2010

EROSION & SEDIMENT CONTROL DESIGN GUIDANCE

Office of Environmental Services

Minnesota Department of Transportation

1/1/2010

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EROSION AND SEDIMENT CONTROL

Erosion and runoff can be a serious problem along roadsides, both during and after construction. In addition to losing valuable soil resources, erosion results in an unhealthy environment for growing vegetation, pollutes waterways with sediment, and results in costly maintenance activities to repair damage. Damage at a site may include rilled and gullied slopes, washed-out ditches, damage to pavements and drainage structures, clogged pipes, and flooding. Damage to water bodies occurs when they become filled with polluting sediment, making them susceptible to flooding and stream bank erosion.

Erosion is caused when wind or water blows or washes away the land surface and results in sediment as a byproduct. The presence of vegetation retards erosion. A recent study showed in a given rainfall episode, an acre of bare soil can lose up to 45 kg **(100 lbs)** of sediment, mulched soil up to 9 kg **(20 lbs)**, but well vegetated soil only about 0.45 kg **(1 lb)**. Clearly, the presence of well-established vegetation, or even a mulch cover, will preserve the soil and reduce the effects of erosion on an area. The six types of erosion are listed in Table 1-01A.

Table 1-01A
TYPES OF EROSION

Type of erosion	Description	Technique for Minimization
Raindrop splash	The impact of the raindrop dislodges soil, causing bare soil to splash into the air. The effect of the splash also increases compaction and destroys open soil structure.	Stabilize the soil with mulch or permanent cover to prevent raindrop impact**.**
Sheet erosion	The transporting of soil loosened by raindrop splash and removal of soil from sloping land in thin layers. It is a function of soil type, depth**,** and flow velocity.	Divert overland flow away from the slope or break up long slopes with terraces.
Rill erosion	When sheet flow becomes concentrated in small, defined channels. Most rainfall erosion occurs this way.	Stabilizing slopes and divert flow. Repair damage immediately with disking or tilling.
Gully erosion	Occurs when sheet flow becomes concentrated in large defined channels. This occurs in unrepaired rill erosion areas.	Same as rill erosion, but gully erosion requires extensive repair.
Channel erosion	Channel erosion occurs at stream banks and causes sediment scar along the channel bottom.	Proper design through stream geomorphology.
Wind erosion	Wearing away of soil by wind.	Cover bare soil.

Soil erosion and the resulting sedimentation are principal causes of water pollution. By volume, sediment exceeds the national sewage load 400 times. Studies show that erosion during highway construction is 10 to 500 times greater than that produced by farming, which in turn is 25 times greater than that of natural geologic processes. Erosion not only has detrimental effects on the environment, but it also causes damage to highway drainage systems, roadside and adjacent areas, and even to the pavement structure itself. Considerable public resentment can be expected if the resulting sedimentation occurs in scenic ponds, reservoirs, residential yards, rivers, or streams. Soil erosion during highway construction increases costs, and causes needless delays and repairs.

There are many serious consequences of soil erosion and they cannot be overemphasized. Agencies imposing restrictions and requirements during construction activities include the FHWA, the Pollution Control Agency, the Department of Natural Resources (DNR), Corps of Engineers, and local Watershed Districts.

Proper shaping of the ground and re-establishing vegetation are the basic erosion prevention methods. If performed properly, the resulting erosion potential will be minimized. At times, vegetation will not withstand the anticipated flow conditions. In these areas, bioengineered and/or hard-armored structures or channel liners may be needed.

For implementation, see the Mn/DOT Standard Plans Manual. These sheets are also available on the Mn/DOT Technical Support web site. All project specific temporary and permanent erosion and sedimentation plan sheets should be included in grading and surfacing construction plans. All applicable Standard Plan Sheets must also be included.

1-01 NPDES and MS4 Storm Water Permit Programs

Pursuant to the Clean Water Act, the Environmental Protection Agency (EPA) has developed a permit program named the National Pollutant Discharge Elimination System (NPDES). The Minnesota Pollution Control Agency (MPCA) has authority over the NPDES permit program in Minnesota. The permit to discharge storm water associated with construction activities is MN R100001, commonly referred to as the NPDES Construction Storm Water Permit. The permit to discharge storm water associated with urban storm sewer systems is MN R 04000, commonly referred to as the MS4 General Permit.

1-01.01 Construction Activity NPDES Storm Water Permit

Construction site storm water runoff ultimately ends up in our wetlands, streams, lakes, and rivers. To protect these environmental areas the NPDES construction site stormwater permit program was established. MPCA's storm water permit program is designed to reduce the pollution and damage caused by runoff from construction sites.

The MPCA is currently in Phase II of the program which requires a construction permit when 0.40 ha (**1 acre**) or more of land are disturbed. This program requires the development of the Storm Water Pollution Prevention Plan (SWPPP) for all permitted construction projects. The SWPPP must be incorporated into the construction plans package. Specific items that need to be addressed in the SWPPP include the following:

1. Labeling critical areas that require temporary stabilization within 61 m (**200 feet**) of surface waters;
2. Providing methods and amounts of temporary erosion control best management practices (BMP) to temporarily stabilize above the critical areas (rapid stabilization);
3. Location of BMP for temporary erosion and sediment control;
4. Direction of water flow;
5. Identification of surface waters, including impaired and special waters, within One mile of the project receiving storm water runoff from the site;
6. Sediment basins, if applicable;
7. Permanent turf establishment;
8. Storm drain inlet protection;
9. Location of areas not to be disturbed;
10. Protection measures when working in surface waters; and
11. Site plan requirement areas.

A site plan requirement area is a location where there exists a critical environmental construction issue. The designer is to identify these areas and the contractor must provide, to the engineer for approval, a method of operation to minimize the environmental disturbance. The site plan requirement area is a tool for the contractor and Mn/DOT to use to protect the critical resources.

The permit also requires a narrative be included in the plans. This narrative will list Standard Specifications or Special Provisions that are applicable to the NPDES Permit. The items that may be included in the narrative are:

1. Agency contacts, i.e. MPCA, DNR, United States Army Corps of Engineers (USACE), etc.;
2. Dewatering;
3. Hazardous materials, debris, and chemical containment, including concrete washout;
4. Project construction staging for erosion control;
5. Sequencing of pond construction, if any;
6. Unique environmental concerns and protection measures;

7. Unique storm water management features, requirements, and staging;
8. Protection measure provided for Special and/or Impaired Waters; and
9. A tabulation of site plan requirement areas on the project.

A substantial portion of the requirements are included and detailed in Standard Specifications for Construction and in the Special Provisions. Additional items that are not addressed in the Standard Specifications or Special Provisions need to be included in the plan sheets or the plan specific Special Provisions where applicable.

The SWPPP also defines the chain of responsibility for all operations of the construction project. The contractor shall furnish a certified Erosion Control Supervisor who will oversee implementation of the SWPPP during construction. Designers must determine whether the contractor's certified Erosion Control Supervisor shall be incidental or provided as a lump sum pay item in the plan proposal. Table 1-01B provides recommended guidelines.

Table 1-01B (Dual Units)
EROSION CONTROL SUPERVISOR

Description of Project	Method of Payment
Minor impacts projects with less than 4 ha (**10 acres**) disturbance such as mill and overlay projects, turn lanes, signalization, etc	Incidental
Major impact projects such as grading/surfacing, **bridge construction over rivers, etc.**	Lump Sum
Minor projects that have significant impacts such as culvert replacements in streams, work on river/stream banks and shorelines.	Lump Sum

Application instructions for the General Storm Water Permit for Construction Activity (MN R100001) can be found on line under the construction activity link on the Minnesota Pollution Control (MPCA) website, under the Stormwater and Construction links, or under Erosion Control on the Highway Project Development Process (HPDP) Mn/DOT website. Designers must know the requirements of this program to provide proper documentation within the Plans.

1-01.01.01 NPDES Permit application process

Erosion and Sediment Control Provisions must be incorporated into all Mn/DOT projects that disturb soil regardless of whether and NPDES Permit is required. Minor projects such as widening roadway shoulders and turn lanes need provisions for re-vegetating disturbed areas and/or protecting adjacent critical areas. Minor projects such as culvert replacements need provisions for working in drainage ways and protecting water resources. Bridge construction projects over rivers and streams will require detailed Erosion/Sediment Control Plans because of working in and/or near a water body. These Provisions apply to Mn/DOT projects designed by Consultants and Design/Build Contractors as well as those designed internally.

Plans must take into account the complexity of the project, the erosion potential and the potential for off site damage. Designers must familiarize themselves with the requirements in the Permit especially in regard to protecting critical resource areas listed in appendix A of the NPDES Permit.

Technical assistance can be obtained from Mn/DOT's Hydraulic Engineers, Mn/DOT's Water Resource Personnel and/or from Mn/DOT's Erosion Control Engineering Unit.

1-01.01.01.01 Plan Review Process

The Design Engineer shall determine whether plan review is required by the MPCA for the project. For projects that disturb less than 20 ha **(50 acres)** there is no plan review required by the MPCA. For projects less than 20 ha (50 acres) the Permit Application can be filled out and the Permit Process initiated upon completion of the Project Design Plans.

For projects that disturb more than 20 ha (**50 acres**), but do not have a discharge point on the project that is within1.6 km (1.0 mile) of and flow to special or impaired waters, there is no plan review required by the MPCA. The Permit Application can be filled out and the permit process initiated upon completion of the project design plans. Project Managers and Designers must verify that the project lies outside the 1.6 km **(1.0 mile)** zone described in the permit.

For projects that disturb 20 ha **(50 acres)** and more and discharge to a point within 1.6 km **(1.0 mile)** of special and/or impaired waters, plan review is required by the MPCA. These special and impaired waters are listed on the MPCA Web at http://www.pca.state.mn.us/water/stormwater/stormwater-c.html

As described in the Mn/DOT and MPCA Memorandum of Understanding, for Storm Water Pollution Prevention Plan review by the MPCA will consist of review of the project plans in the form of concepts, approved layout and conceptual design provisions along with other information mentioned above in the beginning this section. The plan review which may require up to 30 days by the MPCA will be in the form of a review process whereby feedback and revisions maybe necessary. Additional plan review if required by other local permitting authorities should also be completed at the same time. Therefore, submittals for SWPP Plan Review and Approval to the MPCA should occur after the completion of the approved layout and between the 30% and 50% detail plan preparation stage. To ensure proper timing we recommend that MPCA review dates are entered in the Mn/DOT Program and Project Management System (PPMS). This would be done under activity number 1280-permits, and can also be included on the general project screen that lists all the permits required on the project. The submittal package should include approved layout, major stormwater management features such as ponds, flow arrows, soil types and adjacent receiving waters within 1.6 km **(1 mile)** of the project boundary indicated. Exact erosion/sediment control pay items and details such as silt fence, temporary ditch checks, etc. normally incorporated into the plan package at a later date do not need to be included for the initial submittals but will be required prior to final approval by the MPCA.

Mn/DOT will assemble the initial plan submittal information required by MPCA for design/build projects. Mn/DOT will develop the approved layout and indicate receiving water bodies along with preliminary concept locations for permanent treatment facilities. Upon award of Contract the Design/Build Contractor will prepare a SWPP Concept Plan. The Design/Build Contractor will submit the approved layout and SWPP Concept Plan to the MPCA at least 60 days prior to the start of project construction.

