Standards on product.[1]
Gravel and Stone	81 cubic meters per 1000 square meters			Should be 6 mm to 60 mm in size. Gravel and stone should be washed before placed in sensitive areas.

1. These materials should have a minimum of 40% moisture content to keep them fireproof.

- Vegetation may establish itself over permanent mulch when soils are favorable. This provides additional stabilization and aesthetic enhancement, and it can minimize thermal pollution (See also SEEDING BMP).

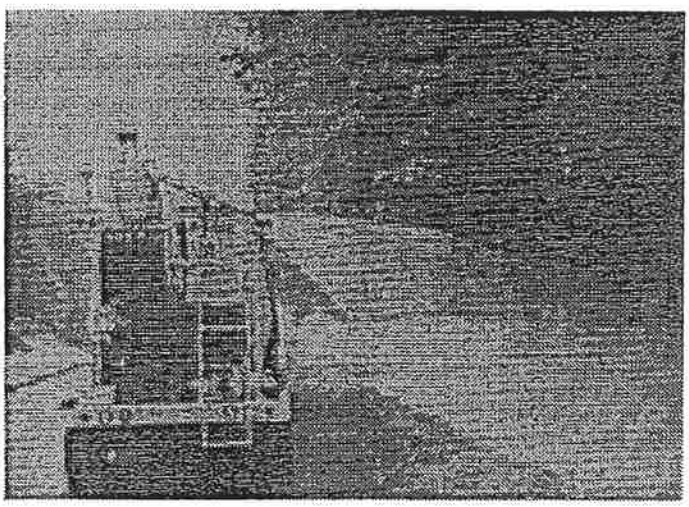
Maintenance/Performance of Mulching:

When Mulch is applied as a temporary erosion control measure, it needs to be inspected daily and in particular before rainstorms. If any bare soil is exposed, additional mulch should be applied. When it has been applied over seed, periodic inspections of the area should take place to ensure 95% of the soil surface becomes covered with vegetation. Vegetation is not considered established until a ground cover is achieved which is mature enough to control soil erosion and to survive severe weather conditions. When long term mulch is used either alone or in conjunction with landscape plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface. Repair as needed.

2. SEEDING

What Is It?

Seeding is used to establish a temporary vegetative cover on soil exposed for up to 12 months, or for a permanent vegetative cover on exposed soil where perennial vegetation is needed for long term protection. Temporary seeding reduces erosion and sedimentation by stabilizing areas that will not be brought to final grade for up to 1 year. It can also be used to reduce mud and dust from disturbed areas during construction. Permanent seeding establishes vegetation that holds soil particles in place, reduces the velocity of runoff, and promotes greater infiltration of the runoff into the soil.



When and Where To Use It:

Temporary seed is applied to disturbed areas when they are not fine-graded for periods of several weeks to 1 year. Such areas include disturbed areas, stockpiles, dikes, dams, sides of sediment basins, temporary road embankments, etc. Permanent seeding is appropriate for any location where long-lived vegetative cover is desirable to permanently stabilize the soil, reduce sedimentation from runoff, and to enhance the environment. Permanent seeding is especially important in areas such as buffer areas, filter strips, vegetative ditches/swales, steep slopes and stream banks. It is also appropriate to use permanent seed mix in rough graded areas that will not be brought to final grade for a year or more. Seed is applied within 2 weeks after grading operations cease. In sensitive watersheds the final seeding is applied within 1 week. Exposed soils that are not immediately seeded should be mulched pursuant to the MULCHING BMP.

What To Consider:

- **VTRANS STANDARD SPECIFICATION** Section 651. provide information on materials and construction requirements.
- Temporary seeding is relatively inexpensive and can prevent costly maintenance of other erosion control measures.
- Loam or other soil amendments may be necessary to establish permanent growth in areas where top soils have been removed, where soils are dense, impermeable, or low in organics, or other areas where mulch and fertilizer alone cannot improve soil quality. Failure to follow sound agronomic recommendations will often result in an inadequate growth of vegetation that provides little or no erosion control.
- No conventional fertilizers are applied within 76 m of all water resources. Fertilizers contain phosphorus and nitrogen that can degrade water quality. When possible, use #3 seed mix in these areas.
- Permanent grass cover along with other vegetation, helps prevent thermal water pollution from affecting cold water fisheries (see TREES, SHRUBS, VINES and GROUND COVERS BMP).
- Mulch is to be applied to all seeded areas in accordance with the MULCHING BMP
- Permanent Seeding is performed in combination with other structural and non-structural erosion and sediment control practices until permanent vegetation has been firmly established. Additional measures to consider include: road ditch turnouts, check dams, temporary erosion control blankets, temporary slope drains, and diversions.
- If temporary seeding cannot be firmly established by the end of the growing season, other measures should be taken to stabilize the area for winter.
- Nutrients and pesticides used to establish and maintain vegetation must be managed to protect surface and ground water quality.
- Permanent seeding is accomplished within the planting seasons as specified in the **VTRANS STANDARD SPECIFICATION** Section 651.03. Late fall seeding may fail and cause water quality deterioration during the next runoff event. If permanent seeding cannot be firmly established by the end of the growing season, then other measures should be taken to stabilize the area for the winter (see MULCHING BMP).

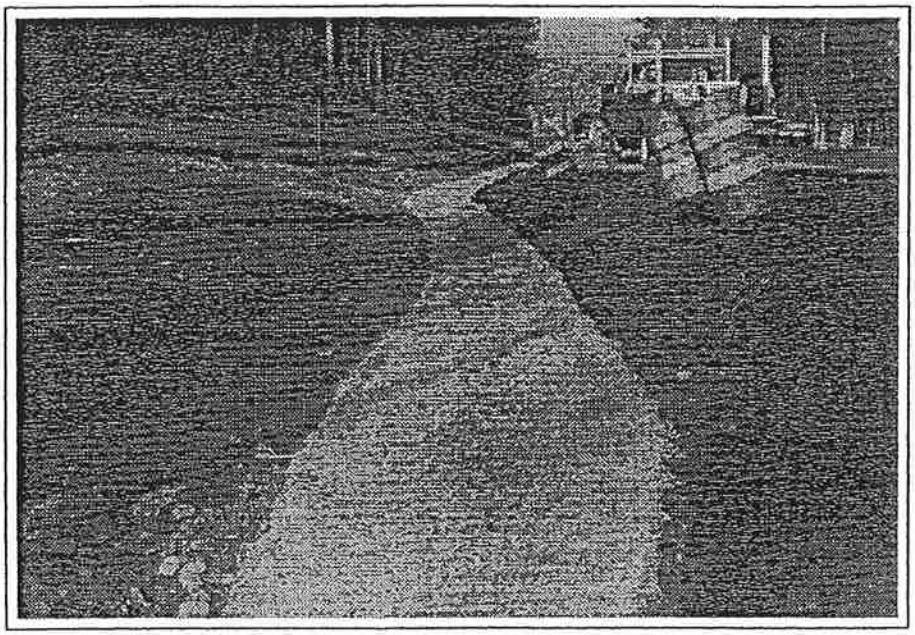
Maintenance/Performance of Permanent Seeding:

Supplemental watering of seeded areas will be necessary during dry times. Applied water shall be uniformly sprayed on seeded areas in such a manner to avoid washing out seed or soil. Seeding should be inspected periodically to ensure that a minimum of 95% of the soil surface is covered by vegetation. If the seed catch falls short of this, reseeding is necessary. Grasses are not considered established until a ground cover is achieved which is mature enough to control soil erosion and to survive severe weather conditions. During this time it is important to maintain other erosion and sedimentation controls such as silt fences and filter berms. If any evidence of erosion or sedimentation is apparent, repairs should be made, and perhaps additional erosion control measures installed such as diversions, temporary slope drains, etc.

3. EROSION CONTROL BLANKETS

What Are They?

Erosion control blankets are made of biodegradable materials such as jute matting, excelsior wood fiber, coconut fiber, straw or interwoven paper strips, and a netting made of a biodegradable polypropylene or extruded plastic. These materials are formed into sheets that are used as temporary or permanent mulching to stabilize disturbed slopes. Erosion control blankets provide the same benefits as other types of mulching, but are much more stable and longer lasting than normal mulches and can be used in areas of moderate concentrated flow such as ditches and swales.



When and Where to Use Them:

Temporary erosion control blankets are used to stabilize ditches and swales with profile grades of less than 6% under low to moderate flow conditions. In addition, temporary erosion control blankets should be installed on slopes where the soil is erodable but will support vegetation, and may be used on shoulder berms, esplanade strips, and curb sections. Consult with Office of Environmental Services (OES) Landscape Section for more information on when to install extended use erosion control blankets.

What to Consider:

- See **VTRANS STANDARD SPECIFICATION** Section 654 for information on installation.
- See **STANDARD DETAILS** 600(18) AND 600(19) for more information.

- Seed is always sown under blankets, regardless of whether or not hydroseeding will occur later on in the project.

- The exact type of erosion control blanket to be used for a particular application is based on the manufacturer's recommendations and specifications.

- Use adequate amounts of anchoring staples to avoid floating blankets into culverts and across open channels.

- **Permits are required for work in streambeds.** Consult Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division, Application and address located in the Appendix.

Erosion control blankets should be laid and stapled down on smooth, prepared surfaces, and maintain continuous contact with the disturbed soil surface to be effective. This is especially important when using rigid materials. Failure to maintain contact will allow stormwater to flow underneath the blanket causing mounding and erosion.

CHANNEL LINING: If the blanket is to be used as ditch/swale protection, a flow analysis of the channel should be completed. See the DITCH/SWALE PROTECTION BMP for design information.

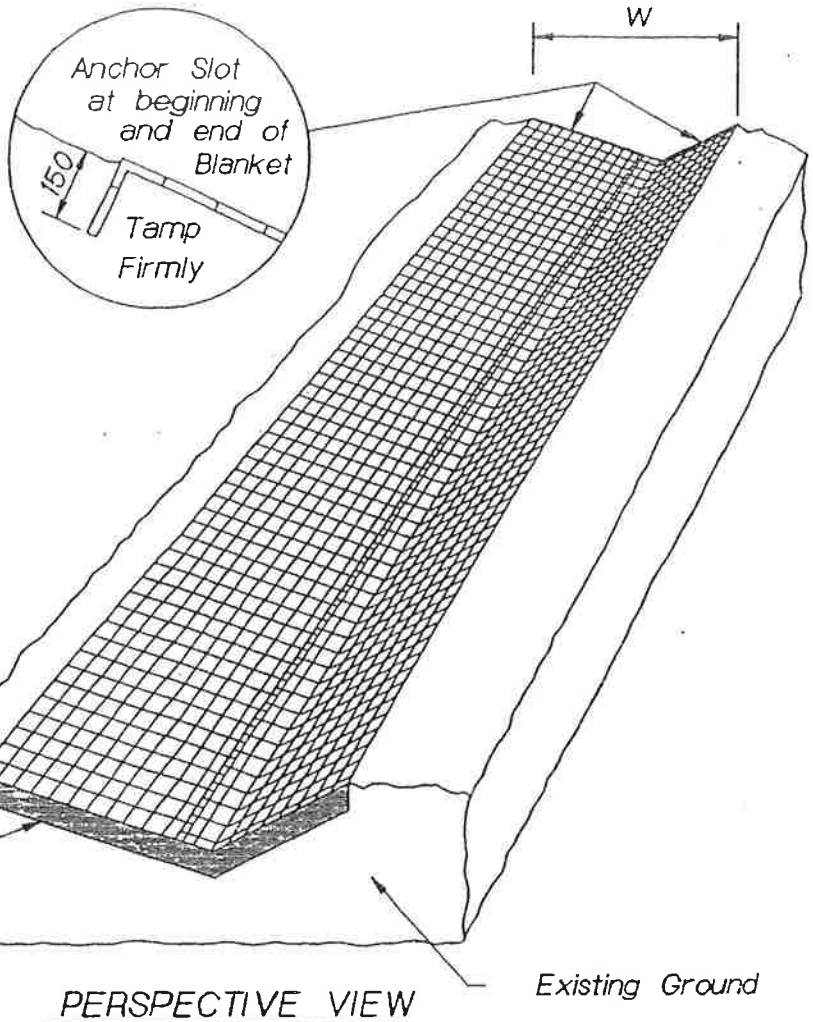
- Concentrated Flow Areas: Care should be taken in choosing erosion control blankets to be used in areas of concentrated flows such as dry streambeds, ditches and swales because the performance parameters of the various types of blankets vary significantly. Contact the Landscape Section in OES for additional information in choosing the appropriate blanket for these applications.

SLOPE STABILIZATION: All slopes greater than 1:2 should be protected with temporary or extended use erosion control blankets.

See **SLOPE STABILIZATION BMP** for design information.

Maintenance/Performance of Erosion Control Blankets:

Erosion control blankets should be inspected periodically and prior to, during and after storm events to ensure that the blanket is in continuous contact with the soil surface and in good repair until grasses are firmly established (95% of the soil surface is covered with grass). Blankets should be repaired and re-stapled as necessary to ensure proper function.

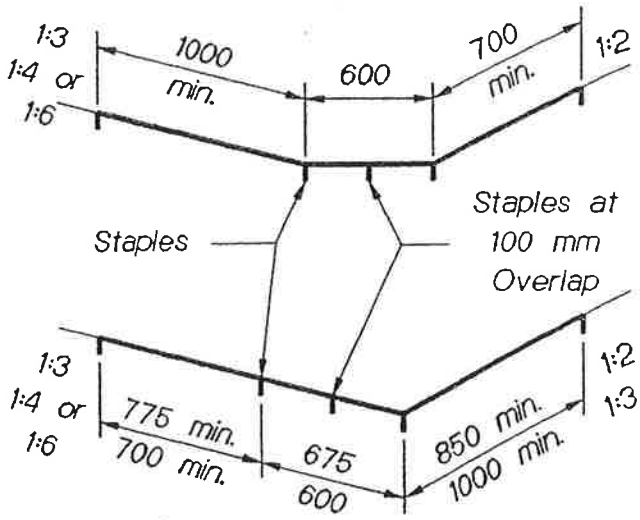


PERSPECTIVE VIEW

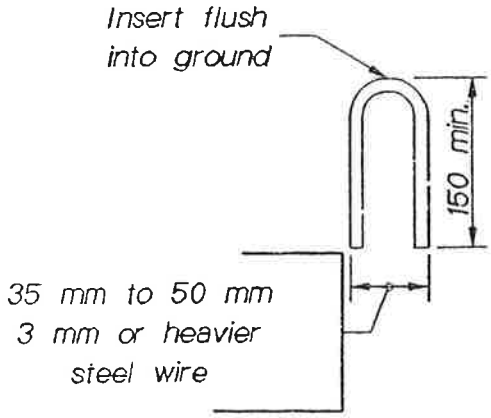
NOTE:

Width (W) may vary depending upon the type of material chosen for use. See Section 717.061 of the Standard Specifications.

Dimensions in mm unless noted.



STAPLE LOCATIONS



WIRE STAPLE

NOTE:

Staple spacing shall be at 900 mm C/C along blanket except at 100 mm overlap which shall be at 450 mm C/C. or as directed by manufacturer.

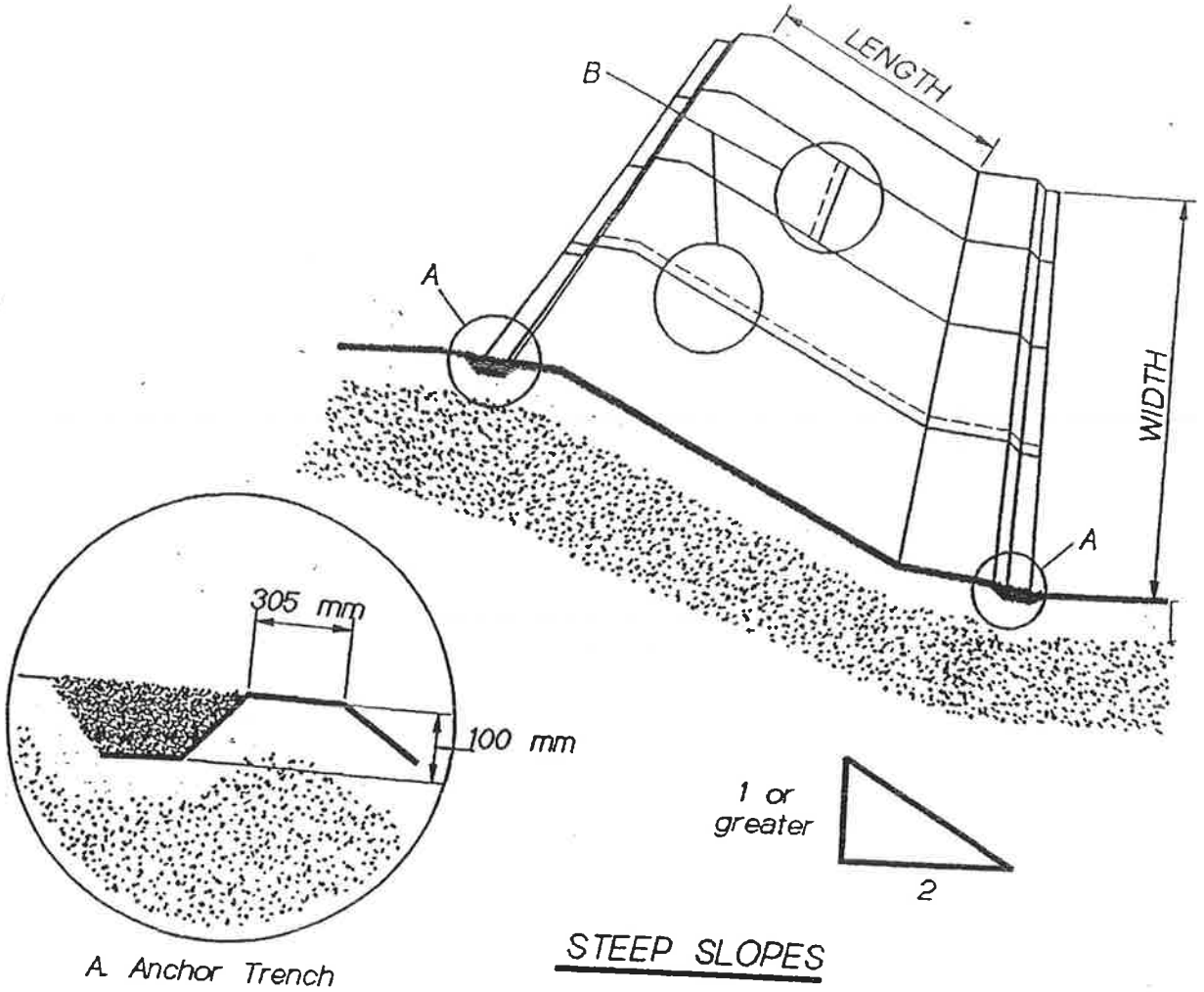
⚠1

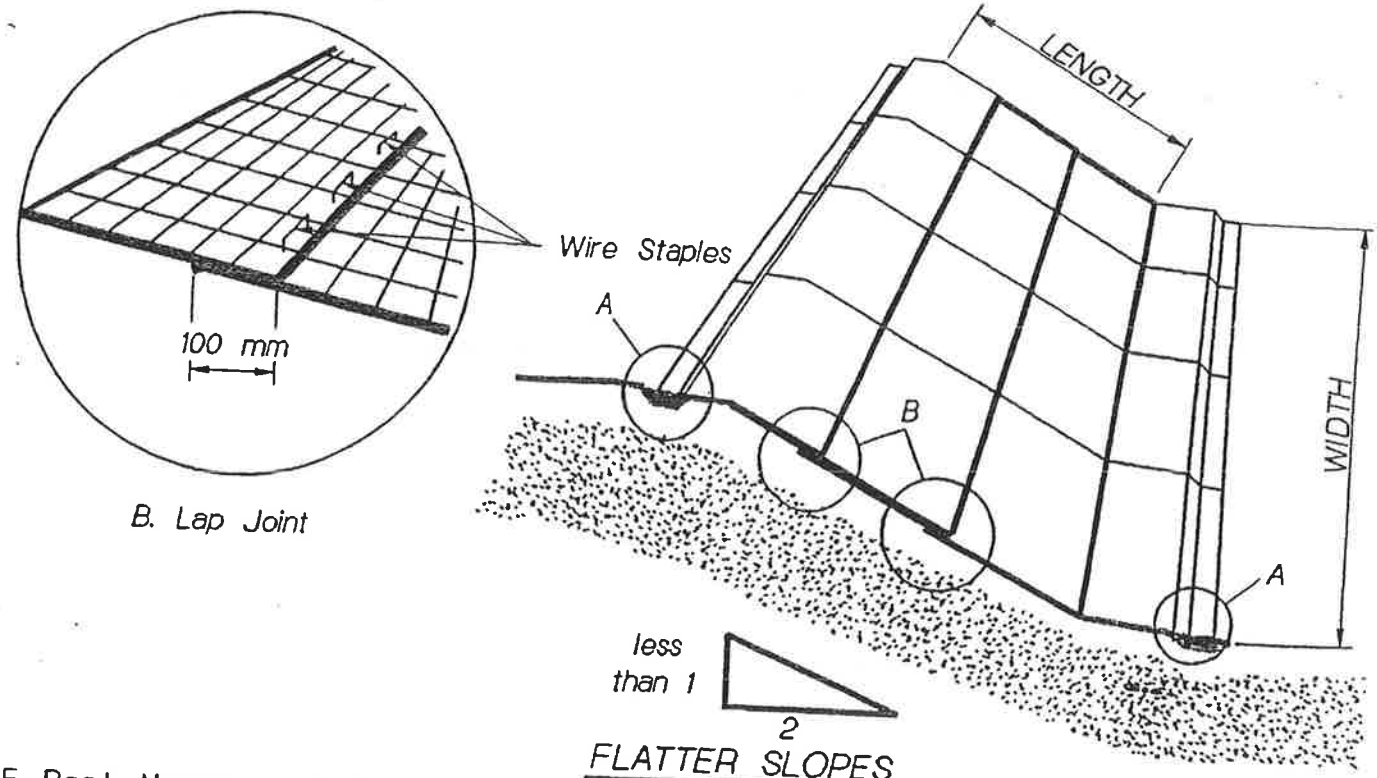
REF: Best Management Practice for Erosion and Sediment Control - Erosion Control Blanket

Ditch Application

600(18)

Standard Detail





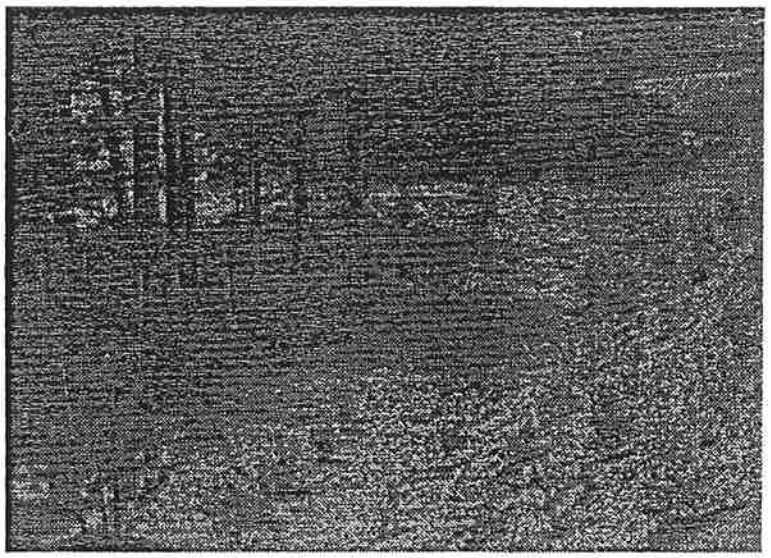
REF: Best Management Practice for Erosion and Sediment Control - Erosion Control Blanket

Slope Application

4. TREES, SHRUBS, VINES, AND GROUND COVERS

What are They?

Trees, shrubs, vines, and ground covers are used for permanent vegetative stabilization of disturbed areas where vegetation other than turf is preferred. In addition, they provide food and shelter for wildlife where improved wildlife habitat is desirable. They shade and moderate water temperature, assimilate pollutants, and recycle nutrients.



When and Where To Use Them:

- On steep or rocky slopes where mowing is not feasible.
- Should not be used on slopes steeper than 1:2 because they will not get enough water.
- Where ornamental plants are desirable for landscaping purposes.
- In shady areas where turf maintenance is difficult.
- In areas where pedestrian movement is to be limited.
- Where woody plants are desirable for soil conservation or to establish wildlife habitat.
- Along the banks of waterbodies to provide stabilization, shading and leaf litter for fish habitat.
- In restored or newly created vegetated buffers.
- On causeways for stabilization and habitat.
- Where leaf litter/organic layer is needed to adsorb pollutants.

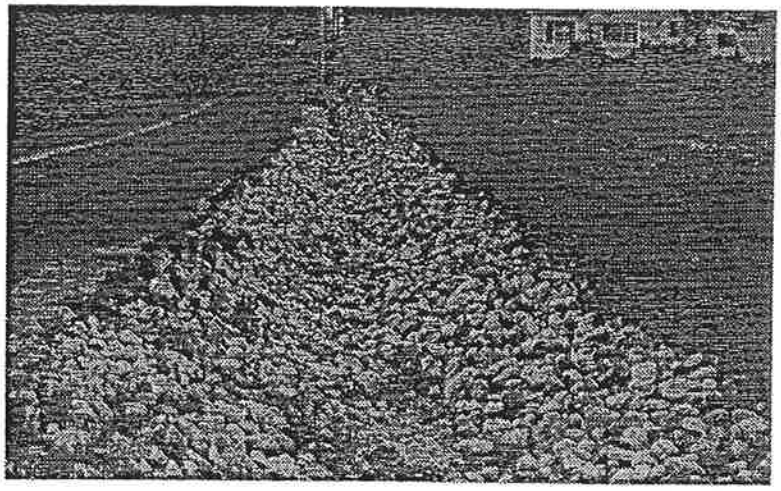
What to Consider:

- Refer to **VTRANS STANDARD SPECIFICATION** Section 656.
- It is always preferable to minimize cutting of existing vegetation rather than resorting to replanting.
- Mulched tree and shrub plantings are very beneficial for fish habitat along stream banks since they shade the water (counteracting thermal pollution), and provide leaf litter (a food source.)
- Tree, shrub, vine, and ground cover plantings are beneficial when constructing buffers in cases where natural vegetation has been removed.
- Careful plant selection can improve wildlife habitat for food and nesting areas.
- On cut and fill slopes adjacent to paved areas of shopping centers, schools, industrial parks, or other non-residential projects, woody plants and ground covers can be used to control erosion. They will also control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover.
- Avoid planting in snow storage areas.

5. DITCH/SWALE PROTECTION

What It It?

Ditch/swale protection is the application of vegetative or structural linings to an open channel to protect the channel from erosion. It is a basic element of any stormwater and erosion control plan.



When and Where To Use It:

All ditches and swales should be protected. The measures used for this protection vary depending upon the profile grade of the ditch and volume of flow. The minimum standards for erosion and sediment control in ditching operations are listed under the Design Standards.

What to Consider:

- The following **VTRANS STANDARD SPECIFICATION** Sections contain information on relevant materials: 203,649,651,654, and 706
- Review Chapter II of this manual, Principles of Erosion and Sediment Control, for more information about using ditch/swale protection.
- Temporary check dams should be installed while ditches are under construction and vegetation is not yet established, or when permanent armoring has not yet been installed. Spacing of check dams shall be in accordance with the CHECK DAM BMP Design Standards.
- Blasted ledge rock or tailings may be unsuitable due to fines. The material may need to be screened to meet VTRANS specifications.
- Long, stone ditch sections may contribute to thermal warming of water, and are of concern when the ditch drains to a coldwater fishery.

- Energy dissipating devices such as level spreaders, sediment traps, plunge pools and road ditch turnouts should be constructed wherever possible prior to releasing concentrated runoff adjacent to natural waterbodies such as streams, rivers, ponds, and lakes. Natural vegetative buffer areas should be left undisturbed if at all possible.

Design Standards

Hydraulic analysis associated with ditch/swale protection is a process which selects and evaluates alternatives according to established criteria. These criteria are the standards established by the Department to insure that a highway facility meets its intended purpose without endangering the structural integrity of the facility itself and without undue adverse effects on the environment or the public welfare.

Listed below are examples of design criteria which shall be considered for channel design as applied to ditches, ditch turnouts, diversions and downspouts:

- Channel side slopes shall not exceed the angle of repose of the soil and/or lining and shall be 1:2 or flatter in the case of rock rip rap lining.

- Flexible linings shall be designed according to the method of allowable tractive force.

- The design discharge for permanent ditch/swale linings shall have a ten year storm frequency, while temporary linings shall be designed for the two year storm frequency flow.

- In permanent channels, 150 mm of freeboard should be provided, but for temporary channels, no freeboard is required.

For a quick reference guideline based on the maximum gradient of the channel, the following will apply:

1. 0% - 2% Use an erosion control blanket in high flows.
2. 2% - 6% Use an erosion control blanket
3. >6% Use stone ditch protection.

Table 1 can also be used as a reference for permissable velocities of grass and earth lined channels.

Maintenance/Performance of Ditch/Swale Protection

See the individual BMPs for EROSION CONTROL BLANKETS, SEEDING AND CHECK DAMS for maintenance information.

Permissible Velocities: Grass and Earth Lined Channels

Channel Slope	Lining	Permissible Velocity*
0.5%	Bermudagrass	1.8 m/s
	Reed canary grass	1.5 m/s
	Tall fescue	1.5 m/s
	Kentucky bluegrass	1.5 m/s
	Grasslegume mixture	1.2 m/s
	Red fescue	1.2 m/s
	Redtop	1.2 m/s
	Sericea lespedeza	1.2 m/s
	Annual lespedeza	1.2 m/s

Channel Slope	Lining	Permissible Velocity*
Small grains (temp)		
5-10%	Bermudagrass	1.5 m/s
	Reed canarygrass	1.2 m/s
	Tall fescue	1.2 m/s
	Kentucky bluegrass	1.2 m/s
	Grasslegume mixture	0.9 m/s
> 10%	Bermudagrass	1.2 m/s
	Reed can arygr as s	0.9 m/s
	Tall fescue	0.9 m/s
	Kentucky bluegrass	0.9 m/s

· For highly erodible soils, decrease permissible velocities by 25%

Earth Linings

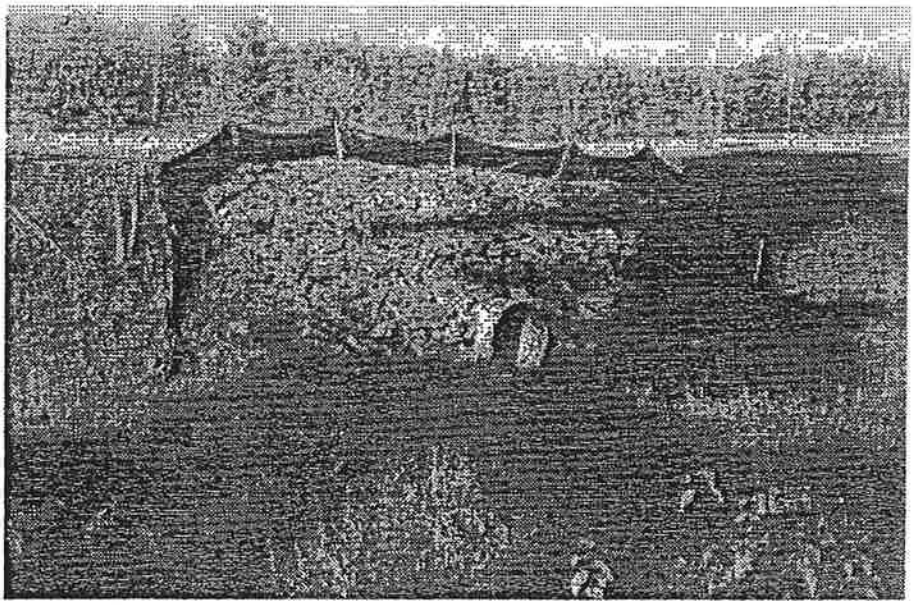
Soil Types	Permissible Velocity
Fine Sand (noncolloidal)	0.76 m/s
Sandy Loam (noncolloidal)	0.76 m/s
Silt Loam (noncolloidal)	0.9 m/s
Ordinary Firm Loam	1.1 m/s
Fine Gravel	1.5 m/s
Stiff Clay (very colloidal)	1.5 m/s
Graded, Loam to Cobbles (noncolloidal)	1.5 m/s
Graded, Silt to CoWles (colloidal)	1.5 m/s
Alluvial Silts (noncolloidal)	1.1 m/s
Alluvial Silts (colloidal)	1.5 m/s
Coarse Gravel (noncolloidal)	1.8 m/s
Cobbles and Shingles	1.7 m/s
Shales and Hard Pans	1.8 m/s

Referenced from Model Drainage Manual, 1991, American Association of State Highway and Transportation Officials (AASHTO).

6. CULVERT INLET PROTECTION

What Is It?

Culvert Inlet Protection is a protective armor for the immediate area around the inlet of a pipe or culvert subject to erosion. It protects the inlet of the culvert from scour and deterioration.



When and Where To Use It:

This practice applies to the inlets of all roadway culverts and to principal spillways in ponds. This protection also applies to natural streams and brooks.

What to Consider:

- See **ROADWAY CULVERT END SLOPE TREATMENT STANDARD DETAIL** 600(22)
- See **VTRANS STANDARD SPECIFICATION** Section 601 for construction requirements
- Where fish passage or migration is an issue or concern, an Inlet :pool" may be constructed (contact Vermont Department of Fish and Wildlife)
- These rigid and flexible devices should be installed in accordance with **VTRANS STANDARD SPECIFICATION** Sections 501, 601,and 613

- Structural or rigid inlet protection such as inlet headwalls can be used in conjunction with flexible inlet protection for larger riveted and structural plate pipes and arches.

- Plantings to provide shade should be considered if a large amount of rip rap or concrete will be used around a culvert that has a cold water fishery.

Design Standards

All inlets to culvert pipes will be adequately protected from scour caused by the entrance velocity, turbulance, and suction of the water entering the inlet. Three common groups of practices can be used: vegetative, flexible, and structural/rigid. Protective measures shall extend no less than one pipe diameter, or maximum dimension on rectangular conduit, on the sides, top and approach channel.

Determining the type of protection required should be based on either the maximum permissible velocity or the maximum permissible shear stress of the material to be used.

Vegetative Measures

Vegetation shall be installed according to TREES, SHRUBS, VINES AND GROUND COVER BMP. All newly seeded areas must be mulched. Mulch must be anchored with netting or matting. Refer to the MULCHING and SEEDING BMPs, as well as EROSION CONTROL BLANKET BMP. When stabilizing with vegetative measures, either HDS No. 3[1] or HEC No 15[2], should be used to assure that the permissible limits will not be exceeded.

Flexible Measures

Flexible inlet stabilization measures shall extend at least one pipe diameter beyond the outside of the pipe. Flexible liners such as rock rip rap and gabions shall be underlain by a gravel filter or appropriate geotextile material to protect from piping of fines. Geotextile shall be installed according to manufacturer's recommendations.

Rip rap shall be installed according to **VTRANS STANDARD SPECIFICATION** Section 613 and be of a size to withstand the velocity of flow expected. See Standard Detail 600(22) for installation requirements.

Gabion mats shall be installed and constructed as specified by the design engineer and any VTRANS Standards

Structural/Rigid Materials

Rigid inlet retaining wall types shall be reinforced enough to be able to withstand the settling, frostheaving, and other associated loadings without cracking or otherwise failing.

Structural non-rigid retaining walls built of various kinds of block shall slope inward at least 1:1/2 and have protection from piping as per wall manufacturer's recommendation.

