Rainwater and Land Development

Ohio's Standards for Stormwater Management Land Development and Urban Stream Protection

Second Edition 1996

Previously Water Management and Sediment Control in Urbanizing Areas

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ABSTRACT: Streams, inclusive of their riparian areas, are vital environmental features and extremely sensitive to urbanization. The intent for this book is to allow land development to occur with less of an impact on water resources, principally streams.

This book defines Ohio's standards and specifications for stormwater practices implemented during land development. It is an update of Water Management and Sediment Control for Urbanizing Areas (NRCS 1980). The target audience are those involved in the design of individual projects.

This book has three parts, starting with a general framework for integrating water resource protection into site planning. The second part is three chapters on post-construction pollution prevention: post-construction stormwater quality treatment, permanent runoff control and stream channel construction and restoration. The last part contains four more chapters, which present standards and specifications for sediment control, temporary runoff control, soil stabilization and construction pollutants other than sediment.

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PREFACE

WHY RAINWATER?

Streams are, in many ways, the most valuable environmental feature of a landscape. They are critical from a myriad of perspectives—water quality, drainage, public infrastructure, biological diversity, environmental stability—the list goes on from the esoteric to the most pragmatic. All of these relationships stand to lose if the integrity of streams and other related water resources is diminished.

Every stream and river reaches an equilibrium in size, shape and character. This equilibrium depends on the specific environmental conditions of its watershed. When conditions change, the stream responds. No activity changes watershed conditions as much as urbanization. Urbanization, more than any other common land use, damages the quality of streams.

The first efforts to offset the impacts of urbanization focused on isolated issues, specifically, controlling peak rates of runoff from relatively rare large storms and applying generic solutions to reduce sediment pollution from construction sites. However, urbanization changes watersheds in a multitude of ways, and cookie—cutter solutions cannot manage the impacts. Traditional approaches, when used alone, have fallen short of maintaining the integrity of water resources.

Success depends on recognizing specific water resources, understanding the relevant impacts and tailoring a comprehensive inventory of tools to individual situations. Success requires acknowledging the difference between a narrow focus on single problems versus comprehensive water resource protection. The difference is epitomized by the difference between rare storms and common rain, between stormwater and rainwater.

THIS BOOK'S ROLE

The way land is initially developed is one area which has a tremendous bearing on the prospects for quality urban streams. This book offers a comprehensive source of general standards which can be implemented as land is being developed. It is up to the site designer and the plan reviewer to tailor practices to specific site conditions. It is up to local governments to determine what issues in addition to new development must be addressed to ensure the quality of water resources.

AUTHORITY

Ohio's Division of Soil and Water Conservation was charged with defining standards in 1979 by the Ohio Revised Code (ORC) Chapter 1511. The Natural Resources Conservation Service has a longstanding reputation nationally for defining technically sound standards for conservation practices. Finally Ohio EPA, by ORC Chapter 6111, is responsible for administering the NPDES program to which stormwater was added by amendments to the Water Quality Act in 1987. With much input from people in industry, academia, local stormwater programs and other states, these three agencies have defined standard practices for the State of Ohio.

The standards themselves are not requirements. In Ohio, responsibility for regulating stormwater is held by both local and state authorities. Locally, municipalities, townships and counties all have authority to regulate stormwater. Ohio EPA administers the state regulations which require stormwater permits for construction sites.

PART I

Stormwater Planning

INTEGRATING STORMWATER MANAGEMENT INTO SITE PLANNING

Opportunities for managing stormwater on a new development site begin with the first visions of what that piece of land is to become. From this first step and through each successive step, good stormwater management can only be accomplished if it is an integral part of the land development process.

This book is targeted specifically for use during site planning and design. When design is complete, the plans themselves take on the sole burden for communicating this information. Construction documents need to incorporate a complete design for managing stormwater. Implementation hinges on conveying this information to the people who will ultimately be involved in construction.

This chapter's organization follows the sequence that stormwater management opportunities arise during the planning/design process. It starts with **site layout concepts**. Things to be considered include: preserving existing drainageways and minimizing impervious area. Because it is not possible to preserve all drainageways the next topics deal with **channel work**. Then **permanent stormwater management structures** for detention and runoff treatment are discussed. Finally, the impacts of construction itself, primary **sediment pollution** will be addressed.

SITE LAYOUT

Decisions made in early site layout may, quite possibly, have a greater influence on stormwater than all other practices discussed. Site layout decisions are, however, more planning considerations than structures or practices that need specifications and, thus, are not specifically included in Parts II or III of this book. This should not distract or lessen the priority given to early site layout's effects on stormwater pollution prevention. An excellent resource on site layout, *Designing Open Space Subdivisions,* is listed in the information sources section at the end of this book.

Site Drainage--Keep as much of the existing drainage system as possible. Minimize the extent to which storm drains and constructed ditches replace natural drainage ways. Even swales and ephemeral drainage without defined channels provide valuable stormwater benefits and should be preserved where feasible.

Back-Off Streams and Stay Away From Riparian Areas--Riparian systems provide many stormwater benefits, not the least of which is making water cleaner. Water is purified as it flows across a buffer and enters a stream. Also, the water quality of streams themselves is improved by forested riparian areas. Other benefits include a self-maintaining drainage system, flood storage, groundwater recharge and a complex interaction of aquatic habitats.

The benefits provided by riparian areas are easily lost if their importance is not recognized. Deliberate protection is usually required to prevent encroachment. Encroachment may include clearing trees, filling, channel modification, and at its most extreme, replacing the channel with an enclosed drainage system. A fundamental part of stormwater management is to devise ways of avoiding encroachment upon riparian areas, then to preserve these critical parts of the landscape as designated open space.

Minimize Impervious Area--Nearly every stormwater problem is proportional to the extent of impervious area. Unfortunately, there is usually not much opportunity for a site planner or designer to reduce the amount of impervious surfaces. Some possibilities which should be used where possible are clustering development, reduced road widths, modular pavers for remote parking rather than pavement or gravel.

Reducing urban sprawl may be the most effective way to reduce impervious area. However, urban sprawl is a much more far-reaching issue than stormwater. Reducing urban sprawl probably can be accomplished better through community land use planning than individual site layout.

Minimizing the area devoted to parking generally offers the most practical potential for reducing impervious surfaces. Parking standards often are based on the idea of "the more the better." This is true particularly at large commercial retail and multifamily sites. Possibilities for reducing parking may be discovered when the problems of excess impervious surface are considered in the balance. Hopefully, there will be some latitude for reducing parking within minimum parking standards. For example, minimum standards are often exceeded, parking may be shared between compatible uses, and variances may be an option. Of course, the area not taken up by parking must be replaced with open space or landscaping, not other impervious surfaces.

STREAM CHANNEL RESTORATION AND CONSTRUCTION

Doing work to existing stream channels will almost certainly degrade the integrity of water resources and should be avoided. However, sometimes work will be done in channels anyway. Channel work should only be undertaken when the drainage benefits have been carefully weighed against the environmental impacts.

A new development site rarely requires major channel work. The focus here is for

1) Situations where no other alternative exists to doing channel work, or
2) The channel has been degraded by previous modifications and the site development offers an opportunity for improving the integrity of the water resource.

If stream channel construction or restoration work is undertaken, in-depth planning will be needed. Even small restoration projects require an investigation of the specific site conditions, including studying surrounding reaches of stream. Successfully applying the standard practices provided in this book will require a good understanding of stream dynamics. Obtaining additional technical resource material is recommended. Please see Appendix C, Information Sources. In addition to developing a plan for channel work, the designer should be involved on site during construction.

STORMWATER RUNOFF CONTROL--POST CONSTRUCTION

A fundamental goal of stormwater management is to mimic the way runoff left the site before development. Land development creates impervious surfaces which result in less infiltration. Less rain soaking into the ground means a greater volume of runoff. More runoff together with improved conveyance means faster runoff rates. Furthermore, simply using the land after it's developed produces pollutants. While there are more pollutants being produced, the land is also less able to assimilate pollutants. So the water is dirtier, there is more of it and it's running off faster as a result of land development. Again, the challenging goal of stormwater management is to develop land in such a way that runoff resembles the way runoff left the site before development.

Expanding Stormwater Management from Just Flood Control--Historically, flooding has been the primary issue addressed by stormwater. Most local governments enforce standard stormwater detention requirements, setting peak discharge rate limits, controlling flood-producing storms or large infrequent rain events. Many of these peak rate criteria do little for the problems of polluted runoff, streambank erosion or maintaining base flows during dry weather periods. Controlling large storms, 2-year (yr.) return frequency and greater, protects downstream properties from flooding but it does little, if anything, to protect the integrity of water resources. Large storm peak rate control is just one part of stormwater management.

Several multipurpose stormwater management techniques can be used in conjunction with flood control structures. These include 1) extended detention ponds, which detain regular small storm events; 2) infiltration trenches; 3) configuration of detention ponds to enhance pollutant treatment with wetland vegetation, permanent pools, etc.

Ponds and big structures are not the only approaches to mimicking predevelopment runoff characteristics. The way runoff is routed though a site also offers potential stormwater benefits: 1) Runoff may be routed through filter strips prior to being collected in a confined drainage system; 2) Concentrated runoff may be dispersed by a level spreader and routed though streamside forested buffer strips; and 3) Conveyance channels should be stable.

Selecting Pollutant Treatment Practices--Requirements for pollution treatment are generally more opportunistic than those for other stormwater practices. The appropriateness of specific post-construction pollution treatment practices tends to be more dependent on a greater number of site conditions. For example, while detention ponds and sediment traps may be incorporated into most any site, an infiltration trench is limited to very specific soil conditions. Also, water quality ponds are not usually feasible by themselves unless serving a dual purpose along with detention, or there is a particularly high pollutant load or a high downstream pollution threat. The approach recommended to the site planner is to use each practice unless there is a reason it can't be used. Recognize the limits of each pollution treatment practice and, if site conditions do not preclude their use, they should be used. This is also the way many regulations require post—construction pollution treatment practices.

Existing Subsurface Drainage--Since many of the areas being developed are presently or were once used for farming purposes, there are likely to be subsurface drain tiles. These subsurface tiles often served several farms and if broken or disrupted by construction activities can cause severe drainage problems to adjoining land and to individual development sites near these drains. If drain tiles are expected to continue to function after development, every effort should be made to locate these tile lines before construction starts and to reroute them when located during construction.

Tile lines were not installed to function as storm drains and therefore should not be used as outlets for stormwater runoff. Such use often exceeds the capacity of the tile causing it to fail or the surrounding properties to suffer drainage problems.

SEDIMENT POLLUTION CONTROL--DURING CONSTRUCTION

Few activities cause the magnitude of disturbance construction sites do. Adding to the challenge is the busy, rapidly changing nature of construction sites, making it doubly difficult to control sediment pollution.

One way to break down the plan of attack is to think first about structures to trap sediment. Silt fence, ponds and inlet protection all trap sediment. They receive runoff, separate the sediment out, and let the water continue on its way. Unfortunately, separating soil suspended in runoff is difficult. Practical practices have limited efficiency even when operating at their best. Furthermore, they routinely don't operate at their best.

Construction sites will erode and sediment control practices are needed. Fortunately, sediment control practices are straightforward and easy to incorporate into a stormwater pollution prevention plan. Sediment trapping structures can be easily specified. They are structures that can be designed, bid on and built without too many surprises or variation from the typical ways of doing the business of land development.

Stopping soil from eroding in the first place is quite a different matter. Much more than sediment control structures, controlling erosion is a nuisance. And it's needed in the midst of hectic construction schedules. Erosion control might not be worth the bother, except that it happens to be extremely effective. Money and effort spent on erosion control typically has the highest return in terms of the quantity of sediment prevented from washing off site.

Erosion control usually requires a change in the way of doing the business of land development. For example, phasing construction and limiting areas disturbed may restrict construction operations. Also, seeding could be left until the entire project is complete, and done in one step if it were not for its erosion control benefits. Seeding and mulching, whether temporary or permanent, are best done several times during the construction process.

To encourage the use of erosion control as an approach to reducing sediment pollution, regulation limit the length of time areas can sit bare between construction operations. Construction documents should 1) clearly state this requirement, 2) specify phased construction operations, and 3) identify areas that will likely require temporary seeding.

Individual homesites create an additional set of challenges. First, for single-family residential development, the highest sediment pollution rates typically occur during the home-building phase. This is due to the intensity of activity and the fact that the drainage system is usually functional at this point. Second, a large number of contractors and subcontractors are working on-site, sometimes for a short period of time. Sediment pollution can be significantly reduced if the initial plan is designed to remain in effect well into the building of individual homes. The initial sediment control system of settling ponds, diversions, etc., should remain functional as far into the home-building phase as is feasible. General specifications for individual homesites and small parcels are discussed in the standard "Small Lot Building Sites".

Other Construction Site Pollutants

Sediment is not the only pollutant construction sites may produce. Other pollutants include petrochemicals (oil, gasoline, and asphalt); pesticides; herbicides; solid wastes such as construction debris, wood, metal, roofing materials; construction chemicals such as acids, soil additives, concrete drying compounds, waste water (aggregate wash water, herbicide wash water, concrete cooling water, core drilling waste water, and clean-up water from concrete mixers); garbage; cement lime; and fertilizers. Good erosion and sediment control will prevent some sediments containing these pollutants from leaving the site. However, pollutants carried in solution, as surface films, or attached to fine clay particles will not be stopped by erosion and sediment controls and are nearly impossible to control in runoff.

Good management, storage and handling procedures can prevent pollution from occurring in the first place. In most cases, management of these materials will be the responsibility of contractors. The construction documents should state the requirement for controlling pollutants in addition to sediment. The plan should go on to define who is responsible for the management of these materials.

What Is a SWPPP?

A Construction Site Stormwater Pollution Prevention Plan (SWPPP) describes all the elements of a stormwater strategy that are constructed or implemented during construction.

Construction Documents--Plans, drawings or construction documents are what the contractors bid on and will be used on-site during construction. They must convey the information needed by the contractors to implement practices. Included are detail drawings, notes and instructions on the plan sheets.

Supporting Narrative--A narrative should be developed for the benefit of the plan reviewer. It contains information to help with the review such as a description of the site-specific characteristics, planned land use, justification or reasons for the SWPPP design incorporating certain practices and not others, and supporting calculations. The construction documents should be complete enough so that it will not be necessary for the person implementing the plan to have the narrative.

Site Information Needed to Develop a SWPPP

Topography--Pre- and postdevelopment contours lines are necessary for designing a SWPPP. Information obtained from a survey of the site is usually more than adequate. Another source is United States Geological Survey Quadrangle Maps (USGS Quads). They are useful for general watershed topography or for on-site design if the development site is unusually straightforward. USGS Quads are available from ODNR Division of Geological Survey, (614) 265-6576.

Soils--Information can be obtained by on-site investigation and from Soil Survey of the County. Soil Surveys can be obtained from county Soil and Water Conservation District offices. See the list of resource agencies at back of this book for phone numbers.

Vegetation--An inventory of existing vegetation may be accomplished from on-site investigation and from aerial photography. The Department of Natural Resources sells aerial photos. They may be obtained by contacting the Division of Real Estate and Land Management at (614) 265-6395.

STEPS FOR PLANNING AND DESIGN

These procedures may help produce a comprehensive SWPPP, one which will incorporate an effective stormwater strategy as part of the site development. Applicable regulations such as municipal ordinances or the NPDES Storm Water Permit may provide additional specific information and must be referenced. Not all regulations require all that is described in the procedures and of course regulations may address additional issues, i.e., wetlands or slope stability, etc.

I. Layout

A. Configure the site layout to keep the natural drainage system intact. Balance the stormwater benefits provided by the natural drainage system against possible conflicts with the intended land use and on-site drainage improvement.

B. Provide a buffer strip along streams.

1. Forested buffer strips should encompass the flood plain and adjoining wetlands.

2. Put the buffer strip under discrete ownership. If the property is being subdivided, individual parcels should not extend into the buffer strip. Some options are to have the buffer in common open space owned by a homeowners association, or donated to a conservation organization, park district, or other public entity.

3. Establish easements containing the buffer strip as minimum protection of the buffer, especially if separate ownership is not possible.

4. Design a visual barrier such as a permanent fence or signage.

C. Scrutinize every possibility for minimizing the amount of impervious area to be created.

1. Cluster development to the extent possible on individual sites.

2. Minimize parking, road widths, etc., and replace with open space or landscaping, not other impervious surfaces.

3. Use modular pavers, or other pervious surface as an alternative to pavement for remote parking and low traffic areas.

II. Stream Channel Work

A. Where increased conveyance and improved drainage are needed, do not create ditches or enclose waterways but instead apply stream channel construction and restoration practices such as multi-stage channels.

B. If no other feasible alternative exists and a stream must be relocated, design the new channel with stream construction and restoration practices.

C. Improve existing ditches or other extensively degraded channels by reestablishing forested riparian buffers and in-stream channel restoration practices.

III. Runoff Control

III. Runoff Control--Design the permanent on-site drainage system to be stable for the design storm, or at least the 10-yr. return frequency storm. This should include roadside ditches, storm drain outlets, pond outlet pipes, etc.

IV. Sediment Control

A. Design sediment control structures to do the following:

1. Sediment control structures must intercept runoff through all stages of development. They must be designed to allow installation prior to disturbing the rest of the site.

2. Sediment control practices must handle the runoff before, during and after the on-site drainage system is constructed.

B. Sediment Ponds

1. Use sediment ponds as the first priority sediment trapping practice. They are generally considered practical for drainage areas with 0.5 acre (ac.) or more disturbed by construction.

2. Sediment ponds must be drawn on the plans. They must be drawn to scale with necessary notes regarding the excavated depth and outlet structure.

3. Specify where temporary diversion dikes will be used to redirect runoff such as:

   a. Collect and route runoff from the construction site to sediment ponds.

   b. Keep clean runoff from off-site separate from sediment-laden runoff.

   c. Route runoff away from steep slopes such as cut or fill slopes.

V. Erosion Control

A. Manage concentrated flow to minimize erosion.

1. Route runoff through stable channels to vegetated areas and away from work areas and steep slopes.

2. Specify requirements for prompt stabilization of channels.

3. Set limits for work within waterways.

B. Minimize the area bare and susceptible to erosion.

1. Include the written requirements for soil stabilization in the construction documents, i.e., maximum length of time areas may be bare and dormant.

2. Define the limits of clearing and grading. Where this corresponds to tree preservation areas or some other critical limit to clearing, specify a temporary fence be constructed before clearing begins.

3. Specify individual areas to be cleared and the timing or sequence of the clearing as related to other construction operations.

4. Specify individual areas to be permanently stabilized and the timing or order of the stabilization as related to other construction operations.

5. Include temporary seed specifications and seed mix.

6. Specify individual areas to have temporary seeding applied and the timing or sequence of seeding as related to other construction operations.

VI. Construction Pollutants Other than Sediment--Include written requirements for proper handling, storage and disposal of hazardous materials and potential pollutants other than sediment including: fuel storage and spill cleanup; hazardous materials storage, use and disposal; solid waste and construction debris disposal; and equipment washdown.

VII. Information to Help with Plan Review--Include the following information:

A. Location Map.

B. Pre and Post Contours.

C. Pertinent off-site information.

1. Drainage areas and anything unusual about them.

2. Name water bodies in addition to any on-site—at least describe where the runoff is going, including the name of the immediate receiving stream and an eventual stream large enough that the reviewer can find it on a map without too much difficulty.

D. Calculation supporting design of structural practices.

POST-CONSTRUCTION POLLUTION PREVENTION

POST-CONSTRUCTION STORMWATER QUALITY TREATMENT

Forested Buffer Strip

Description

A forested buffer strip is a strip of riparian forest, i.e., adjacent to streams, rivers and other water bodies. They are designed to remove pollutants associated with urban stormwater runoff by deposition, absorption, adsorption, plant uptake, denitrification, and other processes, thereby protecting water quality.

Buffer strips reliably remove a high percentage of nutrients, sediment, organic matter, pesticides and other pollutants from urban stormwater runoff prior to entry into water bodies.

Additional functions are to

- remove pollutants from stream flows during periods of over-bank flow;
- reduce the flashiness of stream flows by reducing high flows and sustaining increased low flows;
- reduce water temperatures by shading;
- provide wildlife habitat and protect and create aquatic habitat;
- provide detritus (leaves and woody debris), which are needed energy supplies for the stream ecosystem; and
- reduce streambank erosion by stabilizing streambanks and dissipating flow energy.

Creating buffer strips is not only planting trees, but also must include runoff control and soil preparation.

Conditions Where Practice Applies

Forested buffer strips are most often used on lands adjacent to rivers, permanent streams and intermittent streams. They may also be used at the margins of environmentally sensitive ponds, lakes or wetlands especially if a significant amount of inflow occurs as sheet flow runoff.

Lands must be capable of maintaining minimal soil compaction and a dense forest understory to achieve the following pollutant removal mechanisms:

- Subsurface nutrient buffering processes, such as denitrification, which occurs where soil oxygen, soil moisture, and organic matter are adequate.
- Nutrient uptake by plants, which occurs where runoff infiltrates or where the water table is within the root zone.
- Filtration, which occurs on soils that are not compacted and have dense surface vegetation and forest leaf litter.

Planning and Design Criteria

Determining the Width of the Buffer Strip--The minimum width of the buffer strip on each side of the stream shall be two and one-half times the stream width as measured from the top of the streambanks or 50 feet (ft.), whichever is greater.

Ideally, buffer strips will expand from the minimum width defined above to encompass all of the flood plain and adjoining wetlands. This may be based on designated flood plains or soil hydrologic groups as shown in the county soil survey report. The width of the buffer strip should increase to occupy any soils designated in the county soil survey as Hydrologic Group D and those soils of Hydrologic Group C, which are subject to frequent flooding.

Note: If a primary goal for a specific buffer strip is to provide a wildlife travel corridor, then the recommended minimum width of a forested corridor is 300 ft. This is the total forested width including the buffer strips on both sides of the stream.

Flow into the Buffer Strip--To avoid runoff circumventing the treatment process, buffer strips will be designed to encourage sheet flow and infiltration. Concentrated flows from storm drains, swales and ditches must be converted to uniform, shallow sheet flow before entering the buffer strip. This may be accomplished by land shaping and constructing level spreaders (see specification "Level Spreader").

Overuse--Riparian areas are often popular recreation areas, but overuse will result in soil compaction and loss of vegetation, damaging the pollutant removal capacity of the buffer strip. Recreation may be necessary for the feasibility of the buffer area and can coexist with water quality objectives. Foot traffic should be limited with defined trails and stabilized access points to the stream. Planting dense thorny foliage will also discourage damaging foot traffic.

Reforestation Methods

- **Natural Regeneration**--Simply establishing a preservation area or "no-mow" zone may be enough to allow natural forest regeneration if there are existing trees in the area to be reforested. This may not work in areas without trees, which have been farmed or have managed turf. Areas with intrusive species or dense turf may require some site preparation to improve regeneration potential. If adjacent trees are planned as the primary seed source for the regeneration, a professional forester or other knowledgeable person should be consulted.

- **Transplant Woody Plants**--Materials may be obtained either from a nursery or through other available sites. Cuttings such as willow posts and stakes are discussed in Streambank Stabilization Specifications.

- A combination of tree planting and natural regeneration may be a good choice for certain areas. For example, natural regeneration may be adequate for the majority of a buffer strip but trees may need to be planted adjacent to the stream to expedite streambank stabilization or to restore a tree canopy over the stream.

Preserving Existing Vegetation--Existing forest vegetation should not be removed from the buffer strip area. To provide leaves, detritus and woody debris to the stream ecosystem, all vegetation, including dead trees and stable overhanging trees, should be left on the streambanks. Tree removal for increased flow capacity, should only be considered when the impacts to the stream ecosystem have been recognized and appropriately weighed.

Species Selection--As a minimum, 10-15 species of trees and shrubs should be used at each site with an emphasis on native species. Tree and shrub species must suit the site's moisture and light conditions. In open areas, it may be useful to mix hardier pioneer species (two-thirds) with later successional species (one-third) in recognition of the difficult environment for new plants. In areas of partial shade, a large proportion of shade-tolerant species should be used. On all sites, a mixture of dominant tree species, understory and herbaceous plants is also recommended. Species should be mixed randomly across the site.

Stocking Rates--Reforestation stocking rates of 600-1,000 seedlings per acre or 500 containerized stock per acre are commonly used standards. If planting in the fall or in high use areas, seedlings are not generally recommended.

Site Preparation--Site preparation may include soil amendments based on soil analysis, soil aeration through discing or plowing and vegetation control. If soils are of high quality, and relatively uncompacted, site preparation may be limited to the digging of planting beds.

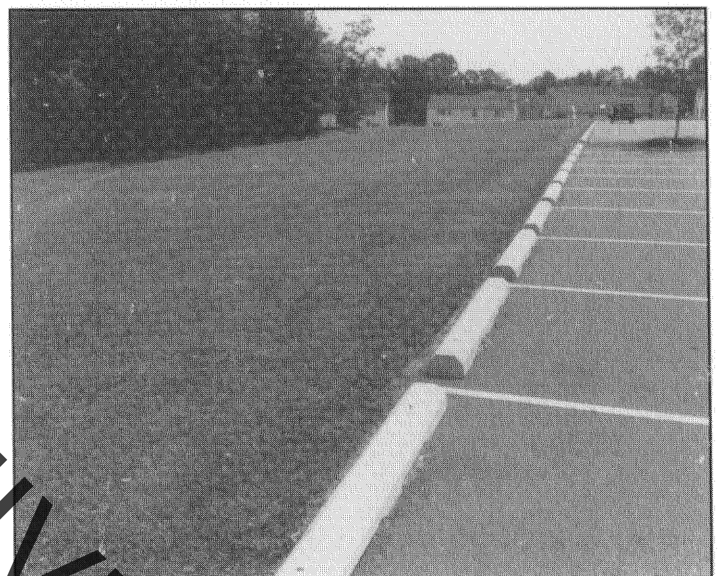
Stabilization--A cover of annual grains such as wheat or oats at 1 to 1 ½ bu./ac. may need to be planted to temporarily stabilize soil during the establishment period.

Maintenance--Maintenance plans covering a 3-yr. period after planting should be defined. As a general guidance, within the first 2 yr., maintenance monitoring should be conducted two to four times per month during the spring and summer. Once per month in the fall/winter should be more than adequate. On these

Specifications
for
Buffer Strip

NOTE: SEE SPECIFICATIONS FOR LEVEL SPREADER, TREE PRESERVATION AREA AND STREAMBANK STABILIZATION.

Grass Filter Strip



Description

Grass filter strips improve the water quality of small sheet flows from developed areas. They are uniform strips of dense turf or meadow grasses with minimum slope, designed to accept diffuse flows from parking lots or other impervious surfaces usually prior to runoff being collected by curbs, ditches or storm drains.

Dense turf creates a thick porous mat which dissipates small flows causing deposition and filtration of particulates. Other pollutant removal mechanisms are nutrient uptake, adsorption, and infiltration. Grass filter strips are generally not very effective for treating soluble pollutants. Their overall effectiveness is highly variable depending on the quality of turf, slope, and flow rates.

PLANNING CONSIDERATIONS

Grass Filter Strips at the Source vs. Buffer Strips at the Resource--Grass filter strips are used as close as possible to the source of runoff. They are integrated throughout a development site such as along the edges of parking lots. Buffer strips, on the other hand, are used adjacent to perennial and intermittent stream channels. Grass filter strips are planted to turf while buffer strips have diverse forest vegetation. Grass filter and buffer strips both treat sheet flow runoff but buffer strips also provide many additional functions important to the riparian system: shading, bank stability, leaf litter and detritus, etc.

Application--Grass filter strips are an adaptable practice that often can be incorporated throughout a development site, obtaining multiple use from turf areas. More natural meadow areas also may be used for grass filter strips. The site's topography must allow shallow slopes and sheet flow runoff through the filter strip. Filter strips may intercept runoff as sheet flow or more elaborate designs may employ a level spreader to dissipate concentrated flows.

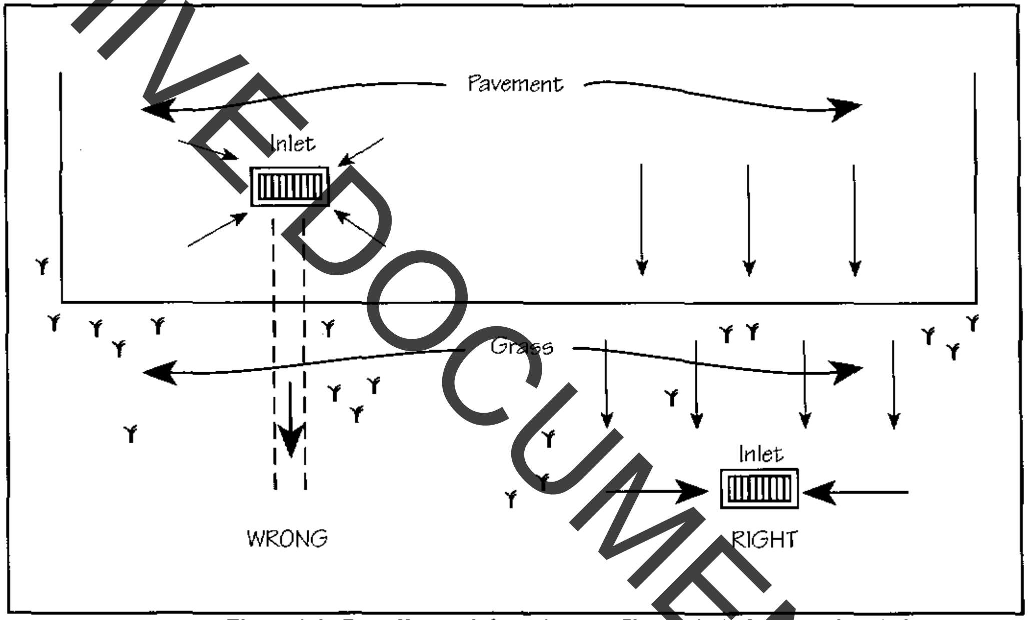


Figure 1-1 Runoff routed through grass filter strip before entering drainage system

DESIGN CRITERIA

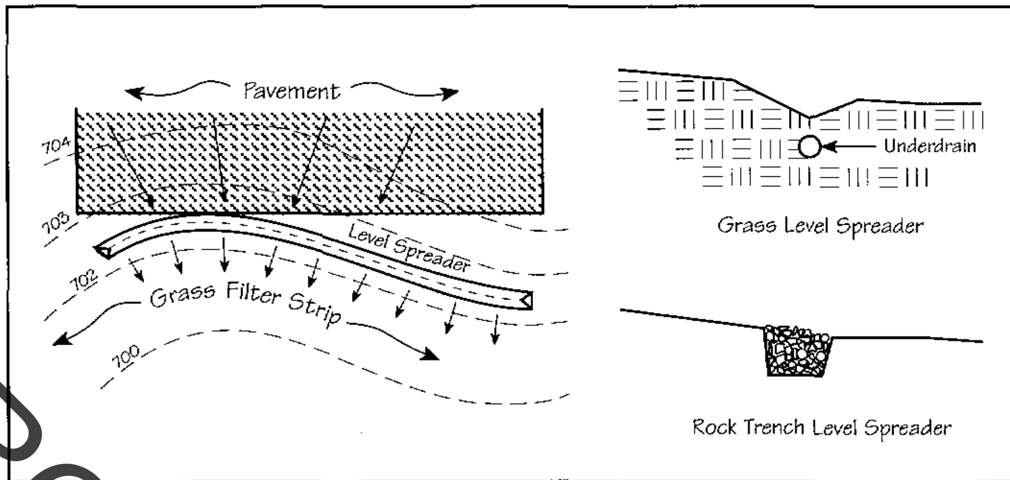


Figure 1-2 Grass Filter Strip with level spreader to distribute flow

Slope--The slope of a grass filter strip should be as flat as possible. However, if standing water may create a nuisance, slopes should be sufficient to provide positive drainage. To avoid runoff converging into concentrated flows, slopes must be less than 5%.

Slope Length--Reliable pollutant removal can be achieved if the slope length (the distance water flows through a filter strip) is as shown below and if the quantity of runoff will be small enough to maintain sheet flow:

Filter Strip Flow Length		
Slope of Filter Strip	Particulate Trapping Efficiency	
	75%	90%
1%	10 ft.	50 ft.
2%	30 ft.	120 ft.
3%	40 ft.	135 ft.
4%	60 ft.	170 ft.
5%	75 ft.	210 ft.

Pedestrian and Vehicular Traffic--Heavy use should be avoided to minimize soil compaction and maintain quality dense vegetation.

Establishing Vegetation--Dense vegetation is critical to effective filter strips. Poor stands of vegetation may even result in a grass filter strip eroding and becoming a source of pollution. Soil preparation and planting is deserving of special attention (see Specifications for Permanent Seeding).

Maintenance--Only a minimum amount of maintenance should be necessary to ensure continued functioning of grass filter strips. The most significant concern is gully formation from unexpected concentrated flows which must be remedied. Vegetation will function if it is maintained as manicured lawn (less fertilizer and pesticides) or natural meadow. It must be kept healthy and will benefit from at least annual mowing.

Specifications
for
Grass Filter Strip

NOTE: SEE SPECIFICATIONS FOR PERMANENT SEEDING.

1. Filter strips shall be graded to prevent runoff from concentrating. Depressions, ridges and swales shall be graded out to achieve a uniform slope having a level grade across the slope.

2. Soil compaction shall be minimized in the filter strip area. Work shall be performed only when the soil moisture is low.

3. A subsoiler, plow or other implement shall be used to decrease soil compaction and allow maximum infiltration. Subsoiling shall be done when the soil moisture is low enough to allow the soil to crack or fracture.

4. Because a dense vegetation is critical to effective filter strips, only a dense stand of vegetation without rills or gullies shall be acceptable. If rills or gullies form or if vegetative cover is not dense, a new seedbed shall be prepared and replanted.

Infiltration Trench

Description

Infiltration facilities collect stormwater runoff and allow it to infiltrate into the ground. These structures provide temporary underground storage in the form of a trench or other storage chamber filled with uniform graded stone. They operate in two stages, the first being sediment removal, consisting of filter strips or a settling pond. Only after most sediment is removed does runoff enter the second storage stage and allow infiltration.

Infiltration is the single most efficient post-construction stormwater practice, providing several benefits other control practices don't. Most notably, infiltration tends to reverse the hydrologic consequences of urban development by reducing peak discharge and increasing base flow to local streams. Unfortunately, infiltration trenches must be very carefully constructed to ensure they will continue to function, and they often have high long-term maintenance requirements. Infiltration practices also are limited by site constraints, particularly soils, which must be within a narrow range of permeability.

Conditions Where Practice Applies

Drainage Area and Site Layout--Infiltration trenches offer much flexibility at incorporating water quality treatment into a site's drainage system. They may be used prior to runoff entering the site's drainage system, such as along parking lot perimeters. They can be located in small areas, which cannot readily accommodate wet ponds or similar facilities. Conversely, infiltration trenches are not practical for larger areas.

Size--Infiltration trenches are generally not considered practical for sites larger than 5 ac.

Industrial--This practice should not be used in heavy industrial areas, areas with chemical storage, pesticide storage or fueling stations in order to reduce the risk of groundwater contamination from substances which may not be removed by this practice.

Infiltration Rates--Infiltration rates must be at least 0.52 inch per hour (in./hr.) but not more than 2.4 in./hr. Rates slower than the minimum will be unreasonably large and are more prone to failure. Higher infiltration rates will not provide adequate runoff treatment and protection against groundwater contamination.

Drainage Wells--Drainage wells, injection wells or improved sinkholes are sometimes used to dispose of stormwater but they are not a stormwater pollution control practice and should not be confused with infiltration practices. Drainage wells do not provide treatment of stormwater which is accomplished in infiltration practices by slow infiltration through the soil. Drainage wells can cause contaminants to enter groundwater, and if their depth is greater than the largest surface dimension, they may be regulated by Ohio EPA's Division of Drinking and Groundwaters, Underground Injection Control Unit.

Undisturbed Soil--Trenches should not be constructed on areas which have been filled.

Stable Slopes--Trenches should not be used in slip prone areas where they may cause slope instability.

PLANNING CONSIDERATIONS

Sediment Clogging--The principle threat to infiltration trenches and a common reason for their failure is sediment contamination clogging and sealing off the permeable soil. An effective sediment trapping system is an essential part of all infiltration trench designs.

Maintenance--Infiltration structures have relatively low regular maintenance requirements but are likely to have significant long-term maintenance needs. When planning an infiltration structure, maintenance must be addressed to help ensure a reliable long-term maintenance program.

Groundwater Protection--Precautions must be taken to guard against the facility introducing contaminants into water supply aquifers. Excessively permeable soils will not effectively stop pollutants and should not be used for infiltration practices. Infiltration structures should not be located within 100 ft. from an active water supply well. Normally, infiltration through soil is a highly effective and safe means of removing pollutants and protecting groundwater from contamination. Removal mechanisms involve sorption, precipitation, trapping, and bacterial degradation or transformation and are quite complex.

Design Criteria

Soil Infiltration Capacity--Soil infiltration rates within the trench must be between 0.52 and 2.4 in./hr.

Storage Requirements--Storage capacity for 0.5 in. of runoff per acre of drainage area is required for reliable water quality treatment. Additional storage may be added if the structure also will be used for stormwater discharge rate control, reducing flooding and stream channel erosion. The storage capacity of the reservoir is equal to the volume of the runoff times the pore volume ratio of the stone fill. A common value for uniform graded crushed stone is 0.4; in which case Storage Volume = 0.4 x Trench Volume.

Drain Time Requirements--The infiltration facility shall be designed with a maximum drain time of 48 hr. for the 0.5 in. of runoff detained for water quality treatment. If additional runoff storage is used for stream channel erosion protection or flooding control, 72-hr. drawdown is acceptable.

Dimensions--The dimensions of the storage reservoir are made by fitting the length, width, and depth into a configuration which satisfies drain-time and storage volume requirements. The trench dimensions shall be sized by accepted engineering methods such as those outlined below.

1. **Determine Initial Storage Depth**--The bottom of the infiltration trench must be deeper than 2 ft. to avoid freezing and shallow enough to leave at least 5 ft. between seasonal high-water table or bedrock and the trench bottom. Soil morphology also must be considered in determining the dimensions of the storage reservoir to utilize the optimum horizons or strata. The presence of a thin, slowly permeable soil horizon may require a trench depth which completely penetrates it to more permeable underlying material. Long trenches may need to be curved parallel to the topographic contour in order to keep the trench bottom elevation within the optimum depth in the soil profile.

2. **Determine Area of Trench Bottom**:

$$A_{min} = \frac{V}{E * T}$$

Where: A_{min} = Area of the bottom of the trench (ft.^{2})
V = Volume of Fluid Storage (ft.^{3})
(Trench volume less volume of stone)
E = Exfiltration Rate (ft./hr.)
(Soil infiltration rate at trench bottom)
T = Drain-Time (hr.)

3. **Determine Length and Width**--A long, narrow trench is less affected by water table mounding. If depth to seasonal high-water table or bedrock is within 5 ft. of the trench bottom, it is advisable to design the trench as long and narrow as possible.

Sediment Control--The potential for failure of infiltration practices due to clogging by sediments is of great concern. Failure will result if sediment is not trapped before entering the trench. It is imperative that the facility design include a durable, maintainable system for removing sediment from stormwater before it enters the infiltration structure. Sediment trapping pretreatment should be designed so that runoff will bypass the infiltration structure when the pretreatment becomes clogged or otherwise fails.

- **Concentrated Flow**--Pretreatment of runoff first collected by the site's drainage system then entering an infiltration structure as concentrated flow offers much opportunity for innovation. Treatment may be accomplished to some extent before it enters the drainage system through the use of grass filter strips or ponds to remove sediment before it enters the infiltration trench.

- **Sheet Flow**--Pretreatment of runoff entering an infiltration structure as dispersed sheet flow is more practical. Water entering though the entire top of the infiltration trench may first flow through grass filter strips at least 25 ft. wide, then through a filter constructed as the top layer of the trench itself.

- **Geotextile**--The sides and top of the trench must be lined with geotextile to restrict the amount of sediment entering the structure. The top layer of the geotextile should be covered by 6-12 in. of smaller sized gravel (0.75-in. diameter). This top layer of gravel and geotextile must be replaceable. The bottom of the trench must NOT be covered with geotextile, which can become clogged with sediment, preventing infiltration.

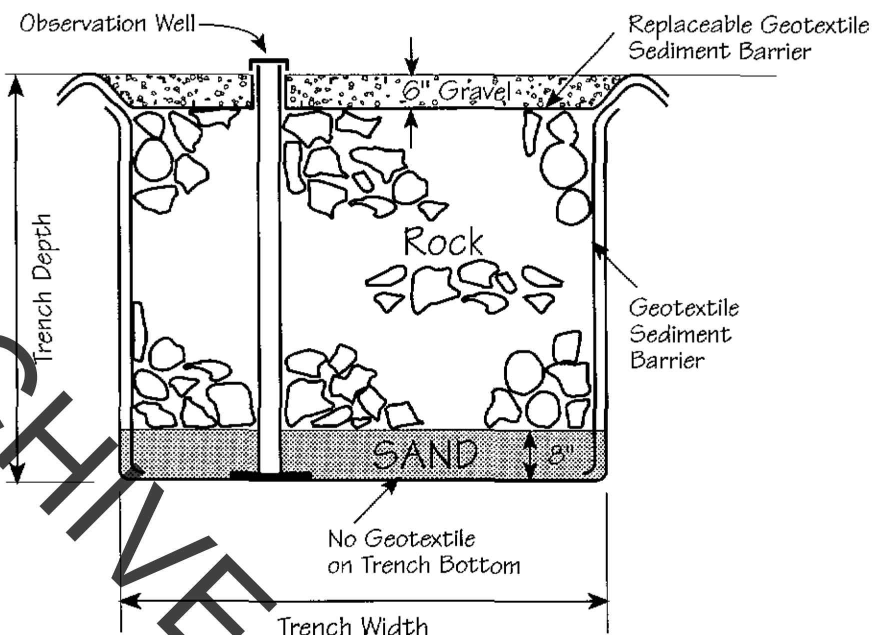
- **Bottom Sand Filter**--To promote continued infiltration, the bottom of the trench should be covered with a clean layer of sand.

Observation Well--An observation well, consisting of a perforated vertical pipe should be installed in the trench to monitor performance. The original depth of the observation well must be marked on the top of the well.

Overflow--Infiltration trenches, like all stormwater facilities, must be designed to handle storms which exceed their storage capacity without damage. Discharges must be non-erosive and overflow must always freely pass over or through the infiltration trench without being restricted by sediment filters. For example, infiltration trenches that accept concentrated runoff from a subsurface pipe must have an overflow structure that collects overflow from within the structure rather than forcing runoff up and out through the geotextile cover.

Construction Sediment--Infiltration practices must not receive runoff until the entire construction area is stabilized.

Specifications
for
Infiltration Trench



1. SEDIMENT SHALL BE PREVENTED FROM ENTERING THE INFILTRATION TRENCH. Sediment clogging and sealing off the permeable soil is the most common cause of infiltration trench failure. Runoff from the construction site shall NOT be allowed to flow to the trench until construction is complete and upslope areas have been stabilized. If storm drains enter the infiltration trench directly and cannot be rerouted they shall be sealed with a masonry plug through construction.

2. The infiltration trench design may include a system for removing sediment from stormwater before it enters the structure however this system shall NOT be used to control sediment during construction.

3. Trench excavation and backfilling of sand and rock shall be done when the soil moisture is low enough to allow the soil to crack or fracture. No trench excavation or fill shall occur on wet soil to prevent compaction and maintain soil permeability.

4. Bottom Sand Filter--The bottom of the trench shall be covered with an 8-in. layer of clean sand. The sand layer shall be placed the same day excavation is completed.

5. Observation Well--A 4-in.-diameter rigid, perforated vertical pipe shall be installed in the trench. The vertical pipe shall be securely and permanently attached to a base to prevent upward movement. The top of the vertical pipe shall have a secure removable cap. The original depth shall be permanently marked on the top of the observation well.

6. Geotextile--The sides and top of the trench shall be lined with geotextile. The bottom of the trench shall NOT be covered with geotextile, which can become clogged with sediment, preventing infiltration.

7. Rock--Rock fill shall be clean, well graded, uniform size crushed rock. Poorly graded rock has less void space available for runoff storage and shall not be accepted.

8. Gravel Top Layer--The top layer of the geotextile shall be covered by 6 in. of gravel (0.75-in. diameter).

WATER QUALITY PONDS

DESCRIPTION

Water quality ponds are stormwater ponds designed to treat runoff and improve water quality. By incorporating specific design features, water quality ponds remove pollutants by settling, altering and biological uptake in addition to protecting downstream areas from erosion and flooding.

Design features include: long detention times, permanent pools, settling bays where water enters the pond, long flow lengths, shallow wetland environments, aquatic plants, optimum depth, and shading water from the sun. Ponds designed with these water quality features also can reduce pond maintenance, improve esthetics and provide wildlife habitat.

CONDITIONS WHERE PRACTICE APPLIES

Water quality ponds apply to all sites with impervious surfaces. They are easily incorporated on sites where a stormwater pond is to be constructed to control downstream erosion and flooding. They also may be retrofitted into existing stormwater ponds. Even where detention ponds are not necessary for flood control or to prevent downstream channel erosion, water quality ponds should be constructed. Water quality ponds may not be adequate for heavy industrial areas that may require a more extensive design.

PLANNING CONSIDERATIONS

Each stormwater treatment practice discussed in this chapter has applications which they can best meet. Ponds, however, are the most widely applicable practice for water quality treatment. The advantages of ponds for water quality treatment include:

- Ponds are relatively durable and require much less maintenance than some other practices.
- Ponds constructed for flood control and stream channel erosion control are easily modified to treat stormwater runoff quality.
- Well designed ponds can be very effective at treating polluted runoff.