The MPCA will review and approve the SWPPP plans and provide the Mn/DOT Manager a letter stating the Plan has been reviewed and accepted. The Mn/DOT Project Manager will attach the Project Plan Approval Letter to the Permit Application. The MPCA will then process the Permit Application with the attached Project Plan Approval Letter in the same manner as projects that authorize permit coverage after 7 days.

For any projects requiring plan review by the MPCA, the MPCA will generally provide approval during the concept stage. However, the MPCA reserves the right to review and approve the detailed or completed Stormwater Pollution Prevention Plan for any project.

Table 1-01C
Summary of Plan Review Process

Type of Project	Concept Plan Submittal Deadline	Coordinator	Submittal
Projects less than 20 ha (50 acres)	No formal plan review required by Permit	Project Designer	NA
Projects 20 ha (50 acres) and more not discharging to special or impaired waters	No formal plan review required by Permit	Project Designer	NA
Projects discharging to special/ impaired waters and greater than 20 ha (50 acres) disturbance	Mn/DOT Design or Consultant Design 30 % - 50% detail plan preparation stage	Project Designer	Approved Layout, 30% Plan (2)
	Design/Build Projects Approved layout prepared by Mn/DOT SWPP Concept Plan prepared by contractor no later than 60 days prior to start of project construction	Mn/DOT Project Manager Design (1) Contractor	Approved Layout SWPP Concept Plan (2)

(1) The SWPP Concept Plan shall be developed by the Design/Build Contractor
(2) The 30% plan as well as the SWPP Concept Plan shall indicate major stormwater management features such as ponds.

1-01.01.01.02 Completing the Permit Application Form

The Permit Application Form can be obtained from the Minnesota Pollution Control Agency, 520 Lafayette Road North, St. Paul, MN 55155-4194 or their website:
http://www.pca.state.mn.us/water/stormwater/stormwater-c.html - forms

The Design Engineer completes sections 1, 2, 3, 5-12 of the Permit Application. Section 14 the primary contact will be the construction Resident Engineer and the secondary contact should be the Design Engineer. The Primary contact or alternate contact can sign the permit application. The Design Engineer shall then submit the partially completed permit including any Project Plan Approval Letters fro MPCA to Nancy Boeve (651) 366-4243, MS 650 Contracts and Lettings Unit, in the Office of Construction and Innovative Contracting prior to the letting. Any Project Plan approval letters received from the MPCA, will be considered part of the permit application.

1-01.01.01.03 Application for Permit By Contractor

The Contracts and Lettings Unit will transmit the partially completed permit application to the Contractor with all the other Contract Award documents. The Contractor will completes sections 4, 13, and 15 and send s the Application, including the Application Fee (for which the Contractor is responsible) to the MPCA. Construction can begin as early as 7 days. The contractor may elect to apply through the MPCA online application process. The contractor will utilize the permit application received by Mn/DOT to fill in the project information for the online application. The online application process can be found on the MPCA website. Once the online application is completed and application fee sent, construction can begin as early as 3 days. The contractor must return a copy of their Permit application sent to the MPCA to the contracts and letting Unit, along with the Permit affidavit stating that they have paid the permit fee. This is a contingency of contract approval by Mn/DOT.

In accordance with the NPDES Permit Application Process along with Mn/DOT Specifications 1702 and 1717, the Contractor shall obtain the NPDES Permit. As required in the Permit, the Contractor shall be a co-permittee.

For Design/Build Projects, the Design /Build Contractor will be responsible for all requirements relative to completing the Permit Application and obtaining the Project NPDES Permit from the MPCA.

1-01.01.01.04 Permit Compliance by Contractor

Contractors will partner with Mn/DOT and ensure compliance for those portions of the Permit in which Contractor is referenced. As stated in the Permit, the Contractor is responsible for controlling erosion and sedimentation during the construction activities, maintaining the erosion control devices, conducting the required erosion control inspections, and maintaining the permit inspection log.

Standard Specifications and Special Provisions requiring Permit compliance by Contractors are included on all Mn/DOT projects. According to our Specifications and Special Provisions, the Contractor will provide an Erosion Control Supervisor, maintain an NPDES Quality Control Program, and comply with all Permit requirements. Withholding for exposed erodible soils and deductions for noncompliance are also included in Mn/DOT Project Specifications.

1-01.01.01.05 Construction Project Administration

Once a project has been awarded, the Project Engineer is responsible for administering the Contract. During construction the Project Engineer is responsible for administering provisions of Erosion/ Sediment Control Plan, enforcement of Specifications, and compliance with the Owner portions of the Permit. For Design/Build Projects, the Design/Build Contractor is responsible for all Permit Provisions relative to Design and Construction. This includes both Contractor and Owner compliance requirements referenced in the Permit.

1-01.01.01.06 Certification Training Requirements

Certified personnel are required on all Mn/DOT projects requiring an NPDES Permit. Rigorous requirements for the design of Stormwater Pollution Prevention Plans and Contract Administration by Owners as well as Contractors responsibilities are contained in the new Permit. Therefore, Design Personnel, Construction Personnel, Consultants and Contractors working on Mn/DOT projects must be thoroughly familiar with Permit Requirement.

Effective with the 2003 construction season, Mn/DOT implemented the Erosion/Sediment Control Certification training requirements for Mn/DOT Construction and Contractor Personnel. Special Provisions requiring the certification are included on Mn/DOT Projects.

The Certification Training Program also includes Mn/DOT Design Personnel, Design Consultants, and Design/Build Contractors. The Certification Training Requirements are in response to the rigorous Design Provisions contained in the Phase II Permit. Effective with the 2004 Construction Project Lettings, Mn/DOT requires trained personnel prepare the Stormwater Pollution Plan for Projects. Mn/DOT Personnel, Consultant Designers, and Design/Build Contractors are required to attend Designing Stormwater Pollution Prevention Plans training. At least one person should be certified on a Project Design Team. The certified person may be a squad leader, an engineer or a design technician. The certified person will function as a lead worker providing guidance and or review for other members of the design team.

The Certification Training Program is offered in partnership with the University of Minnesota, Bioproducts and Biosystems Engineering.

The University of Minnesota is offering three categories of certification as follows:

Erosion/Sediment Control Inspector/Installer
Erosion/Sediment Control Site Management
Design of Storm Water Pollution Prevention Plans
(AKA Erosions/Sediment Control Plans).

Detailed information can be obtained by calling the University of Minnesota at 612-625-9733 or through the website http://www.erosion.umn.edu/

1-01.02 Municipal Separate Storm Sewer Systems (MS4)

Storm water runoff is often transported to the municipal separate storm sewer system (MS4) and is ultimately discharged into local rivers and streams without treatment. A municipal separate storm sewer system (MS4) is a conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, storm drains) which are:

1. Owned or operated by a state, city, town, county, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage districts, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under Section 208 of the Clean Water Act that discharges to waters of the United States;
2. Designed or used for collecting or conveying storm water;
3. Not a combined sewer; and
4. Not part of a publicly owned treatment works.

In 1990, the EPA promulgated rules establishing Phase I of the NPDES Storm Water Program. The Phase I Storm Water Program for MS4 requires operators of "medium" and "large" MS4, those that serve a population of 100,000 or greater, to implement a storm water management program. The Minnesota Pollution Control Agency is now in Phase II of the NPDES Storm Water Program. The Phase II rule extends coverage of the NPDES Storm Water Program to certain "small" MS4.

The Phase II Rule covers, on a nationwide basis, all small MS4 located in urbanized areas as defined by the Bureau of the Census (unless waived by the NPDES permitting authority), on a case-by-case basis.

Because Mn/DOT owns and operates transportation infrastructure within the MS4 designated municipalities, Mn/DOT must also participate in the MS4 Permit Program. The Mn/DOT Districts that have MS4 designated municipalities, townships, and counties, must apply for permit coverage and develop MS4 Storm Water Pollution Prevention programs. Contact the Office of Environmental Services, Erosion Control Unit, for a list of MS4 cities within your district.

The EPA's Storm Water Phase II Rule establishes an MS4 Storm Water Pollution Prevention program that is intended to improve the Nation's waterways by reducing the quantity of pollutants that storm water picks up and carries into the storm sewer systems during storm events. Common pollutants include oil and grease from the roadways, pesticides from lawns, sediment from construction sites and carelessly discarded trash. When deposited into waterways through MS4 discharges, these pollutants can impair the waterways, thereby discouraging recreational use of the resources, contaminating drinking water supplies and interfering with the habitat for fish, other aquatic life, and wildlife.

The primary goal of the MS4 Storm Water Pollution Prevention program is to restore and maintain the chemical, physical, and biological integrity of waters of the state through management and treatment of urban storm water runoff. In attempt to accomplish this goal, all MS4 permitted entities are required to have a Storm Water Pollution Prevention program that addresses water quality issues related to the discharge of storm water.

The Phase II Rule defines a MS4 Storm Water Pollution Prevention program as a program comprising six elements that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving water bodies. The six MS4 program elements, termed "minimum control measures" are the following:

1. Public Education and Outreach;
2. Public Participation/Involvement;
3. Illicit Discharge Detection and Elimination;
4. Construction Site Runoff Control;

5. Post Construction Runoff Control; and
6. Pollution Prevention/Good Housekeeping.

Information and requirements for the MPCA, MS4 General Permit can be found on the Minnesota Pollution Control Agency web site or through the Mn/DOT Office of Environmental Services web site.

1-02 Temporary Erosion and Sediment Control

1-02.01 General

Of all phases of highway development and maintenance, the construction phase produces the most erosion and sediment. During construction, vegetation is cleared, areas are opened up, drainage channels and ditches are dug and left open, fills are placed and cuts are made. During the time when vulnerable areas are unprotected, rain and winds can occur and cause erosion. As erosion removes soil from the construction site, gullies in slopes and ditches will form to the extent that reshaping is required. Sediment can also plug culverts and drainage structures.

In addition to the erosion damage that occurs on the project, off-site damage can occur in the form of siltation in streams, lakes, reservoirs, and adjacent lands. On a geologic time scale, the duration of a construction project is relatively short, but this limited period of accelerated erosion can have irreversible effects at the site, in rivers and streams, and on land downstream. Poor public relations between the contracting agency and adjacent residents can also develop. Thus, it is important to control erosion and limit its negative impacts. Preventing problems before they occur will cost less than fixing them later.

It is important to specify in the construction and soils notes of the plan to hold back dollars for acres open to erosion. This is an incentive for the contractor to minimize areas open at one time and establish permanent protection to slopes in quicker timeframes. One must determine how much to holdback and can be determined by proximity to the resource waters and whether these waters are special or impaired. This can range from $3,000 to $10,000 per acre.

1-02.01.01 Important Elements of Temporary Erosion and Sediment Control

1. Construction plan packages that include grading must have a temporary erosion and sediment control plan that contains pay items with estimated quantities for temporary erosion and sediment control items. The temporary plan should contain general guidance for ongoing erosion and sediment control during construction.

2. Identify critical areas on the temporary erosion/sediment control plan. Measure the size of the areas and state the method of rapid stabilization. Each critical area should also be listed in tabulated form by location, size, and method of rapid stabilization. The statement of estimated quantities should list the total area for each method of rapid stabilization and reference the tab sheet number.
3. Use a silt fence as a last method of defense for sediment control. Do not rely solely on a silt fence to protect of f site resource waters.
4. Although temporary mulching and temporary seeding/mulching are very effective at controlling erosion, they are temporary measures. Mulch quantities must be sufficient to allow for more than one mulching, depending on staging or project duration.