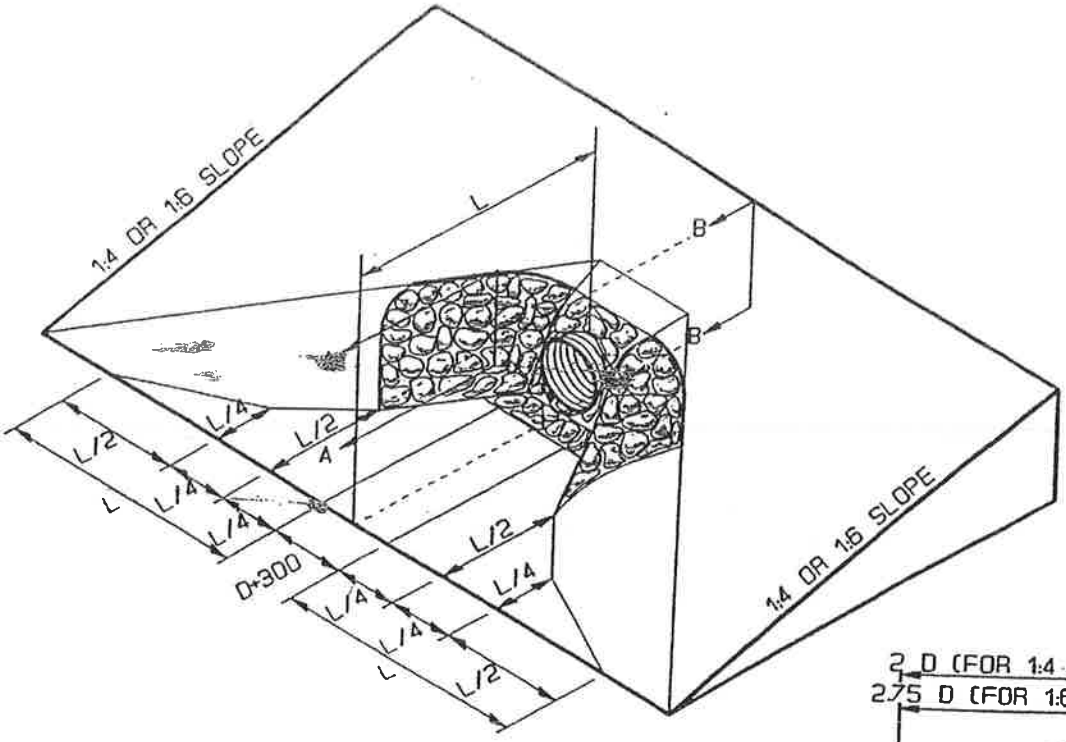
Maintenance/Performance of Culvert Inlet Protection:

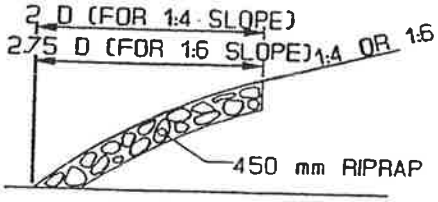
Culvert Inlet Protection must be inspected periodically, and repaired as necessary. See the BMP's for EROSION CONTROL BLANKETS, and SEEDING for maintenance information.

REFERENCES:

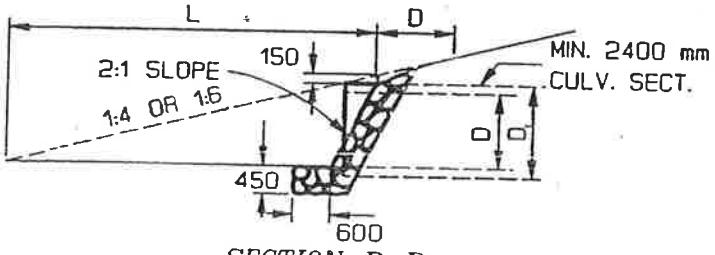
[1]Hydraulic Design Series No. 3, Federal Highway Administration, Reprinted 1979.

[2]Hydraulic Engineering Circular No. 15 (HEC #15), Publication No. FHWA-IP-87-7, April 1988.





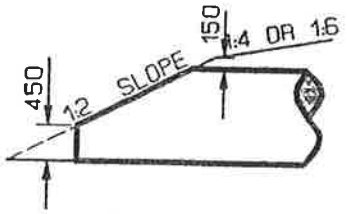
SECTION A–A
90° TO ROADWAY C.L.



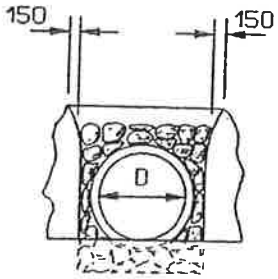
SECTION B–B

TABLE B

CULVERT DIAMETER	L 1:4 SLOPE	L 1:6 SLOPE
450	2.7 m	3.9 m
525	3.0 m	4.5 m
600	3.3 m	5.0 m
750	3.9 m	6.0 m
900	4.6 m	6.9 m
1050	5.2 m	7.8 m
1200	5.8 m	8.8 m
1350	6.7 m	9.8 m
1500	7.3 m	10.8 m
1650	7.9 m	11.8 m
1800	8.7 m	12.8 m
2100	9.9 m	14.7 m

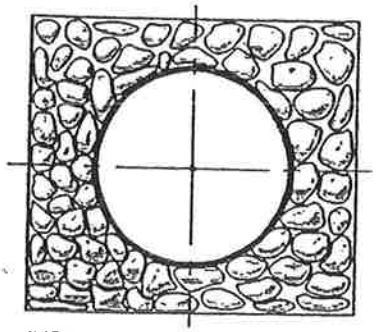


CULVERTS CUT ON 1:2 SLOPE



FRONT VIEW

1. THE DIMENSIONS SHOWN ARE APPROXIMATES AND MAY BE MODIFIED BY THE RESIDENT ENGINEER.
2. RIPRAP WILL BE REQUIRED ON PORTIONS OF THE CULVERT END TREATMENT 1:1 AND STEEPER. THE REMAINING PORTION SHALL OR LOAMED, SEEDED AND HAY MULCHED AS DIRECTED BY THE ENGINEER.
3. CULVERTS INSTALLED ON 1:2 SLOPES SHALL HAVE RIPRAP LAID ON 1:2 SLOPE AROUND THE INLET AND OUTLET.



INSTALL RIPRAP 600 mm AROUND DIAMETER OF PIPE ON 1:2 GUARD RAIL SLOPES.

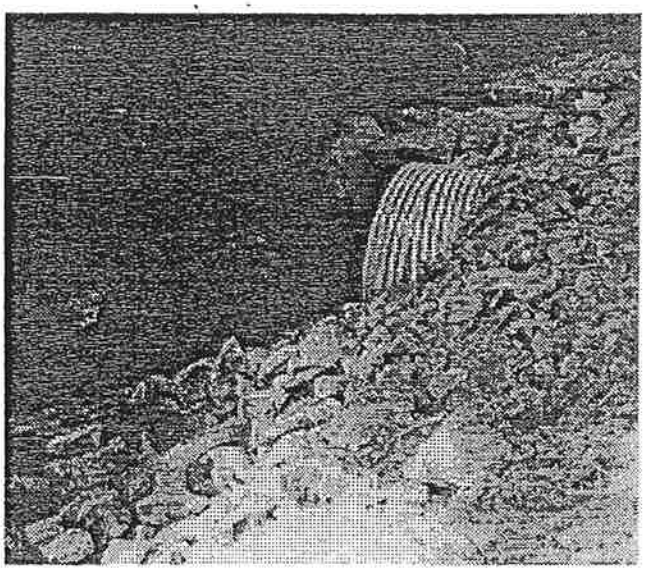
REF: Best Management Practice for Erosion and Sediment Control - Culvert Inlet Protection, Culvert Outlet Protection

Roadway Culvert End Slope Treatment

7. CULVERT OUTLET PROTECTION

What Is It?

Culvert Outlet Protection is a protective armor for the immediate area around the outlet of a pipe or culvert subject to erosion. It protects the outlet and receiving channel of culverts and pipes from scour and deterioration. This protective armor normally consists of an end slope treatment, apron and/or plunge pool for additional protection.



When And Where To Use It:

These practices apply to the outlets of all culverts designed to carry surface water, and to principal spillway pipes in sediment traps and basins.

What To Consider:

- See **STANDARD DETAIL** 600(22) on Roadway Culvert End Slope Treatment for more information.
- See **VTRANS STANDARD SPECIFICATION** Section 601 for construction requirements
- Pipes installed in or outletting to streams may require permits, Contact Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division
- When replacing a culvert that is hanging above a stream channel, contact the Vermont Department of Fish and Wildlife to see if fish passage or migration is an issue.
- The outlet pipes and structurally lined channels are points of critical erosion potential because the water is concentrated. To prevent scour at outlets, a flow transition structure

or energy dissipater (such as a rip rap apron or plunge pool) is needed to absorb the initial impact of the flow and reduce the velocity to a level which will not erode the receiving area or channel.

- Flexible outlet protection such as rip rap or gabion mats should be underlain by the appropriate geotextile material to prevent the piping of fines, which can cause turbidity in the water and undermine protection. For slopes steeper than 1:2 and large box culverts or plate arches, consult the Bridge Design Section for guidance.

- Structural or rigid outlet protection such as outlet headwalls may be used in conjunction with flexible outlet protection for larger riveted and structural plate pipes and arches.

- Paved channels and plunge pools are not encouraged in permanent streams, unless called for by Fish and Wildlife.

- Rip rap in a stream bottom causes thermal warming and should be minimized.

- Culverts greater than 900 mm should be designed under the supervision of a professional engineer. See Design Standards for more information.

Shade outlet with vegetation whenever possible when working in a stream with a cold water fishery.

Design Standards:

There are two areas to consider at all culvert outlets when designing protection against erosion.

The first area is the embankment on top and to the sides of the culvert, referred to as the "end slope". This area should be protected in the same manner as described in the CULVERT INLET PROTECTION BMP. A detailed description of the lengths , widths, and depths of rip rap required to protect the end slope, are provided in **STANDARD DETAIL** 600(22)

The second area is the outlet splash zone. This area requires a more detailed analysis as to the protection required. The two recommended methods of outlet protection are rip rap lined plunge pools and aprons. The decision of which method is to be used should be based on the drainage system that is being outlet and the receiving area of the outlet. In the case where fish passage must be maintained, plunge pools with hanging culverts are not to be used. Level aprons should be provided in this situation.

PROTECTION DESIGN: The ability to predict the magnitude and geometry of localized scour at culvert outlets is a useful evaluation tool in the control and management of erosion at the outlet. However, previously developed equations have been extremely conservative. Therefore, it is advantageous to investigate localized scour in non cohesive and cohesive materials at culvert outlets. Federal Highway Administrations Report No. FHWA/RD-82/011 Scour at Culvert

Outlets in Mixed Bed Materials[1], provides a thorough discussion of the theory and the design parameters used to provide protection.

There is also a computer program, developed by John J. Simon, P.E. of Balanced Engineering in Lewiston, Maine that can be used to design the protection required at the outlet. Simon's program will calculate the plunge pool or apron sizing, provided that the input parameters are carefully chosen. The users assume full responsibility for the use of the program and must check the results, as deemed necessary, by other methods to satisfy themselves of their correctness.

A quick reference guideline, for sizing plunge pools and aprons, is as follows:

Generally, the rip rap placed to line either the plunge pool or the apron shall be a minimum of 450 mm in depth and the stone size should meet the requirements of the materials Standard Specification 703.26 Plain Rip rap. The rip rap shall be separated from the bed material by underlying the stone with erosion control geotextile to prevent piping of fines.

PLUNGE POOLS: Protection at culverts up to and including 900 mm, can use the following equations based on the diameter of the outlet pipe (d). All pools designed for pipes greater than 900 mm, should be completed under the supervision of a professional engineer. The length (L), width (W) and depth (D) dimensions calculated relate to the level bottom dimensions of the pool. The side slopes of the pool are to be 1:2. Therefore, the total area required is based on the following:

$$L = 4 \times d \qquad W = 2 \times d \qquad D = 1 \times d$$

The outlet end of the pool should be a level lip to prevent reconcentrating the flow and furthering erosion.

APRONS: In general, the apron length should be at least as long as the diameter of the pipe. For example, a 300 mm pipe would require a minimum length apron of 300 mm. This method however, should be monitored to determine if further protection is required. For further detailed analysis, consult the FHWA document cited previously or John J. Simon's computer program.

Maintenance/Performance of Culvert Outlet Protection:

All aprons and plunge pools shall be inspected periodically for damage and repairs should be made as needed. If there is evidence of erosion or scouring, modify the apron or pool as needed to provide long-term protection while keeping fish passage requirements in mind. Sediment which has accumulated in the pool should be removed when the level of the sediment reaches ½ the depth of the basin.

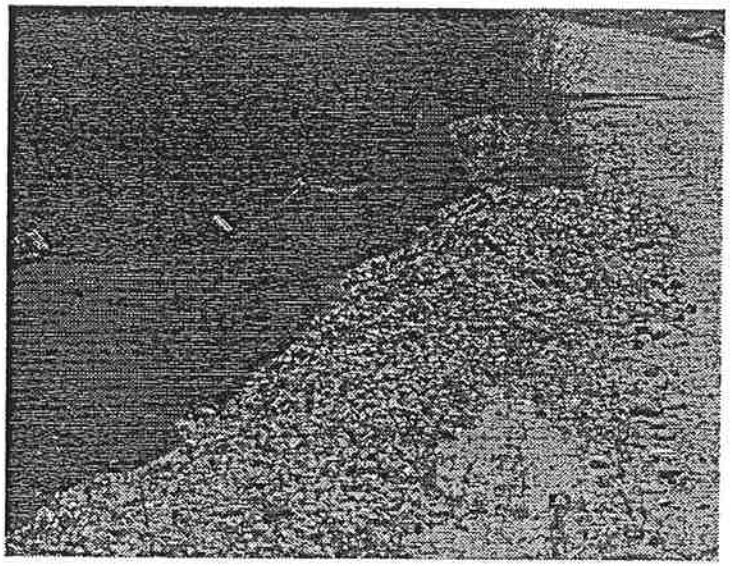
REFERENCES:

[1] Federal Highway Administration, Report No. FHWA/RD-82/011, Scour at culvert outlets in mixed bed materials, September 1982.

8. SEDIMENT BARRIERS

What Are They?

A Sediment Barrier is a temporary barrier installed parallel to the toe of a slope being disturbed. It can be constructed of silt fence, hay bales, or berms constructed of bark mulch, wood waste compost or any combination of these materials. Its primary purpose is to intercept and retain small amounts of sediment resulting from sheet or rill erosion of upslope disturbed areas.



When and Where to Use Them:

Sediment barriers are installed prior to any soil disturbance in the drainage area. They are installed in areas where sedimentation is likely to move outside normal construction limits, and can pollute or degrade adjacent wetlands and/or watercourses, as well as in areas where sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.

What to Consider:

- See **SILT FENCE SEDIMENT BARRIER, HAY BALE SEDIMENT BARRIER** and **BARK FILTER BERM STANDARD DETAILS 600(41), 600(42)** and **600(43)**

- Sediment barriers are not to be installed in streams, waterways or areas of channelized flow.
- These barriers are effective only if installed correctly and maintained properly.
- Sediment barriers become clogged with sediment very quickly and should be inspected and replaced often.

- Hay bales are only used as barriers for periods of less than 60 days, and are not to be left in place over the winter season.

- Silt fence may be used for periods of 60 days or longer depending on ultraviolet stability and manufacturer's recommendation.

- Silt fence and hay bale sediment barriers must be entrenched to be effective, which causes soil disturbance during installation. Additional disturbance occurs when removing these barriers requiring additional stabilization measures such as mulch and seed.

- To minimize soil disturbance, silt fence may be cut off at ground level when leaving the site instead of pulling it out of the ground.

- Sediment barriers should be placed on a contour to prevent flow along the berm.

- Filter berms constructed of wood waste compost/bark mulch are an alternative that don't require soil disturbance to install, and unlike silt fence and hay bales, they do not require removal when no longer required. The material can simply be left in place and it will decompose and naturally become vegetated.

- Filter berms should have a relatively level area immediately uphill to accommodate ponding and promote stability.

- In high sheet flow areas and highly sensitive resource areas, silt fence may be used in conjunction with filter berms. The berm should be placed in back and downhill of the fence. The anchor flap of the silt fence may be held down with the compost berm so the ground is not disturbed during removal of the fence.

- Rock filter berms can be used as an energy dissipation device or as a measure to filter stormwater. When used as a filter device the filter berm should not be placed in channelized flow. Rock filter berms can be used in multiple rows to better facilitate filtering of stormwater.

- Rock filter berms can be difficult to remove, but may be scattered rather than removed in areas that do not require mowing.

Design Standards

Silt Fence and Hay Bale

Silt fence and hay bale barriers, refer to **STANDARD DETAILS 600(41)** and **600(42)**

Bark Filter Berms

The filter berm shall consist of bark mulch mix and fragmented wood generated from water-flume handling systems.

The mix shall conform to the following standards:

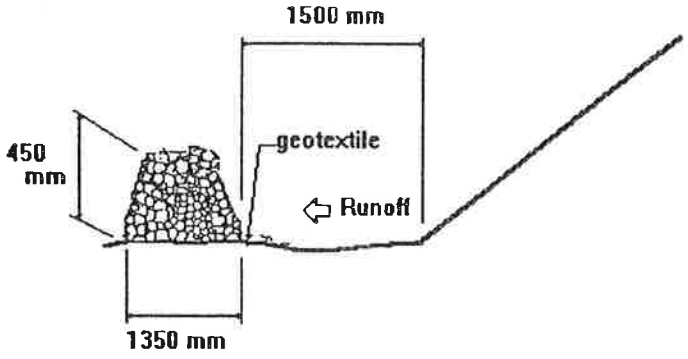
(a.) Moisture content - 30-60%.
(b.) pH - 5.0 - 8.0.
(c.) Screen size - 100% less than 75 mm, maximum 70% less than 25 mm.
(d.) No less than 40% organic material (dry weight) by loss of ignition.
(e.) No stones larger than 50 mm in diameter.
(f.) See BARK FILTER BERM STANDARD DETAIL (600)43 for width and height specifications.

The composted berm shall be placed, uncompacted, along a relatively level contour.

Rock Filter Berms

Filter berms shall be laid on geotextile to facilitate removal. Rock filter berms should be a minimum of 450 mm high by 1350 mm wide.

When filtering of stormwater is a desired result, the geotextile shall be wrapped over a bottom layer of stone and then covered with another layer of stone. The bottom layer of stone shall be approximately 300 mm high or two-thirds the height of the filter berm. The figure below illustrates these specifications.

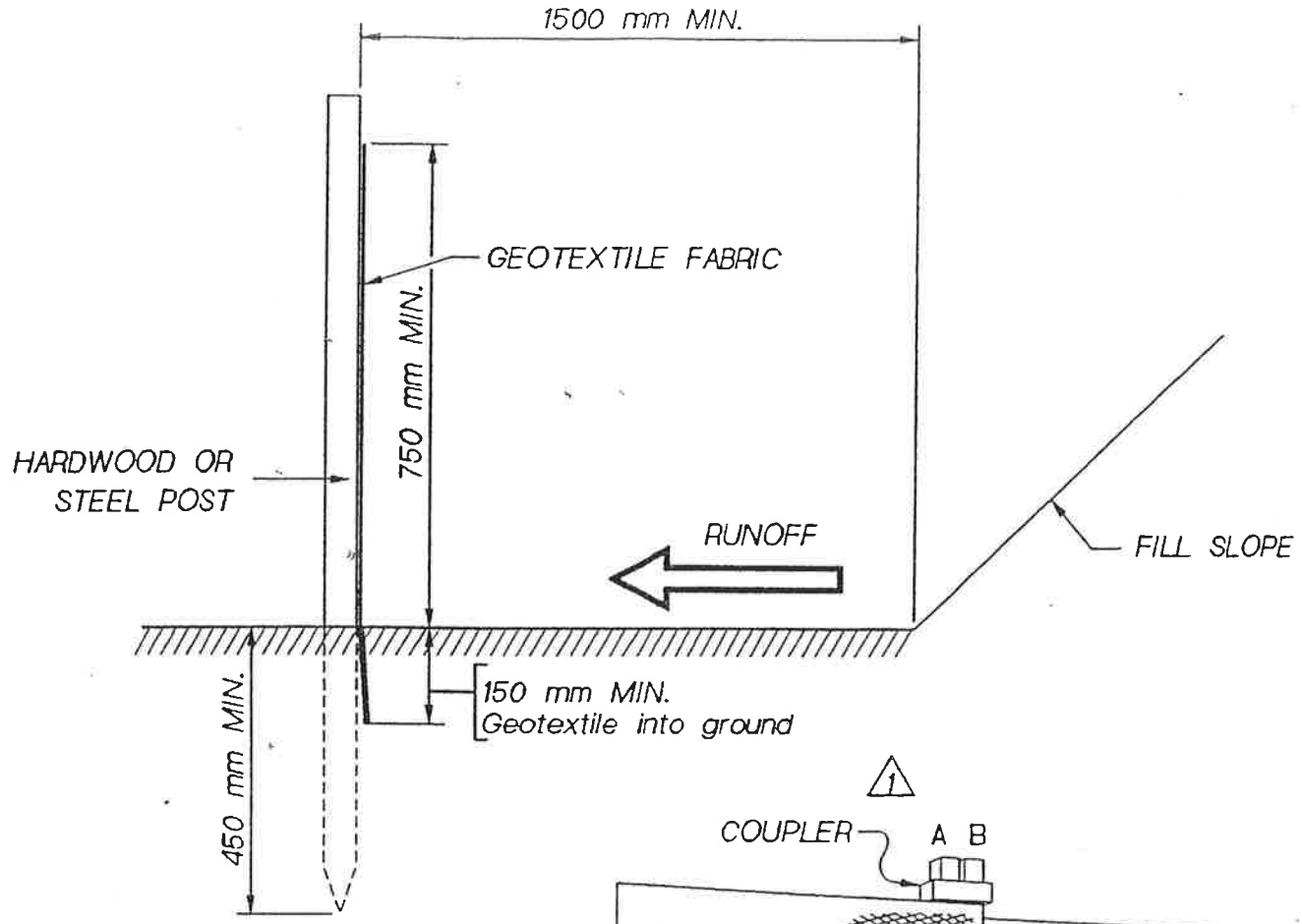


ROCK FILTER BERM

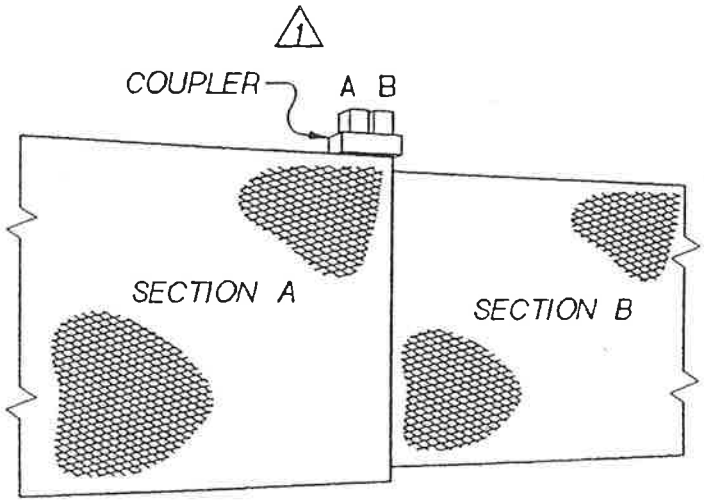
Stone size: When filtration is the desired effect, the stone will be wrapped with geotextile. Stone within the berm, both under and over the geotextile can range in size from French Drain Stone to Riprap. When constructing a filter berm as a velocity check only, the berm can be constructed without the geotextile. In this case, the stone shall be Crushed Stone for sheet flow or Stone Ditch Protection for concentrated flow applications.

Maintenance/Performance of Sediment Barriers

All Sediment Barriers require frequent inspection and maintenance to be effective. They must be inspected before, during and after each rainfall, and at least daily during extended periods of rain. Should the barrier become ineffective as evidenced by decomposition of the filter fabric on silt fence, breakage of the bales or bindings on hay bales, or observance of flow escaping underneath any type of barrier, immediate repairs must be made. Reshape berms as needed. Sediment must be removed when deposits reach 1/2 the height of the barrier. Sediments removed must be placed in an approved site and stabilized.



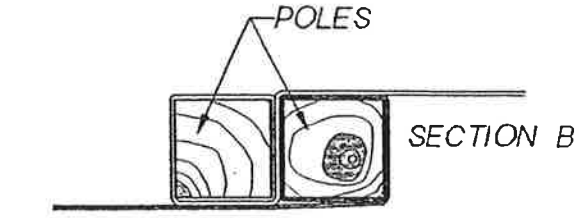
SIDE VIEW



JOINING SECTIONS

1 POSTS MAY BE WIRED TOGETHER WHEN JOINING SECTIONS

THE COUPLER CAN BE ANY ACCEPTABLE DEVICE USED TO TIE THE POLES TOGETHER.

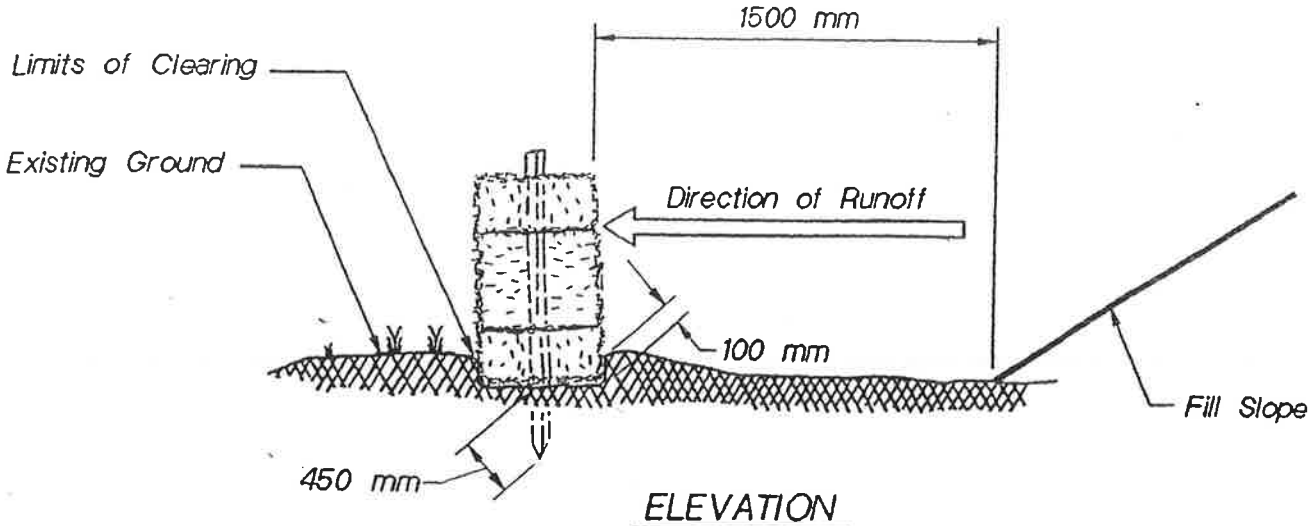


TOP VIEW

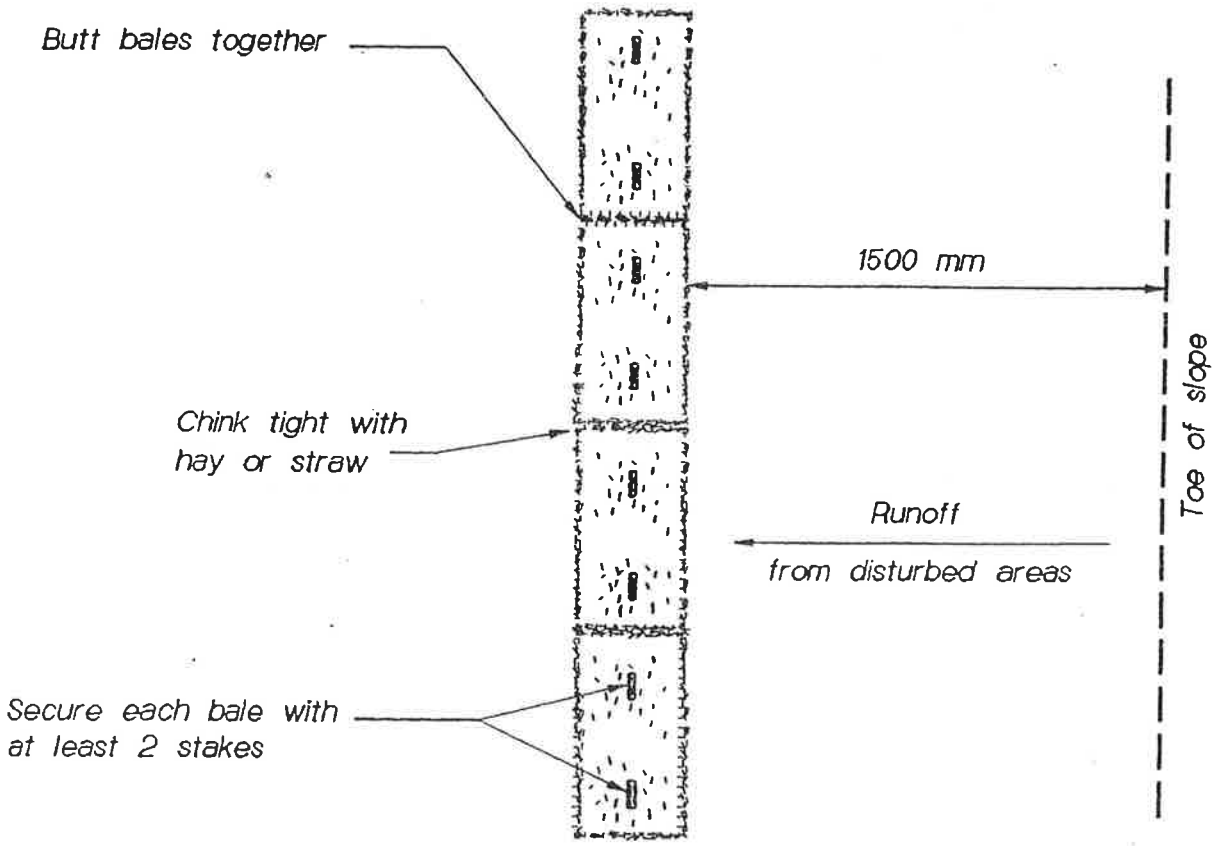
REF: Best Management Practice for Erosion and Sediment Control - Sediment Barriers

Silt Fence Sediment Barrier

600(41)



ELEVATION



PLAN

Note:

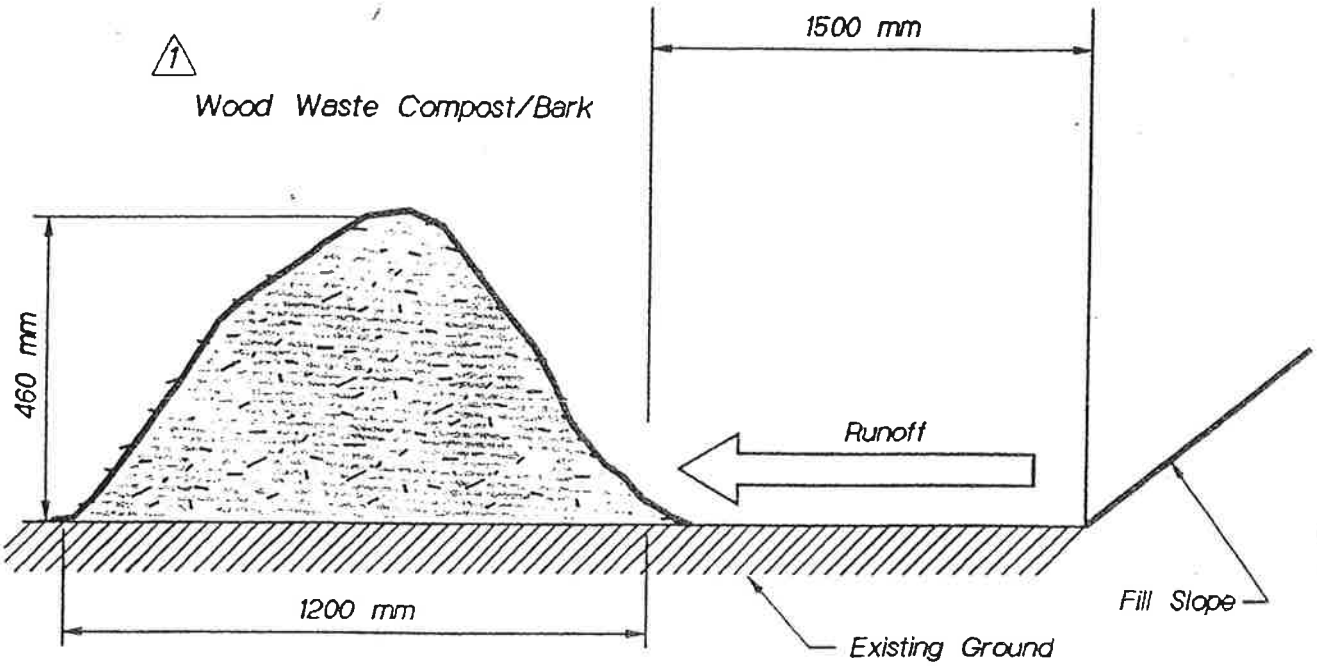
(2) Use hay bales in drainage ditches only for low flow conditions and when specified on the Erosion Control Plans. Do not leave in ditches during winter months.

(1)

REF: Best Management Practice for Erosion and Sediment Control - Sediment Barriers

Haybale Sediment Barrier

600(42)



NOTE:

Wood Waste Compost/Bark Filter Berms may be used in combination with Silt Fence to improve sediment removal and prevent clogging of the Wood Waste Compost/Bark Berm by larger sediment particles. (Silt fence placed to filter runnoff before Wood Waste Compost/Bark)

REF: Best Management Practice for Erosion and Sediment Control - Sediment Barriers

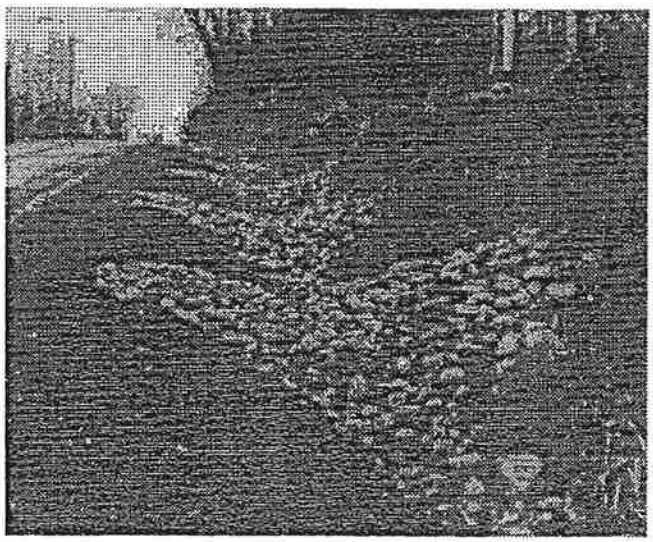
Wood Waste Compost/Bark Filter Berm

600(43)

9. CHECK DAMS

What Are They?

Check dams are small dams usually constructed of dumped stone. In some cases for temporary use, they may be constructed with hay bales. They are constructed across a swale or drainage ditch to reduce flow velocity of concentrated stormwater runoff, thereby reducing the rate of erosion of the ditch before the permanent protection is established. Check dams may be designed for permanent use for special purposes. This includes reducing the direct discharge of winter sand deposits into streams and wetlands.



When and Where To Use Them:

Check dams are used in small open channels which are under construction, or are downstream from a disturbed area, until permanent ditch/swale protection has been sufficiently established. They are used in open channels which receive runoff from watersheds that are 4 hectares or less. These structures are not to be installed in streams.

What To Consider:

- See **STANDARD DETAILS 600(23), 600(24),** and **600(25)** for information on installation of check dams.

- Hay bales are unsuitable in high flow areas regardless of the drainage area size.
- Check dams lose efficiency of sediment control on slopes greater than 15%, however they are often needed in this situation to reduce flow velocities.
- Only stone check dams may be left over winter, provided they have sufficient weir sag in their centers.