Ponds constructed for flood control and stream channel erosion control often work well for water quality control; however, without specific design objectives, just as often they don't work for water quality control. For example, dry detention basins designed for controlling rare large storm events may pass the runoff from frequent storms completely unrestricted. Monitoring has shown some poorly designed ponds can actually be responsible for increasing downstream pollutant loads.

DESIGN CRITERIA

The following are specific design features that provide water quality benefits. These design features, while providing benefits individually, work best in tandem. To maximize stormwater treatment, ponds should be designed with as many of the following design features as possible:

- Extended Detention
- Wet Pool
- Forebay
- Aquatic Benches and Wetlands
- Optimum Flow Length
- Reverse Flow Pipe
- Optimum Pool Depth
- Shading and Buffer Plants
- Runoff Reuse

Extended Detention:

Definition--Stormwater ponds with extended detention temporarily detain a portion of runoff long enough to allow pollutants to settle while slowly releasing the stored runoff. Average rainfall events are released over 12-24 hr.

Multi-use Ponds--Extended detention is an adaptable design feature. It may be used in wet ponds or in dry ponds. It can be used with any of the other water quality design features discussed here. Extended detention can also easily be used in retrofit projects, adding water quality treatment to existing ponds.

Stream Channel Erosion--Conventional stormwater discharge rate control criteria often addresses large, infrequent rainfall events of 1- or 2-yr. return frequency and greater. Controlling large storms can effectively reduce downstream flooding and, to some extent, reduce stream channel erosion. Unfortunately, significant stream channel erosion usually results from development even when conventional detention criteria are met. The slow release of small rainfall events with extended detention further mimics the predevelopment hydrology and adds greater stream channel erosion control.

Detention Volume--The volume of runoff detained by extended detention is equal to 50% of a 2-yr. 24-hr. storm.

Release Rate--The outlet structure should be sized to release the volume of extended detention runoff over a 40-hr. period after the rainfall event. This sizing criteria should result in average runoff events which are responsible for transporting the majority of the pollutants to be released over 12-24 hr.

Wet Pool:

Definition--Stormwater ponds with a wet pool have some portion of their total storage volume permanently retained and do not drain between runoff events. Wet ponds may or may not have additional temporary storage for flood control, streambank erosion control or extended detention for additional water quality treatment.

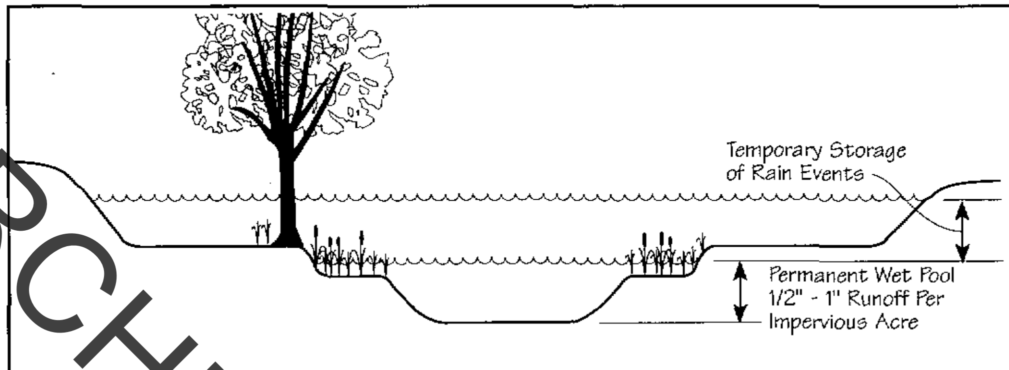


Figure 1-3 Permanent wet pool within a stormwater detention basin

Means of Treatment--Ponds with permanent pools treat runoff primarily by settling. The long residence times also allow for some biological uptake of soluble pollutants.

Effectiveness--A permanent wet pool is the pond design feature with the single greatest effect on water quality. Pollutant removal rates are dependent on the volume of the pool. Permanent pool volume equal to 0.5-1.0 in. of runoff per acre impervious area will reliably achieve moderate to high removal rates.

Additional benefits--Wet ponds also have the potential to be a valuable amenity and to provide wildlife habitat.

Site Constraints--A major constraint is insufficient contributing watershed area to maintain a permanent pool during dry weather. The minimum required watershed area depends on the infiltration rates of the soils within the pond. However, permanent pools may be difficult to maintain if the contributing watershed area is less than 10 ac. and if the ratio of drainage area to water surface area is less than 6:1.

A series of soil borings should be taken at the proposed pond site prior to final design to characterize bedrock, soil infiltration rates, and the adequacy of excavated soils for use as core or embankment fill.

Size--Wet pools, when used alone to treat urban runoff quality, should retain between 0.5-1.0 in. of runoff per impervious acre treated.

Forebay:

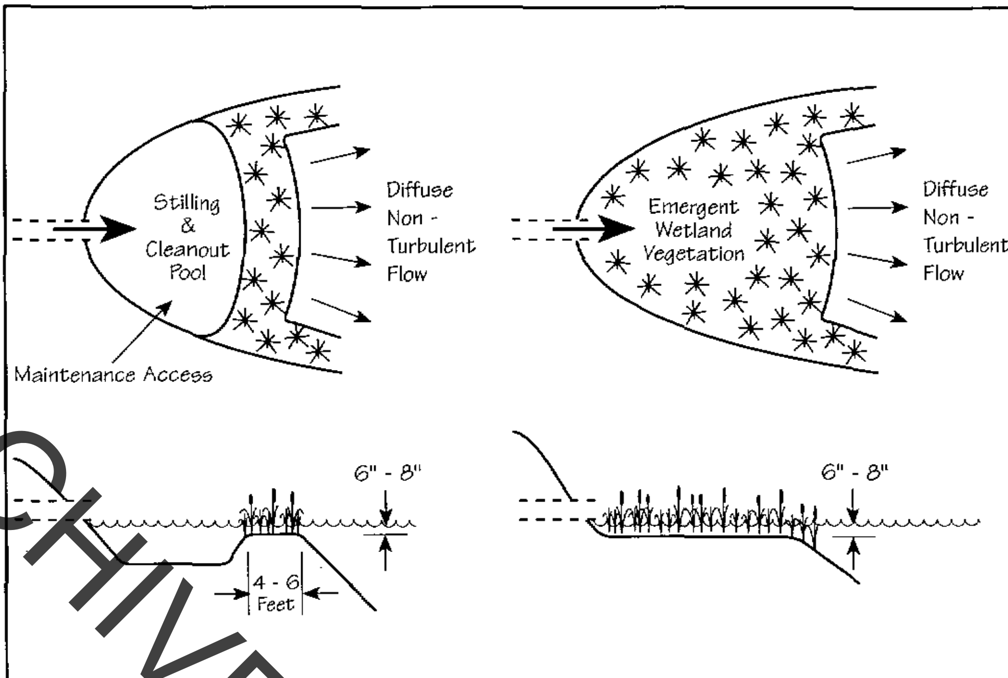


Figure 1-4 Water quality pond forebay

Definition--A forebay is a settling pool located at the inlet to a pond. It is separated from the rest of the wet pool by a submerged dike planted with emergent wetland vegetation. It is primarily used to improve the settling efficiency of a pond but also lessens maintenance by promoting settling in a confined, easily accessible location.

Means of Treatment--Forebays promote settling in several ways: 1) by segmenting or dividing the pond into cells which reduces mixing and promotes plug flow, 2) by converting the high velocity concentrated inflow from a pipe to a wide uniform slow flow to the normal pool area, 3) by dissipating flows through emergent vegetation.

Size--For ponds with a single inlet, a forebay may occupy from 8-25% of the normal pool area. Forebays should be large enough to avoid scour and re-suspension of trapped sediment and sized for ease of construction and cleanout. Forebays should have a water depth of at least 3 ft.

Emergent Vegetation--The submerged dike separating the forebay from the rest of the wet pool should be 6-12 in. below the normal water surface elevation and planted with hardy emergent wetland vegetation. See Aquatic Benches and Wetlands section for planting details.

Maintenance Access--A forebay is intended to trap and accumulate sediment. To accommodate relatively frequent sediment cleanout, easy equipment access should be provided to the forebay. This should include gradual slopes without obstructions and an access easement.

Aquatic Benches and Wetlands:

Definition--Stormwater ponds that include areas of wetland environments, enhanced to maximize water quality treatment. The wetland may occupy the entire pond surface area or only a wetland fringe or shallow aquatic bench.

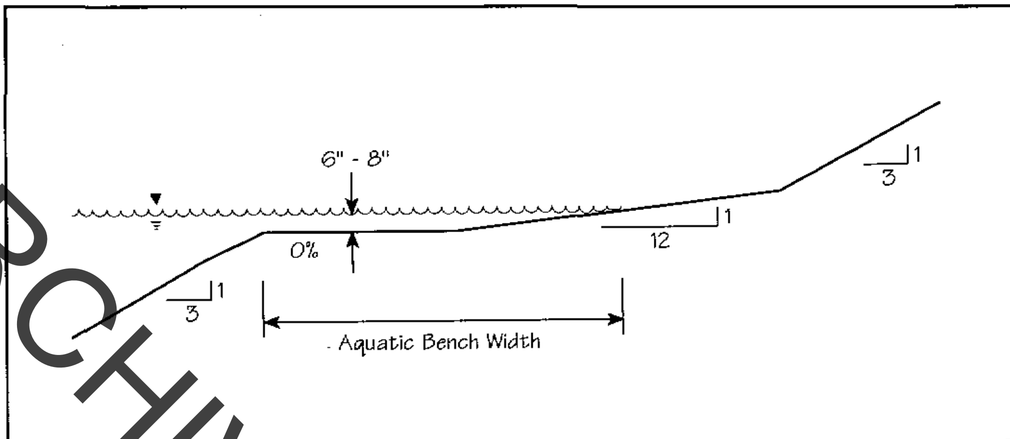


Figure 1-5 Water quality pond side slope forms an aquatic bench

Means of Treatment--Wetlands, like most water quality practices, treat stormwater runoff primarily through gravitational settling. In addition to promoting settling, wetland vegetation stabilizes the deposited sediment. Wetlands can further treat stormwater in ways most other treatment practices cannot, by plant uptake, adsorption, physical filtration, microbial decomposition and shading.

- Wetland plants can take up excess nutrients. Too much nitrogen and phosphorus causes algae blooms and fish kills as well as health hazards.
- Wetland plants readily absorb heavy metals, and other toxic wastes.
- Microorganisms that thrive in wetland plant root systems eat and decompose pollutants. These microorganisms that live among the plants are very good at breaking down poisonous organic compounds such as benzene, toluene and PCBs into harmless elements that the microorganisms and plants can digest.

Size--The surface area of a wetland should be greater than 2% of the contributing watershed when used alone to treat urban runoff. When used as one water quality design feature within a stormwater pond, wetland vegetation should occupy at least 20% of the wet pool's water surface.

Wetland Depth--The average depth should be between 6 and 12 in.. This depth may vary but must accommodate 1) the depth appropriate for the type of wetland vegetation planted, and 2) adequate volume of runoff stored within the wetland. Wetland diversity and stability will be improved if a variety of depths are created with complex subsurface contours and irregular shapes to provide more edge effect.

Deep areas, greater than 3 ft., should be created at the outlet structure so that vegetation and sediment buildup do not interfere with outflow from the basin. Incorporating a deep pool at the inlet to the pond may be used to promote initial settling and dissipate concentrated inflow.

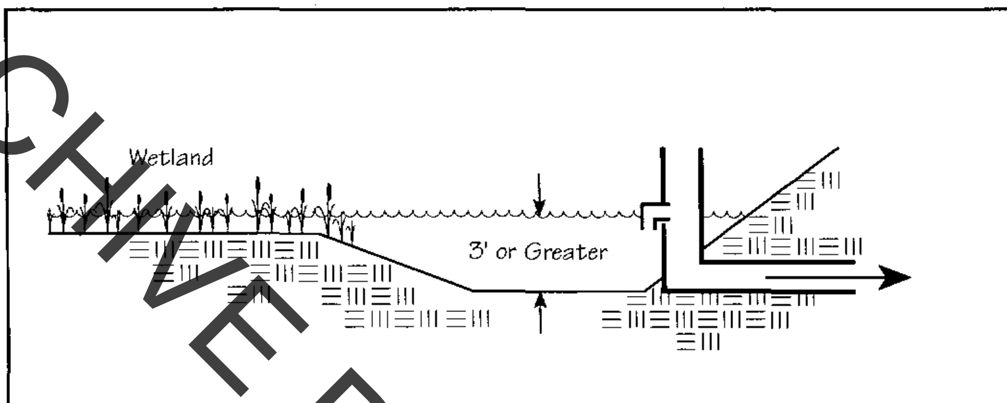


Figure 1-6 Open water around outlet structure of wetland

Vegetation--Six to eight species of wetland plants should be planted. Species that have worked well in constructed urban wetlands include: common three square, arrowhead, soft stem bulrush, wild rice, pickerelweed, sweetflag, smartweeds, spike rush, soft rush, and a number of other sedges.

Planting Layout--Initial planting should cover at least 30% of the wetland area, concentrated in several portions of the pond and have densities of four to five plants/square yard. Planting clusters of single species will improve the quality and diversity plantings.

Grading or Discing the Basin Before Planting--The basin substrate should be soft enough to permit relatively easy insertion of the plants into the soil. If the basin has been recently graded or excavated, the soil should be sufficiently soft. However, if the basin soil is compacted or hard subsoil is encountered, planting will be difficult. In these cases, it is recommended that the basin soil be disced or otherwise loosened before planting.

Treatment of Plant Material--For successful establishment of wetland vegetation the nursery stock must be correctly handled prior to planting. For growing plants, this consists of keeping the roots moist at all times, and in keeping the plants out of direct sunlight as much as possible. Vegetation should be planted as soon as possible to avoid damage during on-site storage. Dormant plant material should be stored under conditions similar to those under which the material was stored at the nursery.

Flow Length:

Definition--Optimizing the pond shape and flow distance through a pond to promote water quality treatment.

Means of Treatment--Settling is the primary pollutant removal mechanism sought when addressing flow length as a water quality design feature. Ponds designed with optimum flow length will avoid the problem of dead storage or incoming water short-circuiting through the pond. Optimum flow length also will minimize turbulence within the pond and resuspension of deposited sediments. The effectiveness of wetland treatment is also dependent on flow length providing contact time with wetland vegetation.

Length to Width Ratio--The ratio of flow length to pond width should be at least 3:1. To increase a pond's flow length, the contours of the pond may be configured to form baffles. Submerged aquatic benches can work for this purpose.

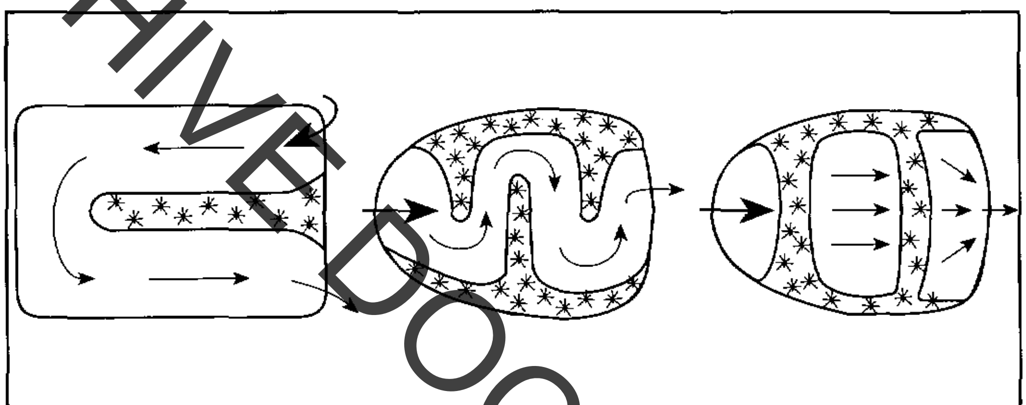


Figure 1-7 Flow routing to enhance water quality treatment

Dewatering Between Separate Cells:

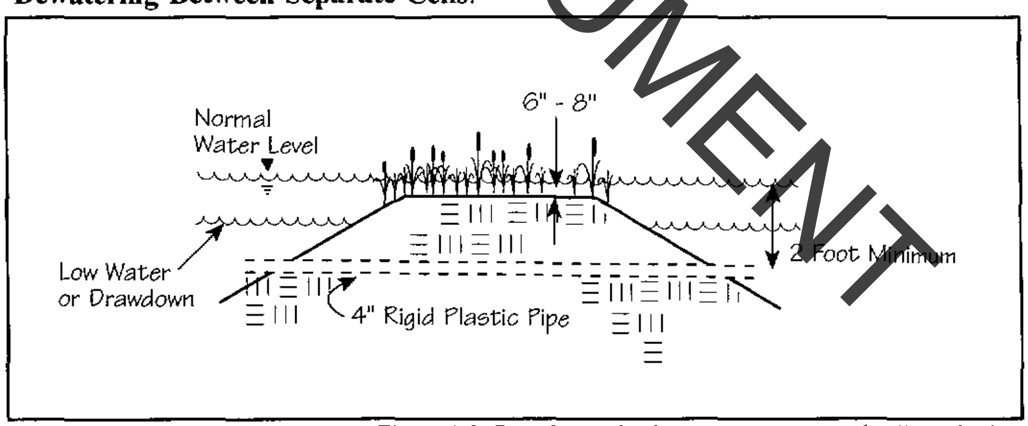


Figure 1-8 Drawdown pipe between separate pond cells or forebay

Reverse Flow Pipe:

Definition--A reverse flow pipe is part of a pond's outlet structure that draws water from below the water surface. Ponds with slow release rates, such as extended detention ponds, require small outlet control structures which are prone to becoming clogged. By drawing water from below the water surface, reverse flow pipes avoid floating debris and are less likely to become clogged. Reverse flow pipes also improve water quality treatment by trapping floating pollutants. They may be constructed with a pipe on a negative slope or with a down turned pipe elbow.

Discharge Elevation--Pond outlet control structures should be designed to draw water from below the pond's normal water surface level and above the midpoint of the normal pool elevation.

Design--Reverse flow outlets may be constructed with a straight pipe set on a negative slope. A pipe with a 90-degree elbow also may be used either inside the riser and facing upward or outside the riser facing down.

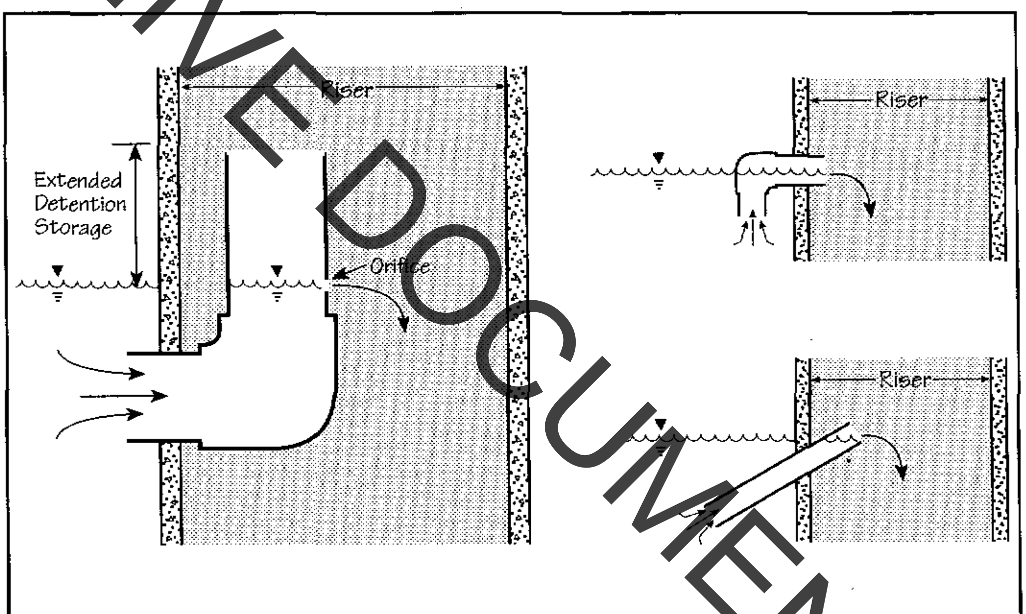


Figure 1-9 Reverse flow structures reduce clogging of slow release and trap floating pollutants

Pool Depth:

Optimum Treatment Depth--An average pool depth of 4-6 ft. is optimal for water quality treatment. Maximum depth should not exceed 10 ft. Areas deeper than 6 ft. should occupy only a relatively small portion of the pond's total area. Water deeper than 6 ft. may stratify and create anaerobic conditions that can cause pollutants which are normally bound in the sediment (e.g., metals and phosphorus) to become soluble; their release back to the water column can reduce the effectiveness of the pond.

Side Slopes--Depth should be carefully manipulated at the pond edges. This area is critical for safety and shore line stability. It also provides opportunities for creative pond scaping.

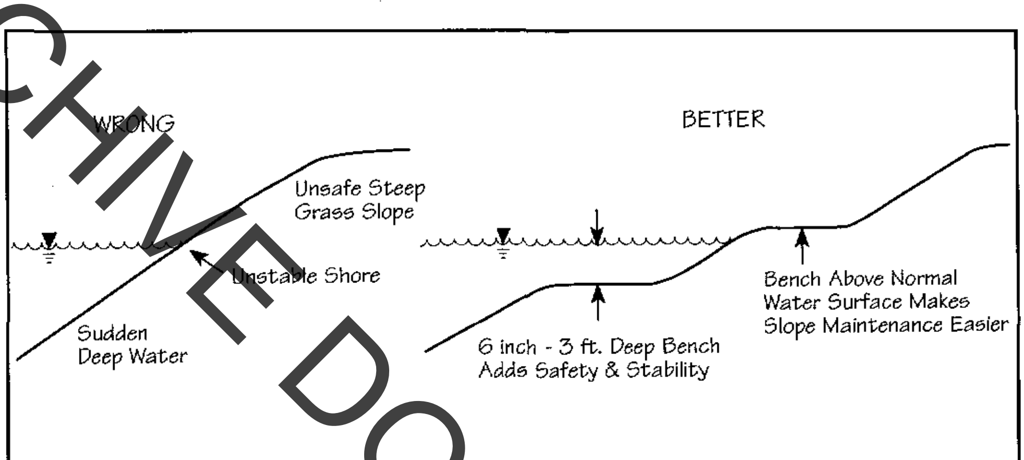


Figure 1-10 Pond side slopes to improve safety, stability and water quality treatment

Shading:

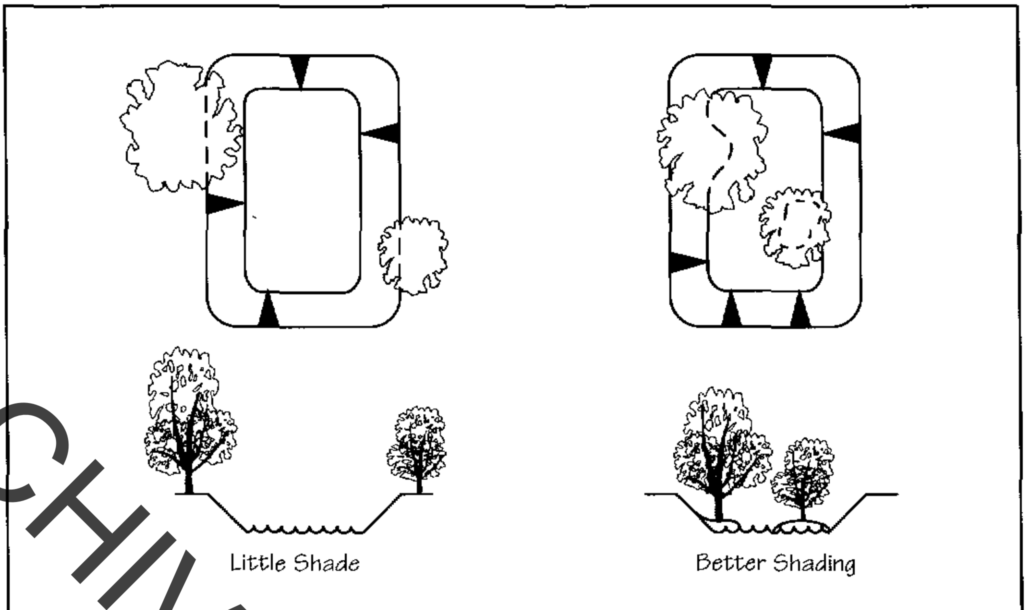


Figure 1-11 Tree placement to shade ponds and reduce thermal impacts

Thermal Impacts--Increased water temperature is a potential negative impact of stormwater ponds. Release of warm water from a permanent pool or wetland may adversely impact the thermal regime of receiving waters, particularly if the receiving water is a cold-water fishery. The pool acts as a heat sink between storm events during the summer months. When water is displaced from the pool and released downstream, it can be as much as 10 F warmer than naturally occurring base flow. Large impervious surfaces also act as heat sinks during the summer and can warm surface runoff to 90 F. In either case, the increased water temperature can be critical for cold-water stream systems where fish and other aquatic life are constrained by maximum summertime water temperatures.

Shading--Shading a pond can significantly reduce thermal impacts. Trees should be planted around the pond, particularly on the south and west sides to offer the most protection from the summer sun. Trees planted on islands or peninsulas should also be considered. Because tree roots can damage dams, trees must not be planted on the embankment itself. Wetland vegetation also contributes to shading and reduces thermal impacts.

Leaf Litter--Leaf litter introduces nutrients to the pond and adds to the accumulation of sediment. However, while nutrients and sediment are pollutants, nutrients in plant material or detritus are more readily utilized by aquatic insects and become part of the food chain. Fallen leaves are a vital part of aquatic environments, whereas soluble nutrients and nutrients attached to fine sediments easily wash through a pond system or promote algal growth.

Maintenance

While maintenance is inevitable, the amount of maintenance required and its cost can vary considerably depending on the initial design of a pond. A number of design features are helpful in this regard:

Sediment Storage--Reducing the frequency of sediment cleanout can easily be achieved by increasing the volume available for sediment storage before a nuisance or performance problem is created. If the pond is used for sediment control during construction, it should be cleaned out when the site is stabilized as the cost of cleanout will be considerably less expensive during construction than in the future.

On-Site Disposal--Transporting dredged sediment is often the largest cost associated with pond cleanout. This can be avoided by providing an area on-site for future sediment disposal. A disposal site should be designated during site design.

Forebay--Trapping most sediments in a confined, easily accessible forebay can reduce maintenance costs.

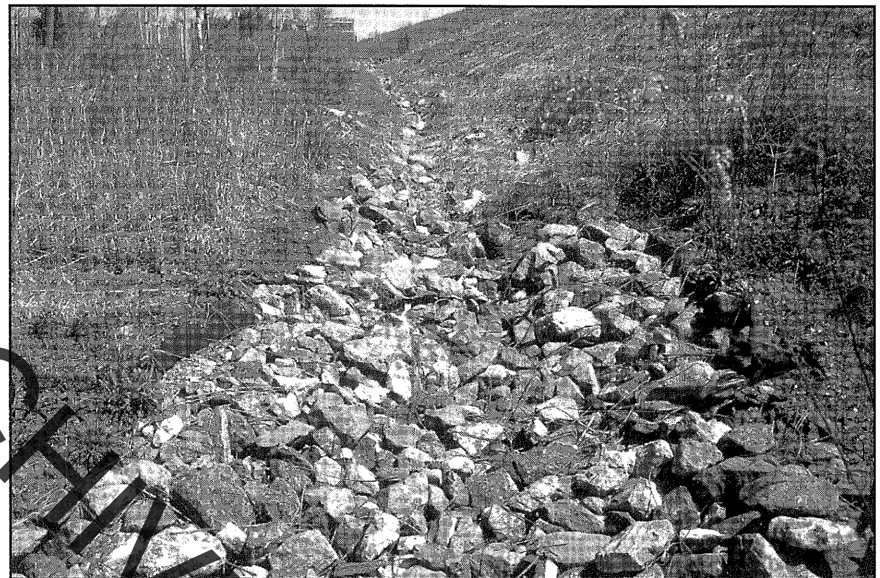
Maintenance Easements--Maintenance easements must be established to allow access to the pond, particularly to the forebays, embankment and outlet structure. Maintenance easements may also be needed for sediment disposal areas.

Disposal of Pollutants--Water quality treatment practices are intended to trap pollutants. The fate of these pollutants must be considered. Trapped sediment is usually clean enough for on-site use. The large volume of sediment poses the most common disposal problem. Sediments may also have high concentrations of hydrocarbons, nutrients and heavy metals. Soil tests should be done if the pond has received spills, is in a highly industrial area, or if the watershed has intensive traffic.

Sediment should be spoiled in areas which will keep pollutants bound in the sediment (e.g., metals and phosphorous). To avoid these pollutants from becoming soluble, acid and anaerobic conditions, such as wetlands, should be avoided.

PERMANENT RUNOFF CONTROL

Conveyance Channel



Description

A stormwater conveyance channel is a permanent, designed waterway, swale or ditch; sized and lined with vegetation, matting or riprap used to convey stormwater runoff without allowing channel erosion. In addition stormwater conveyance channels may be constructed to improve water quality.

Conditions Where Practice Applies

This practice is applicable where constructed channels are needed to improve drainage or convey stormwater such as roadside ditches or above steep-cut slopes.

This practice applies generally to small channels having flow only during storm events. Chapter 3, Stream Channel Construction and Restoration, should be referenced for larger channels having seasonal low or perennial flow. Conveyance channels should not be used if flow is greater than 100 cubic feet per second (cfs) from a 10-yr.-frequency storm.

PLANNING CONSIDERATIONS

Constructed Channels vs. Natural Drainageways--Discretion must be used when replacing natural channels with constructed stormwater conveyance channels. Natural drainage systems, even small intermittent and ephemeral drainageways, provide many hydraulic and environmental benefits not duplicated by constructed channels.

Permits--Permits for stream channel modifications may be required by local government. Additionally, the U.S. Army Corps of Engineers and the Ohio Environmental Protection Agency, through Sections 404 and 401, respectively, of the Clean Water Act, may require a permit for stream modifications. It is best to contact your local district office of the Corps to determine what both agencies' permit requirements are for your project.

Water Quality--Besides the primary design objective of providing a stable channel, water quality benefits may also be achieved. Runoff may be treated by stormwater conveyance channels which are designed to promote settling and infiltration. Although treatment efficiency is usually low, it may be maximized by creating grass-lined channels that are wide and have minimal slope.

Diverting Runoff from Steep Slopes--Channels may be used as permanent diversions at the top of steep slopes or at intervals across slopes to shorten the flow length on steep erodible slopes. The need for diversions shall be determined by considering outlet conditions, slope erodibility and water's influence on slip-prone slopes.

DESIGN CRITERIA

Runoff Calculations--Channels generally shall be designed so that the velocity of flow expected from a 10-yr. frequency storm does not exceed the permissible velocity for the type of lining used. NRCS's TR-55 or other suitable method shall be used for determining flow rate. Use Manning's Equation or other suitable method to determine velocity.

Capacity--Runoff computation will be based upon the most severe soil and cover conditions that will exist in the area draining into the waterway during the planned life of the structure.

Critical Areas--A channel's capacity shall be adequate to carry the peak rate of runoff from a 10-yr. frequency storm. Where high-hazard conditions exist, higher frequency storms should be chosen to provide protection compatible with conditions. Where fill is used to create the channel, such as when diverting runoff across or above a steep slope, the ridge height shall include a minimum of 0.3 ft. freeboard and a settlement factor of 10% in addition to the design flow depth.

Noncritical Areas--Where out-of-bank flow will not cause erosion, property damage or flood damage, no minimum size channel is required. These conditions will most often occur in areas with little slope and established woody vegetation.

Cross-Section Shape

- **Vee-shaped channels** generally are used where the quantity of water to be handled is relatively small, such as roadside ditches. Because vee-shaped channels are prone to create erosion problems they should not be used in channels with high-flow velocity or prolonged low-flow conditions.

- **Trapezoidal channels** often are used where the quantity of water to be carried is large and velocities high. Channels constructed to treat stormwater runoff should be trapezoidal in shape to promote settling and infiltration.

- **Parabolic channels** most closely approximate natural flow characteristics at low as well as high flows. Although generally preferred for esthetic reasons, design and construction procedures are more complex.

Design Velocity of Vegetative Lining:

Grass Lining
Maximum Flow Velocity for a 10-Yr. Frequency Storm

Soil		Maximum Velocity (fps)		
Texture	Type	Seed Lining	Seed & Matting	Sod
Sand, Silt, Sandy Loam, Silt Loam	Sand	1.5	3.0	3.5
Silty Clay Loam, Sandy Clay Loam	Firm Loam	2.0	4.0	4.0
Clay	Clay	2.5	4.0	5.0
N/A	Gravel	3.5	5.0	6.0
N/A	Weathering Shale	4.5	5.0	N/A

Note: Soil texture/type can be determined from the soil surveys. If the channel is on fill, the soil should be tested.

Establishing Vegetation--Stabilization should be done according to the appropriate Standards and Specifications for Vegetative Practices.

- **For design velocities of less than 3.5 fps**, seeding and mulching may be used for the establishment of the desired vegetation. It is recommended that when conditions permit, temporary diversion or other means be used to prevent water from entering the diversion during the establishment of vegetation.

- **For design velocities of more than 3.5 fps**, the diversion shall be stabilized with sod, with seeding protected by jute or excelsior matting, or with seeding and mulching including temporary diversion of water until the vegetation is established.

Check Dams--Check dams may be incorporated to enhance water quality benefits by maximizing the detention time within the swale or to increase channel stability by decreasing flow velocities. The structures should be of a more durable nature than those normally designed for temporary erosion control. Check dams should be used where they will not be considered a nuisance or create a high maintenance burden.

Rock Lining--Rock-lined channels shall be designed by accepted engineering methods such as the Federal Highway Administration Circular No. 15 or Figure 2-1. The chart will determine rock size using flow depth and velocity obtained from Manning's equation. Geotextile must be placed beneath all riprap to prevent the underlying soil from eroding and undermining the riprap.

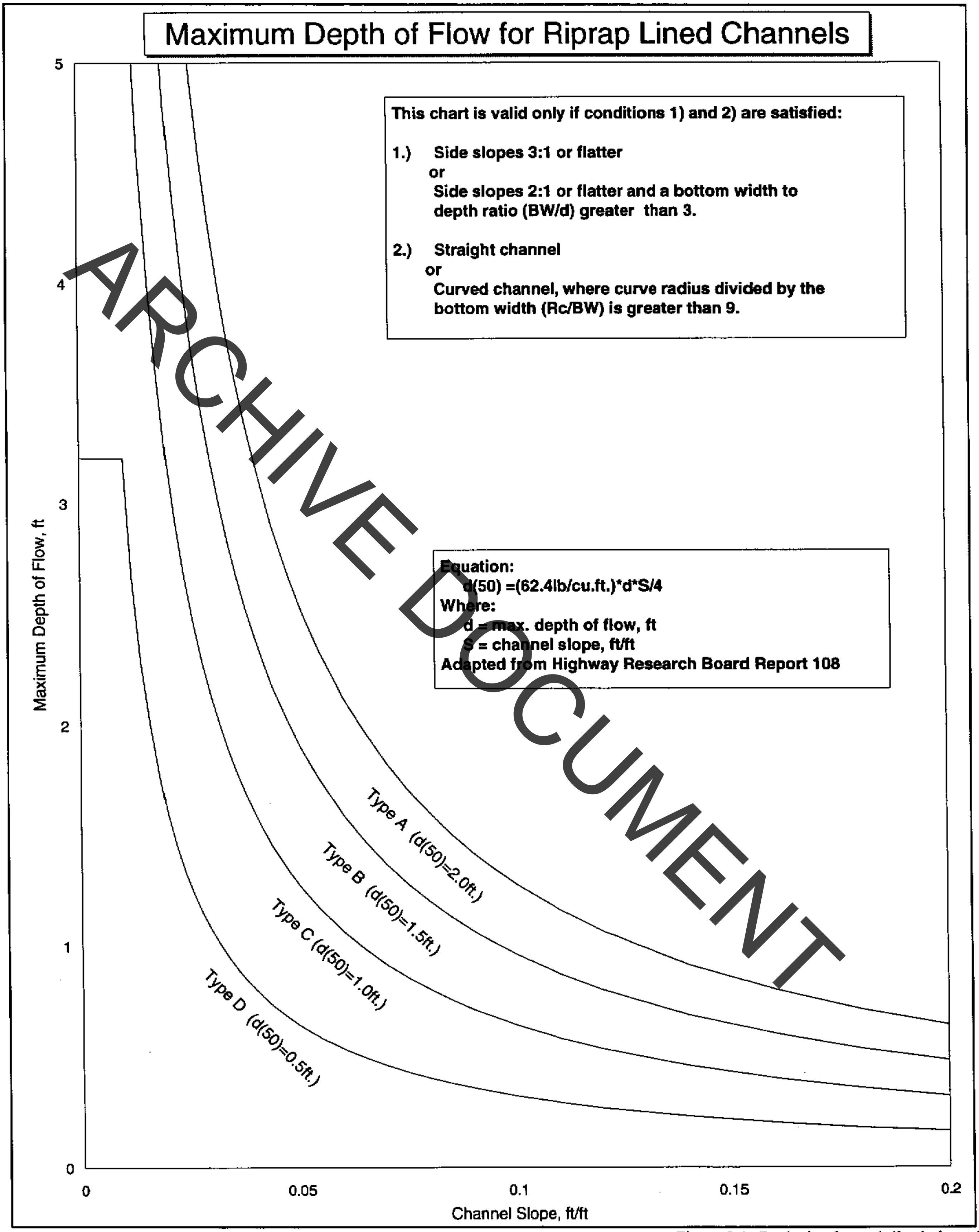


Figure 2-1 Rock size for rock-lined channels

Specifications
for
Grass Lined Channel

1. The channel shall be excavated and shaped to the proper grade and cross section.

2. Fill material used in the construction of the channel shall be well compacted to prevent unequal settlement.

3. Earth removed and not needed in construction shall be graded and sloped or disposed of so that it will not restrict flow to the channel or interfere with its functioning.

4. Stabilization shall be done according to the appropriate specifications for seeding, vegetative practices, sod and matting.

5. Construction shall be sequenced so that channels are stabilized prior to becoming operational or without delays after the channel becomes operational.

6. Gullies that may form in the channel or other erosion damage that occurs before the grass lining becomes established shall be repaired without delay.

Specifications
for

Rock Channel Protection

1. Subgrade for the filter and riprap shall be prepared to the required lines and grades as shown on the plan.

2. Riprap shall conform to the grading limits as shown on the plan.

3. No abrupt deviations from the design grade or horizontal alignment shall be permitted.

4. Geotextile shall be woven or nonwoven monofilament yarn and shall meet the following:
   - Thickness 20-60 mils.
   - Grab Strength 90-120 lb.
   - ASTM D-1777 and ASTM D-1682

5. Geotextile shall be laid with the long dimension parallel to the direction of flow and shall be laid loosely but without wrinkles and creases. Where joints are necessary, strips shall be placed to provide a 12-in. minimum overlap, with the upstream strip overlapping the downstream strip.

6. Riprap may be placed by equipment but shall be placed in a manner to prevent slippage or damage to the geotextile.

7. Riprap shall be placed by a method that does not cause segregation of sizes. Extensive pushing with a dozer causes segregation and shall be avoided by delivering riprap near its final location within the channel.

8. Construction shall be sequenced so that riprap channel protection is placed and functional without delays when the channel becomes operational.

Type of Rock or Riprap	Size of Rock	
	50% by weight	85% by weight
Type D	> 6 in.	3 - 12 in.
Type C	> 12 in.	6 - 18 in.
Type B	> 18 in.	12 - 24 in.
Type A	> 24 in.	18 - 30 in.

Specifications
for

Permanent Diversion

1. Trees, brush, stumps, and materials that may become obstructions shall be removed and disposed of so as not to interfere with the proper functioning of the diversion channel.

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

3. Fills shall be compacted with construction equipment in such a manner that the entire surface of the fill will be traversed by not less than one tread track of the equipment.

4. Fertilizing, seeding, and mulching shall conform to the recommendations in the applicable vegetative specification.

Level Spreader

Description

A level spreader is a weir used to stop the formation of gullies by converting concentrated flow to sheet flow where pipes or channels discharge to nearly level areas such as flood plains. The top of the level spreader is constructed at the same elevation as the surrounding ground and usually made of rock.

Conditions Where Practice Applies

Level spreaders may be used:

1. Within broad, flat, semi-defined channels where flow is to remain diffuse and gullies must be prevented from forming.

2. At the end of storm drains or channels, which can be designed to release flows onto a nearly flat area such as a flood plain or wetland.

3. Where small concentrated flows, less than 30 cfs from a 10-yr. frequency storm, can be converted to sheet flow and released to areas with dense vegetation and slopes less than 5%.

4. Level spreaders should NOT be used where the natural topography will reconcentrate flows immediately below the point of discharge or on highly erosive soils where gully formation is a concern.

PLANNING CONSIDERATIONS

Level spreaders may be used to:

- Increase infiltration and groundwater recharge,
- Provide water quality treatment of the water flowing from a storm drain system by ensuring sheet flow through a buffer strip or riparian corridor,
- Minimize disturbance of the riparian corridor and the stream channel,
- Reduce the length of storm drain or channel needed.
- Preserve natural vegetation,
- Terminate a storm drain or channel where there is no accessible receiving channel.

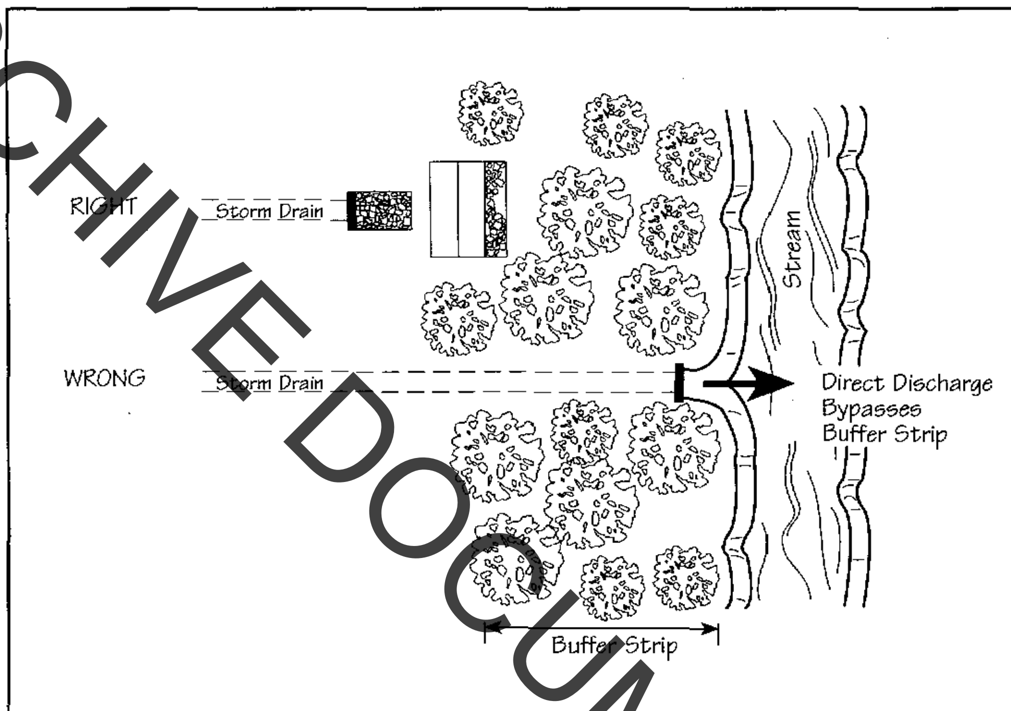


Figure 2-2 Converting concentrated flow to sheet avoids flow from bypassing forested buffer

Outlet Protection vs. Level Spreaders--Both practices are used as a transition at the end of concrete channels or pipe outlets. Outlet protection can be used alone where flow will continue as concentrated flow, but in a less modified channel at a slower velocity. Level spreaders should be used along with outlet protection where the flow can be converted to and continue as sheet flow.

DESIGN CRITERIA

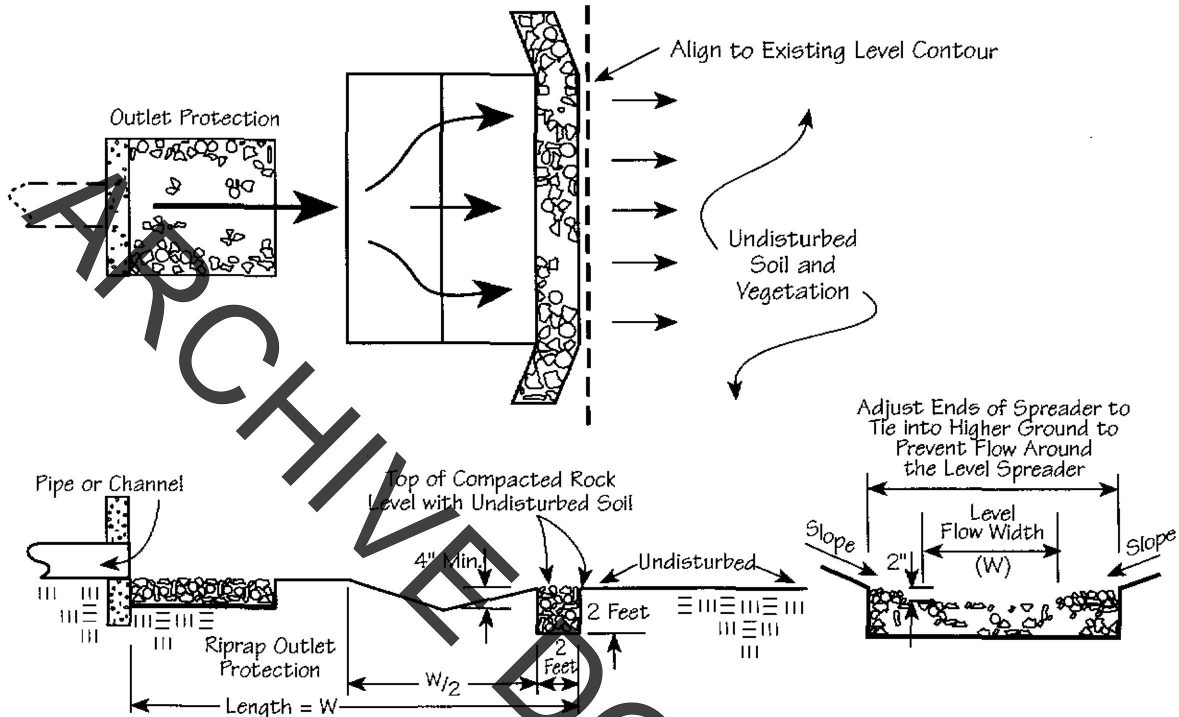
Weir Width (Perpendicular to Flow)--Minimum level spreader widths shall be based on the peak rate of flow from a 10-yr. frequency storm and the following table. The values in the table are general recommendations assuming the area receiving the flow is well vegetated and has little slope. Adjustments may be made based on erosion potential or other site conditions.