1-02.01.02 Staging

Staging is an important part of erosion control on a project. As provided in the plans over the duration of the project, controlling erosion during construction hinges on the timely installation of the permanent erosion protection materials. Placing sod, mulch, and seed promptly as the project progresses reduces the length of time areas are left unprotected and susceptible to excessive erosion.

In addition to the timely placement of permanent erosion control measures, temporary measures must also be provided during construction. These measures may include temporary devices to route drainage and collect sediment during construction.

When designing a project, the designer should account for final locations of detention ponds and their purpose. If temporary ponds are required as part of the permit, they should be constructed and stabilized first. Drainage should then be routed to the ponds.

1-02.02 Temporary Erosion Control Best Management Practices

Temporary erosion control best management practices are devices and methods needed to control erosion. Erosion control is protecting and preventing the exposed soil from eroding, with correct shaping, temporary seed, mulch, blanket**,** and other needed devices. These other devices may include sandbag barriers, temporary drains for fill slopes or temporary flumes to safely carry water down a slope. See Table 1-02A.

Table 1-02A (Dual Units)
TEMPORARY EROSION CONTROL BEST MANAGEMENT PRACTICES

Practice	General Effectiveness	Application Areas
Shaping and Grading	Good to excellent	• Slopes and ditches as construction progresses
Mulch/Seed	Excellent	• Bare soil • All exposed slopes that will not be worked on within the time frame allowed • Idle areas, including stock piles
Erosion Control Blanket	Excellent	• Slopes steeper than 1:3 • Erosive ditch bottoms (v-shaped) • Ditch bottoms that outlet to a surface water • Highly erodible areas such as bridge slopes, pipe outlets, high volume exit points
Temporary Drain on Slope	Good	• To convey drainage down cut or fill slopes
Bituminous Flume	Good	• To convey concentrated drainage on temporary fills, temporary bypasses**,** or temporary ditches • Use on projects with erosive potential longer than one season**.**
Rock Flume	Good	• Use on projects with erosive potential longer than one season.
Sod Flume	Good	• Use on projects with erosive potential longer than one season.
Diversion Mound	Good	• For use at the top of backslope or fill slope • Can be used to divert runoff from a work area • Shoulder work perimeter control

1-02.02.01 Shaping

See the shaping discussion in Section 1-03.02.01.

1-02.02.02 Slope Stabilization

During construction, temporary slope stabilization may be necessary to comply with the NPDES permit and Mn/DOT's Standard Specifications. In order to protect exposed slopes left idle, drainage ditches, and critical areas, the following temporary erosion control methods may be used:

1. Apply Type 1 mulch for a slope not at final grade with exposed soil that is not being worked on for longer than seven days.
2. Apply Type 1 mulch and a temporary seed mixture for a slope that is close to final grade (without topsoil) and will be left idle longer than 14 days.
3. For slopes steeper than 1:3 or in sandy soil areas, apply a temporary seed mixture and erosion control blanket.
4. For stockpiles left idle for less than 1 month, apply Type 1 mulch, disc anchored or tackified with Type 1 hydraulic soil stabilizer.
5. For stockpiles left idle for periods more than 1 month, apply a temporary seed mixture and Type 6 hydraulic soil stabilizer.

Use of a geotextile cover can also be substituted in the plan or as a field change for either of these temporary methods. If there is geotextile fabric included in the plan as a permanent feature later then it can also be used as a temporary cover prior to using it in its permanent state. Note that these are separate operations and should be adjusted for in the plans as separate pay items .A note in the plans may be needed explaining the use.

1-02.02.03 Mulching

Temporary mulch protects the soil from rainfall impact and overland flow, and promotes the growth of temporary vegetation by protecting the seed and fostering germination. Temporary mulch should be specified on stockpile areas, exposed slopes near environmentally critical areas, and staged construction areas. Type 1 mulch held in place by disc anchoring can be used for this purpose. If disc anchoring is not possible, a tackifier (Mn/DOT Standard Spec. 3884) should be sprayed over the mulch. Type 6 Hydraulic Soil Stabilizer can be used on slopes 1:2 or steeper, or areas with limited access instead of Type 1 mulch.

1-02.02.04 Seeding

Temporary seeding will be required in graded areas where the permanent seeding cannot be performed, i.e. temporary bypasses. Stockpiles may require temporary seeding if they will be there for periods longer than one month.

1-02.02.05 Erosion Control Blankets

Temporary erosion control blankets should be specified for the last 61 m (**200 ft**), or more if needed, of all ditch bottoms in which the ditch drains directly into a surface water. This length is dependent on ditch slope, soil conditions, water velocities and volumes expected, and open soil areas above the ditch. Sloped areas adjacent to this length needs temporary blanket if steeper than 1:3 (rise: run).

Always specify wood fiber blankets for ditches. The tabulations need to separate and specify quantities of wood fiber blankets from straw blankets of the same category. The plans need to specify locations of each type.

1-02.02.06 Down Drains

Temporary down drains consisting of enclosed metal pipe, plastic pipe, or flexible rubber pipe may be used to carry concentrated runoff from the top of a slope to the bottom and thus reduce erosion. The temporary drains may be used on fill slopes, cut slopes, cut-to-fill transition swales, drainage ways**,** bridge ends and other locations where a temporary structure may be required to carry water prior to the installation of permanent storm water facilities, or while vegetation is establishing. The design limits are a 2-year, 24-hour storm and can usually handle a maximum drainage area of 1.2 hectares (**3 acres**). When a temporary drain is placed on a broken back fill slope, a temporary soil berm should be constructed along the slope breakpoint with additional berms constructed to guide water into the drain as necessary. Where possible, the drain should be at a low point, with the spacing between drains at a minimum interval of 150 m (**500 ft**) along the fill slope. For drains spaced at 150 m (**500 ft**) intervals along a fill, a 250 mm (**10 in.**) diameter smooth conduit or corrugated metal pipe may be used.

The outlet ends of all temporary drains must have some means of dissipating the energy to control erosion at the outlet. Dissipaters can be rock riprap and/or a tee attached to a cross pipe**,** or another device that would slow the water.

1-02.02.07 Bituminous-Lined Flumes, Rock Flumes, and Sod Flumes

Temporary bituminous, rock**,** and sod flumes can convey drainage on temporary fills, bypasses, or ditches. They can also remain in place to become permanent flumes. The sod flume method is the best in terms of safety. Sod flumes with netting underneath the sod add enough strength to the roots to allow them to sustain shear stresses comparable to rock and bituminous flumes.

1-02.02.08 Diversion Mounds and Berms

Temporary diversion mounds divert runoff away from a work area and/or to protect slopes. Diversion mounds can be used on drainage areas up to 2 hectares (**5 acres**) and where the grade of the diversion will be less than five percent. A detail is included in the Standard Plan sheet. Diversion mound or berm will need temporary stabilization of seed and /or mulch depending on the length of time this system is in place. Diversion mounds constructed of soil should not be constructed adjacent to bodies of water or wetlands without redundancy. Outfalls of diversion mounds will need to have some type of energy dissipater to reduce downstream scour and erosion.

1-02.03 Temporary Sediment Control Best Management Practices

Temporary methods and devices to contain sediment that has eroded from within the project limits will be covered in this section. Many permits require the installation of sediment control devices before land disturbing activities begin. See Table 1-0.02B. As a minimum, the temporary erosion/sediment control plan should include:

1. Perimeter control near critical areas,
2. Sediment traps and sediment basins,
3. Inlet protection for storm drains,
4. Culvert protection,
5. Ditch checks for drainage ways,
6. Rapid stabilization of critical areas near Waters of the State, and
7. Additional temporary measures for severe erosion prone areas.

Designers need to identify critical locations on the temporary sediment/erosion control plans where the above practices are needed. The above are temporary measures and are in addition to the provisions contained in a project's permanent erosion/sediment control plan. Other best management practices to use in addition to the above-mentioned practices include:

1. Sand bag barriers,
2. Dewatering,
3. Construction entrances/exits,
4. Sediment removal,
5. Flotation silt curtains, and
6. Bale berms.

Table 1-02B (Dual Units)
TEMPORARY SEDIMENT CONTROL DEVICES

Device	**General Effectiveness**	**Areas to Use**
Perimeter control-Silt Fence[1]	Fair to Good	Toe of slopes, around stockpiles, to protect adjacent areas See Section 1-0.02.03.01
Sandbag Barrier	Good	To protect excavations, for culvert replacements To dike channel changes and to serve as sumps during de-watering
Sediment Trap	Good	Ditch bottoms or areas where runoff leaves the project limits.
Temporary Sediment Basin	Good	Where 4+ contiguous hectares (**10+ contiguous acres**) of exposed soil contribute to a point of discharge before leaving the project limits, or entering a surface water
Inlet Protection	Good	Catch Basins, storm drain inlets
Culvert Protection	Good	Culvert ends
Flotation Silt Curtain		Open standing water during construction
▪ Moving water	Poor	Streams and rivers with currents less than 1.5 m/s (**5 ft/sec**) and depths of 0.9 to 3.3 m (**3 to 11 ft**).
▪ Work area	Good	Areas of moving or still water (to confine a work area and for containing overflows from a weir, settling pond, or standpipes)
▪ Still water	Fair to Good	Lakes or large bodies of water with no current
Bale Berms	Fair	Wetland areas with limited access (as shown in Figure 1-0.02A) Ditch bottoms on rough graded sites (for turf establishment) Slope diversions See Section 1-0.02.03.01**.**
Diversion Mounds	Good	The perimeter of construction, toe of slopes, around stockpiles See Section 1-0.02.02.08**.**

[1]Use silt fence in combination with other erosion control devices.

1-02.03.01 Perimeter Control

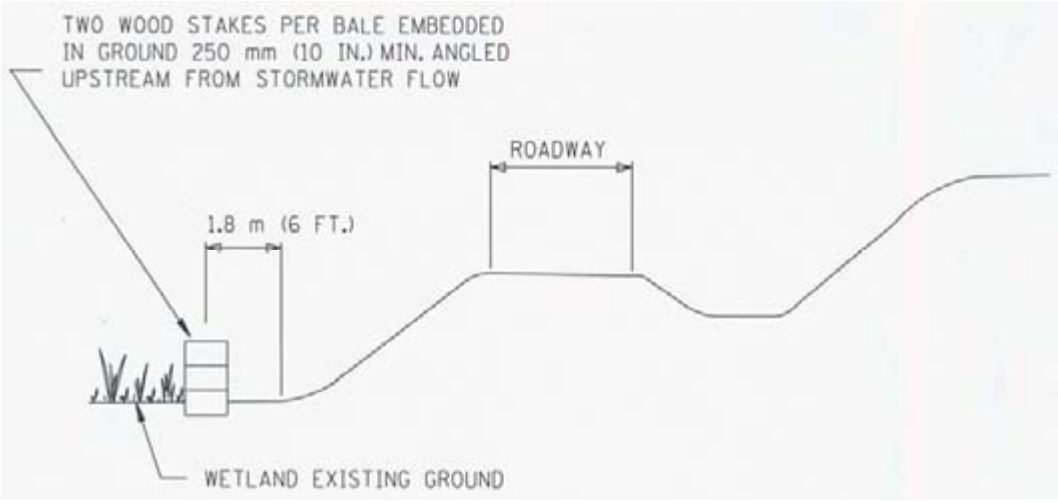
Perimeter control should be used to protect surface waters and other adjacent critical areas, such as wetlands and sensitive-use areas such as golf courses. The purpose of these controls is to prevent any off-site damage by preventing the amount of sediment leaving the site. In most cases, the controls will remain in place throughout construction. In order to be effective, do not use these controls over the total project length, but in strategic locations.

