923

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/VA-R13		

4. Title and Subtitle	5. Report Date
VDOT Manual of Practice for Planning Stormwater Management	January 1992
	6. Performing Organization Code 2758-057-940
7. Author(s) Shaw L. Yu & Robert J. Kaighn, Jr.	8. Preforming Organization Report No.
9. Performing Organization Name and Address Virginia Transportation Research Council Box 3817, University Station Charlottesville, Virginia 22903-0817	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Virginia Department of Transportation 1401 E. Broad Street Richmond, Virginia 23219	13. Type of Report and Period Covered Final Report July 1990–August 1991 14. Sponsoring Agency Code

15. Supplementary Notes

In Cooperation with the U.S. Department of Transportation Federal Highway Administration.

16. Abstract

The final report is in the form of a manual of practice for the VDOT to use in planning its stormwater management strategies. The manual was proposed to aid in the selection and design of erosion control practices and stormwater control practices for transportation projects in Virginia. Information obtained from Virginia, other states, and the literature was compiled to help describe the best management practices that will comply with the applicable regulations. Discussed herein are site selection, design of practices, and maintenance and safety considerations. Other topics discussed include applicable federal and state regulations and computer models.

17. Key Words	18. Distribution Statement
Stormwater management, regulations, best management practices, erosion and sediment control, manual of practices	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Clasif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	190	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

FINAL REPORT

VDOT MANUAL OF PRACTICE FOR PLANNING STORMWATER MANAGEMENT

Shaw L. Yu, Ph.D.
Faculty Research Scientist

Robert J. Kaighn, Jr.
Graduate Research Assistant

(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by
the Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

March 1992
VTRC 92-R13

ENVIRONMENTAL RESEARCH ADVISORY COMMITTEE

ACKNOWLEDGMENTS

This manual was written under the general supervision of Dr. Gary R. Allen, Director of the Virginia Transportation Research Council. Special thanks go to Harry E. Brown, former Senior Research Scientist and Team Leader, for his assistance during the course of this study. The project was financed with HPR funds administered by the Federal Highway Administration.

Calvin F. Boles III, State Hydraulics Engineer, VDOT, and his colleagues Charles McIver and David LeGrande are gratefully acknowledged for their assistance and many suggestions and comments made throughout the duration of this project.

The authors also thank Roger Howe, Linda Evans, Linda Barsel, Randy Combs, and Arlene Fewell, all of VTRC, for their assistance in the production of this report.

TABLE OF CONTENTS

9301

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

Chapter 1

OVERVIEW

1.1 INTRODUCTION

Traditionally, the purpose of highway drainage has always been "to remove stormwater runoff from the roadway." This philosophy is still prevalent in highway drainage design manuals throughout the United States. However, changes reflecting concerns about stormwater runoff pollution are forthcoming due to the Environmental Protection Agency (EPA) stormwater regulations passed in 1990. In some states, such as Virginia, stormwater management (SWM) regulations are already in effect and transportation activities must comply with them.

The EPA stormwater regulations require that major municipal and industrial (including transportation) stormwater discharges be permitted in accordance with the provisions of the EPA's National Pollutant Discharge Elimination System (NPDES) program by late 1992. The impact of the NPDES requirements on transportation operations will mainly be in three areas:

1. highway storm sewers that convey runoff to a municipal system that is subject to permitting
2. construction projects that will disturb an area greater than 5 acres
3. relevant facilities such as maintenance shops, material handling facilities, and contractor batch plants

In Virginia, it is expected that the NPDES Permit Program will be administered by the State Water Control Board. Currently, the Board is working with the EPA to develop a "general permit" program that will be applicable to the Virginia Department of Transportation (VDOT) to address items 2 and 3.

In addition to the EPA regulations, VDOT must also comply with the Chesapeake Bay Preservation Act, the Virginia Stormwater Management Regulations (SWMR), and the Virginia Erosion and Sediment Control Regulations (ESCR). The SWMR and the ESCR are administered by the Virginia Department of Conservation and Recreation.

1.2 OBJECTIVES OF THIS MANUAL

One of the key requirements of both the EPA and the Virginia stormwater regulations is the use of "best management practices" (BMPs) for controlling the quantity and quality of stormwater runoff. These BMPs include nonstructural methods, such as management of deicing compound usage, and structural methods, such as the use of detention basins. On the other hand, the erosion and sediment (E&S) control regulations require the use of facilities such as sedimentation basins for controlling erosion during road construction. It was, therefore, a prudent approach to develop a manual of practice for VDOT to implement in order to satisfy both the stormwater and the E&S control regulations.

The objectives of this manual are as follows:

1. To document the relevant federal, state, and local regulations regarding SWM and E&S control.

2. To provide information on BMPs in terms of the following:

   - capability to control the quantity of stormwater runoff
   - efficiency in removing stormwater runoff pollution
   - design guidelines
   - maintenance and safety considerations

3. To assist transportation engineers in planning, selecting, and designing BMPs.

1.3 OUTLINE OF THIS MANUAL

Chapter 2 discusses various federal and state regulations, including the NPDES Stormwater Permit Regulations, the Virginia ESCR and SWMR, and the Chesapeake Bay Preservation Act.

Chapters 3, 4, and 5 discuss the different practices used to control the quantity and quality of stormwater runoff. Chapter 3 addresses the selection of a BMP for a particular site. Chapter 4 discusses the different BMPs and their design. Chapter 5 describes the maintenance and safety aspects of the BMPs.

Chapter 6 discusses some of the commonly used computer models for SWM, and Chapter 7 provides case examples from highway projects.

The Virginia and the EPA regulations are provided in the appendixes.

Chapter 2

REVIEW OF GENERAL CRITERIA AND REGULATIONS

2.1 INTRODUCTION

The criteria summarized in Sections 2.2 and 2.3 were taken from regulations set forth by the VDCR and the implementation procedures of VDOT. State projects that disturb more than 10,000 square feet of land are required to comply with the ESCR, and projects that disturb 1 acre or more are required to comply with the SWMR. Unlike the ESCR, which are valid from the beginning of the land-clearing activity, the SWMR are considered applicable upon the completion of construction.

Section 2.4 summarizes the Chesapeake Bay Preservation Act and its effects on VDOT. Section 2.5 discusses the EPA's new NPDES regulations, and Section 2.6 reviews regulations from three other states. The ESCR, SWMR, Chesapeake Bay Preservation Act, and NPDES regulations are included in Appendix A.

2.2 EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION

In July 1990, the VDCR adopted the updated ESCR, which became effective in September 1990. The primary method used to control erosion is the establishment of vegetative stabilization. The following regulations must be complied with:

- Vegetative controls shall be applied within 48 hours after stabilization becomes necessary.
- Permanent or temporary stabilization shall be applied to an area when the final grade is reached or if an area reaches a stage in which it will remain dormant for more than 15 days.
- Permanent stabilization shall be applied to areas that will remain dormant for more than 1 year.
- Stockpiles shall be stabilized and/or protected with trapping measures.
- Seeding on slopes shall be staged to reduce the amount of exposed soil at any point in time.
- Slopes shall be permanently stabilized in steps, depending on their vertical height:

  —slopes with a height greater than 75 feet shall be stabilized in 25-foot increments

  —slopes with a height greater than 20 feet but less than 75 feet shall be stabilized in three equal increments

—slopes with a height greater than 5 feet but less than 20 feet shall be stabilized in two equal increments

—slopes with a height of 5 feet or less may be seeded in one application.

- There shall be a permanent vegetative cover on areas that are not temporarily stabilized or where construction activities are completed. This cover shall not be considered "established" until it is determined that it will inhibit erosion and is mature enough to survive.

- All sediment trapping measures shall be in place before upslope construction begins, and stabilization shall be applied to earthen control structures, such as dams and dikes, within 48 hours of installation.

- When all temporary E&S controls are no longer needed, or within 30 days after the final site stabilization, all of the control measures shall be removed unless they are otherwise proved to be necessary. Trapped sediment and the disturbed areas where the controls were located shall be permanently stabilized.

- If runoff from an area of 3 acres or more flows across a disturbed area, a sediment basin shall be used as the control measure. It shall be designed to accommodate the anticipated loading, and the outlet should be designed to accommodate the entire drainage area.

- Cut and fill slopes shall be stabilized to minimize erosion. Concentrated runoff shall not flow down a cut or fill slope unless it is contained in an adequate channel, flume, or slope drain to prohibit erosion. Measures shall be taken to protect the slope from erosion where water seeps from a slope face.

- Storm sewer inlets made operable during construction shall be protected so that sediment-laden runoff cannot enter without being adequately treated (usually by filtering and/or settling). New stormwater conveyances shall have adequate channel linings and outlet protection.

- When work is being conducted in a live watercourse, all applicable federal, state, and local regulations shall be complied with. When a live watercourse must be crossed twice in a 6-month period, a nonerodible temporary stream crossing shall be provided. Work in a live watercourse shall be done so as to minimize both encroachment and sediment transport. Causeways and cofferdams shall be constructed of nonerodible materials; earthen fill may be used in their construction if it is covered by nonerodible materials. When work in the watercourse is complete, the bed and the banks of the watercourse shall be stabilized.

- When underground utility lines are being installed, no more than 500 linear feet of a trench may be opened at one time and excavated material shall be placed on the uphill side of the trench. Effluent from dewatering shall be treated to remove sediment and discharged in a manner that does not adversely affect flowing streams or off-site property. The area shall be restabilized in accordance with the previously stated criteria, and the work shall be in compliance with all other regulations.

- The vehicular tracking of soil onto public roads shall be minimized. The roads shall be cleaned at the end of each day by shoveling or sweeping of the tracked sediment to a control area. Street washing may be done only after the road has been swept or shoveled.

- Downstream areas shall be protected from sediment deposition, erosion, and damage from increased volume and velocity of stormwater runoff. Increased volumes of sheet flows that may cause erosion or sedimentation on adjacent property shall be diverted to a stable outlet, an adequate channel, or a detention facility. Concentrated runoff leaving a site shall be discharged directly into an adequate natural or manmade channel or into a storm sewer system or pipe. The channel will be considered adequate if one of the following can be proven:

  —the total drainage area to the point of analysis within the channel is 100 times greater than the contributing area of the project

  —for natural channels, a 2-year 24-hour storm will not overtop the channel banks or cause erosion of the channel banks or bed

  —for manmade channels, a 10-year 24-hour storm will not overtop the channel banks and a 2-year 24-hour storm will not cause erosion of the channel banks or bed

  —for pipes and storm sewers, a 10-year 24-hour storm will be contained within the system.

  If none of the previously described conditions can be met, then one of the following measures must be taken:

  —the channel shall be improved so that a 10-year 24-hour storm will not overtop its banks and a 2-year 24-hour storm will not cause erosion to the channel banks or bed

  —the pipe or pipe system shall be improved so that a 10-year 24-hour storm is contained within the system

  —a new site plan shall be developed so that site runoff is conveyed by adequate channels and piping systems

  —a combination of improvements, site plan changes, and detention/retention or other measures that will satisfactorily prevent downstream erosion shall be taken.

- All hydrologic analysis shall be based on the existing watershed characteristics and the ultimate development condition within the project limits.

2.3 POSTCONSTRUCTION STORMWATER MANAGEMENT CONTROLS

Effective January 1, 1991, all state agencies must comply with Virginia's SWMR on any land-clearing activity disturbing more than 1 acre. The following regulations apply:

- When developing in an area regulated by a locality, the agency shall honor the locality's requirement to the extent practicable.
- Construction shall comply with applicable laws and regulations, and appropriate permits shall be obtained.
- Construction shall be avoided in flood plains and shall be in compliance with the regulations of the National Flood Insurance Program.
- Utility rights of way shall be checked to ensure that they are not within stormwater impoundment areas (if utility lines are covered with water, repairs and maintenance are more difficult).
- To reduce the risk of flooding, the peak flow from the developed area shall not exceed the predevelopment flows resulting from a 2- and a 10-year storm (individually, not in combination). The peak flows can be estimated by use of a 24-hour storm from the method of the Soil Conservation Service (SCS) or the estimated maximum runoff when empirical formulae such as the rational method are used. For these calculations, preconstruction land conditions are assumed to be in good condition.
- The discharge from an SWM facility should flow into an adequately sized channel and maintain a nonerosive velocity while in the channel. It is widely thought that the postconstruction discharge velocity will not be erosive if the 2-year preconstruction velocity is maintained.
- The runoff shall be detained for an extended period of time, thus allowing some of the pollutants to settle out. A water quality volume (WQV) equal to the first 0.5 inch of runoff from the developed area shall be treated. For detention basins, the WQV shall be detained at least 30 hours from the time of peak storage of the WQV until the basin is empty again, thus allowing enough time for adequate treatment. To prevent the outlet from clogging, a minimum 3-inch outlet shall be used even if the detention time is thereby decreased. For a retention basin, the permanent pool volume shall be at least 3 times the WQV; this will allow for a sufficient detention time. For an infiltration facility, the WQV shall be infiltrated from the facility within 48 hours.

Other methods, including using vegetated swales and buffers, minimizing impervious surfaces, and land use planning, can be used in conjunction with, but not in place of, these measures. The use of such practices will not only improve the quality and reduce the quantity of stormwater runoff from a developed area but can also lead to a reduction in the total cost needed for SWM. The requirements for quality are summarized in Table 1.

Table 1
REQUIREMENTS FOR MANAGEMENT PRACTICES IN VIRGINIA

Management Practice	Quality Requirement	Quantity Requirement
Detention basin	Detain WQV[a] for 30 hr (minimum 3-in opening)	Postconstruction 2- and 10-yr peak flows equal to preconstruction levels; maintain a nonerosive velocity
Retention basin	Permanent pool is 3 × WQV	
Infiltration facility	WQV infiltrated in 48 hr	

[a]WQV = water quality volume, taken as the first 0.5 inch of stormwater runoff.
Data from Virginia Department of Conservation and Recreation.[6]

2.4 CHESAPEAKE BAY PRESERVATION ACT

To protect the Chesapeake Bay from non–point source pollution, the Chesapeake Bay Preservation Act was created to reduce the amount of pollutants flowing into the bay. Areas affected by the act are in Tidewater Virginia (most areas east of I-95). The act does not supersede the SWMR or the ESCR but is an additional requirement. In these areas, localities have designated Chesapeake Bay preservation areas (CBPAs) where development could severely affect water quality. These areas include a 100-foot buffer around wetlands, tidal shores, tributary streams, and floodplains; areas with highly erodible or permeable soils; and other areas designated by the locality. If development occurs in one of these CBPAs, the following requirements apply:

1. no net increase in non–point source pollution for new development
2. a 10% reduction in non–point source pollution for redevelopment
3. a 40% reduction in non–point source pollution for development on agricultural and silvicultural lands.

These requirements are implemented by computation of the pre- and post-development loadings of a selected "keystone" pollutant. The keystone pollutant used for this purpose is phosphorus. Phosphorus is used because it contributes significantly to problems of water quality in receiving water bodies, such as the Chesapeake Bay. Also, a reduction in phosphorus will most likely lead to a proportional reduction in most other pollutants.

Public roads are exempt from these requirements if they are in compliance with the SWMR and the ESCR. Section 4.5B of the Chesapeake Bay Preservation Act states:

> Construction, installation, operation, and maintenance of . . . public roads and their appurtenant structures in accordance with the regulations promulgated pursuant to (i) Erosion and Sediment Control Law and (ii) the Stormwater Management Act, or an erosion and sediment control plan approved by the Department of Conservation and Recre-

ation, will be deemed to constitute compliance with these regulations. The exemption of public roads is further conditioned on the following:

a. Optimization of the road alignment and design, consistent with other applicable requirements to prevent or otherwise minimize (i) encroachment in the Resource Protection Area and (ii) adverse effects on water quality;

b. Local governments may choose to exempt (i) all public roads as defined in §1.4 of these regulations, or (ii) only those public roads constructed by the Virginia Department of Transportation.

Where a public road is defined in §1.4 as:

> a publicly-owned road designed and constructed in accordance with policies, procedures and criteria of the Virginia Department of Transportation, including regulations promulgated pursuant to (i) the Erosion and Sediment Control Law and (ii) the Virginia Stormwater Management Act. This definition includes those roads where the Virginia Department of Transportation exercises direct supervision over the design or construction activities, or both.

Other VDOT projects in CBPAs must be in compliance with the requirements, along with the ESCR and the SWMR. A hotline has been established for questions about the act: 1-800-CHES-BAY.

2.5 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In November 1990, the EPA established new regulations regarding the discharge of stormwater runoff under the NPDES. By November 1992 and May 1993, the discharge of stormwater runoff from large (population greater than 250,000) and medium (population greater 100,000 but less than 250,000) municipal storm sewer systems, respectively, will require an NPDES permit. In Virginia, the municipalities affected are the cities of Norfolk, Virginia Beach, Alexandria, Chesapeake, Hampton, Newport News, Portsmouth, Richmond, and Roanoke and the counties of Fairfax, Arlington, Henrico, and Chesterfield. When stormwater runoff from a VDOT project site discharges into one of these municipal storm sewers, VDOT could be asked to provide information on the discharge and be involved in the application process, or even be a coapplicant. Transportation facilities classified as Standard Industrial Classifications (SIC) 40, 41, 42 (except 4221–25), 43, 44, 45, and 5171 are subject to permit requirements under the category of "runoff from industrial activities." Also covered by the new regulations are construction projects that disturb more than 5 acres. These projects will require a permit describing the nature of the construction and the stormwater control measures used during and after construction.

Three requirements will take effect in May 1992. A summary of the NPDES requirements for a permit application for stormwater discharges is included in the Appendix. A hotline has been established for questions about the new NPDES regulations, in particular dealing with stormwater: (703)-821-4660. Stormwater discharges from industrial activity, including discharges from transportation facilities such as vehicle maintenance shops, equipment cleaning operations, material handling facilities, and general building or heavy equipment contractors, will require a permit. This will affect district, residency, and area headquarter shops; loading docks; heavy equipment storage and parking areas; and deicing storage areas.

Batch manufacturing plants set up for project operations will require a permit if stormwater discharges from the site go into state waters. For example, if a paving contractor creates a batch plant for paving operations, an NPDES permit may be required.

2.6 REGULATIONS FROM OTHER STATES

In this section, regulations from several other states are reviewed to provide a brief description of how some other states are dealing with SWM issues.

2.6.1 Florida

Florida has established an SWM program requiring a discharge permit for new stormwater discharge facilities. These facilities should be designed to comply with water quality standards. The facilities that the program suggests will be needed for treating the runoff from 1 1/2 inches of rainfall (this amount may vary depending on the site) include detention basins (wet and dry ponds), filtration systems (including not only infiltration facilities but also systems filtering runoff through a granular media and discharging via an underdrain pipe), retention basins (infiltration basins), and grassed swales (which are to be designed to infiltrate 80% of the stormwater runoff over 72 hours from a 3-year 1-hour event).

2.6.2 North Carolina

North Carolina's regulations are very similar to those of Florida requiring a permit for discharges. Methods of treating the required stormwater volume (the runoff from 1 to 1 1/2 inches of rainfall, depending on particular site conditions) are infiltration systems (including basins, vegetative filters, and swales) and wet ponds. The regulations also allow the use of innovative systems that are not well-established methods for controlling stormwater runoff but are reasonably expected to be successful.

2.6.3 Vermont

An agreement is proposed between Vermont's Agency of Transportation (AOT) and Agency of Natural Resources (ANR) that would allow the use of overland flow and grassed swales to treat runoff. These areas should be designed to have 100 linear feet of swale or filter per impervious acre at a slope of less than 5% and at a maximum velocity of 2 feet per second for the runoff from a 10-year 24-hour storm. Quantity is also discussed in this agreement, and the AOT must control the peak discharge from a 10-year 24-hour storm when the drainage area above the AOT project is less than 30 square miles.

Chapter 3

SELECTING A CONTROL PRACTICE FOR A PARTICULAR SITE

3.1 INTRODUCTION

The selection of a control practice for either E&S control or SWM is very important. Every project is different, and thus each could use various practices that would function more efficiently for the given circumstances.

3.2 EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION

For the control of erosion and sedimentation, a wide variety of measures are available to the engineer and planner. Although many of the practices seem dissimilar, they all attempt to prevent soil from eroding and reduce the amount of sediment in the runoff. Overall, prevention is the best method of E&S control. The measures described in this section should be used wherever possible.

3.2.1 Vegetative Controls

The two types of vegetative controls are temporary seeding, required on areas that will be dormant for 15 days or more, and permanent seeding, required on areas that will be dormant for 1 year or more. The type of vegetation that is applied depends on the season, site conditions, and relative costs of the different types of vegetation.

3.2.1.1 Temporary Seeding

The selection of the type of temporary stabilization is dependent on season, site conditions, and relative cost. Descriptions of several types of temporary seeding are given in the *Virginia Erosion & Sediment Control Field Manual.*[4] A selection can be made from the descriptions based on season and site conditions. Table 2 shows the seeding dates for selected temporary seeding. Cost should also be considered when a choice is made.

3.2.1.2 Permanent Seeding

The selection of the type of permanent stabilization is dependent on climate, topography, soils, land use, planting season, and relative cost. Usually, a mixture of seeds is applied to an area, including some rapid growth varieties and some more permanent species. Descriptions of several types of permanent seeding are given in the *Virginia Erosion & Sediment Control Field Manual.*[4] A selection can be made from the descriptions based on season and site conditions. Cost should also be considered when a choice is made. Tables 3 through 6 were taken from the *Virginia*

Table 2
SEEDING DATES FOR SELECTED TEMPORARY STABILIZATION

Species	Seeding Dates		
	3/1 to 4/30	4/30 to 8/15	8/15 to 11/1
Oats	•		
Rye	•		•
German millet		•	
Korean lespedeza	•	•	
Weeping lovegrass		•	
Annual ryegrass	•		•
Crimson clover			•

Source: Virginia Soil and Water Conservation Commision. 1980. *Virginia erosion and sediment control handbook*. Richmond.

Erosion & Sediment Control Handbook.[6] The first two tables describe seeding mixtures rates and planting season dates for different site conditions and different regions of Virginia. The last two tables describe some common erosion control grasses.

3.2.2 Structural Controls

Structural (nonvegetative) practices should be used in conjunction with vegetative soil stabilization to reduce the amount of erosion. The primary purpose of these controls is to reduce the erosive power of runoff and facilitate ponding, thus allowing time for eroded sediment to be settled out of the runoff.

In choosing different controls, the engineer is constrained in some areas. For example, drainage from a site larger than 3 acres must be controlled by a sediment basin. However, at other locations on a project, there are a wide variety of controls to choose from, including diversion dikes, silt fences, brush barriers, and check dams. In choosing a control device, it is necessary to consider the degree of control required (relative to the sensitivity of adjacent areas), runoff characteristics, and cost. For example, Table 7 compares the filtering efficiencies and rate of flow through three types of sediment filtering material. Depending on how much removal is required and other considerations, the optimum filter material can be selected for a particular site.

Another consideration is how the facility can be incorporated into future needs. For example, a properly designed sediment basin can also be used as an SWM pond after construction is finished. Cost should also be considered when a control device is chosen.