Level Spreader Width (Perpendicular to Flow)	
Flow Rate (cfs)	Weir Width (ft.)
< 7	10
7 - 10	15
10 - 13	20
13 - 16	25
16 - 20	30
20 - 25	35
25 - 30	40

Weir Materials--Riprap of ODOT Type C rock will be suitable for most conditions, although grass may be adequate for the most stable conditions with flat even terrain. Concrete or pressure-treated timbers also may be used.

Specifications
for

Riprap Level Spreader



1. Construct level rock weir on a level contour to ensure uniform spreading of storm runoff, converting concentrated flow to sheet flow.

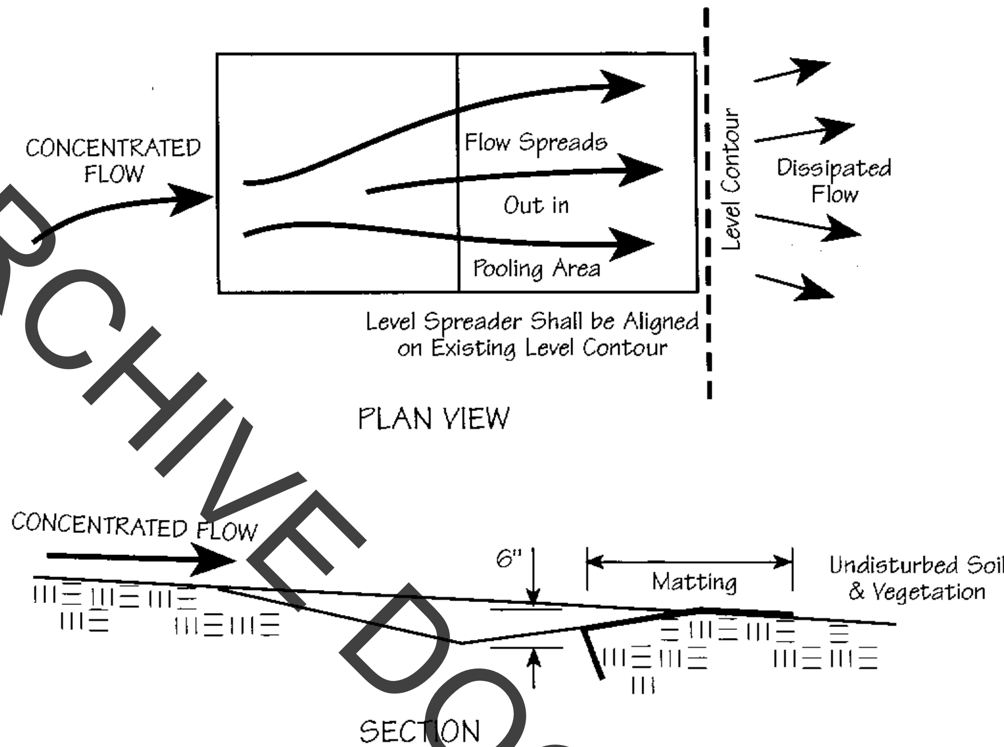
2. Rock shall be ODOT Type C where 50% of the material by weight is greater than 12 in. and 85% is 6-18 in.

3. Level spreaders must be constructed on undisturbed soil, NOT on fill.

4. Storm runoff passing over the level spreader must outlet to erosion-resistant areas with established existing vegetation.

5. Rock in level spreader shall be compacted with at least two passes of heavy machinery to prevent further settling.

Specifications
for
Grass Level Spreader



1. The outlet edge of the pooling area shall be cut on a level contour to ensure uniform spreading of storm runoff, converting concentrated flow to sheet flow.

2. Level spreaders must be constructed on undisturbed soil, NOT on fill material.

3. Storm runoff passing over the level spreader must outlet to erosion-resistant areas with established existing vegetation.

Outlet Protection

Description

A rock or riprap apron typically needed at the outlet of storm drains, culverts and constructed open channels as an erosion-resistant transition area where concentrated high-velocity flows enter less modified channels or natural streams.

Planning Considerations

Outlet Protection vs. Level Spreaders--Both practices are used as a transition at the end of concrete channels or pipe outlets. Outlet protection can be used alone where flow will continue as concentrated flow, but in a less modified channel at a slower velocity. Level spreaders should be used along with outlet protection where the flow can be converted to and continue as sheet flow.

Design Criteria

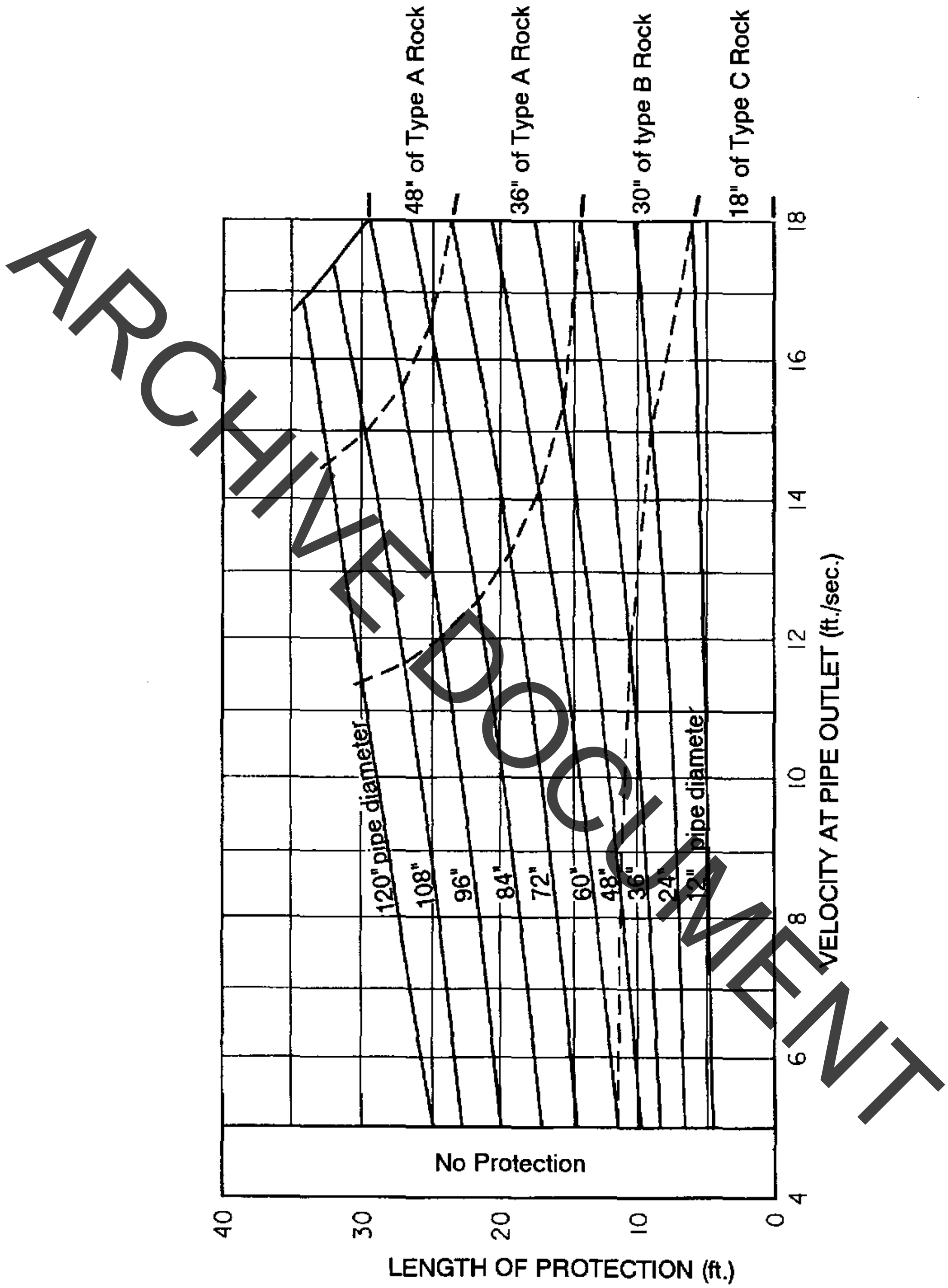
Outlet protection shall be designed to be stable for the discharge velocities expected from a 10-yr. frequency storm. It shall be designed to meet the following criteria or by other accepted engineering methods.

Width--The width of the rock apron should be the width of the headwall or 4 ft. wider than the pipe diameter, whichever is greater.

Bottom Grade--The apron should be constructed with no slope along its length. The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There should be no overfall at the end of the apron.

Filter--To prevent the underlying soil from movement through the riprap, geotextile shall be placed under the riprap.

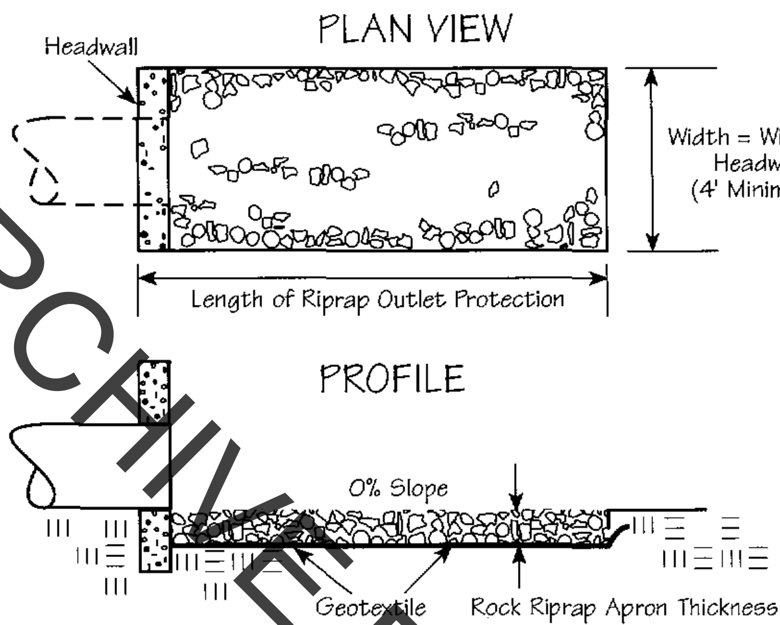
Length and Rock Size--Use the velocity at the outlet, pipe diameter and Figure 2-3 to find the rock size and length of outlet protection needed.



Source: ODOT Location and Design Manual, 1992

Figure 2-3 Outlet protection length

Specifications
for
Outlet Protection



1. The subgrade for the filter and riprap shall be prepared to the required lines and grades as shown on the plan.

2. The riprap shall conform to the grading limits as shown on the plan.

3. Geotextile shall be woven or nonwoven monofilament yarn and shall meet the following:
   - Thickness 20-60 mils
   - Grab Strength 90-120 lb.
   - ASTM D-1777 and ASTM D-1682

4. Riprap may be placed by equipment but shall be placed in a manner to prevent damage to the geotextile.

Type of Rock or Riprap	Size of Rock	
	50% by weight	85% by weight
Type D	> 6 in.	3 - 12 in.
Type C	> 12 in.	6 - 18 in.
Type B	> 18 in.	12 - 24 in.
Type A	> 24 in.	18 - 30 in.

SUBSURFACE DRAINAGE

DESCRIPTION

An underground perforated pipe used to remove excess water from the soil.

CONDITIONS WHERE PRACTICE APPLIES

Subsurface drains may be used:

- Where poor surface drainage results in standing water and wet soils such as may occur in stormwater detention ponds or swales with little slope.
- Where internal drainage of slopes is needed to improve their stability and reduce erosion.
- Behind bulkheads, retaining walls, etc. to provide internal drainage.
- Where existing subsurface drains, which are interrupted or destroyed by construction operations, must be replaced.

DESIGN CRITERIA

Subsurface drainage shall be designed by acceptable engineering methods such as those outlined in Chapter 14, Engineering Field Manual for Conservation Practices, NRCS or the following:

Capacity

- **Relief Subsurface Drainage**--Relief subsurface drainage is laid out in a uniform pattern. The spacing between drains and their capacity should be based on a minimum removal rate of 1 in. of groundwater in 24 hr. (0.042 cfs/ac.). The design capacity must be increased accordingly to accommodate any surface water directly entering the system.

- **Interceptor Drains**--Interceptor drains placed across slope, random or single drain lines shall be based on the following table.

Interceptor, Random and Single Drain Line Inflow Rates				
Soil Texture	Inflow Rate/1,000 Ft. of Line (cfs)			
	Land Slope			
	0-2%	2-5%	5-12%	> 12%
Coarse Sand and Gravel	1.00	1.10	1.20	1.30
Sand	0.50	0.55	0.60	0.65
Sandy Loam	0.25	0.28	0.30	0.33
Silt Loam	0.10	0.11	0.12	0.13
Clay and Clay Loam	0.20	0.22	0.24	0.26

Size

The size of the drain may be determined by using the following nomograph. The minimum size shall be 3 in.

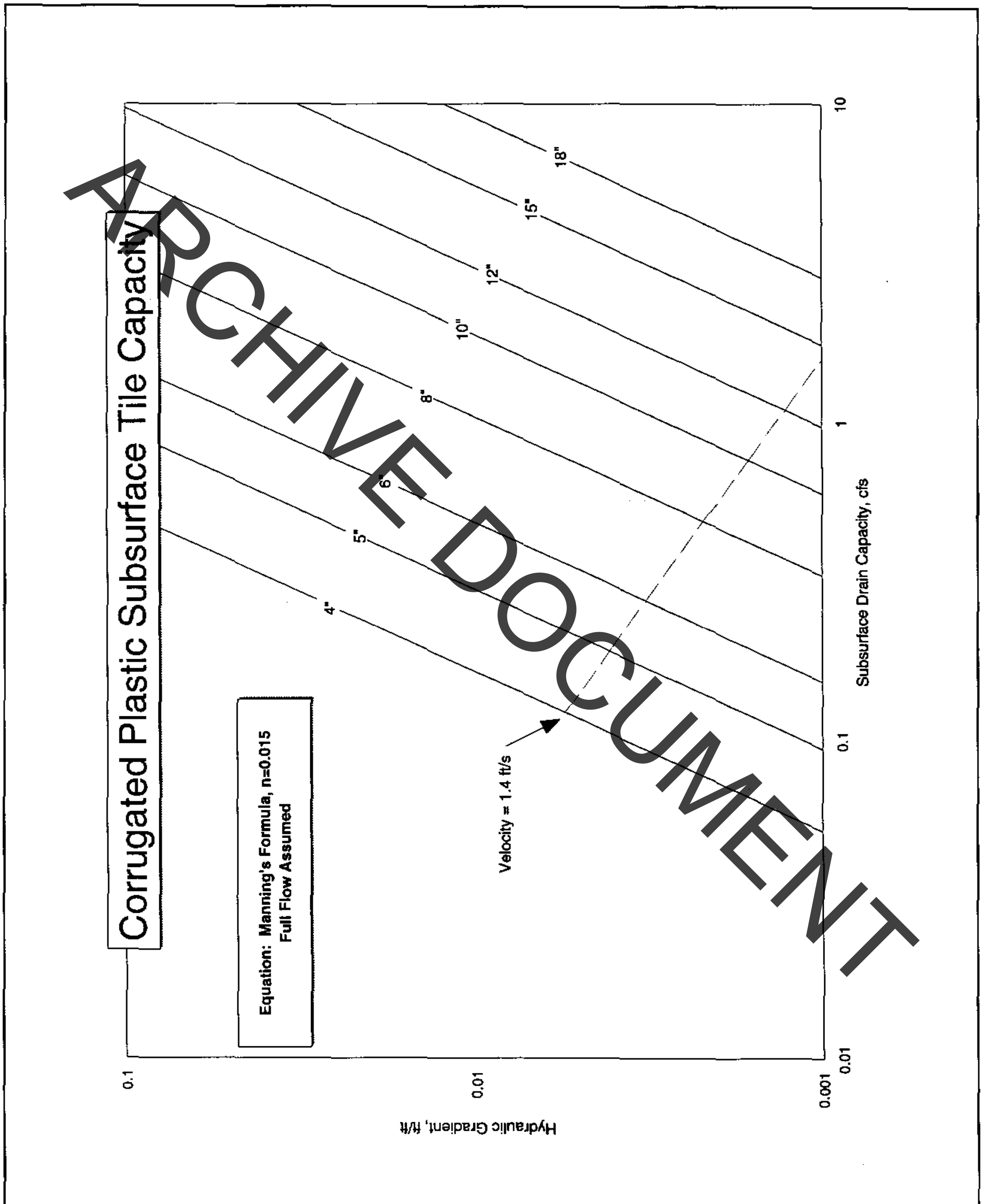


Figure 2-4 Corrugated plastic subsurface tile capacity

Velocity and Grade

- **Minimum velocity**--The minimum velocity required to prevent silting is 1.4 ft./sec.

- **Maximum velocity:**

Maximum Velocities for Various Soil Textures	
Soil Texture	Maximum Velocity ft./sec.
Sandy and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand and Gravel	9.0

Depth and Spacing

- **Relief Drains**--Relief drains installed in a uniform pattern should have equal spacing between drains and the drains should be at the same depth. Maximum depth is limited by the allowable load on the pipe, depth to impermeable layers in the soil, and outlet requirements. The minimum depth is 24 in. under normal conditions. Spacing between drains is dependent on soil permeability and the depth of the drain. In general, however, a depth of 3 ft. and a spacing of 50 ft. will be adequate.

- **Interceptor Drains**--Installation of an interceptor drain is influenced mainly by the depth to which the water table is to be lowered. The maximum depth is limited by the allowable load on the pipe and the distance to an impermeable layer. Minimum depth should be the same as for relief drains.

Filters and Filter Material--Soil conditions may require the use of a filter to prevent erosion around the conduit and sediment accumulations inside. The need for a filter shall be determined by the characteristics of the soil material at the drain depth, the velocity of flow and the backfill material.

- **Sand and Gravel Filters**--The sand and gravel filter shall cover the conduit by not less than 3 in. Not more than 10% of the filter material shall pass the No. 60 sieve.

- **Fabric Filters**--Fabric filters can be either woven or nonwoven monofilament yarns and shall have a sieve opening ranging from 40-80. The envelope shall be placed in such a manner that, once the conduit is installed, it shall completely encase the conduit.

Increase Flow Envelopes--Envelopes shall be used around and above subsurface drains where needed to increase the flow into the conduit.

- **Envelope Depth**

  Envelopes shall consist of not less than 3 in. of sand and gravel.

  Interceptor drains shall have envelope material to the upper most seepage strata.

  Envelopes placed behind bulkheads and retaining walls shall go to within 12 in. of the top of the structure.

- **Envelope Material**

  Envelope material shall consist of sand and gravel material which shall pass a 1½-in. sieve, 90-100% shall pass a 3/4-in. sieve, and not more than 10% shall pass a No. 60 sieve.

Conduit Support

- The conduit shall be placed on a sand and gravel bedding. A minimum of 3 in. of sand and gravel shall be placed on the bottom of a conventional trench before the conduit is placed.

- The conduit may require additional support on soft or yielding soils such as where the conduit crosses a deeper utility trench that may continue to settle. The conduit may be supported by:
  Adding gravel or other suitable material to the trench,
  By placing the conduit on a plank or other rigid support, or
  By using long sections of rigid perforated or watertight pipe.

- Where rocky or gravelly soils are expected to be encountered, heavy-duty corrugated plastic drainage tubing should be specified.

Outlet Structure

Animal Guards--Animal guards shall be installed on the outlet end of the pipe.

End Section--A rigid section of pipe shall be used as the last section of pipe at the outlet end. The pipe should be 10 ft. in length and made of a continuous corrugated metal, cast iron or PVC. It shall have no perforations and no envelope material shall be used around the rigid pipe. The outlet end should be 1 ft. above the normal elevation of the receiving channel's low flow.

Upper End of Drain--The upper end of each subsurface drain shall be capped with a tight-fitting cap unless it is connected to a structure.

Specifications
for
Subsurface Drainage

1. Deformed, warped, or damaged pipe shall not be used.

2. All subsurface drains shall be laid to a uniform line and grade. The pipe or tubing shall be laid with the perforations DOWN.

3. Envelope material shall consist of either geotextile or a sand and gravel material which shall pass a 1½-in. sieve, 90-100% shall pass a 3/4-in. sieve, and not more than 10% shall pass a No. 60 sieve.

4. The upper end of each subsurface drain line shall be capped with a tight-fitting cap of the same material as the conduit or other durable material unless connected to an inlet structure.

5. A continuous 10-ft. section of corrugated metal pipe or rigid PVC without perforations shall be used at the outlet of the drain line. No envelope material shall be used around the 10-ft. end section of pipe. An animal guard shall be installed on the outlet end of the pipe.

6. Backfilling shall be done immediately after placing the pipe. The backfill material shall not contain rocks or other sharp objects which may damage or displace the pipe.

Chapter 3

Stream Channel Construction and Restoration

Eddy Rocks

Description

Eddy rocks are groupings of large rocks placed in the stream channel. They can dissipate high-flow energy, improve the appearance of channels and provide important habitat. The habitat includes calm eddies, protective cover and deep scour holes which develop in the channel bed, downstream from eddy rocks during high flows.

Conditions Where Practice Applies

Eddy rocks as described here are used in small relocated streams or modified channels which have a uniform shape and little cover. They may be used where erosive velocities need to be reduced, where habitat needs to be improved or where the esthetics of a channel are to be improved.

DESIGN CRITERIA

Rock Size--Rocks must be large enough to resist displacement during high flow. If the bottom is stable, a rock of 2-ft. diameter or about 1,000 lb. will resist movement in current velocities up to 10 ft./sec. A 4-ft. rock will be stable in velocities up to about 13 ft./sec. Partially burying rocks (one-third their diameter) or supporting them with footer rocks further improves their stability.

The maximum size should be related somewhat to the width of the stream. Usually, a rock should not be greater in its largest dimension than one-fifth of the width of the channel. However, in small channels steeper than 3% rocks may be up to one-third the channel width.

Materials--Rocks alone are the most commonly used material but, if rocks of sufficient size are not available or accessible to the site, root wads may be substituted. Root wads must however be anchored securely with cable fastened to duck bill anchors, Laconia anchors, etc.

Eddy Rock Placement

- Groups of three to seven rocks should be placed in a staggered patterned so when the current is deflected around one rock it flows into another.

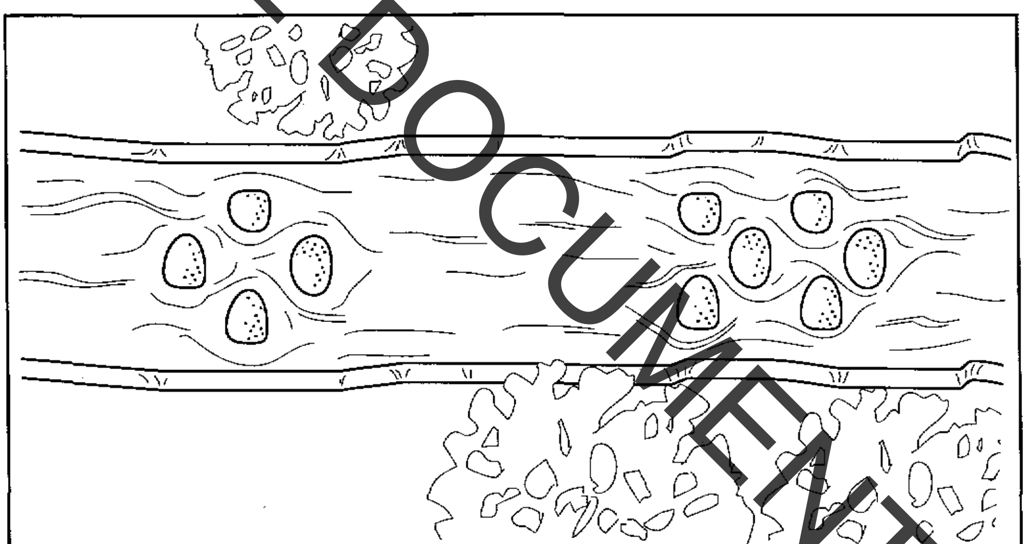


Figure 3-1 Eddy rocks placed in clusters

- Rocks should be placed in the center half of a channel in straight runs where they will be in swift current during high flow. They may also be placed at the beginning or end of an outside bend pool. They should not be placed in riffle areas since one of their effects is to create scour holes and riffles are areas of deposition during high flows.

- Rocks should be placed perpendicular to the flow.

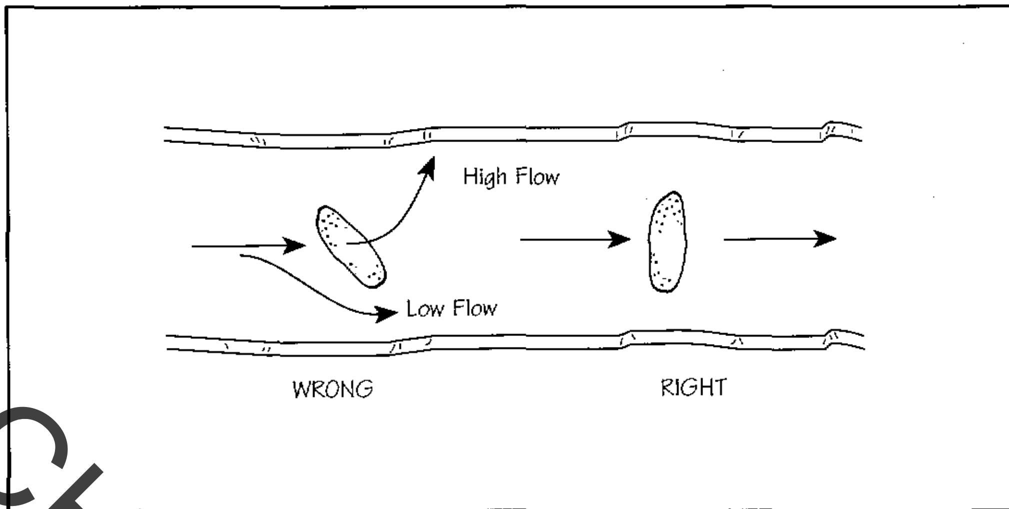


Figure 3-2 Placement of eddy rocks to avoid misdirecting high flows

- Rocks should project above the surface during normal low flows and be submerged during bankfull flows. (Bankfull flow generally corresponds to a recurrence interval of 1.5 yr.) Rocks allowed to shift in moving substrates will eventually be buried. To prevent shifting, rocks should be placed so that one-third of their size is buried in stable material. In deep unstable substrates and larger streams a footer rock should be placed in a deep excavation so that the eddy rock sits on top and upstream from the footer rock.

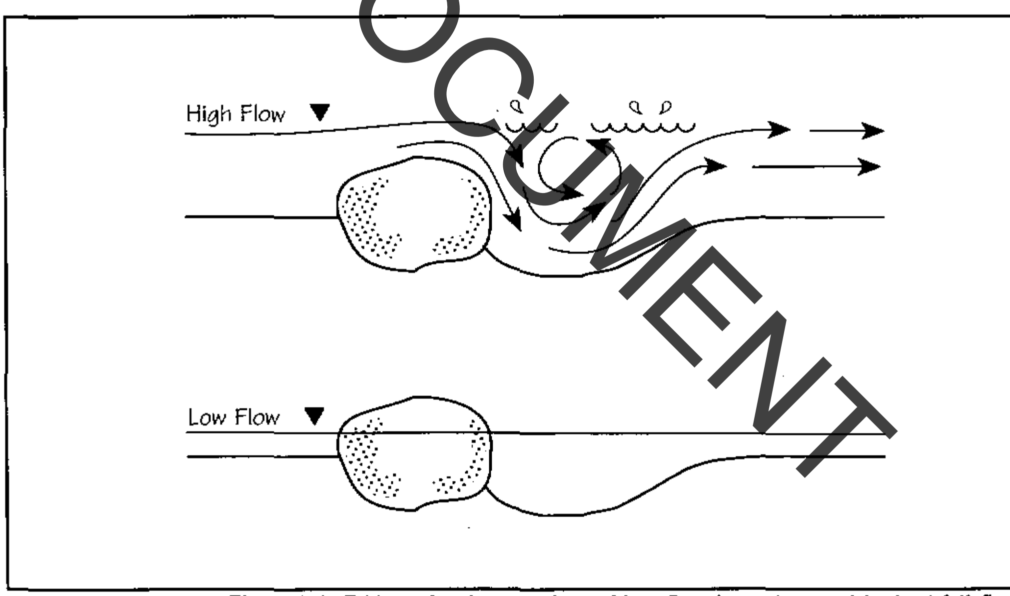
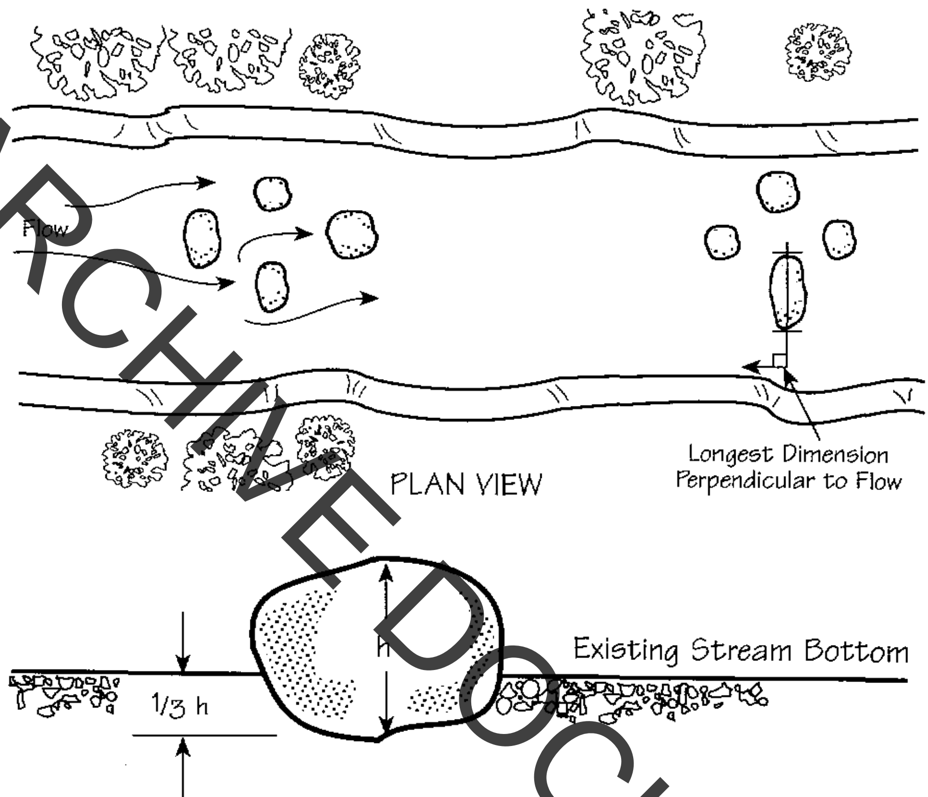


Figure 3-3 Eddy rocks above surface of low flow but submerged by bankfull flow

Specifications
for
Eddy Rocks



1. Eddy rocks shall be larger than 2 ft. except in small channels where they shall be no more than one-fifth the width of the channel.

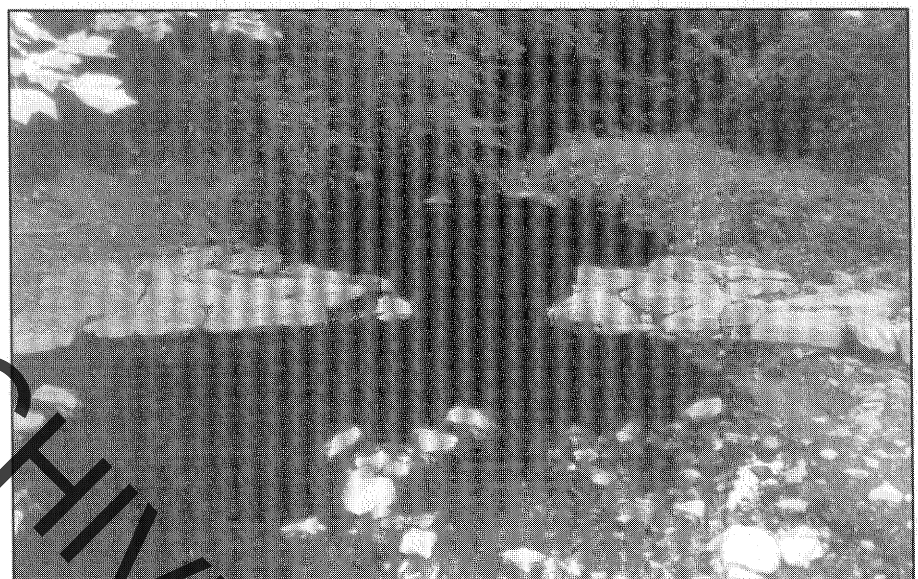
2. Groups of three to seven rocks shall be placed in a staggered patterned so current deflected around one rock then flows into another.

3. Eddy rocks shall be placed in the center half of a channel in straight runs where they will be in swift current during high flow. However, they shall not be placed in riffles.

4. Rocks shall be placed with their longest dimension perpendicular to the flow, not angled to one bank or the other.

5. Rocks shall be placed so they will project above the surface during low flows and be submerged during high flows. Also, they shall be placed in an excavation so that they are at least one-third buried in the channel bed.

Deflectors



Description

Deflectors, also called hard points or wing deflectors, are spurs of rock, logs or gabions that extend from the bank into the stream. They stabilize streambanks by creating slack water adjacent to banks, directing current away from the banks and dissipating flow energy. They also add diversity to the channel by concentrating the flow and creating deep pools. Alternating deflectors in a straight channel can encourage a meandering pattern with a narrower, deeper flow. Double deflectors, spaced opposite each other, can cause a long, deep scour hole to form downstream.

Conditions Where Practice Applies

Deflectors are described here for use in modified channels having uniform shape and little cover or in small streams with unstable banks. There is a much wider range of applications for deflectors but they are beyond the scope of these standards.

Design Criteria

Materials:

Rock--The best materials for deflectors are often large rocks, preferably angular in shape to allow interlocking. The larger rocks should be arranged near the point of the deflector. Soil may be filled around the rock and planted.

Logs--Logs and timbers also may be used for deflectors. Because the logs which are not continually submerged will eventually will decay, the design should incorporate live plant material to take over the deflectors' function. See the specification for Streambank Stabilization.

Effect on Direction of Flow--All deflectors direct the flow toward the opposite bank at low-stream stages; however, during high stages, their effect may be different as shown in Figure 3-4. When deflectors are submerged the flow will be directed perpendicular from the downstream edge. If the downstream edge of a deflector faces the streambank, it will force the current into the bank immediately downstream and cause erosion or "back-cutting." To avoid erosion of the adjacent bank, the downstream edge of deflectors must always face directly downstream or toward the opposite bank. This can be achieved with triangular or wedge-shaped deflectors. It can also be achieved with linear deflectors but only if it is angled upstream. These are sometimes called vanes and should form a 20—degree angle with the upstream bank.

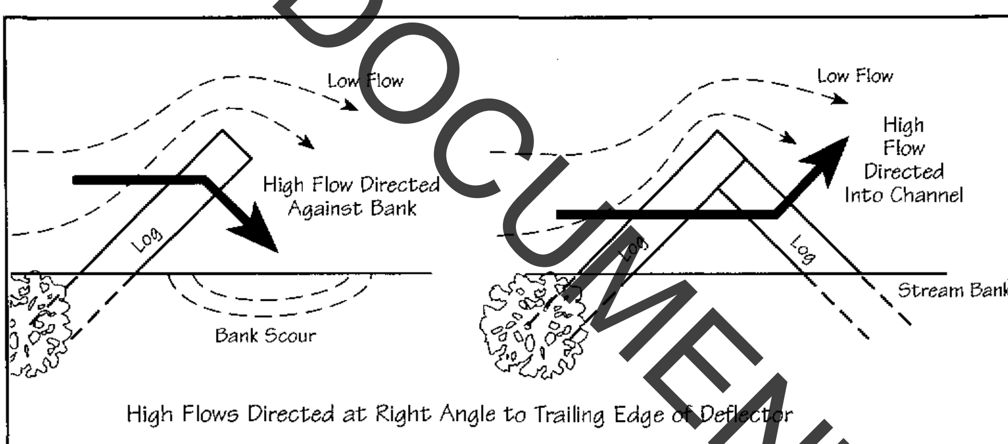


Figure 3-4 Deflector design to avoid directing high flow against streambank

Planting--Live plantings should be incorporated into current deflectors. Some of the best examples of current deflectors are the ones old sycamore trees have formed when the channel erodes slowly back and the tree is left projecting into the channel with a solid lattice of roots forming an ideal current deflector. Following the examples of natural channels, plantings can be adapted to the specific channel conditions.

Riprap--To prevent erosion of the streambank, riprap may be needed to protect the bank upstream and downstream from the deflector. Depending on the bank configuration, riprap should extend in each direction one to two times as far as the deflector extends into the channel.

Length--The deflectors should project into the stream channel about one-fifth to one-third the width of the channel.

Depth--To prevent undermining, the body of the deflector should be embedded into stable streambed substrate. Where much scour is anticipated the deflectors tip may be supported with large footer rocks placed in an excavation beneath and slightly downstream of the deflector.

Height--Deflectors should project above the water surface during low flows and be submerged during high flows or when flows are at bankfull. If less turbulence and bed scour are desired, the deflector may be sloped from the bankfull elevation at the bank, down to the elevation of normal low flow at the tip.

Configuration and Spacing--Depending on the purpose of the deflector, the following spacing criteria should be used:

1. **Alternating**--Deflectors used to create meanders or narrow the width of a low-flow channel shall be placed on alternating banks a distance equal to five to seven stream widths apart or based on meander spacing of similar undisturbed portion of the stream. Alternating deflectors should not be used in unstable channels or where erosion is likely to be a problem on the opposite banks from the deflector. Keeping the deflectors low will lessen this potential.

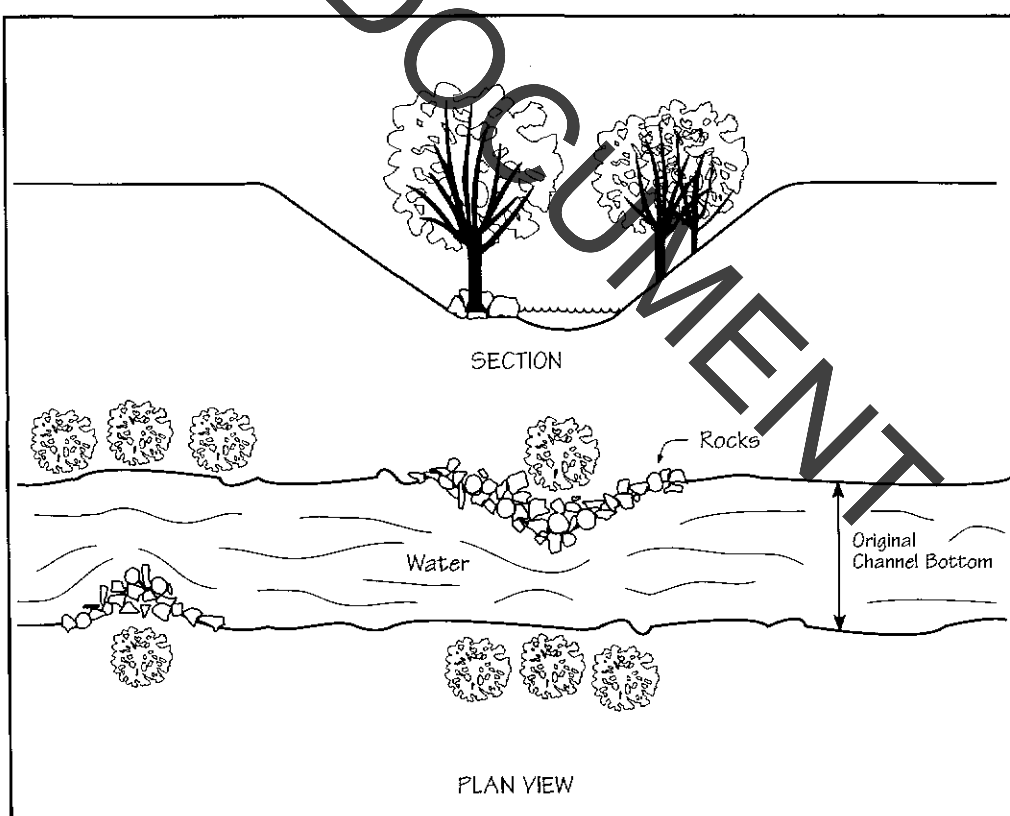


Figure 3-5 Alternating patterns of deflectors in straight channel

2. **Streambank Protection**--Deflectors can be used to control streambank erosion on the outside bends of meanders. Note that deflectors constructed for this purpose usually require about the same amount of rock as armoring the banks with riprap. To position the deflectors, use Figure 3-6 and the following procedure:

   - First, identify the center line of flow before it enters the eroding bend. Point A is located by extending the center line to intersect the eroding bank.

   - Next, draw a line parallel to the center line of flow and through the tips of the deflector to be constructed at Point A. The intersection of this line with the bank is Point B. The distance from deflector A to the next deflector, C, is twice the distance from Point A to B.

   - The location of deflector D is determined by drawing a line through the tips of deflectors A and C to the line's intersection with the eroding bank. Each successive deflector is located the same way.

   - An additional deflector, K, should be constructed upstream from deflector A. The distance upstream should be the same as the spacing between deflectors A and C. Deflector K should be about half the length of the other deflectors.

   - The entire section of bank instability should be protected by the deflectors. If erosion occurs upstream of point K, additional deflectors are needed.

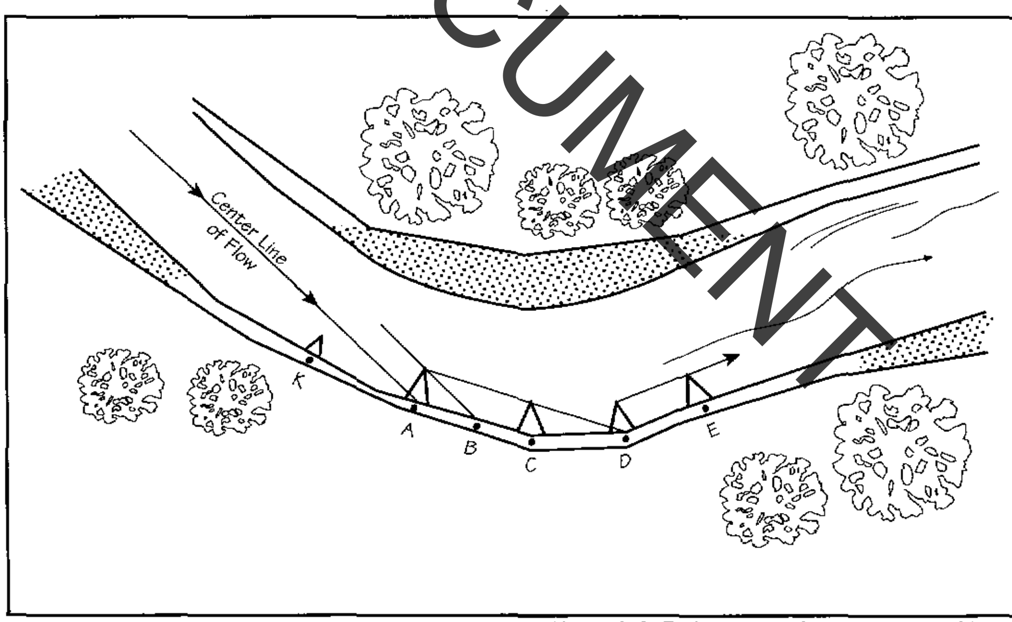


Figure 3-6 Deflector spacing on outside of bends

3. **Opposite**--Deflectors can be constructed one on each bank opposite each other. The restricted flow will create a scour hole downstream and narrow the stream.