When large amounts of sheet flow from undisturbed areas enter the construction area, prevent erosion and runoff by diverting the runoff around the site. Soil, silt fences, and bales are effective tools for this diversion.

Machine-sliced silt fences are effective for perimeter control when located and installed correctly. When used correctly, these fences will control sheet flow, but not concentrated flows. Silt fence should be located to protect environmentally sensitive areas, such as surface waters, and to keep sediment-laden sheet flow from leaving the project.

Topsoil berms can be an effective tool for perimeter control. Used in conjunction with rock weepers and sediment traps to treat and control volume and velocity of stormwater. Rock weepers can be incorporated into the berm at various designed locations to filter and direct cleaned storm water off the project site.

Bale berms can be used to protect wetlands or standing water, where silt fence would be very difficult to place, and/or the water is too shallow for a silt curtain, see Figure 1-02A. They can also be used for temporary sediment control (Table 1-02B). See also section 1-02.02.08 for use of diversion mounds to control runoff.



BALE BERMS
Figure 1-02A

1-02.03.02 Sandbag Barriers

Temporary sandbag barriers can be used as inlet protection, temporary weirs, and in bridge construction as barriers between bridge abutments and water. See Section 1-02.04, “Working in or Near Streams”.

1-02.03.03 Sediment Traps

Temporary sediment traps are small, excavated sediment storage areas without flow control sections or defined side slopes that are often field-located and temporary in nature. See Standard Plans. Sediment traps should be used when it is necessary to protect downstream sensitive areas, or to reduce flow velocity and trap sediments on a long ditch run. Typical locations include the downgrade end of a cut section, ditch bottoms steeper than three percent, medians, depressions within the project limits, and other associated areas.

The length, width**,** and depth of the trap can vary according to project conditions. Sediment traps are limited to drainage areas of 0.8 hectares (**2 acres**) or less. In highly erodible areas, a series of traps may be placed, with a minimum spacing of 90 m (**300 ft**) between traps. Questions and a review of the adequacy of proposed installations at critical or sensitive locations should be referred to the District Hydraulics Engineer.

1-02.03.04 Sediment Basins

Temporary sediment basins serve functions similar to those of sediment traps, but on a larger scale. Sediment basins have a longer design life (the length of the construction project or, in some cases, permanent). Basins are needed to capture runoff from 4+ contiguous hectares (**10+ contiguous acres**) of exposed soil before the runoff leaves the project limits or enters surface waters. Basins are located where they will not be impacted by later phases of construction and are designed to be drained and cleaned out when half the sediment storage capacity has been filled up.

The District Hydraulics Engineer can provide assistance and advice on the design of both temporary and permanent sediment basins.

1-02.03.05 Inlet Protection

Temporary storm drain inlet protection measures are designed to minimize the amount of sediment that enters a storm sewer system. A storm drain inlet protection measure includes a temporary barrier that has the capability to filter or settle out sediment before it enters the storm sewer. Exposed soil around the inlet, and slopes that drain to the inlet, must have temporary cover within 61 m (**200 ft**) of that inlet if the pipe outlets to a surface water.

It is not practical to control drainage areas larger than 0.4 hectare (**1 acre**) with this measure alone. The inlet protection should be left in place and maintained until a uniform 70% final vegetative cover is established. The designer must select a device that satisfies local hydraulic conditions such that hazardous conditions are not created.

The Standard Plans give several alternatives for temporary inlet protection that are described in the Mn/DOT Standard Specifications for Construction. Some inlets may require two or more different types of inlet protection depending on the phase of construction . Therefore, the plans need to show the number of inlets that need protection on a project, throughout the life of the project.

1-02.03.06 Culvert Protection

Temporary culvert protection will be needed on intakes for incomplete**,** permanent drainage structures. This protects the culvert from the inflow of sediment-laden runoff. During construction, a roadway embankment with a culvert may be converted into a sediment trap when temporary culvert protection is installed at the inlet end. This temporary type of installation should be used when critical areas are exposed, a large amount of sediment is expected to accumulate, and/or it is necessary to protect off-site areas at the culvert outlet. Because of the freeboard required, standpipes on culvert inlets are used only in deeper ditches (those deeper than 915 mm (**36 in.**) and/or in off-take ditches where a small ponding area can be developed without danger to upstream areas). Sediment traps can be used in shallow ditches when it is necessary to protect sensitive areas. Because of the damage that could occur as the result of failure, standpipes are not recommended when the plan culvert diameter exceeds 915 mm (**36 in.**), or for more than a type II 10-year, 24 hour storm. Weir devices can be used at the culvert end to treat shallower flows. The Standard Plan gives several alternatives for temporary culvert protection. The plans need to show the number of culverts needing protection on a project, throughout the life of a project. Some culverts may require different protection devices at each stage or one type through all stages.

1-02.03.07 Ditch Checks

Temporary ditch checks may be used to trap sediment and/or reduce runoff velocities in ditches and drainage ways. Typically, ditches with grades of 1.5 to 5 percent should be considered for velocity control. The

six types of ditch checks that are outlined in Standard Specification 3889 are listed in Table 1-02C. The application of these products is based on the expected and desired runoff flow.

Spacing for ditch checks is generally = (height of the check x ditch grade as a percent) / (100). For example, with a 1.5% ditch grade and a bioroll blanket system, the ditch checks would be placed every 10 m **(33 ft)**. The formulas are below.

[(0.15 m ÷ 1.5) x 100 = 10 m] (Metric)

[(**0.5 ft ÷ 1.5**) **x 100 = 33 ft**]. (English)

Table 1-02C (Dual Units)
TEMPORARY DITCH CHECK SELECTION

Type	Name	Description (See Standard Plans and Standard Specification 3889)	Use
1	Sliced-in Silt Fence	The sliced-in silt fence consists of a high-flow geotextile fabric secured to posts, and sliced into the ground.	• 2-3% ditch grade, less than 0.40 hectare (**1 acre**) of drainage area entering the ditch • The above criteria also applies to biorolls • Must be removed before permanent seeding
2	Bioroll	The bioroll consists of straw or wood excelsior and is enclosed in polyester or plastic netting, 150 to 178 mm (**6 to 7 in.**) in diameter. This is a Type 2 Storm Water Filter Log, Standard Specification 3897.	• • 2-3% grade, less than 0.40 hectare (**1 acre**) of drainage area entering the ditch Lasts one season • May be left and become mulch • Can be used for inlet protection
3	Bioroll Blanket System	This system consists of the bioroll placed on top of a category 3, Standard Specification 3885 erosion control blanket.	• 1.5-2% grade, with less than 0.80 hectares (**2 acres**) of drainage entering the ditch • Can be permanently left in place • Lasts one season
4			No longer in use
5	Rock Weeper	This system consists of a geotextile liner, coarse concrete aggregate, and riprap. The rock weeper may cause water to pond while it filters sediment.	• 3-5% grade with less than a 1.6 hectares (**4 acre**) drainage area entering the ditch • Drainage to Special Waters use with flocculant
6	Geotextile Triangular Dike	The geotextile triangular dike consists of triangular urethane foam enclosed in a woven geotextile fabric.	• 2-3% grade with less than a 1.6 hectares **(4 acres)** drainage area entering the ditch • Use on rough grading**.** • Reusable • Must remove before permanent seeding
7	Rock Check	Class I – IV riprap is placed over a secured geotextile fabric liner-across the ditch in a berm approximately 600 mm (**2 ft**) high. Riprap size is dependent on expected flow quantity, velocity, and duration**.**	• 3-5% ditch grade with less than a 1.6 hectare **(4 acres)** drainage area entering the ditch • Use in high flow areas • Long duration • Remove rock once ditch is stabilized

1-02.03.08 Filter Logs

Filter logs typically slow and filter water in ditches, around inlets, and on the contour of long slopes. Standard Specification 3897 covers the four different types of filter logs. Due to their filtering qualities they typically pond more water. This should be considered when specifying their use. The compost filter log has the highest filtering qualities and the rock log the lowest. The rock log functions well as a temporary ditch check that withstands flow velocities better than a bioroll. When runoff will drain into Special Waters a combination of the filter log and the sediment trap with or without a flocculant sock (Mn/DOT Standard Specification 3898) can be used. This method will settle the fine clay and silt particles out prior to discharging into Special Waters. Special Waters are defined by the Minnesota Pollution Control Agency.

1-02.03.09 Dewatering

During dewatering operations discharging sediment-laden water directly back into surface waters, or into a drainage pipe or ditch that flows directly to surface waters should not occur. A sediment trap or other means should be used to settle the sediments before the discharged water enters these areas.

Some sediment is too small to be settled or filtered out of the sediment-laden water. These silt and clay particles can end up entering a critical surface water and cloud the water turning it to a murky brown color. To settle out these fine particles a flocculant can be specified. (Standard Specification 3898). For further information, contact the Stormwater Engineering Unit.

1-02.03.10 Construction Exits

At construction access locations, a construction entrance pad will reduce the amount of mud transported onto paved roads by vehicles or surface runoff. Construction entrance pads provide an area where mud can be removed from vehicle tires before entering public roads. Construction entrance pads can be rock, wood mulch, temporary paving, or any other appropriate Best Management Practice available to the contractor.

The exit pad, which should extend the full width of the access location and be 15 m **(50 ft)** in length or more as needed. To prevent the tracking of mud onto paved roads, the entrance pad will need maintenance. This maintenance may require periodic topdressing, or removal and reinstallation of the pad. A wash rack installed on the entrance pad may make cleaning more convenient and effective. See Standard Plan sheet for more information.

The rock exit pad should contain 25 to 50 mm **(1 to 2 in.**) size washed rock, with a 150 mm **(6 in.)** minimum thickness. A geotextile fabric may be used under the aggregate to minimize the migration of stone into the underlying soil.

1-02.03.11 Sediment Removal

At any time during construction, the contractor may have to remove sediment trapped in retention devices or deposited in retention ponds. Sediment removal shall consist of excavating and other associated operations to restore the capacity of any temporary sediment control device. When sediment reaches one-third of the height of a silt fence device or equivalent, remove the sediment or replace the device if it is not functioning properly. Sediment basins must be cleaned out when sediment reaches half of the storage volume. Street sweeping to remove sediment from paved surfaces is required to prevent dirt from entering catch basins and water bodies. A pick up sweeper will be the only type accepted, and should be noted on the plans.

Because of weather conditions, field changes, and other unpredictable situations, estimated quantities for temporary erosion and sediment control can be hard to predict. Table 1-0.02D provides some guidelines to use.

Table 1-02D (Dual Units)
ESTIMATED QUANTITIES GUIDELINES FOR TEMPORARY EROSION/SEDIMENT CONTROL

Practice	Material	Estimated Quantity
Temporary Mulching	Mulch Type 1, 3	100% of the permanent seed quantity
Temporary Mulching	Hydraulic Soil Stabilizer, Type 6	20% of the total permanent seed quantity
Temporary seeding and mulching	Seed mixes 100, 110, 130, 150	20% of the total permanent seed quantity area
Ditch stabilizing	Category 3 erosion control blanket	100% of first 61 m (**200 ft**) from surface waters
Concentrated runoff prevention	Category 3 erosion control blanket, sediment basin	Where needed in concentrated flow areas
Protecting Inlets	Inlet Protection	Count each inlet that drains to surface waters, off project limits, or to a ditch that drains to surface waters Lump Sum or by number of inlets on the project.
Controlling Ditch Velocity	Temporary ditch checks	See Table 1-0.02C
Maintaining Devices	Sediment removal, backhoe	2 hrs for each sediment trap per construction season.