Table 3
PERMANENT SEEDING MIXTURES, RATES AND DATES:
NORTHERN PIEDMONT AND MOUNTAIN REGION

Site Conditions	Seeding Mixtures		Rates		Dates		
			Per Acre	Per 100 ft²	3/15 to 5/1	5/1 to 8/15	8/15 to 10/1
High maintenance lawns	1. Kentucky bluegrass—a blend of 4 or more varieties	100%	140 lb	3 lb	•		•
	(No variety shall be more than 30% of total mixture.)						
	Note: Up to 50% of mixture may be red fescue where lawns are shaded.						
	2. Tall fescue	80%	200 lb	6 lb	•		•
	Kentucky bluegrass (Kenblue or So. Dakota Cert.)	10%					
	Note: May also be used on low-maintenance lawns.						
Low maintenance, general use	3. Tall fescue	50%	80 lb	2 lb	•	•[a,b]	•
	Ladino clover	10%					
	Red clover	10%					
	Korean lespedeza	15%					
	Annual ryegrass	15%					
	4. Tall fescue	50%	70 lb	1 1/2 lb	•	•[a]	•
	Sericea lespedeza	30%					
	Annual ryegrass	15%					
	Redtop	5%					
Slopes	5. Crown vetch	50%	40 lb	1 lb	•		•
	Perennial ryegrass	40%					
	Redtop	10%					
	6. Flat pea	50%	80 lb	2 lb	•		•
	Tall fescue	50%					

continues

Table 3 (continued)

Site Conditions	Seeding Mixtures		Rates		Dates		
			Per Acre	Per 100 ft²	3/15 to 5/1	5/1 to 8/15	8/15 to 10/1
Droughty areas	7. Tall fescue	65%	80 lb	2 lb	•		•
	Reed canarygrass	20%					
	Annual ryegrass	15%					
	8. Tall fescue	60%	70 lb	1 1/2 lb	•	•[a]	•
	Sericea lespedeza	30%					
	Redtop	10%					

[a] After May 15, use 10 lb/A German miller or 2 lb/A weeping lovegrass in place of annual ryegrass or redtop.
[b] After May 15, omit Korean lespedeza and increase red clover to 20% of mixture.
Source: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook*. Richmond.

Table 4
PERMANENT SEEDING MIXTURES, RATES AND DATES: SOUTHERN PIEDMONT AND COASTAL PLAIN

Site Conditions	Seeding Mixtures		Rates		Dates		
			Per Acre	Per 100 ft^2	3/15 to 5/1	5/1 to 8/15	8/15 to 10/1
High-maintenance lawns	1. Tall fescue	90%	250 lb	6 lb	•		•
	Kentucky bluegrass	10%					
Low maintenance, general use	2. Tall fescue	50%	80 lb	2 lb	•	•[a,b]	•
	Ladino clover	10%					
	Red clover	10%					
	Korean lespedeza	15%					
	Annual ryegrass	15%					
	3. Tall fescue	50%	70 lb	1 1/2 lb	•	•[a]	•
	Sericea lespedeza	30%					
	Annual ryegrass	20%					
Droughty areas, sandy soils	4. Tall fescue	50%	80 lb	2 lb	•	•[a,b]	•
	Sericea lespedeza	20%					
	Korean lespedeza	15%					
	Annual ryegrass	15%					
Poorly drained areas	5. Tall fescue	65%	80 lb	2 lb	•	•[a,b]	•
	Korean lespedeza	20%					
	Annual ryegrass	10%					
	Redtop	5%					

[a] After May 1, use 10 lb/A German miller or 2 lb/A weeping lovegrass in place of annual ryegrass.
[b] After May 1, Korean lespedeza will not reseed itself. The amount of other legumes may be increased accordingly.
Source: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

Table 5
CHARACTERISTICS OF GRASSES APPROPRIATE FOR PERMANENT EROSION CONTROL

Common Name (Botanical Name)	Life Cycle	Season	Sod-Former	Bunch Grass	Gernibnation Time in Days	pH Range	Drainage: Droughty	Drainage: Well	Drainage: Mod. Well	Drainage: Somewhat Poorly	Drainage: Poorly	Drainage: Flood Tolerant	Maintenance Requirements	Remarks	Suggested Varieties for Virginia
Kentucky bluegrass (*Poa pratense*)	P	C	•		10–28	6.0–7.0		•	•	•		•	Needs fertile soil, favorable moisture, and liberal phosphorus.	Suitable for fine turf. Poor drought and heat tolerance.	Many
Perennial ryegrass (*Lolium perenne*)	sP	C		•	5–14	5.5–7.5		•	•	•		•	Similar to bluegrass.	Best when used with bluegrass as 20% or less of mixture. Quick germination.	Manhattan Citation Pennfine
Red fescue (*Festucca rubra*)	P	C	•		7–21	4.5–6.5	•	•	•	•			Do not fertilize heavily with nitrogen.	Include in fine turf. Shade and drought tolerant. Persists best in cool environments.	Pennlawn Jamestown
Reed canarygrass (*Phalaris arundinacea*)	P	C	•		5–21	5.0–7.5	•	•	•	•	•	•	Do not mow closely or often.	Tall, coarse; adapted to wet soils, waterways, muck, and peat soils.	Io
Tall fescue (*Festuca arundinacea*)	P	C		•	5–14	5.5–8.0		•	•	•			Mow often to prevent bunchiness.	Widely adapted. Tolerates drought, infertility.	Kentucky 31
German millet (*Setaria italica*)	A	W		•	4–14	4.5-7.0	•	•	•	•			Do not use in fine turf.	Warm season temporary or companion grass.	No named varieties

continues

Table 5 (continued)

Common Name (Botanical Name)	Life Cycle	Season	Sod-Former	Bunch Grass	Germibnation Time in Days	pH Range	Drainage: Droughty	Drainage: Well	Drainage: Mod. Well	Drainage: Somewhat Poorly	Drainage: Poorly	Drainage: Flood Tolerant	Maintenance Requirements	Remarks	Suggested Varieties for Virginia
Oats (*Avena sativa*)	A	C		•	5–14	5.5–7.0		•	•				Do not use in fine turf.	Cool season temporary or companion grass. Use spring oats.	Lang
Annual ryegrass (*Lolium multiflorum*)	A	C		•	5–14	5.5–7.5		•	•	•		•	Do not use in fine turf.	Cool season temporary or companion grass. Cannot tolerate temperature extremes or drought. Somewhat shade tolerant.	No named varieties
Redtop (*Agrostis alba*)	sP	C	•		5–10	4.0–7.5	•	•	•	•	•	•	Do not use in fine turf.	Cool season companion grass. Adapted to very acid, infertile soils. Can be used on smooth, steep slopes.	No named varieties
Rye (*Secale cereale*)	A	P		•	4–7	5.5–7.0	•	•	•	•			Do not use in fine turf.	Cool season temporary or companion grass, best used in late fall seedings.	Abruzzi
Weeping lovegrass (*Evagrstis curvula*)	sP	W		•	5–14	4.5–8.0	•	•	•	•			Mow yearly to encourage persistence.	Warm season temporary or companion grass. Tolerates acid, infertile soils; steep, droughty slopes.	No named varieties

A = annual; P = perennial; sP = short-lived perennial, lasts 3–4 years; W = warm-season plant, grows in summer; C = cool-season plant, grows in spring and fall.
Source: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

Table 6
CHARACTERISTICS OF LEGUMES APPROPRIATE FOR PERMANENT EROSION CONTROL

Common Name (Botanical Name)	Life Cycle	Season	Germination Time In Days	pH Range	Drainage Tolerance: Droughty	Well	Mod. Well	Somewhat Poorly	Poorly	Maintenance Requirements	Remarks	Suggested Varieties for Virginia
Red clover (*Trigolium pratense*)	sP	C	7–21	6.0–7.0		•	•	•		Needs high phosphorus and potassium. Do not mow frequently.	Single plants, 10–18 inches tall; long tap roots. Useful with tall fescue in low-maintenance stands. Will reseed itself.	Kenstar Chesapeake Kenland Pennscott
White clover (*Trifolium repens*)	P	C	7–21	6.0–7.5		•	•			Needs favorable moisture, high fertility, high pH.	Prostrate plants spread by stolons. Cannot persist with tall plants.	Tillman Common White Dutch
Crown vetch (*Coronilla varia*)	P	C	14–21	5.5–8.3	•	•	•			Needs high lime or calcareous soil, high phosphorus. Will not persist under frequent mowing. Will not tolerate wet soil.	18–24 inches tall. Has spreading rootstocks. Tolerates acid to pH 5.0 when soil has high lime content. Deep rooted, somewhat shade tolerant. Useful on steep slopes and rocky areas.	Chemung Penngift Emerald
Flatpea (*Lathyrus silvestrus*)	P	C	14–28	5.0–8.3	•	•	•	•	•	Needs lime and high phosphorus. Do not mow closely.	Prostrate, spreading plants 2–3 feet tall. Adapted to drought, low fertility, partial shade, cold winters. Chokes out woody vegetation.	Lathco
Annual lespedezas (*Lespedeza striata*, *L. stipulacea*)	A	W	5–14	5.0–7.0	•	•	•	•	•	Do not mow closely.	Companion legume for warm seasons. Acid tolerant. Short tap roots. Will reseed itself.	Kobe

continues

95

Table 6 (continued)

Common Name (Botanical Name)	Life Cycle	Season	Germination Time In Days	pH Range	Drainage Tolerance: Droughty	Well	Mod. Well	Somewhat Poorly	Poorly	Maintenance Requirements	Remarks	Suggested Varieties for Virginia
Sericea lespedeza (*Lespedeza cuneata*)	P	W	7–28	5.0–7.0	•	•	•	•		Will not persist under frequent mowing.	Very deep rooted. Drought tolerant. Useful on infertile slopes. Does not persist in coastal plain.	Serala Interstate

A = annual; P = perennial; sP = short-lived perennial, lasts 3–4 years; W = warm-season plant, grows in summer; C = cool-season plant, grows in spring and fall.
Source: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

Table 7
FLOW RATES AND FILTERING EFFICIENCIES
OF VARIOUS SEDIMENT FILTER MATERIALS

Material	Flow Rate (gal/sq ft/min)	Filter Efficiency (%)
Straw	5.6	67
Burlap (10-oz fabric)	2.4	84
Synthetic fabric	0.3 (average)	97 (average)

Source: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

3.3 POSTCONSTRUCTION STORMWATER MANAGEMENT CONTROLS

After construction is finished, it is still necessary to control stormwater runoff. This can be done through a variety of BMPs. BMPs include the use of ponds, infiltration facilities, and vegetated filters. All of these practices can help achieve the requirements of the standards, but some are better suited to a given situation than others. Table 8 illustrates how different constraints can help determine which BMP is most suitable for a particular site. The engineer is also referred to Chapter 4, which provides more detailed descriptions of the BMPs.

The following factors should be considered when a choice is made:

- *Area served.* Ponds usually require a minimum drainage area in order to operate properly. This is to allow for the minimum practical orifice size of 3 inches and to maintain an adequate water level in the pond. Infiltration facilities and filters/swales are not suited for large areas because of size and cost constraints.

- *Infiltration rates.* Ponds are affected only at the extreme ranges of soil permeability. Wet ponds on soil with a high rate of infiltration must be lined in order to maintain a permanent pool, and dry ponds on soil with a low rate of infiltration could have problems with standing water that will not infiltrate, causing maintenance difficulties and, perhaps, insect breeding. The infiltration rate is obviously important. The minimum allowable infiltration rate is 0.27 inch per hour, but 0.5 inch per hour is much more desirable. Facilities with a low infiltration rate will be much larger and more susceptible to clogging than ones with a higher rate. Vegetative practices, which use infiltration, can also be used where there is no infiltration. Studies (e.g., 7, 8) have shown that filtering without infiltration can remove pollutants for quality control and that check dams can be used to pond stormwater to control quantity.

- *Depth to groundwater and bedrock.* Although ponds are usually not affected by a high groundwater table, there can be problems with the contamination of groundwater under a pond. A high water table might cause a dry pond to have an unwanted pool on its bottom. Bedrock close to the surface could make excavation difficult and expensive. Infiltration facilities should have at least 4 feet of clearance between the bottom of the facility and the seasonably high water table.

Table 8
SELECTING A MANAGEMENT PRACTICE

Practice	Area Served	Infiltration Rate (in/hr)	Depth to Ground-water/Bedrock	High Sediment Inputs	Space Required	Quantity Control	Other Benefits
Detention basin	Usually >10 A	Usually not a problem[a]	Bedrock can make excavation hard	Can handle[e]	Can cause problem	Easily provided	Can be incorporated into other uses
Retention pond	Usually >10 A	Usually not a problem[b]	Bedrock can make excavation hard	Can handle[e]	Can cause problem	Easily provided	Can have wildlife/ recreational benefits
Infiltration trench	Usually <10 A	>0.27 is re-commended[c]	4 ft minimum to both	Will clog facility[f]	Adaptable	Can make facility too large	Facility not very noticeable
Infiltration basin	Usually <30 A	>0.27 is re-commended	4 ft minimum to both	Will clog facility[f]	Adaptable	Easily provided	Groundwater recharge
Filter strip/swale	<10 A	Usually not a problem[d]	Can limit infiltration	Can cause problem	Adaptable	Can make facility too large	Can be used with other practices

[a]Very impermeable soil may cause standing water problems.
[b]If infiltration is high, an impermeable liner may be required to maintain permanent pool.
[c]Infiltration rates of 0.5 in/hr are much more feasible; 0.27 in/hr is only the minimum.
[d]Although infiltration is the primary method used to control quality and quantity, studies by Oakland and others[7,8] have shown that pollutants are removed through filtering and quantity can be controlled by check dams when there is no infiltration available.
[e]Will require increased maintenance.
[f]High sediment inputs can clog the facility and make it ineffective. Filter strips can be used to reduce the sediment load before the stormwater enters the facility.
Data from Schueler.[7]

Infiltration facilities should also provide at least 4 feet of clearance to the bedrock. Both of these depth restrictions are to ensure that the stormwater is filtered sufficiently by the soil before entering groundwater. The bottom of an infiltration facility should be placed below the frost line to ensure its functioning during the winter.

- *Sediment input.* Stormwater containing a large amount of sediment will fill the facility rapidly. Ponds can handle the input but may require increased maintenance for removal of accumulated sediment so that the storage in the pond is not significantly decreased and the pond will continue to function properly. Infiltration facilities may clog with a high sediment input. Filter strips can be used to reduce the sediment content before runoff reaches the infiltration facility. However, extremely high loads may make infiltration infeasible. Filter strips and swales may also become clogged with sediment.

- *Space consumption.* Because of the requirements regarding size and length-to-width ratio, ponds can be less adaptable to sites where space is limited. However, infiltration facilities have few dimensional restrictions on how their storage volume is created. They can be dug deep, shallow, and in any shape. Swales and vegetative filters will still require a large surface area, but they can be configured to a wide variety of shapes.

- *Quantity control.* Ponds can very easily be designed to control a 2-, 10-, and even a 100-year storm. Infiltration facilities will have to be made much larger to control the less frequent storms; their outflow is more constant (the infiltration rate), but the pond's outflow varies with the design of the outlet structure(s). Infiltration facilities may be designed with overflow structures to control quantity while still infiltrating the WQV.

- *Quality control.* The degree of quality control provided by each BMP depends on the type of practice and its associated design. In general, detention time has been found to be an important factor in determining the effectiveness of quality control. The detention time of the stormwater is usually much greater in a wet pond than in a dry pond, which leads to a higher effectiveness for wet ponds. Infiltration uses gravity settling and filtration and can be quite effective if properly designed and maintained. Swales and filter strips are associated with a relatively moderate pollutant removal rate because the stormwater is usually not detained very long with these controls.

- *Erosion control.* All of the described practices result in erosion control. Ponds and basins can control erosion through the proper design of their outlet structures. Swales and filter strips can be designed with erosion-resistant plants and check dams to control erosion. Infiltration trenches are usually designed to allow excess runoff to flow over the facility. This overflow should be controlled to reduce the possibility of downslope erosion.

- *Other benefits.* Benefits other than quantity and quality control should also be considered when a particular practice is selected. Dry pond areas can be used for recreational purposes. Wet ponds can provide recreational space and/or a habitat for wildlife. Infiltration trenches are not very noticeable, appearing as gravel strips, and infiltration basins can yield substantial groundwater recharge. The vegetative controls are usually used for pretreatment (i.e., to filter sediment from the runoff) before the stormwater enters a main facility. The use of these practices is easily integrated into landscape design plans.

Chapter 4

DESIGNING CONTROLS

4.1 INTRODUCTION

This section discusses the considerations for designing construction phase controls (E&S controls) and postconstruction controls (SWM controls). Site considerations and design guidelines are discussed for each method of control.

4.2 EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION

The design of a wide variety of construction phase controls, or E&S controls, are discussed in this section. These controls are structural in nature. Vegetative controls are discussed in Chapter 3. More information about these controls can be found in the *Virginia Erosion & Sediment Control Handbook*,[6] *Virginia Erosion & Sediment Control Field Manual*,[4] and the SCS's *Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas*.[1] Much of the information in this section was taken from these sources.

Figure 1 shows some of the typical practices currently used by VDOT, most of which are described in the next few sections.

4.2.1 Sediment Basins

4.2.1.1 Description

Sediment basins are required on sites where the runoff from a drainage area greater than 3 acres flows across a disturbed area. For example, in a drainage area, 2 acres of land are disturbed and the drainage area above the site contributes 1 acre of runoff. Since a total of 3 acres are drained across the disturbed area, a basin is required at the bottom of the site.

The basin functions by allowing the sediment-laden runoff to pond in the bottom of the basin, where the suspended sediment settles. Because it functions similarly to a BMP pond, it can be designed to function as one after construction is completed.

The two basic types of sediment basins are those with outflow going through a riser and those with a rock check dam outlet. Because of the small size of the disturbed drainage area usually found on highway projects, the rock check dam is more commonly used by VDOT.

4.2.1.2 Design

- *Location.* The basin should be located at the lowest possible point so that it can receive the largest amount of runoff from the disturbed area. The natural

960

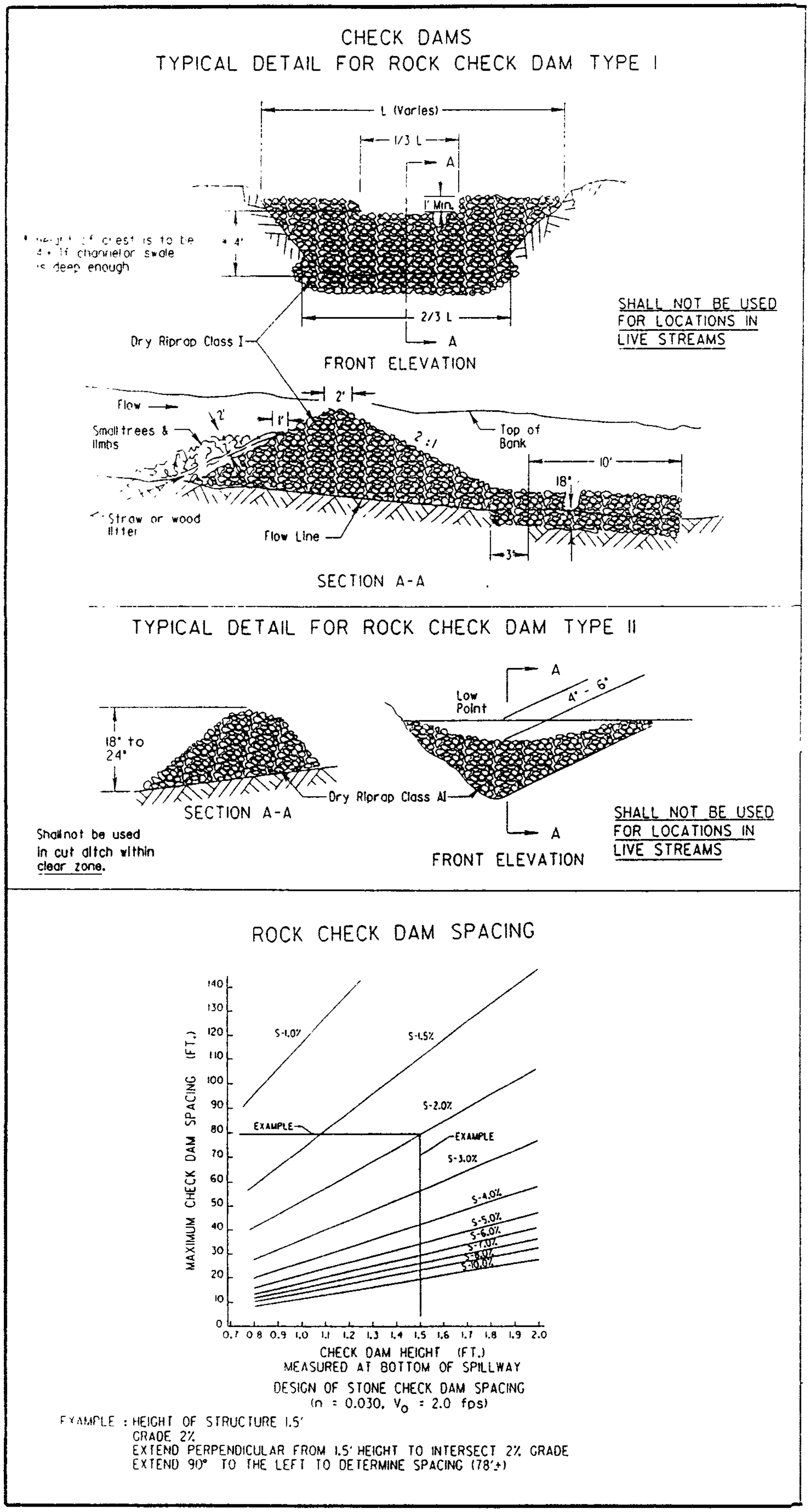
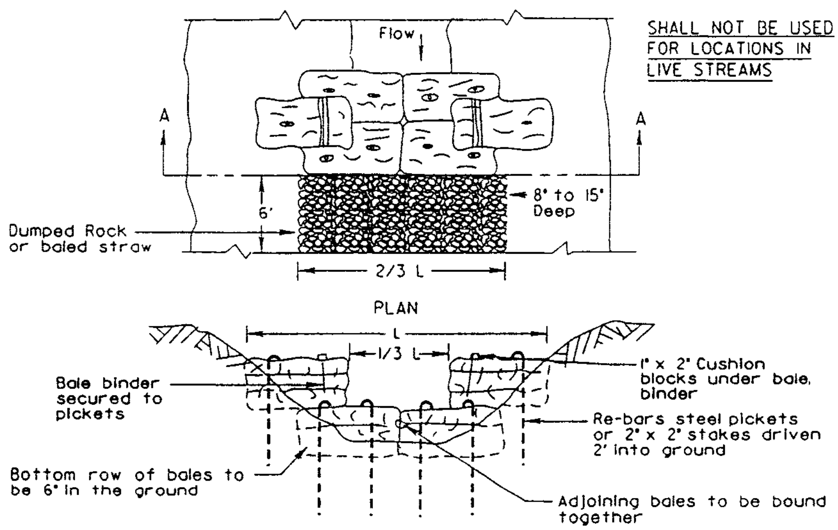


Figure 1. Typical E&S practices used by VDOT (*continues*).

DESIGN FEATU
OR TO REGULA
MAY BE SUBJE
NECESSARY BY

BALED STRAW CHECK DAM
TYPICAL DETAIL FOR BALED STRAW CHECK DAM

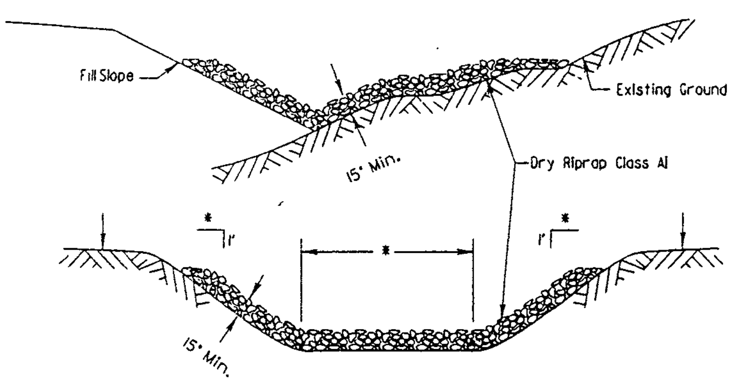


NOTES:

Baled Straw Check Dams are to be used with open channels and contributing drainage areas of less than 10 acres.