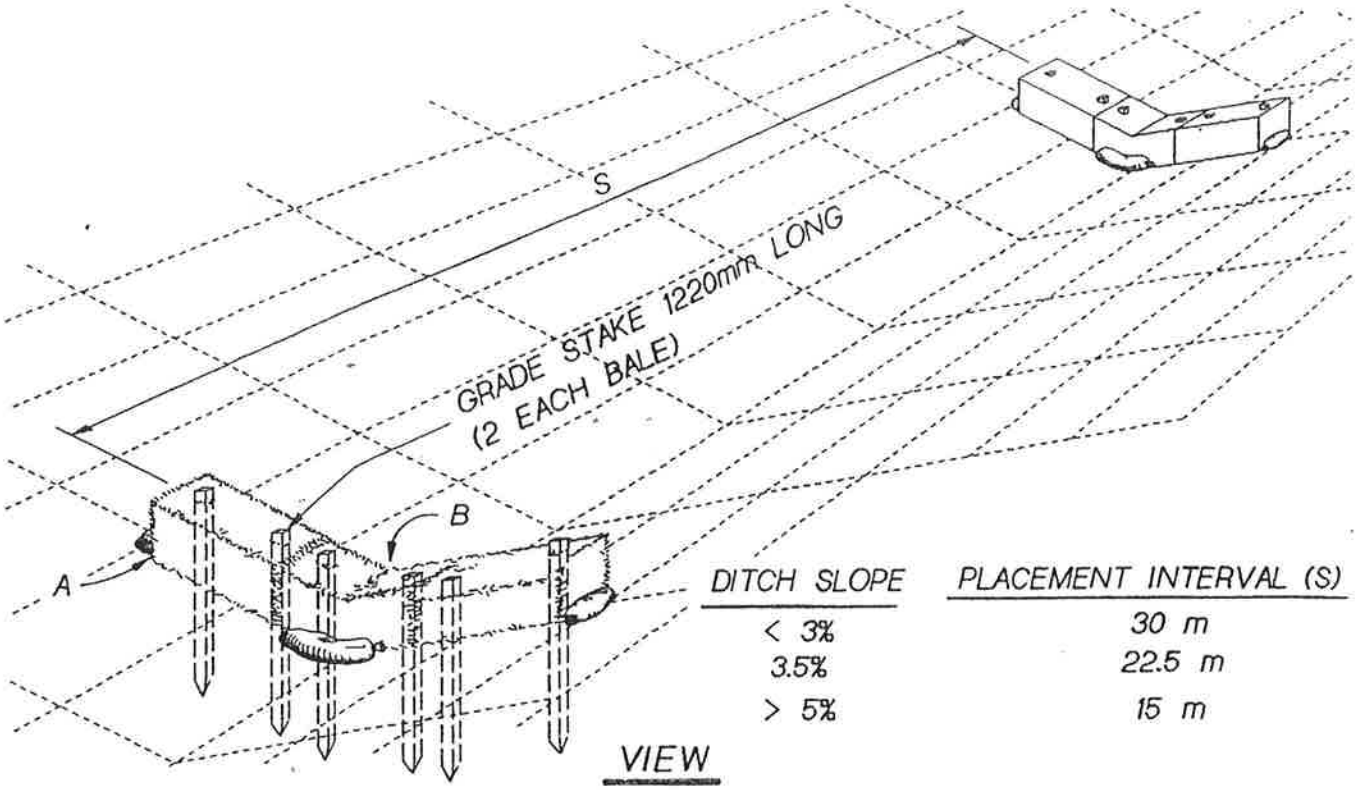
- Whenever possible use stone instead of hay bales. It is more efficient, durable, easier to construct, and there is little soil disturbance during removal (it can be spread and pressed into the ditch soil).

Design Standards:

- Dam spacing shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- The contributing drainage areas must be 4 hectares or less.
- Dumped stone check dams are composed of hard, durable rock that conforms to stone ditch protection (see **VTrans STANDARD SPECIFICATION** Section 706.04; **NOTE**: the stone should be well graded and on the smaller side of the gradation limits).

Maintenance/Performance of Temporary Check Dams:

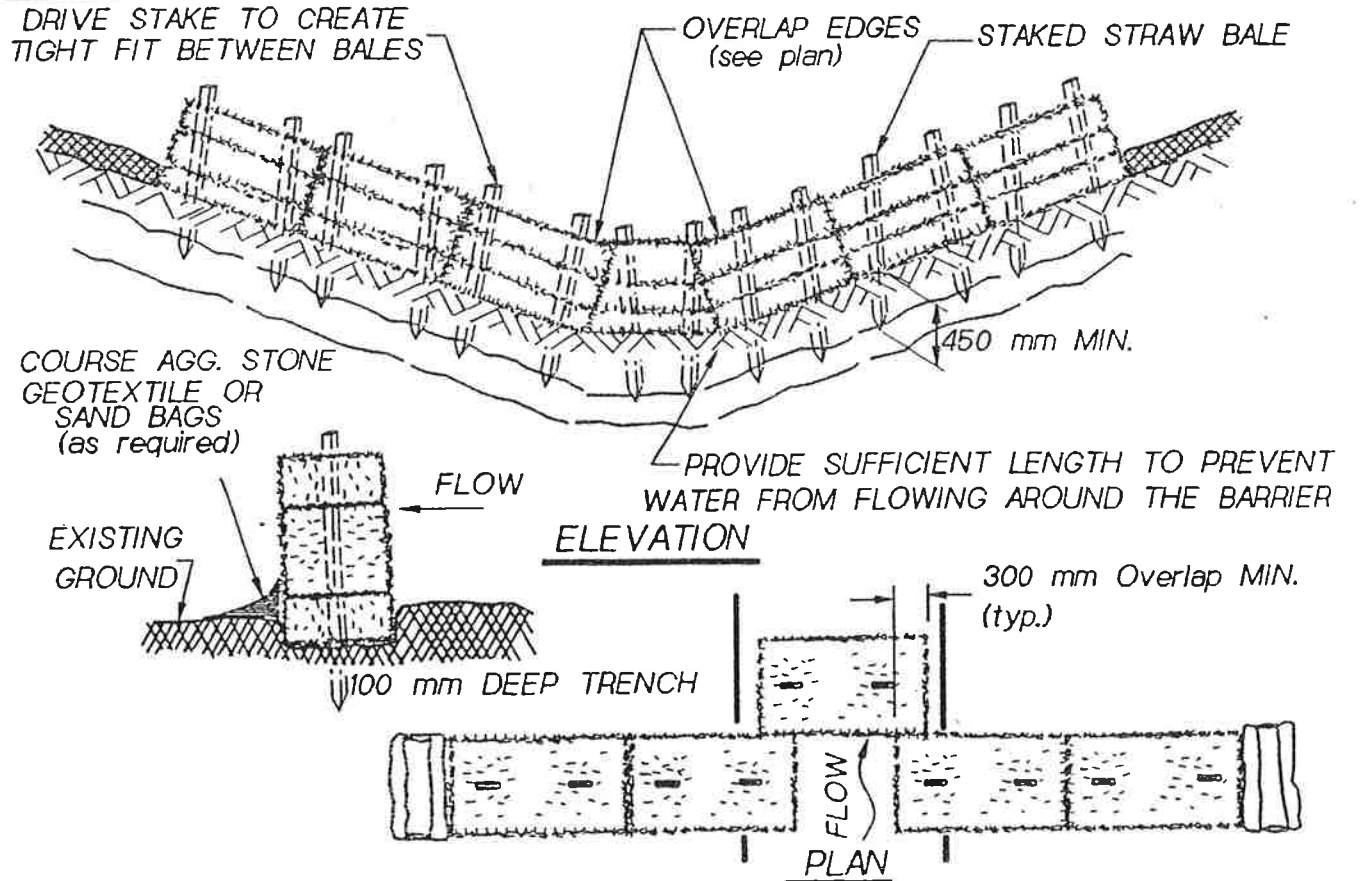
- Check dams should be checked for sediment accumulation and for erosion caused by high flows around the edges of the dam before, during and after each storm event. They should be checked frequently during winter and early spring months even if the project is inactive.
- Sediment should be removed from behind the check dam when it has accumulated to 1/2 the original height of the dam. Any erosion present should be repaired and the check dam should be adjusted to prevent further erosion.
- In ditches or swales, check dams are removed only when vegetation has been established sufficiently or permanent linings have been installed to protect the swale or ditch.
- Areas disturbed during check dam removal should be mulched and seeded immediately.



DITCH SLOPE	PLACEMENT INTERVAL (S)
< 3%	30 m
3.5%	22.5 m
> 5%	15 m

VIEW

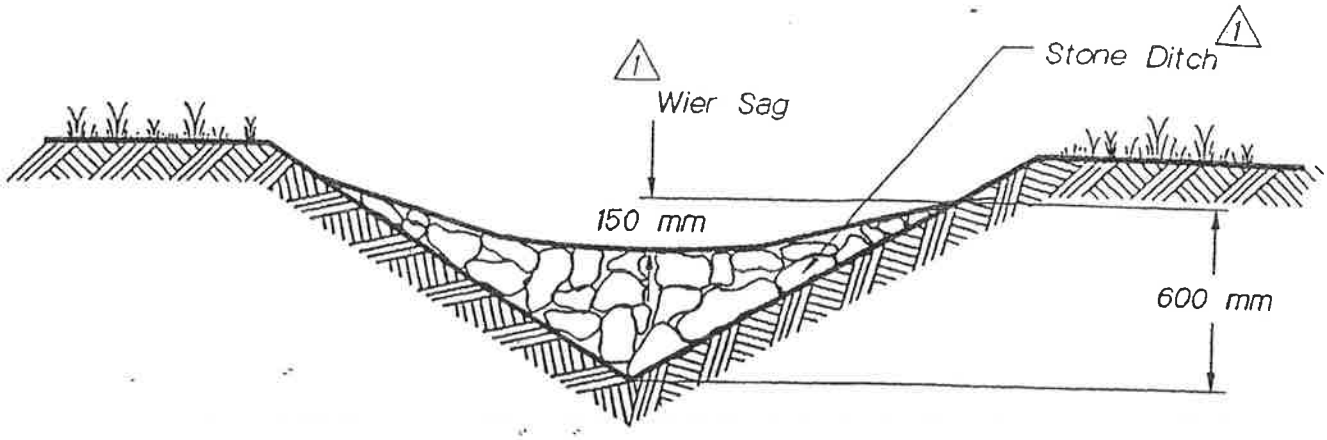
NOTE: PLACE SUFFICIENT BALES TO ESTABLISH ELEVATIONS AT "A" AT LEAST 150 mm ABOVE OVERFLOW AT "B".



REF: Best Management Practice for Erosion and Sediment Control - Check Dams

Hay Bale Temporary Check Dam

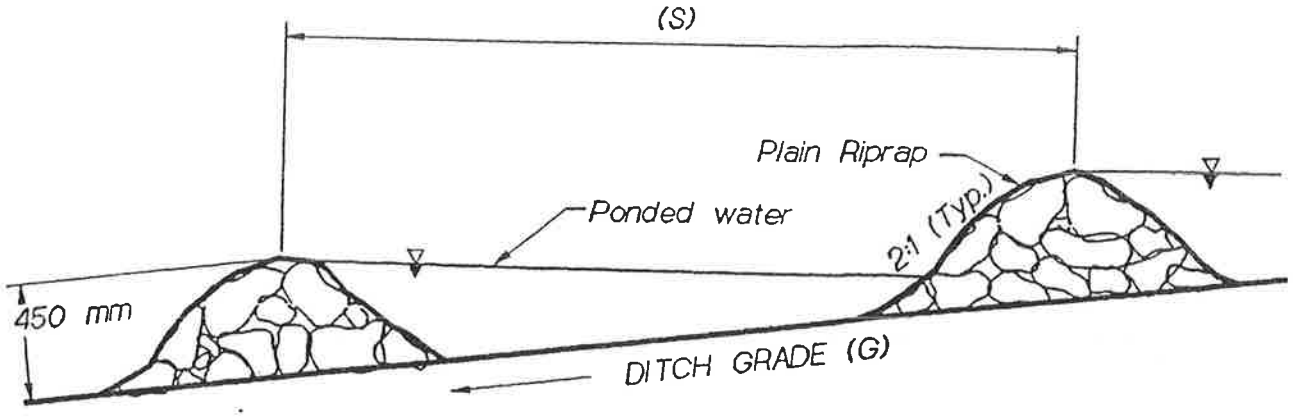
600(24)



CROSS SECTION

V DITCH

DITCH SLOPE	PLACEMENT INTERVAL (S)
< 3%	30 m
3.5 %	22.5 m
> 5%	15 m



PROFILE @ ℄ DITCH

REF: Best Management Practice for Erosion and Sediment Control - Check Dams

Dumped Stone Check Dam

600(25)

10. STABILIZED CONSTRUCTION ENTRANCES

What Are They?

A Stabilized Construction Entrance helps to reduce the amount of soil tracked off the construction site and onto existing paved roads. The driveway entrance is overlain with geotextile and large stone. This reduces the amount of sediment which may deposit in existing drainage structures and reduces dust which is a nuisance to the traveling public, a safety and health hazard and a regulated pollutant.

When And Where To Use Them:

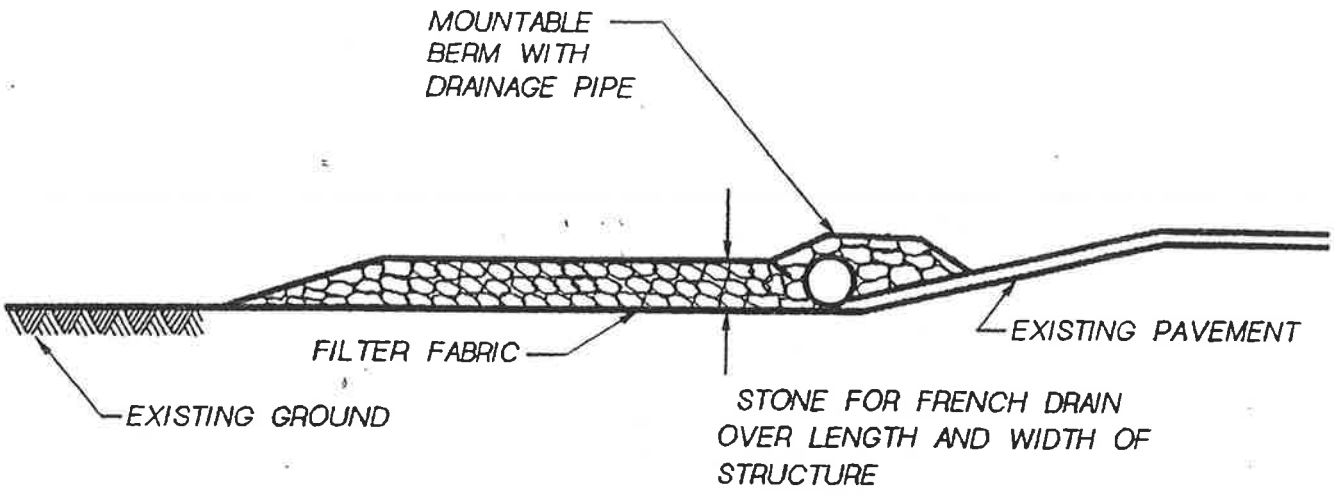
Stabilized construction entrances shall be installed at every point where construction vehicles leave or enter a paved road from a nonpaved construction site. They are used in areas near sensitive waterbodies.

What to Consider:

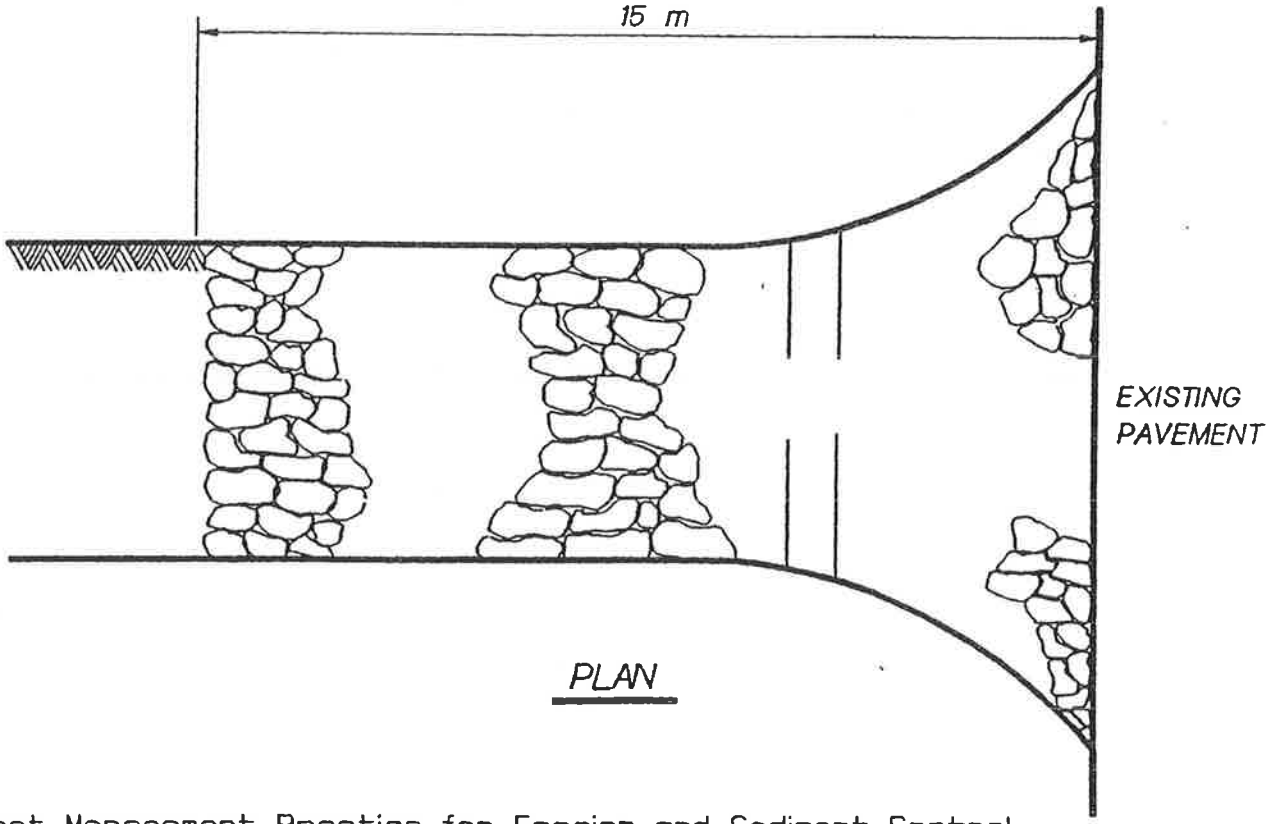
- See STANDARD DETAIL 600(44) for Stabilized Construction Entrance.
- Stone ditch protection may be used in lieu of stone for french drain (see **VTrans STANDARD SPECIFICATION** Section 706.04)
- Stabilized Construction Entrances should be wide enough so that the largest construction vehicle will fit in the entrance with at least one meter on each side to spare. If two-way traffic is likely, the entrance should be wide enough to allow 2 vehicles to pass.
- If the entrance is constructed across a swale or stream, a stream crossing is provided.
- Stone used for entrances is large enough so that it will not be picked up and tracked off site.
- Stone is rounded or subangular in shape to prevent puncturing tires.

Maintenance/Performance of Stabilized Construction Entrances:

Entrances are inspected to insure that they are operating effectively. Additional stone may need to be added periodically to maintain the line and grade, and soil that is tracked onto the adjoining paved roadway should be swept off for safety purposes.



PROFILE



PLAN

REF: Best Management Practice for Erosion and Sediment Control - Stabilized Construction Entrance

Stabilized Construction Entrance

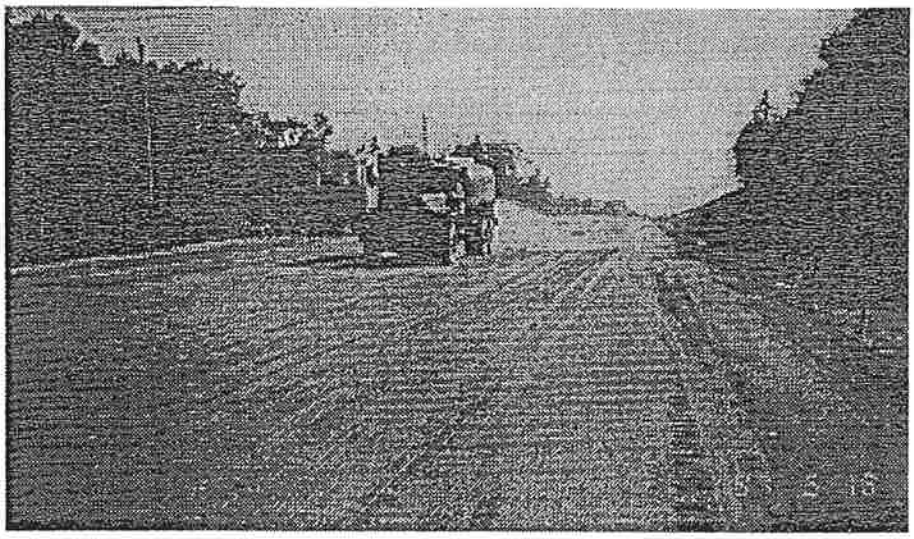
600(44)

11. DUST CONTROL

What Is It?

Dust Control is the use of various methods to prevent the blowing or movement of dust or silt on and off site. Dust is a particulate material and a regulated pollutant, as well as a nuisance and potential safety hazard to the traveling public. Various dust control methods include:

- Vegetative Cover: See SEEDING BMP.
- Mulching: See MULCHING BMP.
- Calcium Chloride: Calcium Chloride may be applied by a mechanical spreader as loose, dry granules or flakes at a rate which keeps the soil surface moist, but not so much as to cause water pollution or plant damage.
- Water: Sprinkling water on dry, exposed soil prevents dust particles from becoming airborne, and is normally performed using a water distributor truck.
- Stone: Covering the surface with crushed stone. See MULCHING BMP for more information.



When And Where To Use It:

The above mentioned methods of dust control are used when open, dry areas of soil are disturbed on the site. Highway reconstruction activities and extensive grading and grubbing operations during dry weather increase the likelihood that dust control measures may be necessary. Dry areas subject to traffic in construction areas should be constantly evaluated for dust production, and these methods applied as necessary.

What to Consider:

- Stabilized construction entrances should be used to reduce tracking mud onto roadways which, when dry, can become airborne. See **STABILIZED CONSTRUCTION ENTRANCE BMP. STANDARD DETAIL 600(44)** provides information for controlling dust near construction site entrances.

- Minimize the area of disturbed soil at any one time subject to wind erosion.

- Conserve existing vegetation as much and as long as possible. Long open corridors where wind can travel a great distance and gain velocity are more susceptible to wind erosion. Leave existing vegetation in place and consider staged construction to reduce these long open areas.

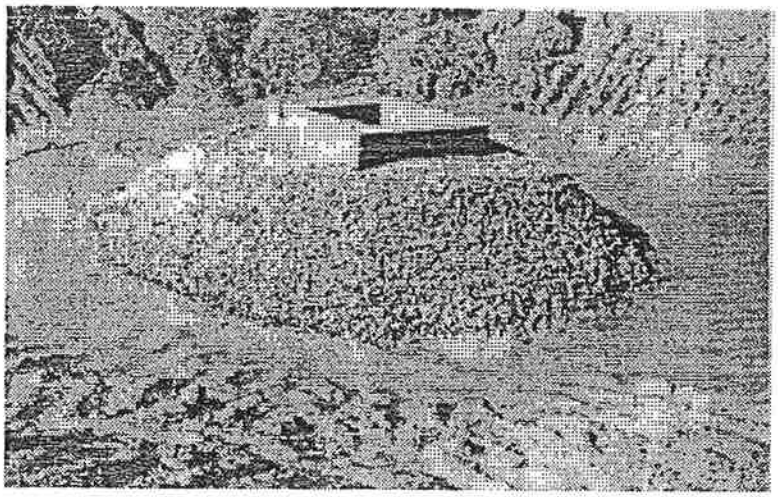
- Excessive sprinkling to the point of runoff on a construction site can mobilize soil particles from the site, shortening the life of erosion control measures down slope.

Maintenance/Performance of Dust Control Measures:

When Temporary dust control measures are used, repetitive treatments should be applied as needed to accomplish control.

12. STORM DRAIN INLET PROTECTION

What Is It? Temporary Storm Inlet Protection is a sediment filter system installed around a storm drain inlet to filter out sediment. These mechanisms prevent an influx of sediment from entering the inlet structures during construction and prevent deposition of sediment in the drainage system or receiving channels. Inlet protection may be composed of gravel and stone with a geotextile filter, block and gravel, sandbags, or silt fence.



Source: North Carolina Erosion Control Manual

When And Where To Use It:

These temporary protections are installed where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. These measures are intended for drainage areas of 0.4 hectares or less. Runoff from larger drainage areas should be routed through a Sediment Trap or Sediment Basin (see SEDIMENT TRAP and SEDIMENT BASIN BMPs). This BMP should be used in conjunction with other BMPs. Four types of Storm Inlet filters include:

- Silt Fence Inlet Protection (See Standard Detail 600(32)): These can be installed to protect inlet structures located in sumps or other unpaved areas that will only receive low quantity and low velocity runoff as sheet flow.
- Block and Stone Filters (see Standard Detail 600(33)): These structures can be installed in areas that will receive higher quantities and velocities of storm water runoff, but ponding is not desirable. Runoff may overflow these structures during particularly heavy runoff events.
- Gravel and Geotextile Filters (see Standard Detail 600(34)): These structures can be installed in areas that will receive higher quantities and velocities of storm water runoff, when ponding is not a major concern. All runoff is forced to pass through the filter gravel in these structures. Geotextile may be used in lieu of wire mesh.
- Sand Bag Inlet Protection (see Standard Detail 600(35)): These are used in urban or developed areas where curbing near stormdrains is not disturbed by construction.

What To Consider:

- The best way to keep sediment from entering the storm water drainage system is to stabilize disturbed areas as quickly as possible to prevent erosion/sedimentation.
- Storm Drain Inlet Protection structures shall be installed prior to disturbing the contributing drainage areas.
- The design should allow for easy access and cleanup.

Design Standards:

Stone for ditch protection shall be used all of the inlets (see VTrans STANDARD SPECIFICATION Section 706).

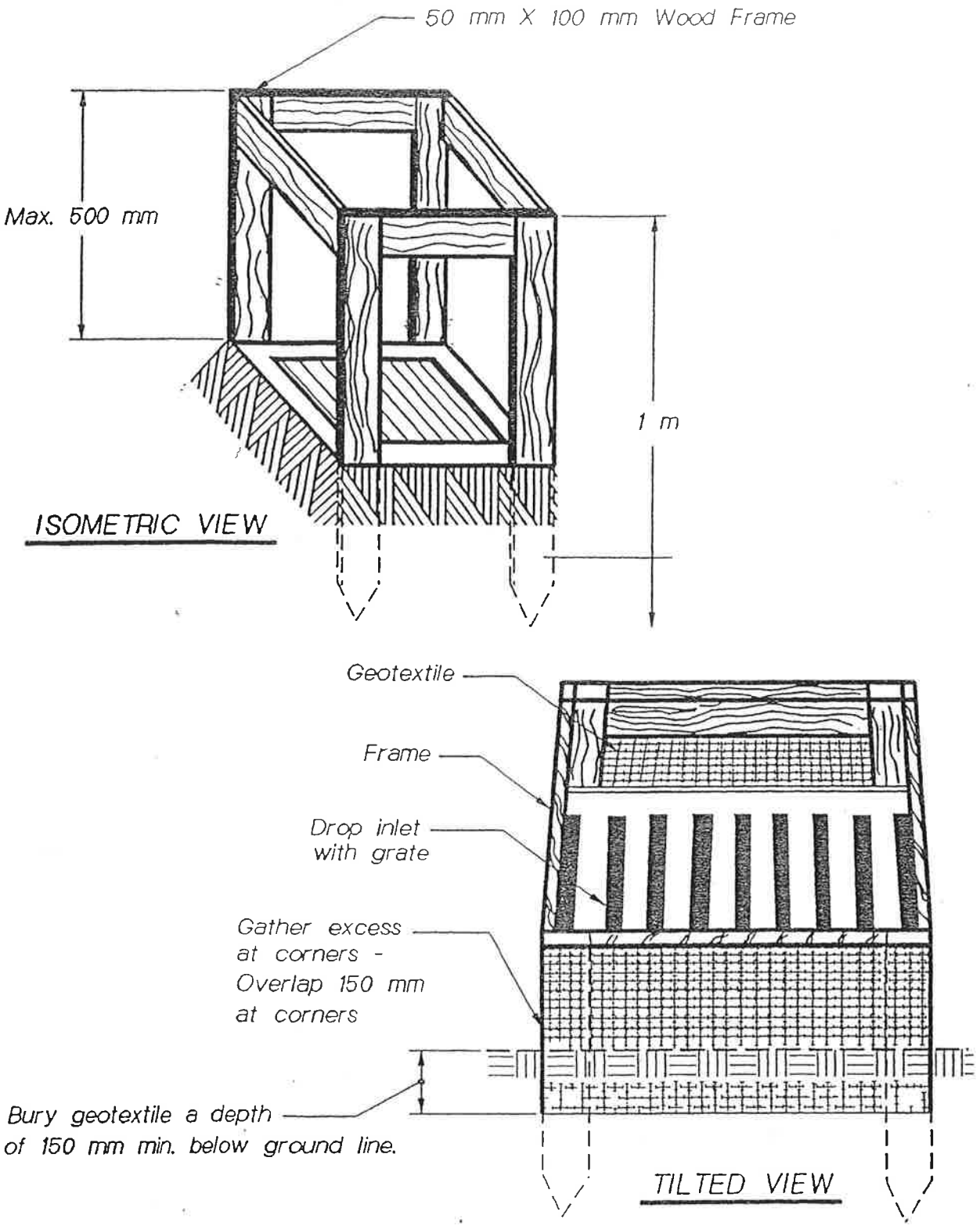
Geotextile shall have a minimum permeability of 0.01 mm/sec. (see VTrans STANDARD SPECIFICATION Section 649)

Silt Fence Inlet Protection: Do not place filter fabric underneath the inlet grate since the collected sediment may fall into the drain inlet when the fabric is removed or replaced.

Sand Bag Barrier: Flow from a storm should not over top the curb. In areas of high clay and silts, use filter fabric and gravel as additional filter barrier. Construct sandbags in accordance with SANDBAG COFFERDAM BMP.

Maintenance / Performance of Storm Drain Inlet Protection:

Temporary Storm Drain Inlet Protection shall be inspected regularly, especially before and after storm events. Repairs to the structures, and removal of sediment shall be accomplished as often as necessary. Remove these devices only after the disturbed drainage areas are permanently stabilized.

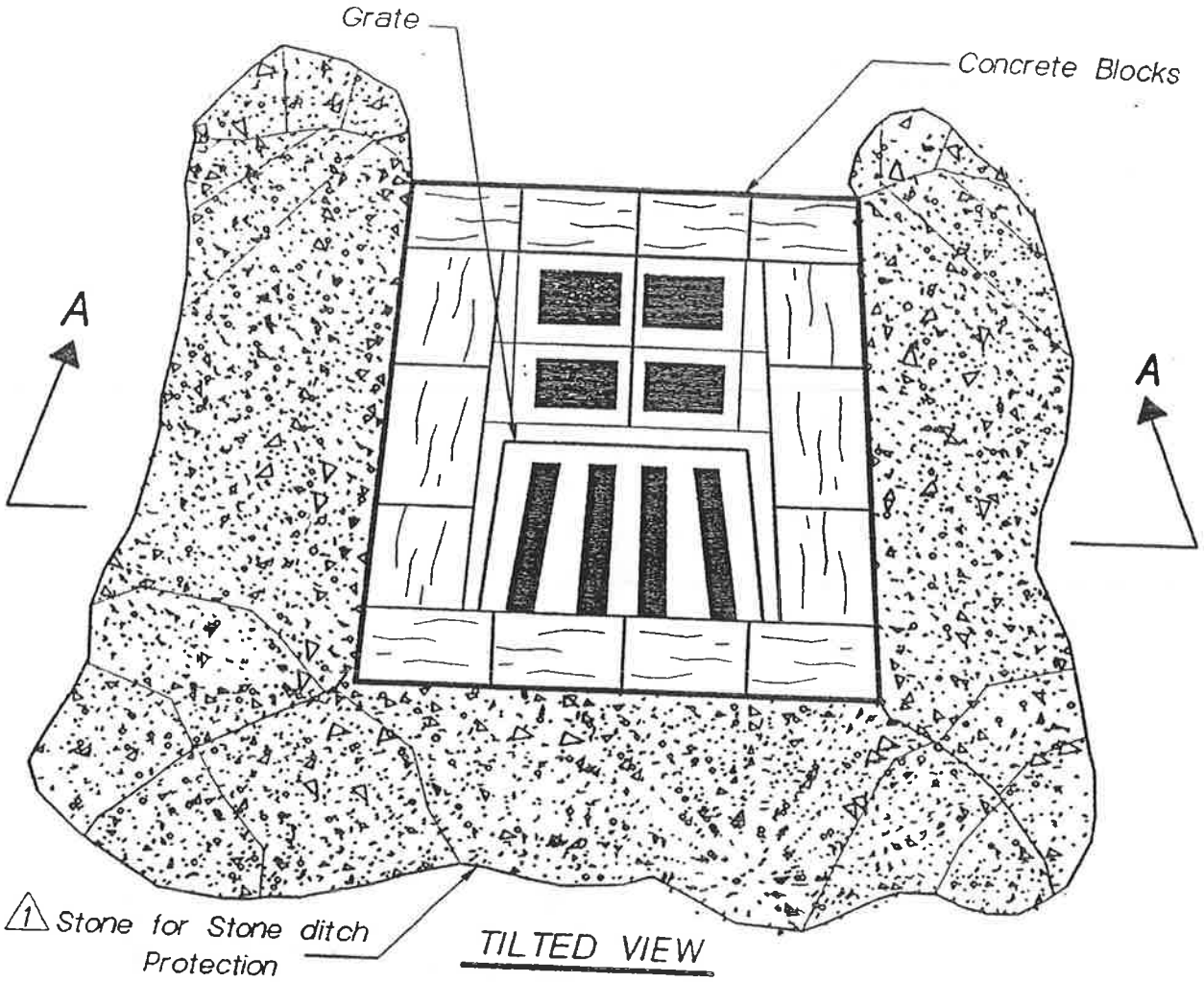


Note: Use Silt Fence inlet protection in sump locations only.
Sheet flow less than 0.4 Ha Drainage Area
Not in paved areas or with Concentrated flows

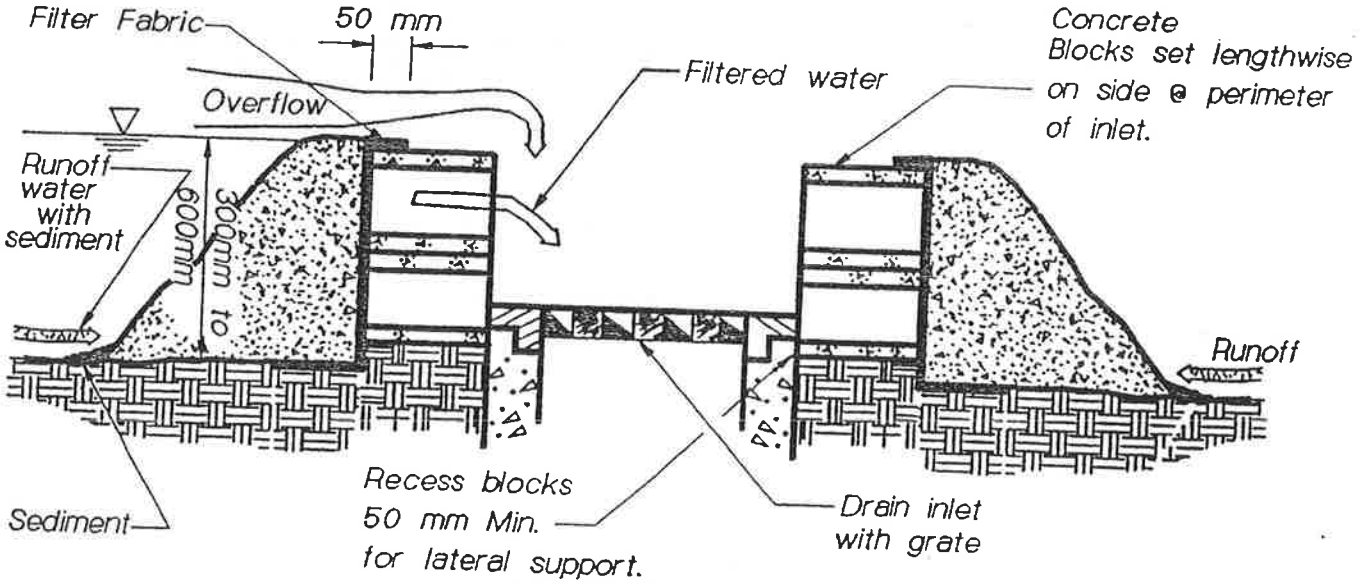
REF: Best Management Practice for Erosion and Sediment Control - Storm Drain Inlet Protection

Silt Fence CB/Inlet Grate Unit Protection

600(32)