1-02.03.12 Rapid Stabilization

Providing temporary methods during construction for the stabilization of critical erosive prone areas has always been a challenge in construction. Rapid stabilization methods provide the opportunity to quickly stabilize small critical areas above waters of the state. Examples of critical areas that will need rapid stabilization include, but are not limited to:

1. Embankment slopes abutting wetlands and lakes;
2. Bridge slopes draining towards rivers and streams;
3. Disturbed areas around culvert inlets and outlets;
4. Roadside ditches draining from construction sites;
5. Disturbed slopes near storm drain inlets;
6. Disturbed medians and ditches draining into storm drain inlets;
7. Disturbed banks of rivers, lakes and streams; and
8. Topsoil piles and excess soil piles.

The rapid stabilization methods should be used for areas within 30 m **(100 ft)** of Waters of the State. Designers will need to include size and number of areas requiring rapid stabilization. The number of areas will impact the number of times that a seeding/mulching subcontractor may need to mobilize onto the project.

Five rapid stabilization methods are shown in Table 1-02E. Along with the description are suggested applications for each method. Each method is a complete unit and can be provided in the temporary erosion /sediment control plans as complete unit, i.e. the amount of seed/fertilizer and other incidental items will not need to be itemized. For Method 3 design purposes, 3.8 m^3 of slurry mix will cover 1/14 ha **(1000 gallons will cover 1/6 acre)**.

Table 1-02E
RAPID STABILIZATION METHODS

Method	Description	Suggested Applications
1	Temporary mulch/disc anchored	Disturbed slopes 1:3 and flatter
2	Temporary mulch/tackifier	Disturbed slopes steeper than 1:3
3	Temporary Hydromulch/seed	Soil piles, inaccessible areas
4	Temporary erosion control blanket	Culverts, ditch bottoms, critical slopes
5	Temporary rock	Drainageways, ditch outlets

1-02.04 Working In or Near Streams

Four sediment control devices are described for working in or around streams: sediment mats, sandbags, temporary stream crossings, and flotation silt curtains. Each is outlined in the following list.

1. Sediment Mat:

   A sediment mat is a temporary erosion control device used in the streambed to collect sediments that enter the stream during construction. The sediment mat is used effectively during culvert replacements and bridge work. When construction is complete, the mat is removed and placed onto the stream bank and seeded. The sediment mat is restricted to streams having a maximum flow velocity of 1.5 m/s (**5 ft/sec**) and a maximum water depth of 600 mm (**2 ft**).

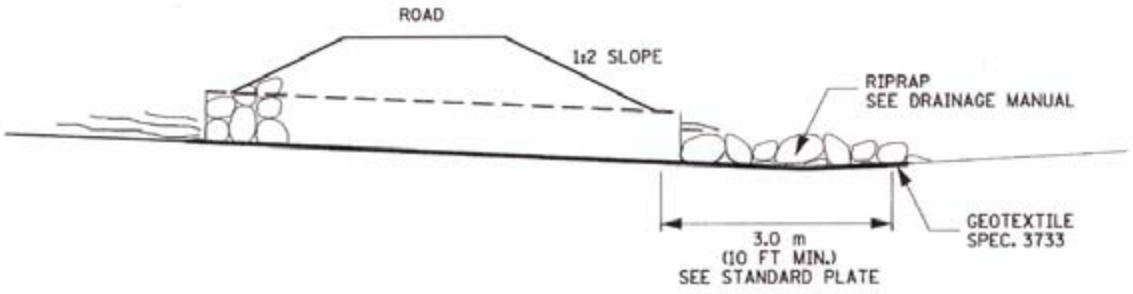
2. Sandbags:

   Sandbags can be used to dike off areas to help settle out sediments during dewatering, and to block off areas with erosive soil from a body of water. They can also be used to protect inlets and as ditch checks. See Standard Specification 3893.

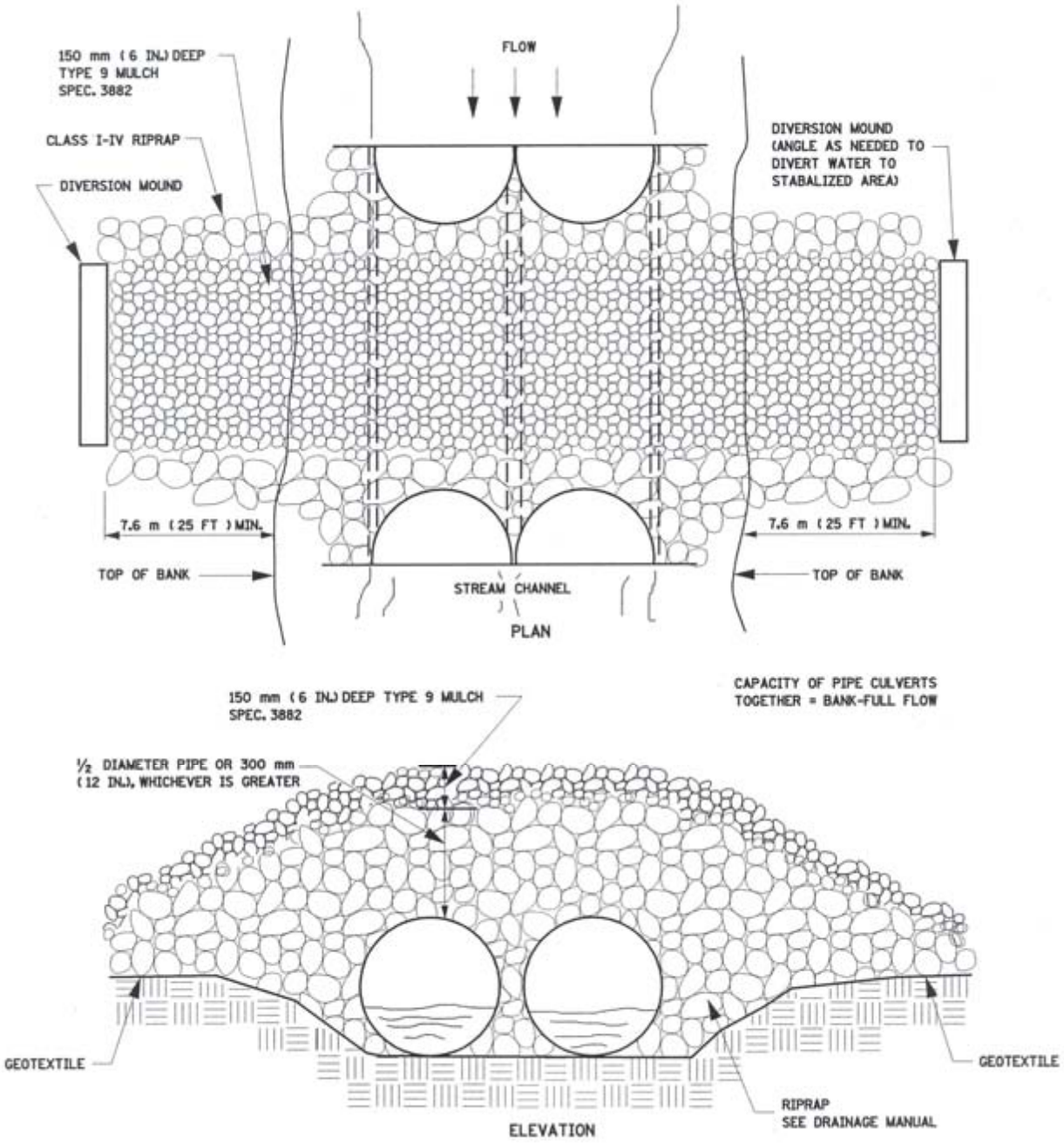
3. Stream Crossings:

   Temporary stream crossings, such as haul roads and work roads across major streams and rivers**,** may be designed and included in the plans. These plans should show a profile grade, culvert end locations, and the minimum size of culvert or temporary bridge. Use clean rock fill, and in most instances, provide riprap on the temporary crossing to prevent erosion. A geotextile should be used to cover the streambed and stream banks to reduce settlement and improve stability of the ford or culvert crossing. The geotextile fabric should extend a min. of 150 mm **(6 in.)** beyond the end of the rock. Approaches should be covered with aggregate or wood chips to prevent tracking on to the crossing. A ford crossing consists of clean rock on top of the geotextile placed in the stream allowing the stream to flow over it. A temporary stream crossing may be able to be constructed certain times of the year if it does not impact

fish spawning. See DNR or Corps of Engineer permit. Figures 1-0.02B and 1-0.02C show temporary stream crossings. Use of a temporary beam bridge for stream crossings is most applicable to narrow and deep channels. Temporary beam bridge crossings are preferable to other types of stream crossings because they cause the least disturbance to the stream. Consult the District Hydraulics Engineer when designing temporary stream crossings.



PROFILE VIEW TEMPORARY STREAM CROSSING
Figure 1-02B (Dual Units)



TEMPORARY STREAM CROSSING
Figure 1-02C (Dual Units)

4. Flotation Silt Curtains

Flotation silt curtains can be used in moving water, still water, or in an area containing both moving and still water. It can be used in moving streams and rivers with currents and depths meeting requirements on the Standard Plan and in the Mn/DOT Standard Specifications for Construction. Silt curtains placed in moving water should not extend across the water from shore to shore. Curtains should divert sediment to the shoreline for removal. Curtains can be placed close to a disturbed river shoreline to protect it from the water current's erosive forces. This product can confine a work area or contain overflows from weirs, settling ponds or standpipes, see Table 1-02B.

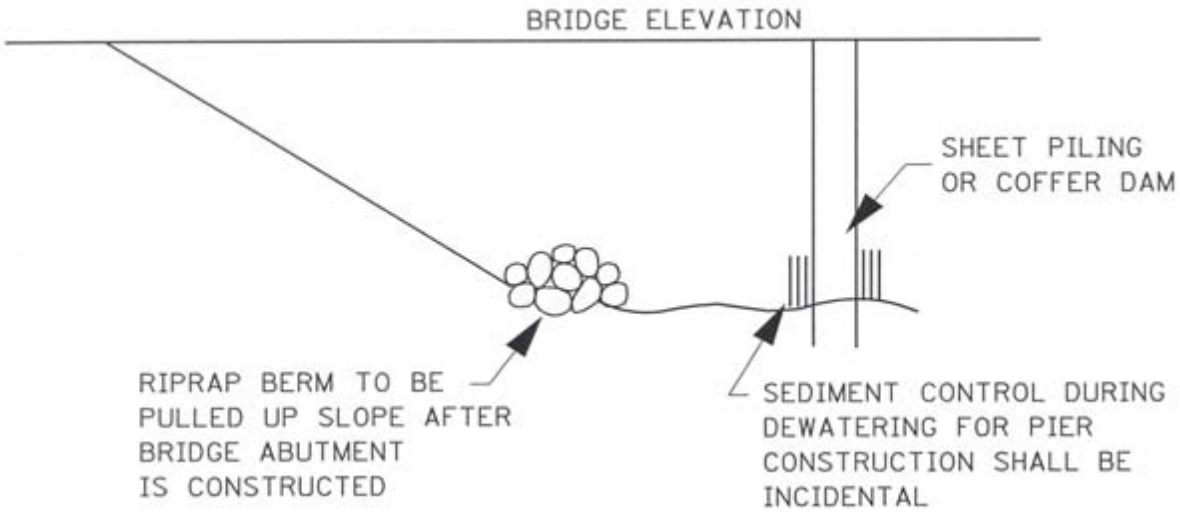
1-02.04.01 Bridge Abutments

Figure 1-02D shows sediment control during bridge construction. When used during construction, riprap can act as a barrier between the exposed soil and the water when it is keyed into the toe. When ready, the contractor can perform slope protection on the end slope and pull up the rock berm on the slope.