The number of bales required will vary according to actual ground conditions. Dams are to be two bales high where possible.

SUGGESTED METHOD OF PLACING RIPRAP FOR EROSION CONTROL IN CHANNELS, DITCHES, & AT TOE OF FILL SLOPES



NOTES:

The depth of protection will depend on whatever depth is attainable, with the riprap being evenly spread with the quantity shown on these plans. Riprap may be added or deleted as found necessary by the Engineer.

* Side slopes and bottom width (if trapezoidal) shown in typical section of proposed ditch or channel.

Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

96.

TURES RELATING TO CONSTRUCTION
LATION AND CONTROL OF TRAFFIC
JECT TO CHANGE AS DEEMED
BY THE DEPARTMENT

REVISED	FHWA REGION	STATE	FEDERAL AID PROJECT	ROUTE	STATE PROJECT	SHEET NO
	3	VA.				

GENERAL NOTES

THE BINDING OF BALED STRAW SHALL BE ADEQUATE TO MAINTAIN THE INTEGRITY OF THE BALES FOR THEIR INTENDED USEFUL LIFE. IN THE EVENT THE BINDING FAILS, THE CONTRACTOR SHALL REBIND OR OTHERWISE REPLACE THE BALES AT NO ADDITIONAL COST TO THE DEPARTMENT. ADJOINING BALES IN BALED STRAW SILT BARRIER SHALL BE ENTRENCHED, TIED TOGETHER AND STAKED TO PREVENT MOVEMENT. IF SILT REMOVAL IS IMPRACTICAL, ADDITIONAL COURSES SHALL BE PLACED AS DIRECTED BY THE ENGINEER AND WILL BE PAID FOR AT THE PRICE BID PER LINEAR FOOT OF TEMPORARY FILTER BARRIER.

ALL CHANNEL CHANGES ARE TO BE CONSTRUCTED DURING THE EARLIEST STAGE OF CONSTRUCTION AND ARE TO BE CONSTRUCTED 'IN THE DRY' WHEREVER POSSIBLE. STABILIZATION OR VEGETATION IS TO BE ESTABLISHED BEFORE FLOW IS REDIRECTED THROUGH THE CONSTRUCTED AREA AS DIRECTED BY THE ENGINEER.

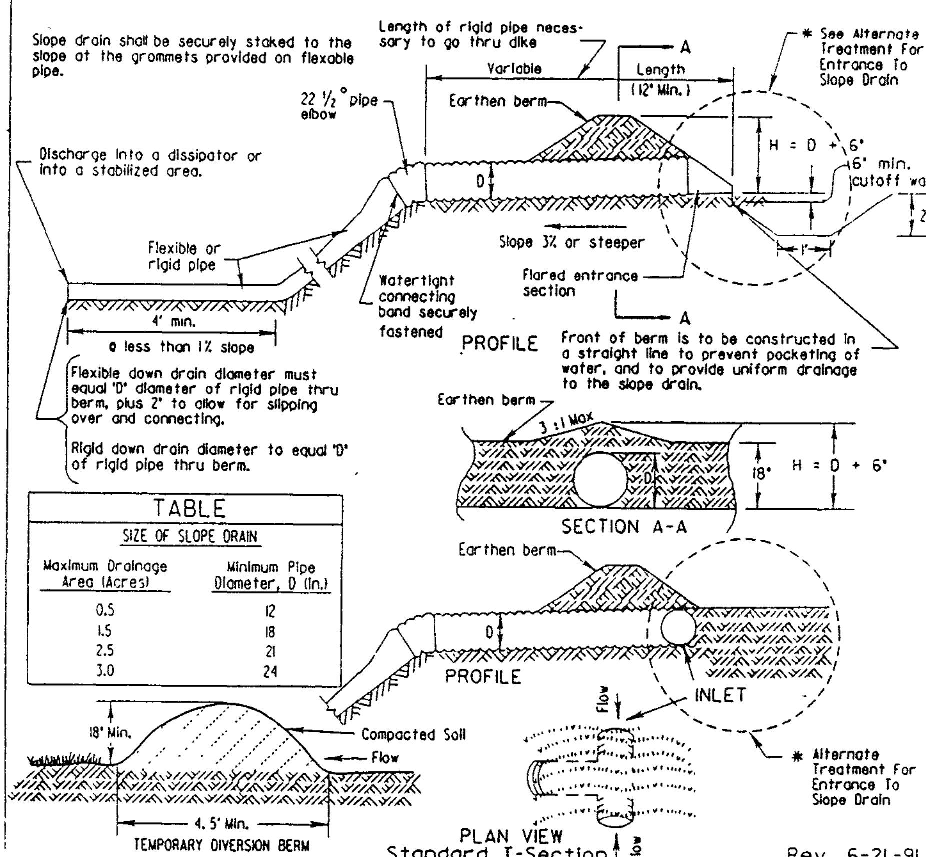
IF REMOVAL OF BRUSH SILT BARRIER IS REQUIRED BY THE ENGINEER, THE COST OF REMOVAL AND DISPOSAL OF BRUSH SHALL BE IN ACCORDANCE WITH SECTION 109.05 OF THE SPECIFICATIONS.

THE LOCATIONS OF THE CHECK DAMS AS SHOWN ON THESE PLANS ARE APPROX. ONLY. SUCH LOCATIONS MAY BE CHANGED OR DAMS MAY BE ADDED OR DELETED AS DIRECTED BY THE ENGINEER.

ROCK FOR CHECK DAMS, EROSION CONTROL & RIPRAP IN CHANNELS TO BE IN ACCORDANCE WITH SECTION 418 OF THE ROAD & BRIDGE SPECIFICATIONS.

SILT REMOVAL AND SEDIMENT CLEANOUT FROM EROSION AND SEDIMENT CONTROL ITEMS WILL BE PERFORMED WHEN THE ITEM REACHES ½ OF ITS CAPACITY, HEIGHT OR DEPTH. PAYMENT WILL BE IN C.Y. OF SILTATION CONTROL EXCAVATION.

TEMPORARY BERM & SLOPE DRAIN



TABLE

SIZE OF SLOPE DRAIN

Maximum Drainage Area (Acres)	Minimum Pipe Diameter, D (In.)
0.5	12
1.5	18
2.5	21
3.0	24

Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

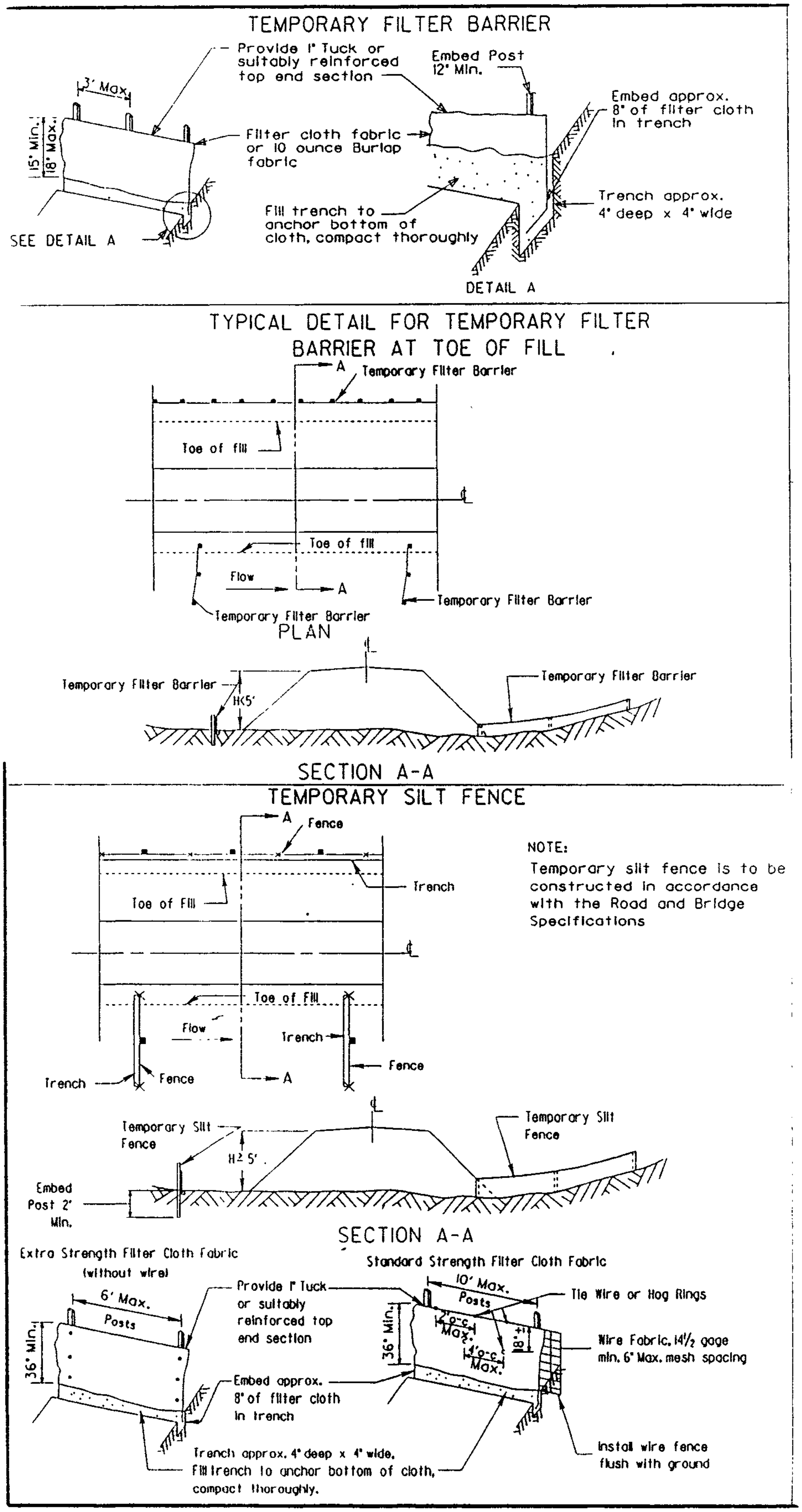
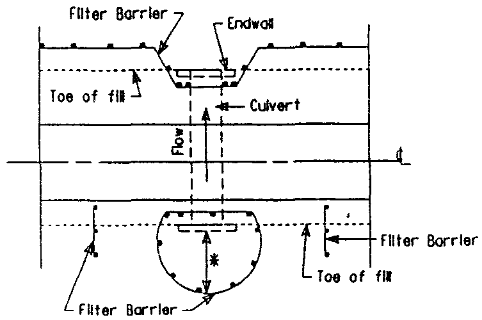


Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

969

TYPICAL DETAIL FOR TEMPORARY FILTER BARRIER AT CULVERT OR PIPE

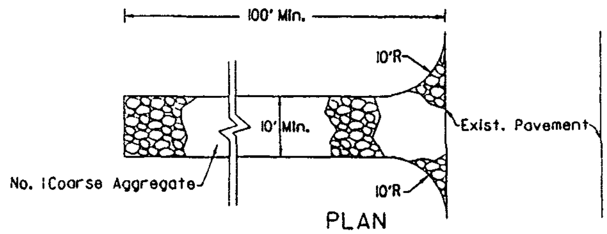
DESIGN FE
OR TO RE
MAY BE S
NECESSAR



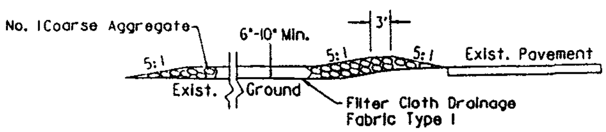
* Distance is 6' minimum if flow is toward the embankment. To be contained in right of way or easement.

When straw bales are substituted, they are to be entrenched 4" Min. with 2 stakes per bale to prevent movement.

SUGGESTED STABILIZED CONSTRUCTION ENTRANCE



PLAN



PROFILE

Surface water shall be piped under the construction entrance. If piping is impractical, a mountable berm with 5:1 slopes will be permitted.

The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way shall be removed immediately.

Wheels shall be cleaned to remove sediment prior to entrance onto public rights-of-way. When washing is required, it shall be done on an area stabilized with stone and which drains into an approved sediment trapping device.

Periodic inspection and needed maintenance shall be provided after heavy use and each rain.

Cost of Stabilized Construction Entrances are to be included in other pay items.

Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

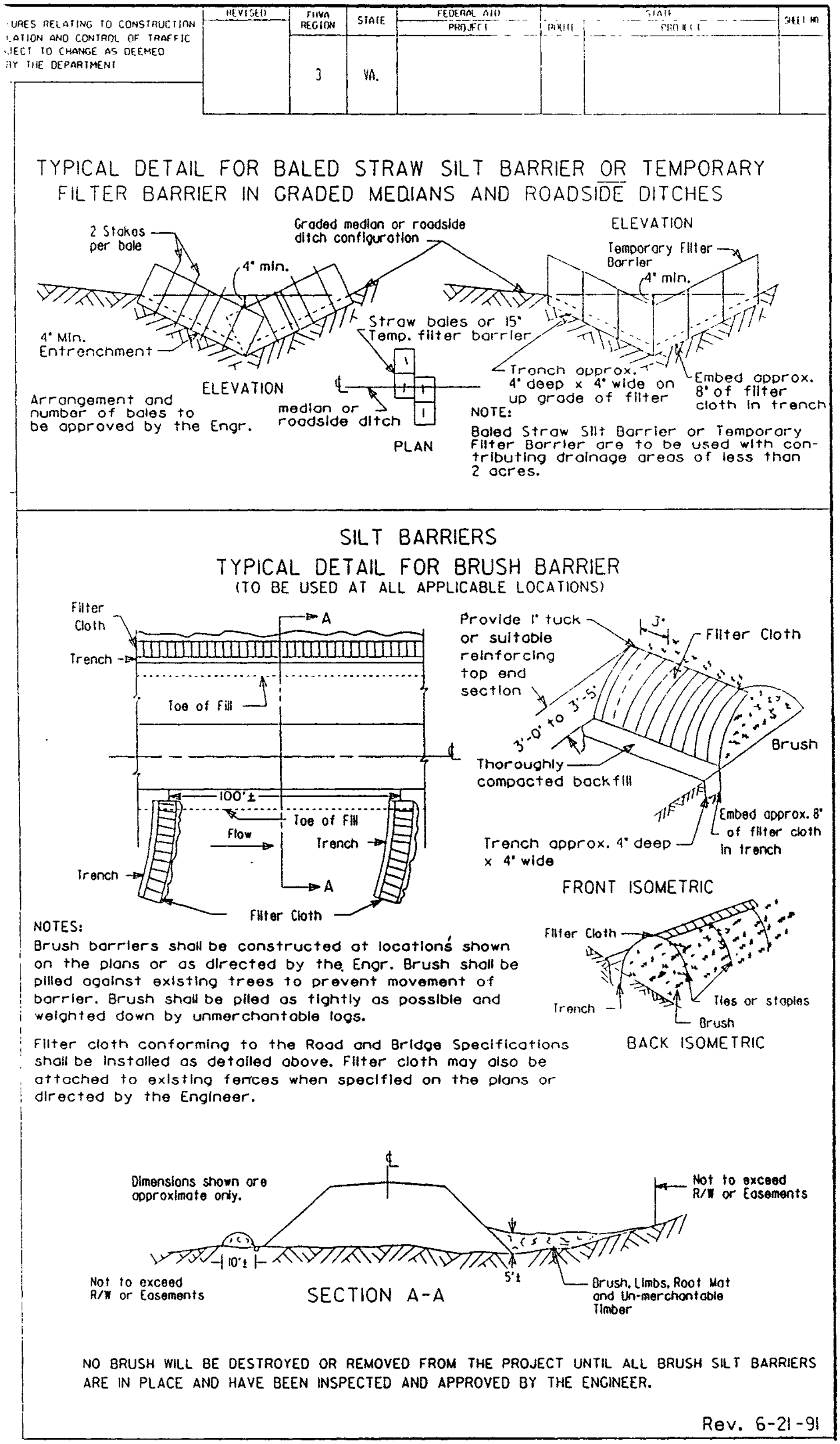
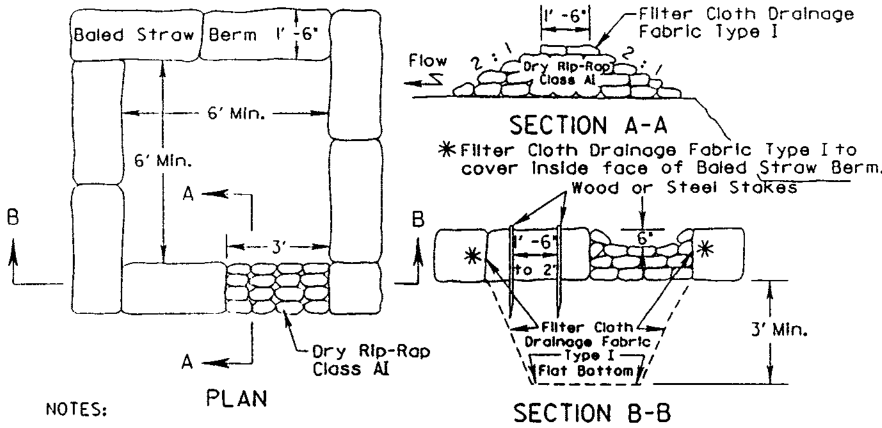


Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

TYPICAL DEWATERING BASIN



NOTES:

This work shall consist of the construction of a dewatering basin for the purpose of receiving sediment-ladened water pumped from a construction site to follow filtration before the water reenters the waterway. Pumping into these basins shall cease when the flow from the basin becomes sediment-ladened.

Surface water flow shall be diverted around this device.

The outfall from the basin(s) shall have a stabilized conveyance to receiving waters.

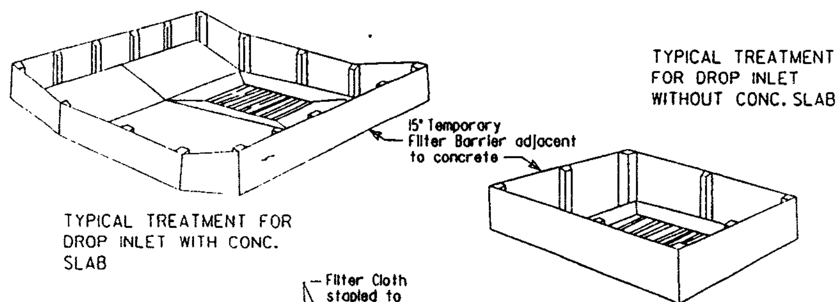
Once the dewatering basin becomes filled to 1/2 of the excavated depth, accumulated sediment shall be removed and disposed of in an approved disposal area outside of the 100-year floodplain unless otherwise approved on the plans.

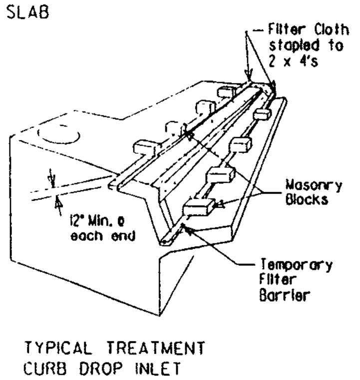
Sediment control devices are to remain in place until all disturbed areas are stabilized and the Engineer approves their removal. Ground contours shall be returned to their original condition unless specifically approved otherwise by the Engineer.

BASIS OF PAYMENT:

Dewatering Basin is to be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, maintaining and removing all items included in Dewatering Basin, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

DROP INLET SILT TRAP



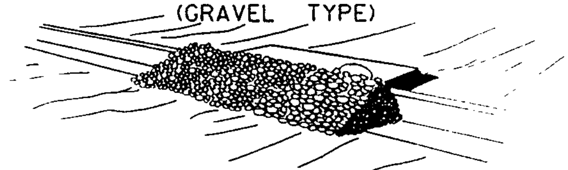


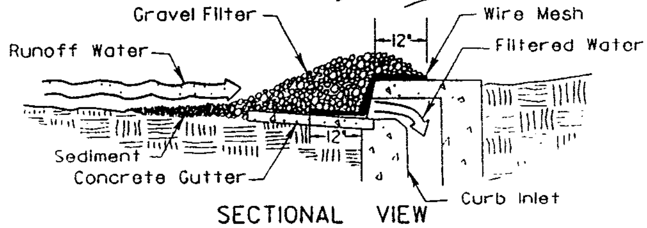
Drop inlet silt traps will be measured for payment in linear feet of Temporary Filter Barrier.

Curb Drop Inlet Filter Barrier will be measured in linear feet along the throat and paid for as Temporary Filter Barrier.

Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

ALTERNATE DROP INLET SILT TRAP
(GRAVEL TYPE)





SECTIONAL VIEW

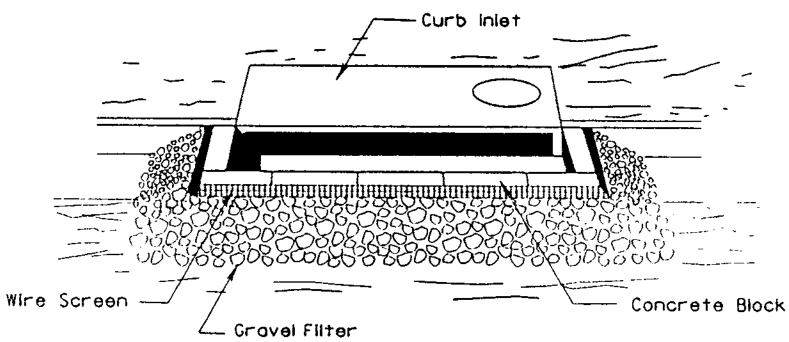
Specific Application

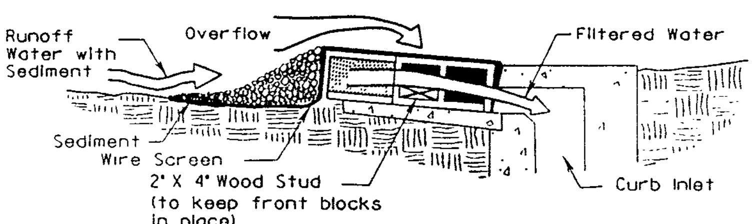
This method of inlet protection is applicable at curb inlets where ponding in front of the structure is not likely to cause inconvenience or damage to adjacent structures and unprotected areas.

BASIS OF PAYMENT:

Drop Inlet Silt Traps will be measured for payment in linear feet of Temporary Filter Barrier.

ALTERNATE DROP INLET SILT TRAP
(BLOCK AND GRAVEL TYPE)





SECTIONAL VIEW

Specific Application

This method of inlet protection is applicable at curb inlets where an overflow capability is necessary to prevent excessive ponding in front of the structure.

BASIS OF PAYMENT:

Drop Inlet Silt Traps will be measured for payment in linear feet of Temporary Filter Barrier.

Figure 1 (continued). Typical E&S practices used by VDOT (*continues*).