TILTED VIEW

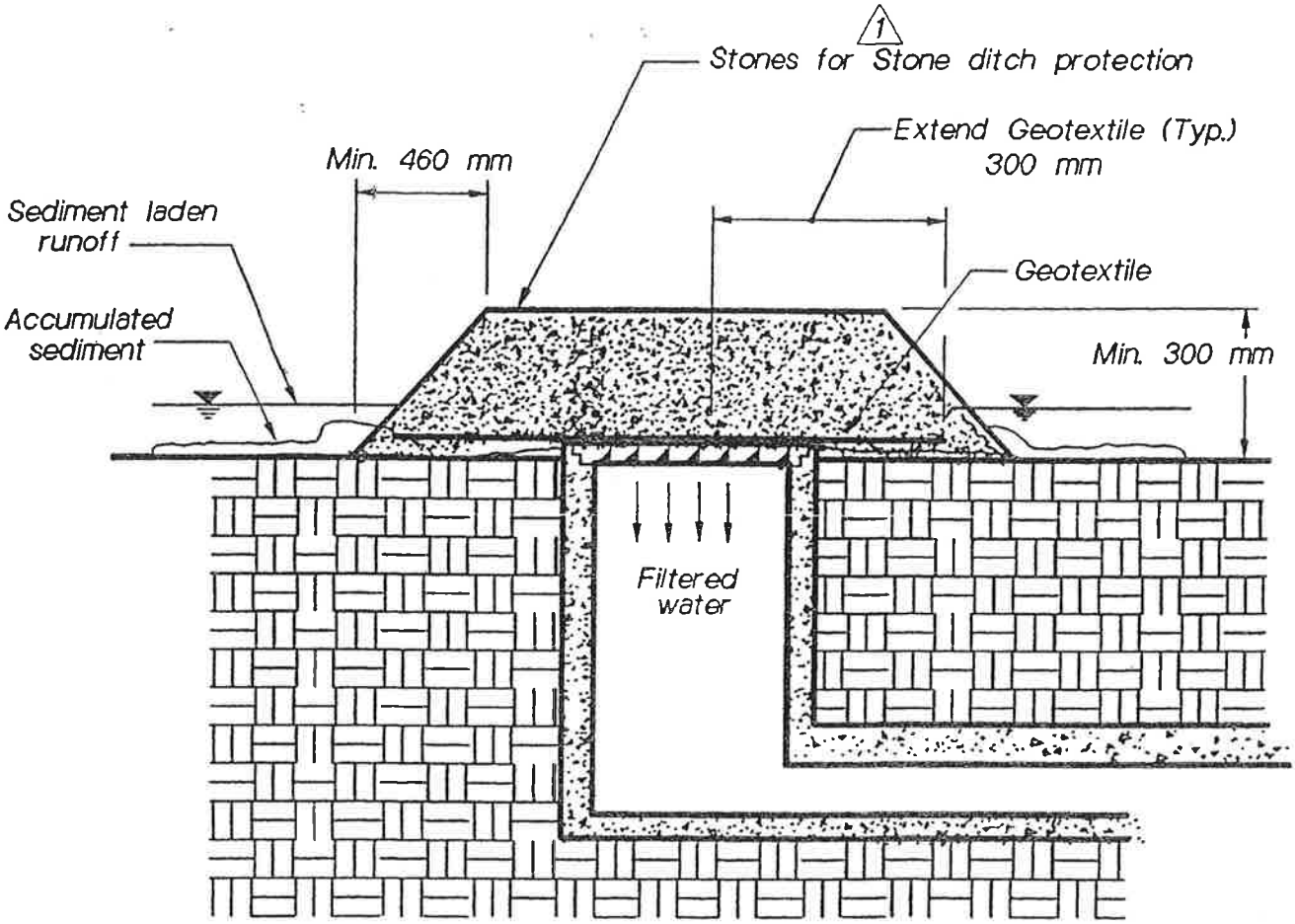


SECTION A-A

REF: Best Management Practice for Erosion and Sediment Control - Storm Drain Inlet Protection

1 Block and Stone CB/Inlet Grate Protection

600(33)



SECTION

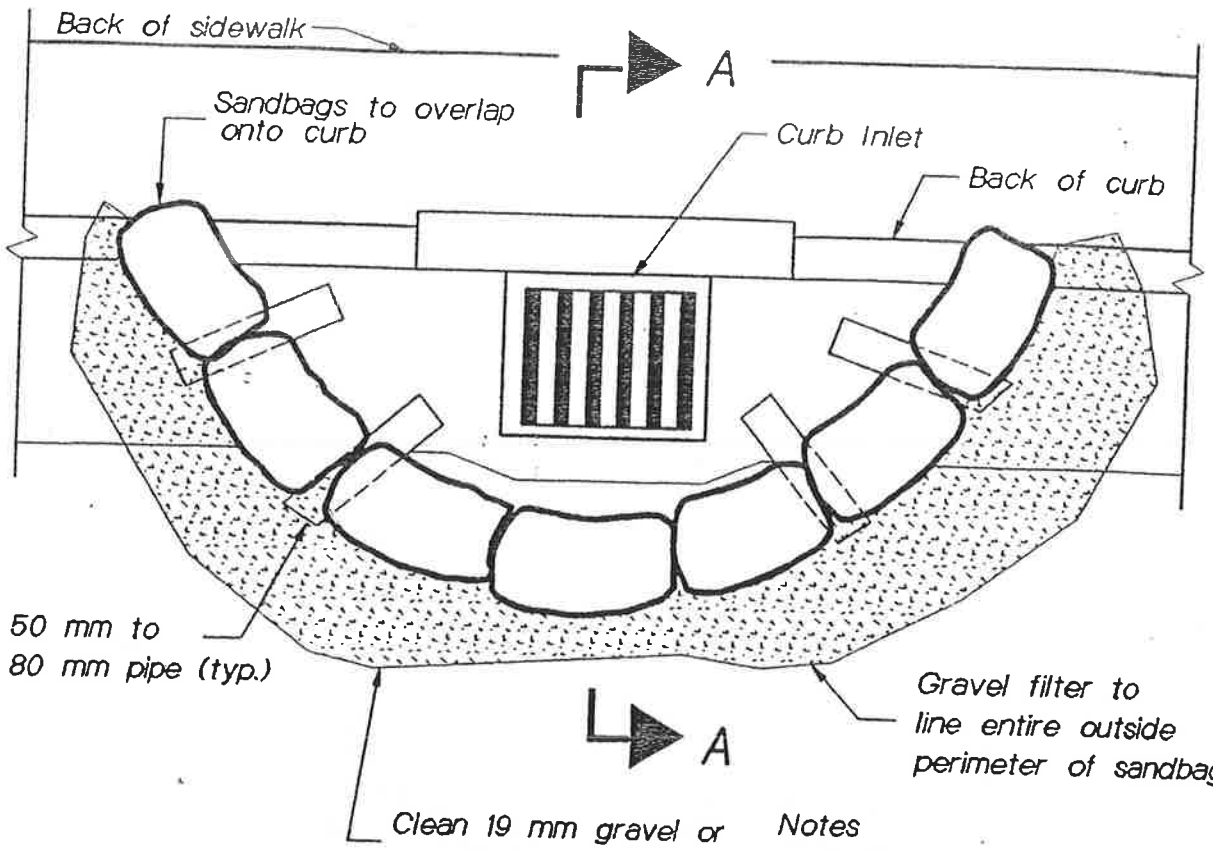
1

Note: Use gravel and geotextile inlet protection only in sump locations where heavy concentrated flows are expected. Do not use where ponding around the structure might cause inconvenience or damage.

REF: Best Management Practice for Erosion and Sediment Control - Storm Drain Inlet Protection

Gravel & Geotextile CB/ Inlet Grate Unit Protection

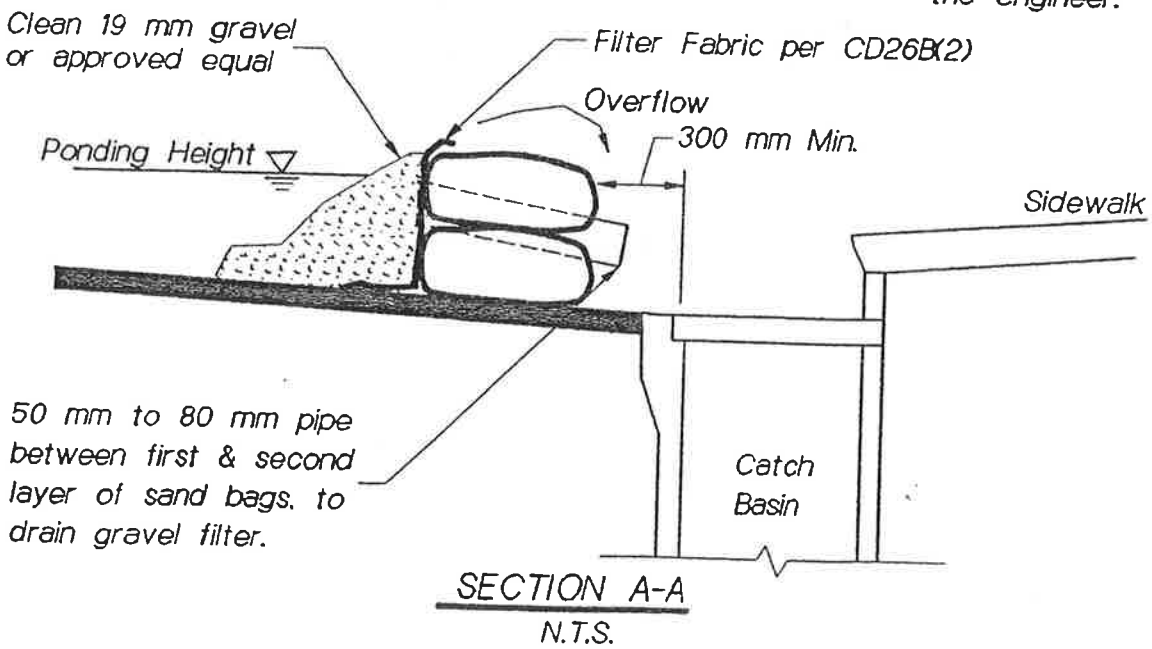
600(34)



PLAN VIEW

Notes

1. Not applicable in areas with high silt and clays without filter fabric.
2. Periodically remove and replace gravel. Old gravel may be used as backfill material if approved by the engineer.



SECTION A-A

N.T.S.

REF: Best Management Practice for Erosion and Sediment Control - Storm Drain Inlet Protection

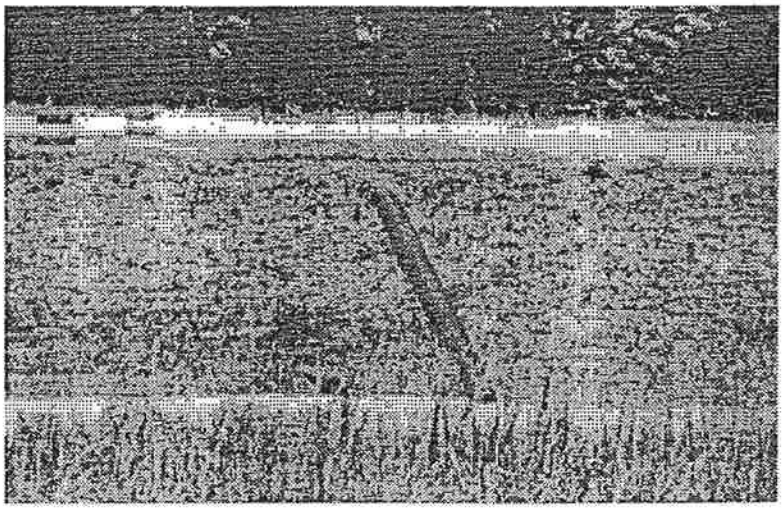
Storm Drain Inlet Protection

600-35

13. TEMPORARY SLOPE DRAINS

What Are They?

Temporary slope drains are flexible conduits which are installed from the top to the bottom of a cut or fill slope. Their purpose is to intercept and safely transport concentrated runoff down an unstabilized slope to a stabilized area at or near the toe of slope.



When And Where To Use Them:

Temporary Slope Drains are normally used on cut or fill slopes before permanent stormwater drainage structures are installed. There is often a delay between the time a cut or fill slope is completed, and the time a permanent drainage system can be installed. Newly seeded and mulched slopes, or slopes still under construction are particularly susceptible to rill and gully erosion and temporary slope drains can prevent this type of erosion. In some cases pipe slope drains can be used during embankment construction by continually adding sections to the top of the flexible pipe as the height of the embankment increases.

What To Consider:

- See **TEMPORARY SLOPE DRAINS STANDARD DETAILS 600(20)** and **600(21)**

- These structures are normally used in conjunction with temporary berms or diversions, and can be effectively used to convey stormwater from an entire drainage area above the slope to the toe without causing erosion if installed properly.

- When flexible pipe drains are used they must be anchored and sized properly for the volume of runoff expected. Failure to do this can result in failure of the system, and severe gully erosion of the slope.

- Soil around and under the pipe entrance should be compacted to prevent saturation and pipe failure.

- Both the inlet and outlet of the drains must be stabilized; use appropriate inlet and outlet protection **BMP (STANDARD DETAIL 600(21).**

- All connections in these drains must be watertight, and the flexible conduit must be staked securely to the slope.

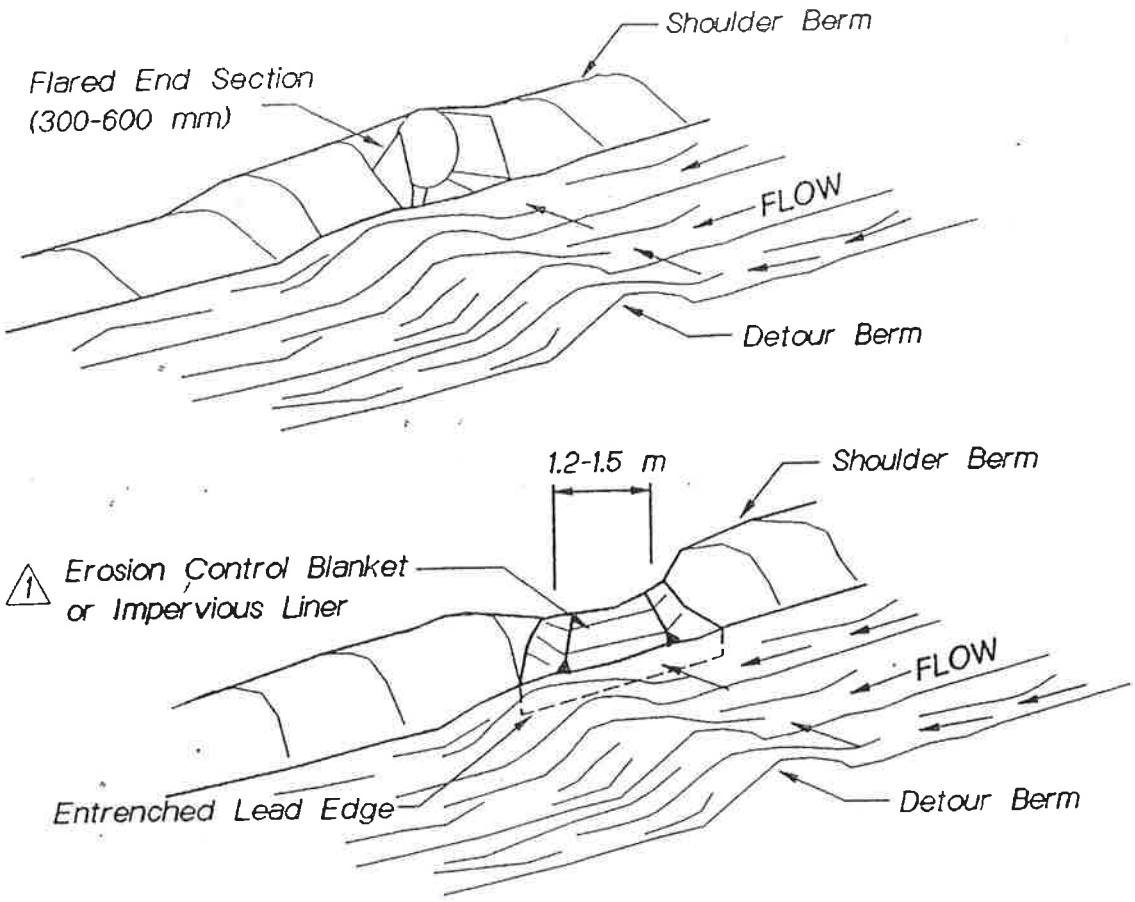
Design Standards:

The maximum allowable drainage area for slope drains is 0.2 hectares per drain.

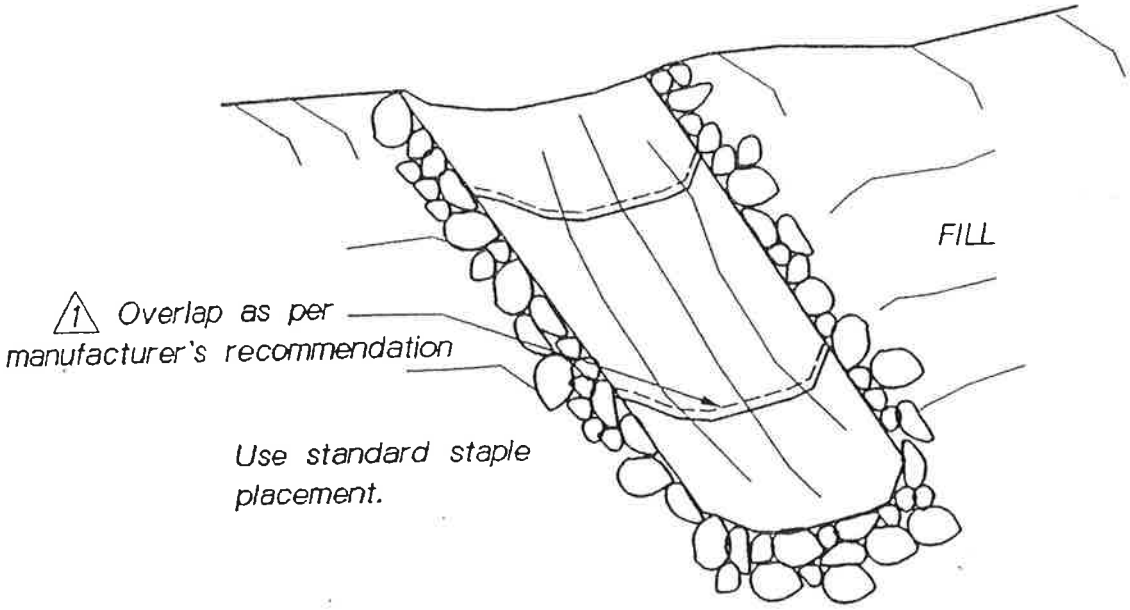
Open chute drains should be constructed on a streaight alignment to prevent splash over in a turn.

Maintenance/Performance Of Temporary Slope Drains:

Temporary slope drains must be inspected at least weekly and before, during and after any storm event. If the slope drain has any undercutting or the inlet or outlet areas have evidence of erosion, repairs must be made immediately. Inspect for any evidence of clogging of the slope drain, and make sure that the flexible conduit is staked securely to the slope.



SLOPE DRAIN INLETS

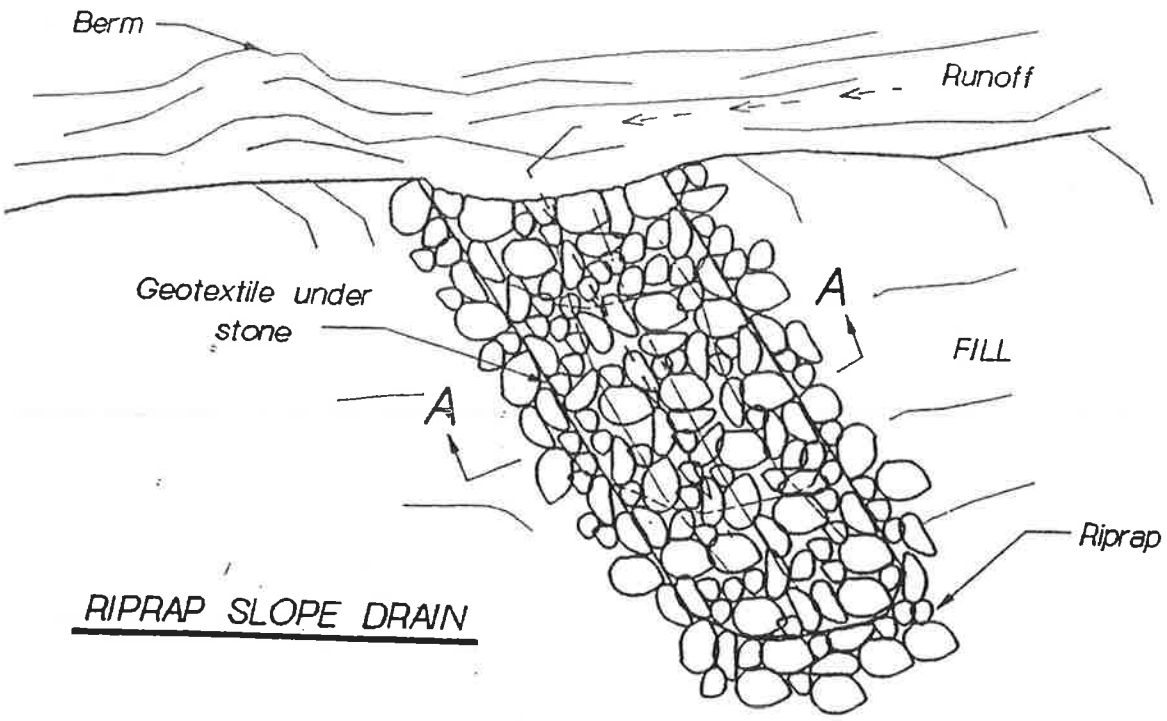


DITCH LINER: EROSION CONTROL BLANKET (or Impervious Liner)

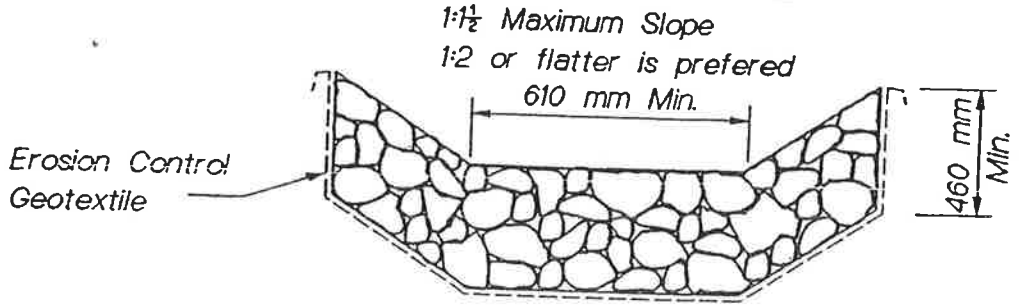
Best Management Practice for Erosion and Sediment Control -
Temporary Slope Drains)

Temporary Slope Drains

600(20)



RIPRAP SLOPE DRAIN



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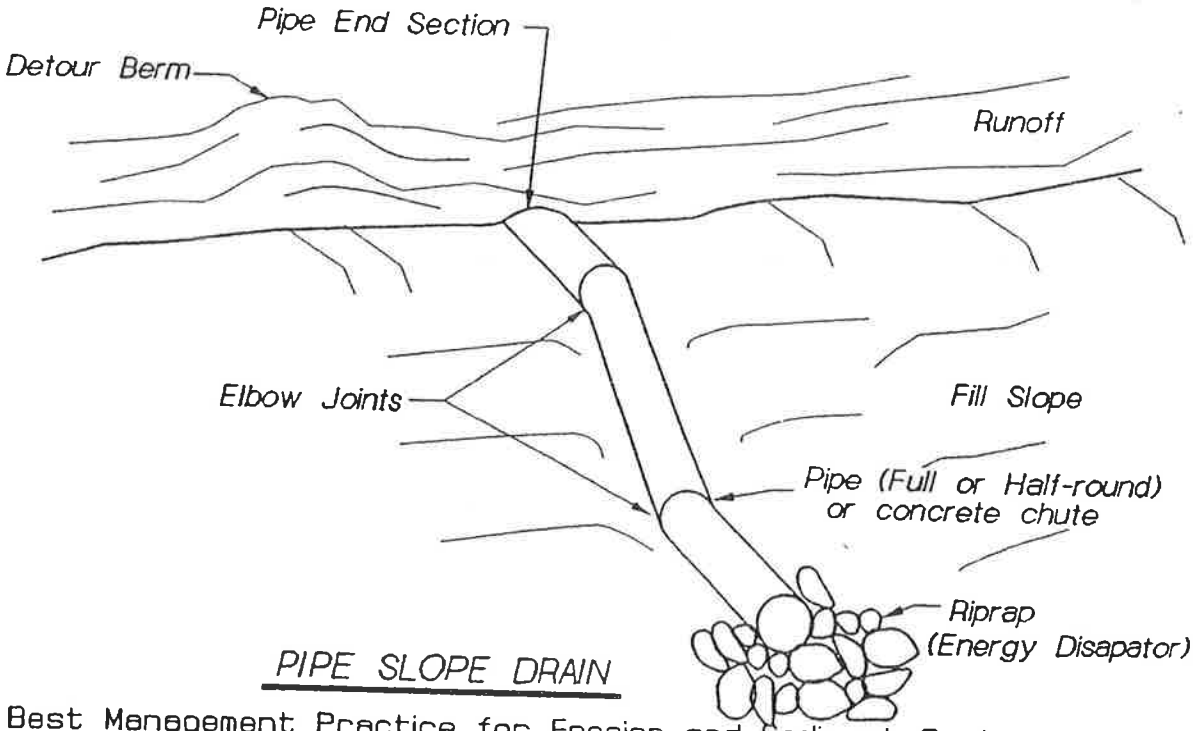


PIPE SLOPE DRAIN

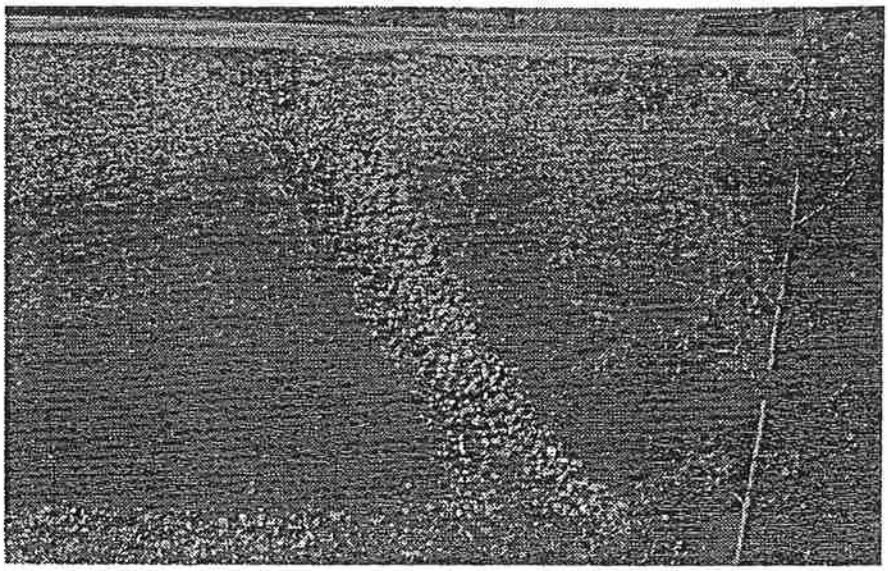
REF: Best Management Practice for Erosion and Sediment Control - Temporary Slope Drains

Temporary Slope Drains

14. RIPRAP DOWNSPOUT

What Is It?

A riprap downspout is an open channel armored with riprap used to convey stormwater runoff from the top of a steep slope to the bottom of the slope in a controlled and stable manner.



When And Where To Use It:

Riprap Downspouts are used in areas where it is necessary to control the movement of runoff down a steep grade such as a roadway cut backslope, or a large fill slope.

What To Consider:

- See **RIPRAP SLOPE DRAIN STANDARD DETAIL 600(21)** and **TEMPORARY SLOPE DRAIN BMP**
- These structures reduce the erosive capability of flowing water by providing a stable conduit for the water. All riprap downspouts discharge water onto a stabilized area. Energy dissipators such as a riprap apron or splash pad are installed to provide flow transition. In some cases, steps can be incorporated into the downspout to slow down water velocity.
- If adjacent to a waterbody, riprap downspouts may be combined with a sediment removal BMP.
- These structures provide protection to facilities adjacent to steep slopes from slides and other slope failures caused by excessive, uncontrolled runoff down the slope.
- Riprap downspouts may cause thermal pollution to nearby streams by warming stormwater runoff.

Design Standards:

LOCATION

There are three locations where a riprap downspout is recommended. The first is where an existing rill has formed on a backslope and has become a natural drain for an area above. The second is to provide a stabilized outlet for a diversion constructed on top of or within the slope. The third is where fill and cut sections meet and form a natural trough.

CAPACITY

A downspout used to stabilize an existing rill does not always require a detailed sizing design.

When a downspout is to be used to provide a stable outlet for a diversion, the capacity of the downspout should be based on the storm frequency chosen to construct the diversion. In most situations, a 10 year frequency storm should be used.

CHANNEL DESIGN

The downspout channel is recommended to be parabolic in shape. The minimum depth of the channel should be 0.3 m to allow for the downspout to still function without erosion if ice has built up in the channel. In the case of constructing a stabilized outlet for a diversion, the cross-sectional area shall be determined for the expected design flow.

Erosion Control Geotextile is used under riprap downspouts to prevent piping of fines, except in cases where the slope of the channel is greater than 1:2. On these steep slopes, the geotextile should be omitted or loosely placed to reduce the likelihood of slip plane failure of the downspout. On those slopes larger riprap should be placed at the bottom for greater stability.

A splash pad or apron should be provided at the toe of sloped channel. The width of the pad should be consistent with the channel width design. The pad should initially be constructed 1 m long and monitored after a heavy rain event to determine if further protection is required.

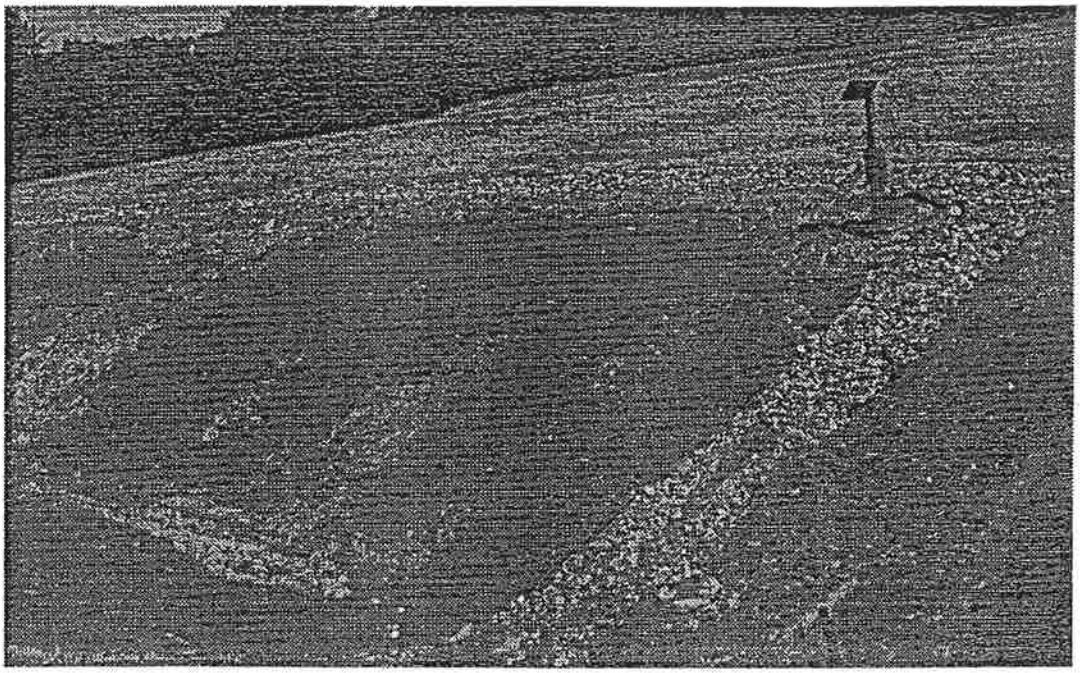
Maintenance/Performance of Riprap Downspouts:

Riprap Downspouts should be inspected periodically to ensure that they are functioning property, and that no erosion is occurring adjacent to or downstream from the structure. If evidence of erosion or impaired operation is evident, repairs should be made immediately. Undercutting of the sidewall commonly shortens the lifespan of downspouts so special attention should be paid to this during inspections.

15. HILLSIDE DIVERSIONS

What Are They?

A diversion is a channel constructed across a slope with a supporting berm on the downhill side which is used to divert excess surface water runoff from disturbed soil areas to areas where it can be safely discharged without environmental impacts. They can be both permanent structures and temporary for the duration of a construction project.



When and Where to Use Them:

Diversions are used in areas where concentrated runoff or sheet flow from higher lying areas is potentially damaging to areas down slope. They are also used to intercept and control runoff on construction sites, especially with moist, unstable soils, and where runoff may have beneficial uses in nearby areas.

What to Consider:

- See **STANDARD DETAIL 600(26)** for temporary and permanent diversions.
- Diversions should not be substituted for terracing slopes where such practices are more appropriate for erosion control and structural integrity.
- Diversions may be used in conjunction with energy dissipating devices and/or sediment traps prior to discharging runoff into adjacent natural watercourses.

- Diversions should be stabilized before being used (see DITCH/SWALE PROTECTION and SEEDING BMP).

- Temporary diversions are in place for short durations and should be protected with erosion control blankets, temporary seeding, and mulching.

- Permanent diversions should be designed under the supervision of a professional engineer.

Design Standards:

In most instances, diversions are constructed using a standard design or specifically sized for site flow conditions.

LOCATION

Diversion location should be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (where seepage is a problem) and the development layout.

CAPACITY

The diversion channel shall have a minimum capacity to carry the runoff expected from a 10 year frequency storm with a freeboard of at least 100 mm.

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high risk areas and those designed to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved. Refer to SCS TR-60[1].

CHANNEL DESIGN

The diversion channel may be parabolic or trapezoidal. The cross-sectional area shall be determined for the expected design flow.

BERM DESIGN

The supporting ridge cross-section shall meet the following criteria:

* The side slopes shall be no steeper than 1:2.
* The width at the design water elevation shall be a minimum of 1.2 meters.
* The minimum freeboard shall be 100 mm.
* The berm shall be compacted by machine.

OUTLET

Diversions shall have adequate outlets to convey concentrated runoff without erosion. See RIP RAP DOWNSPOUT or SLOPE DRAIN BMPs.

STABILIZATION

Stabilization must be put in place in conjunction with the construction of the diversion.

If there are disturbed areas draining into the diversion, they shall be seeded and stablized prior to or at the same time the diversion is constructed.

GENERAL CONSIDERATIONS

All trees, brush, stumps, obstructions and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.

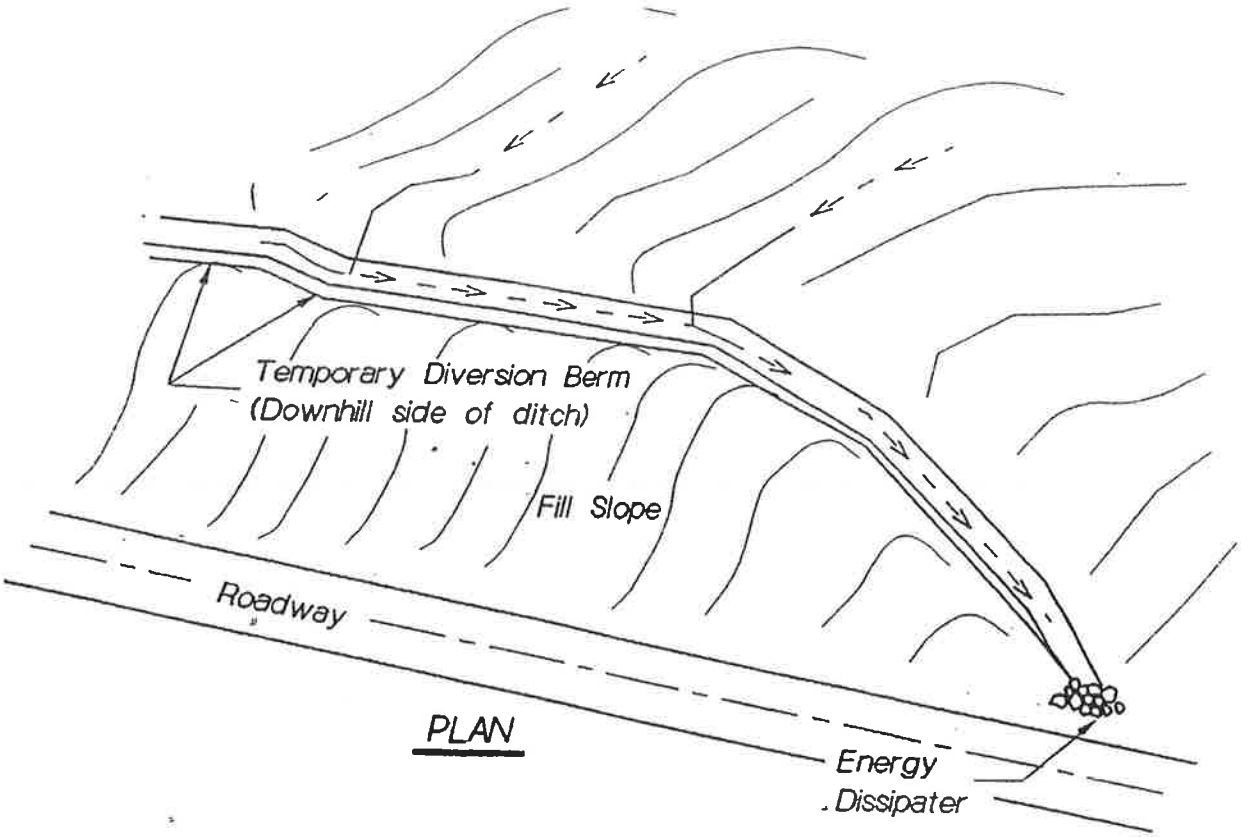
The diversion shall be excavated or shaped to line, grade and cross-section as required to meet the criteria specified, free of irregularities which will impede flow.