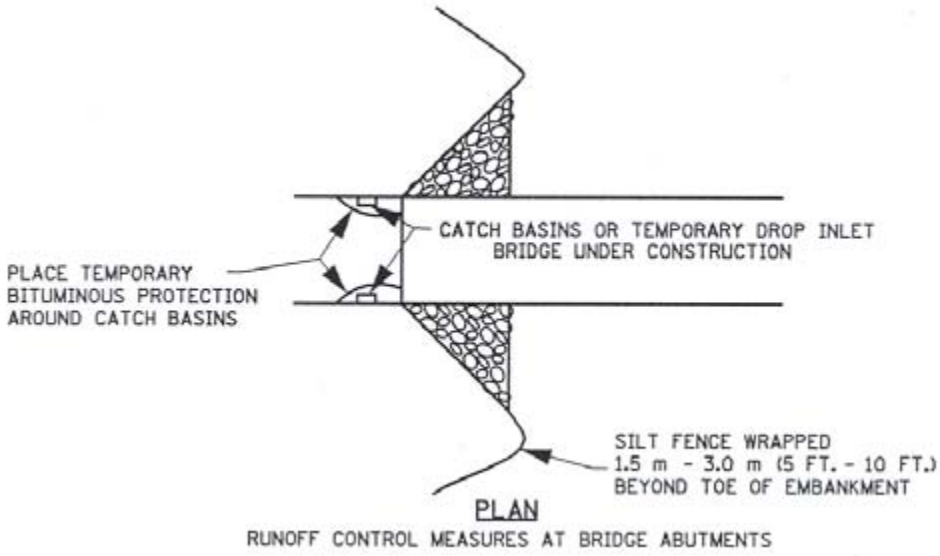
The three types of temporary bridge abutment protection practices are shown on the Mn/DOT Standard Plans. They are:

1. Buffers in areas with low embankment, (silt fences are used and wrapped around the toe of the embankment);
2. Buffers in areas with a high embankment (3.0 m (**10 ft**) or greater), (sand bags are used as a barrier adjacent to the water, along with silt fence); and
3. Sheet piles on short bridges, sensitive areas, or areas with small working space.

Figure 1-02E shows runoff control measures at bridge abutments to direct runoff from the bridge deck into catch basins or temporary drop inlets. This will prevent the concentrated runoff from flowing over the inslope and eroding the bank.



SEDIMENT CONTROL DURING BRIDGE CONSTRUCTION
Figure 1-02D



TYPICAL CONTROL MEASURES AT BRIDGE ABUTMENTS
Figure 1-02E

1-02.05 Working In or Near Public Waters

When doing work in or near Public Waters as defined by the Minnesota Department of Natural Resources (DNR) the designer should follow a best practices document developed by the DNR. The document is named Best Practices for Meeting General Public Waters Permit (GP) 2004-0001 and can be found on the DNR web site under Construction permits. The Public Waters Permit can also be found at the DNR Web site. The name of the permit is General Permit (GP) 2004-0001 (Issued by the DNR to Mn/DOT). The Mn/DOT HPDP website also has a link to the Best Practices document and the Public Waters Permit.

1-03 Permanent Erosion Control

1-03.01 General

Permanent erosion control measures are different from temporary measures because they are primarily designed to function after projects are complete. They include proper earthwork shaping, rounding**,** and transitioning, and properly preparing surfaces for expected storm water flow rates and volumes. Avoid disturbing areas where re-stabilization or re-vegetating will be difficult. A summary of design guidelines that minimize erosion potential follows:

1. Avoid steep, unstable slope angles. Weigh the initial cost of additional right of way against the long-term costs of construction and maintenance.
2. Incorporate sediment basins and other erosion or sediment control devices, temporary and permanent.
3. Use a smooth grade line with gradual changes to avoid numerous breaks, minimize the number of cut to fill ditch section transitions, and avoid short lengths of grade.
4. Preserve the natural and existing drainage patterns to the greatest extent possible. Avoid placing the low points of vertical curves in cut sections. Avoid low grade lines requiring ditch sections in areas that are swampy or have a high water table.
5. Set construction limits that provide space for slope rounding, preserve trees and shrubs, and prevent excessive clearing.

6. Avoid or minimize earthwork balancing that requires hauling dirt across streams.
7. Do not disturb steep stabilized slopes of rock debris, soil**,** or stream banks. If the project is "short of dirt", obtain borrow instead of disturbing these critical areas.
8. Consider using independent alignments to fit divided highways to the terrain and to adjust grades.

9. Avoid irregular ditch profiles and steep ditch grades where possible. If steep ditches are necessary**,** locate the steep section at the head of the ditch instead of at the outlet.
10. A note may be provided in the plan that states ditch bottoms should be graded to a radial shape to reduce erosion.
11. Minimize channel changes. When channel changes are required, adjust the new channel cross-section alignment and/or length to match the existing flow velocity.
12. Locate and align culverts to avoid erosion at inlets and outlets. To allow direct entrance and exit conditions, place structures as near to the natural flow line as possible, and in line with the flow direction. Avoid placing outlets at curved sections or channels, or where the outflow can drop and cause scour.
13. Where possible avoid problems associated with locating ditches at the toe of fill slopes.
14. Maximize the use of natural materials such as soils, sod, seed, mulch, and riprap to reduce costs and increase the likelihood of achieving permanent erosion control. Open metal, concrete, or bituminous flumes are subject to undermining, deteriorate with freezing and thawing, and frequently fail over time. Consider the natural materials and topographic features first to prevent erosion.
15. Review the plans by drainage area to assure erosion control practices are adequate.
16. Evaluate the grade line and cross sections for possible erosion problems, especially in ditches, cut-to-fill ditch section transitions, at vertical curve low points, and any other area where water may accumulate.
17. Request and use available technical assistance. A quick detail review with additional Department input can save hours of costly changes and minimize problems. Technical assistance in each respective area is available from the Geotechnical Engineering Section on the Office of Materials website, Office of Environmental Services (www.dot.state.mn.us/environment), the District Hydraulics Sections, or the District Materials Sections.

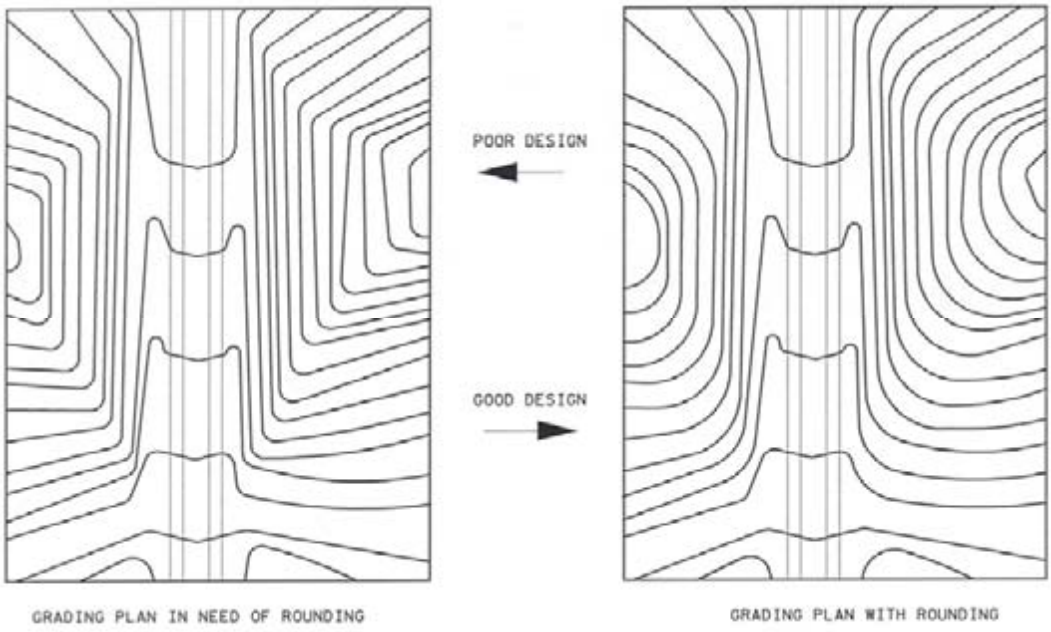
1-03.02 Permanent Erosion Control Best Management Practices

Permanent erosion control best management practices are devices and methods that prevent erosion on an on-going basis. Proper design features and natural materials or methods are the most effective means of erosion control.

1-03.02.01 Shaping

One of the most important erosion prevention techniques is proper shaping and/or contouring. Proper shaping methods include rounding slopes and ditches, blending cuts and fills, eliminating built-in gullies, and feathering cuts. The edges of slopes where cuts or fills intersect the natural ground line should be rounded. See Figure 1-0.03A. Construct slope grades to insure slope stability and conserve existing vegetation and topographic features to reduce erosion.

Many erosion problems can be avoided by good design practices. Avoid hillside locations where steep, deep cuts are required, as they are difficult to stabilize, especially in rock cuts with loose sloughing overburden, in water-bearing strata, or in soils high in silt content. Before slopes can be stabilized, the foundation soils or geologic formations must be stable. In general, the degree of the slope must be flatter than the natural angle of the weakest soil or rock formation in the slope area. Vegetation can only stabilize and control surface erosion, which is normally in the top 1.0 m (**3 ft**) of the soil. Re-vegetation depends directly on slope stability. If slope grades are constructed to insure stability, plant establishment can usually follow.



SHAPING FOR EROSION CONTROL
Figure 1-03A

1-03.02.01.01 Cross Section Slope Rounding

The gentle rounding at the intersection of different roadside slopes should be specified and constructed to make the highway section safe, erosion resistant, and compatible with the landscape. For the location of rounding areas, see the Standard Plan sheet.

1-03.02.01.02 Cut-to-Fill Transitions

Cut to fill transition areas are highly susceptible to erosion. The erosion problem generally starts at the cut to fill transition and extends down along the toe of the embankment slope to the low point.