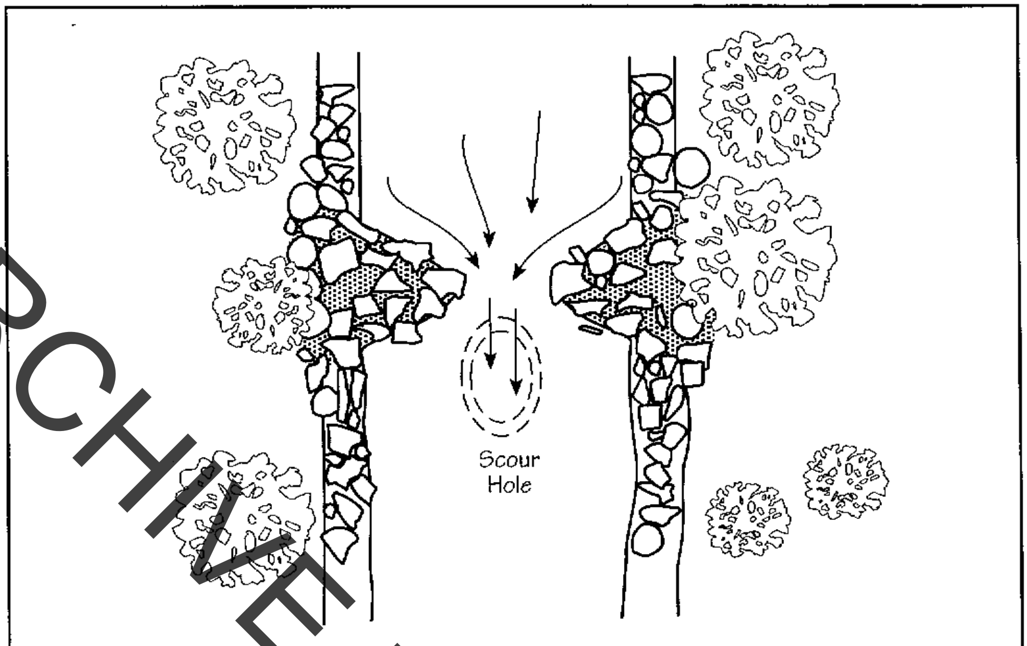
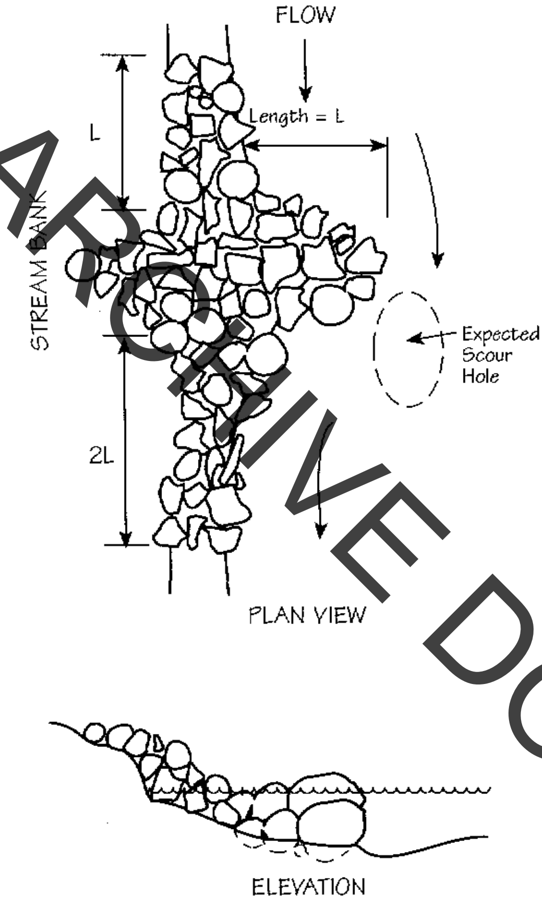
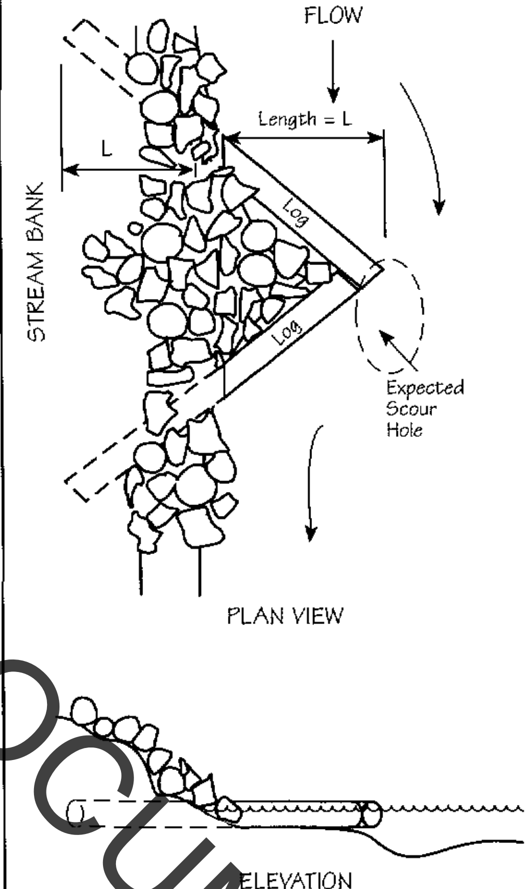


Figure 3-7 Opposite pattern of deflectors

Specifications
for
Deflectors





1. Logs and timbers used in the deflector shall be untreated hardwood in good condition. They shall be placed in a trench cut into the channel bank so that half the log is buried and half projects into the channel. The trench shall be backfilled and compacted.

2. The height of deflectors shall allow them to project above the water surface during low flows and be submerged during high flows.

3. Rock used in the deflectors shall be large enough to be stable for high flows. The largest rocks should be arranged near the point of the deflector. Riprap used to protect the bank shall be ODOT Type C rock.

4. The voids in the rock and riprap shall be filled with soil and planted.

Gravel Riffle

Description

Gravel riffles are supplies of gravel and cobble-sized stone placed at intervals in a stream channel. They are used to promote the formation of stable substrate in relocated channels or channels that have been modified or otherwise heavily impacted. Gravel substrate also provides productive habitat for aquatic insects and areas for spawning.

Planning Considerations

Using gravel riffles should be considered if course gravel substrate is characteristic of a stream but for some reason absent. This is common of deepened, modified or relocated channels. It may also occur where the bedload sediment supply has been stopped by the construction of an instream pond or by putting the upstream channels in an enclosed storm drain system. Constructed gravel riffles are usually of value only in very small channels. The natural bedload of larger streams is more likely to supply enough coarse material.

This practice must only be used to augment the natural channel formation. Supplies of gravel and cobble introduced to a channel will not force a channel into a desired shape but must instead mimic what might eventually accumulate from natural deposition of bedload sediment.

Design Criteria

Size--The length of gravel riffles should be equivalent to one to two times the channel width. They should not be thick enough to act as a dam or back up a significant pool, generally less than 1 ft. thick or no higher than the existing water surface elevation.

Configuration--To concentrate low flows, the gravel should be placed so that it is slightly lower in the middle of the channel and higher by the streambanks.

Material--Gravel size is best determined by examining the substrate and gravel bars in the existing stream channel. Gravel should be sized to be stable at low and medium flows but erodible at high flows or bankfull flow. Gravel will commonly be 1-4 in.

Spacing--The following should be considered to determine appropriate spacing of gravel riffles:

- Gravel riffles should be placed at the crossovers between meanders.
- Add material where existing riffles are forming.
- Spacing may be based on the stream width as estimated from undisturbed sections of channel. Place gravel into the stream at approximately five to seven stream widths apart.
- Match the spacing of riffles in a similar undisturbed portion of the stream.

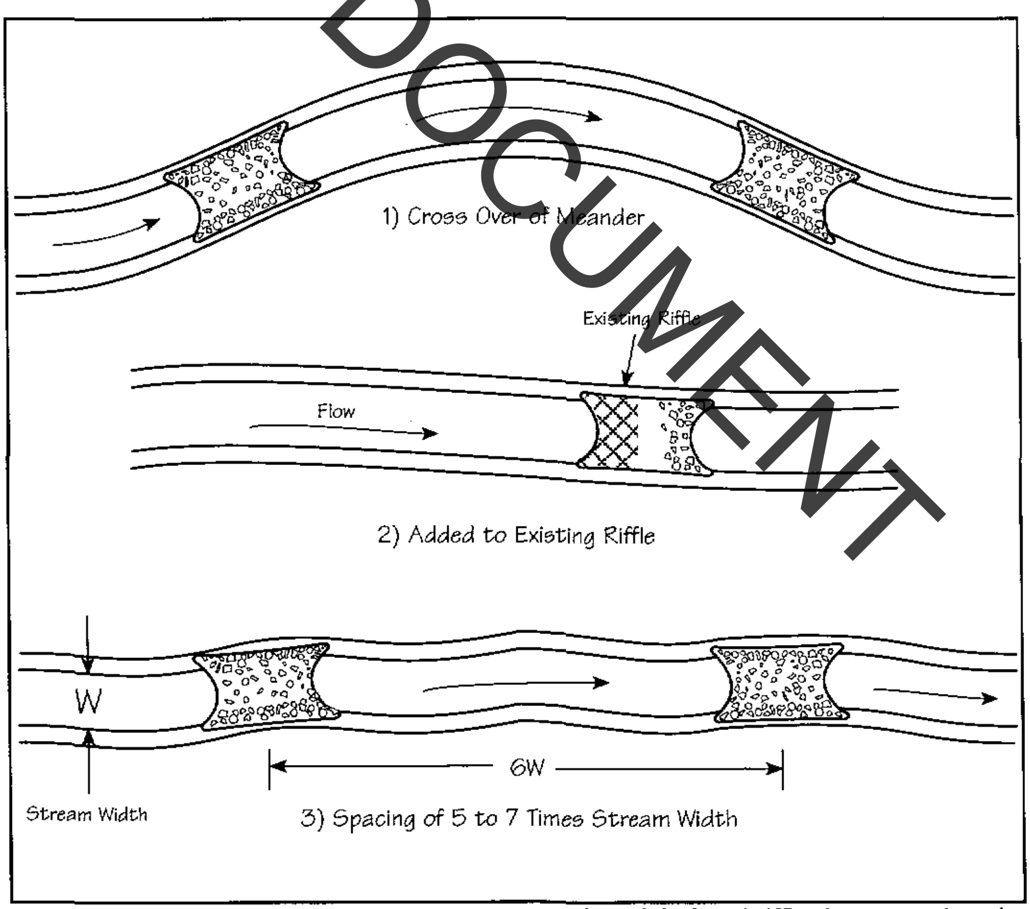
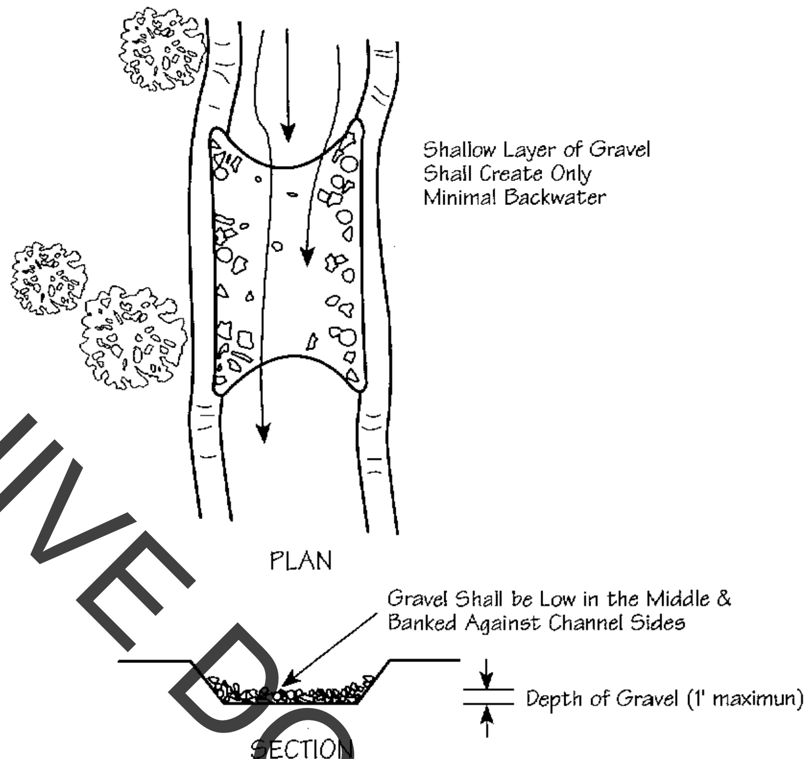


Figure 3-8 Gravel riffle placement and spacing

Specifications
for
Gravel Riffle



1. The length of gravel riffles shall be equivalent to 1.5 times the channel width.

2. The gravel shall NOT be placed so that it acts as a dam or creates a backwater pool. It shall be generally less than 1-ft. thick and no higher than the existing water surface elevation.

3. The gravel shall be placed so that it is slightly lower in the middle of the channel and higher by the streambanks.

4. Gravel size shall be similar to the substrate and gravel bars in the existing stream channel and so that the gravel will be stable at low and medium flows but erodible at high flows.

Multi-Stage Channel

Description

Two-stage channels and three-stage channels are constructed watercourses consisting of smaller channels within larger channels. They provide an alternative to typical channelized ditches and enclosed pipes. Multi-stage channels can be designed to meet conveyance requirements while minimizing environmental impacts and taking advantage of naturally stable channel geometries.

Conditions Where Practice Applies

Multi-stage channels should be used where:

- Channel relocation is unavoidable and a new stream channel must be constructed.
- The conveyance efficiency of a channel must be increased to alleviate flooding.
- The depth of a channel must be increased to accommodate storm drains or drainage outlets.
- Stream restoration would benefit a previously modified or otherwise heavily impacted channel.

Planning Considerations

Doing channel work almost always degrades many of the stream's functions and should be avoided. If it is not feasible to avoid a channel and set aside its riparian area, then there are alternatives to enclosing the channel in a pipe or replacing it with a trapezoidal ditch.

Two-stage channels offer a simple option which is basically a hybrid ditch. This standard is limited to two-stage channels. Three-stage channel designs are based on naturally stable channel forms. Their stages consist of a base flow channel or thalweg, a bankfull channel corresponding roughly to a 1.5-yr. frequency flow, and an active floodplain. Three-stage channels are beyond the scope of this book; however, there are excellent sources of information for their design. See Rosgen, 1996 listed in the information sources section.

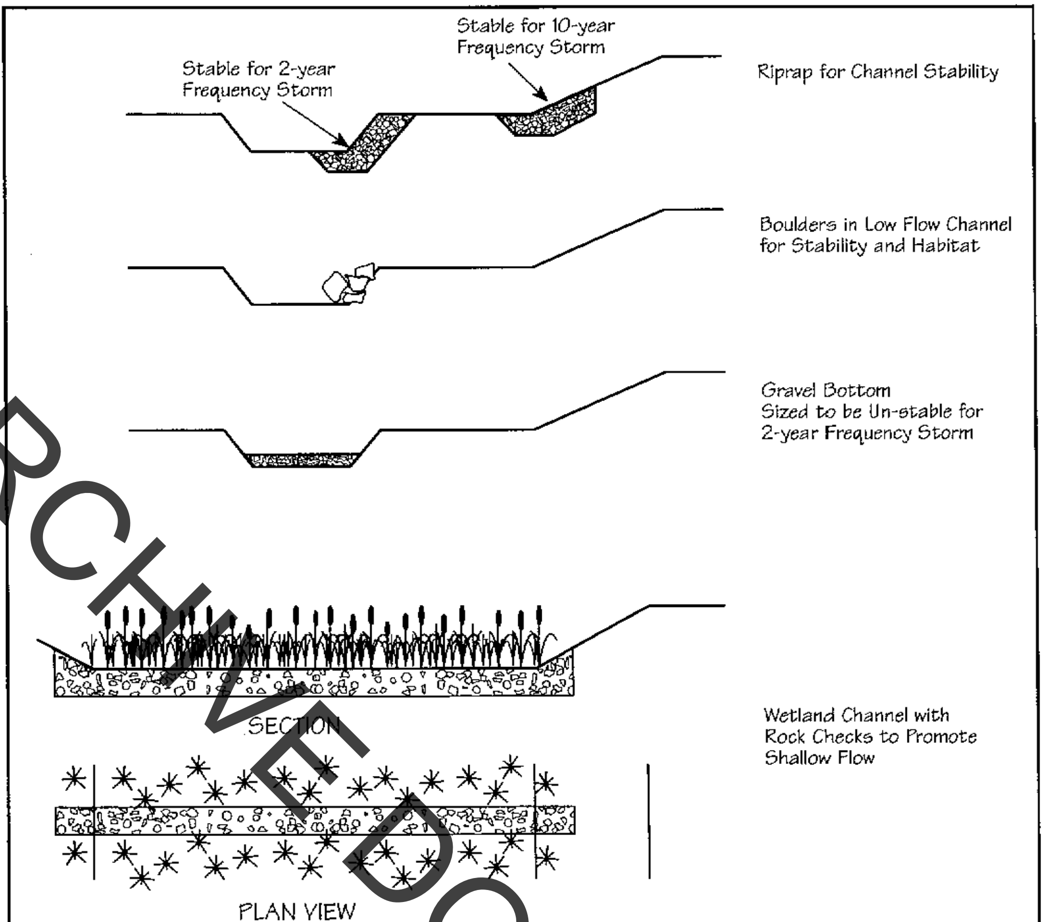


Figure 3-10 Channel restoration and creation design concepts

Low-Flow Channel:

- The flow length of the low-flow channel should equal the original channels flow length.
- The capacity of the low-flow channel should be 50% of the 2-yr. storm event.
- Create features for stream stability, water quality, habitat enhancement, and visual interest, including meanders, eddy rocks, pools and riffles.
- Use a soft-bottomed channel, one with a lining other than concrete, wherever possible to maintain interaction of groundwater and surface water.
- Vortex rock weirs, meanders, or friction from eddy rocks or vegetation can be used to reduce erosion by controlling velocity.
- Minimize the use of riprap armored channels. If used, the riprap above the normal low flow should be covered with soil and planted.

Flood Channel:

- The capacity of the flood channel will of course be based on whatever design storm is necessary. However, the minimum bottom width of the flood channel should be at least three times the top width of the low-flow channel.
- Encourage natural vegetation in the flood channel for the benefits of water quality, bank stability and wildlife.
- When regrading flood plain areas, new channel widths and side slopes should be varied if possible. Where side slopes are to be mowed they should be no steeper than 4:1 slope. Slopes that are planted with shrubs and trees or planted and left to natural succession may be steeper.
- Maintain existing vegetation where possible to create a stable slope.

Restoring Altered Stream Channels--Ditches and channels, which have had fill placed along the channel, typically have narrow flow widths even during high flow. Further modifications of these types of channels can keep necessary flood conveyance capacity while also providing benefits including improved water quality, reduced erosion potential, wildlife habitat and esthetics.

Restoration can be accomplished by excavating terraces on either side of an existing channel to increase the cross-sectional area available for high flows. If the bottom of the existing channel is narrow it may be able to be preserved as the low-flow channel, especially if it has stable course substrates. The excavated terraces should be planted in woody vegetation. Manning's equation should be used to ensure the terraces increase the cross-sectional area enough to convey the desired design flow with the increased resistance of vegetation.

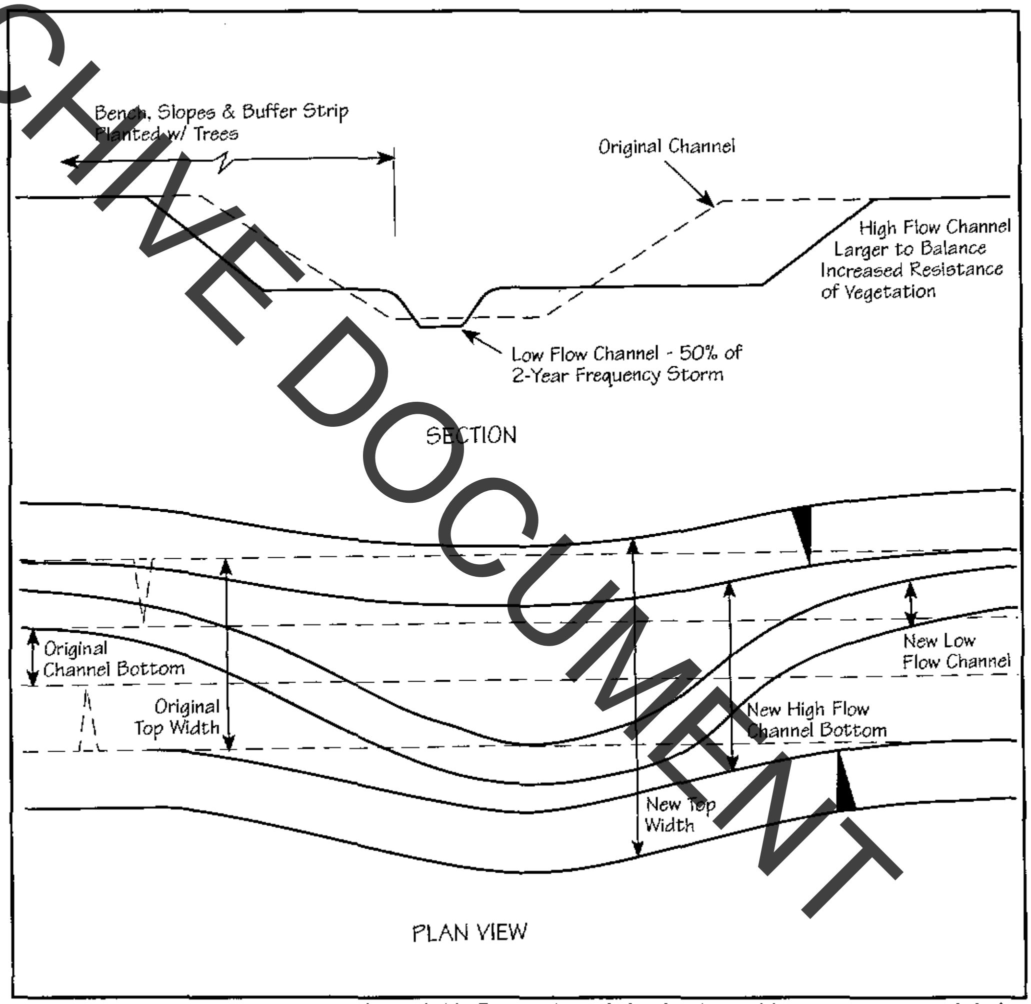
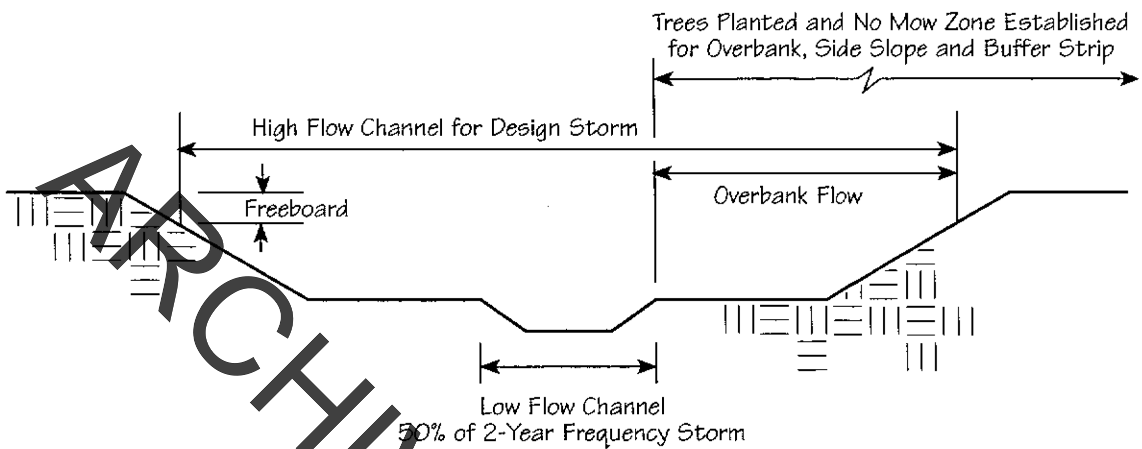


Figure 3-11 Restoration of simple ditch with two-stage channel design

Specifications
for
Two-Stage Channel



1. Create streambeds with natural features for stream stability, water quality, habitat enhancement, and visual interest, including meanders, eddy rocks, pools and riffles.

2. Where side slopes are to be mowed they shall be no steeper than 4:1 slope. Slopes that are planted with shrubs and trees or planted and left to natural succession may be steeper.

3. Maintain existing vegetation where possible to create a stable slope.

4. The existing channel should be preserved as the low-flow channel, especially if it has stable course substrates.

Rock Check

Description

Rock checks are a series of trenches cut across a channel and filled with rock. They are used to prevent the upstream migration of headcuts and to control channel erosion, particularly downcutting.

Planning Considerations

Channels typically erode and enlarge in response to urbanization and the resulting changes in flow regime. The process usually begins by the channel downcutting, becoming deep and entrenched. This condition is unstable and the channel erodes laterally. The whole process may take many years and causes a significant amount of sediment pollution, degraded habitat, property damage, etc.

Rock checks should be considered if a natural channel's drainage area is changing to urban land use, even if detention is a part of land development. This practice is also useful in any channel, natural or constructed, where headcutting is a threat.

DESIGN CRITERIA

Configuration--Rock checks should be flush with the channel bed. They should not obstruct flow or form a dam. Avoid configurations that will cause backwater or a pool upstream from the structure. A common mistake made in stream mitigation is the construction of dams that create stagnant backwater pools, siltation, and barriers to fish. While grade stabilization dams can sometimes be beneficial in constructed channels, they often are misused and are not recommended for instream use.

A plunge pool may eventually form downstream from the rock check. Constructing the rock check to angle or arc upstream will direct flow away from the downstream banks and will focus plunge pool formation toward the middle of the channel.

Depth--An adequate depth for rock checks varies based on channel conditions but should not be less than 15 inches or more than 36 inches.

Length--For channels that may be unstable or where instabilities are anticipated because of changes in the flow regime, the length across the channel must be sufficient to avoid failing even as the channel widens. A total length of two times the channel's top width (two times bankfull width in natural channels) is generally recommended.

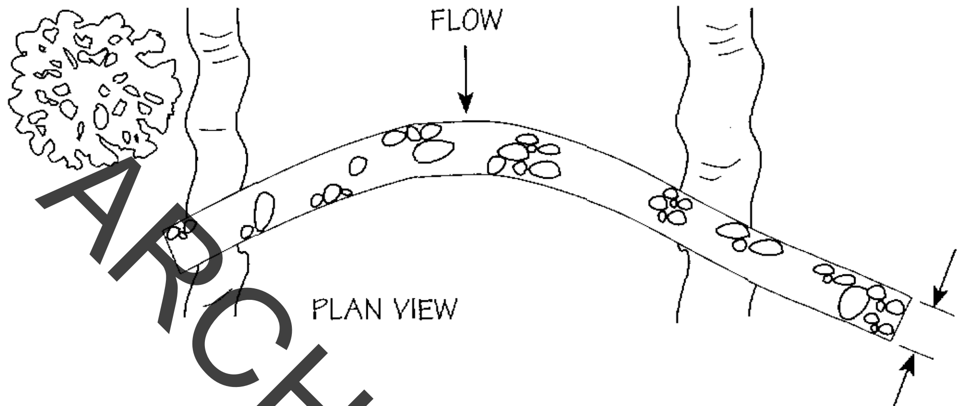
For constructed channels experiencing headcutting, the length of a rock check may be shorter and still sufficient for avoiding erosion around the ends of the rock check. For example trapezoidal channels, the rock check length should equal the channel's top width. For parabolic waterways, the rock check may be 2/3 the channel's top width.

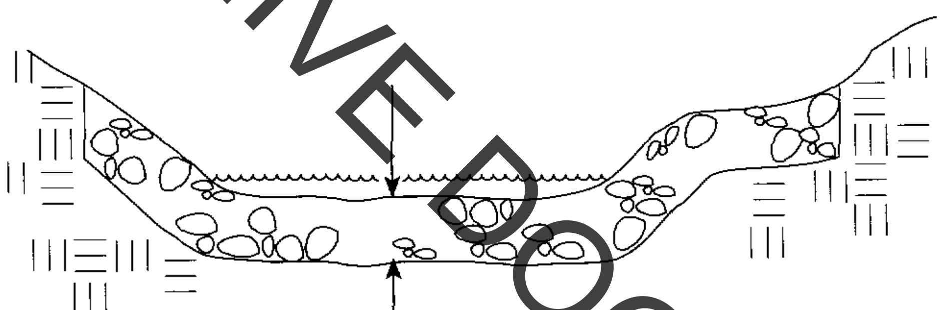
Spacing--In meandering streams rock checks should be constructed in riffles at the crossovers between bends. There should be one constructed at the downstream end of the riffle or two, one at each end of the riffle. In non-meandering constructed channels rock checks should be constructed at the following intervals based on slope:

Rock Check Spacing in Non-Meandering Constructed Channels	
Grade (%)	Maximum Spacing (ft.)
0-1.5	100
1.5-3.0	75
> 3.0	50

Specifications
for

Rock Check





1. Type C rock shall be used.
2. The ends shall extend from the top of the channel into the banks 10 ft. or a distance equal to about one-half the channel width, whichever is less.
3. The trench shall be 1-2 ft. wide and shall be dug to arc or form a vee pointing upstream with the midsection of the rock check farther upstream than where it meets the channel banks.
4. The rock checks shall be flush with the channel so that the finished rock surface is on the same grade as the channel bottom and not creating a dam or ponding water.

STREAMBANK STABILIZATION

DESCRIPTION

This practice controls streambank erosion with plant materials. It provides interim bank protection and introduces tree species able to establish a thick network of roots and branches on a streambank. This practice includes driving live tree cuttings into the bank, planting tree seedlings and/or anchoring trees to the toe of the bank to create a temporary protected environment for trees to become established.

CONDITIONS WHERE PRACTICE APPLIES

Cause of Bank Instability--Vegetative streambank stabilization, as presented here, is most useful on streams with localized instability. Localized instability may be caused by removal of woody vegetation, channel modifications or other site specific impact. If a channel has extensive erosion over long reaches, the solution may still involve vegetative streambank stabilization but is much more in depth and beyond the scope of this standard.

Direct Sun--Most of the tree species and planting techniques described in this practice work best on streambanks that receive near full sun.

Channel Capacity--The design of vegetative streambank stabilization is adaptable and can be made to accommodate different flood conveyance needs. Plant species can be selected which will lay down flat during flood flows creating little resistance, or more rigid species can be planted which are better able to dissipate flow energy and reduce damaging flood velocities.

Planning Considerations

Vegetative streambank protection is just one method of armoring and stabilizing streambanks. Other methods such as riprap, concrete, gabions or more intensive vegetative techniques may be more appropriate where the channel must be kept in a ridged aliment such as around bridges or other structures. This practice, however, can be used in a wide range of conditions, is easily constructed, and provides additional benefits other methods may not, including:

- A natural self-repairing channel equilibrium is established.
- Aquatic habitat benefits from the cover, structure and leaf litter the vegetation provides.
- Shading the channel reduces water temperature and allows higher dissolved oxygen.
- This practice is often much less expensive than other channel armoring practices.
- Construction methods are simple with few equipment needs.

Design Criteria

Grading Streambanks--An option for improving planting conditions is to reduce the streambank slope. This should be accomplished by pulling the bank back and depositing the material away from the stream channel. Situations which may require this are channels with high vertical banks, highly erodible soils or banks prone to sloughing.

Materials--A variety of size stock may be used to establish a dense stand of trees on a streambank. Cuttings may range in size from 12-ft.-long posts to 2-ft.-long stakes; even 0.5-in.-diameter cut willow whips or seedlings may be used. Generally, large cuttings can withstand more severe conditions while smaller stock is easier to handle and is adequate in less severe conditions.

The following criteria should be considered when specifying the size and type of stock to be planted:

Posts--(usually 5 to 7 ft. long, but can be 12 ft. long or more)

Streambank Characteristics--Large dormant posts offer the most initial structural stability. They are useful on steep or overhanging banks that are expected to continue to slough. Cuttings should be large enough to remain in place without breaking or being buried if some sloughing occurs. On potentially very dry streambanks, where water availability for new plants may be a problem, longer posts can be planted deep enough to intercept water.

Stream Flow Characteristics--Large high flood velocities are the cause of damage and bank instability. Large posts offer resistance and dissipate the stream's flow energy. The resistance of large posts may not be desired where high conveyance efficiencies are needed.

Planting Method--Heavy equipment may be required for planting very large posts. A backhoe fitted with a ramrod may be an effective way of creating the holes for planting. Fairly large posts (5-7 ft.) may be driven into streambanks with a hand-held fence-post driver.

Stakes--(usually 1-3 in. in diameter, 1.5-3 ft. long)

Streambank Characteristics--Cuttings 1.5-3 ft. long may be adequate on fairly stable streambanks, which may experience some sloughing, but will not depend on cuttings for initial stability or retention of sloughing banks.

Planting Method--Small cuttings are more available and much easier to handle. A sledgehammer is sufficient for driving stake-size cuttings into most streambanks without pilot holes or heavy equipment.

Seedlings

Streambank Characteristics--Seedlings should not be planted on actively eroding streambanks. Seedlings will not offer any initial bank stability; in fact, planting disturbs the soil and causes some instability. Streambanks should be cut back to a slope no steeper than 2:1.

Stream Flow Characteristics--Species of seedlings are available which offer very little resistance to high flows. Trees such as Bankers Willow or Streamco Willow are low growing and flexible. They lie flat against the streambank during high flows, maximizing the channel's conveyance efficiency. This may be important in areas of localized flooding or in low gradient streams and constructed drainage ditches.

Planting Method--Seedlings are planted with a dibble bar or shovel. Seeding is labor intensive but easily accomplished by people without prior experience.

Revetments--Tree revetments are made by anchoring trees end to end along a streambank. Trees should have many durable branches forming a dense canopy. Trees are often limited to what is available on-site. Recommended trees are oak, bald cypress and, for smaller streams, cedar.

Tree revetments may be used alone or with dormant woody cuttings to protect the new cuttings by slowing the current along the eroding bank. The revetments decrease erosion and allow silt and sand to be deposited along the bank, within the branches of the revetment. The deposited material forms a good environment for new cuttings and a good seedbed for river trees such as cottonwood and sycamore to sprout and grow. The resulting trees spread roots throughout the revetment and streambank. By the time the revetment trees have decayed, the bank should be stabilized by the roots of the living trees. As an added benefit, tree revetments provide excellent fish and wildlife cover.

Plant Species:

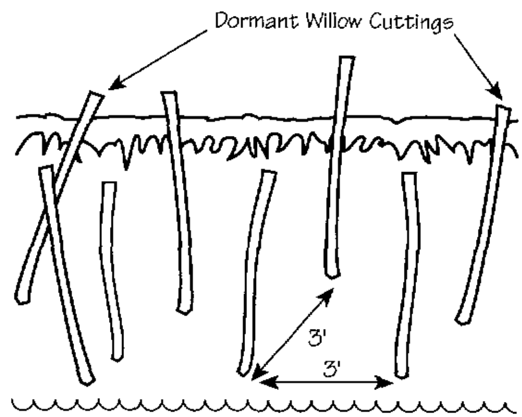
Dormant Woody Cuttings--Plant Species for Streambank Stabilization		
Black Willow	Salix nigra	Any size cutting
White Willow	Salix alba	Any size cutting
Sandbar Willow	Salix interior	Small cutting
Eastern Cottonwood	Populus deltoides	Seedling or any size cutting
Swamp Cottonwood	Populus heterophylla	Seedling or any size cutting

Little Obstruction to Stream Flow--Plant Species for Streambank Stabilization		
Streamco Willow	Salix purpurea	Seedling or small cutting
Bankers Willow	Salix cotteti	Seedling or small cutting

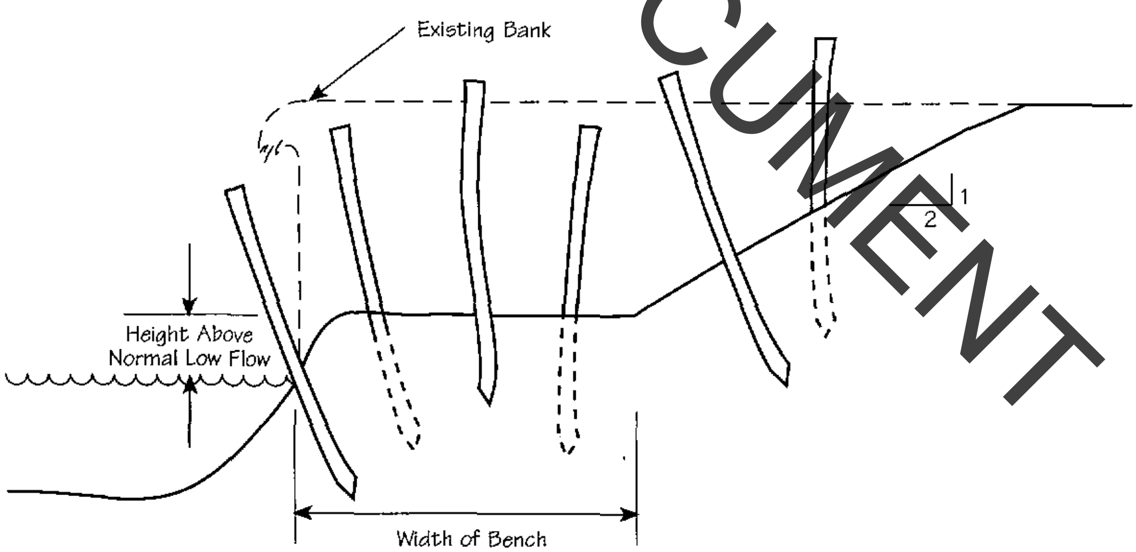
Shade Tolerant--Plant Species for Streambank Stabilization		
Blue Arctic Willow	Salix purpurea nana	Seedling or small cutting
Silky Dogwood	Cornus amomum	Seedling only

Specifications
for
Streambank Stabilization with Dormant Posts and Stakes

Without Grading Bank
SECTION



ELEVATION



With Graded Bank
SECTION

Specifications
for

Streambank Stabilization with Dormant Posts and Stakes

Earthwork--If earthwork is specified, grading operations shall only pull material back from the stream channel. Soil shall not be pushed into the stream channel. The material excavated shall be placed at least 20 ft. back from the top of the newly formed bank.

Planting Periods--All planting materials shall be cut and installed while in a dormant stage from November 1-April 1, preferably in February.

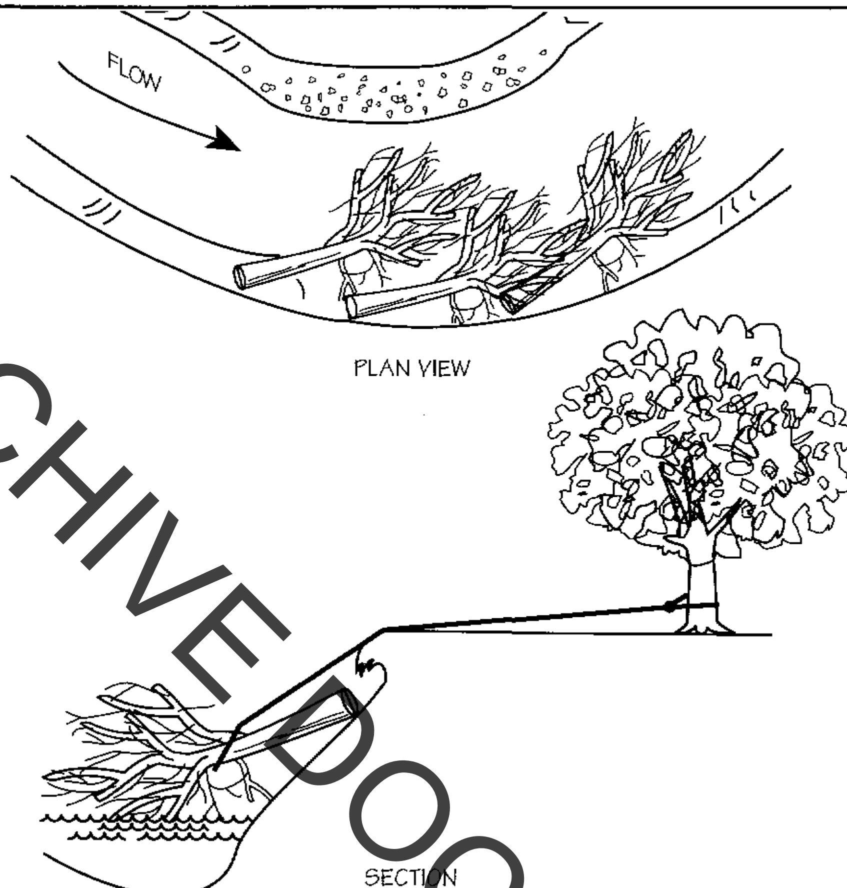
Plant Materials

1. The cuttings specified as posts shall be 3-5 in. in diameter and 5-7 ft. long and generally straight.
2. The cuttings specified as stakes shall be 1.5-3 in. in diameter and 3-5 ft. long and generally straight.
3. The side branches shall be cleanly removed and the bark intact.
4. The base end shall be cut at a 45-degree angle and the top end shall be cut square.
5. The cuttings must be fresh and kept moist and out of direct sunlight. They shall be planted within 36 hr. from the time they are cut. If stored for more than a few hours, the base of the cutting shall be kept in water.

Installation

1. Planting Equipment--Cuttings may be installed using an iron bar or a post hole digger, power auger, or a metal ram on a backhoe or similar equipment. In soft, nonrestricted soils, cuttings may be manually driven into place using a wooden maul. A sledgehammer may be used if it does not cause the planting material to split.
2. Depth of Planting--Cuttings shall be planted so that at least 40% and preferably 50% of the cutting is below ground level.
3. Alignment--Cuttings shall be planted right side up as they were originally growing.
4. Bark Damage--Avoid excessive damage to the bark of the cutting. The top of damaged or split cuttings shall be cut off.
5. Soil Contact--Good contact between the soil and cutting shall be achieved. If the planting holes are dug or punched they shall be smaller in diameter than the cutting.

Specifications
for
Streambank Stabilization with Tree Revetments



Timing--Tree revetments should be built during low water but may be built in any season.

Tree Selection

1. Trees shall have many durable limbs and fine branches. They shall be fresh enough not to be brittle.

2. Size--The diameter of the tree's crown shall cover at least one-third the height of the eroding bank and shall not extend out into the stream channel more than one-third the width of the stream channel.

Placement

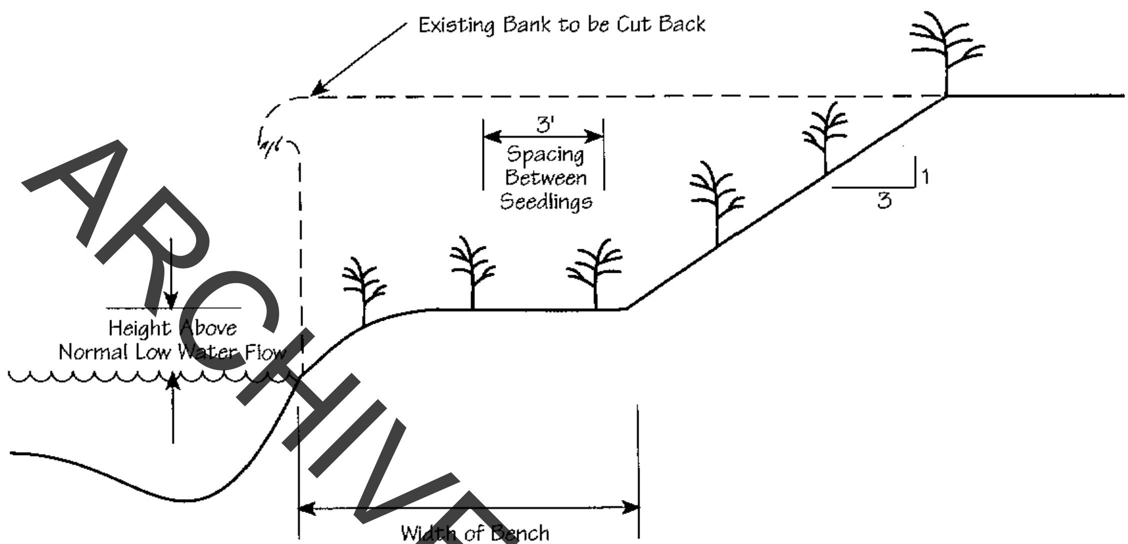
1. Revetment construction shall begin at the downstream end of the eroding streambank. The first tree shall be anchored to the toe of the bank with the butt end pointed upstream. The next tree shall be placed with its top overlapping the butt of the first tree so there is no gap between the two. The cable used to anchor the butt of the first tree shall then be secured to the top of the second tree and a new anchor put in at the butt of the second tree. This process shall continue upstream until the entire section of bank to be stabilized is covered.

Anchoring

1. Trees shall be anchored so they are held tightly against the bank with no slack in the cables.

2. Materials--Anchors shall be sufficient to secure tree revetments during flood flows. They shall be driven earth anchors such as duck bill anchors, Laconia anchors or other approved method. The cable shall be 3/16-in. aircraft cable fastened with cable clamps.

Specifications
for
Streambank Stabilization with Seedlings



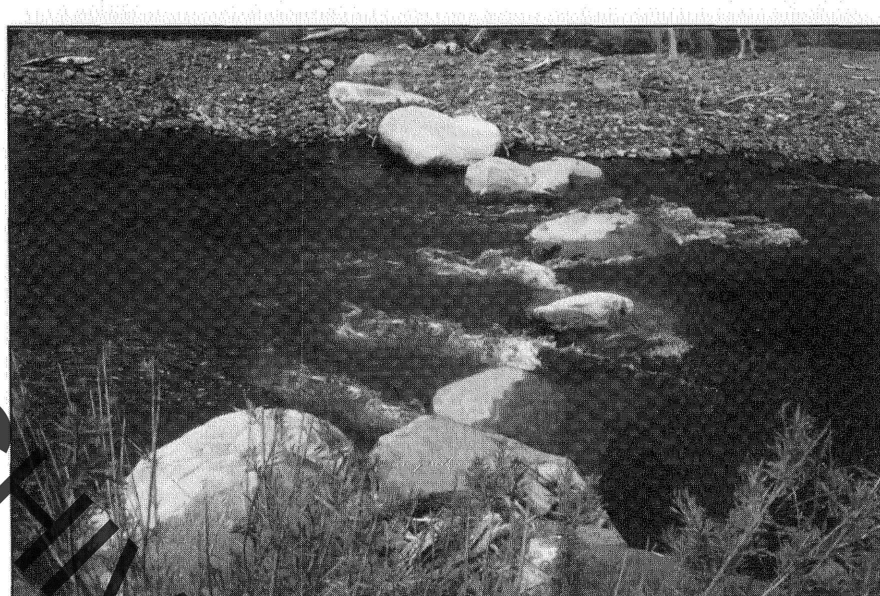
SECTION

1. The grading operation shall only pull material back from the stream channel. Soil shall not be pushed into the stream channel. The excavated material shall be placed at least 20 ft. back from the top of the newly formed bank.