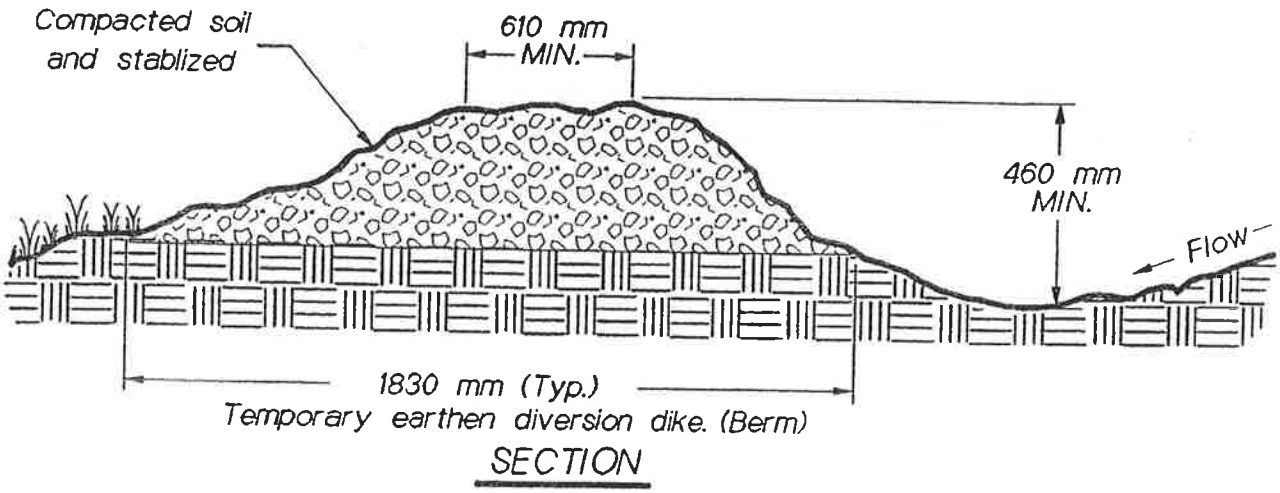
Fills shall be compacted by equipment to prevent unequal settlement that may cause damage in the completed diversion.

All earth removed and not needed in construction shall be reused or disposed of and stabilized so that it will not interfere with the functioning of the diversion.

Maintenance/Performance of Permanent Diversions:

Diversions should be inspected periodically to ensure their capacity, storage, ridge height, vegetative cover, and outlets are able to handle the design flows and are in good repair. Temporary diversions must be inspected before, during and after each storm event and any necessary repairs completed immediately. Temporary erosion control blankets should also be inspected and repaired if necessary. Additional staples may be necessary for erosion control blankets to obtain good contact with the soil to prevent flow under the mat (see EROSION CONTROL BLANKET and DITCH/SWALE BMPs for more information).





REF: Best Management Practice for Erosion and Sediment Control - Temporary Diversion

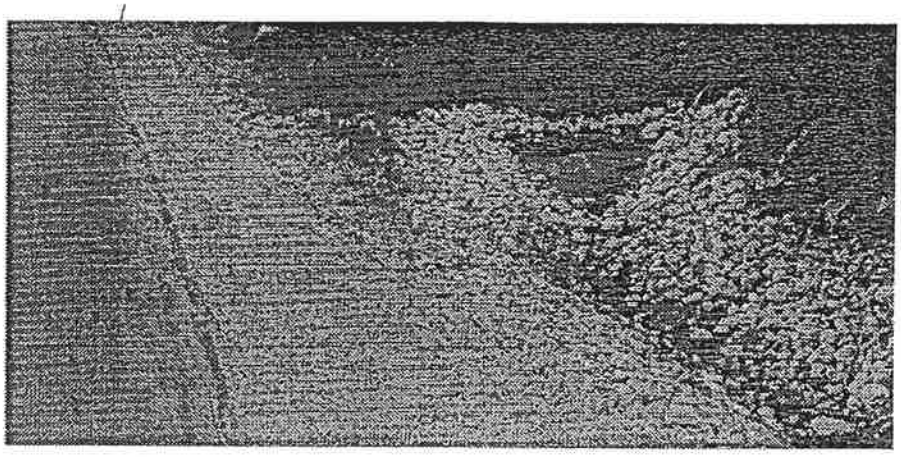
Hillside Diversion

600(26)

16. SEDIMENT TRAPS and BASINS

What Is It?

Sediment Traps and Basins are essentially the same thing, the difference being in the size of the drainage areas they serve. Traps are used for drainage areas less than 2.0 hectares, while basins are used in drainage areas greater than or equal to 2.0 hectares, up to a maximum of 40 hectares. Both are controlled stormwater release structures, formed by excavating or by constructing an earthen embankment across a drainage way or low drainage area. Their purpose is collecting and temporarily detaining stormwater runoff, allowing sediments to settle, and preventing off-site sedimentation of water resources.



When and Where to Use Them:

- Construction projects with disturbed areas.
- To prevent sediment laden storm water from entering streams, lakes or drainage ways.
- At outlets of disturbed areas in watersheds of up to 40 hectares.
- Ditch sediment traps, riprap outlet sediment traps and sediment basins may be used as permanent measures.

What to Consider:

- Where practical, contributing drainage areas should be subdivided into smaller areas, and multiple sediment traps used in lieu of sediment basins.

- Alternative BMPs should be thoroughly investigated for prevention of erosion before selecting sediment basins to remove eroded sediment.

- Basins require large surface areas to permit settling of sediment.

- Single basins are not appropriate for drainage areas greater than 40 hectares. For areas greater than 40 ha, multiple basins should be considered.

- Traps and basins are not to be located in streams.

- Construct traps and basins prior to construction activities.

- Basins with a permanent pool can be an attractive nuisance to children and may require protective fencing.

- Sediment basins shall be designed under the supervision of a registered professional engineer. Designs must be submitted for approval by the Town Engineer.

- Ditch sediment traps may be used as permanent structures.

DESIGN STANDARDS:

DRAINAGE AREA: Each type of sediment trap or basin has a maximum drainage area that it can serve. The maximum drainage areas are as follows:

1. Ditch Sediment Trap	0.8 ha
2. Storm Drain Inlet Sediment Trap	1.2 ha
3. Pipe Outlet Sediment Trap	2.0 ha
4. Riprap Outlet Sediment Trap	6.0 ha
5. Sediment Basin	2.0 ha - 40 ha

LOCATION: Sediment traps and basins should be located so that they can be installed prior to grading or filling in the drainage area they are to protect. They must not be located any closer than 6 meters from a proposed building foundation if the trap is to function during building construction. Locate traps and basins to obtain maximum storage benefit from the terrain for ease of clean-out and disposal of the trapped sediment. Assure that the location will not cause a loss of life or property damage if a failure were to occur. A small sediment trap constructed upstream of the basin may be provided to remove debris and other particles.

TRAP & BASIN SIZE: In order for the sediment trap to function properly, the proper storage volume must be provided. The total contributing drainage area must include both disturbed and undisturbed land no matter if within the right of way or not. This storage is created by a combination of excavation and/or construction of an embankment to detain runoff. The volume of both the trap and basin are measured at the elevation of the crest of the outlet. The size should be able to accommodate a settling zone and sediment storage zone. The settling zone is recommended to have a volume of 130 m^3 / ha. The sediment storage zone recommended volume is 65 m^3/ha. These recommended volumes are based upon 13 mm of runoff over a 24 hour period. Larger or multiple basins may be required to accommodate the local rainfall conditions as

determined by the designing engineer. The best settling efficiency occurs when the design volume is split between multiple basins.

Basin length to width ratio shall be greater than 2:1 (L:W) or baffles are required to prevent short circuiting of the inlet flow. The volume of a constructed trap should be calculated using the standard equation, Volume = 0.4 x surface area x maximum depth.

BASIN BAFFLES: Baffles shall be constructed of 90 mm x 90 mm posts and 1.2 m x 2.4 m x 12 mm thick exterior plywood or the equivalent. Posts shall be set at least 1 m into the ground, no further apart than 2.5 m on center, and shall reach a height of 150 mm below the riser crest elevation.

EMBANKMENT: The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared. The fill for the embankment shall be free of organic or other objectionable material. No material larger than 150 mm shall be used as fill material. The fill shall be placed in no greater than 200 mm lifts. Proper compaction is critical to the stability of the constructed embankment. If the embankment is to be used only temporarily, then the compaction can be completed by completely traversing each layer of fill with construction equipment. If the embankment will be part of a permanent trap or basin, then the embankment shall be constructed in accordance with Standard Specification 203.11 Maintaining the proper moisture content of the fill material is critical for achieving the desired compaction. The embankment should be stabilized with an erosion control blanket, or erosion control geotextile and riprap.

TRAPS: All embankments for sediment traps should not exceed 1.5 m in height as measured at the low point of the original ground along the centerline of the embankment. Embankments should have a minimum 1.2 m wide top and side slopes of 1:2 or flatter. The elevation of the top of any diversion berm directing water to any sediment trap will equal or exceed the maximum height of the outlet structure along the entire length of the trap.

BASINS: Sediment Basin embankments must be designed under the supervision of a registered professional engineer. The dams, spillways, and drainage facilities shall be according to Soil Conservation Service (SCS) standards for ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded at flood stage against the embankment at emergency spillway elevation is 1 m or more. Excavated ponds must be designed to have the capability of draining the temporary storage within a 10 day period.

EXCAVATION: All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimal. Excavated portions of sediment traps shall have 1:2 or flatter slopes.

LINING: Traps or Basins shall be lined with geotextile and plain rip rap (VTrans **STANDARD SPECIFICATIONS 649** and **706**) to allow original depth determination when built up sediment is being removed.

OUTLET: The outlet should be designed, constructed, and maintained in such a manner that sediment does not leave the trap and erosion at or below the outlet does not occur. Sediment traps should outlet onto stabilized ground or into a water course, stabilized channel, or storm drain system.

TRAP STANDARDS:

1. DITCH SEDIMENT TRAP: (Max. Drainage Area: 0.8 ha)

A ditch sediment trap consists of a trap formed by over excavating a swale or a drainage ditch. Ditch sediment traps are placed in surface drainage ditches just before the runoff leaves the right of way, enters a watercourse at the end of cut sections, or immediately before ditch inlets or after stabilized outlets. Once the contributory drainage area is stabilized, the trap may be removed and the swale or ditch reconstructed. The ditch sediment trap should be used only where no other device is feasible. The volume of this trap shall be computed at the elevation of invert of the outlet. See details for Ditch Sediment Trap in **STANDARD DETAIL 600(36).**

2. STORM DRAIN INLET SEDIMENT TRAP: (Max. Drainage Area: 1.2 ha)

A storm drain inlet sediment trap consists of a basin formed by excavation on natural ground that discharges through an opening in a storm drain inlet structure. This opening can either be the inlet opening, or a temporary opening made by omitting bricks or blocks in the inlet.

A yard drain inlet or an inlet in the median strip of a divided highway would use the inlet opening for the trap outlet. The trap should be out of the way so as not to interfere with future compaction or construction. Placing the trap on the opposite side of the opening and diverting water from the roadway to the trap is one means of doing this. The volume of this trap is measured up to the elevation of the crest of the outlet (invert of the inlet opening).

See detail for Storm Drain Inlet Sediment Trap in the **STANDARD DETAIL 600(37).**

3. PIPE OUTLET SEDIMENT TRAP: (Max. Drainage Area: 2.0 ha)

A pipe outlet sediment trap consists of a trap formed by an embankment or excavation. The outlet for the trap is through a perforated riser pipe through the embankment. The outlet pipe and riser should be made of corrugated metal. The top of the embankment shall be at least 0.5 m above the crest of the riser. The top 2/3 of the riser shall be perforated with 25 mm nominal diameter holes or slits spaced 150 mm vertically and horizontally placed into the concave portion of the corrugated pipe.

No holes or slits will be allowed within 150 mm of the top of the horizontal barrel. All pipe connections will be watertight. The riser shall be wrapped with geotextile (filter fabric) with the equivalent sieve size between #40-#80 and secured with strapping or connecting band at the top and bottom of the cloth. The cloth shall cover an area at least 150 mm above the highest hole and 150 mm below the lowest hole. The top of the riser pipe shall not be covered with filter cloth. The riser shall have a base with sufficient weight to prevent flotation of the riser. Two

approved bases are: (1) A concrete base 300 mm thick with the riser embedded 230 mm into the concrete base and (2) A 6.3 mm min. thick steel plate attached to the riser by a continuous weld around the circumference of the riser to form a water tight connection. In either case, each side of the square base measurement shall be the riser diameter plus 600 mm.

Pipe outlet sediment traps may be interchangeable in the field with riprap outlet sediment traps provided that the sediment trap is constructed in accordance with the detail and specifications for that trap.

Select pipe from the following table:

Barrel Diameter* (millimeters)	Riser Diameter* (millimeters)	Max. Drainage Area (hectares)
300	380	0.4
380	460	0.8
460	530	1.2
530	600	1.6
600	685	2.0

* Barrel diameter may be same size as riser diameter. See details for Pipe Outlet Sediment Trap in Standard Detail **600(38)**.

4. RIPRAP OUTLET SEDIMENT TRAP: (Max. Drainage Area: 6.0 ha)

A Riprap Outlet Sediment Trap consists of a trap formed by an excavation and embankment. The outlet of this trap shall be through a partially excavated channel lined with riprap. The outlet channel shall discharge onto a stabilized area or to a watercourse.

The elevation of the top of any dike directing water to a riprap outlet sediment trap will equal or exceed the minimum elevation of the embankment along the entire length of this trap.

Contributing Drainage Area (Hectares)	Depth of Channel (meters)	Length of Weir (meters)
1.0	0.5	1.5
2.0	0.5	3.6
3.0	0.5	4.9
4.0	0.6	3.6
5.0	0.6	4.5
6.0	0.6	5.5

* See Standard Detail **600(39)**.

5. SEDIMENT BASIN STANDARDS: (Max. Drainage Area: 40 ha)

Generally, the design will adhere to the following standards.

- The principal outlet shall consist of a corrugated metal or reinforced concrete riser pipe with dewatering holes and an anti-vortex device and trash rack attached to the top of the riser to prevent floating debris from flowing out of the basin or obstructing the system. This principal structure should be designed to accommodate the inflow design storm.

- Attach the riser pipe (watertight connection) to a horizontal pipe (barrel) which extends through the embankment to the toe of the fill. Anti-seep collars must be provided on barrel.

- Construct an emergency spillway to accommodate flows not carried by the principal outlet. Spillways shall consist of an open channel (earthen or vegetated) over undisturbed material (not fill) or constructed of riprap.

- The spillway control section which is a level portion of the spillway channel at the highest elevation in the channel shall be a minimum of 6 meters in length.

- Paint depth markers on the principal outlet to better define maintenance needs.

- Rock or vegetation shall be used to protect the basin inlet and slopes against erosion.

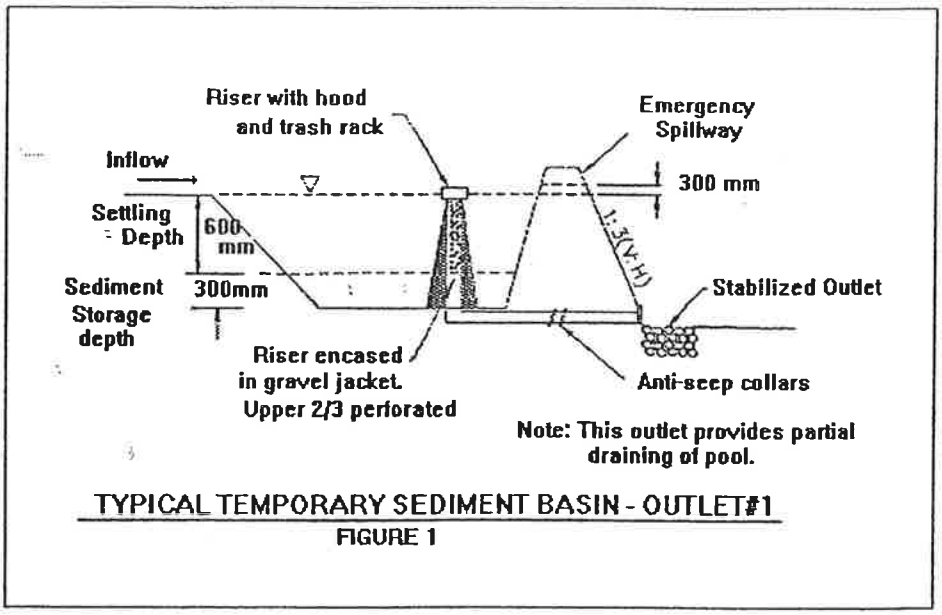
- Side slopes shall be no steeper than 1:3.

- Fencing and other safety measures shall be installed as necessary to protect the public from floodwater and soft sediment.

One of the following dewatering configurations for the principal outlet can be used:

OUTLET #1: See Figure #1

- Perforate the top two-thirds of the riser with 13 mm dia. holes, spaced 200 mm vertically and 250 mm - 300 mm horizontally.
- Wrap with well-secured drainage geotextile.
- Place Type C underdrain stone over perforated holes to approximately 50 mm minimum thickness to assist in prevention of clogging of dewatering holes. Gravel will naturally settle into a cone surrounding the riser pipe.

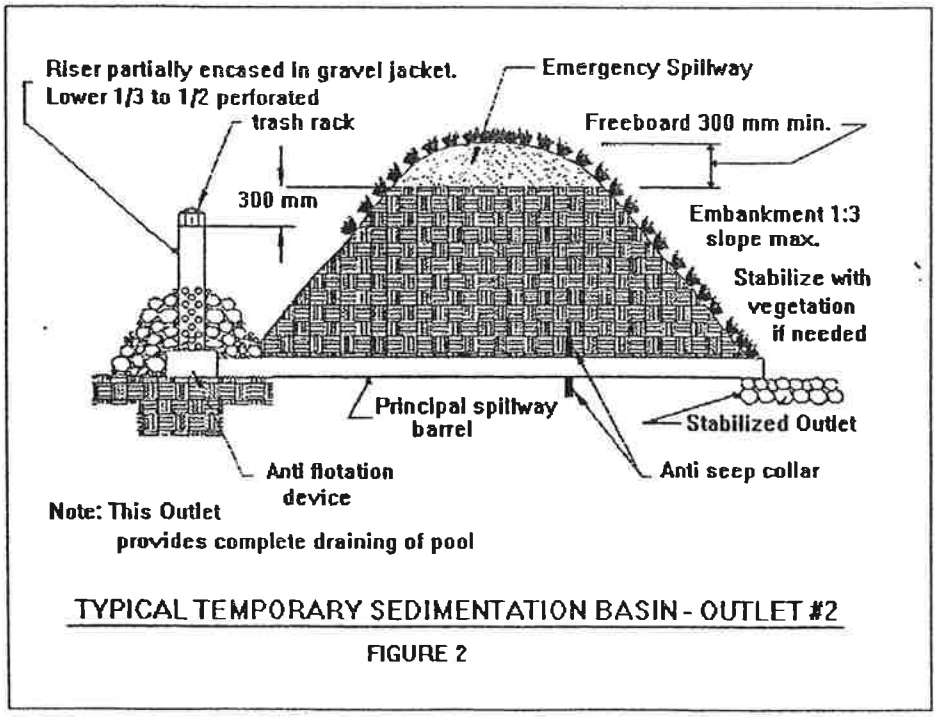


TYPICAL TEMPORARY SEDIMENT BASIN - OUTLET#1

FIGURE 1

OUTLET #2: See Figure #2

- Perforate the lower one-half of the riser pipe with 13 mm dia. holes spaced approximately 75 mm apart, in each outside valley (CMP pipe).
- Place Type C underdrain stone over perforated holes to approximately 50 mm minimum thickness.

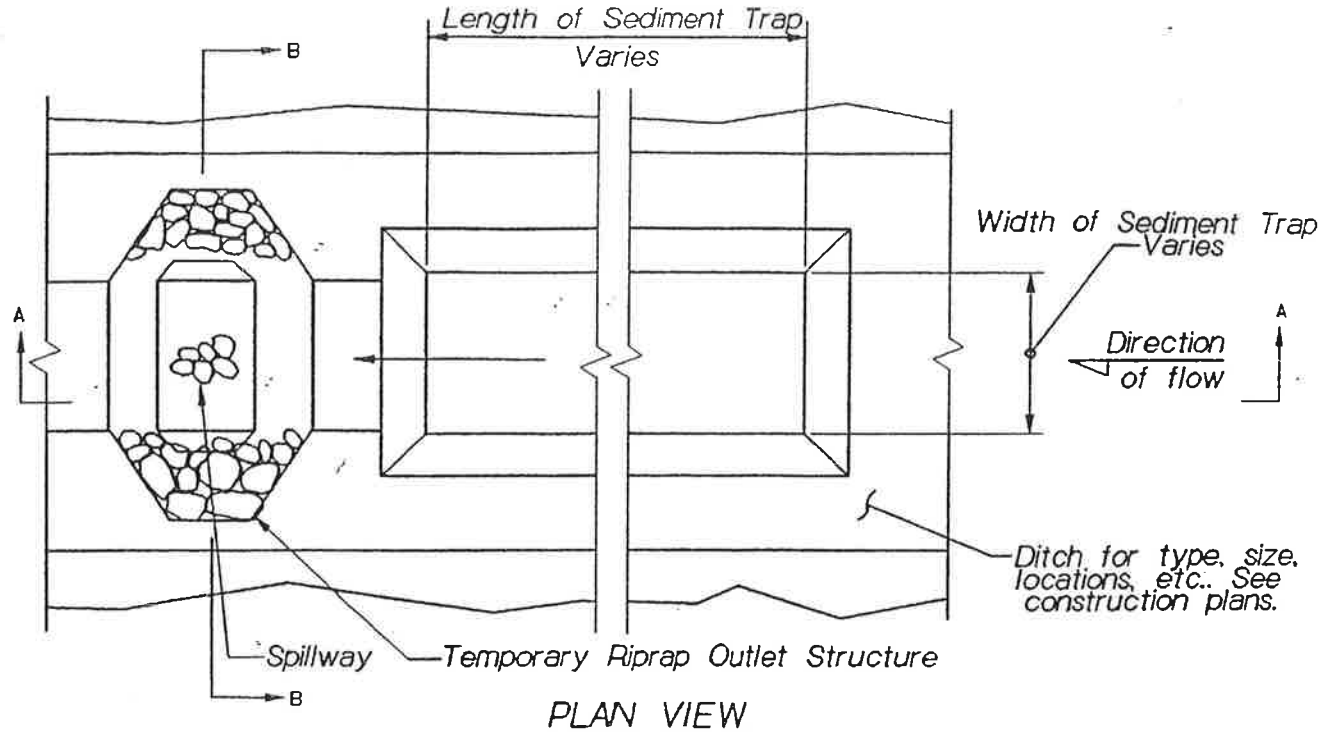


TYPICAL TEMPORARY SEDIMENTATION BASIN - OUTLET #2

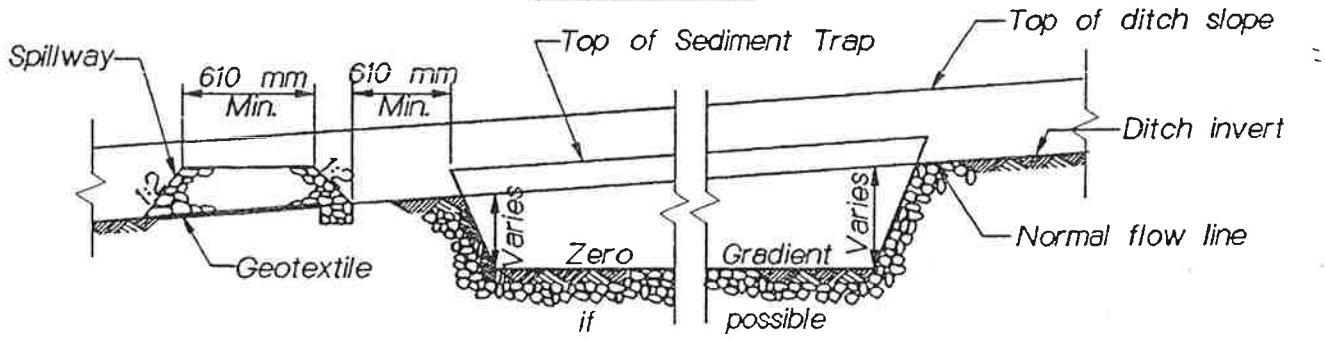
FIGURE 2

Maintenance /Performance Standards of Sediment Traps and Basins:

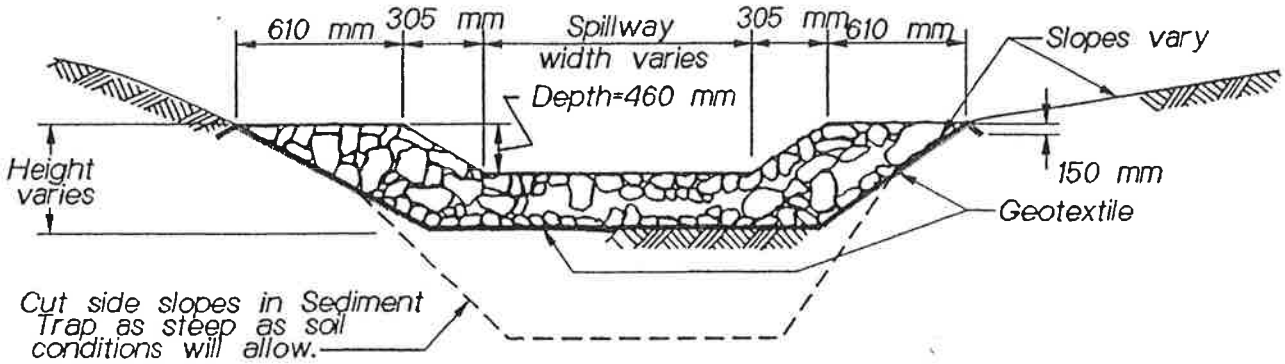
- Inspect temporary sediment basins before, during and after rainfall events and weekly. During extended rainfall events, inspect sediment basins at least every 24 hours.
- Examine embankments for sags, seepage and structural soundness on a continuing basis.
- Check the outlet structure and spillway for any damage or obstructions. Repair damage and remove obstructions as necessary.
- Remove sediment when storage zone is one-third full.
- Performance of Sediment Traps and Basins ranges widely depending on the soil type and adherence to the BMP design standards. Storage volume, dual basins, length to width ratio, type of outlet and use of floating skimmer all influence the efficiency of a basin.



PLAN VIEW



SECTION A-A

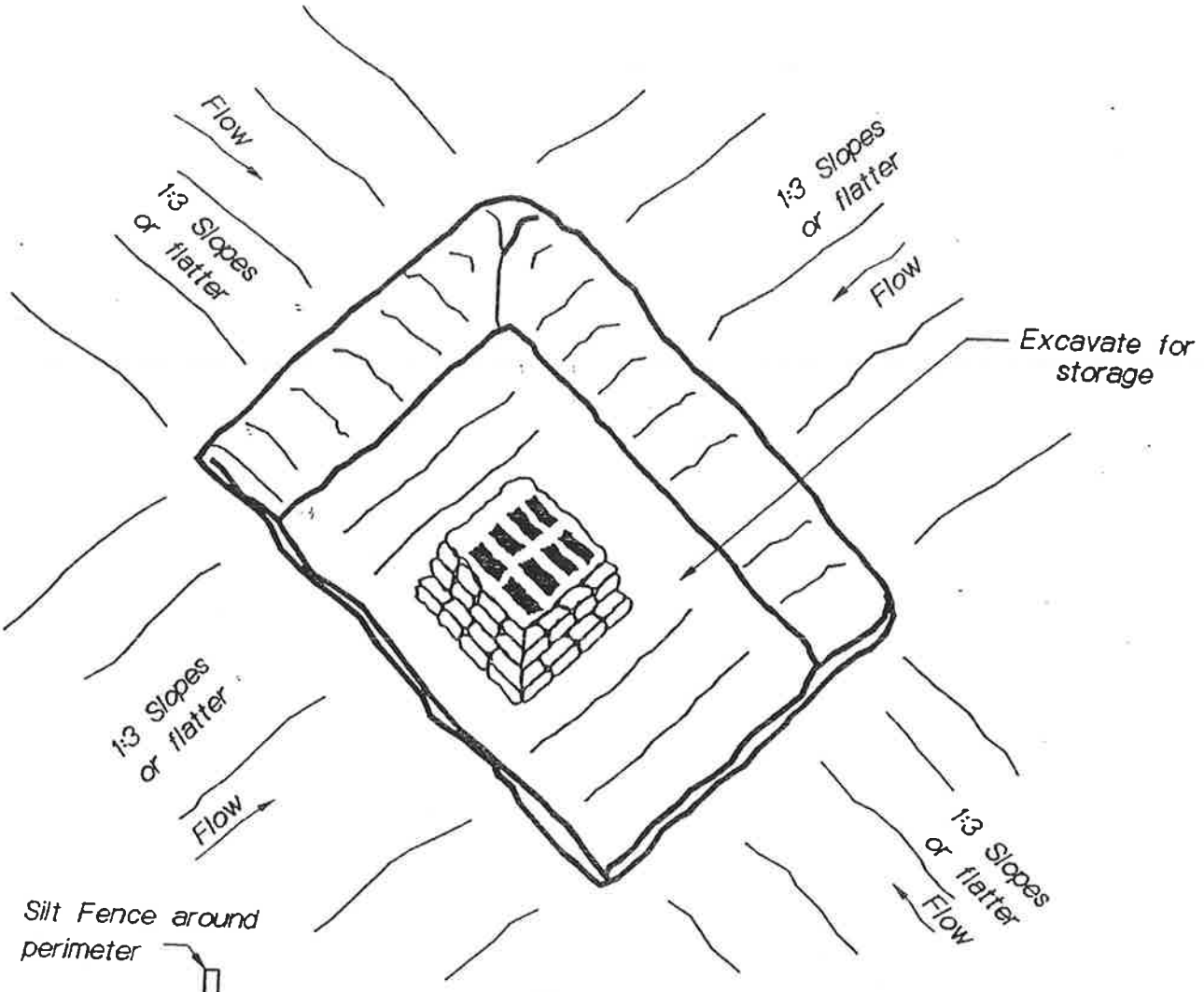


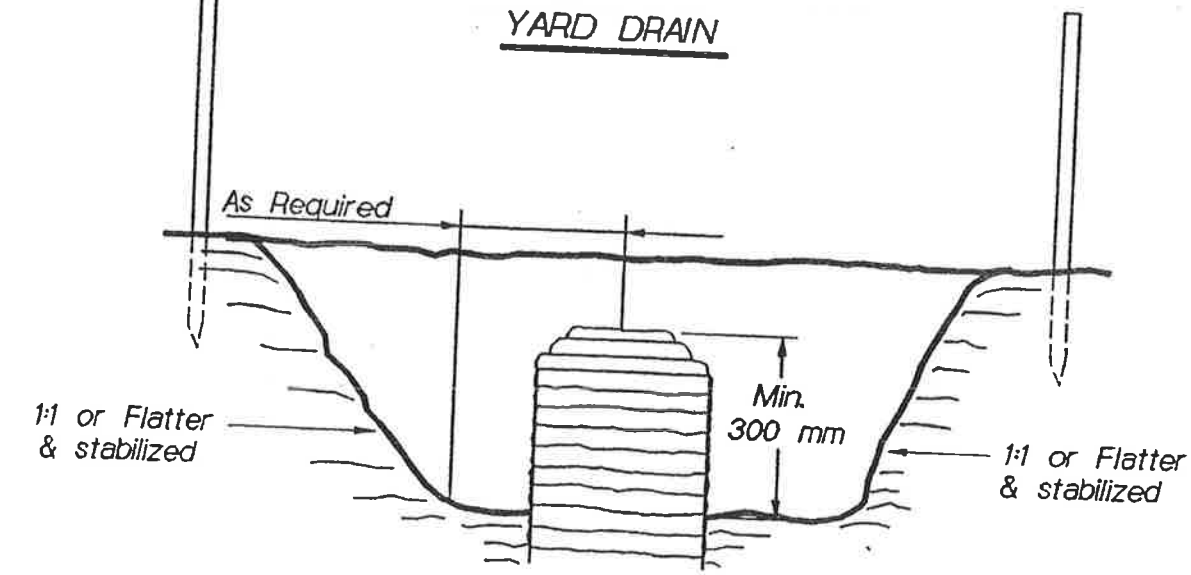
SECTION B-B

REF: Best Management Practice for Erosion and Sediment Control - Sediment Traps

Ditch Sediment Trap

600(36)



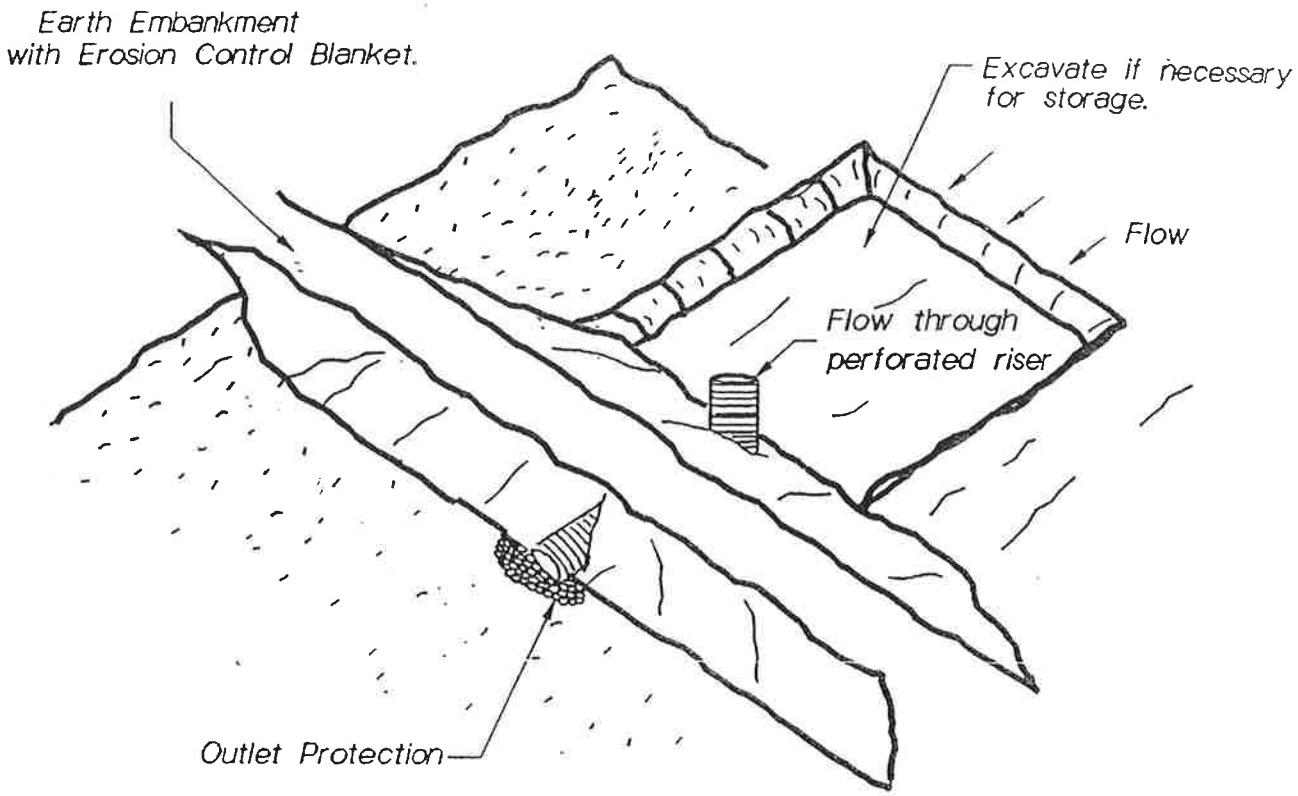


CROSS SECTION

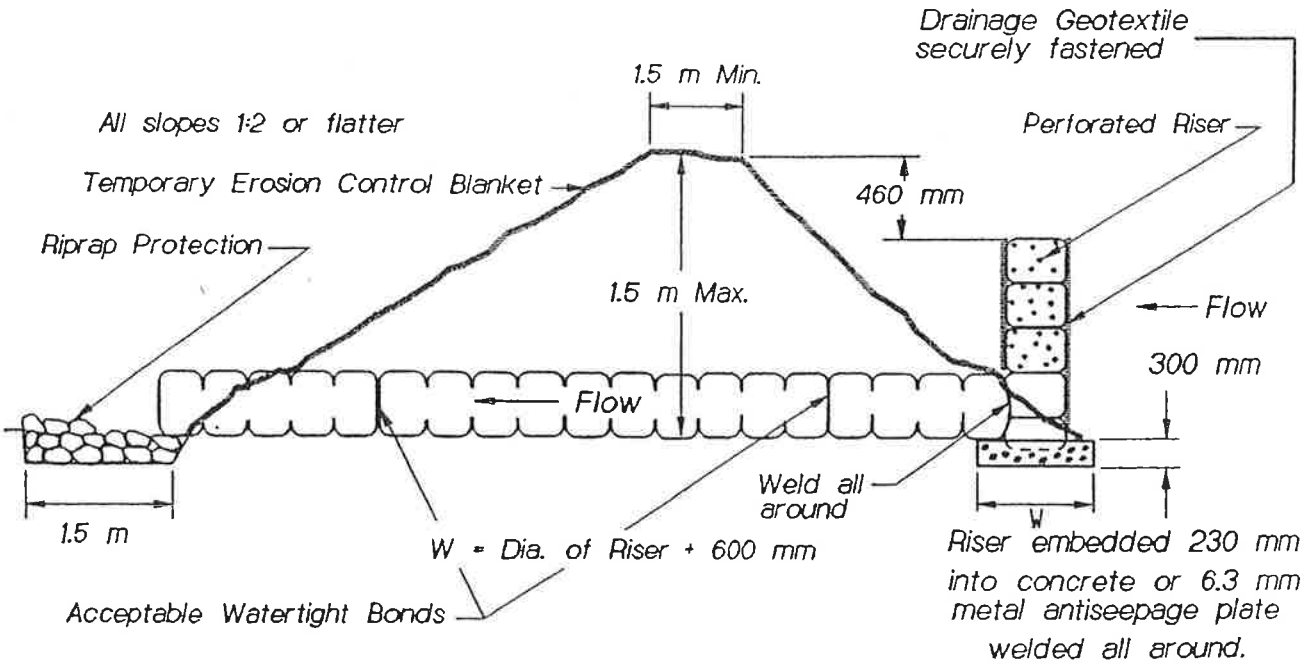
REF: Best Management Practice for Erosion and Sediment Control - Storm Drain Inlet Sediment Trap