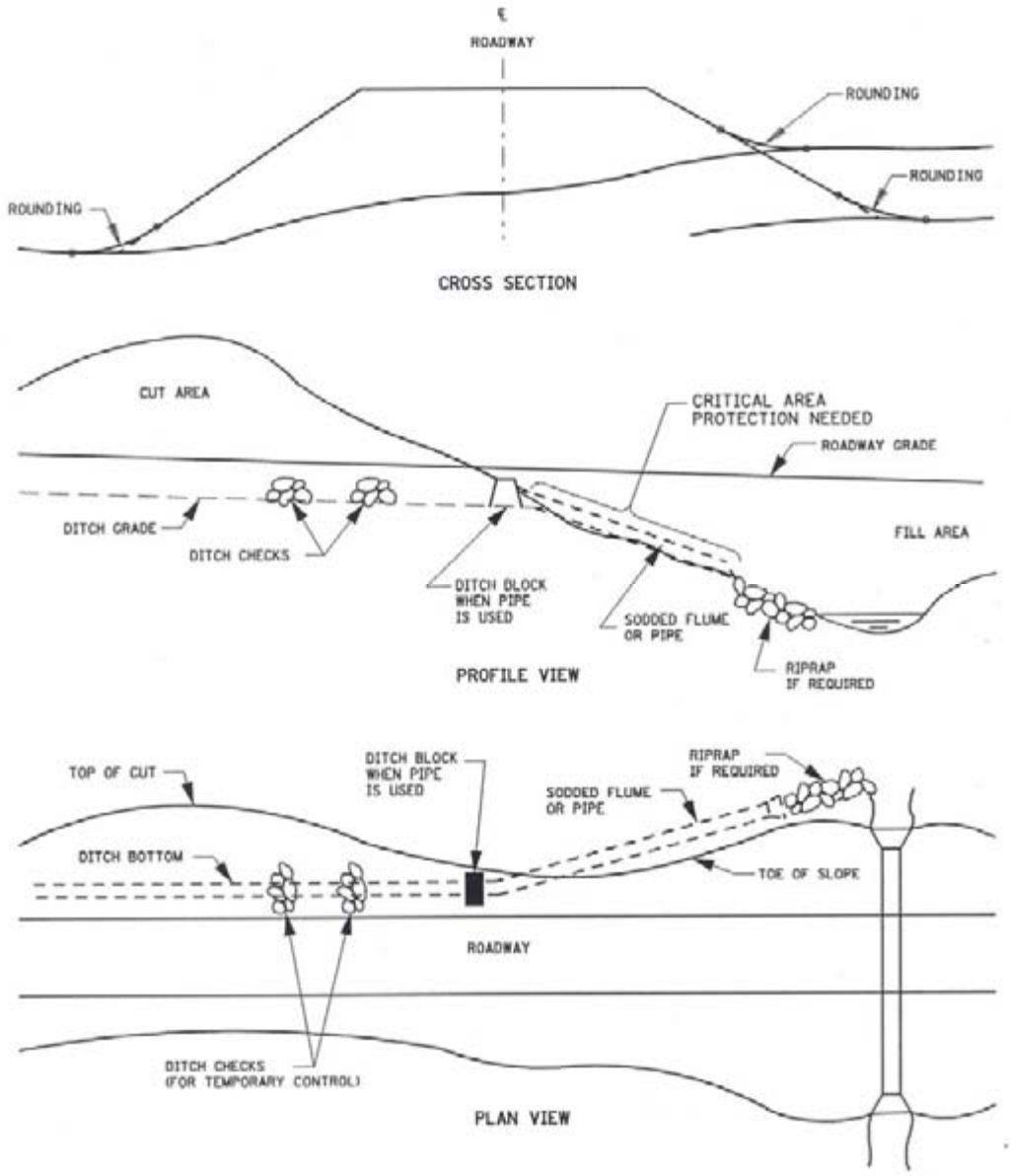
From the cross section shown in Figure 1-0.03B, there are two conditions that affect the shape of the drainage channel at the toe of the fill:

1. The natural ground that is level or slopes away from the fill; or
2. The natural ground that slopes toward the fill.

If the natural ground is level or slopes away from the fill, the toe of the fill should be rounded to blend the fill into the terrain and to divert drainage onto vegetated areas.

If the natural ground slopes toward the fill, a special ditch grade can be considered along the toe of the slope to reduce the erosion potential and to provide the desired rounded cross section for sodding. At ditch grades less than 2 percent, it is generally assumed that the special ditch can be stabilized by providing seeding and mulching and adequate cross-section rounding, however; if drainage is conveyed long distances or if the runoff quantity is large, the designer should request assistance from the District Hydraulics Section. An erosion control blanket lining the ditch bottom may be needed, or if shear stresses are large an erosion stabilization mat may be more appropriate.

If the design indicates that a sod flume is inadequate to convey the runoff flow quantities down the special ditch, the designer should contact the District Hydraulics Sections for assistance.



EROSION CONTROL AT CUT-TO-FILL TRANSITIONS
Figure 1-03B

1-03.02.02 Ditches and Inslopes

Ditches prevent water from reaching the roadway base or sub-base by disposing of surface runoff from the roadway surface and roadside areas. Roadside ditches allow the roadway base to drain and thus prevent saturation and loss of support. For highway application, Mn/DOT uses the trapezoidal shape as a standard for ditches for design purposes. Current construction practice rounds the sharp edges. This cross-section is hydraulically efficient, and is very easily constructed. Besides cross section rounding, both alignment and surface treatment (lining) are significant ways to control erosion in ditches.

Ditch alignment, both horizontal and vertical, should be kept as simple as possible, with smooth curves and transitions to minimize the erosion potential. Although construction is cheaper and less lining is required with a broken-back profile, a uniform ditch profile is more desirable and is comparable to natural channels. Broken-back profiles are comparable to gullies that erode progressively upstream.

1-03.02.02.01 Culvert Ditch Outlets

Properly placed culverts will alleviate ditch maintenance problems by allowing the free flow of drainage runoff. Culvert outlets should be as close to the toe of slope as possible and feature the proper end treatment to prevent erosion, scour, or undermining. Also, protect the culvert outlets from erosion by placing sod, erosion control blanket, riprap, or articulated concrete around the apron.

If it is necessary to reduce water velocity at pipe outlets to prevent erosion, internal or external energy dissipaters can be considered. One common practice is to install a riprap basin. Riprap basins must be installed correctly at the bottom of the slope, have a filter under the riprap, and be designed according to the procedure in the Mn/DOT Drainage Manual. Cabled concrete (precast articulated concrete Spec. 3604) may be needed if the velocity and shear stresses are high or slope problems are encountered. Contact the District Hydraulic Section for outlet protection recommendations.

Where auxiliary outlets are needed during permanent or temporary conditions to prevent large concentrations of water flowing over a slope, protected outlets must be constructed utilizing sod, level spreaders, metal pipe flumes, or plastic pipes.

1-03.02.02.02 Ditch Liners

Erosion damage to drainage ways and ditches can be substantially reduced or prevented by providing proper ditch-liner treatment. Ditch liners should be selected based on the ditch grade and soil type.

The ditch grades listed in Table 1-03A are guides under normal conditions in the design and treatment of ditches. Sod should not be used when the ditch grade exceeds the maximum permissible ditch grade given in Table 1-03A. When exceeded, consult with the District Hydraulics Section for recommendations concerning design of special liners or energy dissipaters.

Table 1-03A (Dual Units)
DITCH GRADES REQUIRING SOD OR EROSION CONTROL BLANKETS

Ditch Protection Type	Ditch Width 2.4 m **(8 ft)** and wider	Ditch Width (1) less than 2.4 m **(8 ft)**
Seed/mulch	2.5%	0-2%
Sod	8.75%	2-7%
Category 3 erosion control blanket	3%	2-3%
Category 4 erosion control blanket	4%	2-4%
Category 5 erosion control blanket	5%	3-5%
Category 6 erosion control blanket	6%	4-6%
Category 7 erosion control blanket	7%	5-7%

Notes:

Category 00, 0, 1 or 2 erosion control blankets are not recommended for a ditch liner.

(1) Narrow ditches require analysis to determine the acceptable slope for that condition.

Several biological/vegetative stabilization techniques can be used to control erosion and stabilize hydraulic channels. These techniques include, but are not restricted to:

1. Granular liners in conjunction with special vegetation in seeping ditches and areas of high water table;
2. Clay ditch liners in conjunction with sod for stabilizing ditches in erodible soils such as loamy sand and sand soils**;**
3. Erosion Stabilization Mats, as described in the Mn/DOT Standard Specifications for Construction;
4. Ditch linings of sod over topsoil; and
5. Riprap mixed or covered with soil and then seeded.

The above techniques are based on increasing the characteristics of the channel to withstand erosion. See Table 1-03B for more uses. Further recommendations in regard to these techniques are available from the MnDOT Office of Environmental Services, Erosion Control Engineering Unit.

Table 1-03B (Dual Units)
DITCH LINER SELECTION

Liner type	Application	Notes
Granular Liner	Streambeds Seeping ditches High water table areas	See the District Hydraulics Engineer
Clay Liner	To replace highly erodible soils, such as sands and silts	Must be 0.15 m (**0.5 ft**) thick and compacted
Erosion Stabilization Mat	Runoff velocity > 2 m/s (**6.5 ft/s**) Should be top soiled, seeded and blanketed	Standard Specification 3888
Riprap	Runoff velocity > 2 m/s (**6.5 ft/s**) Use angular for high flows and rounded in low flow areas	Must provide filter material Standard Specification 2511
Articulated Interlocking Block	Extremely high flow Poor soils High bed shears	Look up on Internet Standard Specification 3604
Articulated Block Mat	Extremely high flow Poor soils High bed shears	Several sizes are available Look up on Internet Standard Specification 3604
Root Rap	Use in areas where riprap is needed, but a softer look is desired	Spec. 2577.3H

1-03.02.02.03 Inslopes on Superelevated Curves

Shoulder inslopes on the inside of superelevated curves (where mowing is anticipated) should have a Category 00 through 1 blanket over the seed for the length of the curve, at a minimum width of 2 m (6 ft) from the edge of the shoulder. Specify a Category 2 or higher blanket in areas where mowing is not anticipated.

1-03.02.02.04 Level Spreaders

The purpose of sod or seed-and-blanket runoff spreaders is to convert concentrated flow into lower velocity sheet flow by spreading the flow out within a stabilized area. Their most common applications are on the low side of superelevated curves. See Table 1-03C for other applications of level spreaders.

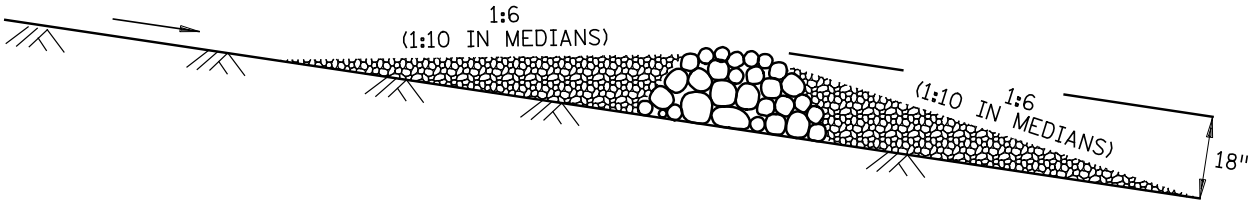
Table 1-03C (Dual Units)
LEVEL SPREADER APPLICATIONS

Condition (Areas Contributing Runoff to 1:3 Slope Area)	Treatment
Bridge deck, roadway and 1:6 safety inslope	Provide a catch basin or flume to intercept bridge runoff in conjunction with sod runoff spreader.
Roadway and 1:6 safety slope	Provide a runoff spreader on all soil types (category 3 blanket and seed).
Only 1:6 safety slope	Spreader is not required unless it is in erodible conditions**,** such as silty soils and fills over 7.5 m (**25 ft**) high.

1-03.02.02.05 Ditch Checks

Permanent ditch checks may be used to trap sediment and/or reduce runoff velocities in ditches and drainage ways. Typically, ditches with grades of 1.5 to 5 percent should be considered for velocity control. The six types of ditch checks that are outlined in Standard Specification 3889 are listed in Table 1-02C. The application of these products is based on the expected and desired runoff flow.

Type 2, 3, 5, and 7 can be used for permanent conditions. Type 5 and 7 will need to be modified to provide proper safety considerations when located within the clear zone. The maximum height for these types will be 450 mm **(1.5 ft)** and the cross section slopes shall be 1:6 or flatter. See Figure 1-03C. The designer may need to provide a note in the plans for this procedure.