96

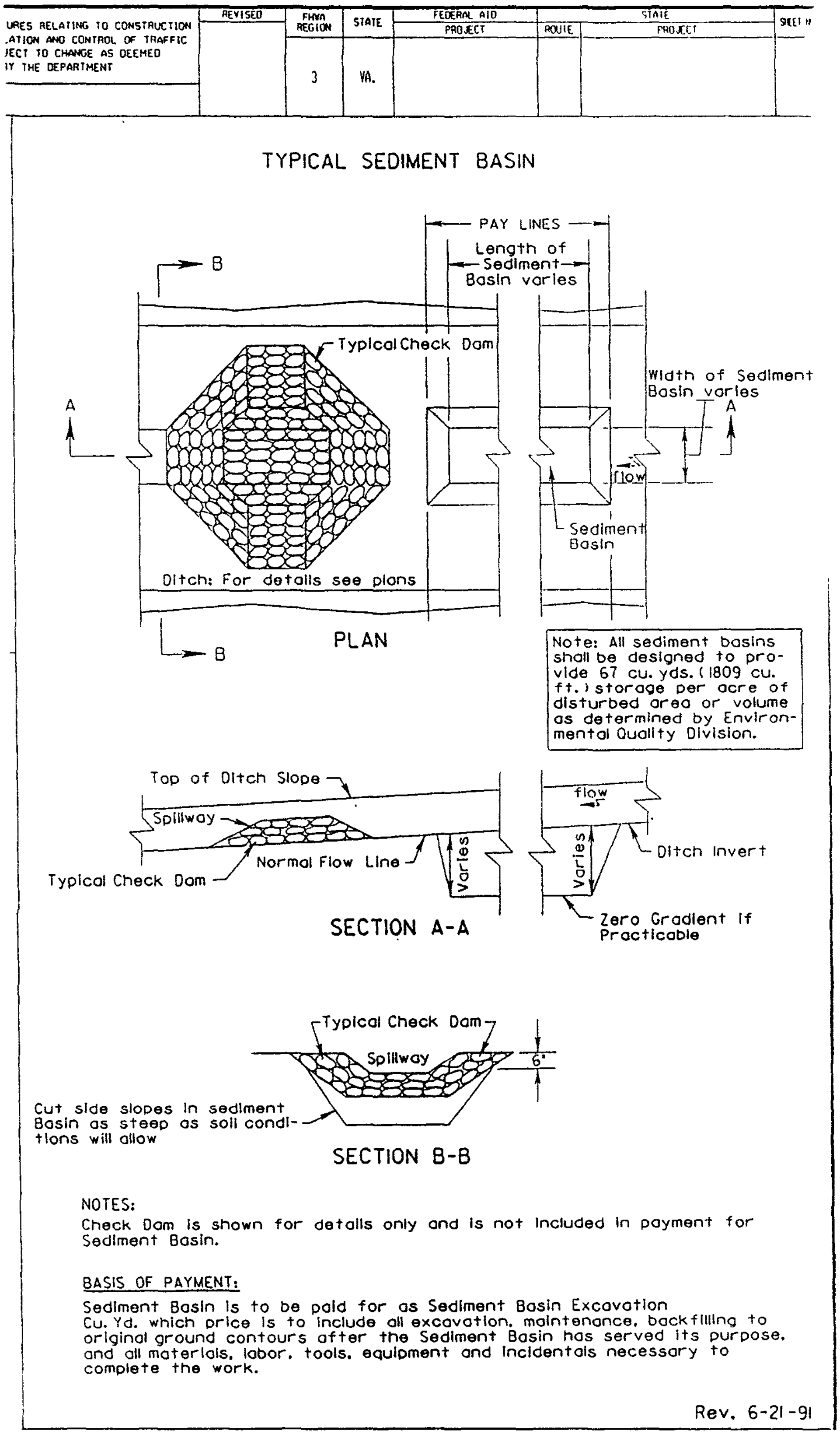


Figure 1 (continued). Typical E&S practices used by VDOT. ***Source*: Virginia Department of Transportation. 1990. *Drainage manual.* Richmond.**

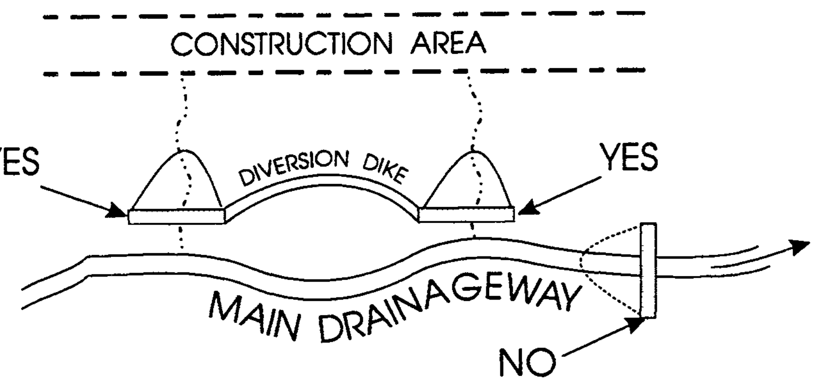


Figure 2. Good and poor locations for sediment basin. *Source:* Transportation Research Board, National Academy of Science. 1980. *Design of sedimentation basins.* NCHRP Synthesis No. 70. Washington, D.C.

drainage ways and depressed areas are well suited for a basin. However, the basin should not be placed in a live stream or major drainage way; this would not only affect the stream but also increase the required size of the basin. Runoff should be treated before it enters these main drainage ways. This can be facilitated through the use of diversion dikes and ditches. Figure 2 shows good and poor locations for a sediment basin.

Other considerations in locating a sediment basin include ease of maintenance access, amount of interference with construction, problems with backwater from larger waterways, major storm flows through the basin, and closeness to populated areas. The consequences of failure should be considered, and fencing may also be required.

- *Size.* The size of the basin is most easily determined by allowing 67 cubic yards (approximately 0.5 acre-inches) of storage per acre of drainage area. However, the rate of sediment yield varies depending on the soil characteristics in the watershed, and a larger volume could be used to reduce the frequency of maintenance. The volume is measured from the crest of the principal spillway to the bottom of the basin. Maintenance is required when the storage volume is halved, and the available storage should never be less than 27 cubic yards (this is discussed further in Chapter 5). These size requirements can be seen in Figure 3.

- *Shape.* A minimum length-to-width ratio of 2:1 is required in order to provide sufficient travel time, ponding, and sediment deposition in the basin. However,

MINIMUM STORAGE VOLUME AND SEDIMENT STORAGE

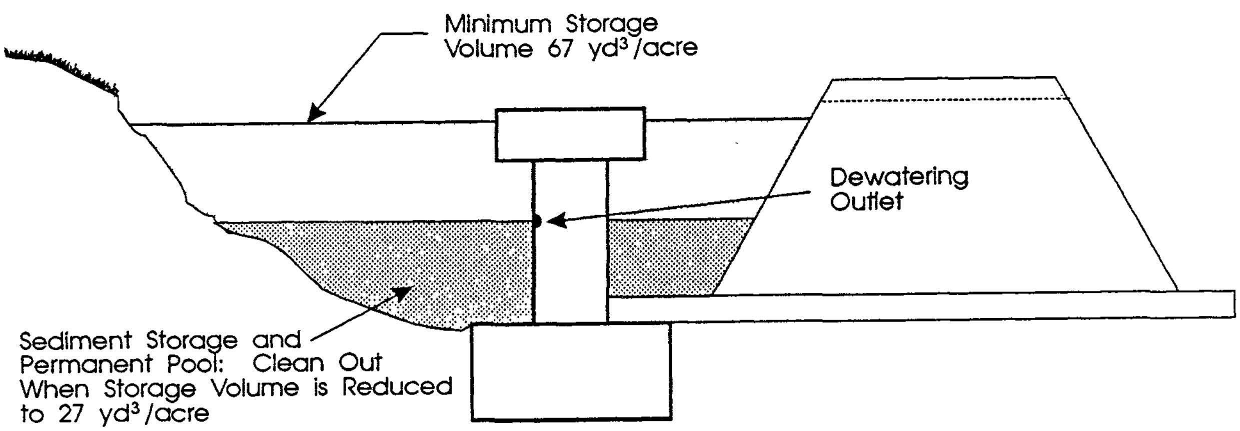


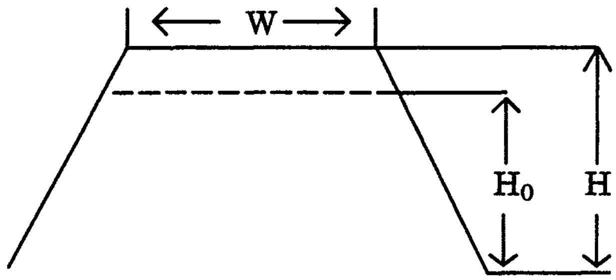
Figure 3. Size requirements for sediment basin. *Source:* Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook*. Richmond.

the larger the ratio, the better the expected removal efficiency. If the minimum 2:1 ratio cannot be attained, the site should be changed, or excavated, or baffles used to increase the ratio (see Figure 26 for examples).

- *Basin depth.* The depth of the basin should be limited to a maximum of 5 feet because of the hazard potential of drowning in ponded water and the possibility of dam failure.

- *Embankment cross section.* The minimum dimensions of the basin's embankment can be determined from Figure 4 for embankments of 5 feet in height or less. For embankments greater than 6 feet, the top width should be 8 to 10 feet. If the top is needed for access, a minimum of 10 feet should be used for the top width. The length-to-width ratio of side slopes should be 2:1 or flatter when the embankment is 5 feet in height or less. For embankments greater than 6 feet, the ratio should be 3:1 or flatter. The embankment should be stabilized within 48 hours of its construction.

- *Outlet design.* There are several outlet configurations that may be used for a sediment basin. The simplest is a rock spillway (weir) over the embankment. A second configuration is a riser pipe acting as the principal spillway and the emergency spillway. A third configuration is a riser pipe acting as the principal spillway and an additional emergency spillway around the embankment built on nonfill material. These three designs can be seen in Figure 5 and are described below.



H	H_0	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

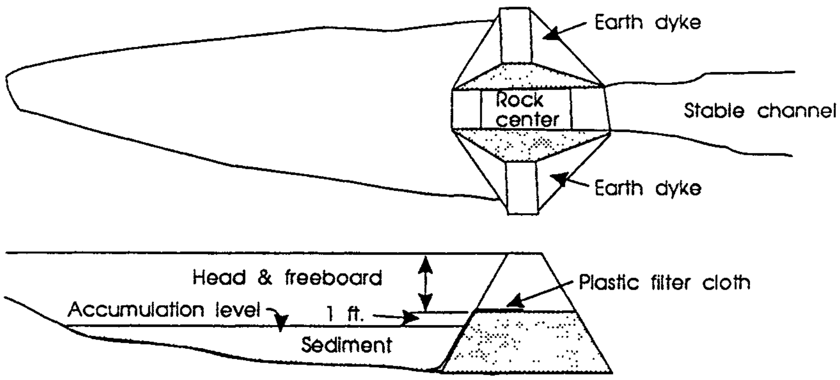
Figure 4. Minimum top width required for sediment basin embankments according to height of embankment (ft). W = width; H = height; H_0 = maximum depth of water. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

1. *Rock spillway.* A typical rock check dam sediment basin is shown in Figure 6. Sediment-laden water is detained in the excavated basin behind the check dam, and overflow from the basin passes through or over the check dam. To improve the removal efficiency of the basin, a filter fabric, or geotextile, can be placed over the check dam. To control erosion and flooding downstream, the overflow from the basin should be discharged into an adequate channel, as defined in Section 2.2.

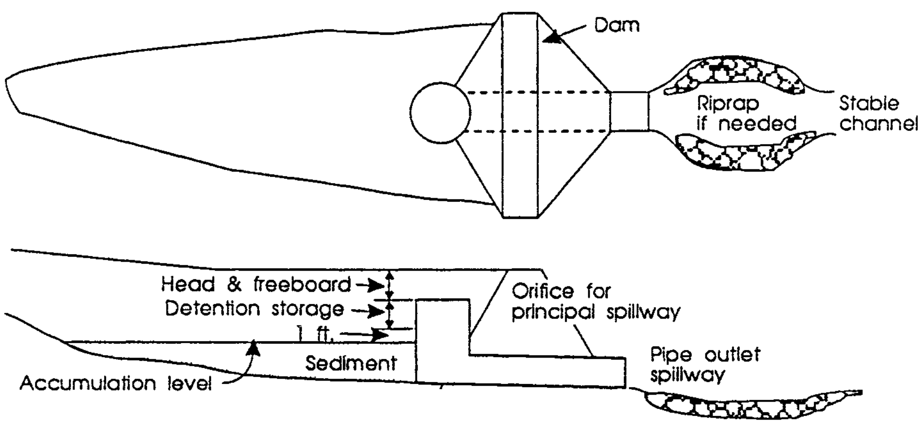
2. *Riser spillway.* The riser outlet is usually used in larger sediment basins because of its ability to control peak flows and the ease in conversion to an SWM basin. It is designed to retain a permanent pool. If the pond is allowed to drain completely, it would be difficult to prevent the lower orifice from being rapidly covered with sediment and the sediment from the pond bottom could be resuspended. Figure 7 shows design elevations for each type of riser.

   Where there is an emergency spillway, the riser spillway should be designed with a minimum capacity of 0.2 cubic feet per second per acre of drainage. If no emergency spillway is included, the riser spillway should be designed to control the peak flow from a 10-year storm. Riser pipes in large basins should be covered with an antivortex/trash-rack hood to improve the hydraulic efficiency and prevent erosion of the banks of the basin. An example of the details of a hood design can be seen in Figure 8.

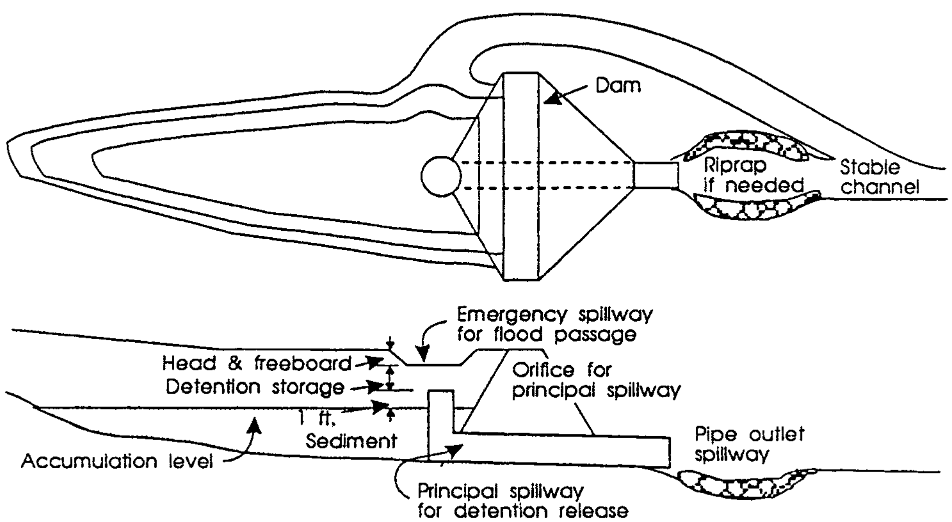
972



A - Sedimentation basin in natural reservoir site with porous rock fill dam for spillway.



B - Sedimentation basin in natural reservoir site with pipe outlet spillway serving for principal and emergency spillways.



C - Sedimentation basin in natural reservoir site with pipe principal spillway and overflow weir emergency spillway.

Figure 5. Types of sediment basins. ***Source:*** **Transportation Research Board, National Academy of Science. 1980.** ***Design of sedimentation basins.*** **NCHRP Synthesis No. 70. Washington, D.C.**

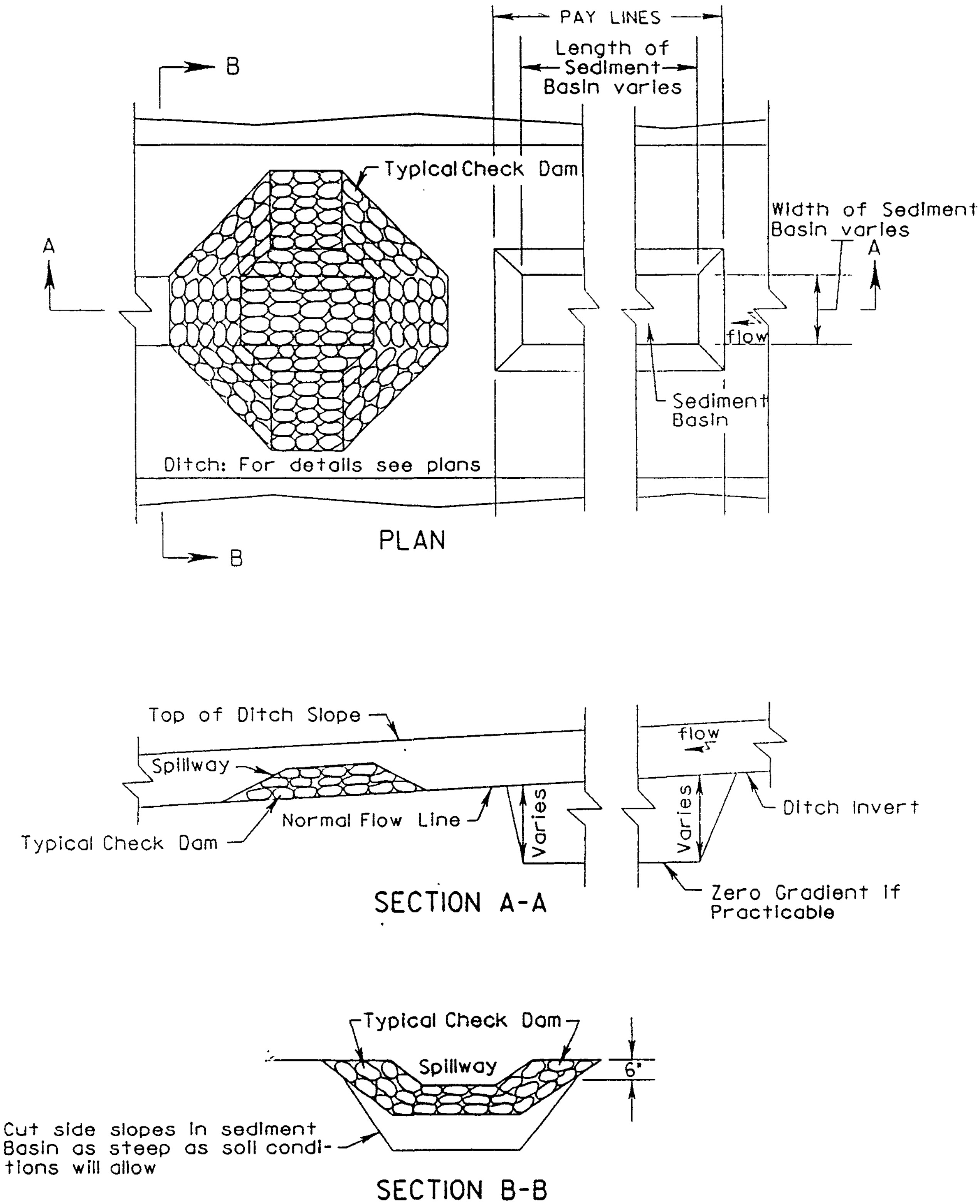
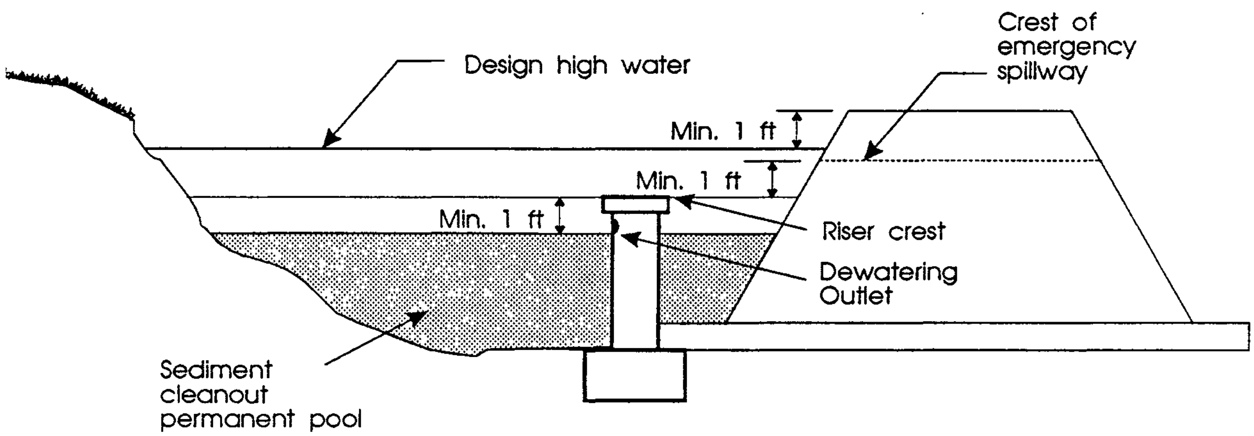


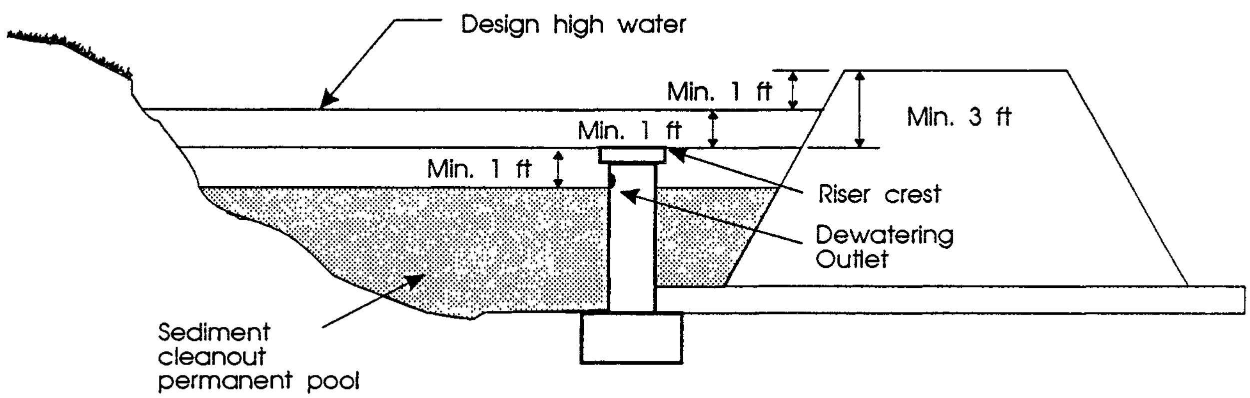
Figure 6. **Suggested details of rock dam sediment basin.** ***Source:*** **Transportation Research Board, National Academy of Science. 1980.** ***Design of sedimentation basins.*** **NCHRP Synthesis No. 70. Washington, D.C.**

974

MINIMUM STORAGE VOLUME AND SEDIMENT STORAGE



Design elevations with emergency spillway



Design elevations without emergency spillway

Figure 7. Two design variations of sediment basin with riser. *Source:* Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

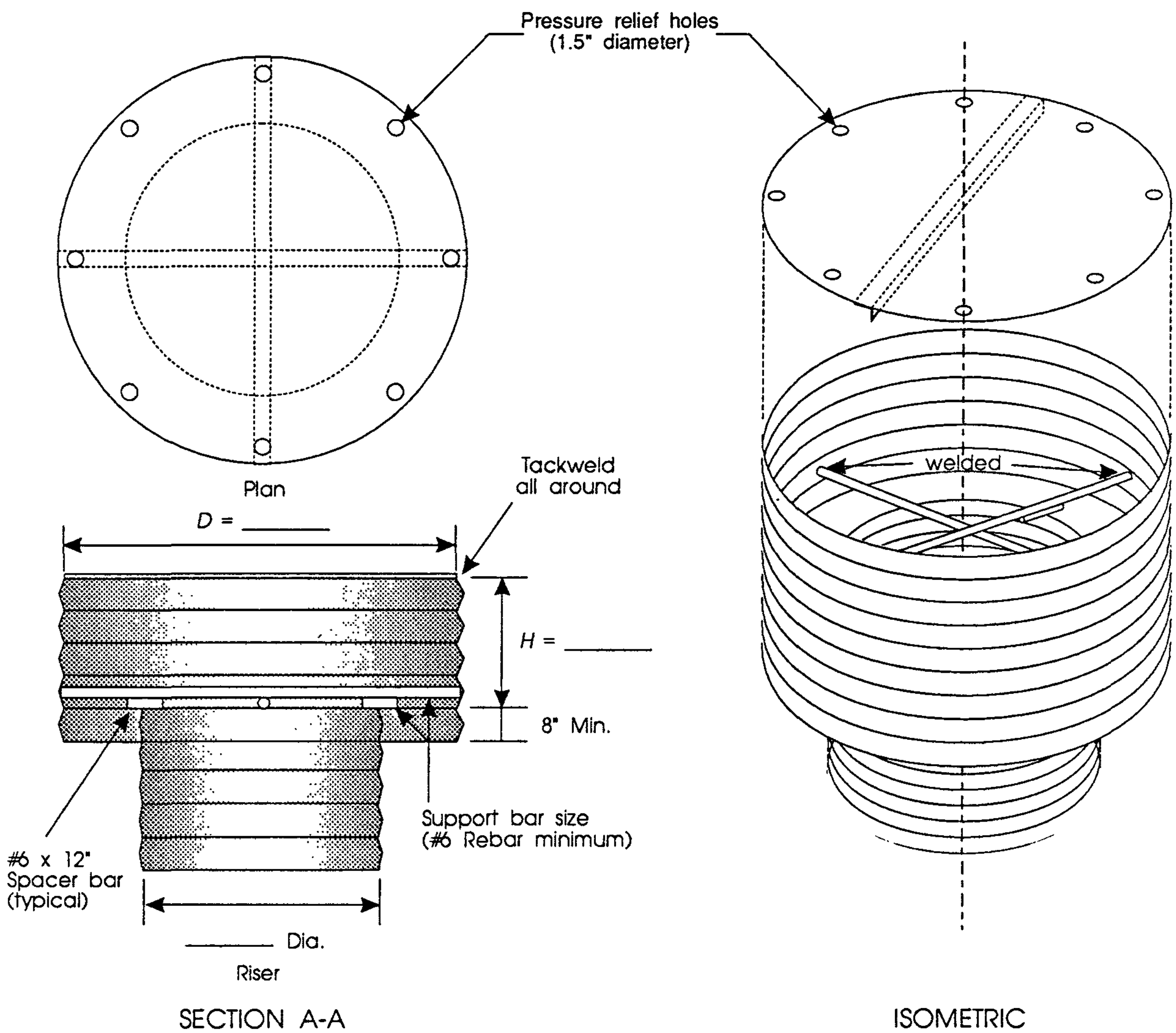


Figure 8. Antivortex hood and trash rack. *Source:* **U.S. Department of Agriculture, Soil Conservation Service. 1975.** ***Standards and specifications for soil erosion and sediment control in developing areas.*** **College Park, Md.**

Dewatering the basin through the use of underdrains can aid in the cleanout of accumulated sediment. Figure 9 shows the design details of a dewatering underdrain system. Dewatering the basin can also be accomplished by having a small orifice in the riser at the sediment cleanout level. This hole should be no smaller than 4 inches in diameter. To protect this outlet, a skimming device can be included in the design, as shown in Figure 10.