Storm Inlet Sediment Trap

600(37)



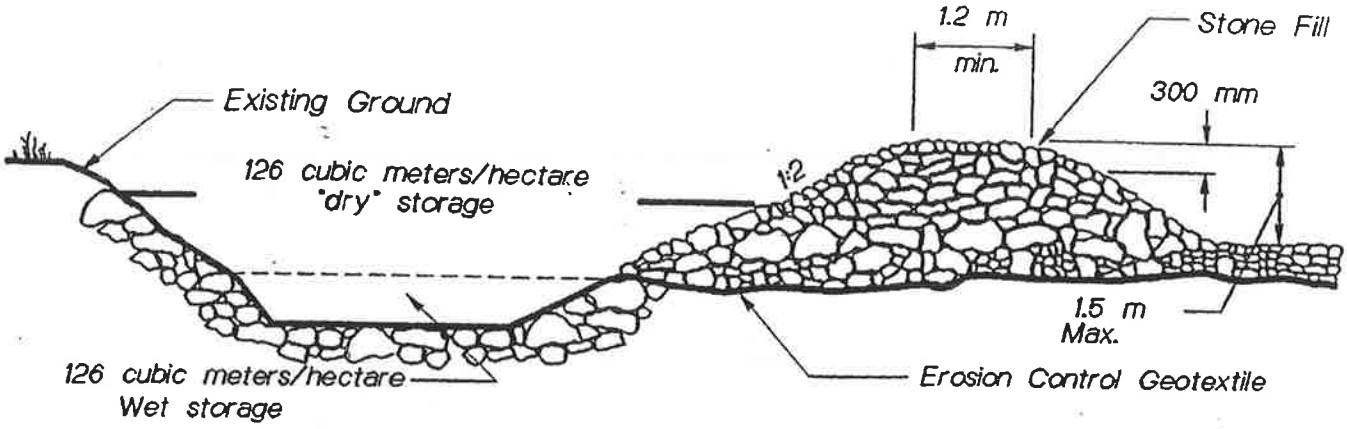
PERSPECTIVE



EMBANKMENT SECTION THRU RISER

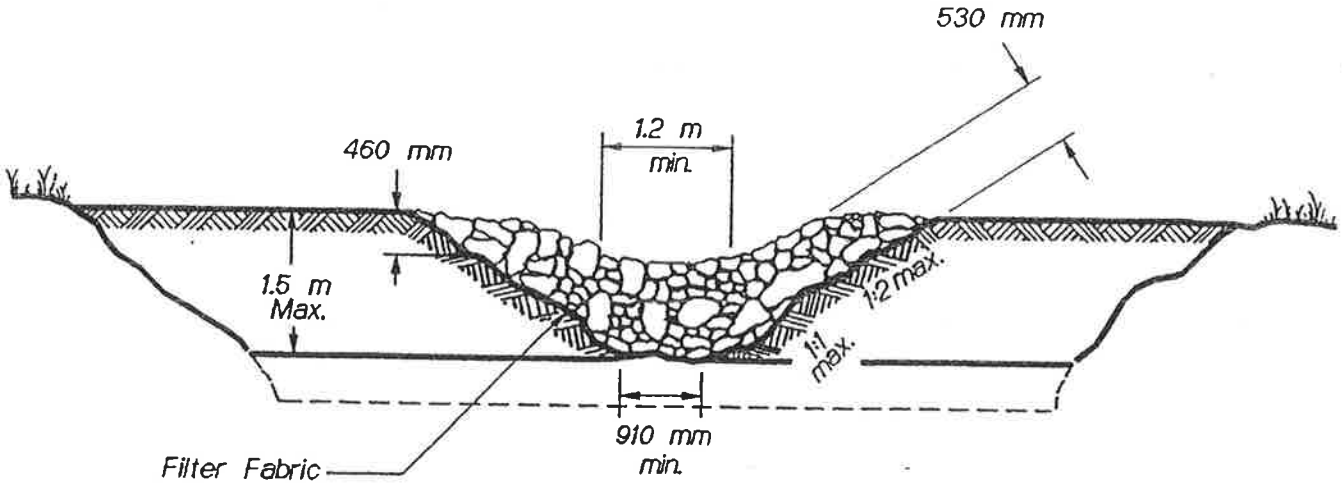
REF: Best Management Practice for Erosion and Sediment Control - Sediment Traps

Pipe Outlet Sediment Trap



CROSS SECTION

(@ ℄ of Outlet)



Outlet

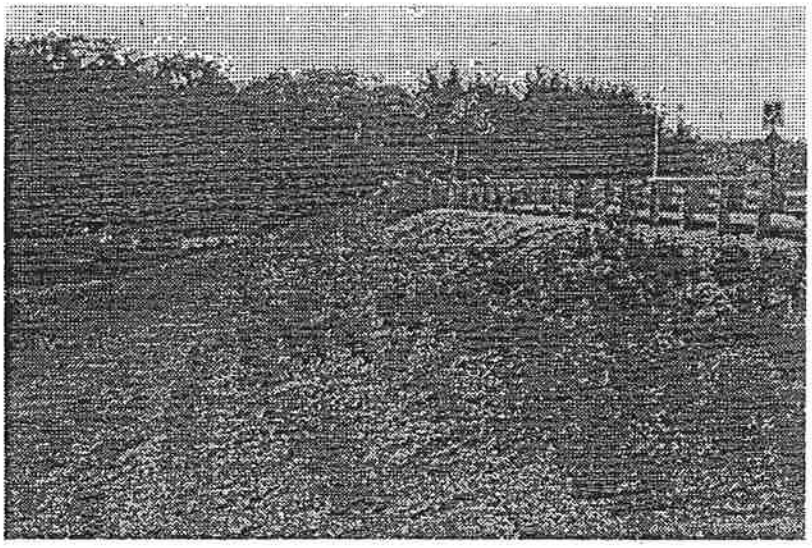
REF: Best Management Practice for Erosion and Sediment Control - Sediment Traps

Riprap Outlet Sediment Trap

600(39)

17. SLOPE STABILIZATION

What Is It? Slope Stabilization is the use of vegetation and/or structural materials to stabilize and protect slopes of roadways, streams, brooks, rivers, lakes, tidal areas or excavated channels against scour and erosion from flowing water.



When and Where To Use It:

This method of stabilization is used on all slopes where stability of the slope is an issue. Generally, the steeper the slope is the more at risk it is of some stability failure. The amount of excess water that runs across or through the slope, is also of concern.

This method is also used along water bodies where embankments are subject to erosion from the action of water, ice, or debris, or subject to damage from human, livestock or vehicular activities.

What To Consider:

- Scour and erosion potential along water bodies must be known, to determine the type of protection required. Along stream and river banks ice flow history, seasonal water depths and flow velocities, should all be determined prior to implementation.
- The presence of erodible or potentially unstable soils should be investigated when the project location is critical.
- Steepness of slope determines which method is to be used.
- Know the upland runoff potential over the stabilized slope of the bank. Check surrounding drainage areas, terrain grades, mapped soils, note forest or grassland cover, major

development activities, etc.

- Keep disturbed earth areas to a minimum. It is far better to minimize cutting and disturbance of existing vegetation than to replant. When trees must be removed, leave the stumps in place to minimize soil disturbance.

- Tree and shrub plantings are very beneficial for fish habitat as they shade the water to reduce thermal pollution, and provide leaf litter as a food source for aquatic organisms.
  See VTrans STANDARD SPECIFICATIONS Section 656.

- Avoid using riprap or other stone and masonry whenever possible when thermal pollution is an issue. In cases where riprap or other masonry is required for stream bank stability, combine it with vegetative plantings and seeding if possible to provide shade and maintain good habitat.

- Nutrients and pesticides used to establish and maintain vegetation should be minimized and managed to protect surface water quality.

- All vegetative stabilization measures should be well established prior to winter or they may fail and cause water quality problems during thaws and/or spring runoff

- Stabilization measures to be installed should tie into existing stable areas..

- Structural stabilization measures must be effective for the design flow and able to withstand storms and floods without serious damage.

- Deflectors constructed of posts, pilings, fencing, rock, brush, or other materials that project into the stream can protect banks at curves and reaches subjected to erosion by high velocity currents as determined by the engineer's hydraulic analysis.
  Contact Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division
- Structural stabilization measures along streams should maintain existing water velocities so that they do not increase downstream erosion potential.

Design Standards:

Slope failure can occur in many different ways. There are several potential failure modes that can take place on a slope, and this manual will not attempt to provide the reader with a complete understanding of these modes. To complete an acceptable slope design, one must have a thorough knowledge of the factors acting on and within a slope, as well as the methods used to ensure the stability of the slope. Due to the structural nature of this design problem, this manual will not provide the information necessary to design, or fix a failed slope. There are many references available that will provide the designer with the tools necessary to complete an adequate design.

SURFACE EROSION

Surface erosion is a problem that can be reasonably solved with this manual. The causes of these problems include rain falling on the slope surface, overland flow velocities being too high, low resistance of the slope surface and subsurface seepage. The following are recommendations of how to control surface erosion:

Falling Rain on Soil Surface

During construction, reduce the force of falling rain on the soil surface by mulching with materials such as straw, nettings or other products. See MULCHING BMP. Use permeable chemical co-polymers that bind the surface. Long-term stabilization can be achieved on some slopes with vegetation. However, a vegetative cover must be maintained or established to meet the criteria in the SEEDING BMP & TREES, SHRUBS, VINES AND GROUND COVER BMP.

Overland Flow Velocities

During construction, reduce overland flow velocities by using temporary cross slope permeable barriers (berms) made from hay bales, filter fabric, wood waste compost/bark or field stone. See SEDIMENT BARRIER BMP- Filter Berm. Long-term stabilization can be achieved by roughening the soil surface by tillage or "tracking" and by decreasing the slopes through land grading. Slope lengths can be decreased by use of permanent cross slope diversions or berms. See HILLSIDE DIVERSION BMP.

Overland Flow Resistance

Increase the resistance to overland flow by roughening the soil surface through tillage or covering the soil surface with sod, stone, or interlocking blocks appropriate for this use

Subsurface Seepage

Decrease soil softening from subsurface seepage by use of an underground drainage system of tile or if seepage is shallow, with surface ditches or swales built into planned berms. See HILLSIDE DIVERSION BMP & DITCH/SWALE BMP

WAVE ACTION

Erosion from wave action at the toe of slopes adjacent to bodies of water such as lakes, ponds, rivers, estuaries, or the ocean should be prevented. The protection of the toe of slopes from the erosive forces of waves using structural/vegetative methods can take many forms. The references most used for slope protection are listed below. These Corps of Engineers manuals contain many options.

It is very difficult to vegetate slopes along shorelines within normal high water. The area above the top of the rock (set at the normal high water) should be vegetated with native grasses, shrubs, and trees as quickly as possible.

HIGH VELOCITY FLOWS AT TOE OF SLOPE

Erosion from high velocity flowing water at the toe of slopes adjacent to streams and rivers must also be prevented. One needs to determine the design velocity, the design height of riprap, and whether the stream bed is aggrading or degrading.

One needs to remember that the velocity in the stream continues to increase with increasing depth of flows. The rate of increase in flow velocity drops off once the water goes above the top of the low bank and has access to the adjacent flood plain.

In general on most small streams and rivers in the northeast, the low banks are at the height of the 2 to 5 yr. storm, making it inappropriate to "partially" riprap any low bank. This is primarily because shrubbery does not have adequate time to mature before being exposed to higher flows and the resistance of the shrubs to velocity may be exceeded at their particular stage of growth. If the project is on the outside high bank of the stream cross section, then placing stone up to the 25 -100 yr. flood or 1 to 2 feet above the opposite flood plain is desirable. The probability is high that heavy shrub growth above this level will exist before high flows are experienced.

Vegetation is possible on riprap slopes. Over time, sediment and debris from flooding may be deposited within the riprap, and any seed that has been transported as well may find the riprap a suitable environment in which to grow. Hydroseeding the riprap is also a possibility if vegetation is needed sooner. The thermal effects of riprap on adjacent water bodies can be a major fisheries concern, therefore, whenever possible the riprap slopes in these areas should be vegetated.

Maintenance of Slope Stabilization:

During construction, the slope should be protected adequately from erosion as described in the MULCHING and SEEDING BMPs as well as protected from excessive water flowing over the surface as described in the DIVERSION BMP. When the slope is in the initial stages of establishing vegetation, inspections should be completed after heavy rainfalls. Once established, slopes should be inspected periodically after the spring thaw. All evidence of erosion or slope failure should be corrected immediately to prevent catastrophic slope failure.

REFERENCES:

1. Low Cost Shore Protection . . . a Guide for Engineers and Contractors, 1981. US Army Corps of Engineers.

2. Low Cost Shore Protection . . . a Property Owner's guide, US Army Corps of Engineers, 1981.

3. Low Cost Shore Protection . . . a Guide for Local Government Officials, 1981.

4. A. R. Jumikis, "Soil Mechanics", D. Van Nostrand Company, Inc., New York, 1962. (for beginning courses)

5. A.R. Jumikis, "Mechanics of Soils", D. Van Nostrand Company, Inc., New York, 1964. (for advanced courses)

6. S.J. Goldman, K. Jackson, T.A. Bursztynsky, EROSION & SEDIMENT CONTROL HANDBOOK, McGraw-Hill Book Co., New York, 1986.

7. L.D. Baver, SOIL PHYSICS, John Wiley & sons, Inc. New York, 1961.

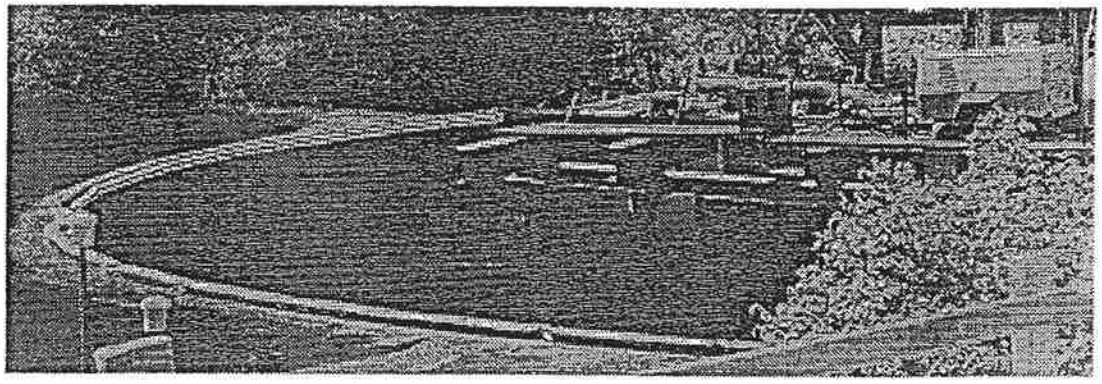
8. "Soil Bioengineering for Upland Slope Protection and Erosion Reduction", USDA-SCS, 1992.

9. "Predicting Rainfall Erosion Losses", Agricultural Handbook #537, USDA-SCS, 1978

18. FLOATING BOOM SUPPORTED SILT FENCE

What is It?

A floating boom supported silt fence is a temporary silt fence barrier that is installed in the water, supported by a flotation boom and utilizes weighting devices to hold the fence in an approximately vertical submerged position from the surface of the water to the design depth. Its primary purpose is to intercept and retain small amounts of sediment resulting from erosion of upslope disturbed areas that has reached the body of water and to intercept and retain sediment resulting from in-water work.



When and Where To Use It:

Floating boom supported silt fence should be installed prior to in-water work activities or any work adjacent to a body of water where sediment from erosion could enter the water. In the case of work within streams such as cofferdams for piers, the silt fence should surround the work area to form a pocket for sediment settling. Floating boom supported silt fence should never be placed across flowing water.

What to Consider:

- Floating boom supported silt fence is effective only if installed correctly and maintained properly.

- Floating boom supported silt fence should be installed so the current in the body of water will not flow directly into the floating boom supported silt fence. This can cause the entire depth of the fence to float on the surface in spite of the weighted bottom or force the water to flow downward under the fence, which may cause streambed erosion .

- A continuous weight shall be placed the entire length of the bottom of the fence to maintain the fence in a vertical submerged position.

- Anchors shall be placed at the ends of the fence, and at intermediate locations if necessary, to hold the fence securely in place.

- Floating boom supported silt fence does not keep sediments out of the waterbody. It forms a barrier between a pocket of water surrounding the work area, where sediment is allowed to settle out and become part of the natural stream bed, and the main water body. Once the silt fence is out of the water, the sediment will move downstream along with natural sediment during future storm events.

- Floating boom supported silt fence may be used for periods of 60 days or longer depending on ultraviolet stability and manufacturer's recommendations.

- Floating boom supported silt fence should be left in place for 24 hours after disturbance has ceased to allow for settling of sediment.

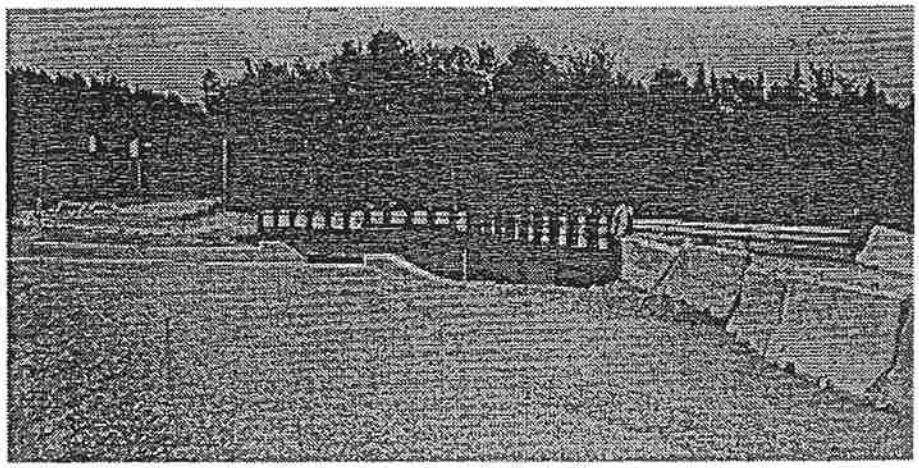
Maintenance/Performance of Silt Boom:

Floating boom supported silt fence requires frequent inspection and maintenance to be effective. It must be inspected on windy days, after large rain events and when there are other construction activities in the vicinity of the floating silt fence. Any damaged areas of silt fence shall be repaired or replaced immediately.

19. TEMPORARY STREAM CROSSING

What Is It?

A temporary stream crossing is a structure placed across or in a stream to provide safe, pollution-free access across a waterway for construction equipment and the general public. The two standard types of temporary stream crossings are bridges and culverts. Temporary stream crossings are necessary to prevent construction equipment from damaging the waterway, blocking fish passage, and tracking sediment and other pollutants into the water.



When And Where To Use It:

This measure is applicable for all waterways on a project site which must be traversed by construction equipment or the general public.

What To Consider:

- See STANDARD DETAILS 600(29) and 600(30) for information on bridges and culverts.

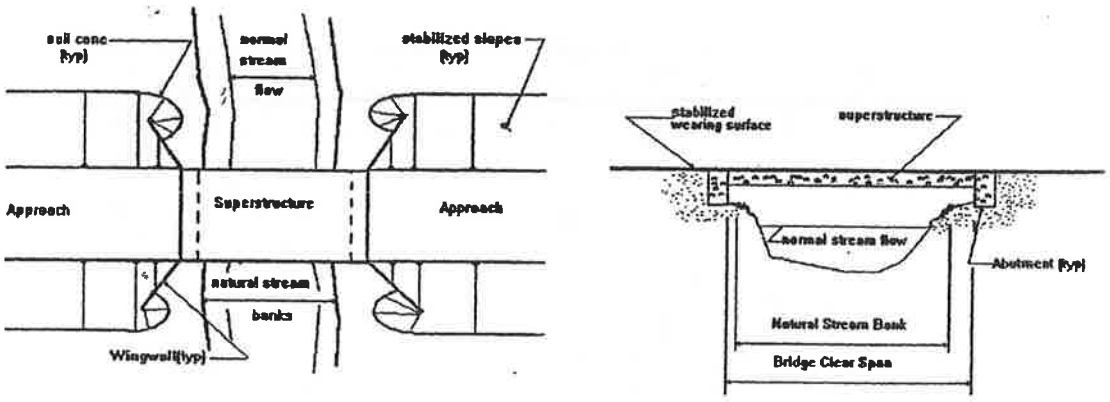
- These structures should be in service for the shortest practical period of time and should be removed as soon as their function is completed.
- These structures maybe subject to regulation by State and Federal agencies.

- The installation of these structures may cause some erosion and movement of sediment due to the disturbance of the stream banks and bottom substrate. If in-stream excavation is necessary to install the temporary stream crossings described in this section, a cofferdam may be necessary in sensitive waterbodies.
- Placement of the temporary structures should be to mimimize or avoid disturbance to wetlands and other natural habitats.

- Fish Passage: Temporary bridges have less potential then do culverts for creating barriers to fish.

- Use paved approaches in sensitive watersheds.
- There may be instances where bridges that completely span waterways will be required instead of culverts.

Design Standards:



Temporary Stream crossings shall be designed according to the following specifications. Approach fills shall be placed on a Geotextile to facilitate removal. Temporary bridge structures shall be designed to pass a minimum of a Q_{10} flood with a maximum backwater of 300 mm. Upstream structure elevations shall be checked for any backwater elevation changes. Temporary Stream Crossing designs shall be submitted to the Construction Manager or, in the case of Maintenance projects, the Assistant Division Engineer, for approval. Temporary Stream Crossing see VTrans STANDARD SPECIFICATIONS Section 528

TEMPORARY BRIDGE:

- There will normally be no time restrictions placed on the construction, use or removal of a temporary bridge where no instream work occurs since the effects on the stream or fish are minimal.
- Bridges should be constructed to span the entire channel whenever possible. No footing, pier or bridge support will be permitted within the channel for waterways less than 2.5 m wide.
- All areas disturbed during the installation of the temporary bridge will be stabilized in accordance with the Slope Stabilization BMP, and/or Sediment Barrier BMP, and others as appropriate.
- Sediment Barriers are to remain in place until all areas disturbed during the removal of the bridge are stabilized.

TEMPORARY CULVERT:

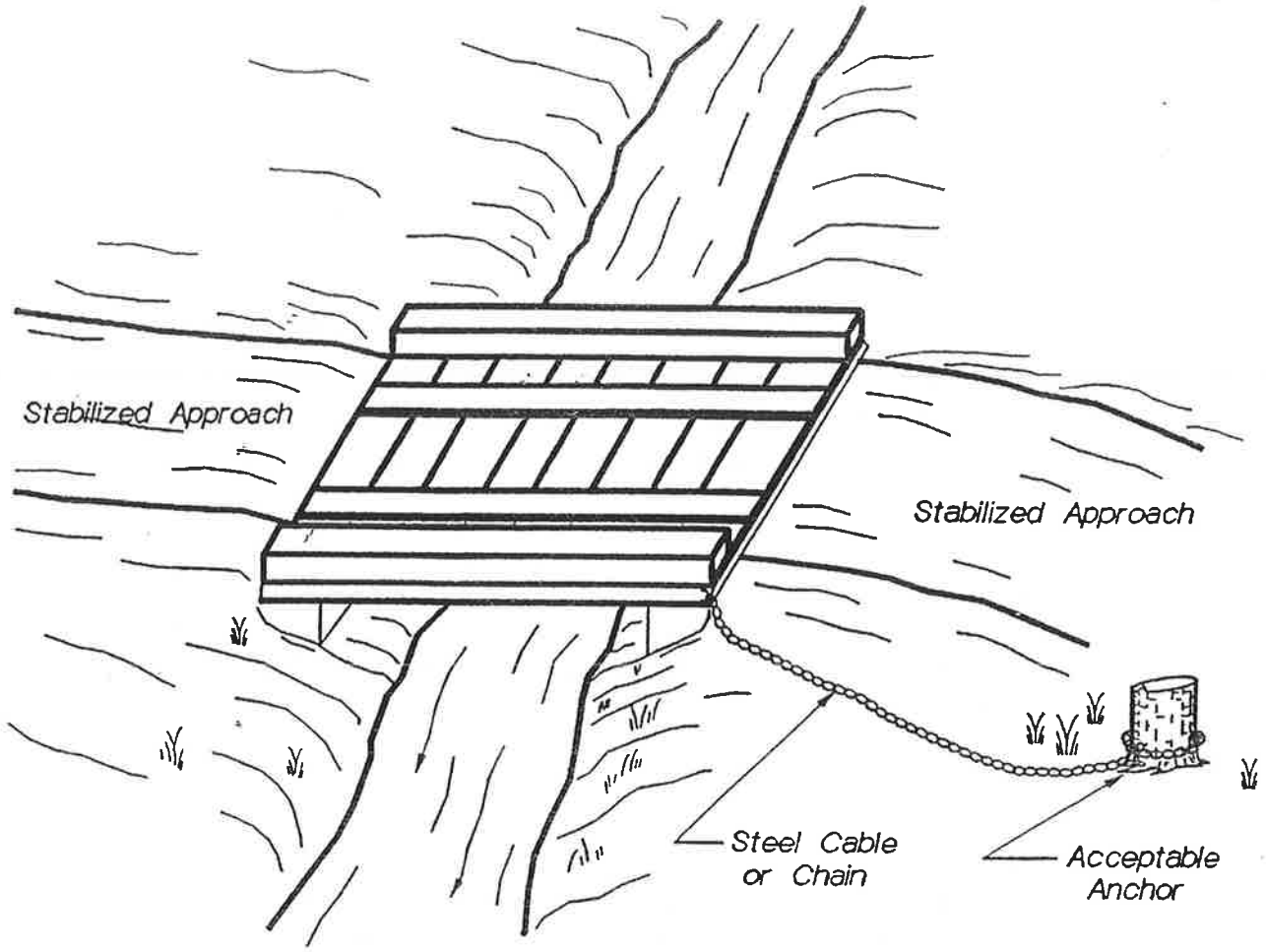
This structure consists of circular pipes, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, to convey slow moving water through the crossing.

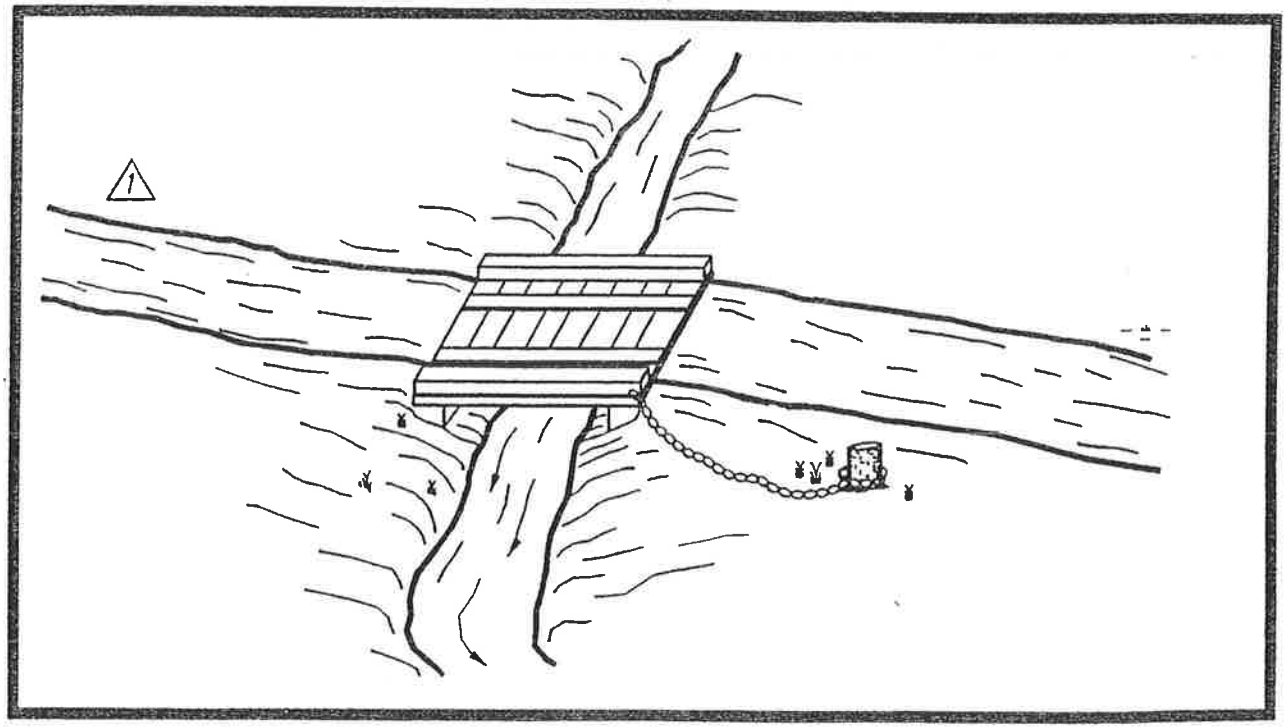
- The culvert may need to be placed 150 mm below the streambed elevation for fish passage.
- A permit from Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division is required to install and remove a temporary access culvert.

- When the culvert has served its purpose and flow has been returned to the original channel, all materials used to construct the crossing shall be removed within 14 calendar days and the original stream channel will be restored and all disturbed areas stabilized.

Maintenance/Performance of Temporary Stream Crossings:

All temporary stream crossings are to be inspected periodically and before, during and after storm events to ensure that the structure is not damaged, that sediment is not entering the stream, and that there are no obstructions to fish passage. Maintenance includes the removal and disposal of any accumulated sediment or debris from the structure to an area outside of the floodplain that is stabilized and not a wetland. Debris may be placed within the floodplain if a permit is acquired.

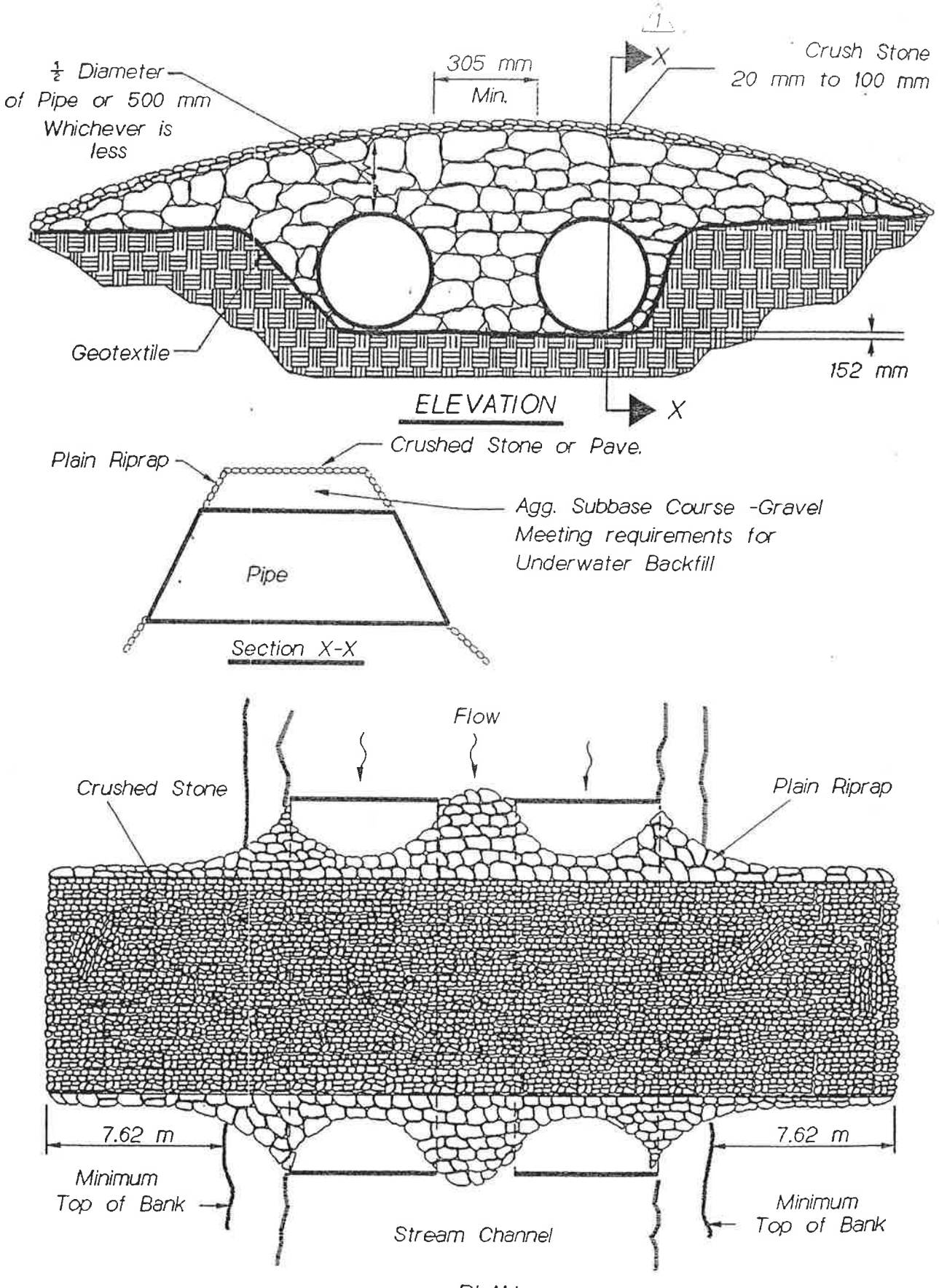




REF: Best Management Practice for Erosion and Sediment Control - Temporary Stream Crossing

Temporary Bridge

600(29)



REF: Best Management Practice for Erosion and Sediment Control - Temporary Stream Crossing

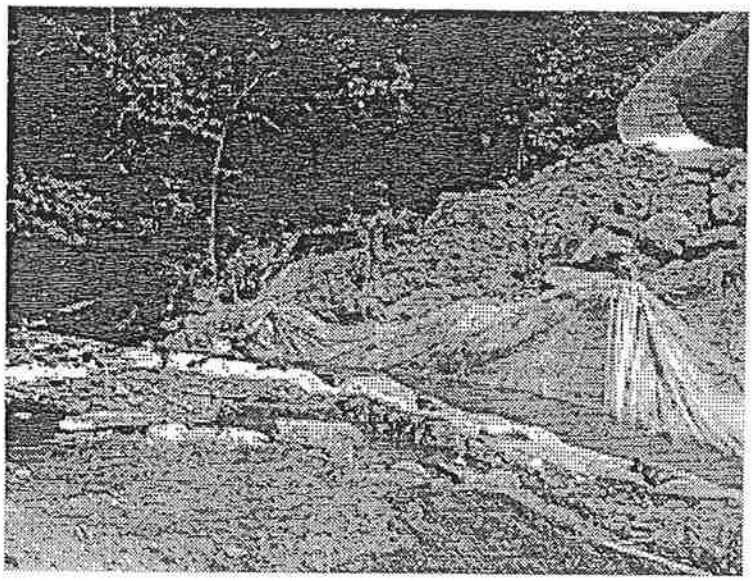
Temporary Culvert

600(30)

20. TEMPORARY STREAM DIVERSION

What Is It?