2. Seedlings shall be planted on 3-ft. centers.

3. The preferred planting method is with a dibble bar. First, a hole large enough to allow the roots of the plant to be maneuvered into the bottom, untwisted and oriented to grow down instead of up shall be made. After the plant is placed at the same depth it originally grew, the dibble bar shall make a new hole a few inches away to close the hole. The job is completed by firming the soil around the seedling with a heel.

Vortex Rock Weir



Description

Vortex rock weirs are a type of check dam made with large rocks placed so there are gaps between the rocks. They are used to direct flow, control channel erosion, narrow and deepen flow and create habitat. Vortex rock weirs may be used as a check dam without many of the adverse impacts check dams often have on channel stability and in-stream habitat.

Planning Considerations

Stream restoration projects and instream mitigation projects often include the construction of dams. Unfortunately dams, whether they are grade stabilization dams, check dams or dams created for habitat have several recurring problems. They often create stagnant silty backwater pools, are barriers to fish and induce streambank erosion and lateral channel migration upstream of the structure by reducing the channel slope. While dams can be beneficial, they are easily misused and commonly cause more problems than benefits.

Vortex rock weirs can do much of what other dams do without the adverse impacts. By having spaces between the rocks and because of its configuration problems are avoided primarily by allowing the stream's sediment, including the bedload, to pass through the structure.

This practice should be considered for use in channels that have become wide and shallow. Creating a narrow and deep flow may be done to improve the stability of channels that are becoming filled with sediment, deter instream gravel bar formation or to improve instream habitat. Vortex rock weirs may also be useful for controlling a channel's lateral migration. Flow may be directed away from streambanks, keeping it concentrated in the middle of the channel. Lastly these structures may be useful for controlling downcutting, much as a rock check or a grade control structure would do.

DESIGN CRITERIA

Rock Size--Rocks must be large enough to resist displacement during high flow. If the bottom is stable, a rock of 2-ft. diameter or about 1,000 lb. will resist movement in current velocities up to 10 ft./sec. A 4-ft. rock will be stable in velocities up to about 13 ft./sec. Partially burying rocks (one-third their diameter) or supporting them with footer rocks further improves their stability. Also, rocks that are angular or flat will be more stable.

Footer Rocks--Rocks are displaced usually by scour of the substrate around the rock and downstream. The rock rolls into the depression and the process continues until the rock is buried. Footer rocks can prevent this type of failure.

Footer rocks are set in a deep excavation. They must be placed deep enough to allow the rocks they support to be resting on top and just upstream. Footer rocks should be needed only where available rock is small or mobile substrate is deep relative to the rock.

Configuration--To prevent washout around the structure, rock should extend into the banks. The distance it should extend into the bank depends on the channel shape and stability. Generally, a distance equal to one-half the channel width or 10 ft., whichever is less, should be sufficient.

A plunge pool should form downstream from the structure. Constructing the dam to angle or arc upstream will direct flow away from the downstream banks and will focus the plunge pool toward the middle of the channel.

The dimensions of vortex rock weirs are based on rock size (D) and the depth of bankfull flow. See the glossary for the definition of bankfull and the diagram on the following page.

- Spacing between rocks should be 0.25 D to 0.5 D,
- Upstream arc of the structure should be 2.5 D to 3 D
- The height of the structure should be lowest in the middle, only 15% of bankfull. The ends should rise up to 100% of bankfull.

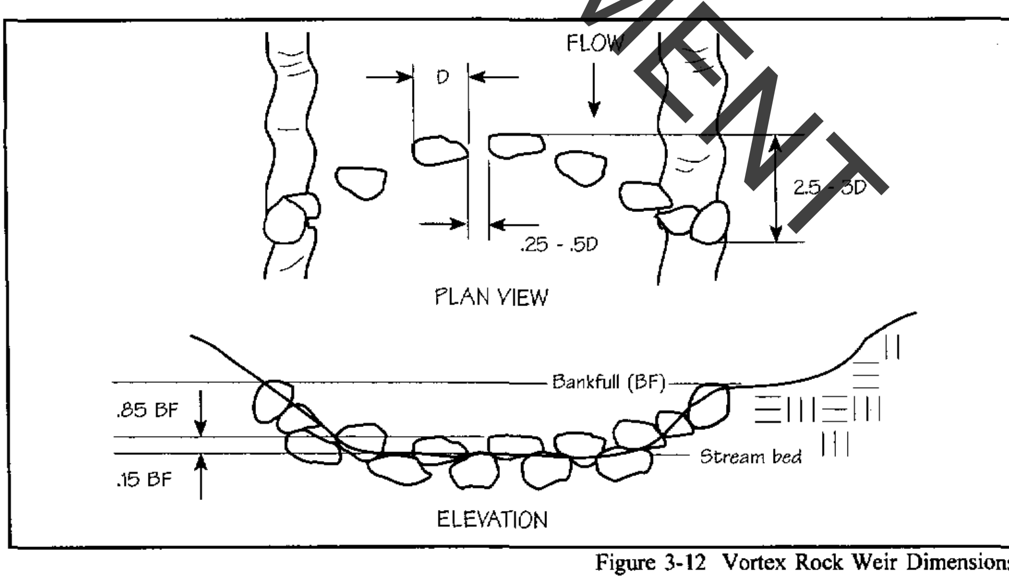
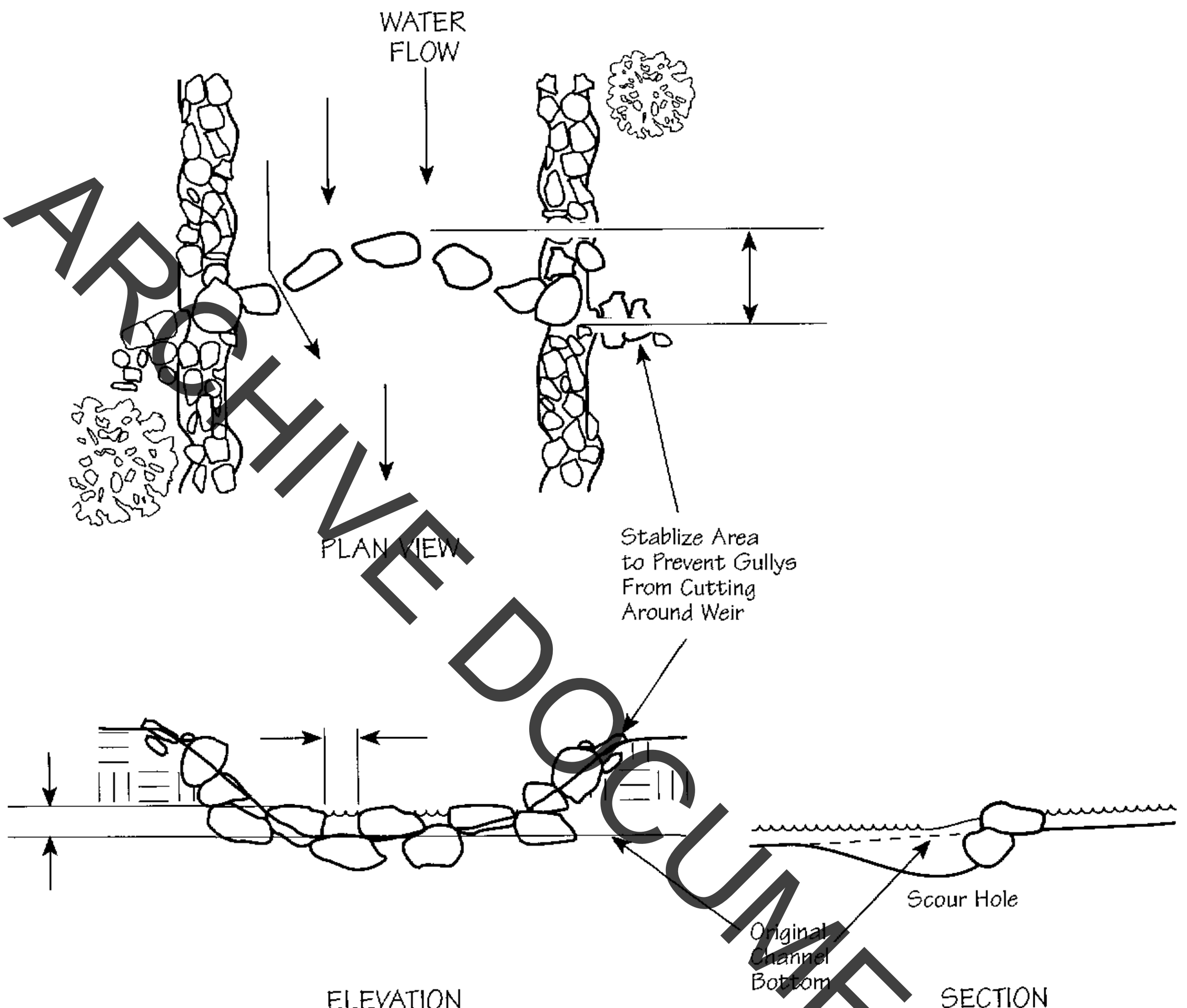


Figure 3-12 Vortex Rock Weir Dimensions

Specifications
for

Vortex Rock Weir



1. Rock shall be at least _____ ft. in diameter.

2. Excavation of the channel bed shall be necessary to place the rocks at the elevations shown in the detail drawing.

3. Footer rocks shall be set in an excavation deep enough to allow the rocks they support to be resting on top and just upstream of them.

4. Rock shall extend up and into the banks 10 ft. or a distance equal to about one-half the channel width, whichever is less.

5. The structure shall be constructed to arc upstream with the midsection of the dam farther upstream than where it meets the streambanks.

PART III

EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

SEDIMENT CONTROL

SEDIMENT BASIN

DESCRIPTION

A sediment basin is a temporary settling pond that releases runoff at a controlled rate. It is designed to slowly release runoff, detaining it long enough to allow most of the sediment to settle. The outlet structure is a designed pipe riser and barrel. The entire structure is removed when construction is complete and the drainage area stabilized.

CONDITIONS WHERE PRACTICE APPLIES

Sediment basins are limited to sites where:

- Failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of private utilities.
- The drainage area is 100 ac. or less.
- The height of the dam is 25 ft. or less, as measured from the natural streambed at center line of dam to the top of dam.
- The basin is to be removed within 36 months after its construction.

Sediment basins exceeding any of these limits shall conform to Ohio Dam Safety Laws, local requirements, or U.S.D.A Natural Resources Conservation Service Standards and Specifications No. 387 for ponds, whichever is more restrictive.

Ohio Dam Safety Laws may apply to basins larger than 15 ac.ft. (24,000 cy) as measured to the top of the dam. Information is available from the Ohio Department of Natural Resources, Division of Water, 1939 Fountain Square Ct., Columbus, Ohio 43224-1336; phone (614) 265-6731.

For temporary sediment control modifications to permanent ponds, see the standards and specifications of Permanent Ponds for Temporary Sediment Control.

PLANNING CONSIDERATIONS

Sediment basins along with sediment traps are generally the most reliable measures used for treating sediment-laden runoff. Sediment basins and traps are usually placed near the perimeter of construction-sites. Construction activity should be phased to allow them to remain functional for as long as possible, ideally until the area contributing runoff is stabilized. Sediment basins have relatively good sediment-trapping efficiencies and require little maintenance compared to other practices used to treat sediment-laden runoff. Settling ponds, both traps and basins, are generally recommended as the principal sediment-control practice for construction-sites.

Effectiveness--Sediment basins by no means trap all the sediment that washes into them. Sometimes more than half the sediment flows through. Therefore, sediment basins as with all sediment controls should be used in conjunction with erosion control practices such as temporary seeding to reduce the total amount of sediment washing to them.

While trapping efficiency varies widely for sediment basins, it is commonly between 60% and 80%. Trapping efficiency should be optimized within site constraints. This can be accomplished by: 1) incorporating design criteria which maximize trapping efficiency, 2) presenting this information clearly in construction documents, and 3) assuring construction is performed according to those documents.

Timing--Sediment basins, along with other sediment-control practices, must be constructed as a first step in any land disturbing activity and must be functional before upslope land disturbance takes place.

Location:

Construction Phases--Sediment basins should be placed so they function through all phases of the site's development, both before and after new drainage systems are constructed.

Diverting Runoff--Temporary diversions at the perimeter of sites often are used to direct runoff to sediment basins (see Temporary Diversion Specification).

Below Storm Drains--Sediment basins may be placed beyond the ends of proposed storm-drain systems. Postponing construction of the last sections of storm drain may be necessary to provide adequate area for the sediment basin between the outlet and receiving water course.

Storm-Drain Diversions--Storm drains may also be temporarily redirected through sediment basins during construction. After construction, the detours are removed and runoff is allowed to flow through the permanent storm drain.

Utilities--Give special consideration to sediment basin location and potential interference with construction of proposed drainageways, utilities and storm drains.

DESIGN CRITERIA

The design criteria includes 1) Pool Design, 2) Embankment Design, 3) Outlet Design, and 4) Emergency Spillway Design.

Design Procedures--In addition to the following design criteria, simple procedures are provided which may be used to meet these requirements. Other accepted engineering design procedures also may be used to meet the design criteria.

Runoff Calculations--Runoff computations must be based upon the worst soil-cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. Runoff must be computed by accepted engineering methods such as the Rational Method, NRCS TR-55, or those outlined in Chapter 2, Estimating Runoff, "Engineering Field Handbook for Conservation Practices," NRCS.

POOL DESIGN CRITERIA:

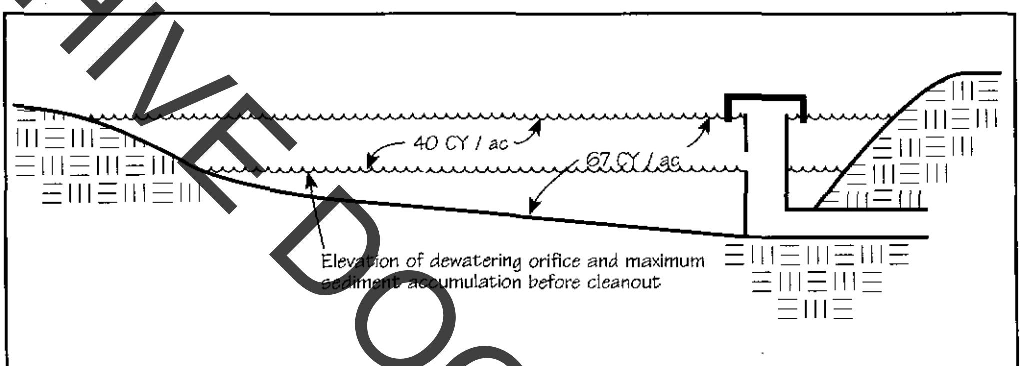


Figure 4-1 Sediment basin total volume made up of runoff storage and wet pool/sediment storage

1. **Plans**--Basin dimensions must be clearly shown (drawn to scale and labeled) on the plans to help in plan review and construction.

2. **Volume**--The minimum volume of sediment basins shall be 67 cy (0.04 ac.-ft.) for each acre of drainage area. This volume is measured below the top of the principal spillway's crest elevation. The drainage area includes the entire area contributing runoff to the sediment basin, off-site as well as on. Sediment basins will be cleaned out before sediment accumulation reduces the volume to 40 cy/ac. The cleanout elevation must be clearly marked on the riser. See maintenance section below.

3. **Increasing Trapping Efficiency**--It is recommended that the designer of a sediment basin strive to incorporate the following features to increase sediment trapping efficiencies. These are optimum criteria and will not be feasible for all sediment basins:

   Depth--The pool shall be configured to maximize the optimum depth of 3 ft. Depths over 5 ft. should be avoided. The depth shall be measured to the top of the principal outlet. Optimum depth is most important for basins that dewater or have temporary storage.

Length-to-Width Ratio--The length-to-width ratio shall be greater than 6:1 and less than 20:1 if feasible within the site's constraints. The width shall be calculated by dividing the surface area by the shortest flow path in the basin. Optimum length to width is most important for basins that do not dewater but remain full between rains.

Porous Baffles--If individual situations require greater trapping efficiency or if optimum depth and length-to-width ratios are not feasible, baffles may be incorporated into the design. Baffles shall be constructed to partition the basin into two or three cells. Baffles shall be porous, constructed of jute matting, rock, plastic safety fence, or other material that will dampen turbulent currents within the pool. Baffle height shall be greater than the principal spillway and less than the emergency spillway. Baffles that become submerged may cause flow just across the top layer of the pond. This allows little mixing with the water below and significantly lowers trapping efficiency.

4. **Safety**--Sediment basins are attractive to children and can be dangerous, particularly where slopes 2:1 or steeper lead directly into water 3 ft. or deeper. Danger is also increased where side slopes are not vegetated. The danger associated with sediment basins shall be minimized by avoiding the above pond configurations and/or by fencing and posting warning signs where appropriate.

EMBANKMENT DESIGN CRITERIA:

1. Embankments should have side slopes 2:1 or flatter. Note that if the basin will be developed into a permanent pond, remaining after construction, the combined side slopes must equal 5:1 or greater.

2. Seepage must be prevented from flowing along the foundation of the embankment. This requires stripping vegetation and topsoil. Cut-off trenches also are needed for all but the most stable conditions such as very low embankments and stable soils.

3. The height should include a 10% settling allowance. Note that the designed height of the embankment may need to be adjusted after designing the spillways.

4. Top Width:

Embankment Top Width	
Embankment Height (ft.)	Top Width (ft.)
< 15	8
15 - 20	10
> 20	12

PRINCIPAL SPILLWAY DESIGN CRITERIA:

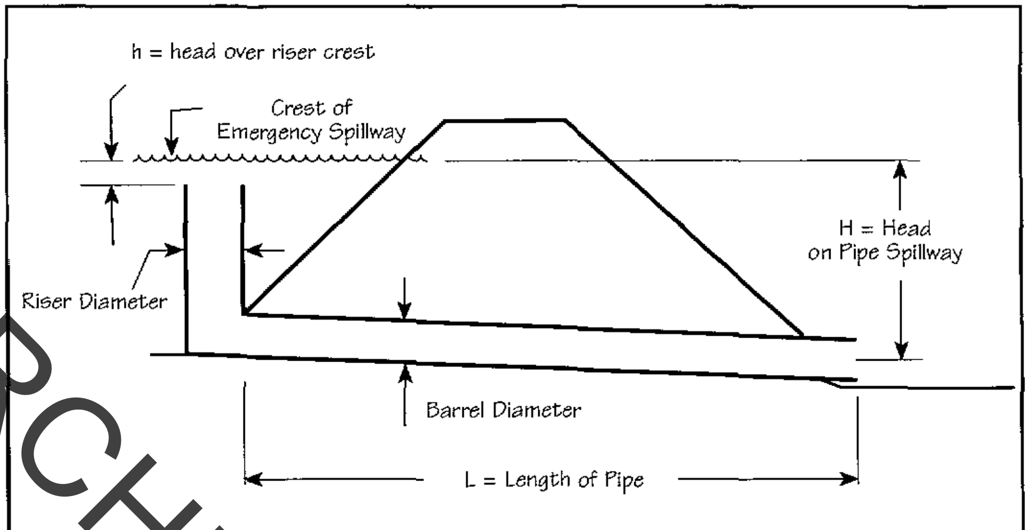


Figure 4-2 Sediment basin principal spillway design

1. **Capacity**--The principal spillway must pass at least 1 cfs/ac. of drainage area when the water surface is at the crest of the emergency spillway. The principal spillway will generally pass less than the 1-yr. frequency storm. Note the importance this places on the detention volume created by dewatering and the integrity of the emergency spillway.

2. **Crest Elevation**--The riser pipe's crest elevation must be a minimum of 1 ft. below the elevation of the emergency spillway.

3. **Sizing Procedure for Riser and Barrel**:
   - Determine Q from the capacity criteria above.
   - Determine **h** as the difference in elevation between the crests of the principal and the emergency spillway as shown in Figure 4-2.
   - Determine H as the difference in elevation between the barrel outlet and crest of the emergency spillway as shown in Figure 4-2.

   - With Q and h, refer to the following Riser Inflow Curves, Figure 4-3, and find the riser size required.
   - With Q and H, refer to the following Pipe Flow Table and find the barrel size required.

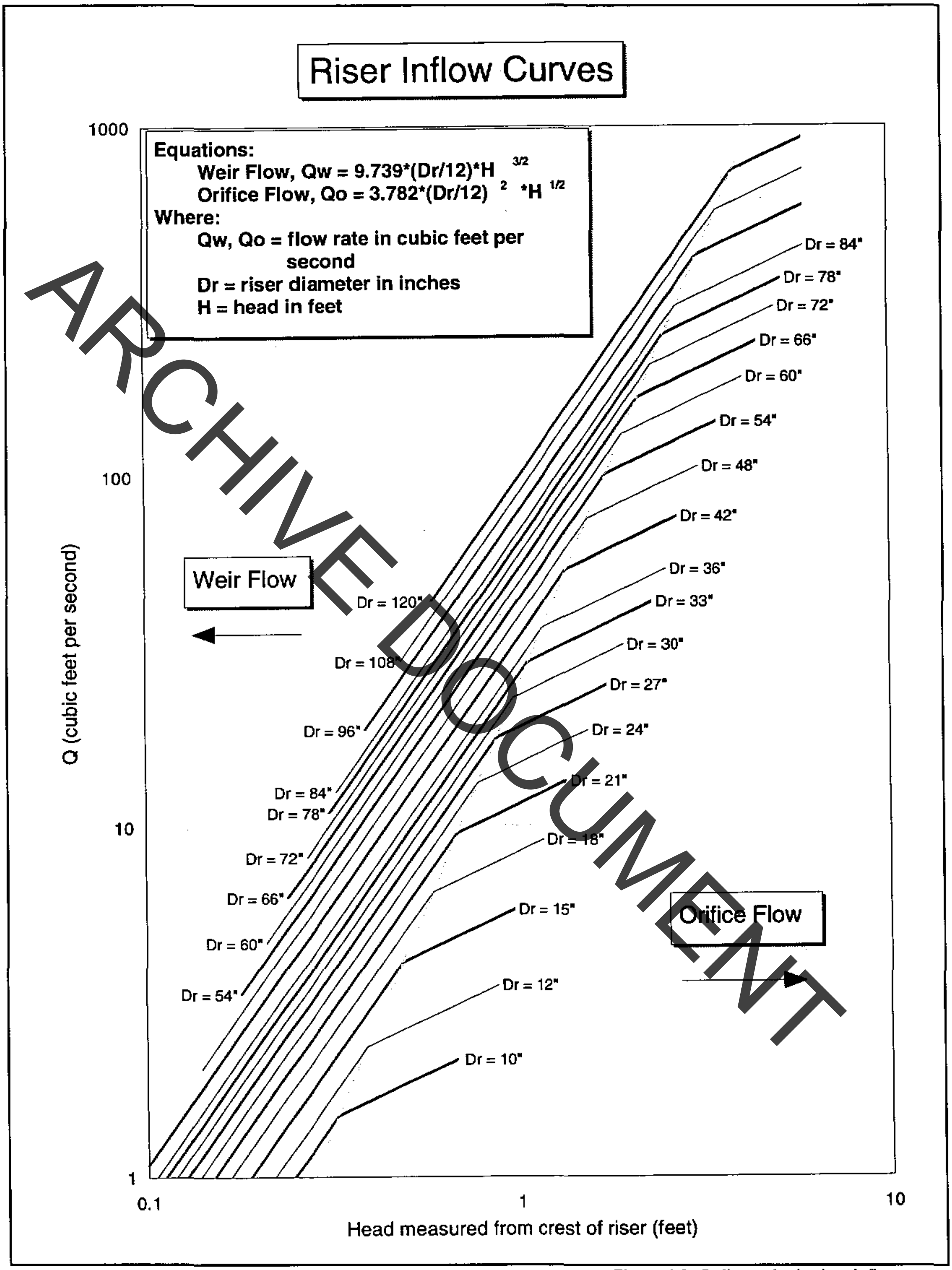


Figure 4-3 Sediment basin riser inflow curves

Barrel Size--For Corrugated Metal Pipe Principal Spillway
Based on flow rate (Q) and head (H)

Head, H (ft.)	Barrel Diameter (in.)													
	6	8	10	12	15	18	21	24	30	36	42	48	54	60
	Flow Rate, Q (cfs)													
1	0.33	0.70	1.25	1.98	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184
5	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343
15	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	299	378
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389
Length L (ft.)	Correction Factors for Pipe Lengths													
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11
40	1.28	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94

4. **Dewatering the Basin**--Automatic dewatering should be part of all sediment basins. While the top 60% of the pond's volume must dewater, the remaining sediment storage volume may remain as wet storage or be dewatered. Dewatering the sediment storage volume is often advantageous to the developer or contractor. Relatively dry material can be handled with on-site equipment rather than expensive draglines often needed to handle wet (un-dewatered) sediments. A standard design for each option is provided.

   Dewatering Option 1, 60% Drawdown--The riser shall have a dewatering orifice with trash guard located to dewater 60% of the pond's volume. This may be estimated as half the height of the riser. The orifice shall be sized to dewater 60% of the pond's volume in 48 to 72 hr. The following table may be used for sizing the dewatering orifice:

Sizing Dewatering Orifice	
Drainage Area to Sediment Basin (ac.)	Diameter of Orifice (in.)
5 - 10	1.5
10 - 20	2
20 - 35	2.5
35 - 55	3
55 - 75	3.5
75 - 100	4

   Dewatering Option 2, 100% Drawdown--The principal spillway riser or an additional riser shall be perforated with 1-in.-diameter holes on 4-in. horizontal and vertical spacing. The perforated riser shall be wrapped with wire mesh, then double wrapped with geotextile.

5. **Riser Base**--The principal spillway must be weighted to prevent flotation. The minimum factor of safety against flotation shall be 1.1. If concrete is used for the weighted riser base, the following formula may be used in calculating the required volume of concrete:

$$V = 0.62HD^2 - \frac{HW_R}{87.6}$$

Where: H = Height Riser (ft.)
D = Diameter Riser (ft.)
W_R = Weight Riser (lb./ft.)
V = Volume of Concrete ($ft.^3$)

6. **Trash Rack**--To prevent the riser from becoming clogged with straw or construction debris, a trash rack should be used. However, if conditions make clogging unlikely, a trash rack may not be necessary. Trash racks should be sized as follows:

Trash Rack Size (in.)		
Riser Diameter	Trash Rack Diameter	Trash Rack Height
15	21	7
18	27	8
21	30	11
24	36	13
27	42	15
36	54	17
42	60	19
48	72	21

7. **Anti-Seep Collars**--Anti-seep collars must be used on the barrel of the principal spillway.
   - Anti-seep collars must increase the seepage flow length by at least 15%.
   - Where more than one collar is used, they shall be spaced approximately 25 ft. apart.

   Anti-seep collars may not be needed if the embankment is less than 10 ft. and the barrel is 12 in. or smaller if made of corrugated metal pipe or 8 in. or smaller if made of smooth walled conduit.

8. **Outlet Protection**--The pipe barrel outlet must be stable and not cause erosion.

EMERGENCY SPILLWAY DESIGN CRITERIA

1. **Location**--Emergency spillways shall be constructed on undisturbed ground. It must not be constructed over the embankment.

2. **Capacity**--The emergency spillway shall have the capacity to pass at least 4 cfs/ac. of drainage area with a minimum freeboard of 1 ft. before overtopping the embankment. Accounting for the embankment settling 10%.

3. **Sizing Procedure**--Having determined the capacity Q, find the spillway width and stage required in the Capacity of Earth Spillways table. The stage is the difference between the pond surface and the crest of the emergency spillway.

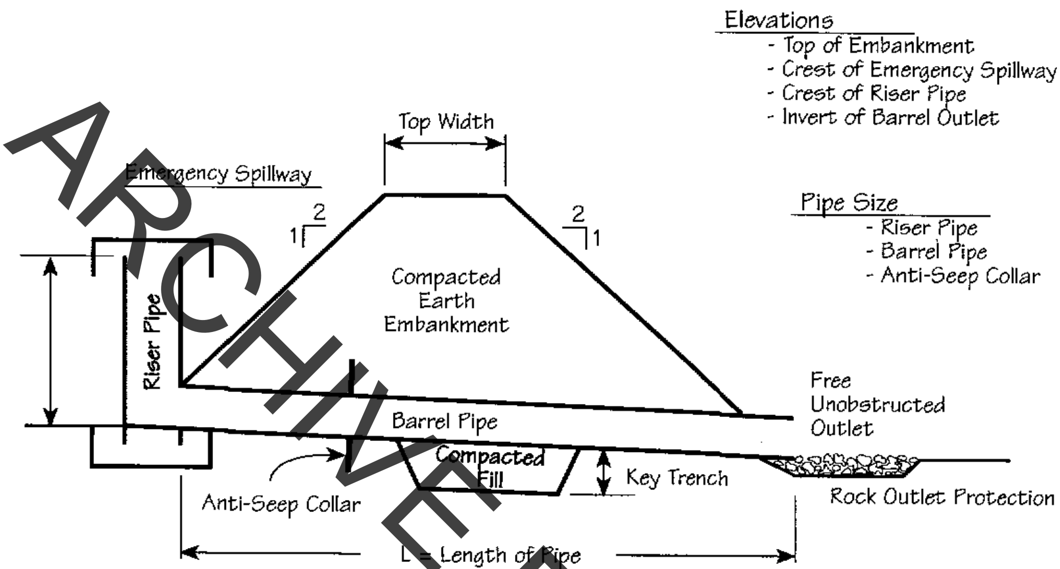
4. **Embankment Height**--Increase the height of the embankment if needed to maintain a minimum freeboard of 1 ft.

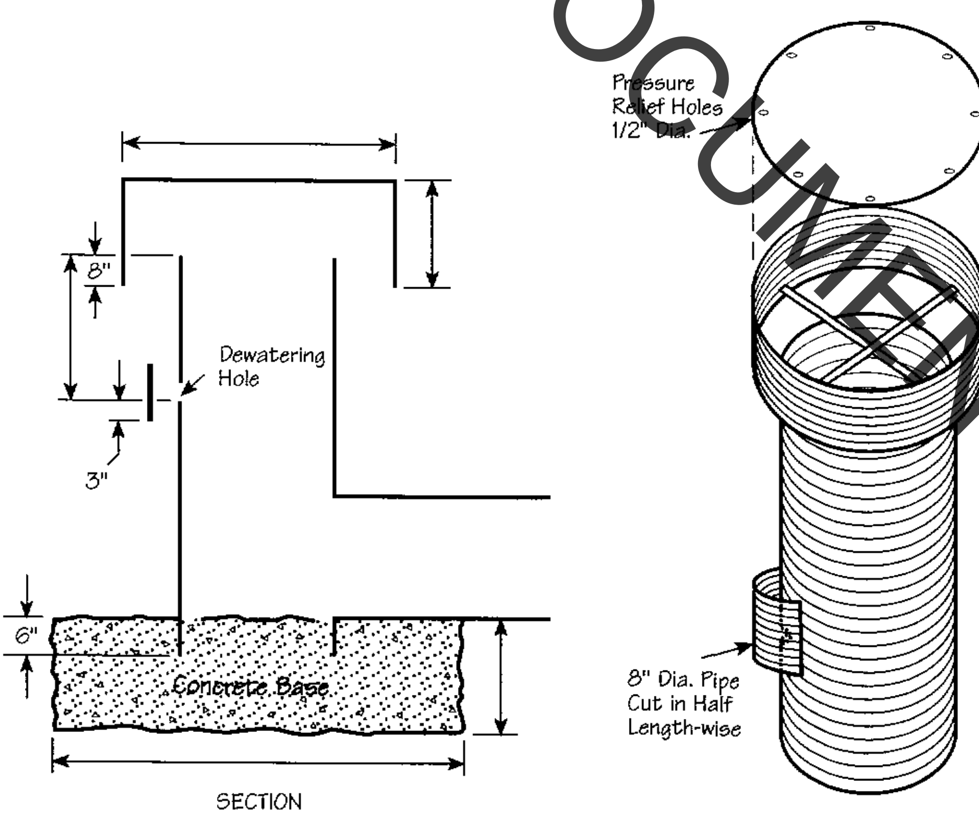
Capacity of Earth Spillways

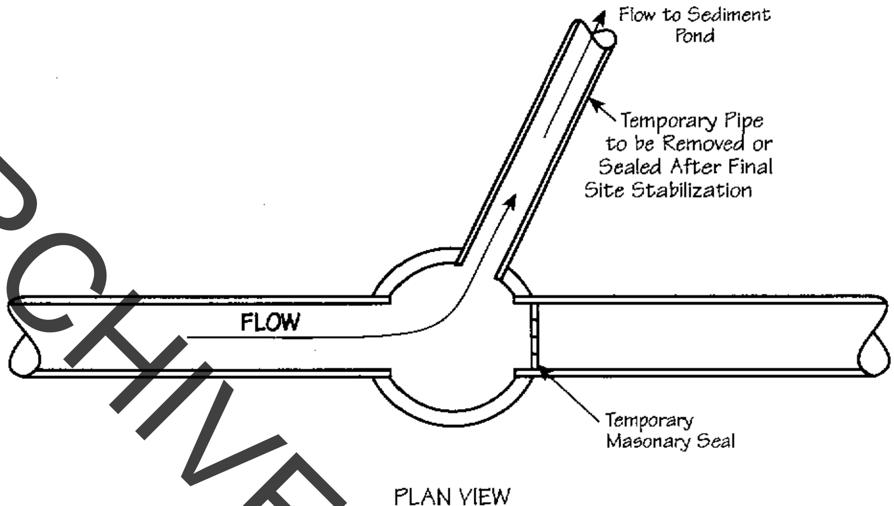
Stage (ft.)	Bottom Width (ft.)																
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	Flow Rate Q (cfs)																
0.5	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
0.6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
0.7	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
0.8	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
0.9	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
1.0	20	24	29	33	38	42	47	51	56	61	63	68	72	77	81	86	90
1.1	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
1.2	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
1.3	32	38	46	53	58	65	73	80	86	91	99	106	112	119	125	133	140
1.4	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
1.5	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	178
1.6	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	187	197
1.7	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
1.8	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
1.9	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
2.0	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
2.1	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
2.2	84	100	116	131	146	163	177	194	210	224	238	253	269	288	301	314	330
2.3	90	108	124	140	158	175	193	208	226	243	258	275	292	306	323	341	354
2.4	99	116	136	152	170	189	206	224	241	260	275	294	312	327	346	364	378

Note: The side slopes cut for the emergency spillway must be no steeper than 2:1.

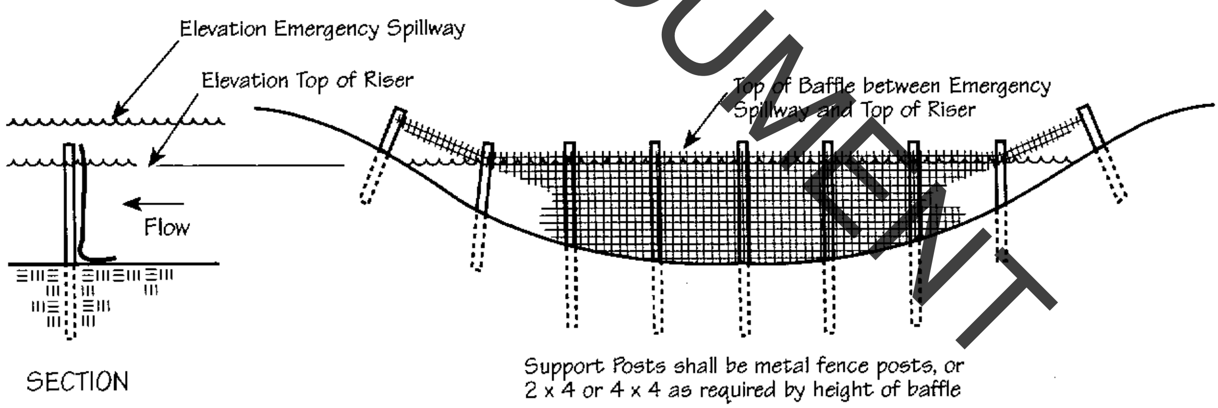
Specifications for Sediment Basins







Temporary Storm Drain Diversion



Baffle

Specifications
for
Sediment Basins

1. Sediment basins shall be constructed and operational before upslope land disturbance begins.

2. Site Preparation--The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared as needed to facilitate sediment cleanout. Gullies and sharp breaks shall be sloped to no steeper than 1:1. The surface of the foundation area will be thoroughly scarified before placement of the embankment material.

3. Cut-Off Trench--The cutoff trench shall be excavated along the centerline of the embankment. The minimum depth shall be 2 ft. unless specified deeper on the plans or as a result of site conditions. The minimum bottom width shall be 4 ft., but wide enough to permit operation of compaction equipment. The trench shall be kept free of standing water during backfill operations.

4. Embankment--The fill material shall be free of all sod, roots, frozen soil, stones over 6 in. in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately 6-in. horizontal layers or of such thickness that the required compaction can be obtained with the equipment used. Construction equipment shall be operated over each layer in a way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it. The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

5. Pipe Spillway--The pipe conduit barrel shall be placed on a firm foundation to the lines and grades shown on the plans. Connections between the riser and barrel, the anti-seep collars and barrel and all pipe joints shall be watertight. Selected backfill material shall be placed around the conduit in layers and each layer shall be compacted to at least the same density as the adjacent embankment. All compaction within 2 ft. of the pipe spillway will be accomplished with hand-operated tamping equipment.

6. Riser Pipe Base--The riser pipe shall be set a minimum of 6 in. in the concrete base.

7. Trash Racks--Both the top of the riser and the dewatering orifice shall be fitted with trash racks firmly fastened to the riser pipe.

8. Emergency Spillway--The emergency spillway shall be cut in undisturbed ground. Accurate construction of the spillway elevation and width is critical and shall be within a tolerance of 0.2 ft.

9. Seed and Mulch--The sediment basin shall be stabilized immediately following its construction. In no case shall the embankment or emergency spillway remain bare for more than 7 days.

10. Sediment Cleanout--Sediment shall be removed and the sediment basin restored to its original dimensions when the sediment has filled one-half the pond's original depth or as indicated on the plans. Sediment removed from the basin shall be placed so that it will not erode.

11. Final removal - Sediment basins shall be removed after the upstream drainage area is stabilized or as indicated in the plans. Dewatering and removal shall NOT cause sediment to be discharged. The sediment basin site and sediment removed from the basin shall be stabilized.

SEDIMENT TRAP

DESCRIPTION

Sediment traps are temporary settling ponds having a simple spillway outlet structure stabilized with geotextile and riprap.

CONDITIONS WHERE PRACTICE APPLIES

Sediment traps are used where the total contributing drainage area is less than 10 ac. If, however, a sediment trap does not have a dam, but its volume is achieved entirely through excavation, a larger drainage area may be allowed without compromising the stability of the sediment trap. (Also see Specifications for Sediment Basins.)

Planning Considerations

Sediment traps are one of the most useful and cost-effective measures for treating sediment-laden runoff. Sediment traps usually are placed near the edge of construction-sites, out of the way of most construction activity. They have relatively good sediment-trapping efficiencies (50-80%) and require little maintenance compared to other practices used to treat sediment-laden runoff.

Timing--Sediment traps, along with other sediment-control practices, must be constructed as a first step in any land-disturbing activity. They must be functional before upslope land disturbance takes place.

Location:

Construction Phases--Sediment traps should be placed so they function through all phases of the site's development, both before and after new drainage systems are constructed.

Diverting Runoff--Temporary diversions at the perimeter of sites often are used to direct runoff to sediment traps (see Temporary Diversion Specifications).

Below Storm Drains--Sediment traps may be placed in drainageways or beyond the ends of proposed storm-sewer systems.

Storm-Sewer Diversions--Storm drains may also be temporarily redirected through sediment traps during construction. After construction, the detours are removed and runoff is allowed to flow through the permanent storm drain as originally intended.

Utilities--Give special consideration to sediment trap location and possible interference with construction of proposed drainageways, utilities and storm drains.

Design Criteria

Sediment Trap Size--The volume of a sediment trap must be 67 cy/ac. of total contributing drainage area. The volume must be measured from below the crest elevation of the outlet. The total volume of the ponding area may be achieved by a combination of excavating and/or a compacted embankment.

Embankment--Embankments for sediment traps must not exceed 5 ft. in height. The top width of embankments must be at least 4-ft.-wide and side slopes 2:1 or flatter. The embankment must be compacted by traversing with heavy equipment while it is being constructed.

Excavation--Excavated side slopes must not exceed 2:1 unless a safety fence is constructed around the ponding area. When filled with muddy water, an excavated pond's depth is often unpredictable and deep; consequently, a safety fence is recommended during construction on all temporary ponds where excavation is used to achieve storage requirements.

Shape--It is recommended that the designer of a sediment trap strive to incorporate the following features to increase sediment-trapping efficiencies:

- Length-to-width ratio greater than 2:1, where length is the distance between the inlet and outlet,
- A wedge shape with the inlet located at the narrow end,
- Shallow depth and maximum surface area.

Outlet Width:

Sediment Trap Outlet Sizing	
Drainage Area (ac.)	Spillway Width (ft.)
< 2	4
2 - 5	8
5 - 10	12
The sediment trap's embankment must be at least 1.5 ft. above the outlet crest.	

Temporary Storm-Drain Diversion--To redirect a storm drain so that it may temporarily discharge into a sediment trap, an "in-line" diversion at an inlet or manhole may be used. This is achieved by installing a pipe stub in the side of a manhole or inlet and temporarily blocking the permanent outfall pipe from that structure. A temporary outfall ditch or pipe may be used to convey storm flow from the stub to a sediment trap or basin. This method may be used just above a permanent outfall or prior to connecting into an existing storm drain system.

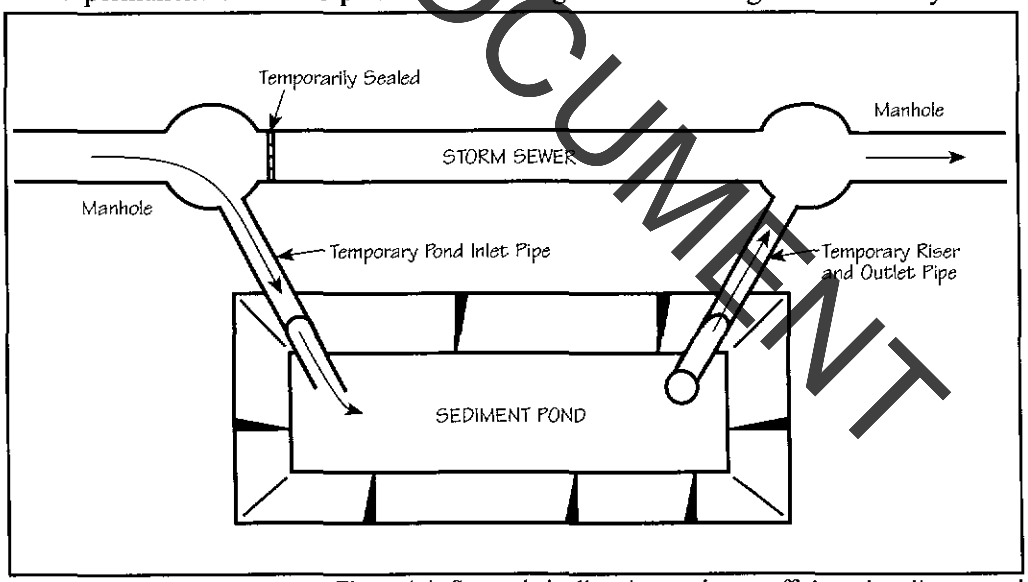


Figure 4-4 Storm drain diversion routing runoff through sediment pond

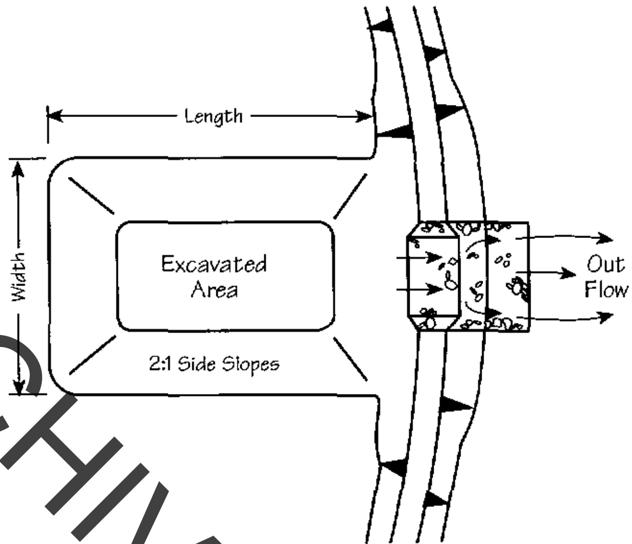
Another option is to delay completion of the permanent storm drain outfall and temporarily divert storm flow into a sediment trap. The trap should be constructed to one side of the proposed permanent storm drain where possible.

Types of Sediment Traps--There are a variety of sediment trap designs. Generally any pond with sufficient storage volume and detention time can be an acceptable sediment trap providing it has a stable outlet structure. One of the most reliable types of outlets is a simple spillway outlet stabilized with geotextile and riprap. Another common design is an excavated sediment trap where the entire required storage volume is achieved by excavation, water is released by simply overflowing to the surrounding ground. If an excavated sediment trap's stability can be demonstrated to the plan approving authority, there is no limit to the size of contributing drainage area.