PERMANENT DITCH CHECK PROFILE
(INSIDE THE CLEAR ZONE)
Figure 1-03C

1-03.02.02.06 Broken-Back Safety Fill Slopes

Because of the complex slope shape, broken-back safety fill slopes have a high erosion potential. Runoff from the roadway may be either sheet or concentrated flow upon entering the steeper inslope. As the runoff flows over the slope, it becomes concentrated by wheel tracks, clods, clumps, minor surface settlement of the topsoil layer, or ridges of soil from the finishing operation. As a result, runoff frequently exits off the steeper slope to the point of intersection as concentrated flow, thus eroding the less steep portion of the inslope. Adding a sod run off spreader will prevent erosion, see Standard Plan sheet.

1-03.02.03 Erosion Control Dike

Water flowing over disturbed earth will erode the soil and either deposit it as sediment in lower areas or pollute waters with its sediment-filled runoff. This erosion must be avoided if possible. One practical method of reducing erosion and the resultant sedimentation or pollution is to prevent storm water from flowing across cut slopes by constructing a permanent slope protection dike.

Since the quantity of runoff is dependent on the rainfall intensity**,** duration, drainage area, topography, type and quantity of vegetation, and the permeability of the soil, the designer will need information from the District Hydraulics Section to determine whether a dike is needed. See Standard Plan sheet.

Dikes can be constructed by placing erosion-resistant embankment material. This method is preferred over using cut and fill or plowing a furrow. If slight rises in the natural ground occur over relatively short distances, shallow cuts may be made, but sod must be used on these cuts to prevent erosion. Where swales occur that would cause flooding beyond the right of way, provide flumes to carry the water down the slope.

1-03.02.04 Storm Water Ponds and Other Treatments

Storm water ponds may be needed to collect the increased water runoff associated with increased impervious surfaces. Storm water ponds may also be required by various permitting agencies for permanent sediment control with special design guidelines. These guidelines should be referred to and followed for the specific project situation. Along with storm water ponds, grassed swales and vegetative filter strips can help reduce sediment from runoff and allow infiltration of runoff. Grassy swales and vegetative strips, rain gardens and other bioretention methods may be needed, especially when the right of way is limited for pond development. Consider porous pavement and on-lot infiltration when designing parking lots. Refer to the Mn/DOT Drainage Manual for additional design guidance or contact District Hydraulics Engineer.

1-03.03 Turf Establishment

The purpose of this subsection is to generalize turf establishment policies and recommendations for the designer. Each site has a different set of conditions that will affect turf establishment materials and needs. Soils, topography, and traffic have a great effect on preparation requirements for areas with turf and their continued

maintenance. Although this section does not include detailed recommendations, it does summarize them so that the designer can analyze his or her particular project, detect inconsistencies, or locate critical areas requiring additional protection.

The Office of Environmental Services, Erosion Control Engineering Unit will continue to develop and distribute annual turf establishment/ erosion control recommendations for each Mn/DOT District. A separate letter addressed to each District Engineer with appropriate copies to Design Engineers will be sent and renewed by July 1 each year. The letter will contain a matrix of recommendations based on the type of project and local conditions. Design personnel will select the turf establishment/erosion control provisions for their respective projects from the matrix. If the designer detects inconsistencies or feels that additional protection may be required in critical areas, he or she should contact the Erosion Control Engineering Unit.

Topsoil depths and amount of topsoil to be salvaged for each project will continue to be included by the Soils Engineer in the Materials Design Recommendation Report.

1-03.03.01 Topsoil

Topsoil is a valuable natural resource. It is the uppermost layer of soil, usually the top 150 - 200 mm **(6 - 8 inches)** and in some areas 600 mm **(2 ft)**. As one of the layers of the soil on the earth's surface, topsoil is sometimes referred to as the "A" horizon. The following provides guidance for topsoil use;

1. All inplace topsoil should remain on site, and be salvaged to the greatest extent possible.
2. On slope easements, remove topsoil to the bottom of the "A" horizon and reapply it uniformly within the easement area.
3. Topsoil information, such as average depth, location, and depth of deep deposits as indicated in the Materials Design Recommendation Report.
4. Consult with District Maintenance personnel regarding the stockpiling of topsoil when a surplus exists.
5. Use topsoil on all areas that will be seeded or sodded.
6. If there is a shortage of salvageable topsoil, use plastic subsoils or organic and muck soils that are up to 20 percent organic matter. Do not use peat because it may dry up, blow away, settle, consolidate, and/or will not support mowing equipment. Before specifying either the subsoils or muck soils to use as topsoil, consult with the District Soils Engineer.
7. Depending on subsoil textures and/or the nature of the area, some projects will require different depths of topsoil. A few include:
    a. Coarse textured subsoils, which may be deeper;
    b. Hydraulic sandfills, which may need as much as 200 mm (**8 in.**); and
    c. Plastic subsoils, which may be shallower.

1-03.03.02 Fertilizer

The fertilizer applied depends on the soil composition. Soil tests are always recommended to determine the appropriate fertilizer analysis and application rate. Soil samples for fertility should be collected according to the Mn/DOT Geotechnical and Pavement Manual.

1. Use fertilizer on areas that will be seeded or sodded.
2. Provide half the fertilizer rate of seeded areas for sodded areas.
3. Refer to the District seeding recommendations for general recommendations.

1-03.03.03 Seeding

Mn/DOT has seed mixes that grow best in specific soils. The seed mixes are also designed for the long-term function; mowed turf, reclamation areas, wetland mitigation. Refer to the District seeding recommendations for general recommendations or contact the Erosion Control Engineering Unit.

1-03.03.04 Mulching

Mulching provides a cover over the seed and bare soil. It keeps soil cooler and moister, allowing for better germination and plant establishment, and provides for temporary erosion control while the vegetation is establishing.

1-03.03.05 Erosion Control Blankets

Standard Specifications includes descriptions of erosion control blankets. Blanket selection is based on slope steepness and length. These two factors have the greatest effect on the increase in energy caused by runoff velocity. Always specify wood fiber blankets for ditches. The tabulations need to separate and specify quantities of wood fiber blankets from straw blankets of the same category.

1-03.03.06 Hydraulic Soil Stabilizers

Standard Specifications includes different descriptions of the different type of soil stabilizers, and Standard Specifications outlines application rates. Generally, hydraulic soil stabilizers are used in areas with limited access and steep slopes. They may be sprayed over the top of other mulches, but should not be used on ditches or seeping slopes.

1-03.03.07 Erosion Stabilization Mats

Erosion stabilization mats are permanent mats that add additional shear strength to the vegetation and allow it to withstand higher shears in concentrated flow areas, such as ditch bottoms. Depending on the bed shear, these mats can be used as an alternative to riprap.

1-03.03.08 Weed Control

Remove weeds prior to restoring wetlands and prairies. Contact the Erosion Control Engineering Unit for guidance and recommendations.

1-03.03.09 Shoulder Mulch Overspraying

Shoulder mulch overspray consists of Type 1 hydraulic soil stabilizer sprayed onto Type 1 mulch on a 1 m (**3 ft**) wide strip immediately abutting either a paved or gravel shoulder. During placement, the area should be seeded, the seedbed firmed, Type 1 mulch placed and the area must be disk-anchored, and oversprayed with Type 1 hydraulic soil stabilizer as a continuous process.

1-03.03.10 Bituminous Material for Shoulder Tack

Bituminous material for shoulder tack may be used for gravel shoulders. See Special Provision 2357 or Mn/DOT Standard Specifications for Construction.

1-03.03.11 Protection Adjacent to Bituminous Shoulders or Curbs

If areas adjacent to the shoulder are not going to have gravel placed, then vegetation is needed. After bituminous shoulders have been placed, the aggregate surfacing extending beyond the bituminous edge should be bladed to provide greater depth of topsoil adjacent to the bituminous shoulder. See Standard Plan Sheet. If the foreslope must be protected by sod, the top of the topsoil should be 25 mm **(1 in.)** below the top of the bituminous so that it will not act as a curb or pond water on the roadway**,** causing water to concentrate after the sod is placed. When sod is placed at the back of a curb, the topsoil should be 25 mm **(1 in.)** below the top of curb. See also Table 1-0.03C.

1-03.04 Soil Bioengineered Systems

Soil bioengineering entails the use of vegetation as the structural and mechanical elements in soil stabilization and is to be used with hard-armor methods. Stream bank stabilization is best accomplished utilizing these methods to leave a naturally stabilized site. Live cuttings and rooted plants are imbedded in the ground to serve as soil reinforcements, hydraulic wicks, drains, and barriers to soil movement. Bioengineering treatments provide sufficient soil stability so native vegetation can further establish and stabilize the soil. For additional information, see the Mn/DOT Standard Specifications for Construction and Standard Plan sheets.

The following list explains different types of soil bioengineering systems:

1. Wattles

The wattling method trenches bundles of tied live, easily rooted woody plants**,** such as willow**,** dogwood, and alder along the contour of a slope. The woody plant must be cut while in its dormant stage in the spring before they leaf out or the fall after they drop their leaves.

The wattles root and grow, control water runoff velocities, stabilize the surface layers of the slope, and increase water infiltration. Contour wattling with willows is best on cut or fill slopes with surface or subsurface moisture, and on stream banks. A coconut/straw blanket can be placed over the soil in the trenches before the wattles are installed to protect the bare seeded soil.

2. Brush Layering

Brush layering involves embedding live branches of shrub or tree species that will root easily on the contours in the face of a slope. They slow runoff velocity and retain sediments from the runoff. Brush layering is more effective than wattling at preventing shallow mass movements. They reduce moisture in steep slopes and assist in stabilizing them. The vegetation extends deeper into the slope rooting along their lengths, and act immediately as small horizontal slope drains. Brush layering works well with the construction of a conventional fill slope operation.

3. Live Stakes

Live stakes are live, rootable woody vegetation cuttings inserted into the ground. Live stakes can be placed in clusters that are installed in chevron-like rows that point downstream. The rows should start at the top of the bank and be directed downstream to the toe. Also placed in joints between riprap and gabions down into the soil, live stakes will root beneath the riprap to reinforce the soil, anchor the riprap**,** and improve drainage by extracting soil moisture. They can also be used to anchor the wattles in a trench, adding additional rooting to a slope.

4. Root-Rap

Root-rap involves placing a gravel channel lining or riprap, and overseeding or planting the completed channel. The root-rap can also be used to stabilize a seeping slope by transporting water down to the toe of the slope.

5. Fiber Rolls

The fiber roll is a device used along the edges of streams, rivers, lakes, and reservoirs. It is a tube of coconut fiber (coir) placed to reduce the water's forces at the toe of the bank and retain soil so vegetation is able to establish and stabilize the soil. Factors to consider when designing include bank steepness, wave height, stream velocity, low-flow conditions, human traffic, and animal traffic.

6. Concrete Armor Units

Concrete armor units are two pieces of concrete that fit together and form a structure similar to a jack. They are placed at the toe of a stream bank to support the toe-of-slope and protect the slope from the water forces on the outside of a bend. The stream alignment may need moving to the stream center and off the erosive stream banks. Specifying rock vanes, bendway weirs or a system of pools and riffles can accomplish this. Stream bank protection using hard armor (riprap, boulders) protection should be carried up the slope to bankfull width for a 2-year design storm. Consult your District Hydraulics Engineer for specific information.