This practice is defined as the diverting of the base flow of a perennial or intermittent stream around a construction area by use of a conduit or small diversion ditch. This allows the installation of a structure in a stream with minimal impact on stream turbidity and/or pH. Work can be done under relatively dry conditions after dewatering the construction area.



Where and When to Use Them:

This practice applies where flows are low enough to allow normal base flows to be handled in a hose, pipe or small diversion channel. It is intended for use in a perennial or intermittent stream during low flow conditions. For projects involving larger streams or rivers that are expected to be under construction for a long period of time, more permanent, engineered structures will be needed.

What To Consider:

- See **TEMPORARY STREAM DIVERSON STANDARD DETAIL 600(27)**
- The diverted flow should be directed back to the same stream channel downstream of the work area to preserve aquatic life.
- Timing of the installation of temporary stream diversions is critical to minimize impacts on fisheries. There are critical time periods for various fish species that may limit when in-stream work can be done. The amount of in-stream work allowed during these periods will be determined on a project by project basis.
  Contact Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division

- Stream velocity will be maintained at a rate similar to existing flow conditions.
- The diversion will be completely constructed and stabilized before the stream is diverted into it and work begins with special attention to the entrance and exit of the diversion.
- The stream should not be diverted until all necessary equipment and materials are on site so the work can proceed quickly and without delay.
- When the diversion is to be in place for more than two weeks, care should be taken to minimize the angle of the entrance and exit to reduce erosion potential.

Design Standards:

- The construction of any specific temporary stream diversion shall not cause backwater above normal flow (upstream structures should be checked for backwater flooding).

1. *Sand Bag - Conduit (pumped or gravity) Diversion*: See COFFERDAM BMP.
2. *Fabric-Based Channel Diversion:* This practice is limited to streams which drain areas less than 2.6 km^2 The channel should be designed to handle the 2 year storm event as a minimum. All erosion and sediment control devices shall be installed as the first order of work. Make sure the area is stabilized so that erosion will not occur downstream.

Excavation Of The Channel: All excavated materials must be stockpiled outside the flood plain, away from specified buffer areas or wetlands, and temporarily mulched and enclosed with a sedimentation barrier to prevent stockpiled material from entering the stream or channel.

Lining The Channel:

- Streams that flow at a rate of 4 m/s or less during the 2 year storm event should be lined with geotextile meeting the requirements of Standard Specification Sub-Section 722.03, Erosion Control Geotextile, Class A. The geotextile shall extend to the tops of the temporary stream diversion and shall be entrenched along with the silt fence. Rip rap shall be placed, as necessary, in the channel to hold the fabric in place.
- Streams that flow at a rate greater than 4 m/s during a 2 year storm event will be lined with a geotextile and anchored with plain rip rap
  (see VTrans Standard Specification 613)
- The geotextile shall be placed such that one piece will line the entire channel, if feasible. If this is not possible, fabric shall be placed from downstream to upstream

so that 600 mm minimum overlaps occur. Longitudinal overlaps are not allowed.

- The fabric will keyed into 600 mm by 600 mm trenches located at the upstream edge of the last section of fabric, and at 15 m intervals (the overlap nearest each 15 m interval). The key-in is from the top of the channel on one side across to the top of the channel on the other side. Rip rap, if applicable, is carefully placed into the trench.

- If the channel is not to be lined with rip rap, the fabric sections shall be secured with hold down pins and washers (450 mm in length minimum and 25 mm minimum diameter respectively). Overlaps shall be pinned along the transverse and longitudinal axes with a 900 mm maximum spacing.

Installing the Cofferdams: The cofferdams (called Temporary Diversion Plugs in the Standard Details) should be constructed in accordance with the COFFERDAM BMP Design Standards.

Cofferdam Sedimentation Basin: Once the upstream and downstream dams are in place and the stream has been successfully diverted through the temporary channel, the construction area can be dewatered. The water pumped from the construction area will be pumped into a cofferdam sedimentation basin to allow the sediment to settle. The sediment-laden water from the construction area must not be allowed to enter directly into the channel or the stream. (See Cofferdam Sedimentation Basin BMP.)

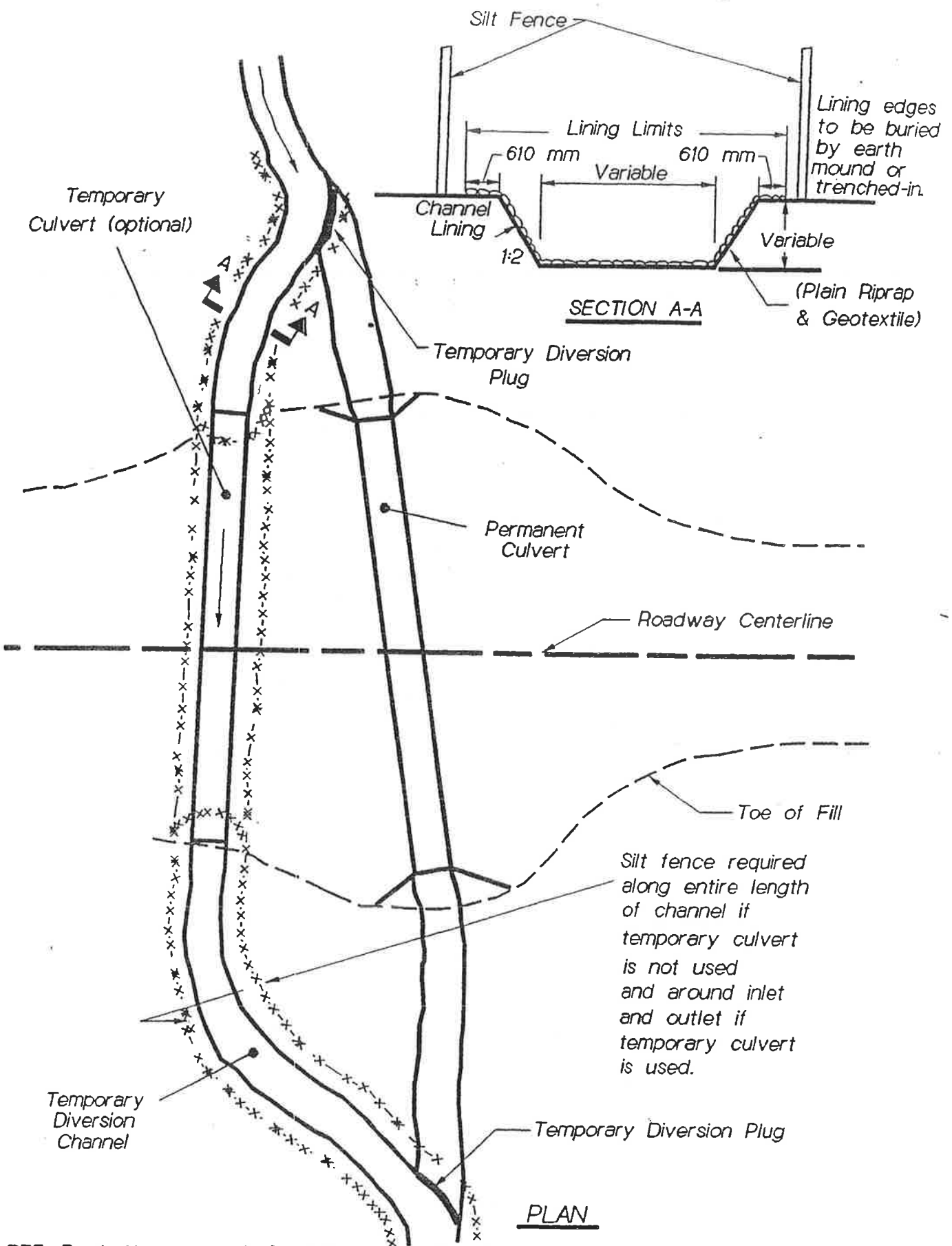
Removal of Temporary Stream Diversions: Water shall not be diverted back into the Construction Zone until all construction has been completed and disturbed areas stabilized. Once flow is resumed through the natural stream bed, the temporary diversion channel shall be backfilled and stabilized. Points of tie-in to the natural channel will also be stabilized. (See the Slope Stabilization BMP for Information)

Maintenance/Performance of Temporary Stream Diversions:

- Periodic Inspection must be performed daily and before, during and after storm events to ensure that the structure is maintained and not damaged, that sediment is not entering the stream and blocking fish passage.

- Sediment or debris trapped in the structure must be removed and disposed of outside the flood plain, wetlands and buffer areas in an approved disposal site or fill area and then stabilized.

- If major storm events are expected, emergency measures must be taken to minimize damage, such as increasing the capacity of the channel using sandbag levees to extend the height of the sides of the channel, or the application of additional rip rap protection.



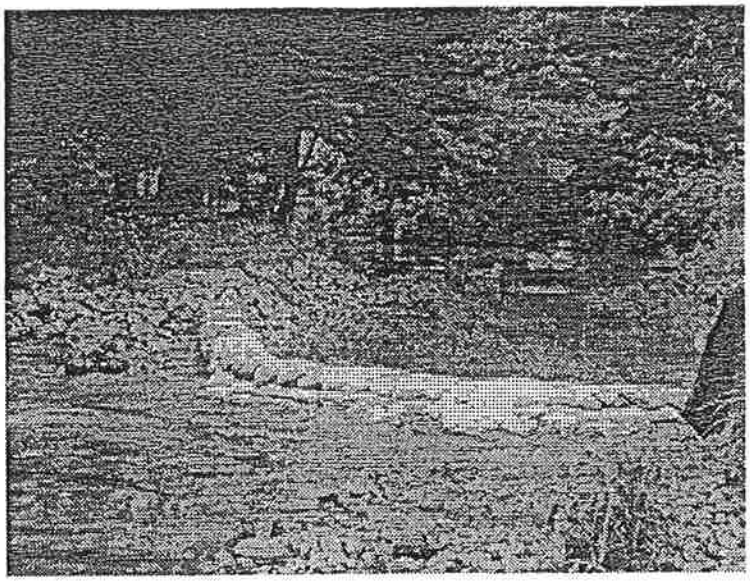
REF: Best Management Practice for Erosion and Sediment Control - Temporary Stream Diversion

Temporary Stream Diversion

21. SANDBAG COFFERDAM

What Is It?

A temporary measure used to dewater and divert water around a work area. This allows the installation of a structure in a stream with minimal stream turbidity impacts. This BMP is used in conjunction with the TEMPORARY STREAM DIVERSION BMP and the COFFERDAM SEDIMENTATION BASIN BMP.



Where and When To Use It:

This practice is used when is it necessary to divert base flow of a stream around the instream work area of a construction project. It keeps the work area dry so that sediments do not reach the water resource. It can be used across the stream bed so that the entire area is kept dry, or used on one side of the stream or river so base flow is maintained through the stream, or can be a cell around a pier in the middle of a stream. This type of cofferdam works best in low flow conditions.

What to Consider:

- Stream velocity, below the cofferdam, shall be maintained at a rate similar to existing flow conditions, above the cofferdam. If the cofferdam is placed across the stream the water shall be pumped downstream below the work area.

- Timing of the installation of cofferdams and all temporary stream diversions is critical to minimize impacts on fisheries. Cofferdams cannot be used across a stream bed at times when fish passage is an issue.
  Contact Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division
- Because the potential for washout is high, the cofferdam must be carefully monitored, and must not be left unattended for any 24 hour period. Weather reports must be followed to be sure storm events will not destroy it. If a storm event is expected, the site must be stabilized in preparation for it.

- Turbid water within the cofferdam should be pumped into a cofferdam sedimentation basin.

- When using this measure across a stream channel it may be necessary to install one cofferdam upstream and another downstream of the work area to prevent water from entering the work area.

Design Standards:

In general, sand bag cofferdams are used when the contributing drainage area is less than 2.6 km^2.

Sand Bag Cofferdams:

Sand Bag Material: Sand bag shall be polypropylene, polyethylene or polyamide woven fabric, minimum unit weight 135 grams per square meter, mullen burst strength exceeding 2,070 kPa and ultraviolet stability exceeding 70 percent. Use of burlap is not acceptable since it rots, is too porous and deteriorates too easily.

Sand Bag Size: Each sand-filled bag shall have a length of 600 mm to 800 mm , width of 400 mm to 450, thickness of 150 mm to 200 mm, and weight of 40 kg to 55 kg. Bag dimensions are nominal, and may vary based on locally available materials.

Alternative bag sizes shall be submitted to the Town Engineer for approval prior to deployment.

Grade of Sand: All sand bag material shall be coarse sand and gravel, free from deleterious material.

Height of Dam: 460 mm minimum height (1 m maximum), measured from the existing streambed to the top of the berm. Sand bags will be placed to create a low spot within the top of the berm to allow for emergency inflow.

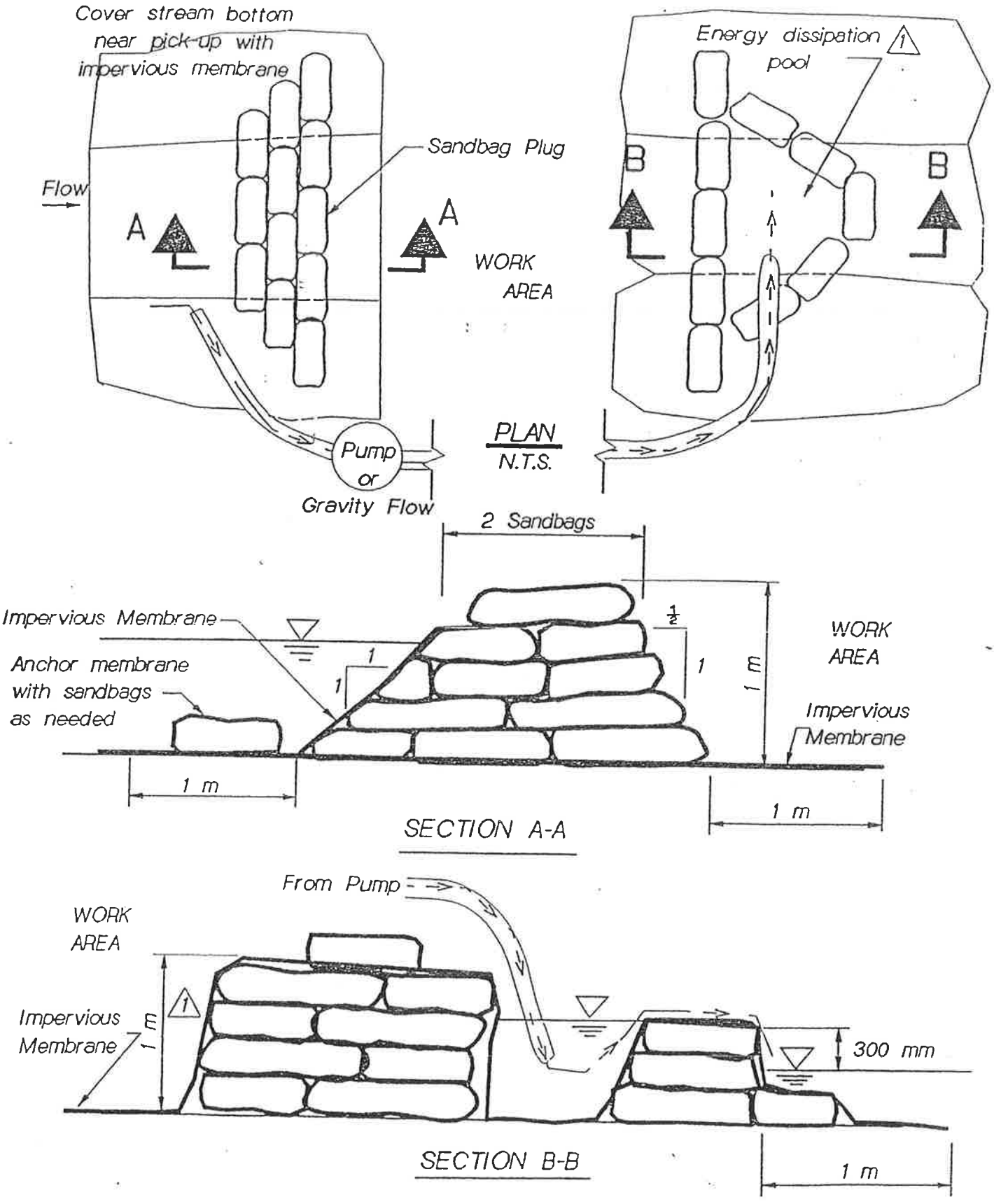
Sand bag cofferdams shall be placed on geotextile to facilitate removal.

Other Cofferdam Types:

Other types of cofferdams including cofferdams over 1 m should be approved by the Town Engineer and the Vermont Agency of Natural Resources, Department of Conservation , Water Quality Division

Maintenance/Performance of Cofferdam:

- Inspect cofferdams for sediment accumulations and remove sediments when the depth reaches one-third of dam height. Dispose of sediments in an approved area and stabilize.
- Inspect before, during and after each rainfall event, and daily throughout use.
- Reshape or replace sand bags as needed.
- Repair washouts or other damage as needed.
- Remove the dam only after accumulated sediments have been removed and disposed of in an approved manner. The sandbags should be removed by hand to prevent breakage and further disturbance of the streambed.
- When using an upstream and downstream dam, remove the downstream dam first.



REF: Best Management Practice for Erosion and Sediment Control - Temporary Stream Diversion

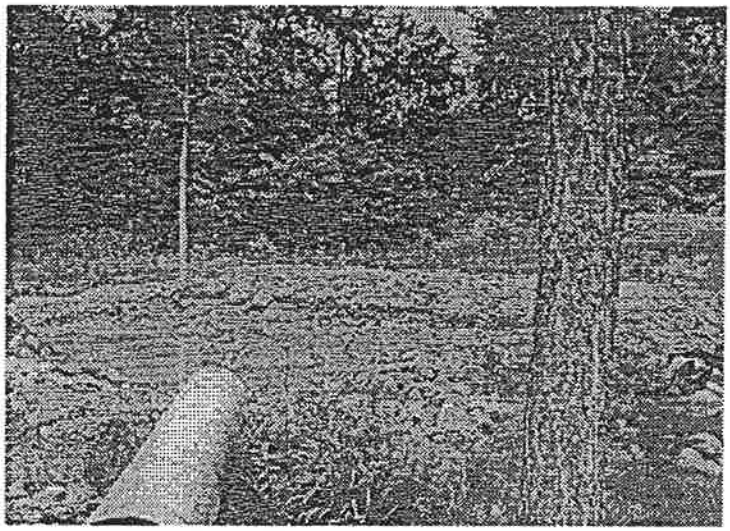
Sandbag Cofferdam Stream Diversion

600(28)

22. COFFERDAM SEDIMENTATION BASIN

What Is It?

A Cofferdam Sedimentation Basin is a water impoundment constructed to collect water pumped from inside a cofferdam or from construction areas being dewatered after a temporary stream diversion is in place. This allows water with high pH or suspended sediments to slowly infiltrate into the soil or evaporate, and prevents sediment from entering the stream or receiving water body.



When And Where To Use It:

This structure is used when pumping water from within a cofferdam, or any other instances where sediment-laden water is being pumped from a construction site and where the release of this water might enter surface water bodies or other environmentally sensitive areas. In addition, it should be used any time water is being pumped that differs in pH from the receiving waters by more than 1 pH unit or would result in pH of 8.5 or more.

What To Consider:

- See **COFFERDAM SEDIMENTATION BASIN STANDARD DETAIL 600(31)**
- Water that comes in contact with fresh Portland Cement Concrete becomes alkaline (increases in pH). Discharge of high pH water into the receiving water body may result in alkaline slug flow capable of killing fish and other aquatic organisms.

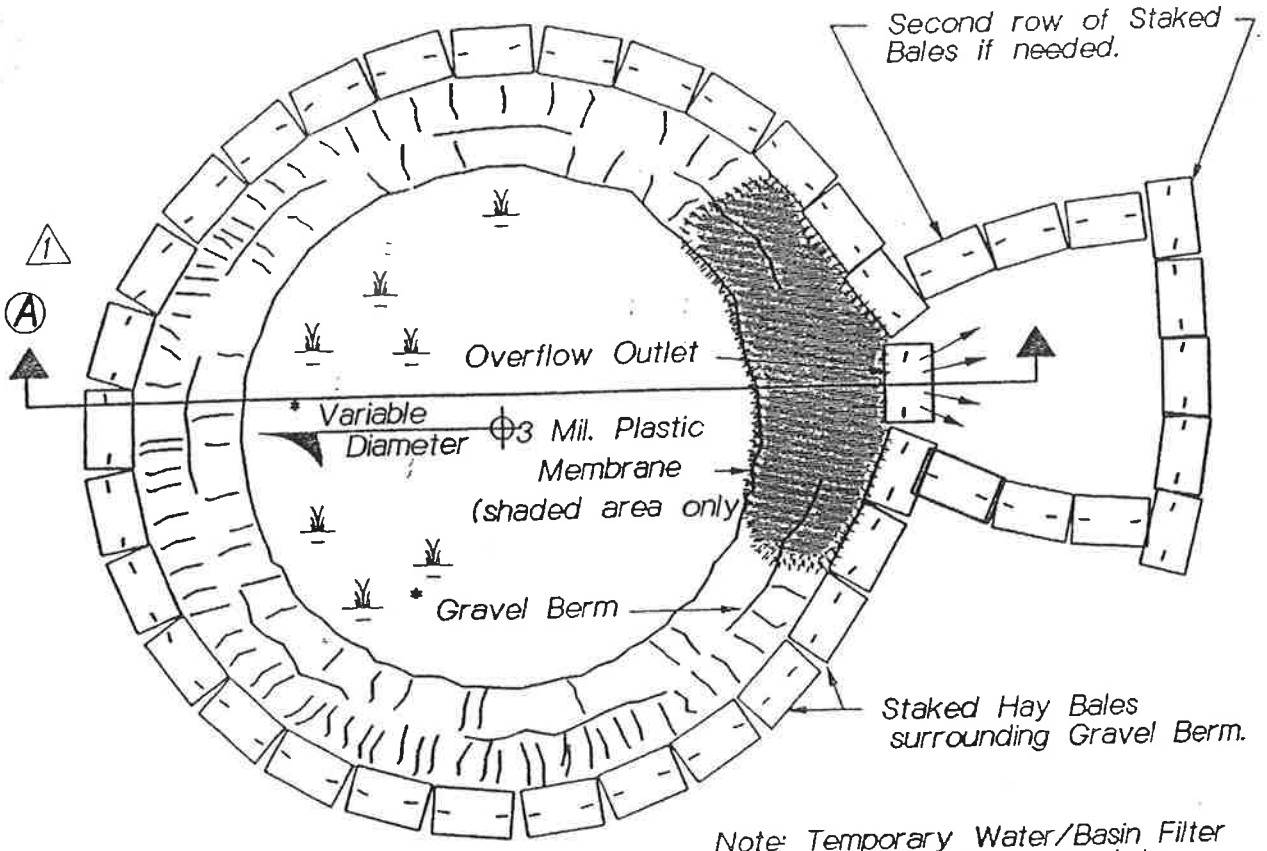
- Most cofferdams will require pumping into an above ground basin. Cofferdam basins must be in place before pumping the cofferdam.
- The size of the basin may require an easement for additional Right of Way during construction and should be anticipated during Right-of-Way acquisitions.
- Discharge side of the pump should be equipped with a check valve.
- The basin should not be installed in environmentally sensitive areas such as wetlands.

Design Standard

- The first goal of designing this measure is to ensure the capacity of the basin will be sufficient to contain all of the pumped water and materials. The rate of infiltration into the earth and through any dikes shall be equal to or greater than the rate of pumping into the basin. When this is not possible to achieve due to frozen ground conditions or limited space available to place this BMP, a series of berms that allow for infiltration through each berm may be used. These must be sized such that water would not overflow the last berm.
- This measure can be designed using sand bags (See Cofferdam BMP for sand bag design criteria), staked hay bales or other materials that can pond and infiltrate water.

Maintenance/Performance of Cofferdam Sedimentation Basins:

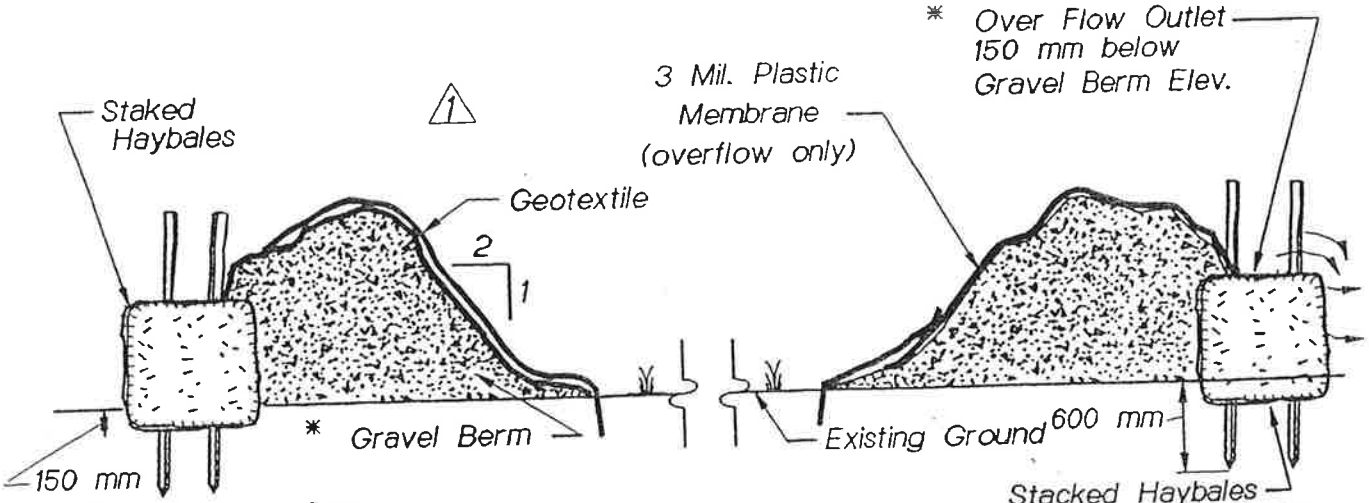
- Basins should be inspected to insure that sediment-laden water does not escape from them and enter the existing water body. Repairs should be made immediately as needed.
- Sediment should be removed from the basin when it is half full. It should be disposed of outside of the flood plain of the water body in an approved disposal area and stabilized.



* Note: Basin dimensions vary with storage capacity needed.

Note: Temporary Water/Basin Filter placed on old ground to allow for percolation into the soil.

PLAN



* Top of Gravel Berm to be 150 mm - 200 mm above the Overflow Outlet elevation.

SECTION (A)

REF: Best Management Practice for Erosion and Sediment Control - Cofferdam Sedimentation Basin

Cofferdam Sedimentation Basin

23. BUFFER AREAS

What Is It?

Buffer areas are vegetated strips of land used for temporary or permanent water quality benefits. Buffer areas are used to assimilate pollutants, provide filtration of stormwater, slow velocity of runoff, prevent erosion, control dust, and provide shade. Buffer areas can be areas of existing vegetation left undisturbed during construction, or they can be newly created.

When And Where To Use Them:

Buffer areas can be used on any site that can support vegetation. They are particularly effective in floodplains, next to wetlands, along stream banks, and adjacent to lakes. Efficiency relates to slope, length and soil type of the buffer.

What to Consider:

- Natural buffers of undisturbed vegetation are especially effective in filtering pollutants from stormwater runoff and should be protected along streams, rivers, tidal waters, as well as in lake and pond watersheds.
- Protection of existing vegetation requires planning. Preservation of existing vegetation is done before any site disturbance begins.
- Buffers are used for stormwater treatment control, not for sedimentation control.

- Buffers are one of the most effective means available for phosphorus pollution control and can be chosen as a Stormwater BMP.

- Establishing new buffer areas requires the establishment of good dense mulch, turf, trees, and shrubs. (See SEEDING and TREES, SHRUBS, VINES, and GROUND COVERS BMPs.) It should be noted that natural buffers are more effective than created buffers.

- A buffer area should be flatter than 1:3 to be fully effective. Steeper slopes will decrease pollutant removal.

- The thickness of the organic layer will improve infiltration of runoff into soils and reduce runoff into resources.

- Runoff must enter a buffer as sheet flow and not channelized flow.

- The minimum buffer width is 7.5 m. The treatment of runoff is increased significantly as the width of the buffer increases up to 75 m.

- Easements may need to be acquired for buffers. Easements would set requirements on the size of the protected area and the extent of thinning that would be allowed in the buffer.

Design Standards

1.) Pretreatment : To prevent a heavy sediment load from damaging the buffer, sites that will have bare soil for a long time can not utilize this BMP without first pretreating the runoff with a sediment control BMP.

2.) Buffer width: Buffer width depends to some extent on the proposed layout, and may be limited by the location of roads, driveways, building sites and suitable septic system locations. Overall site design can be manipulated so as to maximize buffer width while minimizing interference with developed areas. Increasing the buffer width provides greater effectiveness. A minimum width of 7.5 m is recommended to provide phosphorus treatment.

3.) Distribution of runoff over the buffer: To be treated, runoff must enter the buffer as sheet flow and cannot be allowed to channelize. In most cases wooded and non-wooded natural buffers take advantage of the natural microtopography, (the small depressions and mounds of natural ground) to store runoff and allow for maximum infiltration of stormwater. Runoff enters the buffer directly from properly graded road shoulders or through a road ditch turnout with level spreaders (see ROAD DITCH TURNOUT BMP). As a general rule of thumb the drainage area to a buffer area can be twice as large in area. If the drainage area exceeds twice the buffer area, the buffer may be overloaded from the stormwater runoff and not be able to infiltrate or store the runoff.

4.) Buffer vegetation: For buffer strip design and practice in Maine, the following types of vegetation are suggested:

a. Wooded: If the buffer is in a naturally wooded state, including an undisturbed organic duff layer, it is considered "wooded". If the long-term intention for the buffer is to allow it to stay in a wooded state, the buffer can be planted or allowed to revert back to forested conditions so it is considered a "wooded" buffer. A "wooded" buffer used to meet a DEP Stormwater requirement may not be thinned or harvested unless it meets the "Limited Disturbance Standard" described in Appendix B. "Wooded" buffers provide greater uptake and long term retention of runoff and nutrients than non-wooded buffers.

b. Non-wooded: Non-wooded buffers include fields or reverting fields. Examples of non-wooded buffers includes wooded pastures, orchards, hayfields, meadows, managed pasture buffers, and areas of trees from which the ground cover, leaf litter or understory have been removed for landscaping purposes. Non-wooded buffers cannot be managed as lawns and should be mowed infrequently. When mowed, the height should be cropped to not less than 150 mm.

c. Seeded: Seeded buffers include mowed lawns or seeded or sodded areas previously disturbed by construction activity. The limited biomass of these areas restricts their effectiveness for nutrient uptake and retention. The State's phosphorus guidance manual does not recognize treatment factors for seeded buffers, but limited treatment factors are recognized for storm water quality treatment.

When seeding a buffer, a temporary diversion may be required to divert runoff away from the buffer until vegetation is well established. Otherwise, erosion may cause rills that concentrate runoff and short-circuit the buffer. Mulch should also be used to control erosion when establishing vegetation in buffers. See MULCHING BMP and DIVERSIONS BMP.

In order to promote sheet flow into a seeded buffer, the uphill edge of the buffer should be graded level, graded at a uniform gentle slope, or graded at a gentle rounded slope. Any depressions will concentrate runoff and short-circuit the buffer. In some cases, a level spreader can be used to uniformly distribute runoff at the top of the buffer (see LEVEL SPREADER BMP and STANDARD DETAIL 600(45)). Steps should be taken to prevent runoff from bypassing the buffer strip (runoff may travel along the top edge rather than entering the strip). Careful consideration to final grades and an adequately designed and maintained sloped entrance to the buffer strip are important.

5.) Provisions for roadway turnouts: Buffers may be used to intercept runoff from roadways, provided certain design criteria are used. If the road is not ditched on the down slope side, sheet flow from the road may effectively be treated by the buffer. If the road is ditched, ditch turnouts should be provided at intervals along the road. See ROAD DITCH TURNOUT BMP for design information, and STANDARD DETAIL 600(40).

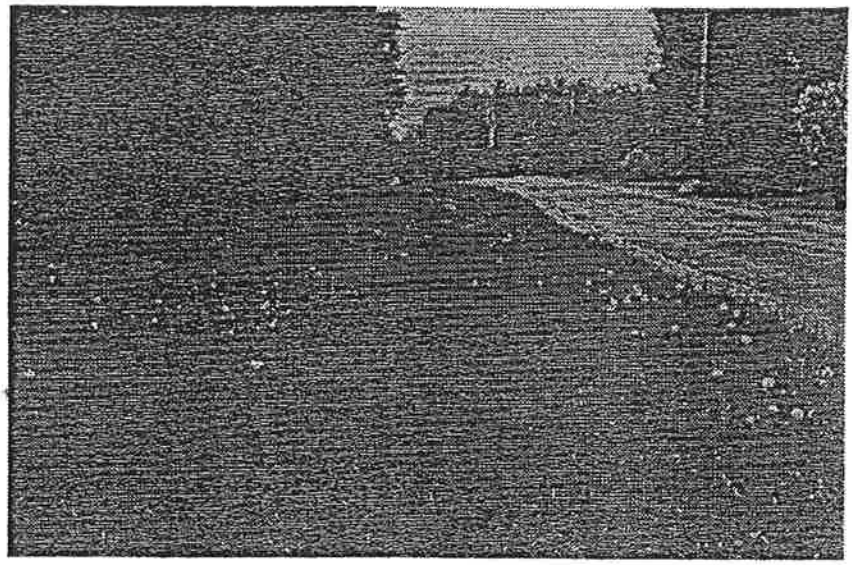
Maintenance/Performance of Buffer Areas:

The maintenance/performance requirements for the Mulching, Seeding and Trees, Vines, Shrubs, and Ground Covers BMPs are applicable to newly planted buffer areas. In addition, buffer areas shall be protected from unintended uses or traffic by signing and/or permanent delineation.

24. VEGETATED SWALE

What Is It?

A vegetated swale is a large vegetated ditch with a dense stand of vegetation that is designed to treat stormwater runoff by settling out sediments and by infiltration.



When and Where to Use It:

Vegetated swales can be incorporated into road ditch systems and are especially helpful to treat stormwater runoff prior to discharge into a stream or other waterbody.

What to Consider:

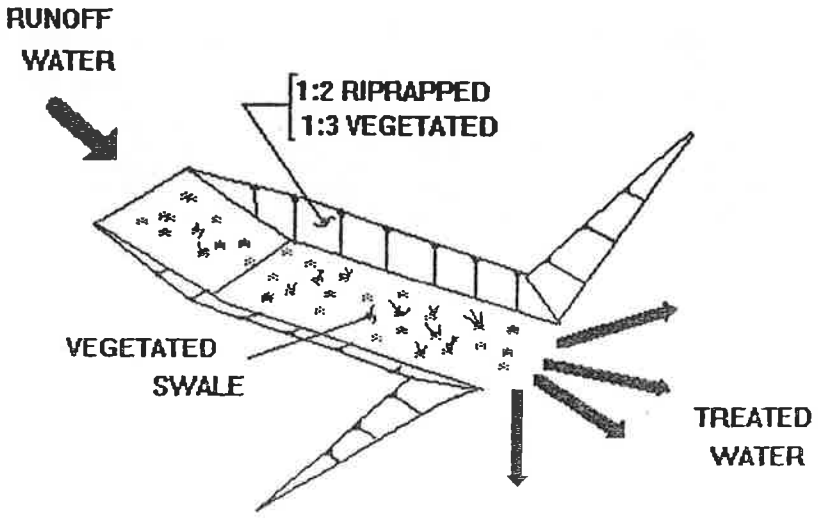
- Vegetated Swales should not be located in wetlands.
- Treatment can be enhanced by installing checkdams and using wider depressions to slow the runoff velocity, promoting settling of more of the fine particles and allowing more time for infiltration to occur.
- Vegetated swales are most effective when the flow depth is shallow and velocities are low. Their usefulness is limited in steep slope areas.
- Vegetated swales should not be located where they will receive stormwater runoff that will pond for extended time periods as this may kill the vegetation, reducing the treatment capability of the swale.
- Vehicular traffic and heavy equipment should not be operated in the swale as this will compact the soils and limit the infiltration rate.