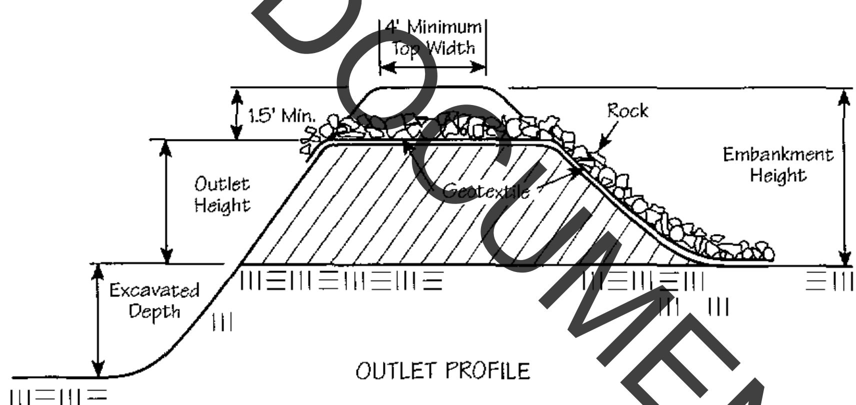
Dewatering Sediment Traps--The standard sediment trap design may be modified to allow partial dewatering between rainfall events. However, designs must not allow rapid dewatering which can severely limit trapping efficiency. Drawdown should take at least 24 hr.

Maintenance--To maintain adequate detention volume and settling efficiency, sediment traps will likely require sediment cleanout one or more times during construction. Sediment cleanout should prevent sediment from ever occupying more than 40% of the pond's volume. Due to the pond's sloping sides, 40% of the pond's volume can be conservatively estimated as one-half the pond's total depth. When sediment is removed, the sediment trap should be restored to its original dimensions. Removed sediment must be deposited in a suitable area and in such a manner that it will not erode.

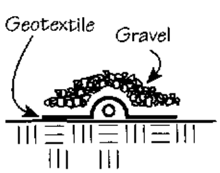
Specifications
for
Sediment Traps



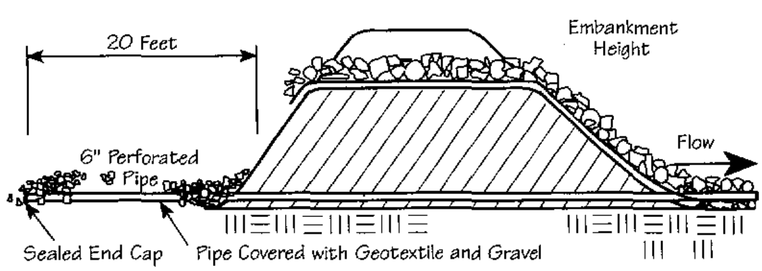
PLAN VIEW



OUTLET PROFILE



DEWATERING PIPE
SECTION



OUTLET PROFILE

Specifications
for
Sediment Traps

1. Sediment traps shall be constructed and operational before upslope land disturbance begins.

2. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared as needed to facilitate sediment cleanout.

3. Fill material used for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Maximum height of the embankment shall be 5 ft. as measured from the surrounding ground.

4. Cut-and-fill slopes shall be 2:1 or flatter.

5. Dikes directing water to the trap shall be higher than the height of the embankment.

6. Temporary seeding shall be established on all nonsubmerged areas of the sediment trap.

7. The storage volume shall be achieved to the dimensions shown in the plans to achieve 67 cy of storage volume below the crest of the outlet for every acre of contributing drainage area.

8. The outlet spillway shall be constructed to the dimensions shown in the plans.

9. Geotextile shall be placed over the bottom and slopes of the outlet spillway. Geotextile shall continue downstream of the embankment to form an apron on the surrounding ground. To prevent runoff from flowing under the geotextile, the sections placed nearest the front shall overlap following sections. Sections of geotextile shall overlap at least 2 ft.

10. Rock used in the outlet spillway shall be placed 1 ft. thick on the geotextile. The rock shall be between Type C and Type D rock where D_{50} is about 8 in.

11. Sediment shall be removed and the sediment trap restored to its original dimensions when the sediment has filled one-half the pond's original depth. Removed sediment shall be spread in a suitable area and stabilized so it will not erode.

12. The structure and accumulated sediment shall be permanently stabilized when the drainage area has been stabilized.

Silt Fence

Description

Silt fence is a sediment-trapping practice utilizing a geotextile fence, topography and vegetation to cause sediment deposition. Silt fence reduces runoff's ability to transport sediment by ponding runoff and dissipating small rills of concentrated flow into uniform sheet flow.

Conditions Where Practice Applies

Silt fence is used where runoff occurs as sheet flow or where flow through small rills can be converted to sheet flow. Silt fence cannot effectively treat flows in gullies, ditches or channels. For more severe conditions see specifications for temporary diversions, sediment traps and sediment basins.

Planning Considerations

Silt Fence vs. Temporary Diversions and Settling Ponds--To treat sheet flow runoff, silt fence is used or diversions are constructed to direct runoff to a sediment pond. Silt fence is most applicable for relatively small areas with flat topography. Silt fence also requires less space and causes less disturbance. A system of diversions and settling ponds, on the other hand, has greater integrity. Compared to silt fence, they can handle much greater flows and are more durable and easier to construct correctly. As a result, earth diversions and settling ponds generally are recommended over silt fence.

Design Criteria

Silt fence as a sediment control practice consists not only of the fence itself but, just as importantly, it entails topography. This is a critical consideration because the sediment removal process relies on deposition not filtering, as often assumed. Silt fence works by dispersing flow, ponding runoff and releasing diffuse flow. However, if silt fence is used without regard to a site's topography, it will typically concentrate runoff, increasing its ability to transport sediment rather than causing deposition.

Level Contour--For silt fence to enhance deposition, it must be placed on the level contour of the land so that flows are dissipated into uniform sheet flow, which has little energy for transporting sediment. Silt fence should never concentrate runoff, which will result if it is placed up and down slopes rather than on the level contour.

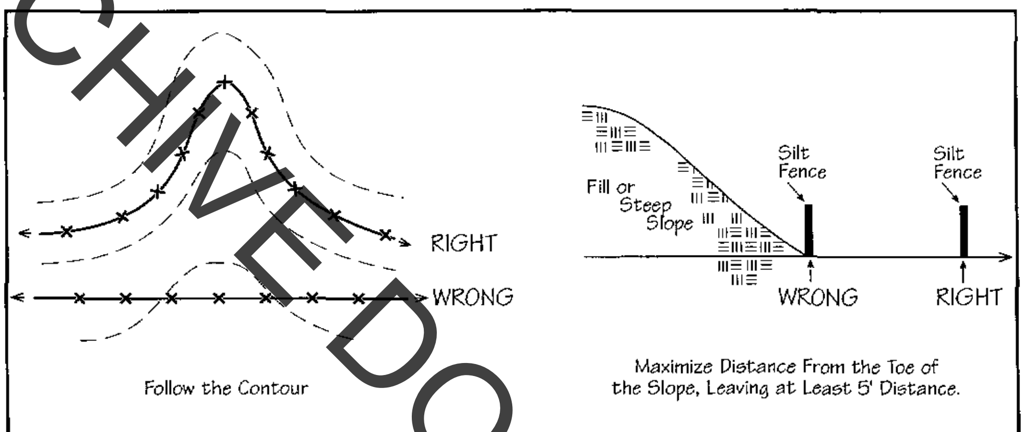


Figure 4-5 Silt fence layout

Flat Slopes--Silt fence must also be used on the flattest areas available. Because of the great importance slope has on water's ability to transport sediment, silt fence should never be placed directly at the toe of a slope if it is at all possible to place it several feet away. Silt fence generally should be placed on the flattest area available to increase the shallow ponding of runoff and maximize space available for deposited sediment.

Flow Around Ends--To prevent water ponded by the silt fence from flowing around the ends, each end must be constructed upslope so that the ends are at a higher elevation.

Vegetation--Dense vegetation also has the effect of dissipating flow energies and causing sediment deposition. Sediment-trapping efficiency will be enhanced where a dense stand of vegetation occurs for several feet both behind and in front of a silt fence.

Drainage Area:

Silt Fence Maximum Drainage Area Based on Slope and Slope Length		
Slope		Slope Length (ft.)
0% - 2%	Flatter than 50:1	250
2% - 10%	50:1 - 10:1	125
10% - 20%	10:1 - 5:1	100
20% - 33%	5:1 - 3:1	75
33% - 50%	3:1 - 2:1	50
> 50%	> 2:1	25

Note: For larger drainage areas, see standards for temporary diversions, sediment traps and sediment basins.

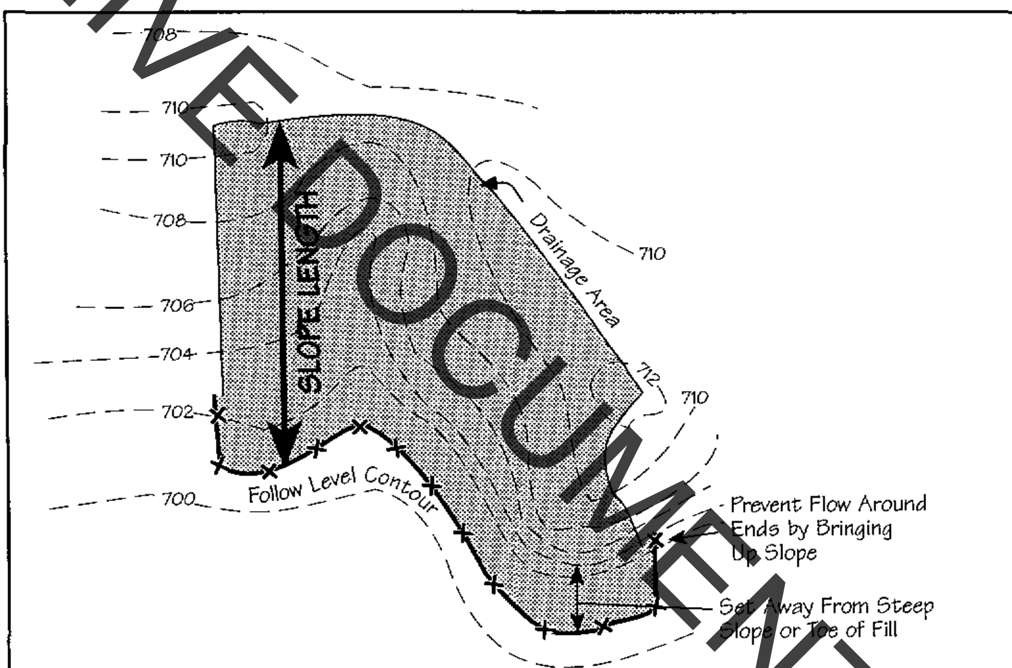
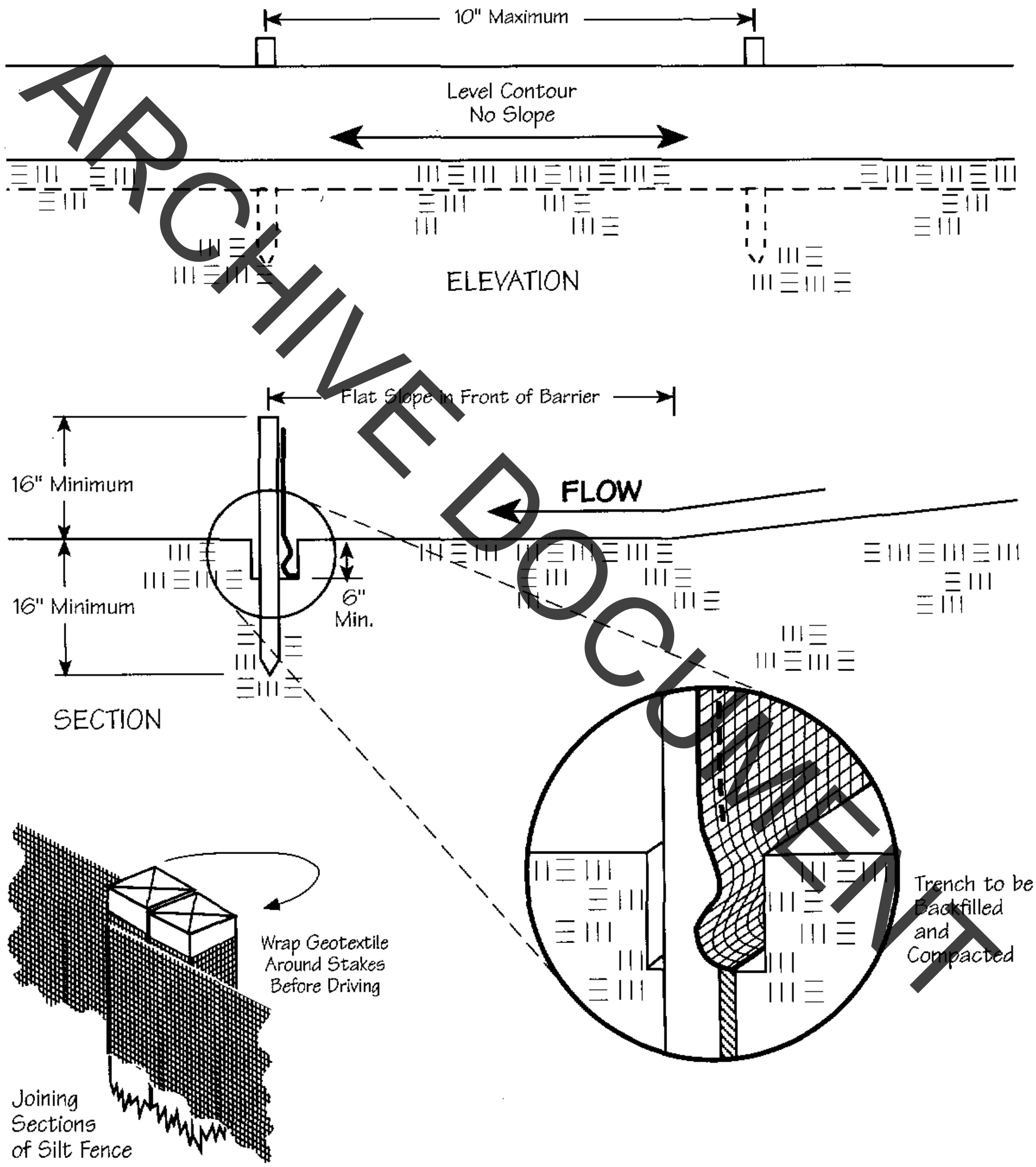


Figure 4-6 Silt fence and allowable drainage area

Dispersing Flow--Proper applications of silt fence will allow all the intercepted runoff to pass as diffused flow through the geotextile. Runoff should never overtop silt fence, flow around the ends, or in any other way flow as concentrated flow from the practice. If this does occur, maintenance, alternative silt fence layout, or other practices are needed.

Specifications for Silt Fence



Specifications
for
Silt Fence

1. Silt fence shall be constructed before upslope land disturbance begins.

2. All silt fence shall be placed as close to the contour as possible so that water will not concentrate at low points in the fence and so that small swales or depressions which may carry small concentrated flows to the silt fence are dissipated along its length.

3. To prevent water ponded by the silt fence from flowing around the ends, each end shall be constructed upslope so that the ends are at a higher elevation.

4. Where possible, silt fence shall be placed on the flattest area available.

5. Where possible, vegetation shall be preserved for 5 ft. (or as much as possible) upslope from the silt fence. If vegetation is removed, it shall be reestablished within 7 days from the installation of the silt fence.

6. The height of the silt fence shall be a minimum of 16 in. above the original ground surface.

7. The silt fence shall be placed in a trench cut a minimum of 6 in. deep. The trench shall be cut with a trencher, cable laying machine, or other suitable device which will ensure an adequately uniform trench depth.

8. The silt fence shall be placed with the stakes on the downslope side of the geotextile and so that 8 in. of cloth are below the ground surface. Excess material shall lay on the bottom of the 6-in.-deep trench. The trench shall be backfilled and compacted.

9. Seams between section of silt fence shall be overlapped with the end stakes of each section wrapped together before driving into the ground.

10. Maintenance--Silt fence shall allow runoff to pass only as diffuse flow through the geotextile. If runoff overtops the silt fence, flows under or around the ends, or in any other way becomes a concentrated flow, one of the following shall be performed, as appropriate: 1) The layout of the silt fence shall be changed, 2) Accumulated sediment shall be removed, or 3) Other practices shall be installed.

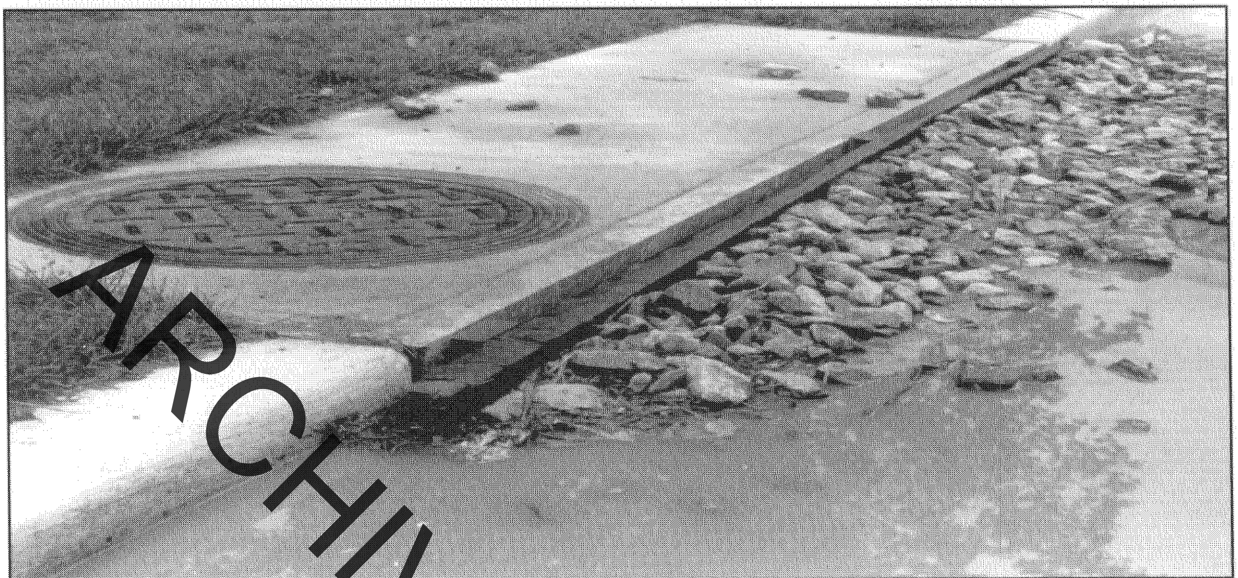
Criteria for Silt Fence Materials

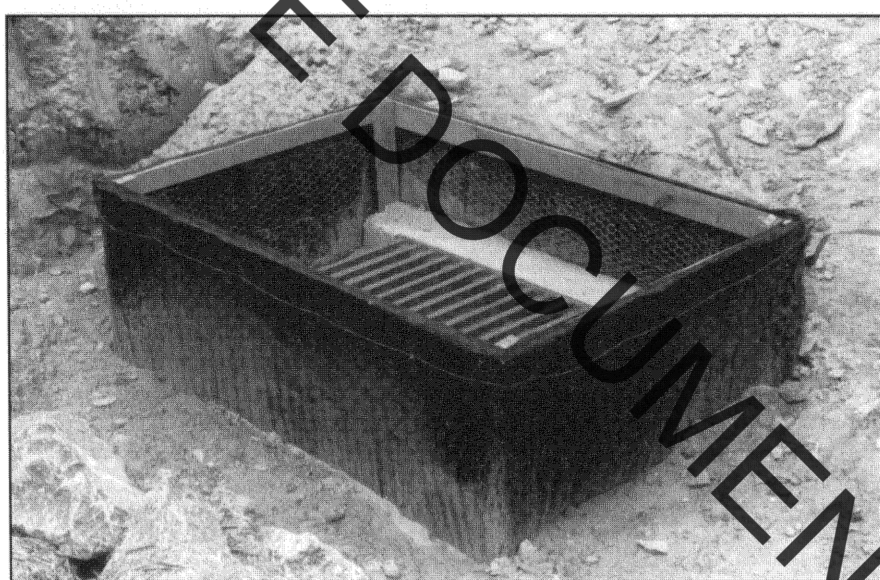
1. Fence Posts--The length shall be a minimum of 32 in. long. Wood posts will be 2-by-2-in. hardwood of sound quality. The maximum spacing between posts shall be 10 ft.

2. Silt Fence Fabric shall be ODOT Type C Geotextile Fabric or as described by the chart below:

Fabric Properties	
Minimum Tensile Strength	120 lbs.
Maximum Elongation at 60 lbs	50%
Minimum Puncture Strength	50 lbs.
Minimum Tear Strength	40 lbs.
Minimum Burst Strength	200 psi
Apparent Opening Size	≤ 0.84mm
Minimum Permittivity	$1X10^{-2}$ sec.$^{-1}$
Ultraviolet Exposure Strength Retention	70%

Storm Drain Inlet Protection





Description

Storm drain inlet protection consists of a geotextile barrier supported around or across a storm drain inlet. It is used to prevent sediment-laden water from entering a storm drain system. It reduces the rate at which sediment-laden water may enter an inlet thereby causing ponding and settling of sediment.

Conditions Where Practice Applies and Planning Considerations

This practice is not generally recommended as a primary means of sediment control. It should only be used if it is not possible to temporarily divert the storm drain outfall into a sediment trap or sediment basin or if it is to be used only for a short period of time during the construction process.

Inlet protection in effect blocks storm drain inlets. The result that blocking storm drain inlets will have on the site's drainage must be considered. Long sloping streets or ditches designed with several inlets along their length may have a significant amount of surface flow accumulate if inlet protection is used. In low areas, a pond will form around inlets. Ponding is necessary for removing sediment from runoff and should be encouraged in conjunction with inlet protection.

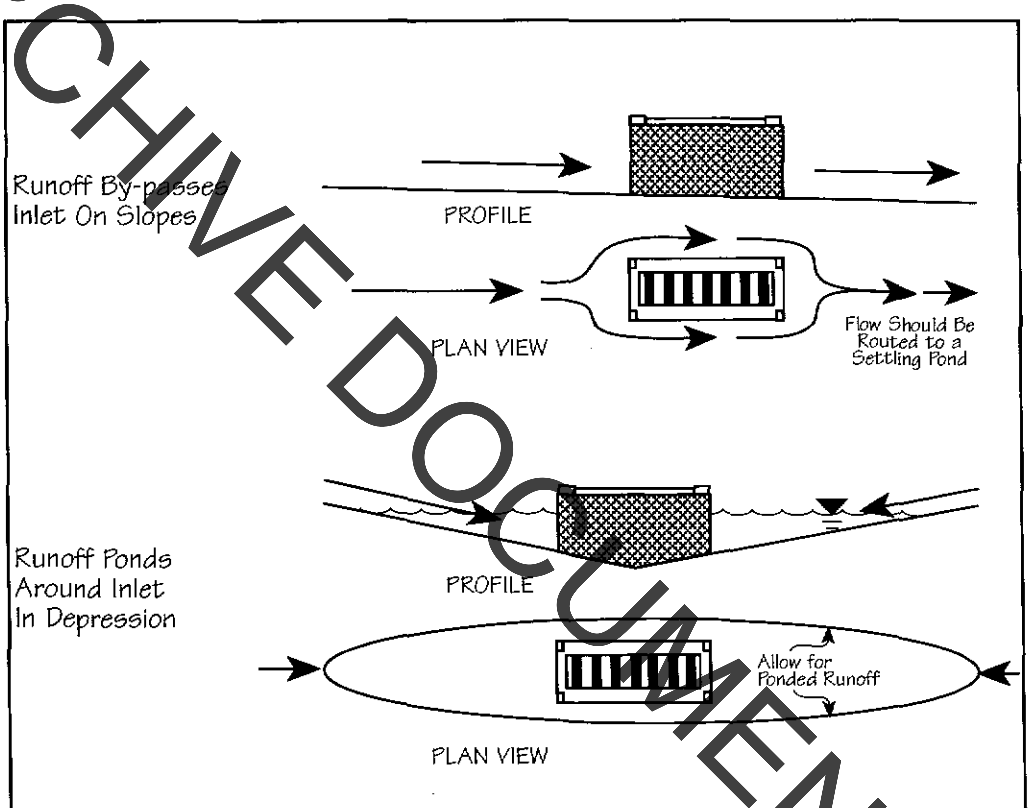
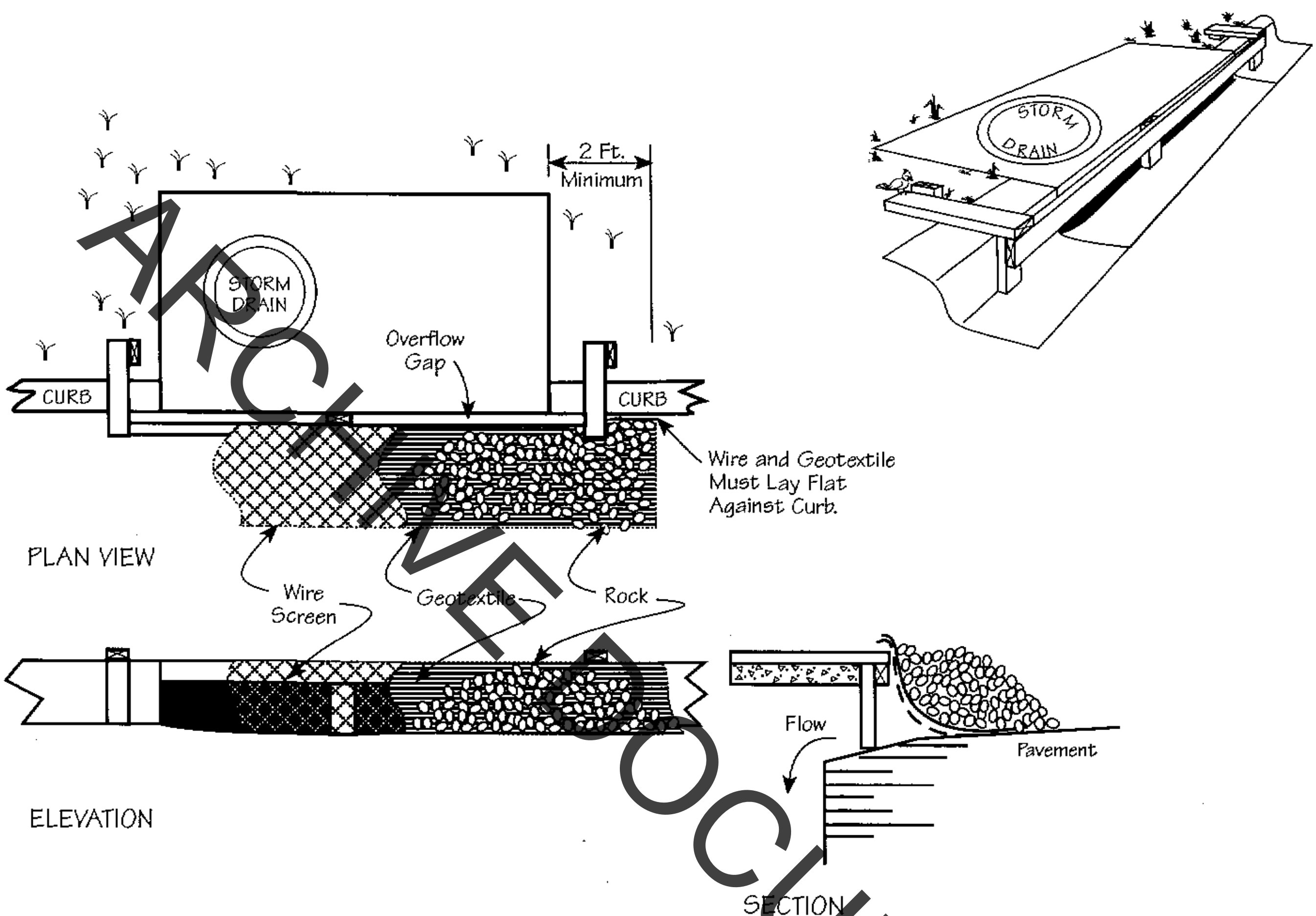


Figure 4-7 Effect of inlet protection on slopes and in depressions

Specifications
for
Curb Inlet Protection



1. Inlet protection shall be constructed either before upslope land disturbance begins or before the storm drain becomes operational.

2. The wooden frame is to be constructed of 2-by-4-in. construction-grade lumber. The end spacers shall be a minimum of 1 ft. beyond both ends of the throat opening. The anchors shall be nailed to 2-by-4-in. stakes driven on the opposite side of the curb.

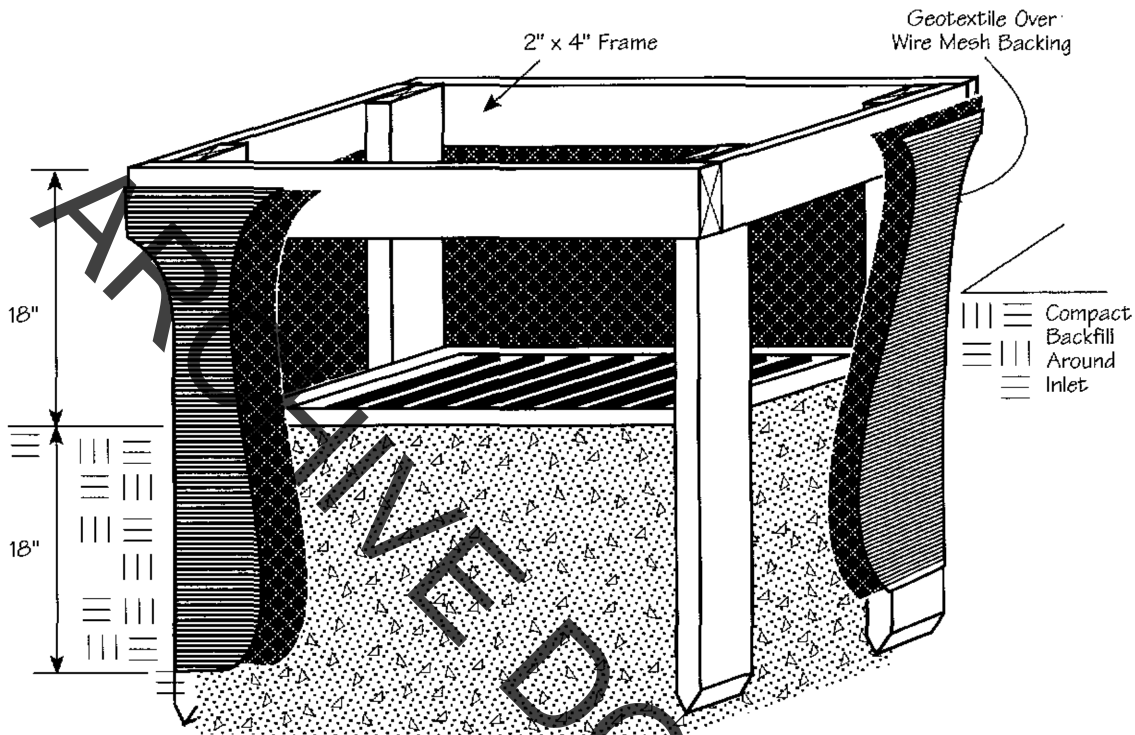
3. The wire mesh shall be of sufficient strength to support fabric and stone. It shall be a continuous piece with a minimum width of 30 in. and 4 ft. longer than the throat length of the inlet, 2 ft. on each side.

4. Geotextile cloth shall have an equivalent opening size (EOS) of 20-40 sieve and be resistant to sunlight. It shall be at least the same size as the wire mesh.

5. The wire mesh and geotextile cloth shall be formed to the concrete gutter and against the face of the curb on both sides of the inlet and securely fastened to the 2-by-4-in. frame.

6. Two-inch stone shall be placed over the wire mesh and geotextile in such a manner as to prevent water from entering the inlet under or around the geotextile cloth.

Specifications
for
Inlet Protection in Swales, Ditch Lines or Yard Inlets



1. Inlet protection shall be constructed either before upslope land disturbance begins or before the storm drain becomes operational.

2. The earth around the inlet shall be excavated completely to a depth at least 18 in.

3. The wooden frame shall be constructed of 2-by-4-in. construction-grade lumber. The 2-by-4-in. posts shall be driven 1 ft. into the ground at four corners of the inlet and the top portion of 2-by-4-in. frame assembled using the overlap joint shown. The top of the frame shall be at least 6 in. below adjacent roads if ponded water would pose a safety hazard to traffic.

4. Wire mesh shall be of sufficient strength to support fabric with water fully impounded against it. It shall be stretched tightly around the frame and fastened securely to the frame.

5. Geotextile shall have an equivalent opening size of 20-40 sieve and be resistant to sunlight. It shall be stretched tightly around the frame and fastened securely. It shall extend from the top of the frame to 18 in. below the inlet notch elevation. The geotextile shall overlap across one side of the inlet so the ends of the cloth are not fastened to the same post.

6. Backfill shall be placed around the inlet in compacted 6-in. layers until the earth is even with notch elevation on ends and top elevation on sides.

7. A compacted earth dike or a check dam shall be constructed in the ditch line below the inlet if the inlet is not in a depression and if runoff bypassing the inlet will not flow to a settling pond. The top of earth dikes shall be at least 6 in. higher than the top of the frame.

Temporary Modifications to Permanent Ponds

Description

Permanent stormwater management ponds may be used for temporary sediment control during construction. Temporary modifications to the outlet of permanent ponds are usually required for suitable sediment trapping efficiency.

Conditions Where Practice Applies

Most permanent stormwater management ponds may be used for temporary sediment control with temporary modifications. However, constraints on the timing of construction operations often restrict their feasibility as a temporary sediment control practice. Like all sediment control practices, sediment ponds must be installed and operational before upslope earthwork begins. Since permanent stormwater ponds do not typically become functional until later in the development process, provisions must be made to have the permanent pond constructed sooner than would otherwise be the case, or other sediment control practices must be operational until the permanent pond is constructed.

Planning Considerations

- The pond's drainage area should consist mostly of the construction-site itself. Significant amounts of off-site runoff should not be routed though any settling pond. Off-site runoff must be considered in the sizing of the pond's storage volume and may necessitate that smaller temporary ponds be constructed which catch only on-site runoff.
- The phasing of operations must permit the pond to be constructed and operational prior to disturbance of the site area contributing runoff to the pond.
- The pond must be accessible for sediment cleanout after the rest of the site has been stabilized. An area must also be set aside for dredged sediment disposal.

Design Criteria

Permanent ponds are beyond the scope of these standards. The embankment and spillways must be designed by a qualified professional using accepted engineering methods. The temporary modifications for sediment control during construction must meet the following design criteria.

Design Approaches--Because of the diversity of outlet structures used in permanent ponds, standard modification designs are not possible. Some design concepts include:

- Dry detention basins have little to no sediment trapping capacity and must be modified. A temporary riser pipe similar to a sediment basin's riser pipe often works.
- Outlet structures of stormwater ponds which will have a permanent pool should be constructed with a temporary dewatering orifice or a separate dewatering riser.
- For small watersheds, a sediment trap may be constructed within a stormwater pond. Using a separate embankment and outlet prevents interference with the permanent outlet.

Procedures--In addition to the design criteria presented here, appendix A has design procedures which may be used to meet these requirements. Other accepted engineering design procedures may also be used to meet the design criteria. Runoff must be computed by accepted engineering methods such as the Rational Method, NRCS TR-55, or those outlined in Chapter 2, Estimating Runoff, "Engineering Field Handbook for Conservation Practices," NRCS.

POOL DESIGN CRITERIA:

Volume--The minimum total volume shall be 67 cy (0.04 ac.-ft.) for each acre of drainage area. This volume is measured below the top of the principal spillway's outlet elevation. The drainage area includes the entire area contributing runoff to the pond, off-site as well as on-site.

Sediment Volume--The pond will be cleaned out before sediment accumulation reduces the volume to 40 cy/ac. The cleanout elevation must be clearly marked on the riser. The pond may be oversized to accommodate estimated sediment accumulation thereby avoiding the need for cleanout at the end of construction. The following sediment accumulation volume is recommended:

Estimating Annual Sediment Volume	
Average Slope of Disturbed Area	Volume of Sediment Per Acre of Disturbed Area (cy)
< 6%	20
10%	45
14%	75
18%	120
Note: It is assumed that erosion control practices will be used.	

Porous Baffles--If individual situations require greater trapping efficiency or if optimum depth and length-to-width ratios are not feasible, baffles may be incorporated into the design. Baffles shall be constructed to partition the basin into two or three cells. Baffles shall be porous, constructed of jute matting, rock, plastic safety fence, or other material that will dampen turbulent currents within the pool. Baffle height shall be greater than the principal spillway and less than the emergency spillway.

PRINCIPAL SPILLWAY DESIGN CRITERIA--The principal spillway including all temporary modifications must meet the following:

- The principal spillway must pass at least 0.2 cfs/ac. of drainage area when the water surface is at the emergency spillway crest elevation.

- Temporary riser pipes must be a minimum of 1 ft. below the elevation of the emergency spillway.

- **Dewatering**--Automatic dewatering should be part of the pond design during site construction. While the top 60% of the pond's volume must dewater, the remaining sediment storage volume may remain as wet storage or be dewatered.

Dewatering Option 1, 60% Drawdown--The riser shall have one or more dewatering holes. They shall be located to dewater 60% of the pond's volume. They shall be sized to dewater this volume in 72 hr. The following equation may be used to determine the area of the dewatering hole(s).

$$A_o = \frac{A_s(2h)^{1/2}}{20{,}400 \times T \times C_d}$$

Where: A_o = surface area of the outlet (ft.^{2})
A_s = surface area of the basin (ft.^{2})
h = head of water above dewatering outlet
T = dewatering time = 72 hr.
C_d = coefficient of contraction for the outlet = 0.6 for sharp edged orifices

Dewatering Option 2, 100% Drawdown--The principal spillway riser or an additional temporary riser shall be perforated with 1-in.-diameter holes on 4-in. horizontal and vertical spacing. The perforated riser shall be wrapped with wire mesh, then double wrapped with geotextile.

Riser Base--Temporary risers must be weighted to prevent flotation. The minimum factor of safety against flotation shall be 1.1. Where concrete is used for the weighted riser base, the following formula may be used in calculating the required volume of concrete:

$$V = 0.62HD^2 - \frac{HW_R}{87.6}$$

Where: H = Height Riser (ft.)
D = Diameter Riser (ft.)
W_R = Weight Riser (lb./ft.)
V = Volume of Concrete (ft.^{3})

Specifications
for

Temporary Modifications to Stormwater Ponds Used for Sediment Control During Construction

NOTE: SEE THE SPECIFICATIONS FOR SEDIMENT BASINS AND SEDIMENT TRAPS.

1. The stormwater pond shall be constructed and all temporary sediment control modifications shall be operational before upslope land disturbance begins.

2. The pond shall be stabilized immediately following its construction. In no case shall the embankment or emergency spillway remain bare for more than 7 days.

3. During site construction, sediment shall be removed when the sediment has filled one-half the pond's original depth or as indicated on the plans.

4. Final removal - Temporary structures or modifications used for sediment control during construction shall be removed only after the upstream drainage area is stabilized or as indicated in the plans. Dewatering and removal shall NOT cause sediment to be discharged.

5. Sediment shall be removed as needed to achieve the design depth and dimensions of the permanent pond.

Chapter 5

Temporary Runoff Control

Check Dam

Description

Check dams are small rock dams constructed in swales, grassed waterways or diversions. They reduce the velocity of concentrated flows, thereby reducing erosion within the swale or waterway. While this practice often traps some sediment, its trapping efficiency is extremely poor, thus, it should not be used as a sediment-trapping practice.

Conditions Where Practice Applies

This practice is limited to use in small open channels where it is necessary to slow the velocity of flows in order to prevent erosion. Applications include temporary swales which, because of their short length of service, are not practical to receive a nonerodible lining or swales which need protection during the establishment of grass linings. See specifications for Rock Check and Gravel Riffle for larger channels and streams.

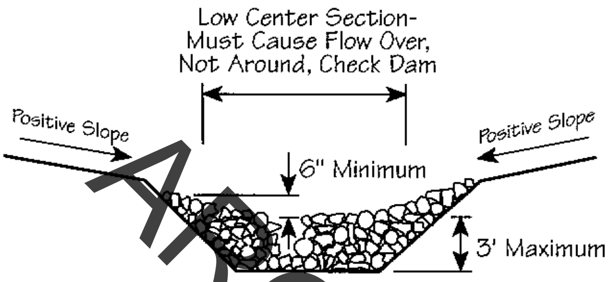
Design Criteria

Design Limits--Check dams must not be relied upon to remove sediment from runoff flowing through a channel but rather are used to reduce erosion of the channel itself. However, innovative applications may produce effective ponding areas behind check dam or silt fence structures adequate to trap sediment from sites with very little slope and very little drainage area, less than 2% slope and less than 2 ac. drainage area.

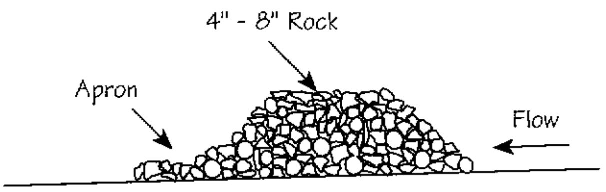
Size Spacing--Individual check dam location should be designed and shown on erosion-control plans. For design guidelines see the following specifications.

Splash Apron--Where check dams are expected to be in use for an extended period of time, a stone apron may be constructed immediately downstream of the check dam to prevent flows from undercutting the structure. The apron should be 6 in. thick and its length two times the height of the dam.

Specifications
for
Check Dam



CROSS SECTION



PROFILE

1. The check dam shall be constructed of 4-8-in.-diameter stone, placed so that it completely covers the width of the channel.

2. The top of the check dam shall be constructed so that the center is approximately 6 in. lower than the outer edges, so water will flow across the center and not around the ends.

3. The maximum height of the check dam at the center of the weir shall not exceed 3 ft.

4. Spacing between dams shall be as shown in the plans or by the following table:

Check Dam Spacing				
Dam Height (ft.)	Channel Slope			
	< 5%	5 - 10%	10 - 15%	15 - 20%
1	65 ft.	30 ft.	20 ft.	15 ft.
2	130 ft.	65 ft.	40 ft.	30 ft.
3	200 ft.	100 ft.	65 ft.	50 ft.

Slope Drain

Description

A temporary slope drain is a pipe or chute placed on a slope to convey surface runoff downslope without causing erosion. It's usually utilized with a diversion constructed to direct runoff away from the steep slope to the inlet of the slope drain.

Conditions Where Practice Applies

Temporary slope drains are used on a steep erosive slope where runoff is collected to prevent erosion and must be conveyed down the slope. This practice is especially useful on road construction or other long fills. This practice may be necessary if runoff cannot easily be directed to the ends of a section of fill. The maximum allowable drainage area for this specification is 5 ac.

DESIGN CRITERIA

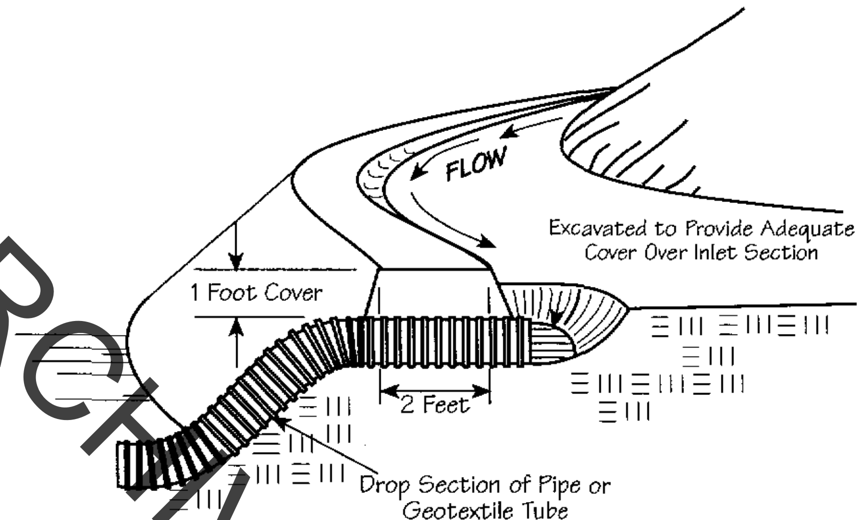
The drop section of the structure may consist of corrugated metal or plastic pipe or flexible tubing made of geotextile.

The size of a slope drain, both inlet and drop sections, should meet the following:

Size of Pipe and Flexible Tubing	
Diameter (in.)	Maximum Drainage Area (ac.)
12	0.5
18	1.5
21	2.5
24	3.5
30	5.0

Outlet--The slope drain must outlet into a sediment trapping device when its drainage area is disturbed. Where clean water is being discharged, it should be discharged to a stabilized vegetated area.