Another important design consideration of the riser is its base. The base needs to be firmly anchored to prevent instability caused by buoyancy. For risers whose height is greater than 10 feet, buoyancy computations must be made to determine the size of the base; a safety factor of 1.25 should be used in this calculation. For risers smaller than 10 feet, two common methods of anchoring that can be seen in Figure 11 are as follows:

- *A concrete base 18 inches thick and twice as wide as the riser diameter.* The riser should be embedded 6 inches into the concrete block.
- *A square steel plate 1/4 inch thick and twice as wide as the riser diameter.* The riser should be welded to this steel plate and covered with 30 inches of stone, gravel, or compacted soil to hold down the base.

Risers less than 6 feet in height may be embedded 3 feet into the ground, and Class I dry riprap placed in the base of the riser to prevent erosion (Figure 11C).

Antiseep collars are required to prevent the failure of the embankment from water seeping along the barrel pipe if the height of the dam exceeds 10 feet or the embankment material has a low silt-clay content (SM or GM Unified Soil Classes).[4]

3. *Emergency spillway.* If the basin is to use an emergency spillway, the spillway should not be built on fill unless adequately protected by riprap. A control section, a level portion of the spillway at the highest portion of the channel, should be at least 20 feet in length. The emergency spillway must be designed so that the peak flow from a 10-year storm can be safely controlled by the basin. If the height of the embankment is greater than 6 feet, a 100-year storm should be safely passed by the basin. Flow over the spillway should be nonerosive (not exceed 6 feet per second for vegetated channels), and flow should be returned to a defined channel downstream at a nonerosive velocity. Figure 12 shows a plan view of a basin with an emergency spillway.

- *Safety.* Safety considerations include the possible fencing in of the basin and the posting of signs around the basin warning the public of the possible danger. In more populated areas and at sites where deep basins must be used, these provisions are even more important.

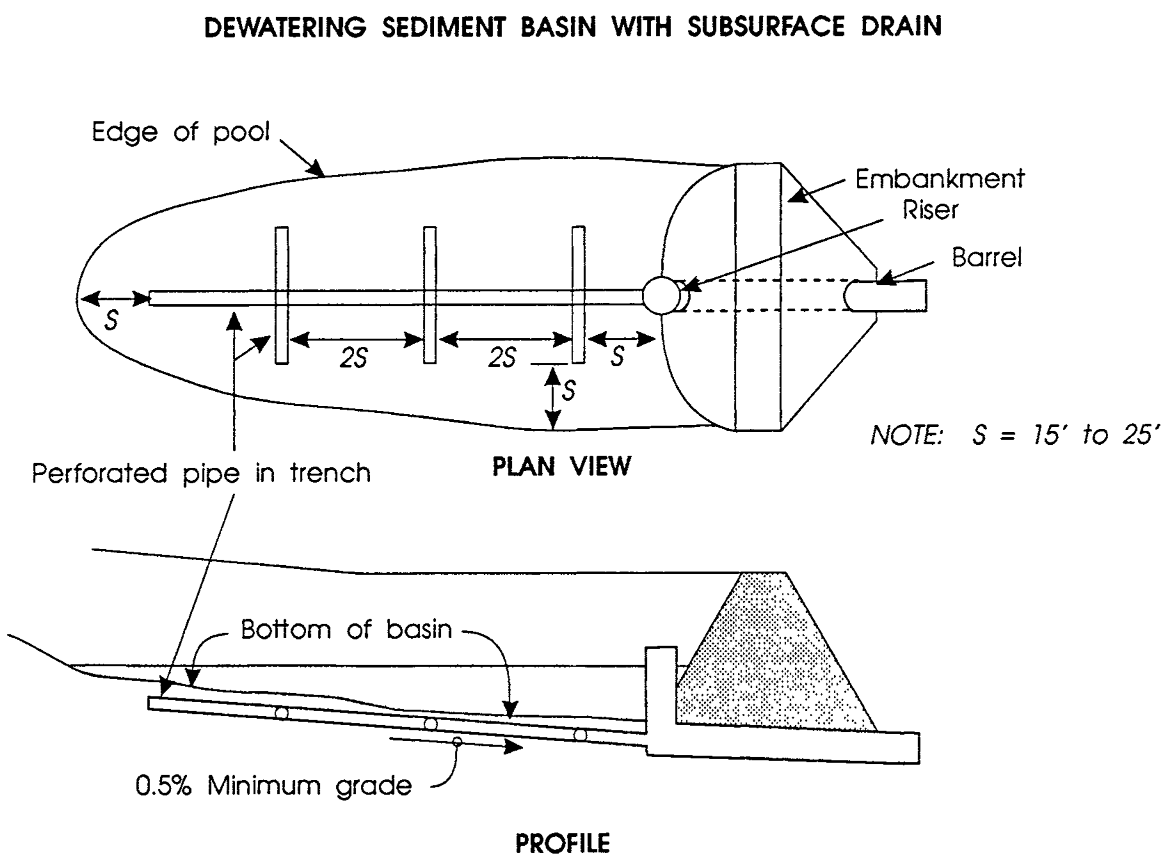
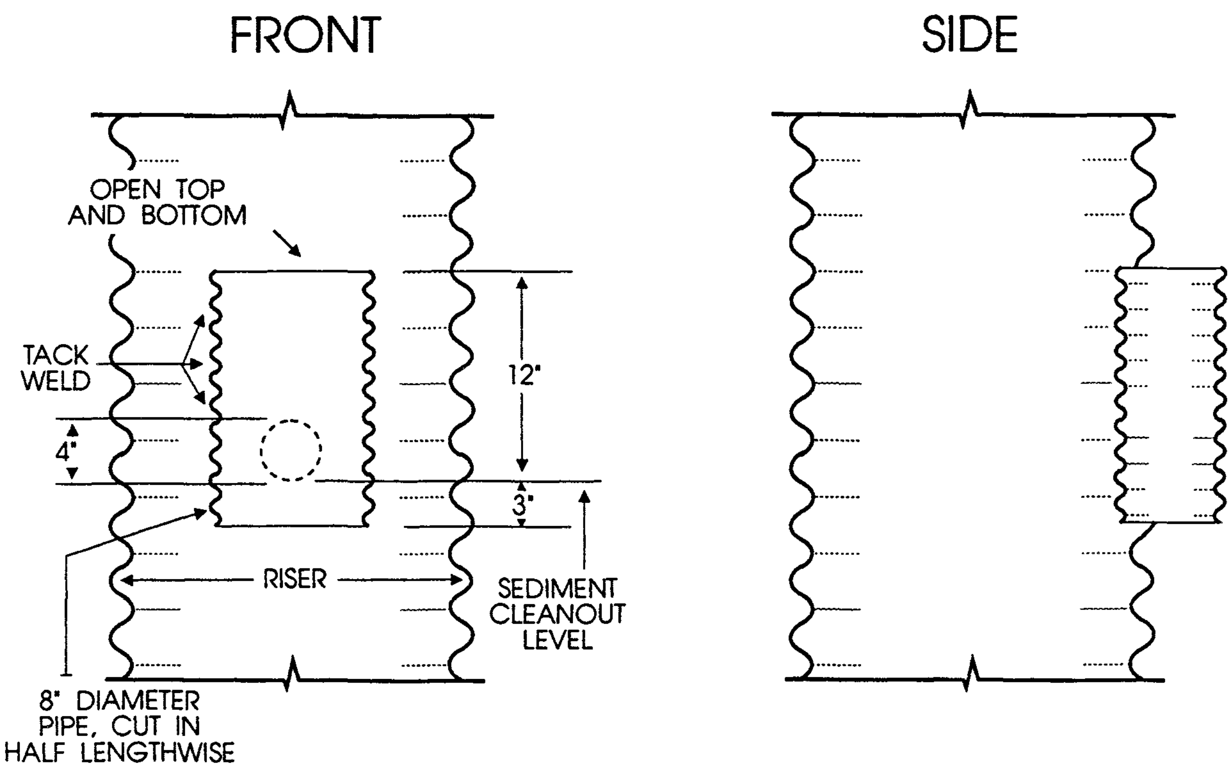


Figure 9. Dewatering with underdrains. *Source:* U.S. Department of Agriculture, Soil Conservation Service. 1975. *Standards and specifications for soil erosion and sediment control in developing areas.* College Park, Md.



EFFICIENT SKIMMER
NON-CLOGGING
FAIRLY EASY TO CONSTRUCT
CAPABLE OF DRAINING DOWN TO SEDIMENT CLEANOUT LEVEL
PASSES BASE FLOW WITHOUT STORAGE OF WATER

Figure 10. Skimmer on riser. *Source:* U.S. Department of Agriculture, Soil Conservation Service. 1975. *Standards and specifications for soil erosion and sediment control in developing areas.* College Park, Md.

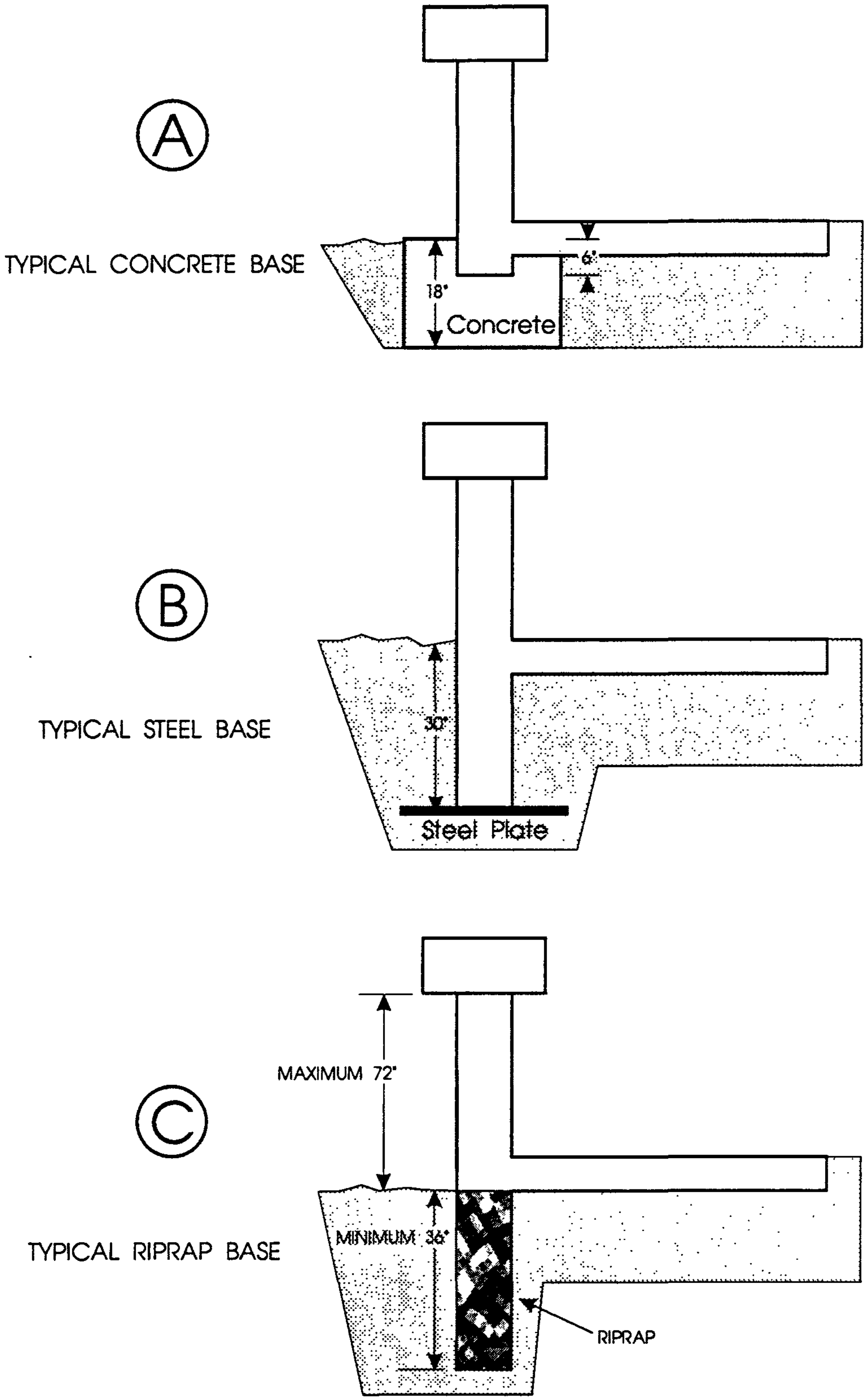


Figure 11. Riser base configurations. *Source:* **U.S. Department of Agriculture, Soil Conservation Service. 1975.** ***Standards and specifications for soil erosion and sediment control in developing areas.*** **College Park, Md.**

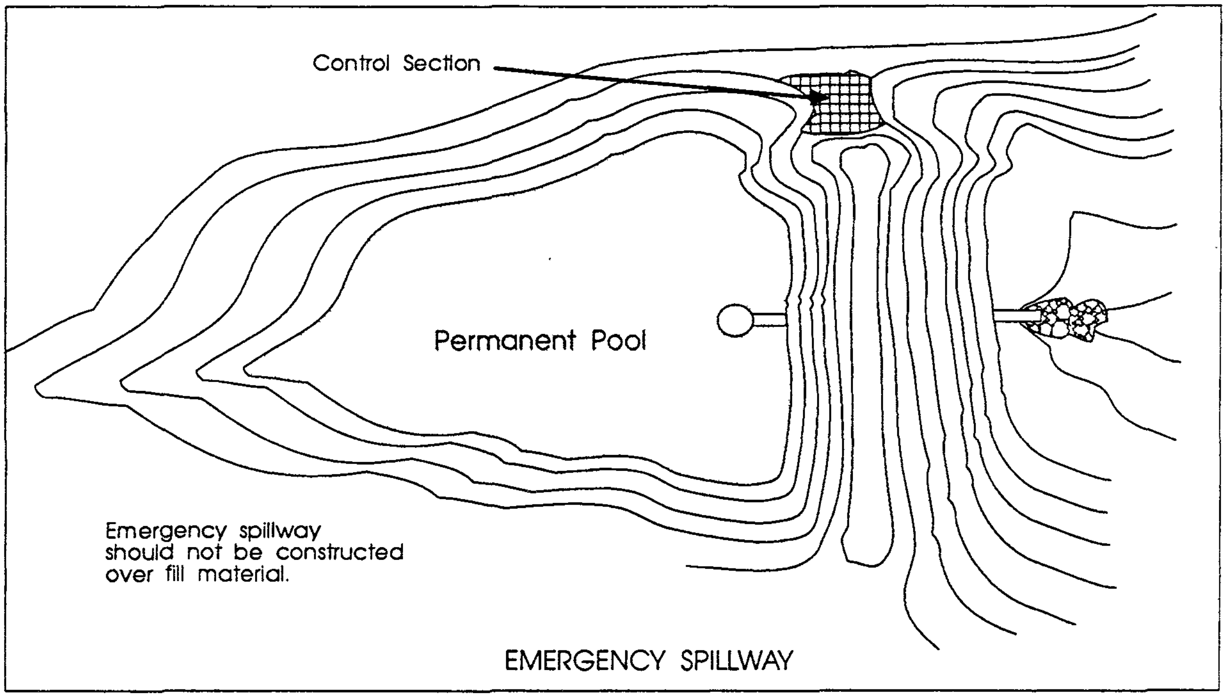


Figure 12. Emergency spillway of sediment basin. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

4.2.2 Check Dams

4.2.2.1 Description

Check dams are used to slow the velocity of a concentrated flow in a natural or manmade drainageway and are usually constructed of rock, logs, or straw bales. Stormwater will be ponded behind the check dam, and sediment will be trapped. Because the amount of sediment that could be trapped by check dams is relatively small, they are limited in use to small open-channel flows that drain no more than 10 acres. Check dams should not be used in live streams.

4.2.2.2 Design

The design specifications of rock, log, and straw bale check dams are shown in Figures 13, 14, and 15, respectively. Straw bale check dams are usually more expensive than the other types and should be used only when it is infeasible to use the other types. Log check dams have a low material cost because the logs can be salvaged from land clearing, but their installation is complicated, which increases the overall cost. Rock check dams have a higher material cost, but their installation is much easier, which may offset the material cost. One advantage of a rock check dam is that it does not disturb the soil as much as a log check dam upon removal.

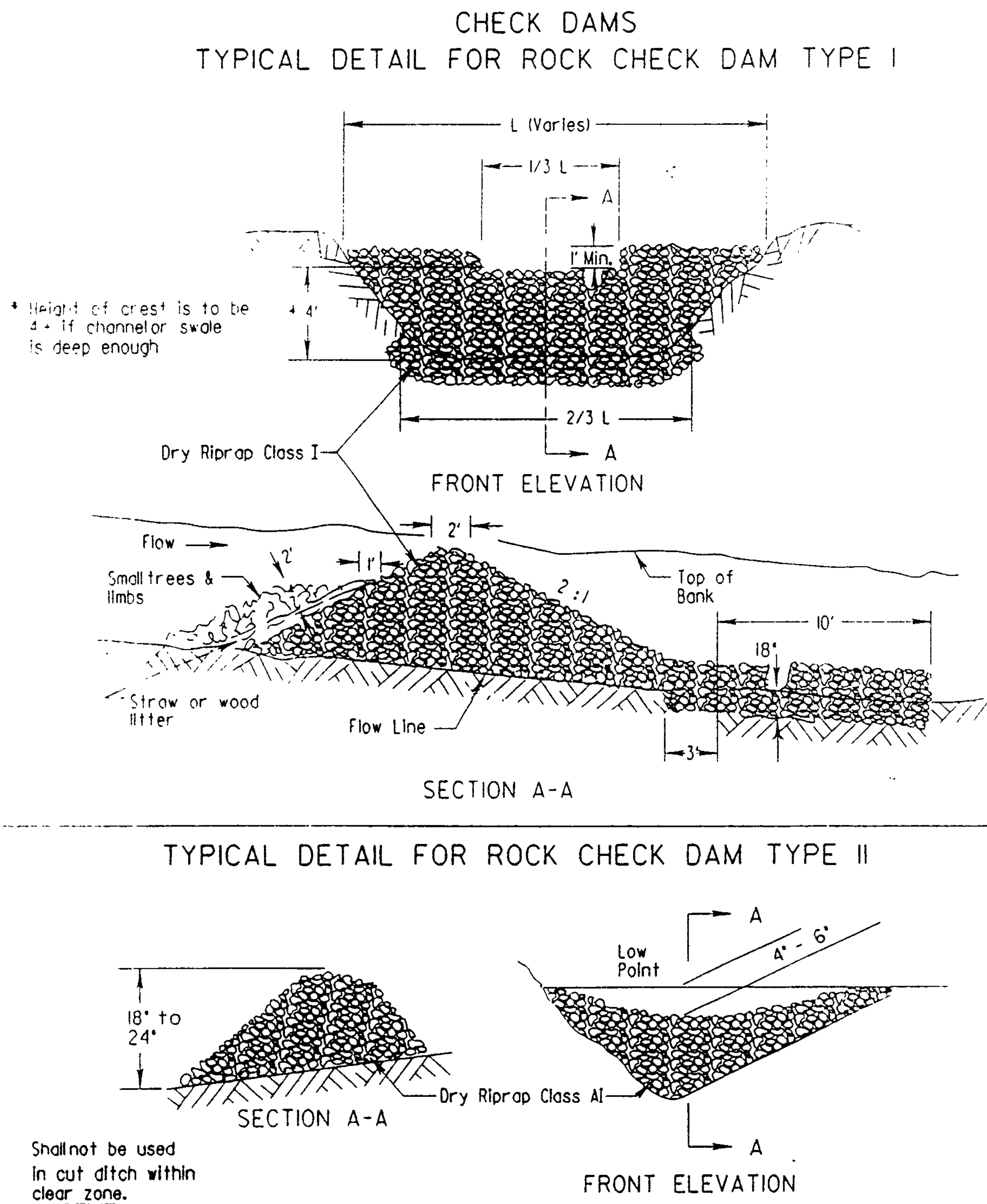


Figure 13. **Rock check dam.** ***Source*****: Virginia Soil and Water Conservation Commission. 1980.** ***Virginia erosion and sediment control handbook.*** **Richmond.**