- The swale needs suitable soils to establish and maintain a vigorous stand of vegetation. Hydrologic group A or B soils will be more effective for infiltration, but other soils will provide some treatment through sedimentation. The Soil Conservation Service Soil Survey manuals can be used to determine the hydrologic group and potential restrictions of various soils.

- The vegetated swale must be mowed yearly in order to maintain a healthy, dense stand of vegetation.

- The vegetated swale must be constructed and stabilized prior to receiving any stormwater runoff. All potential flows should be diverted during the establishment of vegetation.

Design Standards:



CHANNEL:

The channel velocity shall not exceed 0.3 meters per second for the Q1.1 design storm or 0.9 meters per second for Q10. Higher velocities could result in resuspension of the sediments. A maximum flow depth of 0.3 meters is recommended.

A trapezoidal cross-section is recommended. The width of the flat bottom of the swale shall be at least three times the swale depth.

The grade of the vegetated swale shall not exceed 2% to meet Stormwater BMP Standards for TSS Removal. The Standards allow for swales to be constructed on grades up to 5% if checkdams are employed (see CHECK DAMS BMP).

The channel sideslopes shall not exceed 1 :3 if vegetated, or 1:2 if properly stabilized with riprap.

VEGETATION:

The effectiveness of the swale depends upon establishment of thick vegetation (see Table 5.1 in the DITCH/SWALE PROTECTION BMP, see also SEEDING BMP).

CHECK DAMS:

The check dam shall be constructed of plain riprap generally 150 to 300 mm (6-12") high, depending upon the grade of the swale and the desired storage capacity. The area just downstream of the check dam may require a protective lining to prevent erosion. Check dams should have a 'V' or notch across the top to allow overflow, preventing erosion at the ends of the check dam (see CHECK DAMS BMP).

Maintenance/Performance of Vegetated Swales

The vegetated swale must be mowed yearly as a minimum. The grass should not be cut too short as this would reduce the filtering capability of the swale. The mowed height of the grass should be 50 to 100 mm above the maximum flow depth, but should never be less than 150 mm.

Routine maintenance involves repair of any eroded areas, reseeding or sodding of bare spots, removal of trash/debris as well as removal of accumulated sediments. Sediments must be removed before permanent damage to the vegetation occurs.

25. LEVEL SPREADER

What Is It?

A level spreader is an outlet constructed at zero grade across a slope. It consists of a vegetated or mechanical structure used to disperse or "spread" concentrated flow thinly over a receiving area. It spreads water as sheet flow so that it does not cause erosion in the receiving area. An additional benefit of a level spreader is to remove pollutants in runoff by filtration, infiltration, absorption, adsorption, and decomposition.

When And Where To Use It:

Level spreaders are used to convert channelized flow to sheet flow so that erosion of the receiving area does not result. There are two types of level spreaders referred to in this manual. Type A, may be used at the lower portion of a ditch turnout where it is desirable or necessary to disperse concentrated runoff onto vegetated buffer areas adjacent to streams, ponds, and lakes. Type B, may be used at pipe outlets when it is desirable to turn channelized flow, into sheet flow. Level spreaders should not be installed at pipe outlets where fish passage is an issue.

What To Consider:

- See **STANDARD DETAIL 600(45)** for information on design and construction of a level spreader.

- The design and construction of the level spreader relates to the velocity and volume of runoff flows (e.g.. high runoff velocity and volume may require riprap instead of vegetation for stabilizing).

- The receiving buffer area must have a topography that is gradual enough to prevent undue flow concentration before entering a stable watercourse.
- The makeup of the soil within the receiving area directly relates to its erodibility.

Design Standard

Level spreaders are relatively new to the Department, therefore the design should be monitored to evaluate possible successes and failures. The spreader should be constructed on undisturbed soil where possible. The lip shall be installed at a 0% grade. Fill shall be well compacted prior to seeding. The 1.1 yr design storm should be used for flow calculations. Sheet flow depth should be no more than 5 mm.

CAPACITY TYPE A (Into Vegetated Buffer)
The flow area upstream of the level spreader should be sufficient to ensure low approach velocities to the level "lip". The minimum cross-sectional flow area of the level spreader

is equal to the cross-sectional area of the delivery channel. A "rule of thumb" for calculating the length of lip required to transfer the flow from concentrated to sheet flow, is 0.023 $m^3/s/m$. That is for every 0.023 m^3/s of flow, there should be 1 m of level lip. The minimum lip length is 3.7 m. The capacity of each spreader shall be based on the allowable velocity for the soil within the receiving area. If the level spreader will be used to facilitate treatment of pollutants in a buffer area, the drainage area served by the spreader can not be more than half the size of the buffer area.

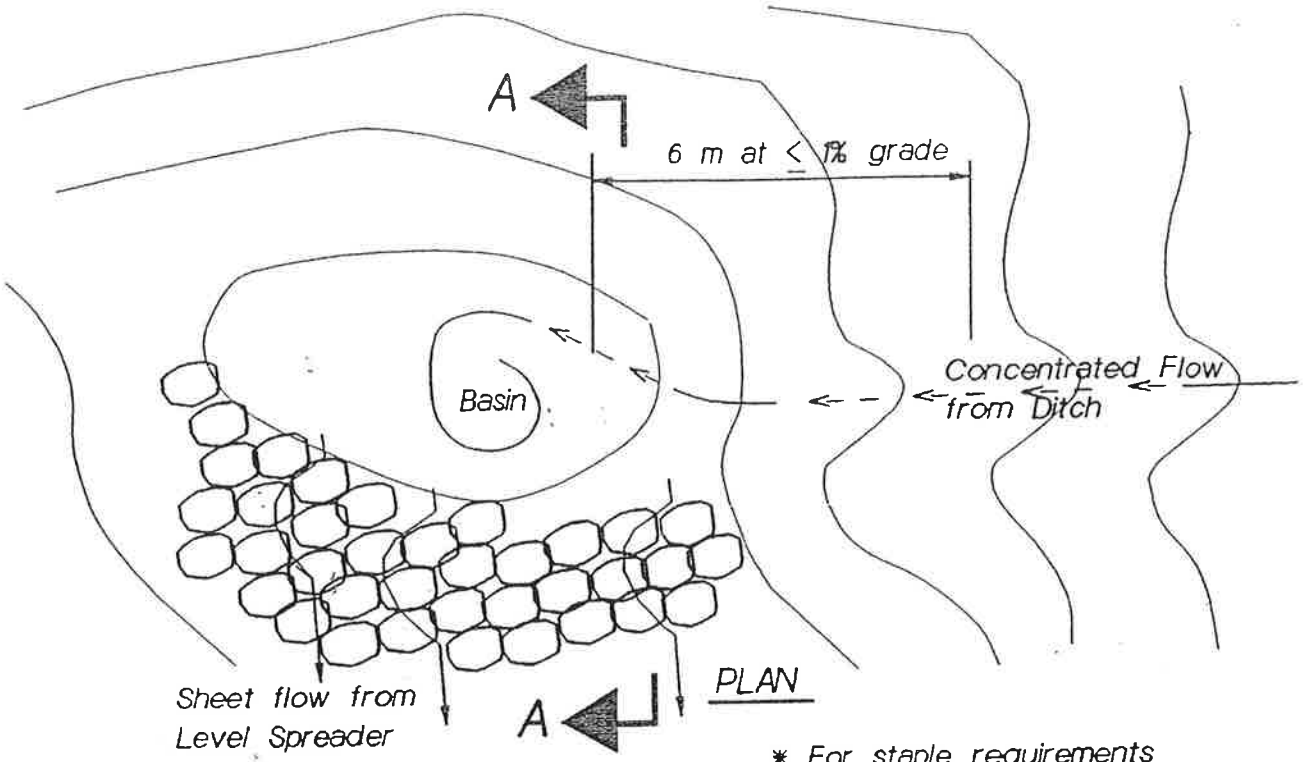
CAPACITY TYPE B (at Pipe Outlet)
The "rule of thumb" for calculating this type of level lip is 0.046 $m^3/s/m$. That is, for every 0.046 m^3/s, there should be 1 m of level lip. This type of spreader should only be constructed of riprap, to prevent any chance of erosion during major storm events.

RECEIVING AREA
The receiving area shall be as flat in cross section perspective as possible to ensure a uniform distribution of flow as otherwise water will cause channelization so the structure will fail. A level spreader shall blend smoothly into the downstream receiving area without any sharp drops or irregularities in order to avoid channelization, turbulence and hydraulic jumps.

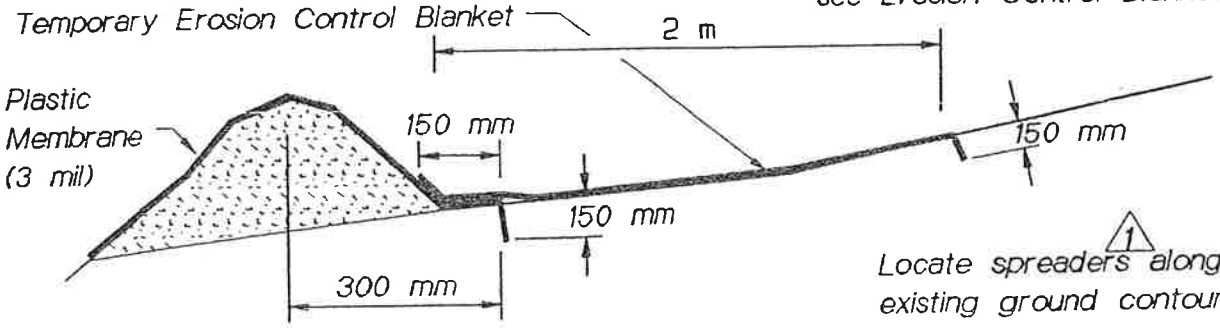
Each level spreader shall have a vegetated receiving area with the capacity to pass the flow without erosion. The receiving area shall be stable prior to the use of the level spreader. If the receiving area is not presently stable, then it should be stabilized in accordance with the SEEDING and EROSION CONTROL BLANKETS BMPs, the BUFFER AREA BMP or the VEGETATED SWALES BMP. In areas where vegetation can't grow, stabilize the receiving area with wood waste compost and appropriate riprap.

Maintenance / Performance of Level Spreaders:

After construction, the level spreader needs to be carefully inspected for any signs of channelization and immediately repaired if channelization exists. The structure will fail if water exits from it in channelized flow. Level spreaders may fill up with winter sand or other settleable solids and these materials must be removed when the spreader is half full or when proper functioning of the structure is inhibited. Any fallen brush should be removed out of the spreader or it will quickly become ineffective.



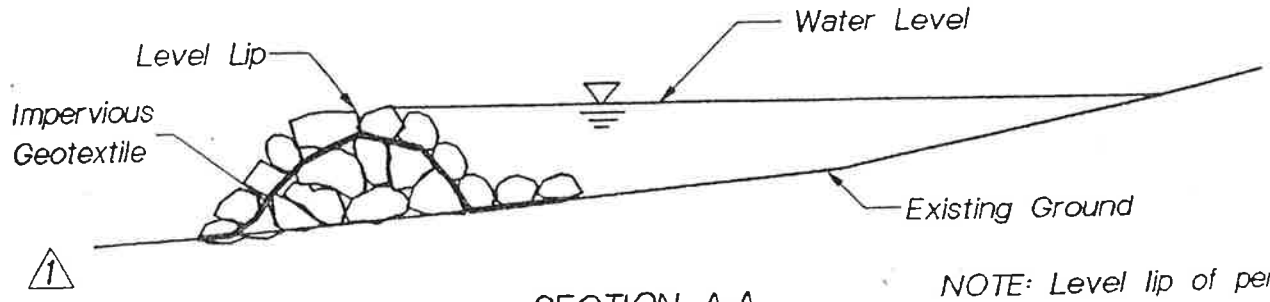
* For staple requirements see Erosion Control Blanket BMP



SECTION A-A
Temporary Geotextile Level Spreader

Locate spreaders along existing ground contours

Existing ground should be minimally disturbed to construct level spreaders.



SECTION A-A
Permanent Riprap Level Spreader

NOTE: Level lip of permanent spreader may be a vegetated earthen berm.

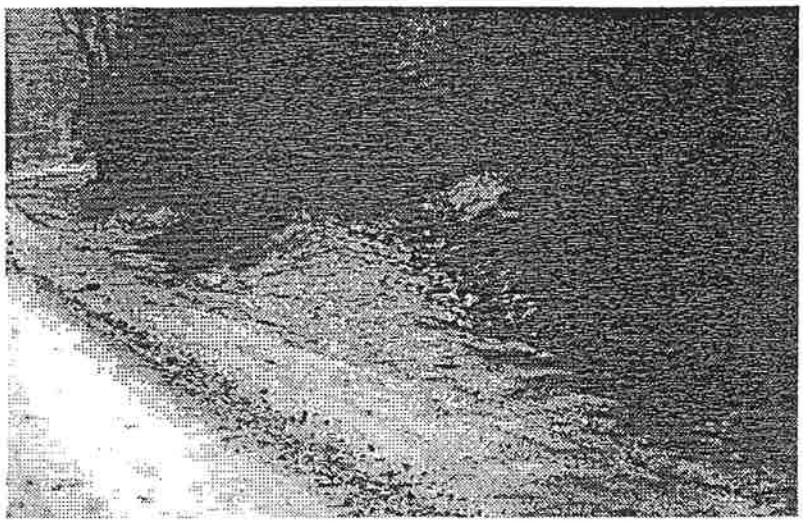
REF: Best Management Practice for Erosion and Sediment Control - Level Spreader

Level Spreader

600(45)

26. ROAD DITCH TURNOUTS

What Is It? Road ditch turnouts consist of a stable ditch, a turnout berm, a ditch sediment trap, a receiving area and an existing natural buffer area. The outlet of the receiving area consists of a combination of stone and existing natural vegetation used to disperse, filter, and spread concentrated flow thinly, as sheet flow, into a buffer area. Turnouts are not intended for sediment removal in the buffer area. The sediment trap prevents the outlet from being filled with sediment and becoming ineffective. Road Ditch Turnouts have been used traditionally to achieve sheet flow into a buffer area for phosphorus removal. However, this BMP was developed to make use of them for erosion control by dividing flow into manageable quantities.



When And Where To Use Them:

- Ditch Turnouts should be used as much as possible but their best use may be on slopes longer than 50 m or greater than 5%, as conditions allow.
- At the lower edge of urban developments where it is desirable or necessary to disperse concentrated runoff onto stable vegetation adjacent to streams, ponds, and lakes and estuaries.
- In urban areas requiring filter strips as part of a management system to treat polluted runoff.

What To Consider:

- See **STANDARD DETAIL 600(40)** for Road Ditch Turnouts.
- If the new project's impervious area is over 0.2 hectares and falls under the DEP-DOT Stormwater Memorandum of Agreement, see Office of Environmental Service's Water Quality Section for help with design of Ditch Turnouts for DEP Phosphorus and TSS removal credits.
- If these structures are not installed correctly they may become a source of erosion.

- Managed use of fertilizer and pesticides to establish and maintain vegetation in ditches or turnout berms is important to maintain efficiency and water quality (See SEEDING BMP).
- Do not direct water towards wellheads, septic systems, residences or vernal pools.
- The receiving area maintains the natural contours across the slope to insure uniform distribution of flow, otherwise water will channelize and the structure will fail.
- Stable vegetated swales should exist below the buffer areas as concentrated flow can be expected to start occurring within 90 m from the discharge point.
- Care should be taken to preserve the undisturbed nature of the vegetation in the natural buffer areas (See BUFFER AREAS BMP).
- Each ditch turnout shall have a stable vegetated area with the capacity to pass the flow without erosion.
- Ditch turnouts should be constructed on undisturbed soil whenever possible.
- The Ditch Sediment Trap should be located close to the roadway to facilitate easy cleaning and maintenance.
- The closer the spacing of Road Ditch Turnouts, the simpler the design of the receiving area will be. This will also create less flow in the ditch which will mean smaller or fewer stones needed to stabilize them. This will result in less cost per turnout and may be the least costly option for the construction and long term maintenance of the project.
- Ditch turnouts only work well if small volumes of runoff drain into the turnout. Otherwise it is likely that the flow volume of the runoff will cause channelization in the buffer. Turnouts should only receive runoff from the road and ditch surface, not from large, uphill watersheds.
- To assure long term viability of the buffer, easements may need to be acquired.

Design Standards:

Road ditch turnouts are composed of the following parts:

TURNOUT BERM:

The turnout berm is stabilized at the same time as the ditch. This can include erosion control blankets and/or vegetation. Side slopes of the berm are no steeper than 1:2 and the minimum height of the berm is 0.6 m. If the peak flow for the turnout, as defined in the equation below, exceeds 0.056 m^3/s, the berm shall be reinforced with geotextile and stone ditch protection. The turnout berm directs the ditch flow to the ditch sediment trap.

DITCH SEDIMENT TRAP:

The ditch sediment trap may consist of a sump, small basin (all shapes), or ditch cells made with check dams along level sections of the trench. The sediment trap directs the flow to the receiving area.

RECEIVING AREA:

The receiving area is where concentrated flow is converted to sheet flow. This is where the various types of turnouts differ from each other. The following Receiving Areas are arranged from the simplest to design, Type A, to the more complicated , Type D. This list also is set up for the amount of drainage each type can handle. Type A handles the least while Type D can handle the most flow into it.

NOTE: Where the receiving area is a seeded buffer, as defined in the BUFFER AREA BMP, it must be built with a sediment trap and according to the standards in the BUFFER AREA BMP.

Riprap Apron System (Type A Turnout);

This system can only be used for a turnout spacing of 45 m or less. It shall be comprised of a 5.0 m long by 2.0 m wide riprap apron. Length shall be in the direction of flow. Aprons shall be 0.6 m deep and as level as is practical as determined by the natural contours of the existing ground. This type of turnout may not require a DITCH SEDIMENT TRAP. This depends on the type and size of the BUFFER AREA. Generally a BUFFER AREA that is at least 20 m long in the direction of flow will not require a trap.

Energy Dissipater & Riprap Apron System (Type B Turnout);

This system is the same as above except as follows. They may be used with designed spacings greater than 45 m as determined by the method described in the upcoming CAPACITY SECTION. They shall also have an Energy Dissipater Device immediately prior to the apron. This device shall be capable of ponding water before entering the apron.

Trench System (Type C Turnout);

A trench shall be constructed along the existing contour that allows the water to gradually flow into the buffer. The trench is typically 4.5 - 6.0 m in length and at least 2.0 m wide across the top. It is typically 1 m deep and shall be filled with French Drain Stone . Erosion control blankets may be used in conjunction with stone. The trench must be constructed to follow the contour.

The trench can also be lined with stone ditch protection and overflow through a stone berm made from French Drain Stone. The stone berm filters the water and allows it to exit in sheet flow. The berm is typically 1.2 m wide by 0.5 m high. The berm must be constructed to follow the contour. This option will facilitate easier maintenance than the stone filled trench.

Level Lip Spreader System (Type C Turnout);

A level lip spreader (see LEVEL SPREADER BMP) can be used after the ditch sediment trap in place of the trench as long as sheet flow is achieved leaving the spreader.

Designed System (Type D Turnout);

A system can be designed to handle concentrated flow over 0.056 m^3/s and convert it to sheet flow. The system can be any combination of the systems described in this section such as a trench system combined with a level lip spreader.

EXISTING BUFFER AREA:

The vegetation in the buffer area must presently be in a stable condition and meet the criteria in the BUFFER AREAS BMP. The buffer area must receive the water in sheet flow.

CAPACITY:

As a good Rule of Thumb, the buffer area should be a minimum of one half the size of the total drainage area draining into it.

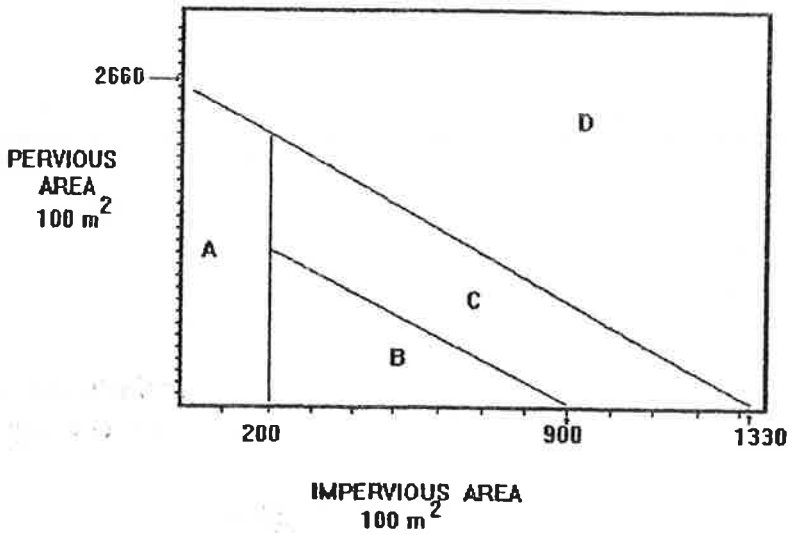
As a general design standard, turnouts should receive no more than 0.056 m^3/s of peak flow. The following formula can be used to calculate the peak flow from a drainage area to a ditch turnout:

$$\text{Peak Flow} = (\text{Impervious Area})(0.000042) + (\text{Pervious Area})(0.000021)$$

$$(m^3/s) = (m^2)\,(m/s) + (m^2)\,(m/s)$$

If the formula yields a peak flow of 0.056 m^3/s or less, the designed turnout spacing is adequate. If the peak flow exceeds 0.056 m^3/s, then the turnout may erode or become ineffective at spreading flow into the buffer. If a turnout must be used when the peak flow exceeds 0.056 m^3/s, additional design criteria and maintenance will be required as detailed throughout this BMP.

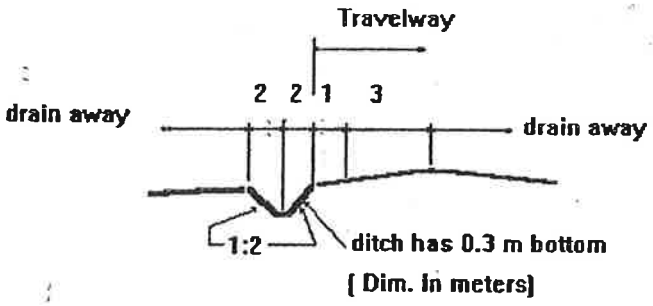
The above formula combined with flow and spacing criteria were used to construct the following nomogragh. This graph can be used to determine what type of turnout is needed as defined in the RECEIVING AREA of the previous section.



The nomograph is used by plotting Pervious Area vs.. Impervious Area. The graphic location of the point tells the designer which type of RECEIVING AREA to use. If the point ends up in "D" or doesn't fit on the graph, the Designer may choose to design a special turnout or reduce the turnout spacing.

EXAMPLE:

The following cross section is on a 900 m down grade.



Choose a spacing >45 m (up to 45 m, a type A is allowed) and determine drainage areas.

Calculate Impervious Area; The spacing of turnouts times the length of road section draining into the ditch equals the impervious area. So in this case, spacing X 4 m.

Calculate Pervious Area; Since it is assumed that no hillside runoff enters the ditch, the spacing of the turnouts times the perimeter of the ditch equals the pervious area. In this case, spacing X 4.77 m. (If there is drainage coming into the ditch it must be added here.)

Plot these areas on the nomogragh and determine what type of turnouts are required with each spacing. Note that there is no one correct answer.

The results of this example are:

Spacing (Estimated)	Pervious Area (Spacing X 4.77)	Impervious Area (Spacing X 4.0)	Type of Turnout (From Nomogragh)
45 m	215 m^2	180 m^2	A
120 m	572 m^2	480 m^2	B
200 m	954 m^2	800 m^2	C

Determine quantity of each type of turnout needed by dividing the length of down grade by the spacing. (this assumes that turnouts can be put where ever designed and not have to be adjusted to fit into the existing contours).

Type of Turnout	Number
A	900/45 = 20
B	900/120 = 8

C 900/200 = 5

The cost of each type of turnout is determined and overall costs can be calculated to determine which option is best.

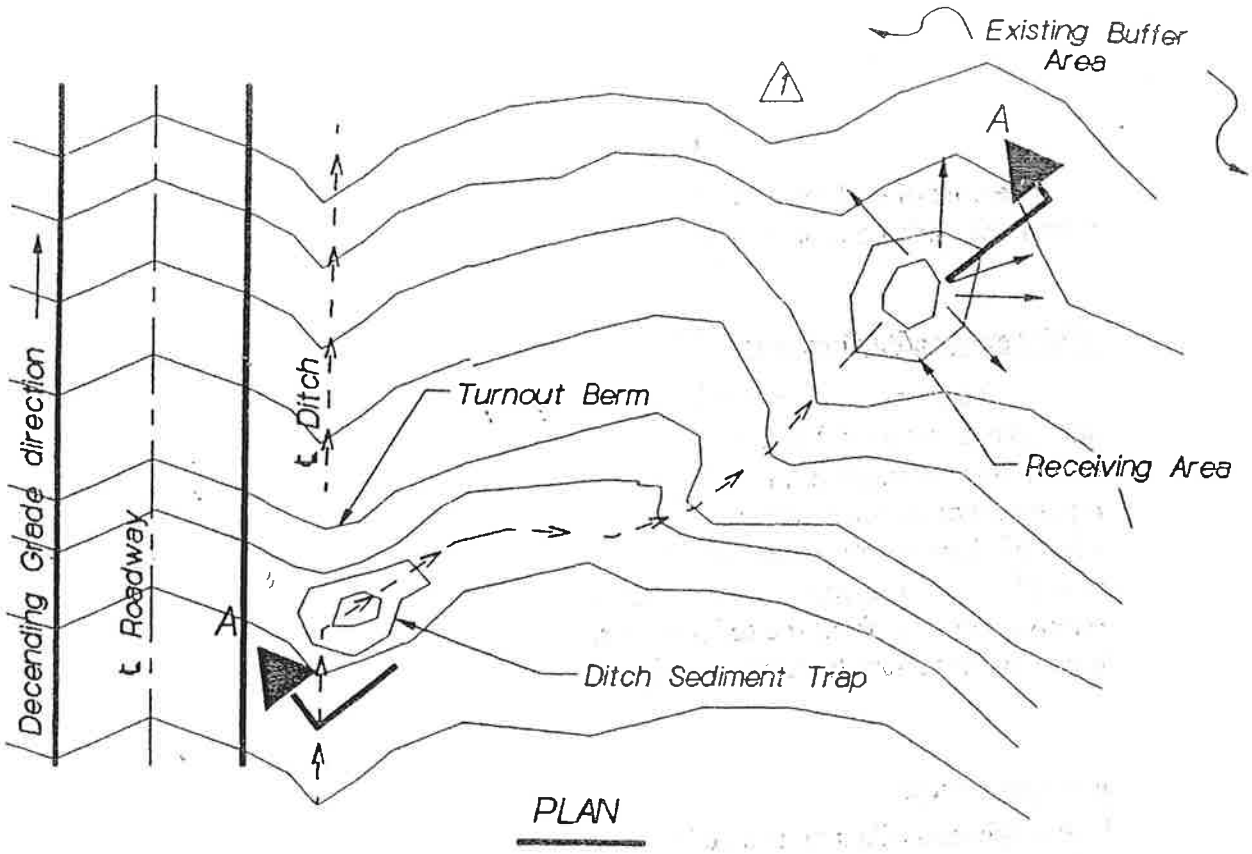
Maintenance/Performance of Road Ditch Turnouts:

Maintenance responsibilities for road ditch turnouts should be coordinated with and agreed to by the Maintenance Division, Town or some other entity prior to installation. Agreement in writing must be reached regarding clean out schedules and repair responsibilities. After construction, road ditch turnouts must be inspected for any signs of channelization, and repaired immediately. This is especially important the first year of use. Structures will fail if water exits in channelized flow. It will be necessary to remove sediment from the sediment trap at least annually. Where flow exceeds 0.056m^3/s, it may be necessary to remove sediment on a more frequent basis.

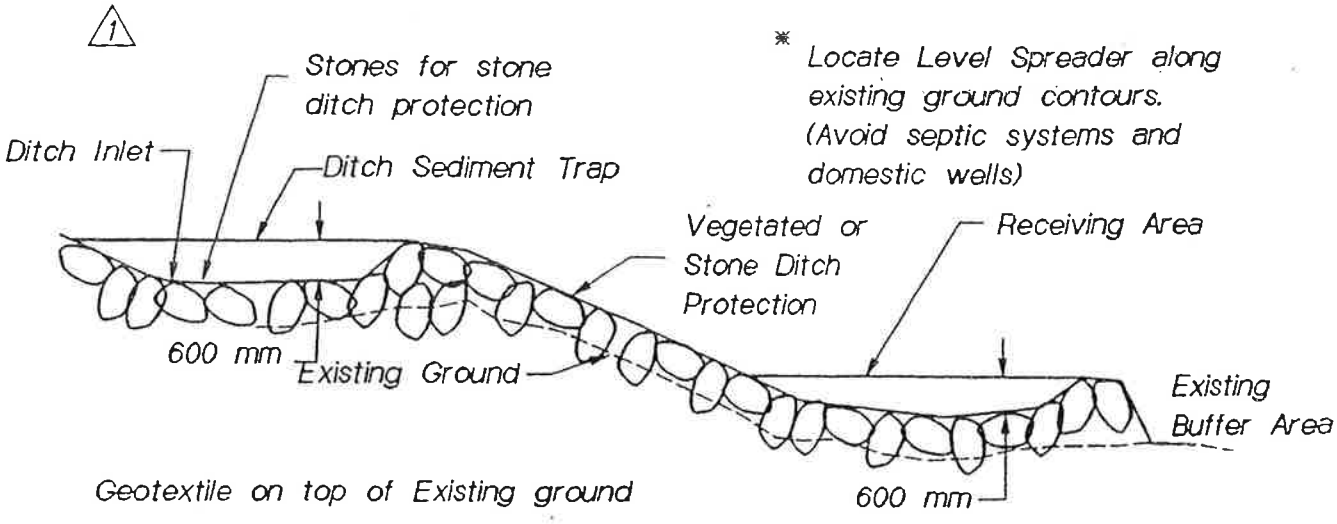
REFERENCES:

[1] "Phosphorous Control in lake Watersheds: A Technical Guide to Evaluating New Development", revision eds. Noel, J., Dennis, J., Dennis, M., and Kuhns, C.. MDEP September 1992.

- The Agency of Natural Resources is developing a new Handbook and guidelines for Storm Water Management



PLAN



SECTION A-A

REF: Best Management Practice for Erosion and Sediment Control - Road Ditch Turnouts

Road Ditch Turnout

600(40)

722.01 Stabilization Geotextile. The geotextile shall have property values expressed in "minimum" or "minimum average roll" values that meet or exceed the values stated below, as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the values stated below.

Woven and nonwoven geotextiles are acceptable and must meet the following requirements:

Geotextile Mechanical Property	Test Method	Minimum Permissable Value
Grab Tensile Strength (both directions)	ASTM D4632 or ASTM D5034 and ASTM D5035	800 N [180 pounds]
Grab Elongation	ASTM D4632 or ASTM D5034 and ASTM 5035	15 percent
Mullen Burst Strength	ASTM D3786 or ASTM D751	2000 kPa [290 psi]
Puncture Strength	Modified ASTM D3787 or modified ASTM D751	330 N [75 pounds]
Trapezoid Tear Strength	ASTM D4533 or ASTM D1117	220 N [50 pounds]

Geotextile Hydraulic Property	Test Method	Permissable Value
Apparent Opening Size (AOS)	CW-02215	Sieves Sizes between 850 µm and 150 µm [U.S. Std. Sieve number(s) between No.20 and No.100]
Permeability	ASTM D4491	0.01 mm/sec

722.02 Drainage Geotextile. The geotextile shall have property values expressed in "minimum" or "minimum average roll" values that meet or exceed the values stated below, as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the values stated below.

Both woven and nonwoven geotextiles are acceptable, however, no "slit-tape" woven fabrics will be permitted. The geotextile must meet the following requirements:

Geotextile Mechanical Property	Test Method	Minimum Permissible Value Class A*	Class B*
Grab Tensile Strength (both directions)	ASTM D4632 or ASTM D5034 and ASTM D5035	800 N [180 pounds]	356 N [80 pounds]
Grab Elongation	ASTM D4632 or ASTM D5034 and ASTM D5035	15 percent	15 percent
Mullen Burst Strength	ASTM D3786 or ASTM D751	2000 kPa [2900 psi]	896 kPa [130 psi]
Puncture Strength Modified or modified	ASTM D 3787 ASTM D751	356 N [80 pounds]	110 N [25 pounds]
Trapezoid Tear Strength	ASTM D4533 or ASTM D1117	220 N [50 pounds]	110 N [25 pounds]

Geotextile Hydraulic Property	Test Method	Permissible Value
Apparent Opening Size (AOS)	CW-02215	Sieves Sizes between 850 µm and 150 µm [U.S. Std. Sieve number(s) between No.20 and No.100]
Permeability	ASTM D4491	0.01 mm/sec

* Class A Drainage applications are those where installation stresses are more severe than Class B applications, such as where very sharp angular aggregate is in contact with the fabric, or a heavy degreed of compaction is required.

* Class B Drainage applications are those where installation stresses are less severe such as where fabric is used with smooth graded surfaces having no sharp angular projections, no sharp angular aggregate is used, or where compaction requirements are light.

722.03 Erosion Control Geotextile. The geotextile shall meet or exceed the values stated below as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the values stated below.

Both woven and nonwoven geotextiles are acceptable, however, no "slit-tape" woven fabrics will be permitted. The geotextile must meet the following requirements:

Geotextile Mechanical Property	Test Method	Minimum Permissible Value Class A*	Class B*
Grab Tensile Strength (both directions)	ASTM D4632 or ASTM D5034 and ASTM D5035	890 N [200 pounds]	400 N [90 pounds]
Grab Elongation	ASTM D4632 or ASTM D5034 and ASTM D5035	15 percent	15 percent
Mullen Burst Strength	ASTM D3786 or ASTM D751	2200 kPa [320 psi]	1000 kPa 145 [psi]
Puncture Strength	Modified ASTM D3787 or modified ASTM D751	356 N [80 pounds]	178 N [40 pounds]
Trapezoid Tear Strength	ASTM D4533 or ASTM D1117	220 N [50 pounds]	130 N [30 pounds]

Geotextile Hydraulic Property	Test Method	Permissible Value
Apparent Opening Size (AOS)	CW-02215	Sieve sizes between 850 µm and 150 µm] [U.S. Std. Sieve number(s) between No.20 and No.100]
Permeability	ASTM D4491	0.01 mm sec

* Class A Erosion control applications are those where installation stresses on the fabric are more severe than Class B such as when no aggregate cushion is used or rock weights are greater than 113 kg [250 pounds].

* Class B Erosion control applications are those where fabric is protected from plain or hand laid riprap or stone ditch protection by a 150 mm [6 inch] thick protective aggregate cushion.

722.04 Reinforcement Geotextile. The geotextile shall have property values expressed in "minimum" or "minimum average roll" values that meet or exceed the values stated below as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the value stated below.

Woven and non-woven geotextiles are acceptable and must meet the following requirements:

Geotextile Mechanical Property	Test Method	Minimum Permissible Value
Grab Tensile Strength (both directions)	ASTM D4632 or ASTM D5034 and ASTM D5035	1200 N [270 pounds]
Grab Elongation	ASTM D4632 or ASTM D5034 and ASTM D5035	15 percent
Mullen Burst Strength	ASTM D3786 or ASTM D751	2960 kPa [430 psi]
Puncture Strength	Modified ASTM D3787 or modified ASTM D751	490 N [110 pounds]
Trapezoid Tear Strength	ASTM D4533 or ASTM D1117	334 N [75 pounds]

Geotextile Hydraulic Property	Test Method	Permissible Value
Apparent Opening Size (AOS)	CW-02215	Sieve size between 850 µm and 150 µm [U.S. Std. Sieve number(s) between No.20 and No.100]
Permeability	ASTM D4491	0.01 mm/sec