Specifications
for
Slope Drain



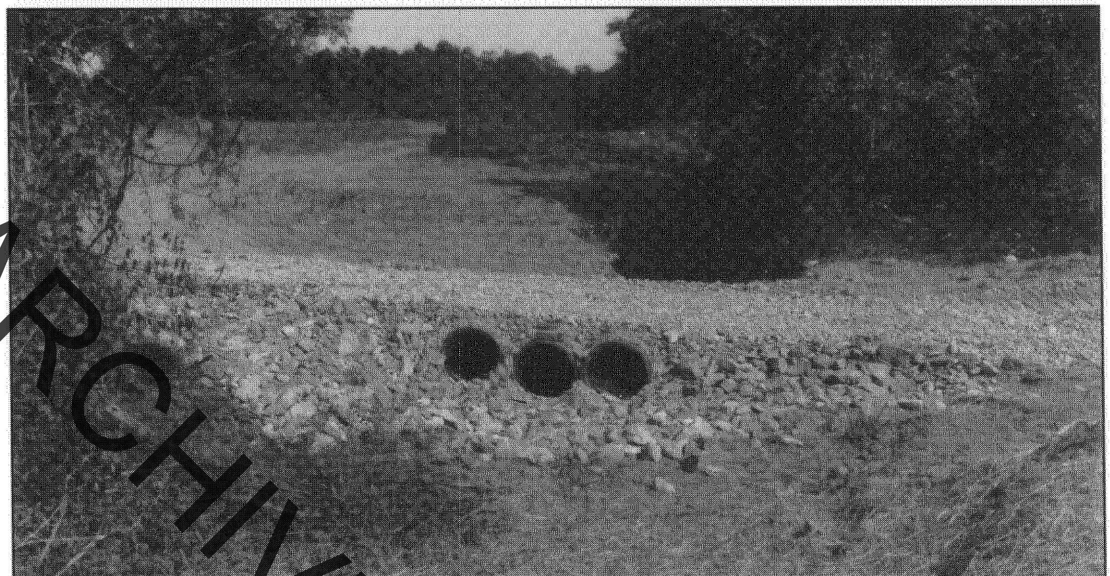
1. The slope drain may be constructed entirely of corrugated metal or plastic pipe or with a rigid pipe at the top of the slope and geotextile tubing anchored to the slope.

2. If geotextile tubing is used for the drop section, it shall be the same diameter as the inlet pipe and shall be constructed of a durable material, securely fastened to the inlet pipe with metal strapping or watertight connection collars and secured with hold-down grommets spaced on 10-ft. centers.

3. The diversions directing runoff to the drop structure shall be at least 1 ft. higher than the top of the slope drain's inlet. This includes soil placed around and over the top of the inlet section. To help accomplish this the invert of the inlet may be set lower than the top of fill.

4. The soil around and under the inlet pipe shall be placed in 4-in. layers and hand compacted to the top of the earth dike or gravel bedding shall be used with ODOT type C riprap placed at the outlet side of the embankment.

Stream Crossing



Description

A stream crossing provides construction traffic temporary access across a stream while reduceing the amount of disturbance and sediment pollution. It is a temporary practice which includes restoring the crossing area after construction. Specifications for three typical kinds of stream crossings are provided: bridges, culverts and fords. Each has specific applications and each is designed to minimize stream damage by leaving banks stable and vegetated and adding only coarse stone fill to the channel.

Planning Considerations

A stream and its entire riparian area should be left undisturbed to the greatest extent feasible. However where construction equipment must cross a stream channel, a temporary stream crossing is necessary. The temporary nature of stream crossings should be stressed. These structures create a channel constriction which can cause flow backups or washouts during periods of high flow. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

The specifications contained in this practice pertain primarily to the environmental impacts of stream crossings. From a safety and utility standpoint, the designer must also be sure that bridge spans, if used, are capable of withstanding the expected loads from heavy construction equipment. The designer must also be aware that such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers for instream modifications (404 permits).

Design Criteria

Selecting Type of Stream Crossing:

Bridge:
- Bridges are preferable to the other types of stream crossings because they cause the least disturbance to the stream.
- Bridges are most applicable for narrow channels and deep channels.

Culvert:
- Culvert stream crossings should NOT be constructed between March 15 and June 15 because of impacts to fish spawning.
- Culvert stream crossings are most suitable for wide-stream channels and for traffic that may be too heavy for a bridge.

Ford:
- Stream fords should NOT be constructed between March 15 and June 15 because of impacts to fish spawning.
- Fords may be used where very little construction traffic is anticipated.
- Fords should not be used to cross channels with streambanks greater than 4 ft. high.

Locating Crossing--Stream crossings should be constructed where they will cause the least amount of disturbance to the channel and surrounding vegetation. Good locations generally include straight sections as opposed to bends and shallow areas rather than deep pools.

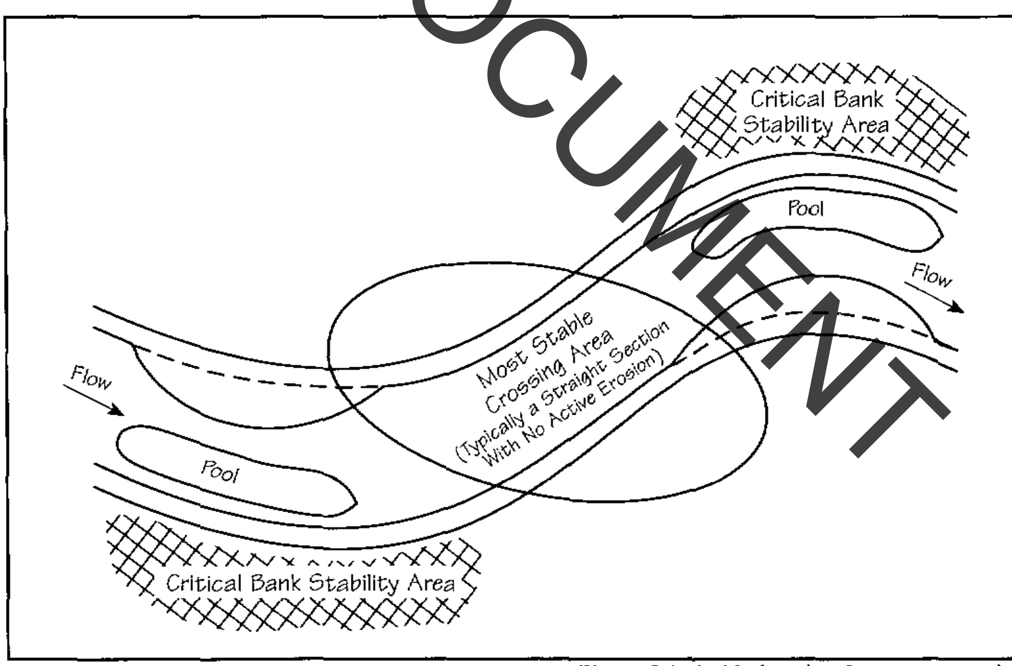


Figure 5-1 Stable location for stream crossing

Crossing Alignment--Stream crossings should be made perpendicular to the channel to minimize the length of channel disturbed. Crossings deviating up to 30 degrees from perpendicular are acceptable.

Width of Crossing--Stream crossings shall be made as narrow as practical to minimize the length of channel disturbed. More importantly, the length of streambank cleared or otherwise disturbed for the stream crossing shall be made as narrow as practical.

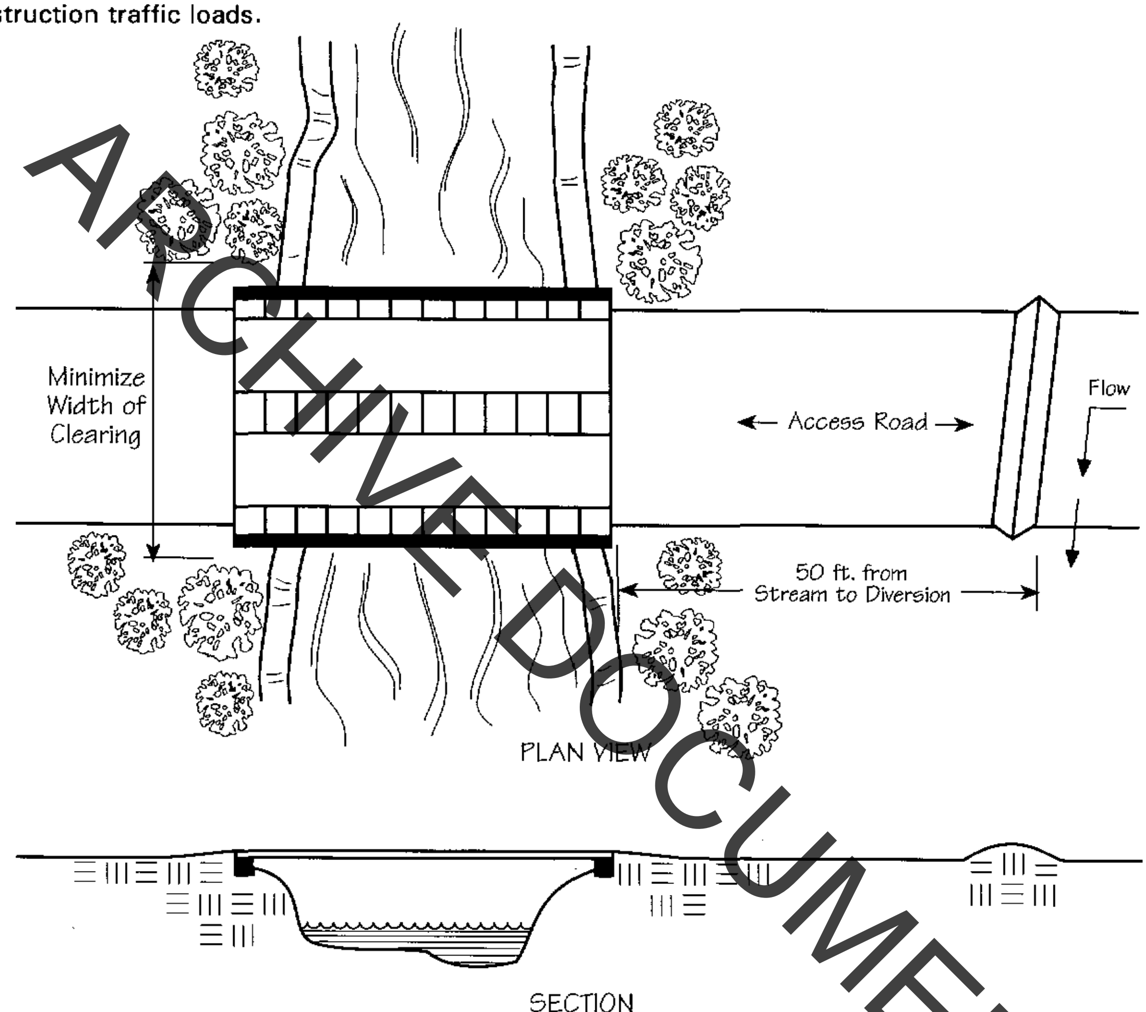
Fish Migration Barriers--Stream crossings shall not cause sudden changes in stream elevation, drops or waterfalls, which could create a barrier to migrating fish.

Approach Road--The access road approaching the stream crossing shall not route sediment-laden runoff directly to the stream. At a minimum distance of 50 ft. from the stream, runoff shall be diverted with water bar or swales to an adequate sediment-trapping practice.

Removal and Stabilization--To minimize obstructions and barriers, all temporary bridges, culverts, gabions and other structures must be removed as soon as the crossing is no longer needed. However, clean stone and rock is usually best left in the channel because removing it causes more disturbance and leaving it may actually be environmentally beneficial. Stone and rock left in the channel must be formed so that it does not impede fish passage. The streambanks must be stabilized. The specifications should define the type of stabilization, ideally woody vegetation, as described in the Buffer Strip section of this book.

Specifications
for
Temporary Access Bridge

This specification does not define the strength of the temporary bridge. It shall be the contractor's responsibility to select bridge construction materials with adequate strength for the anticipated construction traffic loads.



1. Stream Disturbance--Disturbance to the stream shall be kept to a minimum. Streambank vegetation shall be preserved to the maximum extent practical and the stream crossing shall be as narrow as practical.

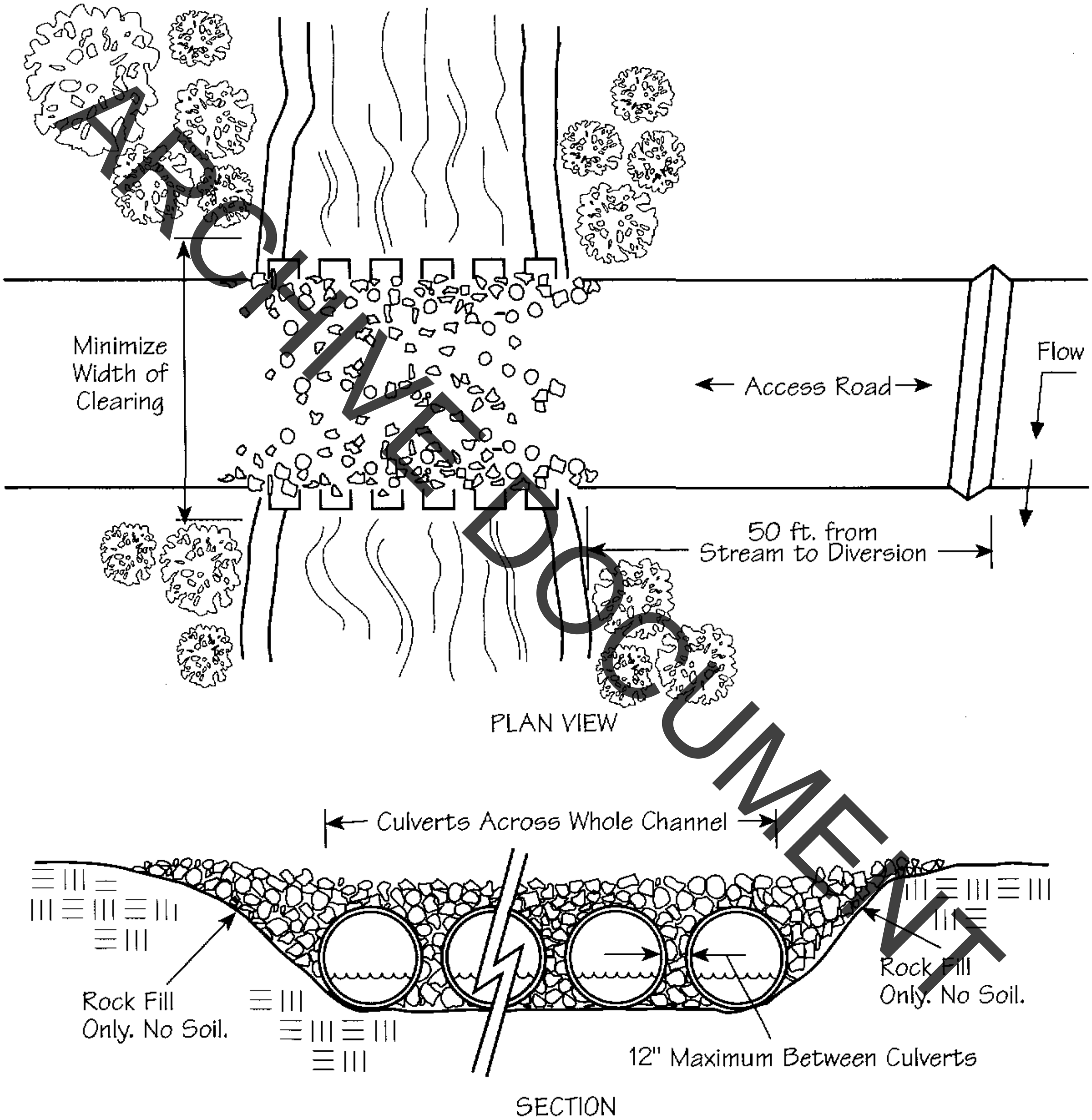
2. Clearing shall be done by cutting NOT grubbing. The roots and stumps shall be left in place to help stabilize the banks and accelerate revegetation.

3. Water shall be prevented from flowing along the road directly to the stream. Diversions and swales shall direct runoff away from the access road to a sediment-control practice.

4. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 ft. as measured from the top-of-bank, then a footing, pier or bridge support may be constructed within the waterway. No more than one additional footing, pier or bridge support shall be permitted for each additional 8-ft. width of the channel. However, no footing, pier or bridge support will be permitted within the channel for waterways less than 8 ft. wide.

5. No fill other than clean stone free from soil shall be placed within the stream channel.

Specifications
for
Culvert Stream Crossing



Specifications
for
Culvert Stream Crossing

1. Stream Disturbance--Disturbance to the stream shall be kept to a minimum. Streambank vegetation shall be preserved to the maximum extent practical and the stream crossing shall be as narrow as practical.

2. Clearing shall be done by cutting NOT grubbing. The roots and stumps shall be left in place to help stabilize the banks and accelerate revegetation.

3. To minimize interference with fish spawning and migration, crossing construction should be avoided where practical from March 15 through June 15.

4. Water shall not be allowed to flow along the road directly to the stream. Diversions and swales shall direct runoff away from the access road to a sediment-control practice.

5. Placement--Culverts shall be placed on the existing streambed to avoid a drop or waterfall at the downstream end of the pipe, which would be a barrier to fish migration. Crossings shall be made in shallow areas rather than deep pools where possible.

6. Culvert Size--Culvert diameter shall be at least three times the depth of normal stream flow at the point of the stream crossing. If the crossing must be placed in deep, slow-moving pools, the culvert diameter may be reduced to twice the depth of normal stream flow. The minimum size culvert that may be used is 18 in.

7. Number of Culverts--There shall be sufficient number of culverts to completely cross the stream channel from streambank to streambank with no more than a 12-in. space between each one.

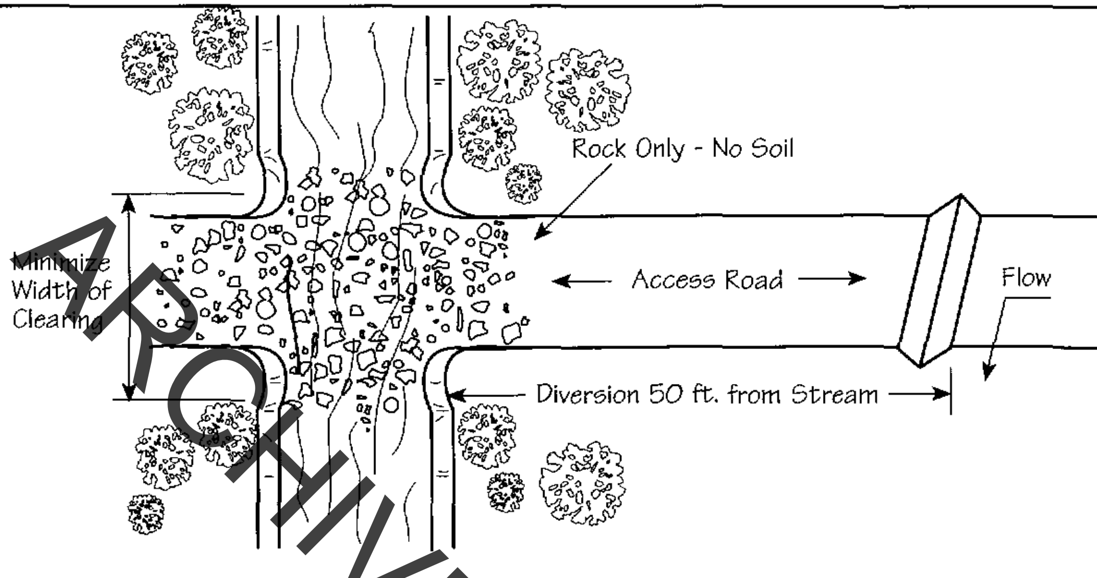
8. Fill and Surface Material--All material placed in the stream channel, around the culverts and on the surface of the crossing shall be stone, rock or aggregate. ODOT No. 1 shall be the minimum acceptable size. To prevent washouts, larger stone and rock may be used and they may be placed in gabion mattresses. NO SOIL SHALL BE USED IN THE CONSTRUCTION OF A STREAM CROSSING OR PLACED IN THE STEAM CHANNEL.

9. Removal--Aggregate stone and rock used for this structure does not need to be removed. Care should be taken so that any aggregate left does not create an impoundment or impede fish passage. All pipes, culverts, gabions or structures must be removed.

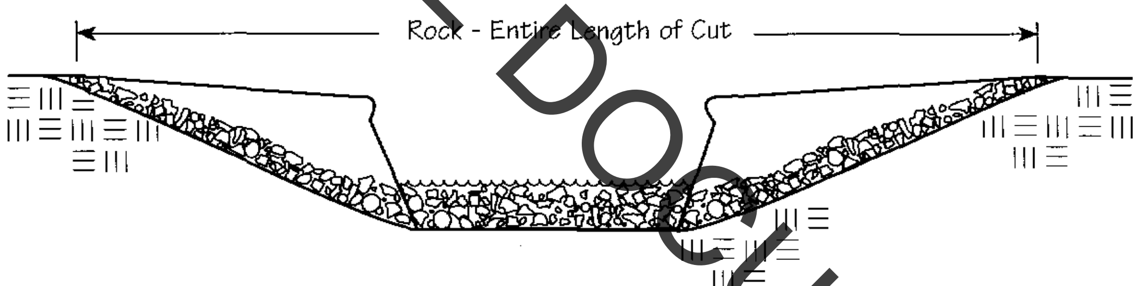
10. Stabilization--Streambanks shall be stabilized. Plantings shall include woody vegetation where practical.

Specifications
for

Temporary Stream Ford



PLAN VIEW



SECTION

1. Timing--No construction or removal of a temporary stream ford will be permitted on perennial streams from March 15 through June 15 to minimize interference with fish spawning and migration.

2. Stream Disturbance--Disturbance to the stream shall be kept to a minimum. Streambank vegetation shall be preserved to the maximum extent practical and the stream crossing shall be as narrow as practical. Clearing shall be done by cutting NOT grubbing where possible.

3. Surface Runoff--Water shall not be allowed to flow along the road directly to the stream. Diversions and swales shall direct runoff away from the access road to a sediment-control practice.

4. Fill and Surface Material--All material placed in the stream channel shall be stone, rock or aggregate. ODOT No. 1 shall be the minimum acceptable size. Larger stone and rock may be used. NO SOIL SHALL BE USED IN THE CONSTRUCTION OF A STREAM FORD OR PLACED IN THE STEAM CHANNEL.

5. Removal--Aggregate, stone and rock used for the stream crossing shall NOT be removed but shall be formed so it does not create an impoundment, impede fish passage, or cause erosion of streambanks.

6. Stabilization--Streambanks shall be stabilized. Plantings shall include woody vegetation where practical.

Stream Utility Crossing

Description

Stream Utility Crossings include pipeline, power line, or road construction projects that cross streams or rivers. Measures used to minimize damage from the construction of utilities across streams start in the planning stages of a project and continue through site restoration. They include: determining the location of the utility, timing construction, construction techniques to reduce sediment pollution, and recreating favorable riparian conditions.

Conditions Where Practice Applies

Stream utility crossing practices apply to the following:

- pipelines including but not limited to gas pipelines, sanitary sewers and water lines,
- overhead electric transmission lines,
- road and bridge construction.

For temporary access of construction traffic across stream channels, see specification for Stream Crossings.

Siting Stream Crossings--The first priority for minimizing the impacts of utility construction across streams is to minimize the length of channel disturbed. This often requires the values of the stream be acknowledged and carefully weighed because, routinely, the easiest and most inexpensive location of utilities, particularly sanitary sewers, is right down the stream channel itself. Unfortunately, this method of locating utilities causes crucial, often permanent, impacts to the stream.

The length of channel disturbed should be minimized by the following:

- The utility should be routed well away from the steam channel and adjacent riparian area. Doing this may require more earthwork through more irregular terrain and more bends in the utility.
- Stream should be crossed as few times as possible.
- Where crossings do occur, they should be generally perpendicular to the stream channel. Crossings deviating up to 30 degrees from perpendicular shall be considered generally perpendicular.
- It may be possible in some situations to have several utility crossings in one location, and/or encase several utilities into one casing. This is most likely feasible on a small scale such as the utilities serving an individual housing development.

Within the stream channel there are areas which are more sensitive to the work required for a utility crossing. Crossings should be located along the stream channel where they will cause the least impact. Crossings should occur where the streambanks are most stable such as the crossovers between bends where the curve of the stream changes direction or along fairly straight sections of channel. Sharp bends and steep banks, especially where showing signs of instability, should be avoided. Deep pools within the channel also should be avoided. These are locations where, during high flow, natural scour is occurring, opposed to riffle areas where deposition occurs. Generally, uniform stretches of stream will be least impacted by a utility crossing.

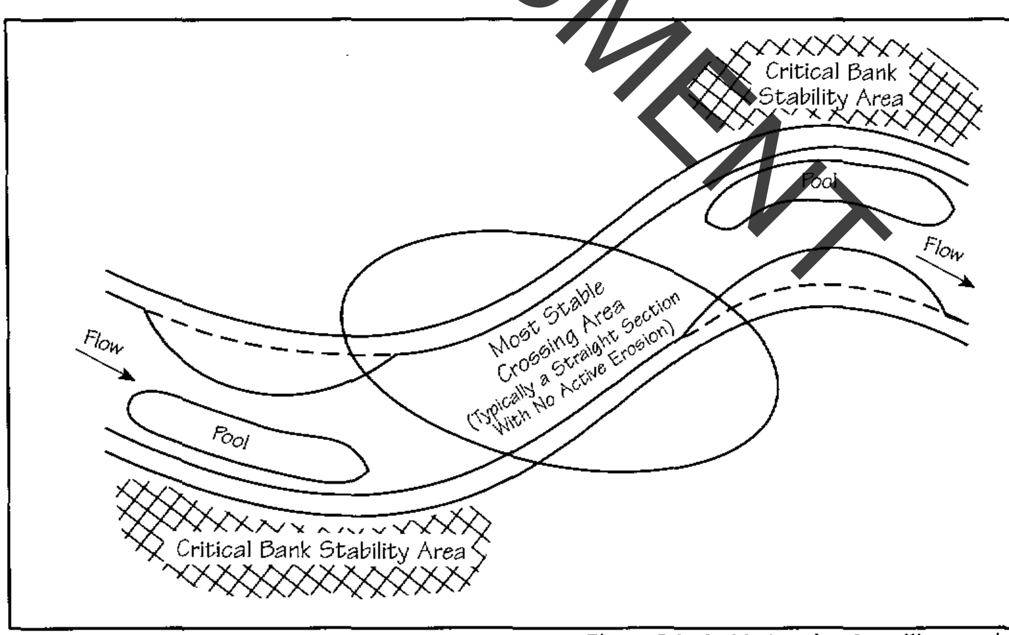


Figure 5-2 Stable location for utility crossing

Construction Season--Utility stream crossing construction is best done during periods of low flow; generally July, August, and September. For perennial streams or important spawning streams, the worst time for construction may be during fish spawning and migration season from March 15 through June 15 or as determined for a particular stream or fish species. This should be taken into consideration along with other construction timing constraints.

Construction Method--In critical crossing situations, the method of construction may be specified. Drilling and boring utility lines under a stream channel cause much less impact than plow-in and trenching methods. Drilling and boring reduce the likelihood of erosion, as well as disturbance of the banks and bottom substrates which typically occurs with both the plow-in and trenching methods. Drilling and boring are usually more expensive and may be unreasonable for certain situations. If a utility line cannot be bored or drilled under the watercourse, the plow-in method should be used where possible. When crossing streams with the plow, a "dry run" is usually recommended prior to attaching the cable or pipe to clear out any possible stumps, logs or other obstructions.

Stream Flow Control--Stream flow should be diverted away from areas where intensive construction will occur.

Confining the Work Area--In large streams with limited areas of disturbance such as along one bank or around a bridge piling, a cofferdam or barricade can be constructed to keep the stream from continually flowing through the disturbed areas. Types of barricades include sheet pilings, sandbags, or turbidity curtains. Sheet pilings are the most durable. Sandbags can be constructed quickly in areas with shallow flow. Turbidity curtains are a geotextile material suspended from floats which hang down to the channel bottom. Unlike sheet pilings and sandbags, turbidity curtains cannot be specified for areas with strong currents or if the work area will be pumped dry.

Staged Construction--A cofferdam of sheet pilings or sand bags also can be used to confine, one-half of the channel until work there is completed and stabilized, then moved to the other side to complete the crossing without ever having the stream flow through the active work area.

Temporary Rerouting--When extensive or prolonged work will be done to the channel, the stream should be routed around the work area if permitted by terrain and the size of stream. Flow may be pumped around the work area or a temporary channel may be constructed. Temporary channels must be stabilized. A geotextile completely lining the channel bottom and side slopes is suitable temporary stabilization.

Limit on Each Crossing

Crossing Width--The limits of disturbance should be as narrow as possible where utilities cross streams. This includes not only construction operations within the channel itself, but also clearing done through the vegetation growing on the streambanks. The width of clearing should be minimized through the entire riparian area. To ensure minimal width of disturbance through the riparian area, materials excavated from trench construction should be placed well back from the streambanks. The width necessary for the crossing should also be clearly specified on the plans as well as the construction and clearing limits.

Duration of Construction--The time between initial disturbance of the stream and final stabilization should be kept to a minimum. The time necessary for an individual utility stream crossing varies significantly, depending on the specific project. Individual projects should be designed to encourage minimum duration of construction activity within the stream channel. Specific time limits may be specified or the crossing construction may be made dependent on other operations. For example, it could be specified that construction could not begin on the crossing until the utility line was in place to within 10 ft. of the streambanks on each side of the stream.

Fill Placed Within the Channel--The only fill permitted in the channel should be clean aggregate, stone or rock. No soil or other fine erodible material shall be placed in the channel. This restriction includes all fill for temporary crossings, diversions, and trench backfill when placed in flowing water. If the stream flow is diverted away from construction activity the material originally excavated from the trench may be used to back fill the trench.

Streambank Restorations--Streambanks should be restored to their original line and grade. Restoration must not result in a narrower channel or flow restriction. Streambanks should be stabilized with riprap or vegetative bank stabilization. Trees should be planted on the entire riparian area, especially the streambanks, to the extent permitted by the type of utility crossing. See Specifications for Streambank Stabilization and Buffer Strips.

Site Work Associated with Utility Stream Crossing

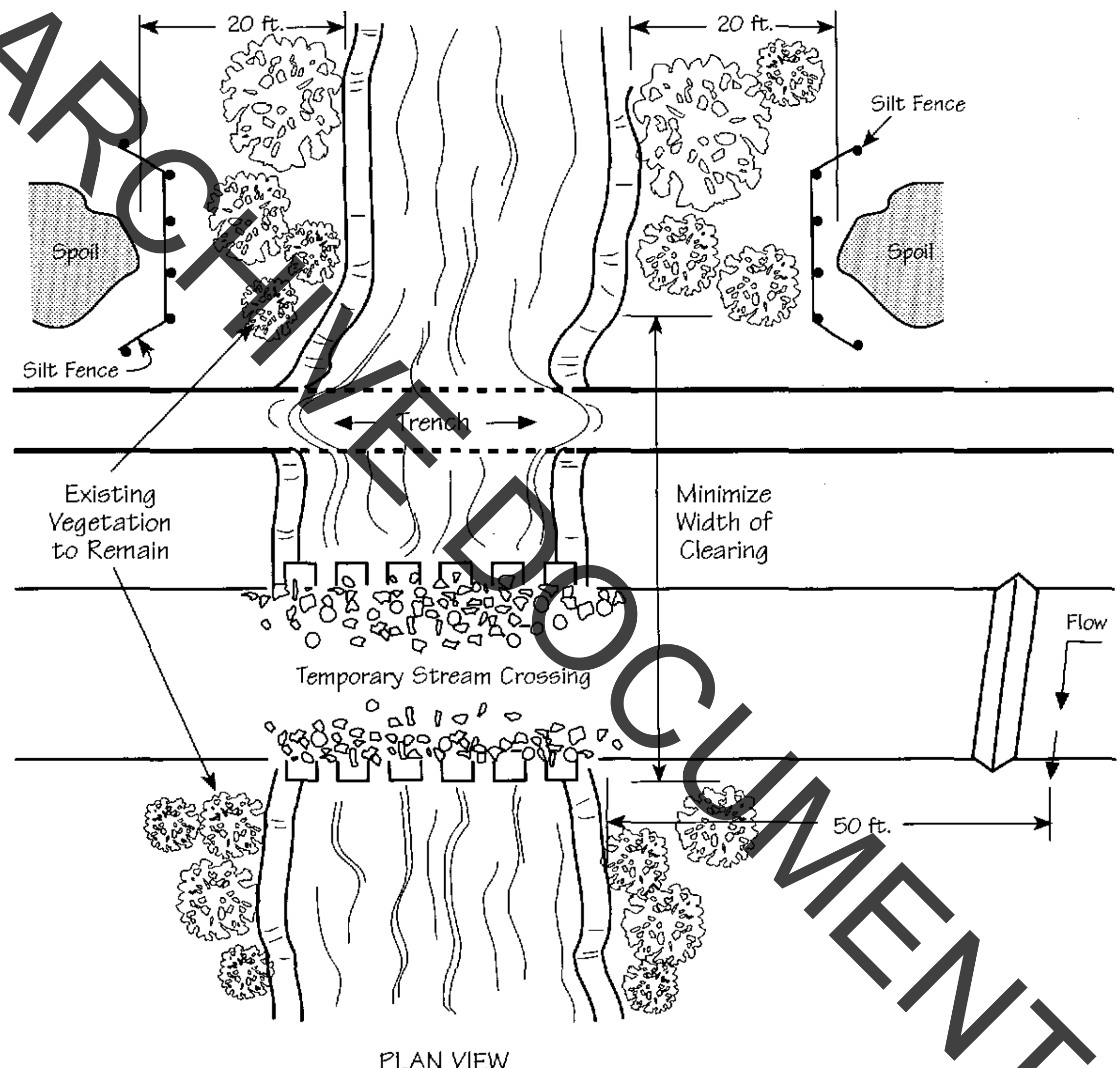
Runoff Control Along the Right-of-Way--Runoff and sediment controls should be used for the access road or utility easement approaching the stream crossing to prevent sediment-laden runoff from being routed directly to the stream. At a minimum distance of 50 ft. from the stream, runoff should be diverted with water bar or swales to a sediment trapping practice.

Dewatering--Trenches and excavations associated with stream crossings frequently require dewatering. Dewatering or pumping operations must not discharge directly to the stream.

- **Water Containing Sediment**--Dewatering must discharge to a settling facility, dewatering sump or a flat, well-vegetated area adequate for removing sediment before the pumped water reaches the stream.
- **Groundwater**--Water pumped from wells is about 55 F which will cause thermal impacts in some situations. High pumping rates near small streams in summer will have major changes in stream metabolism, i.e., throw off spawning. Where this potential occurs, groundwater should not be discharged directly to the stream but roughed through settling ponds or other shallow holding ponds.

Permits--The specifications contained in this practice pertain primarily to the environmental impacts of stream utility crossings. The designer must also be aware that such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers for instream modifications (404 permits) and Ohio Environmental Protection Agency's State Water Quality Certification (401 permits).

Specifications
for
Large Stream Utility Crossing



Specifications
for
Stream Utility Crossing

1. When site conditions allow, one of the following shall be used to divert stream flow or otherwise keep the flow away from construction activity.
   - Drill or bore the utility lines under the stream channel.
   - Construct a cofferdam or barricade of sheet pilings, sandbags or a turbidity curtain to keep the stream from continually flowing through the disturbed areas. Turbidity curtains shall be a pre-assembled system and used only parallel to flow.
   - Stage construction by confining first one-half of the channel until work there is completed and stabilized, then move to the other side to complete the crossing.
   - Route the stream flow around the work area by bridging the trench with a rigid culvert, pumping, or constructing a temporary channel. Temporary channels shall be stabilized by rock or a geotextile completely lining the channel bottom and side slopes.
2. Crossing Width--The width of clearing shall be minimized through the riparian area. The limits of disturbance shall be as narrow as possible including not only construction operations within the channel itself but also clearing done through the vegetation growing on the streambanks.
3. Clearing shall be done by cutting NOT grubbing. The roots and stumps shall be left in place to help stabilize the banks and accelerate revegetation.
4. Material excavated from the trench shall be placed at least 20 ft. from the streambanks.
5. To the extent other constraints allow, stream shall be crossed during periods of low flow.
6. Duration of Construction--The time between initial disturbance of the stream and final stabilization shall be kept to a minimum. Construction shall not begin on the crossing until the utility line is in place to within 10 ft. of the streambank.
7. Fill Placed Within the Channel--The only fill permitted in the channel should be clean aggregate, stone or rock. No soil or other fine erodible material shall be placed in the channel. This restriction includes all fill for temporary crossings, diversions, and trench backfill when placed in flowing water. If the stream flow is diverted away from construction activity the material originally excavated from the trench may be used to backfill the trench.
8. Streambank Restorations--Streambanks shall be restored to their original line and grade and stabilized with riprap or vegetative bank stabilization.
9. Runoff Control Along the Right-of-Way--To prevent sediment-laden runoff from flowing to the stream, runoff shall be diverted with water bar or swales to a sediment trapping practice a minimum of 50 ft. from the stream.
10. Dewatering or pumping water containing sediment shall not be discharge directly to a stream. The flow shall be routed through a settling pond, dewatering sump or a flat, well-vegetated area adequate for removing sediment before the pumped water reaches the stream.
11. Dewatering operations shall not cause significant reductions in stream temperatures. If groundwater is to be discharged in high volumes during summer months, it shall first be routed through a settling pond or overland though a flat well-vegetated area.
12. Permits--In addition to these specifications, stream crossings shall conform to the rules and regulations of the U.S. Army Corps of Engineers for in-stream modifications (404 permits) and Ohio Environmental Protection Agency's State Water Quality Certification (401 permits).

Temporary Diversion

Description

A temporary diversion is a swale and/or dike used to:

- Direct sediment-laden runoff to a settling pond.
- Route clean runoff away from disturbed areas.
- Divert runoff to reduce the effective length of the slope.
- Direct runoff away from steep cut or fill slopes.

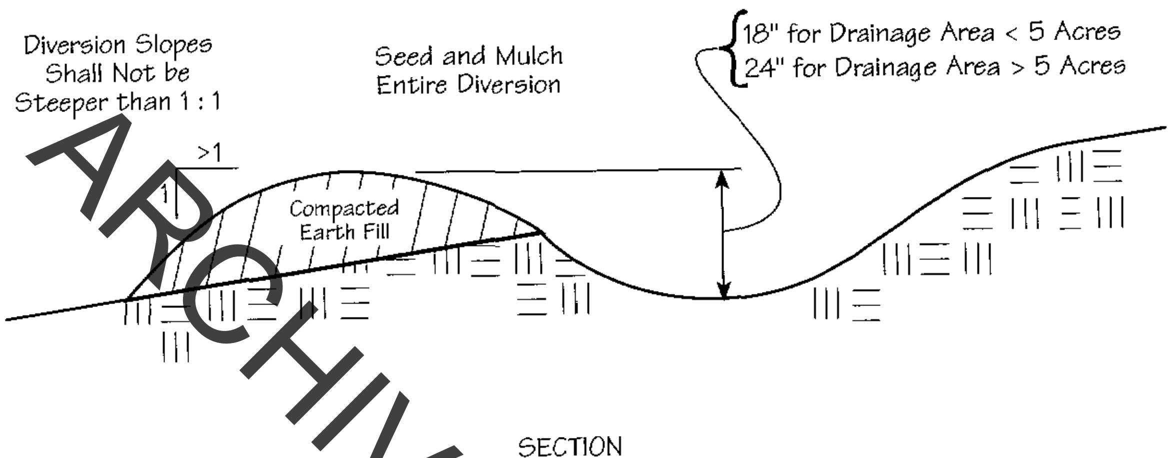
Planning Considerations

Temporary Diversions vs Silt Fence--Two approaches are commonly used to intercept and treat sediment-laden runoff at the perimeter of disturbed areas. One approach is silt fence and the other is diversions directing runoff to settling ponds. When determining which approach is more appropriate, the designer should consider the following:

- Standard temporary diversion designs can accommodate flows up to 10 ac.
- Silt fence can generally accommodate sheet flow from 0.25 ac./100 ft. of fence (see silt fence specification).
- Diversions can be constructed on a grade to direct runoff while silt fence must follow the contour of the land.
- Diversions are durable and require minimum maintenance.
- Diversions are easily constructed.
- Silt fence itself treats runoff and need not be used in conjunction with a settling pond.
- Silt fence requires little space and causes less disturbance around valuable vegetation or structures.

Specifications
for

Temporary Diversion



1. Diversion shall be compacted by traversing with tracked earth-moving equipment.

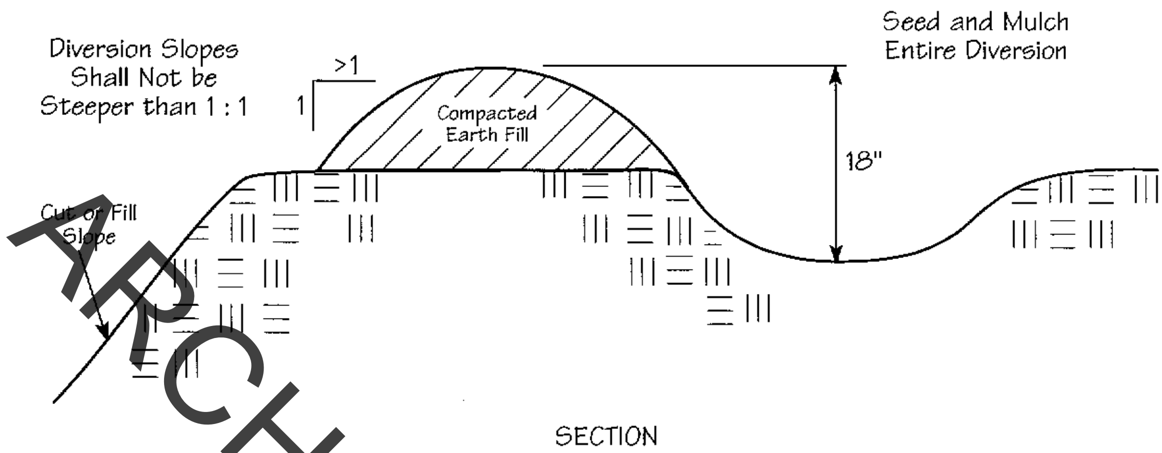
2. Diversions shall not be breached or lowered to allow construction traffic to cross; instead the top width may be made wider and side slopes made flatter than specified above.

3. Diversions shall be stabilized with vegetation and check dams or the following treatments:

Temporary Diversion Stabilization Treatment			
Diversion Slope	< 2 ac.	2 - 5 ac.	5 - 10 ac.
0 - 3%	Seed and Straw	Seed and Straw	Seed and Straw
3 - 5%	Seed and Straw	Seed and Straw	Matting
5 - 8%	Seed and Straw	Matting	Matting
8 - 20%	Seed and Straw	Matting	Engineered

Note: Diversions with steeper slopes or greater drainage areas are beyond the scope of this standard and must be designed for stability.
Seed, straw and matting used shall meet the Specifications for Temporary Seeding, Mulching and Matting.

Specifications
for
Temporary Diversion Above Steep Slopes



Diversions for the temporary protection of cut or fill slopes shall be installed in accordance with the following criteria for drainage areas of 5 acres or less. Larger areas require a diversion design.

1. Diverted runoff shall outlet onto a stabilized undisturbed area, settling pond, or into a drop structure.
2. Diversions shall be compacted by traversing with tracked earth-moving equipment and stabilized with seed and mulch.

Water Bar

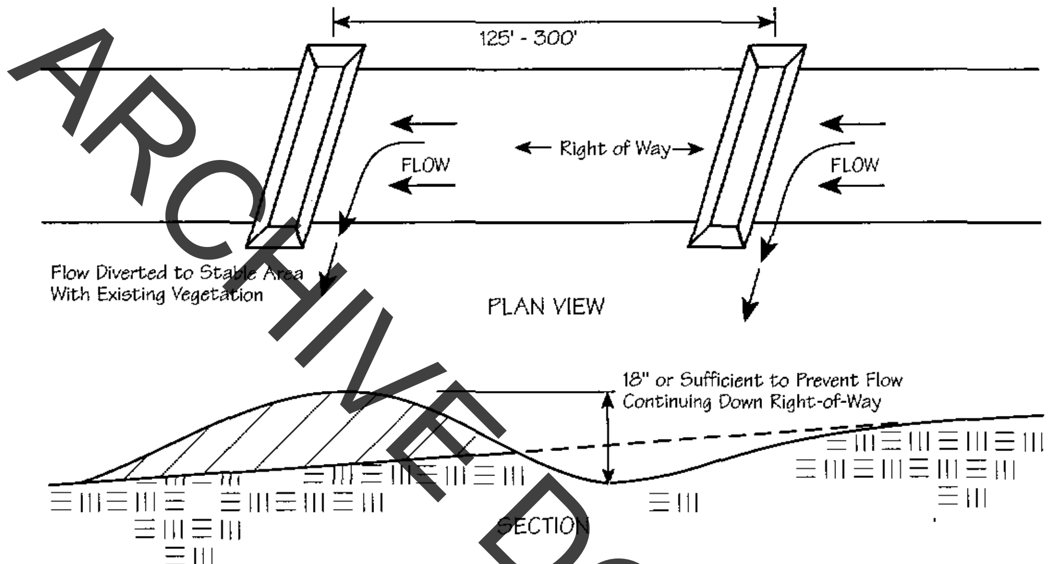
Description

A water bar is a diversion constructed across an access road or utility right-of-way. It is used to direct runoff off roads to prevent it from accumulating and causing erosion.

Conditions Where Practice Applies

Water bars are used across construction entrances, on long or steep access roads, temporary construction roads, or utility right-of-ways that do not have a stable surface or where runoff would otherwise collect in erosive flows.

Specifications
for
Water Bar



1. Water bar dimensions shall be at least:
   Top width--2 ft. minimum
   Height--18 in. unless otherwise noted on the plans.
   Side slopes--Sufficiently flat to accommodate the expected traffic.