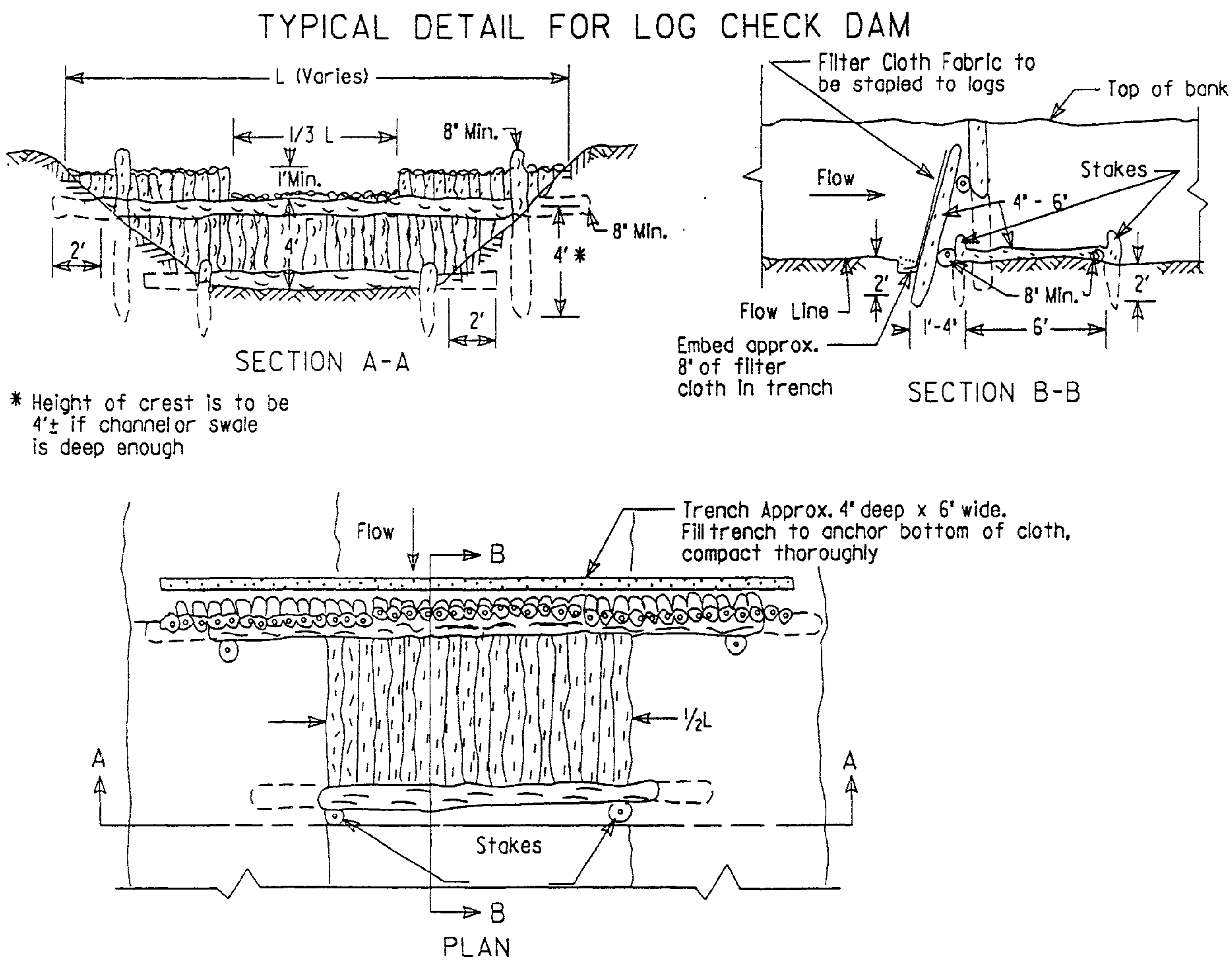
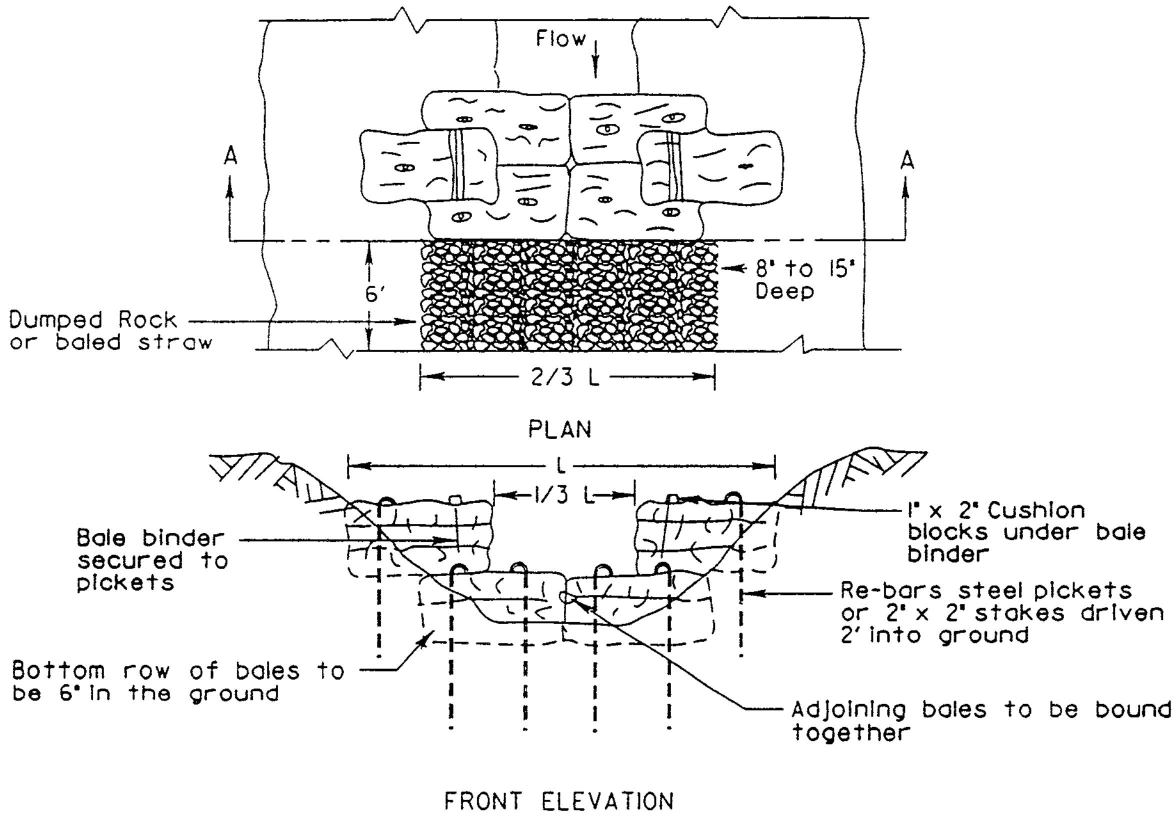


Figure 14. Log check dam. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

BALED STRAW CHECK DAM
TYPICAL DETAIL FOR BALED STRAW CHECK DAM



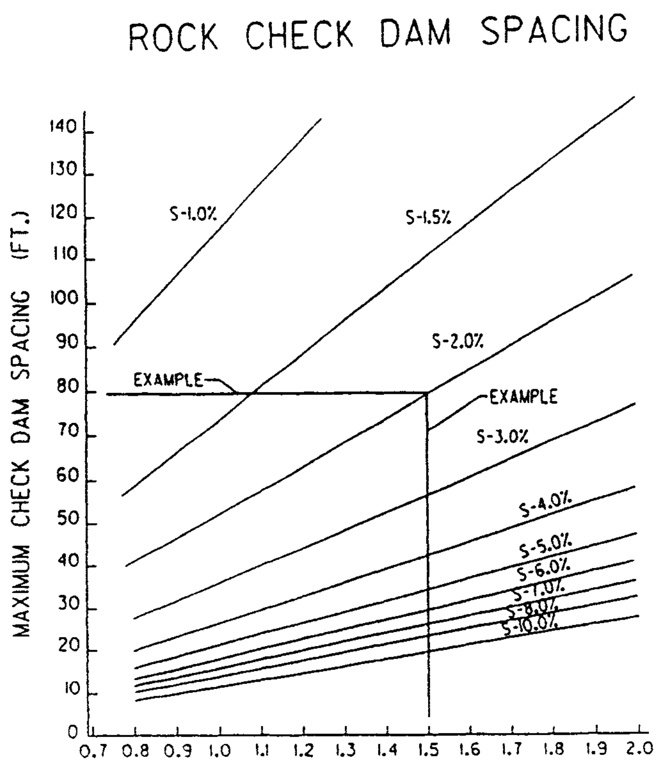
NOTES:

Baled Straw Check Dams are to be used with open channels and contributing drainage areas of less than 10 acres.

The number of bales required will vary according to actual ground conditions. Dams are to be two bales high where possible.

Figure 15. Straw bale check dam. ***Source*****: Virginia Soil and Water Conservation Commission. 1980.** ***Virginia erosion and sediment control handbook.*** **Richmond.**

98



DESIGN OF STONE CHECK DAM SPACING
(n = 0.030, V_O = 2.0 fps)

EXAMPLE : HEIGHT OF STRUCTURE 1.5'
GRADE 2%
EXTEND PERPENDICULAR FROM 1.5' HEIGHT TO INTERSECT 2% GRADE
EXTEND 90° TO THE LEFT TO DETERMINE SPACING (78'±)

Figure 16. Determination of check dam spacing. ***Source*****: Virginia Soil and Water Conservation Commission. 1980.** ***Virginia erosion and sediment control handbook.*** **Richmond.**

The height of a check dam should usually be 2 feet or less. The check dam should be designed so that stormwater will overflow from a low spot in the center of the dam. The area downstream should have riprap to prevent erosion.

The spacing between check dams can be found by the use of Figure 16. In this figure, if the height of the check dam and the slope of the channel are known, the spacing can be read from the vertical axis. It is also recommended that the spacing be such that the toe of the upstream check dam and the crest of the downstream check dam be at the same elevation.

Maintenance will be required when the volume behind the check dam has been half filled with sediment or when the check dam has been damaged by a storm or construction activity.

4.3.3 Silt Fence/Filter Barrier

4.3.3.1 Description

A silt fence is a very popular temporary sediment barrier consisting of filter fabric entrenched and stretched across supporting posts. A wire mesh is sometimes used to strengthen the fence. A smaller version of a silt fence is referred to as a filter barrier.

4.3.3.2 Design

A silt fence can be used on the perimeter of a project to ensure that eroded sediment does not leave the site. It may also be used around the inverts of drainage structures, along the backsides of wing walls and head walls.[5] Because of the pressure of ponded water behind them, silt fences should not be used where large flows are expected. Therefore, their use is limited to overland and sheet flows.

A silt fence has a minimum height of 36 inches and can be used to control runoff where there is no less than 100 feet of fence per quarter acre of drainage area. The slope behind the fence should be no greater than 2:1 and less than 100 feet in length. A fence may also be used in swales or ditches where the drainage area is less than 2 acres. Its useful life is about 5 months.

A filter barrier can be used in a similar manner. A filter barrier is better suited for use in ditches because of its height, which allows water to flow over the barrier before flowing around. The contributing drainage area should be no more than 2 acres to prevent the barrier from being washed out. The height is usually between 15 and 18 inches, and the barrier can be used at the toes of fill when the fill height is 5 feet or less.

Proper placement and installation of a silt fence or a filter barrier can be seen in Figure 17.

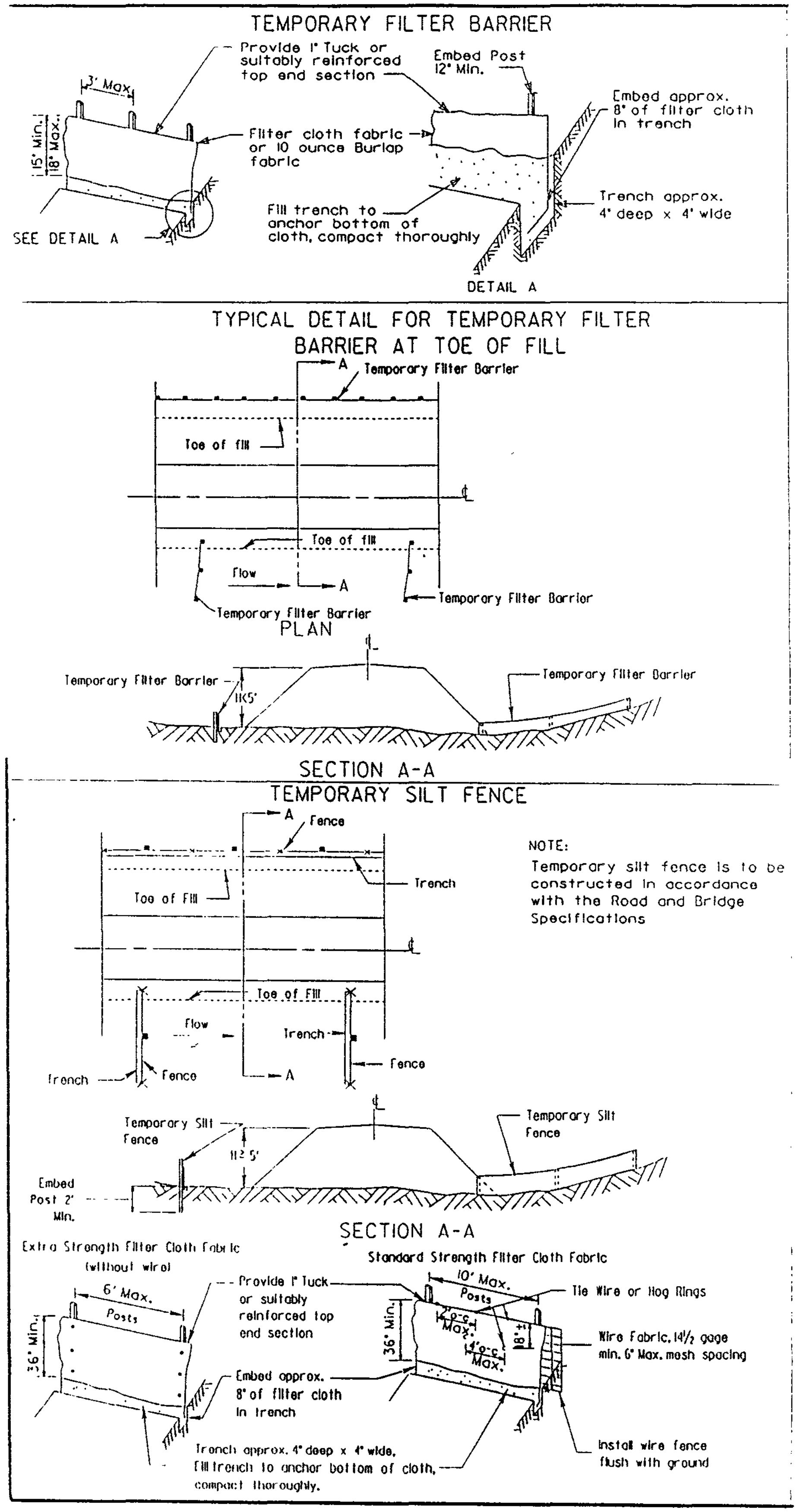


Figure 17. **Silt fence and filter barrier.** ***Source*****: Virginia Soil and Water Conservation Commission. 1980.** ***Virginia erosion and sediment control handbook.*** **Richmond.**

4.3.4 Brush Barrier

4.3.4.1 Description

A brush barrier is constructed of spoil material from the clearing of a site. Instead of being hauled away or burned, brush can be effectively used on the site to control erosion and sediment. A brush barrier works best when constructed in conjunction with filter fabric and evergreen debris. Brush barriers are usually used on the perimeter of a site and at the toe of fills. Because of their unsightly nature, their use is usually restricted to areas of low visibility.

4.3.4.2 Design

For construction, brush should be piled up and densely compacted at about 5 feet from the toe of a fill or on the perimeter of a project. The pile should be 5 feet high and 10 feet wide. Filter fabric can be placed over the brush to complete the construction. Figure 18 shows the placement of the fabric on the barrier.

4.3.5 Diversion Dike

4.3.5.1 Description

A diversion dike is an earthen berm constructed to divert runoff to an acceptable outlet (e.g., to a sediment basin from projects draining 3 acres or more). It can be placed on the perimeter of a project to retain eroded sediment or above the project to stop outside runoff from washing over the disturbed area.

4.3.5.2 Design

A dike has a useful life of about 18 months, and it should be vegetated to minimize its erosion. If it is constructed on a steep slope, the downhill side slope of the dike should be evaluated to determine if it will erode easily. If this is the case, the downhill slope should be flattened. Also, the channel behind the dike should have a slope no greater than 2%. If the slope is greater, the channel must be stabilized to reduce erosion.

A dike should have the minimum dimensions shown in Figure 19. Side slopes should have a length-to-width ratio of 1 1/2:1 or flatter, with a maximum drainage area of 5 acres. A dike should be in place before construction begins, and it should be stabilized within 48 hours of its construction. A dike should be located to minimize interference with, and damage from, construction operations and traffic.

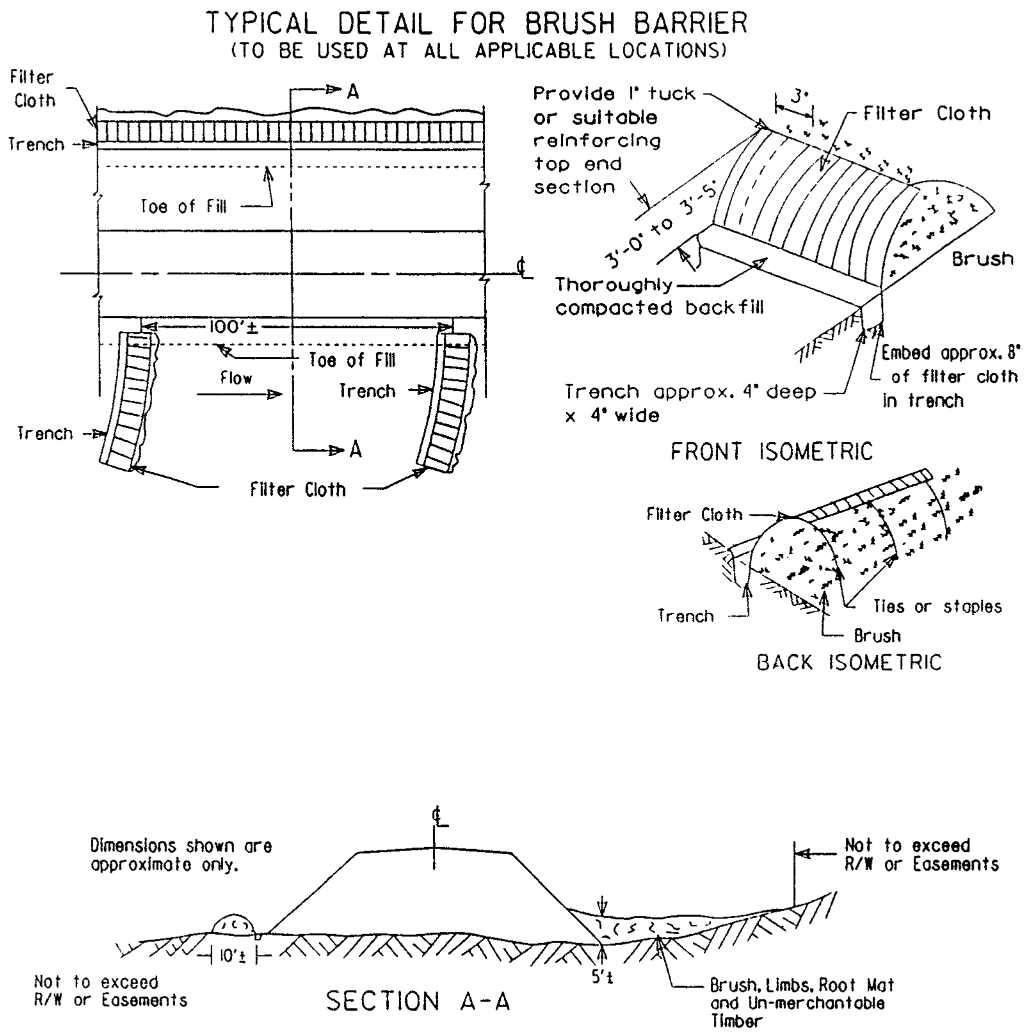


Figure 18. Brush barrier. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

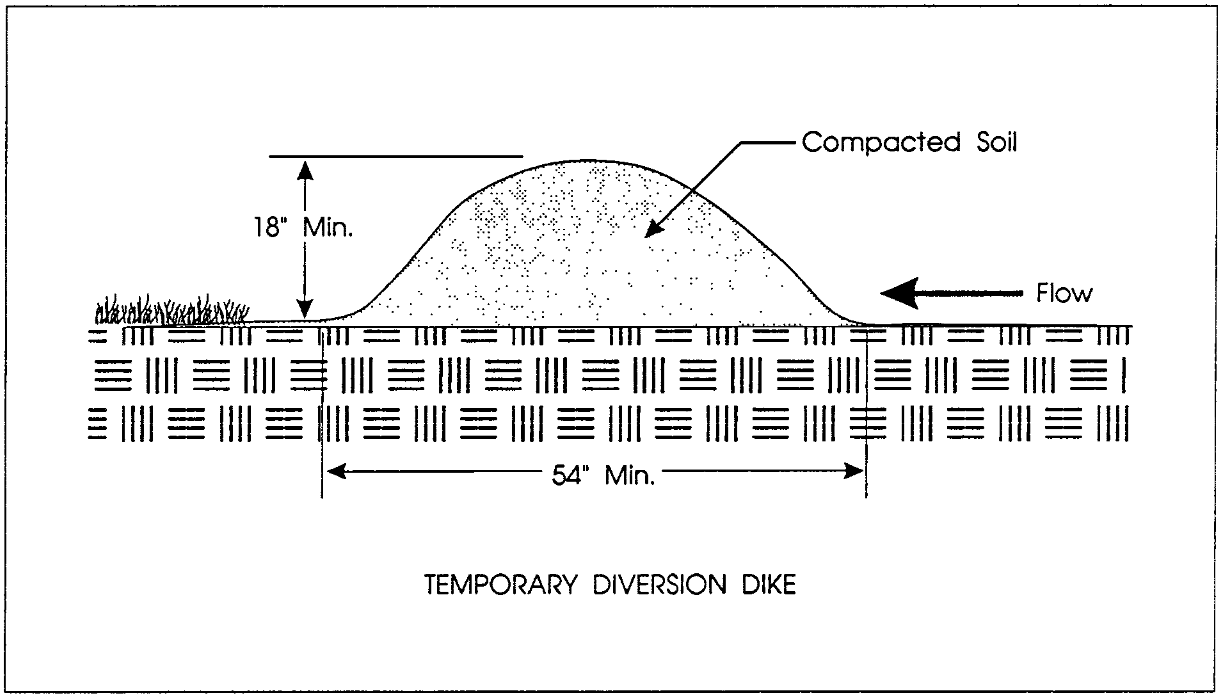


Figure 19. Temporary diversion dike. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook*. Richmond.

4.3.6 Temporary Slope Drain

4.3.6.1 Description

A slope drain is a conduit or tubing used to convey stormwater down a slope to avoid erosion of the slope. It is often used on cut or fill slopes before the permanent drainage way is installed. A slope drain can also be used to convey stormwater down a slope from a control facility.

4.3.6.2 Design

Figure 20 shows the construction specifications for a temporary slope drain.