2. The spacing shall be 125-300 ft. between diversions. The steeper the slope, the closer the spacing shall be.

3. Location--The field location shall be adjusted as needed to provide a stabilized safe outlet.

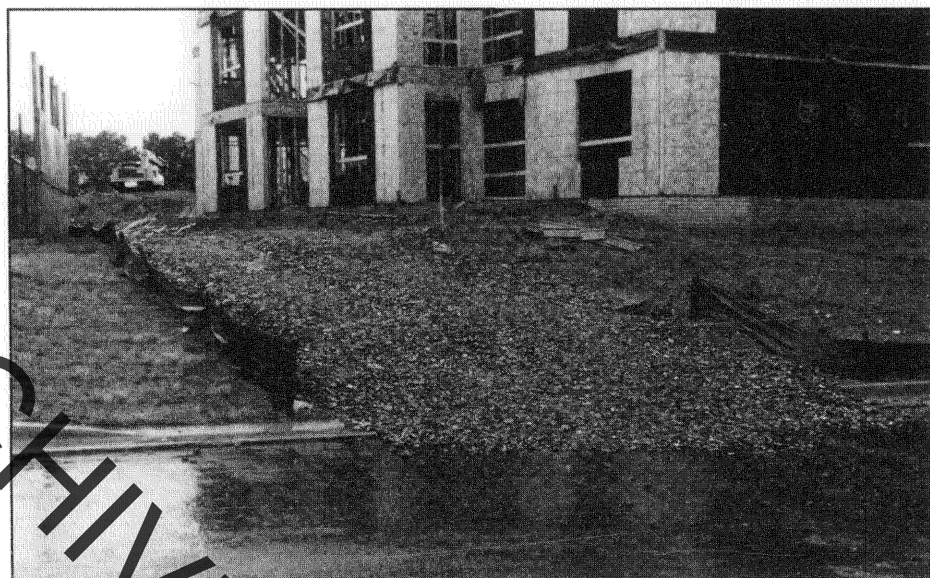
4. Outlet--Diverted runoff shall outlet onto an undisturbed vegetated area or to a settling pond.

5. Diversions shall be compacted by traversing with tracked earth-moving equipment.

CHAPTER 6

SOIL STABILIZATION

Construction Entrance



Description

A construction entrance is a stabilized pad of aggregate over a geotextile base and is used to reduce the amount of mud tracked off-site with construction traffic.

Conditions Where Practice Applies

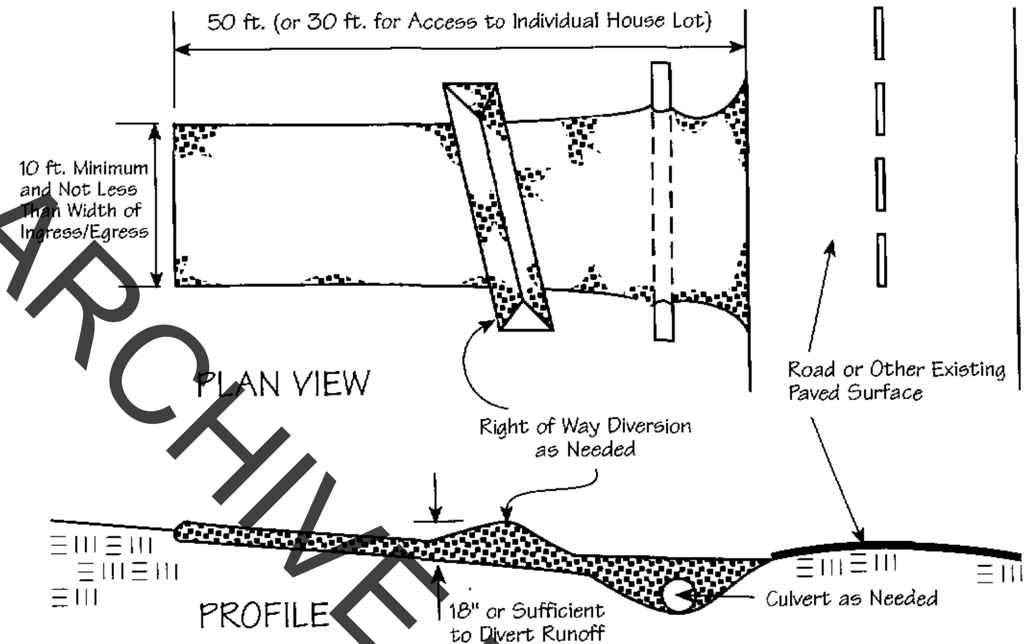
A construction entrance should be used:

- where construction vehicles leave active construction areas onto surfaces where runoff is not checked by sediment controls;
- at all points of egress to public roads;
- where frequent vehicle and equipment ingress/egress is expected such as at the entrance of individual building lots.

Planning Considerations

This practice should not be relied on to remove mud from construction traffic. Most mud is flung from tires as vehicles reach speeds higher than is reached on-site. The best approach to preventing off-site tracking is to keep vehicles that frequently enter and leave a site, away from muddy areas in the first place. Vehicles should be restricted to stabilized areas to the extent practical, and areas where frequent ingress/egress is expected should be stabilized.

Specifications
for
Construction Entrance



1. Stone Size--Two-inch stone shall be used, or recycled concrete equivalent.

2. Length--The construction entrance shall be as long as required to stabilize high traffic areas but not less than 50 ft. (except on single residence lot where a 30-ft. minimum length applies).

3. Thickness--The stone layer shall be at least 6 in. thick.

4. Width--The entrance shall be at least 10 ft. wide, but not less than the full width at points where ingress or egress occurs.

5. Bedding--A geotextile shall be placed over the entire area prior to placing stone. It shall have a Grab Tensile Strength of at least 200 lb. and a Mullen Burst Strength of at least 190 lb.

6. Culvert--A pipe or culvert shall be constructed under the entrance if needed to prevent surface water flowing across the entrance from being directed out onto paved surfaces.

7. Water Bar--A water bar shall be constructed as part of the construction entrance if needed to prevent surface runoff from flowing the length of the construction entrance and out onto paved surfaces.

8. Maintenance--Top dressing of additional stone shall be applied as conditions demand. Mud spilled, dropped, washed or tracked onto public roads, or any surface where runoff is not checked by sediment controls, shall be removed immediately. Removal shall be accomplished by scraping or sweeping.

9. Construction entrances shall not be relied upon to remove mud from vehicles and prevent off-site tracking. Vehicles that enter and leave the construction-site shall be restricted from muddy areas.

Mulching

Description

Applying a protective layer of mulch, usually of straw, to bare soil is used to abate erosion by shielding it from raindrop impact to helping establish vegetation by conserving moisture and creating favorable conditions for seeds to germinate.

Conditions Where Practice Applies

Mulch should be used liberally throughout construction to limit the areas that are bare and susceptible to erosion. Mulch can be used in conjunction with seeding to establish vegetation or by itself to provide erosion control when the season does not allow grass to grow. Mulch and other vegetative practices must be applied on all disturbed portions of construction-sites that will not be re-disturbed for more than 45 days.

Specifications
for

Mulching

1. Mulch and/or other appropriate vegetative practices shall be applied to disturbed areas within 7 days of grading if the area is to remain dormant (undisturbed) for more than 45 days or on areas and portions of the site which can be brought to final grade.

2. Mulch shall consist of one of the following:

   - Straw--Straw shall be unrotted small grain straw applied at the rate of 2 tons/ac. or 90 lb./1,000 sq. ft. (two to three bales). The straw mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000-sq.-ft. sections and place two 45-lb. bales of straw in each section.

   - Hydroseeders--Wood cellulose fiber should be used at 2,000 lb./ac. or 46 lb./1,000 sq. ft.

   - Other--Other acceptable mulches include mulch mattings applied according to manufacturer's recommendations or wood chips applied at 10-20 tons/ac.

3. Mulch Anchoring--Mulch shall be anchored immediately to minimize loss by wind or runoff. The following are acceptable methods for anchoring mulch.

   - Mechanical--Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but be left generally longer than 6 in.

   - Mulch Nettings--Use according to the manufacturer's recommendations, following all placement and anchoring suggestions. Use in areas of water concentration and steep slopes to hold mulch in place.

   - Asphalt Emulsion--For straw mulch, apply at the rate of 160 gal./ac. (0.1 gal./sy) into the mulch as it is being applied or as recommended by the manufacture.

   - Synthetic Binders--For straw mulch, synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Tack or equal may be used at rates recommended by the manufacturer.

   - Wood Cellulose Fiber--Wood cellulose fiber may be used for anchoring straw. The fiber binder shall be applied at a net dry weight of 750 lb./acre. The wood cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 lb./100 gal. of wood cellulose fiber.

MATTING

DESCRIPTION

Matting such as excelsior or jute matting is used to stabilize easily eroded areas such as channels and steep slopes while vegetation is becoming established.

CONDITIONS WHERE PRACTICE APPLIES

Matting should be used on:

- Channels where the designed flow exceeds 3.5 fps,
- Steep slopes,
- Problem areas that have highly erosive soils,
- Areas that may be slow to establish adequate vegetative cover.

Design Criteria

Materials--Matting is available in many acceptable materials that provide excellent soil protection. Two acceptable materials are jute and excelsior matting. Excelsior matting is a wood fiber mulch covered with plastic netting on one or both sides. Jute matting is a woven cloth of jute yarn and may be used in conjunction with organic mulch. Both are widely available, easily installed, and adaptable to most site conditions.

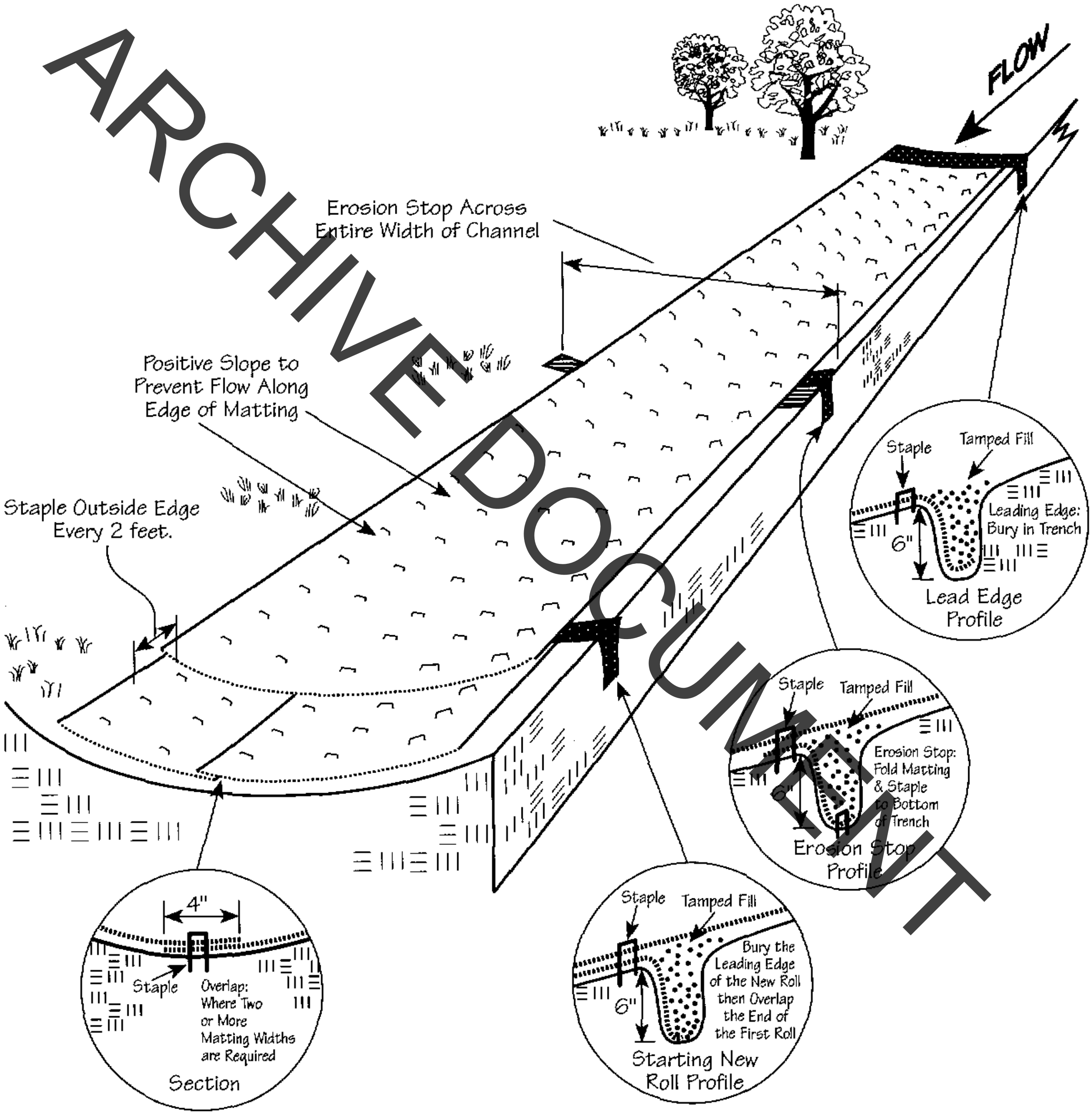
Grade of Matting--The specific grade of a matting should be specified. Matting is available in many different grades for a wide range of uses and site conditions.

Channel Width--Channels often require several widths of mattings. The width of coverage should be specified for individual sections of channel.

Manufacturers Instructions--Matting manufacturers usually provide detailed installation instructions for their products. The manufacturer's instructions should be referenced during design and included in construction plans. If instructions are not available, the following guidelines listed in the specifications for matting may be used.

Erosion Stops--Erosion stops are made of strips of matting placed in narrow trenches 6-12 in. deep across the full cross section of the channel. The strips are installed under the channel lining matting. Erosion stops prevent undermining and gullies from forming beneath the matting. They should be specified when recommended by the matting manufacturer and for areas of high-erosion potential such as where rocky conditions may prevent good soil matting contact, erosive soils or steep slopes. Depending on erosion potential, specifications should require erosion stops spaced from 20-100 ft. apart.

Specifications
for
Matting



Specifications
for
Matting

1. Material--Excelsior matting shall be 48 in. wide and weigh an average of 0.75 lb./sq. yd. or greater. Jute matting shall be 48 in. wide and weigh an average of 1.2 lb./yd or greater. Matting made of other material and providing equal or greater stabilization than the above may be substituted.

2. Site Preparation--After the site has been shaped and graded, a seedbed shall be prepared that is relatively free of foreign material, clods or rocks that are greater that 1.5 in. in diameter. The site shall be prepared to ensure that the matting has good soil contact and the matting will not "bridge" or "tent" over obstructions.

3. Matting shall be held in place as recommended by the manufacturer as adequate for the site conditions or with sod staples. Sod staples are U-shaped wire staples used for fastening sod, jute or excelsior matting and other erosion-control materials to the soil surface. Sod staples shall be No. 11 gauge or heavier and be 6-10 in. in length. In loose or sandy soils longer staples shall be used.

4. Planting--Lime and fertilizer shall be used according to the recommendation of a soil test or the seeding plan. Seed according to the matting manufacturer's recommendations; or, for excelsior matting, seed area to be protected before installation; or, when using jute matting, apply half the seed before and half the seed after installation.

5. Matting shall be installed as specified by the manufacturer as appropriate for the site conditions or the following procedure may be used:

   - After the site is prepared and erosion stops are installed, start laying the mat from the top of the slope or channel and unroll the matting allowing 4-in. overlaps at the edges.

   - Secure the matting by burying the top ends in a trench 6 in. deep and staple the folded ends to the bottom of the trench. Backfill and tamp firmly to the established grade.

   - Staple matting every 12 in. across the width beginning at the edges and every 2 ft. in rows the entire length of the matting. Every other row of staples running the length of the matting should be staggered.

   - To join two rolls together, cut a trench to anchor the end of the new roll and secure it the same as the top roll. Overlap the end of the previous roll 18 in. over the new roll. Continue to staple as described above.

   - When using excelsior matting, the plastic netting shall be on top of the wood fiber.

6. Erosion stops shall be used where recommended by the matting manufacturer and on areas specified where high-erosion potential may cause undermining and gullies to form beneath the matting.

   - Erosion stops shall be made of strips of matting placed in narrow trenches 6-12 in. deep that cover the full cross section of the channel. They shall be spaced according to the manufacturer's recommendations or by the following:
     --3 ft. down the channel from each point of entry of concentrated flow,
     --at points where change in gradient or direction of channel occurs, and
     --on long slopes at spacing from 20-100 ft. depending upon the erodibility of the soil, velocity and volume of flow.

   - Erosion stops shall extend beyond the channel liner to the full design width of the channel, this will check any rills that might form outside or along the edge of the channel lining.

   - Erosion stops shall be constructed with 6 in. deep trench, stapled to the bottom of the trench, backfilled and tamped firmly to conform with the cross section of the channel.

   - If seeding has been done prior to installation of erosion stops, reseed disturbed areas prior to placement of channel liner.

PERMANENT SEEDING

DESCRIPTION

Permanent seeding includes the seedbed preparation, seeding, and the establishment of perennial vegetation used to permanently stabilize soil, prevent sediment pollution, reduce runoff by promoting infiltration, and provide stormwater quality benefits offered by dense vegetation.

CONDITIONS WHERE PRACTICE APPLIES

Permanent seeding should be applied to:

- Areas or portions of construction-sites which can be brought to final grade. Applications of permanent seeding should not be delayed while construction on limited portions of the site is being completed.

- Areas that will be regraded, but will be dormant for a year or more.

PLANNING CONSIDERATIONS

Healthy dense turf will have a dramatic long lasting effect on stormwater quality as well as promoting infiltration and reducing the amount of runoff. To establish quality vegetation, careful preparation of the seedbed, soil, even subsoil is highly encouraged.

Soil Compaction--Stormwater quality and the amount of runoff both vary significantly with soil compaction. Non-compacted soils improve stormwater by promoting:

- dense vegetation,
- high infiltration & lower runoff rates,
- pollutant filtration, deposition & absorption, and
- beneficial biologic activity in the soil.

Construction activity can cause highly compacted soils but also offers the opportunity to improve soil condition. The best time for improving soil condition is during the establishment of permanent vegetation. It is highly recommended that subsoilers, plows or other implements be specified as part of final seedbed preparation. Use discretion in slip-prone areas.

Minimum Soil Conditions--Vegetation cannot be expected to stabilize soil that is unstable due to its texture, structure, water movement or excessively steep slope. The following minimum soil conditions are needed for the establishment and maintenance of a long-lived vegetative cover. If these conditions cannot be met, see the Standards and Specifications for Resoiling.

- Soils must include enough fine-grained material to hold at least a moderate amount of available moisture.
- The soil must be free from material that is toxic or otherwise harmful to plant growth.

Specifications
for
Permanent Seeding

SITE PREPARATION

1. A subsoiler, plow or other implement shall be used to reduce soil compaction and allow maximum infiltration. (Maximizing infiltration will help control both runoff rate and water quality.) Subsoiling should be done when the soil moisture is low enough to allow the soil to crack or fracture. Subsoiling shall not be done on slip-prone areas where soil preparation should be limited to what is necessary for establishing vegetation.

2. The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation and seeding.

3. Resoil shall be applied where needed to establish vegetation.

SEEDBED PREPARATION

1. Lime--Agricultural ground limestone shall be applied to acid soil as recommended by a soil test. In lieu of a soil test, lime shall be applied at the rate of 100 lb./1,000 sq. ft. or 2 tons/ac.

2. Fertilizer--Fertilizer shall be applied as recommended by a soil test. In lieu of a soil test, fertilizer shall be applied at a rate of 12 lb./1,000 sq. ft. or 500 lb./ac. of 10-10-10 or 12-12-12 analysis.

3. The lime and fertilizer shall be worked into the soil with a disk harrow, spring-tooth harrow, or other suitable field implement to a depth of 3 in. On sloping land the soil shall be worked on the contour.

SEEDING DATES AND SOIL CONDITIONS

Seeding should be done March 1 to May 31 or Aug 1 to September 30. These seeding dates are ideal but, with the use of additional mulch and irrigation, seedings may be made any time throughout the growing season. Tillage/seedbed preparation should be done when the soil is dry enough to crumble and not form ribbons when compressed by hand. For winter seeding, see the following section on dormant seeding.

DORMANT SEEDINGS.

1. Seedings shall not be planted from October 1 through November 20. During this period the seeds are likely to germinate but probably will not be able to survive the winter.

2. The following methods may be used for "Dormant Seeding":

   - From October 1 through November 20, prepare the seedbed, add the required amounts of lime and fertilizer, then mulch and anchor. After November 20, and before March 15, broadcast the selected seed mixture. Increase the seeding rates by 50% for this type of seeding.

   - From November 20 through March 15, when soil conditions permit, prepare the seedbed, lime and fertilize, apply the selected seed mixture, mulch and anchor. Increase the seeding rates by 50% for this type of seeding.

   - Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydro-seeder (slurry may include seed and fertilizer) on a firm, moist seedbed.

   - Where feasible, except when a cultipacker type seeder is used, the seedbed should be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land, seeding operations should be on the contour where feasible.

MULCHING

1. Mulch material shall be applied immediately after seeding. Seedings made during optimum seeding dates and with favorable soil conditions and on very flat areas may not need mulch to achieve adequate stabilization. Dormant seeding shall be mulched.

2. Materials

   - Straw--If straw is used it shall be unrotted small-grain straw applied at the rate of 2 tons/ac. or 90 lb./1,000 sq. ft. (two to three bales). The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000-sq.-ft. sections and spread two 45-lb. bales of straw in each section.

   - Hydroseeders--If wood cellulose fiber is used, it shall be used at 2,000 lb./ac. or 46 lb./1,000 sq. ft.

   - Other--Other acceptable mulches include mulch mattings applied according to manufacturer's recommendations or wood chips applied at 6 tons/ac.

3. Straw Mulch Anchoring Methods

   Straw mulch shall be anchored immediately to minimize loss by wind or water.

   - Mechanical--A disk, crimper, or similar type tool shall be set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but, generally, be left longer than 6 in.

   - Mulch Nettings--Nettings shall be used according to the manufacturer's recommendations. Netting may be necessary to hold mulch in place in areas of concentrated runoff and on critical slopes. ,

   - Asphalt Emulsion--Asphalt shall be applied as recommended by the manufacturer or at the rate of 160 gal./ac.

   - Synthetic Binders--Synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Tack or equal may be used at rates recommended by the manufacturer.

   - Wood Cellulose Fiber--Wood cellulose fiber binder shall be applied at a net dry weight of 750 lb./ac. The wood cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 lb./100 gal. of wood cellulose fiber.

IRRIGATION

1. Permanent seeding shall include irrigation to establish vegetation during dry or hot weather or on adverse site conditions as needed for adequate moisture for seed germination and plant growth.

2. Excessive irrigation rates shall be avoided and irrigation monitored to prevent erosion and damage from runoff.

Permanent Seeding			
Seed Mix	**Seeding Rate**		**Notes:**
	lb./ac.	**lb./1,000ft.²**	
General Use			
Creeping Red Fescue Domestic Ryegrass Kentucky Bluegrass	20-40 10-20 10-20	½-1 ¼-½ ¼-½	
Tall Fescue	40	1	
Dwarf Fescue	40	1	
Steep Banks or Cut Slopes			
Tall Fescue	40	1	
Crown Vetch Tall Fescue	10 20	¼ ½	Do not seed later than August.
Flat Pea Tall Fescue	20 20	½ ½	Do not seed later than August.
Road Ditches and Swales			
Tall Fescue	40	1	
Dwarf Fescue Kentucky Bluegrass	90 5	2¼	
Lawns			
Kentucky Bluegrass Perennial Ryegrass	60 60	1½ 1½	
Kentucky Bluegrass Creeping Red Fescue	60 60	1½ 1½	For shaded areas
Note: Other approved seed species may be substituted.			

Specifications
for

Maintenance of Permanent Seeding

1. Permanent seeding shall not be considered established for at least 1 full yr. from the time of planting. Seeded areas shall be inspected for failure and vegetation reestablished as needed. Depending on-site conditions, it may be necessary to irrigate, fertilize, overseed, or reestablish plantings in order to provide permanent vegetation for adequate erosion control.

2. Maintenance fertilization rates shall be established by soil test recommendations or by using the rates shown in the following table.

Maintenance for Permanent Seedings
Fertilization and Mowing

Mixture	Formula	lb./ac.	lb./1,000 ft.^{2}	Time	Mowing
Creeping Red Fescue Ryegrass Kentucky Bluegrass	10-10-10	500	12	Fall, yearly or as needed.	Not closer than 3"
Tall Fescue	10-10-10	500	12		Not closer than 4"
Dwarf Fescue	10-10-10	500	12		Not closer than 2"
Crown Vetch Fescue	0-20-20	400	10	Spring, yearly following establishment and every 4-7 yr. thereafter	Do not mow
Flat Pea Fescue	0-20-20	400	10		Do not mow

Note: Following soil test recommendations is preferred to fertilizer rates shown above.

SODDING

DESCRIPTION

Sod is used to provide immediate soil stabilization in erosive areas such as drainageways and on steep slopes.

CONDITIONS WHERE PRACTICE APPLIES

Sod may be used where immediate cover is required or preferred and where vegetation will be adequate stabilization such as minor swales, around drop inlets, and lawns.

Specifications
for
Sodding

MATERIALS

1. Sod shall be harvested, delivered and installed within a period of 48 hr. Sod not transplanted within this period shall be inspected and approved prior to installation.

2. The sod shall be kept moist and covered during hauling and preparation for placement on the sod bed.

3. Sod shall be machine cut at a uniform soil thickness of 0.75 in., plus or minus 0.25 in., at the time of cutting. Measurements for thickness shall exclude top growth and thatch.

SITE PREPARATION

1. A subsoiler, plow or other implement shall be used to reduce soil compaction and allow maximum infiltration. (Maximizing infiltration will help control both runoff rate and water quality.) Subsoiling shall not be done on slip-prone areas where soil preparation should be limited to what is necessary for establishing vegetation.

2. The area shall be graded and resoiling shall be done where needed.

3. Soil Amendments:
   - Lime--Agricultural ground limestone shall be applied to acid soil as recommended by a soil test. In lieu of a soil test, lime shall be applied at the rate of 100 lb./1,000 sq. ft. or 2 tons/ac.
   - Fertilizer--Fertilizer shall be applied as recommended by a soil test. In lieu of a soil test fertilizer shall be applied at a rate of 12 lb./1,000 sq. ft. or 500 lb./ac. of 10-10-10 or 12-12-12 analysis.
   - The lime and fertilizer shall be worked into the soil with a disk harrow, spring-tooth harrow, or other suitable field implement to a depth of 3 in.

4. Before laying sod, the surface shall be uniformly graded and cleared of all debris, stones and clods larger than 3-in. diameter.

SOD INSTALLATION

1. During periods of excessively high temperatures, the soil shall be lightly irrigated immediately prior to laying the sod.

2. Sod shall not be placed on frozen soil.

3. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly wedged against each other. Lateral joints shall be staggered in a brick-like pattern. Ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would dry the roots.

4. On sloping areas where erosion may be a problem, sod shall be laid with the long edge parallel to the contour and with staggered joints. The sod shall be secured with pegs or staples.

5. As sodding is completed in any one section, the entire area shall be rolled or tamped to ensure solid contact of roots with the soil surface. Sod shall be watered immediately after rolling or tamping until the sod and soil surface below the sod are thoroughly wet. The operations of laying, tamping and irrigating for any piece of sod shall be completed within 8 hr.

SOD MAINTENANCE

1. In the absence of adequate rainfall, watering shall be performed daily or as often as necessary during the first week and in sufficient quantities to maintain moist soil to a depth of 4 in.

2. After the first week, sod shall be watered as necessary to maintain adequate moisture and ensure establishment.

3. The first mowing shall not be attempted until sod is firmly rooted.

Temporary Seeding

Description

Temporary seeding provides erosion control on areas in between construction operations. Grasses which are quick growing are seeded and usually mulched to provide prompt, temporary soil stabilization. It effectively minimizes the area of a construction-site prone to erosion and should be used everywhere the sequence of construction operations allows vegetation to be established.

Conditions Where Practice Applies

Temporary seeding should be applied on exposed soil where additional work (grading, etc.) is not scheduled for more than 45 days. Permanent seeding should be applied if the areas will be idle for more than a year.

Planning Considerations

This practice has the potential to drastically reduce the amount of sediment eroded from a construction-site. Control efficiencies greater than 90% will be achieved with proper applications of temporary seeding. Because practices used to trap sediment are usually much less effective, temporary seeding is to be used even on areas where runoff is treated by sediment trapping practices. Because temporary seeding is highly effective and practical on construction-sites, its liberal use is highly recommended.

Specifications
for
Temporary Seeding

Temporary Seeding Species Selection			
Seeding Dates	Species	Lb./1,000 ft.^{2}	Per Ac.
March 1 to August 15	Oats Tall Fescue Annual Ryegrass	3 1 1	4 bushel 40 lb. 40 lb.
	Perennial Ryegrass Tall Fescue Annual Ryegrass	1 1 1	40 lb. 40 lb. 40 lb.
August 16 to November 1	Rye Tall Fescue Annual Ryegrass	3 1 1	2 bushel 40 lb. 40 lb.
	Wheat Tall Fescue Annual Ryegrass	3 1 1	2 bushel 40 lb. 40 lb.
	Perennial Ryegrass Tall Fescue Annual Ryegrass	1 1 1	40 lb. 40 lb. 40 lb.
November 1 to Spring Seeding	Use mulch only, sodding practices or dormant seeding.		
Note: Other approved seed species may be substituted.			

1. Structural erosion- and sediment-control practices such as diversions and sediment traps shall be installed and stabilized with temporary seeding prior to grading the rest of the construction-site.

2. Temporary seed shall be applied between construction operations on soil that will not be graded or reworked for 45 days or more. These idle areas should be seeded as soon as possible after grading or shall be seeded within 7 days. Several applications of temporary seeding are necessary on typical construction projects.

3. The seedbed should be pulverized and loose to ensure the success of establishing vegetation. However, temporary seeding shall not be postponed if ideal seedbed preparation is not possible.

4. Soil Amendments--Applications of temporary vegetation shall establish adequate stands of vegetation which may require the use of soil amendments. Soil tests should be taken on the site to predict the need for lime and fertilizer.

5. Seeding Method--Seed shall be applied uniformly with a cyclone seeder, drill, cultipacker seeder, or hydroseeder. When feasible, seed that has been broadcast shall be covered by raking or dragging and then lightly tamped into place using a roller or cultipacker. If hydroseeding is used, the seed and fertilizer will be mixed on-site and the seeding shall be done immediately and without interruption.

MULCHING TEMPORARY SEEDING

1. Applications of temporary seeding shall include mulch which shall be applied during or immediately after seeding. Seedings made during optimum seeding dates and with favorable soil conditions and on very flat areas may not need mulch to achieve adequate stabilization.

2. Materials:

   - Straw--If straw is used, it shall be unrotted small-grain straw applied at the rate of 2 tons/ac. or 90 lb./1,000 sq. ft. (two to three bales). The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000-sq.-ft. sections and spread two 45-lb. bales of straw in each section.

   - Hydroseeders--If wood cellulose fiber is used, it shall be used at 2,000 lb./ac. or 46 lb./1,000 sq. ft.

   - Other--Other acceptable mulches include mulch mattings applied according to manufacturer's recommendations or wood chips applied at 6 tons/ac.

3. Straw mulch shall be anchored immediately to minimize loss by wind or water. Anchoring Methods:

   - Mechanical--A disk, crimper, or similar type tool shall be set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but, generally, be left longer than 6 in.

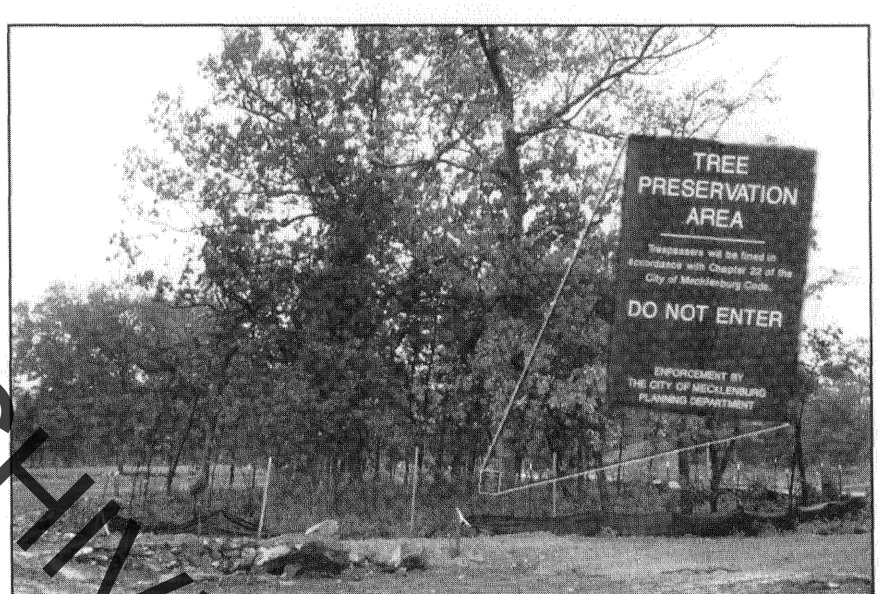
   - Mulch Nettings--Nettings shall be used according to the manufacturer's recommendations. Netting may be necessary to hold mulch in place in areas of concentration runoff and on critical slopes.

   - Asphalt Emulsion--Asphalt shall be applied as recommended by the manufacturer or at the rate of 160 gal./ac.

   - Synthetic Binders--Synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Tack or equal may be used at rates recommended by the manufacturer.

   - Wood-Cellulose Fiber--Wood-cellulose fiber binder shall be applied at a net dry weight of 750 lb./ac. The wood-cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 lb./100 gal.

Tree Preservation Area



Description

Trees that exist on-site prior to development may be protected so they will continue to survive after construction. Tree preservation may be used to protect areas of forest such as buffer strips along streams or to protect individual specimen trees.

Planning Considerations

Forest Delineation--Tree preservation must begin before the location of buildings, roads and utilities is determined. The early site planning should include an inventory of trees. The tree inventory should be considered along with other site characteristics such as topography, streams and wetlands. Useful information in the inventory includes:

- Individuals trees over a given size (ie., 6 in. in diameter),
- Number of trees per size,
- Total number of species,
- Specimen trees.

DESIGN CRITERIA

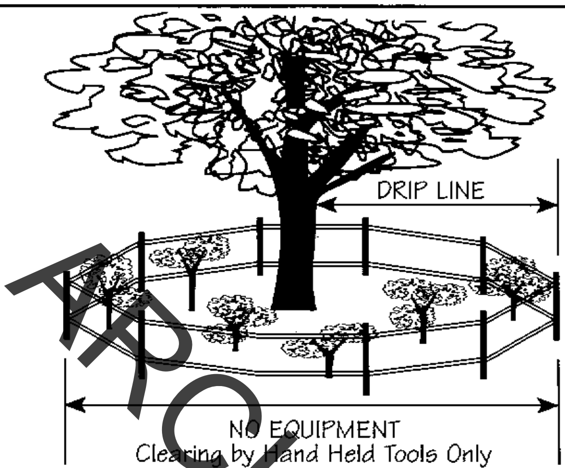
Site Plan--For tree preservation to be effective, the following should be part of the site plan and erosion-control plan:

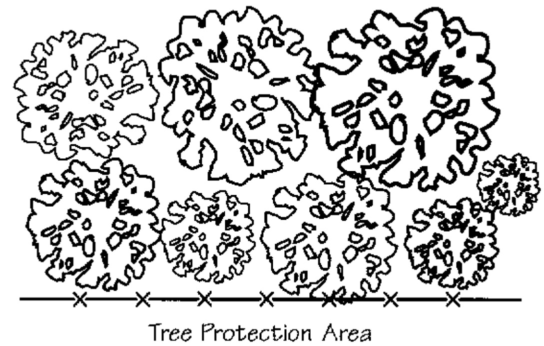
- Limits of clearing and grubbing and tree preservation areas,
- Specimen trees identified by size and type,
- Measures to protect preservation areas during construction,
- Measures to protect preservation areas following construction,
- Areas for reforestation.

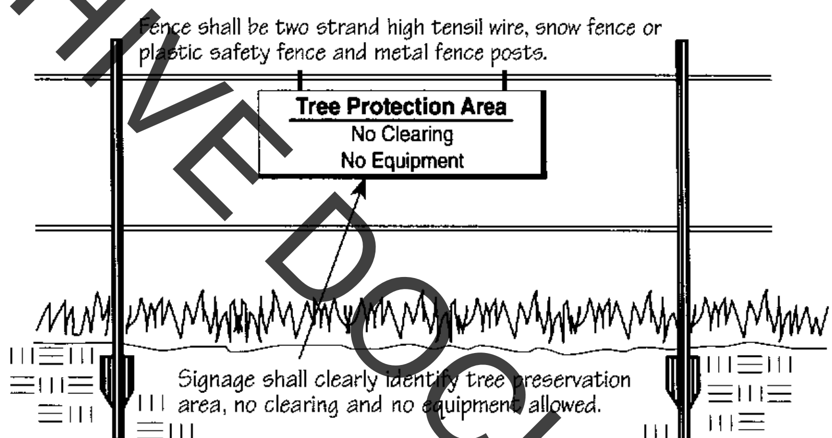
Protection During Construction--Tree protection areas must be made visible during construction. A physical barrier of a fence and signage must be in place prior to clearing and remain in place throughout construction. A tree's root zone is critical to its ability to survive. Damaging the root zone during construction will lead to that tree's death, whether that occurs within 1 yr. or 10. Ninety-five percent of a tree's roots are in the upper 12-18 in. of soil, and the majority of the roots supplying nutrients and water are found just below the soil surface. The critical root zone extends at least to the drip zone of a tree and must be protected from soil compaction, grubbing small trees and other disturbance.

Permanent Visual Barrier--Protecting forest vegetation requires permanent visual barriers to encroachment. It is not enough to protect areas with conservation easements, deed restrictions or even separate ownership. Forested stream buffers, parks and valuable wood lots are often severely degraded by mowing, removal of understory and ground cover, and dumping yard waste. Permanent signs or fences should identify the area and describe allowable uses.

Specifications
for
Tree Preservation Area







1. Tree preservation areas shall be fenced prior to beginning clearing operations.

2. Fence materials shall be metal fence posts with two strands of high tensile wire, plastic fence or snow fence.

3. Signage shall clearly identify the tree protection area and state that no clearing or equipment is allowed within it.

4. Fence shall remain around tree protection areas until after final grading has been completed.

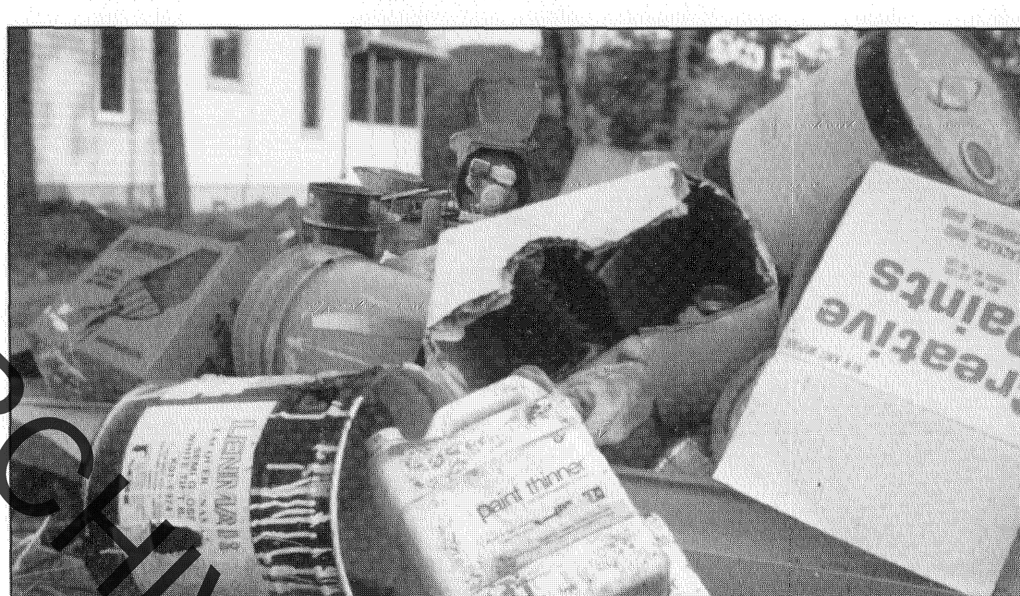
5. Fence shall be placed as shown on plans and beyond the drip line or canopy of trees to be protected.

6. If any clearing is done around specimen trees it shall be done by cutting at ground level with hand held tools and shall not be grubbed or pulled out. No clearing shall be done in buffer strips or other preserved forested areas.

CHAPTER 7

GENERAL POLLUTION PREVENTION PRACTICES

Non-Sediment Pollution Control



Description

Although sediment is the primary pollutant resulting from construction activity, other pollutants need to be considered as well. These include petrochemicals: fuel, oil, and asphalt; and construction chemicals: paints, solvents, fertilizer, soil additives, concrete wash water, etc. Also included are solid wastes and construction debris. Keeping these substances from polluting runoff can be accomplished to a large extent through good housekeeping and following the manufacturer's recommendations for their use and disposal.

Conditions Where Practice Applies

Hazardous and toxic substances are used on virtually all construction-sites. Good management of these substances is always needed.

Planning Considerations

Good erosion and sediment control will prevent some pollutants in addition to sediment from leaving the site; however, pollutants carried in solution or as surface films on runoff water will be carried through most erosion and sediment control practices. These pollutants become nearly impossible to control once present in offsite runoff. Adding to the problem is the fact that construction wastes, many containing toxic chemicals, are routinely buried on-site, dumped on the ground, poured down a storm drain, or disposed of with construction debris. So while typical erosion and sediment-control practices are important for controlling other pollutants, additional preventative measures are needed.

Reducing pollutants other than sediments depends heavily on construction personnel and how they carry out their operations. To help facilitate this, plans should contain standard notes clearly stating requirements to contractors. It also may be appropriate to include requirements for specific provisions for hazardous materials storage, handling and disposal.

Specifications
for
Non-Sediment Pollution Control

1. Construction personnel, including subcontractors who may use or handle hazardous or toxic materials, shall be made aware of the following general guidelines:

Disposal and Handling of Hazardous and Other Construction Waste

DO:
- Prevent spills
- Use products up
- Follow label directions for disposal
- Remove lids from empty bottles and cans when disposing in trash
- Recycle wastes whenever possible

DON'T
- Don't pour into waterways, storm drains or onto the ground
- Don't pour down the sink, floor drain or septic tanks
- Don't bury chemicals or containers
- Don't burn chemicals or containers
- Don't mix chemicals together

2. Containers shall be provided for collection of all waste material including construction debris, trash, petroleum products and any hazardous materials to be used on-site. All waste material shall be disposed of at facilities approved for that material.

3. No waste materials shall be buried on-site. Site personnel, including subcontractors shall be notified that no construction-related materials are to be buried on-site.

4. Mixing, pumping, transferring or otherwise handling construction chemicals such as fertilizer, lime, asphalt, concrete drying compounds, and all other potentially hazardous materials shall be performed in an area away from any watercourse, ditch or storm drain.

5. Equipment fueling and maintenance, oil changing, etc., shall be performed away from watercourses, ditches or storm drains, in an area designated for that purpose. The designated area shall be equipped for recycling oil and catching spills.

6. Concrete wash water shall not be allowed to flow to streams, ditches, storm drains, or any other water conveyance. A sump or pit shall be constructed if needed to contain concrete wash water.

7. If hazardous substances such as oil, diesel fuel, hydraulic fluid, antifreeze, etc. are spilled, leaked, or released onto the soil, the soil should be dug up and disposed of with the trash at a licensed sanitary landfill (not a construction/demolition debris landfill). Spills on pavement shall be absorbed with sawdust or kitty litter and disposed of with the trash at a licensed sanitary landfill. Hazardous or industrial wastes such as most solvents, gasoline, oil-based paints, and cement curing compounds require special handling. Contact Ohio EPA (1-800-282-9378).

8. Spills of 25 gal. or more of petroleum products shall be reported to Ohio EPA (1-800-282-9378), the local fire department, and the Local Emergency Planning Committee within 30 min. of the discovery of the release.

SMALL LOT BUILDING SITES

DESCRIPTION

These are general pollution prevention practices appropriate for small projects or for construction done by separate builders, but which still are part of a larger common plan of development.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies most commonly to builders of single-family homes on lots that have been purchased from a land developer who, typically, has constructed roads and utilities. This standard also may be used for projects too small or short term to justify developing a plan defining specific pollution-control structures. Small short-term projects generally are an acre or less and do not last more than a few weeks.

PLANNING CONSIDERATIONS

Single-family housing development creates a challenging condition for controlling sediment pollution during construction. First, during single-family residential development, the highest sediment pollution rates typically occur in the home-building phase. This is due to the intensity of activity and the fact that the drainage system is usually functional at this point. Second, it is difficult to determine who is responsible for erosion and sediment control as builders purchase lots from the land developer and as numerous contractors and subcontractors become involved.

The initial stormwater pollution prevention plan can do much to reduce the amount of sediment pollution produced throughout single-family housing development. The control practices that can be used on a development-wide scale are much more effective than what can be accomplished on individual lots. Sediment pollution can be significantly reduced if the initial plan is designed to remain in effect well into the building of individual homes. The initial sediment-control system of settling ponds, diversions, etc., should remain functional as far into the home-building phase as is feasible. The initial plan also should describe practices individual builders must implement on individual lots as is described in the following specifications.

Specifications for Small Lot Building Sites

1. Preexisting vegetation shall be retained on idle portions of the building lot for as long as construction operations allow. Clearing shall be done so only active working areas are bare.

2. Temporary seed (annual rye, oats, etc.) and/or mulch shall be applied to areas, such as stockpiles, that are bare and not actively being worked. This shall apply to areas that will not be reworked for 14 days or more.

3. Stockpiles excavated from basements shall be situated away from streets, swales, or other waterways and shall be seeded and/or mulched.

4. Silt fence shall control sheet flow runoff from the building lot. It shall not be constructed in channels or areas of concentrated flow. Other sediment controls such as inlet protection and sediment traps shall also be used as needed to control sediment runoff.

5. Construction vehicle access shall be limited to one route, to the greatest extent practical. The access shall be gravel or crushed rock applied to the driveway area.

6. Mud tracked onto the street or sediment settled around curb inlet protection shall be removed daily or as needed to prevent it from accumulating. It shall be removed by shovelling and scraping and shall NOT be washed off paved surfaces or into storm drains.