950

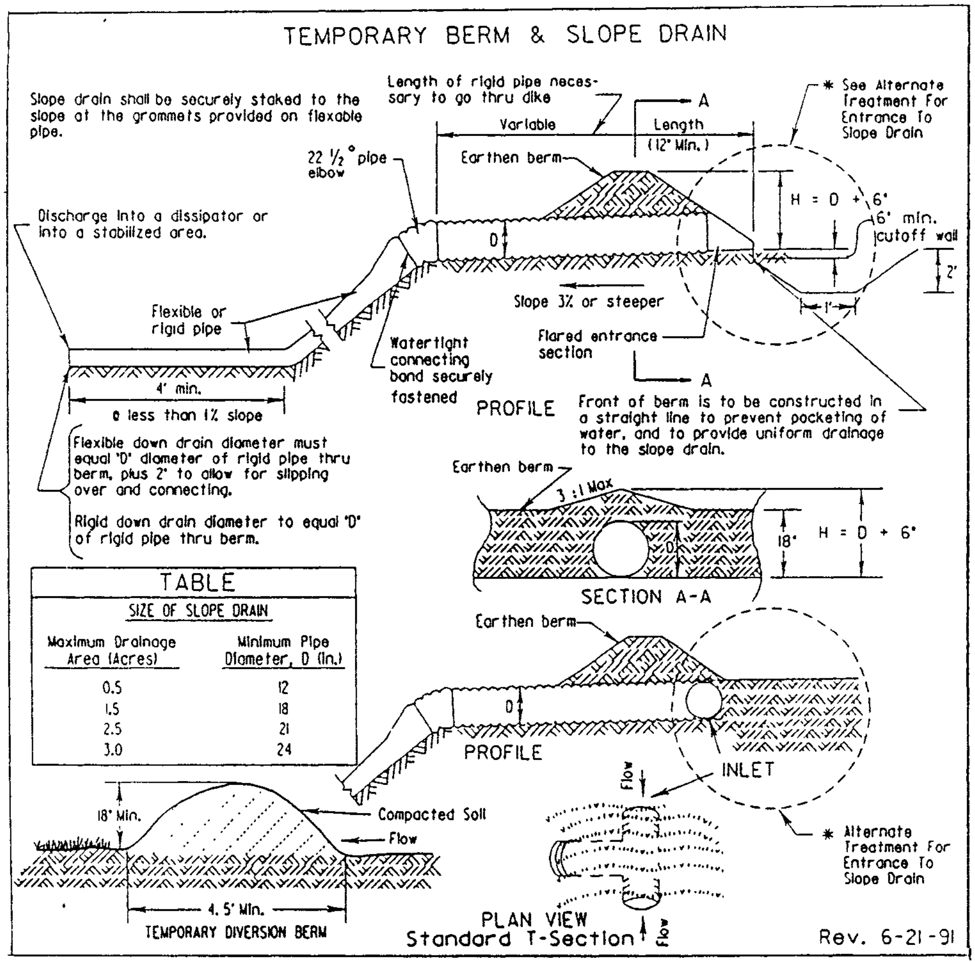


Figure 20. Temporary slope drain. *Source*: Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook.* Richmond.

4.3.7 Dewatering Basin

4.3.7.1 Description

A dewatering basin is a detention area where sediment-laden water that is pumped from a site is treated by sedimentation. The excavated basin is usually constructed of straw bales with a riprap outlet, all of which is covered by a geotextile, or filter cloth.

4.3.7.2 Design

A dewatering basin is designed by multiplying the pumping rate, in gallons per minute, by 16 to obtain the required volume of storage in cubic yards. The accumulated sediment must be removed when the basin is half full. Outflow from the basin should flow in an adequate channel or conveyance to prevent erosion. A typical dewatering basin is shown in Figure 21.

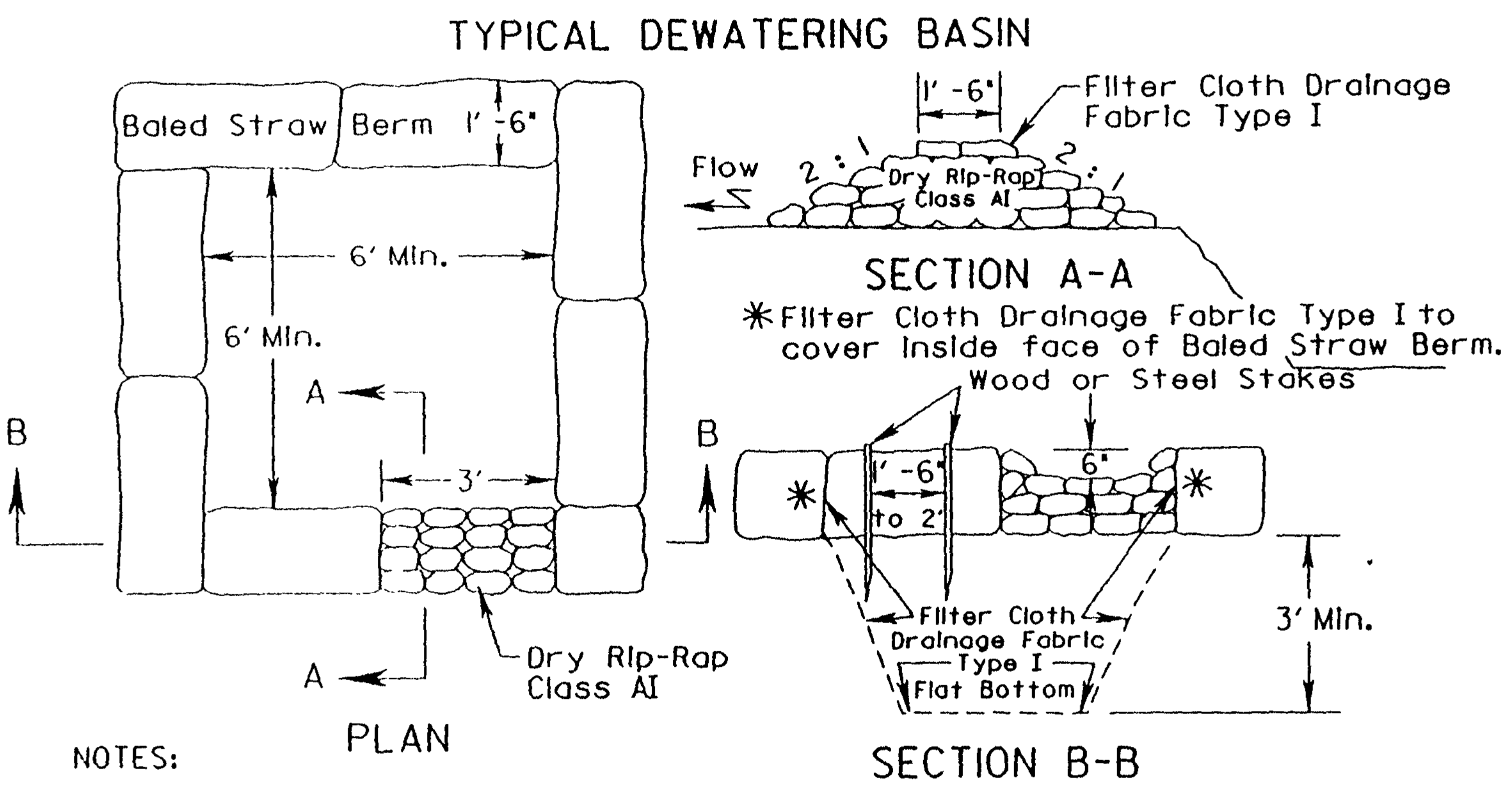


Figure 21. Dewatering basin. *Source:* Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion and sediment control handbook*. Richmond.

4.4 POSTCONSTRUCTION STORMWATER MANAGEMENT CONTROLS

4.4.1 Introduction

After construction has been completed, it is still necessary to control stormwater runoff. Excessive E&S transport, in addition to the degrading of the state's waters and the large peak flows from impervious areas, must be minimized through the use of management controls. The controls described in this section control the quantity and quality of stormwater through detention, infiltration, filtration, biological uptake, or a combination of these methods.

4.4.1.1 Quantity

For quantity purposes, the SWM controls should be designed to reduce the postconstruction peak flow from a 2- and a 10-year storm (considered individually) to the preconstruction level and, in some cases, be able to pass a 100-year storm safely. To control a 2- and a 10-year storm, the storage should be equal to the area between the pre- and postconstruction hydrographs. A simple approximation of this storage volume can be made with equation 1:

$$S = 0.5(Q_{post} - Q_{pre})T_{base} \qquad [1]$$

where S = storage (cubic feet)
Q_{post} = peak flow postconstruction (cubic feet per second)
Q_{pre} = peak flow preconstruction (cubic feet per second)
T_{base} = base time of postdevelopment hydrograph (seconds).

Another approximation of the storage volume can be found using the Pagan method.[10] For this method, data from many small basins were compiled and the curve in Figure 22 was developed. This curve may be used to determine the storage volume for a given drainage area by dividing the predevelopment peak inflow by the postdevelopment peak inflow to obtain the percentage of peak inflow on the y axis. Knowing the percentage of peak inflow, the storage parameter (peak storage in cubic feet over peak inflow in cubic feet per second) can be found by moving horizontally from the y axis to the curve and down to the x axis. By multiplying the storage parameter by the peak inflow, the approximate peak storage can be found. This method should be used only as a first trial and was developed for small watersheds. Experience has shown that this method is conservative.

Other methods can be used to estimate the required amount of storage to control outflows. After a volume has been assumed, the design storm(s) should be routed through the facility to ensure its ability to control the storm(s). Usually, this is a trial and error type of calculation to determine the amount of storage needed. There are computer programs available to facilitate such calculations.

4.4.1.2 Quality

For the quality aspect of SWM, the SWMR require that the WQV be treated to remove pollutants. This treatment can include sedimentation in ponded storm-

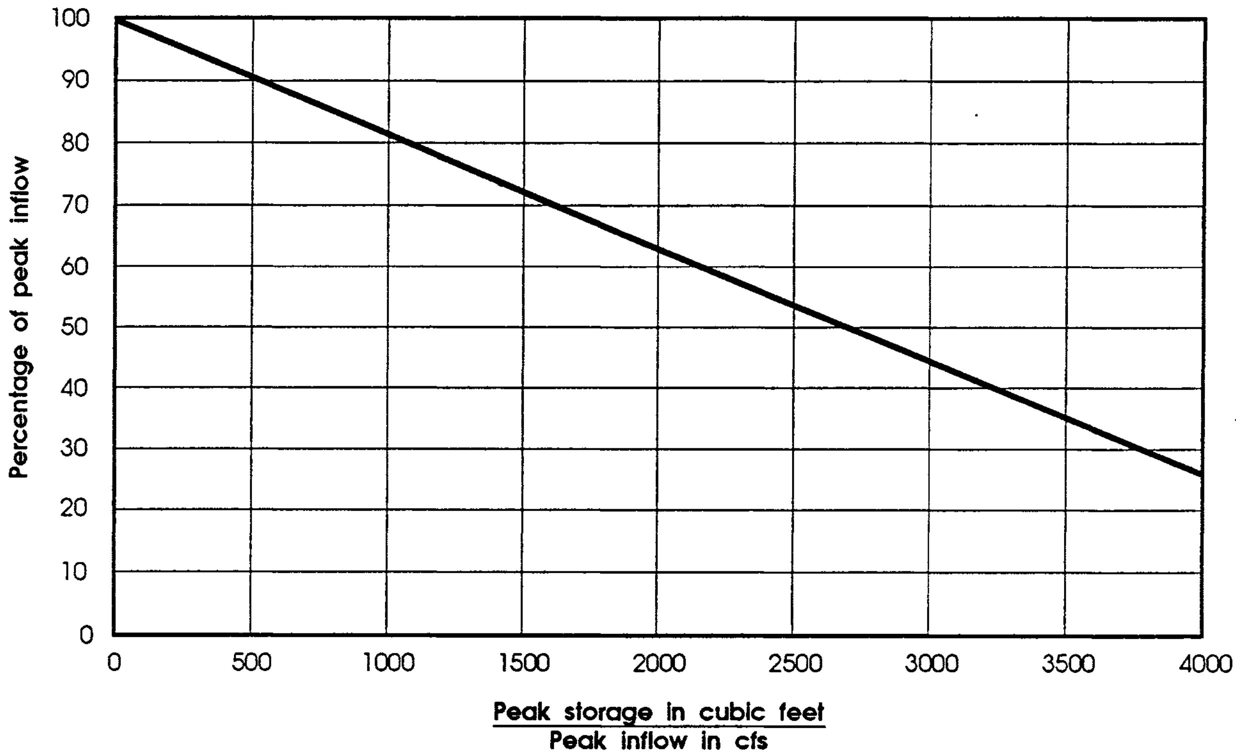


Figure 22. Storage parameter curve. *Source:* Virginia Department of Transportation. 1990. *Drainage manual.* Richmond.

water, filtering by vegetation or a manmade filter, or biological uptake of pollutants by plants and microbes. Most of the different practices described herein use different combinations of methods to remove pollutants. Table 9 shows the different WQVs for various-sized areas.

There are two types of ponds generally used with BMPs: dry ponds (detention basins) and wet ponds (retention basins). The major difference between them is that wet ponds retain a permanent pool but dry ponds do not and are empty most of the time.

4.4.2 Dry Pond (Detention Basin)

4.4.2.1 Description

Detention basins are depressed areas that store runoff during wet weather and are dry the rest of the time. They are very popular because of their comparatively low cost; few design limitations; ability to serve large as well as small watersheds; and ability to be incorporated into other uses, such as recreational areas.

Table 9
VOLUMES AND FLOWS ACCORDING TO SIZE OF AREA

Drainage Area (acres)	WQV (cf)	Average Outflow (30 hr cfs)	Retention Volume (cf)
1.0	1,815	0.0168	5,445
2.0	3,630	0.0336	10,890
3.0	5,445	0.0504	16,335
4.0	7,260	0.0672	21,780
5.0	9,075	0.0840	27,225
6.0	10,890	0.1008	32,670
7.0	12,705	0.1176	38,115
8.0	14,520	0.1344	43,560
9.0	16,335	0.1513	49,005
10.0	18,150	0.1681	54,450
11.0	19,965	0.1849	59,895
12.0	21,780	0.2017	65,340
13.0	23,590	0.2185	70,785
14.0	25,410	0.2353	76,230
15.0	27,225	0.2521	81,675
20.0	36,300	0.3361	108,900
25.0	45,375	0.4201	136,125
30.0	54,450	0.5042	163,350
35.0	63,525	0.5882	190,575
40.0	72,600	0.6722	217,800
45.0	81,675	0.7563	245,025
50.0	90,750	0.8403	272,250

4.4.2.2 Design

- *Quality.* To design the basin for stormwater quality control, the WQV must be routed through the basin. The SWMR specify that the WQV be 0.5 inch multiplied by the project area. The WQV should be detained and released over a period of 30 hours. Equation 2 may be used to obtain the average outflow from the pond:

$$Q_{avg} = \frac{WQV}{T} \qquad [2]$$

where Q_{avg} = average outflow from the basin (cubic feet per second)
WQV = water quality volume (cubic feet)
T = detention time (seconds).

Knowing the average outflow, one can use an appropriate orifice equation to determine the size of the outlet. However, the SWMR specify that the minimum size of the outlet be 3 inches; this is to prevent the outlet from clogging, and it may lead to a detention time under 30 hours. Table 9 shows the WQV and average outflows for different drainage areas.

- *Quantity.* For quantity purposes, the pond should be designed to reduce the postconstruction peak flow from a 2- and a 10-year storm (considered individually) to the preconstruction level, and it should be able to pass a 100-year storm safely. To control a 2- and a 10-year storm, the basin's storage should be equal to the area between the pre- and postconstruction hydrographs.

After a storage volume has been determined for each event, a 2- and a 10-year storm should be routed through the facility to ensure that the peak flows from the postconstruction watershed are not greater than the corresponding preconstruction peak flows. Finally, a 100-year storm should be routed through the facility to ensure that the embankment will not be damaged or fail during the passage of a 100-year storm. It is very common to have several outlets to control the different storms: one for a 2-year storm; one for a 10-year storm; and an emergency spillway to control anything larger, including a 100-year storm. To improve the efficiency of the outlet, it may be necessary to include an antivortex device. Examples of outlet design are shown in Figures 8, 23, and 24.

Routing the storms through the detention basin can be accomplished in many ways. Examples of routing procedures and programs are given in Chapters 6 and 7.

- *Quantity and quality combined.* Combining the two designs (quality and quantity) will yield a dual-purpose detention basin. Several other design variations may be considered to enhance the capabilities of the facility. One consideration is shaping the basin to improve its pollutant-removal capabilities. The length-to-width ratio should be at least 3:1, and a wedge-shaped basin (wider at the outlet) can also improve pollutant removal. The inlet, outlet, and side slopes should be stabilized with riprap and/or vegetation to prevent erosion. The basin floor should also be vegetated to stabilize the soil and increase biological uptake. The pond floor should be sloped no less than 2% to prevent the ponding of stormwater, and the side slopes should allow for easy maintenance access. A marsh or wetland can be established on the pond floor to increase biological uptake, and a sediment forebay (a small sediment trap at the inlet of the basin, either a depressed area or a shallow area with a very flat slope where sediment is easily deposited) can be used to catch the sediment before it fills the basin. The basin can also have two stages: one to hold the smaller storms, and a second, which is rarely inundated and can be used for other purposes, to help store the larger storms. Safety considerations include reducing the chance of drowning by fencing the basin, reducing the maximum depth, and/or including ledges and mild slopes to prevent people from falling in and facilitate their escape from the basin.

- *Outlets.* Outlets for dry basins can be designed in a wide variety of configurations. Most outlets use riser pipes of concrete or corrugated metal. These risers can be designed to control different storms through the use of several orifices on the riser, for example, a small diameter to control the WQV, an orifice to control a 2-year storm, and a larger orifice to control a 10-year storm. This larger flow is usually controlled by stormwater flowing in through the top of the riser, using the entire riser diameter. In the latter case, an antivortex design may be necessary. Larger flows are usually handled by an emergency spillway. Since the WQV outlet must be small to detain the WQV long enough, it can be easily clogged; thus, a minimum size of 3 inches should be used. To prevent clogging, a trash rack may be included in the design to cover the orifices.

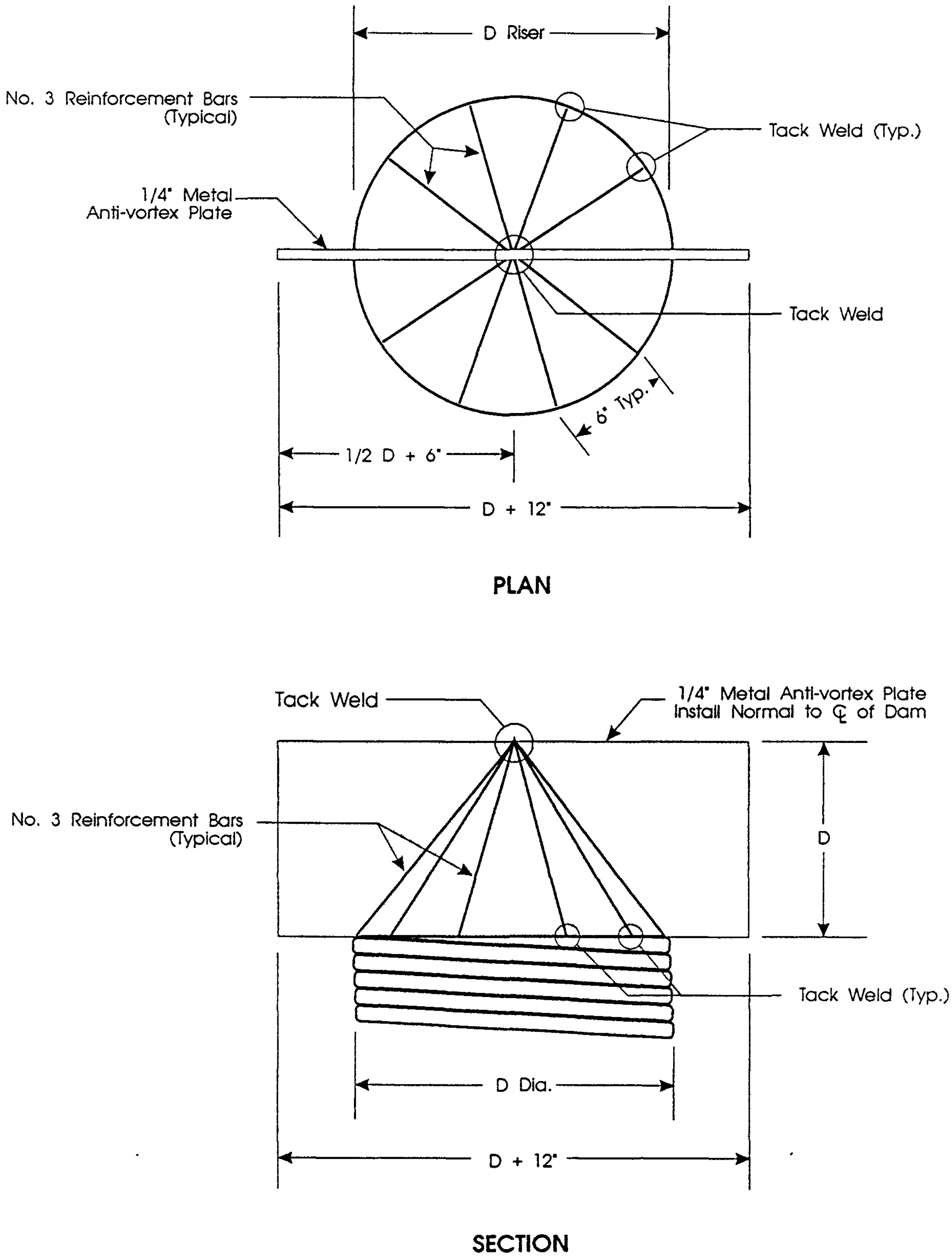


Figure 23. Antivortex plate and trash rack. *Source:* **U.S. Department of Transportation. 1979.** ***Design of urban highway drainage: The state of the art.*** **Publication No. FHWA-75-79-225. Washington, D.C.**

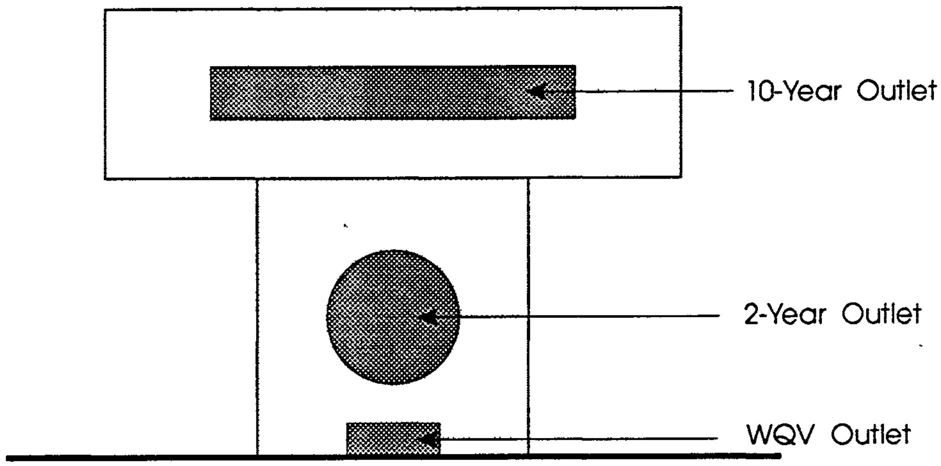


Figure 24. Concrete riser.

- *Maintenance.* Maintenance is important. Grassed areas should be mowed at least twice a year to discourage woody growth. An inspection of the facility should be made at least once a year, preferably during wet weather, to ensure that the basin is functioning properly. Eventually, the sediment will have to be removed from the bottom of the basin. This should be done every 5 to 10 years, depending on how fast the facility fills with sediment. A maintenance right of way, or easement, should be included in the design to allow for easy access to clean the basin.

A schematic drawing of a detention basin is shown in Figure 25, and a summary of the design considerations is given in Table 10.

4.4.3 Wet Pond (Retention Basin)

4.4.3.1 Description

A retention basin is very similar to a detention basin in that it detains stormwater, but it is different in that it retains a permanent pool during dry weather. Retention basins are usually more expensive then detention basins and usually serve large watersheds. Because of their permanent pool, they may also have recreational benefits.

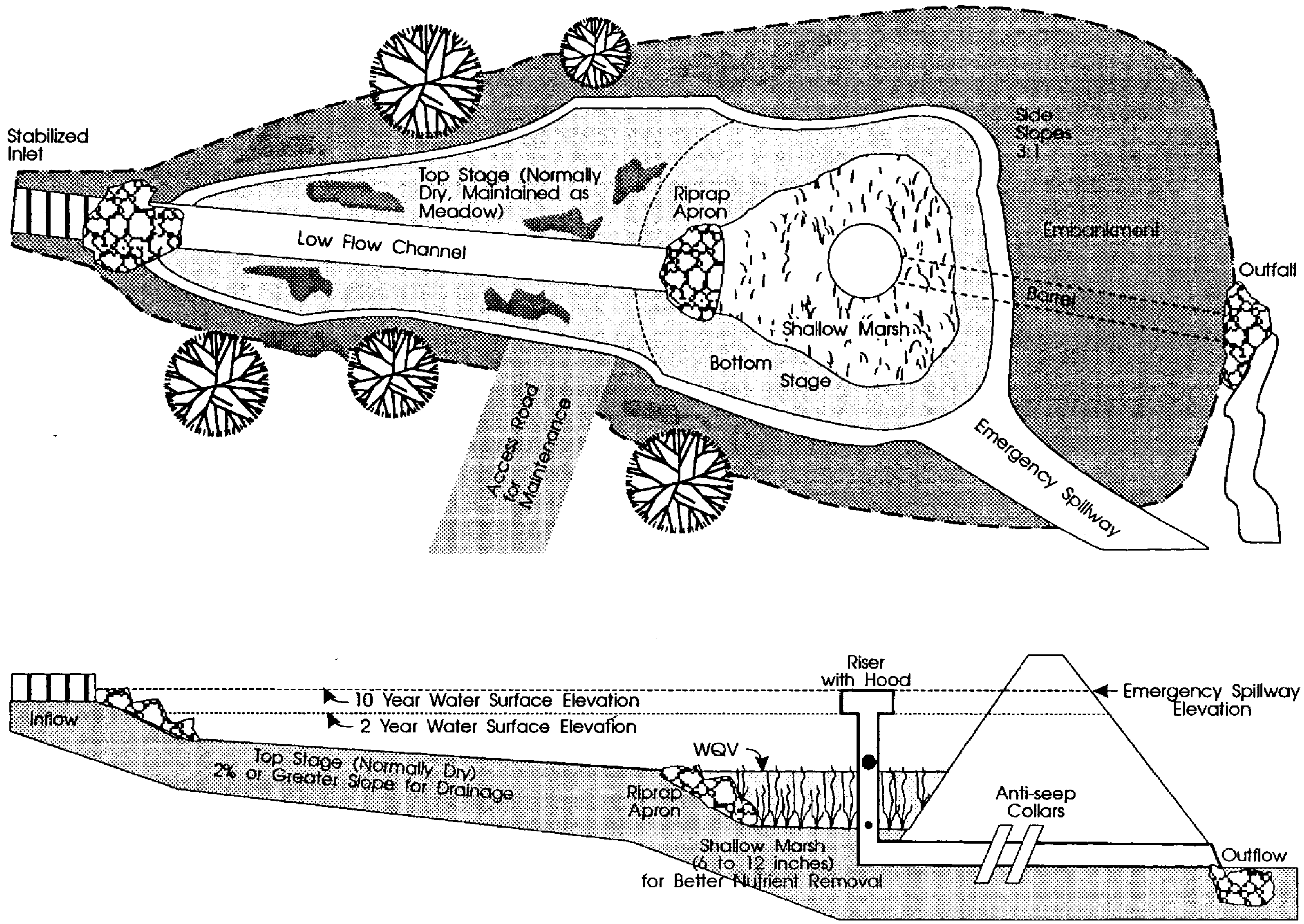


Figure 25. Dry pond. Data from Schueler.[7]

Table 10
SUMMARY OF CONSIDERATIONS FOR A DRY POND

Quality control	Detain WQV for 30 hr (minimum 3-in orifice)
Quantity control	Control 2- and 10-year peak flows and maintain nonerosive velocity
Shape	3:1 length-to-width ratio; wedge shaped (wider at outlet)
Maintenance	Inspect once a year, preferably during wet weather; mow as required (at least twice a year); remove sediment (every 5–10 years)
Other considerations	Side slopes provide easy maintenance access (3h:1v); 2% bottom slope to prevent ponding; sediment forebay to reduce maintenance safety requirements (depth and perimeter ledges)
Pollutant removal	Moderate

4.4.3.2 Design

• *Quality.* For quality purposes, the SWMR state that the permanent pool must be at least 3 times the WQV for the watershed. The theory behind this is that incoming runoff displaces old stormwater from the pond and the new runoff is detained until it is displaced by more runoff from the next storm. A permanent pool of 3 times the WQV should then provide an adequate detention time for the stormwater. Table 9 shows the retention volume for different areas. To enhance pollutant removal, several other considerations may be taken into account.

The shape of the basin can significantly affect the pollutant-removal efficiency of a wet pond. The length-to-width ratio should be at least 3:1. Figure 26 shows pond configurations that may be used to increase the length-to-width ratio. Pond depth should be between 2 and 8 feet; less could allow insect breeding and wind resuspension of settled particles, and more could lead to thermal stratification in the pond and anaerobic conditions in the deep water. A wedge-shaped basin, wider at the outlet, can also improve pollutant removal.

Other considerations include establishing a sediment forebay to remove larger sediments before they fill the basin, including perimeter vegetation to increase biological uptake; making the inlets and outlets erosion resistant, including a safety ledge 1 to 3 feet deep around the perimeter of the basin and/or fencing in the basin along with posting signs warning of potential dangers; and designing the side slopes to allow for easy access for maintenance.

• *Quantity.* For quantity purposes, the retention basin is designed very similarly to the dry pond. The pond should be designed to reduce the peak flow from a 2- and a 10-year storm (considered individually) and be able to pass a 100-year storm safely.

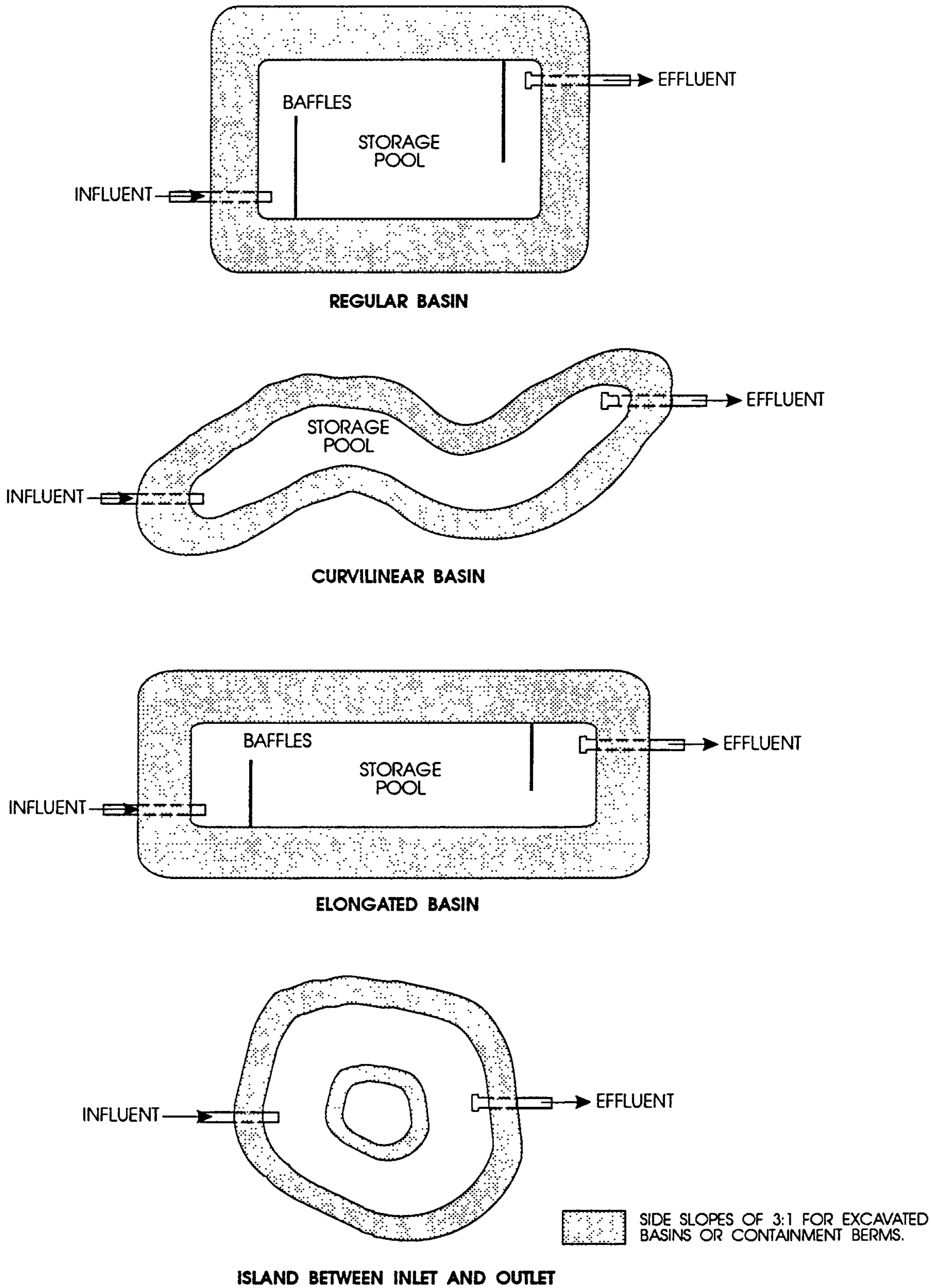


Figure 26. Methods of increasing the length-to-width ratio. *Source:* Schuler, T. R. 1987. *Controlling urban runoff: A practical manual for planning and designing urban BMPs.* Washington, D.C.: Metropolitan Washington Council of Governments.

Routing the storms through the retention basin can be accomplished in many ways. Examples of routing procedures and programs are given in Chapters 6 and 7.

- *Outlet.* Outlets for wet ponds can be designed in a wide variety of configurations. Most outlets use riser pipes of concrete or corrugated metal. These risers can be designed to control different storms through the use of several orifices on the riser. For example, a small orifice is used to control a 2-year storm, and a larger orifice to control a 10-year storm. This larger flow is usually controlled by allowing stormwater to flow in through the top of the riser, using the entire riser diameter. In some cases, an antivortex design may be necessary. Larger flood flows are usually handled by an emergency spillway. If the smallest orifice is easily clogged from floating debris, or if heated pond water causes problems downstream during the summer, the outlet can be modified so that it will release water from below the surface of the pond. Trash racks may also be included to prevent the outlet from clogging.

- *Maintenance.* Proper maintenance is important. The entire area of the dam and any grass around the basin should be mowed at least twice a year to prevent woody growth. If there is vegetation in the pond, it should be harvested so that the bottom of the basin does not fill up with decaying organic matter. The sediment on the bottom will have to be removed every 10 to 20 years, depending on the loading rate, to keep the pond working properly. A valve should be included in the design to drain the pond and allow for sediment removal.

A summary of design considerations is given in Table 11, and a schematic drawing of a retention pond is shown in Figure 27.

Table 11
SUMMARY OF CONSIDERATIONS FOR A WET POND

Quality control	Permanent pool volume is 3 times the WQV
Quantity control	Control 2- and 10-year peak flows
Shape	3:1 length-to-width ratio; wedge shaped (wider at outlet); permanent pool depth from 2–8 ft; perimeter ledges
Maintenance	Inspect once a year, preferably during wet weather; mow at least twice a year; remove sediment every 10–20 years
Safety	Fence around pond; provide shallow (2 ft deep) safety ledge around pond; post signs
Other considerations	Side slopes provide easy maintenance access (3h:1v); perimeter vegetation; sediment forebay; provide valve to drain pond for maintenance
Pollutant removal	Moderate to high

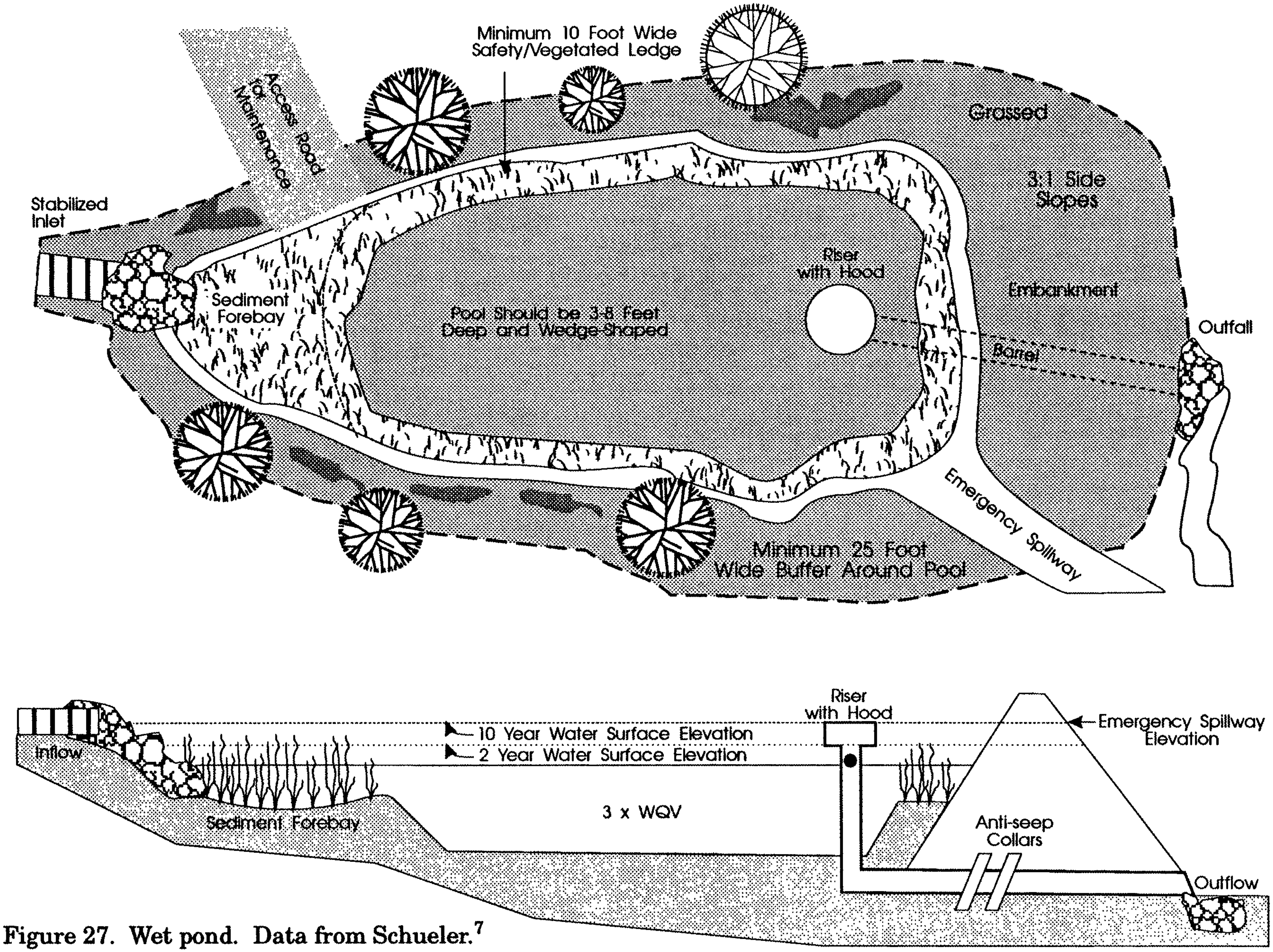


Figure 27. Wet pond. Data from Schueler.[7]

4.4.4 Infiltration Controls

Infiltration controls are BMPs where the primary discharge of stormwater is through infiltration. These include infiltration trenches, infiltration basins, and porous pavement. In some cases, the stormwater is intercepted after it has infiltrated a few feet by an underdrain and is discharged to a storm sewer or surface water. One of the primary concerns with the use of infiltration BMPs is the risk of groundwater contamination. This is why the SWMR state that there must be at least 4 feet between the bottom of the facility to the seasonably high water table and 4 feet to the underlying bedrock. Another factor is the residence time in the facility. Sources recommend that the first flush stormwater be detained for 24 to 72 hours. Table 12 provides some considerations in evaluating an infiltration control. Others are as follows:

- *Site selection.* To evaluate different sites, a report from the Maryland Department of Transportation (MDOT) by McBride and Sternberg[12] described a procedure that rates different sites by using several parameters. The procedure is as follows:

  1. Determine the distance between the site for the BMP and the nearest point of water use, and obtain a score from Table 13.

  2. Determine the depth to groundwater, and obtain a score from Table 14.

Table 12
SUMMARY OF CONSIDERATIONS FOR AN INFILTRATION FACILITY

Quality control	Infiltrate WQV within 48 hr; minimum residence time of 24 hr
Quantity control	Control 2- and 10-year peak flows (could lead to large expensive facility; could be used with detention pond to control quantity)
Shape	Dependent on site constraints and required surface area requirements
Maintenance	Inspect once a year, preferably during wet weather; mow area twice a year; remove sediment every 5–10 years
Other considerations	Filter strip to remove sediments (2–5% slope with minimum 20-ft length); infiltration rate (minimum 0.27 in/hr, 0.5 in/hr is more feasible); depth to groundwater and bedrock (4 ft); effects of facility on quality of groundwater
Pollutant removal	Moderate to high

Table 13
SCORE FOR DISTANCE TO WATER SUPPLY SOURCE

Distance (ft)	Score
< 200	0
200 < 500	1
500 < 1,000	2
1,000 < 1,500	3
1,500 < 2,000	4
≥ 2,000	5

Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures*. Publication No. FHWA-MS-83/04. Baltimore, Md.

Table 14
SCORE FOR DEPTH TO GROUNDWATER

Depth (ft)	Score
< 10	0
10 < 15	1
15 < 20	2
20 < 25	3
25 < 50	4
≥ 50	5

Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures*. Publication No. FHWA-MS-83/04. Baltimore, Md.

3. As noted in Chapter 3, a high solids input will cause an infiltration facility to become clogged. Thus, use Table 15 and determine the site's score for solids loading. The six levels of total solids and their scores were derived from the average daily traffic (ADT) and number of preceding dry days. This table gives higher scores to sites with lower solids loadings, and thus a lower chance of clogging. With a given ADT value, one can obtain the appropriate score from the table.
4. Examine the infiltration capacity of the soil, and refer to Table 16 for the scores of various soil types and depths to groundwater.
5. Look at the use of the underlying aquifer. Table 17 gives the scores for aquifer uses and loadings for the coastal and piedmont regions (of Maryland).
6. After adding the scores, use Table 18 for the site's evaluation.

Table 15
SCORE FOR SOLIDS LOADINGS

Level of Total Solids	Average Daily Traffic (vehicles per day)	Preceding Dry Days	Total Solids (lb)	Score
Light	200 < 400 (rural area)	1–2	0 < 3	5
Moderately light	400 < 5,000 (suburban secondary road)	3–4	3 < 55	4
Moderate	5,000 < 15,000 (suburban primary roads)	5	55 < 180	3
Moderately heavy	15,000 < 30,000 (urban)	6–7	180 < 500	2
Heavy	30,000 < 50,000 (interstate)	8–9	500 < 1,000	1
Extreme	≥ 50,000	10	> 1,000	0

Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures.* Publication No. FHWA-MS-83/04. Baltimore, Md.

Table 16
SCORES FOR SOIL TYPE AND DEPTH TO GROUNDWATER

Depth to Water Table (ft)	Soil Types								
	Clay or consolidated rock (CL, CH, OH)	Sandy clay (75% clay) (OL, MH)	Even clay and sand	Clayey sand (GC, ML)	Thin layers sandy clay	Sand with little clay (GM, SM)	Clean find sand (SW, SP)	Clean coarse sand (SW, SP)	Clean coarse gravel (GW, GP)
> 50	0	0	2	5	6	7	8	11	9
25–49	0	0	2	5	6	7	8	10	9
20–24	0	1	1	4	5	6	7	9	8
15–19	0	1	1	4	5	5	7	8	7
10–14	0	1	1	3	4	5	6	7	6
< 10	0	0	0	0	0	0	0	0	0

Note: The soil types are given in the textural classification, and the unification classification notation (CL, CH, OH, etc.) has been included where appropriate (Spangler, Handy, 1973).
Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures.* Publication No. FHWA-MS-83/04. Baltimore, Md.

Table 17
SCORES FOR AQUIFER USE AND SOLIDS LOADING FOR DIFFERENT REGIONS

Aquifer Type	Runoff Quality: Light	Moderately Light	Moderate	Moderately Heavy	Heavy	Extreme
Coastal Region						
Domestic	4	4	4	3	2	1
Brackish	4	4	4	4	3	3
Second underlying aquifer in use	4	4	4	4	3	2
Piedmont Region						
Domestic	3	3	2	2	1	0
Brackish	4	4	3	3	3	2
Second underlying aquifer in use	4	4	3	3	2	1

Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures.* Publication No. FHWA-MS-83/04. Baltimore, Md.

Table 18
EVALUATION OF TOTAL SCORE

Sum Intervals	Site Evaluation
0–9	Unacceptable
10–13	Poor
14–18	Acceptable
19–23	Very good
24–30	Excellent

Source: McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures.* Publication No. FHWA-MS-83/04. Baltimore, Md.

Upon completion of this procedure, several sites can be compared to determine which is the best for the infiltration BMP or if infiltration is even feasible. Other selection considerations, some of which were introduced in Table 13, include size of drainage area and proximity to foundations (the facility should be no closer than 10 feet down-gradient and 100 feet up-gradient from a foundation).[7]

- *Infiltration rate.* The infiltration rate is a very important parameter when an infiltration facility is designed. It is used to determine the outflow from the facility for quantity and quality control. Infiltration rates of greater than 0.5 inch per hour are preferred for infiltration facilities. After a suitable site for the facility has been found, several soil tests must be made before the facility is designed.

First, borings should be dug at the site to determine the soil types, depth to bedrock and groundwater, and infiltration rates. These parameters can also be determined from county soil maps. The infiltration rate can be determined with varying elevation heads. This can be done with the "falling head test" in the field. The test was described by McBride and Sternberg.[12] This procedure will yield a curve of outflow versus storage, which can be used to route storms through the facility.

- *Observation well.* An observation well should be included in an infiltration facility with a covered bottom (i.e., trenches and pavement) to allow an inspector to determine how well the facility is operating (e.g., whether the stormwater is infiltrating as designed or whether maintenance is required). A schematic of a typical observation well in an infiltration trench is shown in Figure 28. It may also be necessary to install wells in infiltration basins to determine if they are working properly, but this can be determined visually because the stormwater is stored on the surface whereas the storage in trenches and pavement is hidden from view.

4.4.4.1 Infiltration Trench

An infiltration trench is an infiltration facility where a trench is excavated and then filled with a porous medium (see Figure 29). Stormwater is stored in the voids of the fill material until it can be infiltrated. In a variation of this design, the stormwater is collected by an underdrain pipe after the stormwater has been detained and filtered by the trench. Infiltration trenches can be used in median strips (see Figure 30) or adjacent to parking lots.

- *Quality.* The bottom of the facility must be 4 feet above the bedrock and the seasonably high groundwater table, and the bottom of the stone reservoir must be below the frost line. The WQV must be infiltrated within 48 hours. The primary removal mechanisms in trenches are sedimentation and filtration, along with some biological uptake. Filtering is achieved in the top layers of the facility as stormwater enters. In the stone reservoir, the main removal mechanisms are sedimentation and adsorption. As the stormwater leaves, it is filtered again by the underlying soil, where more pollutants will be removed. Unfortunately, all infiltration facilities

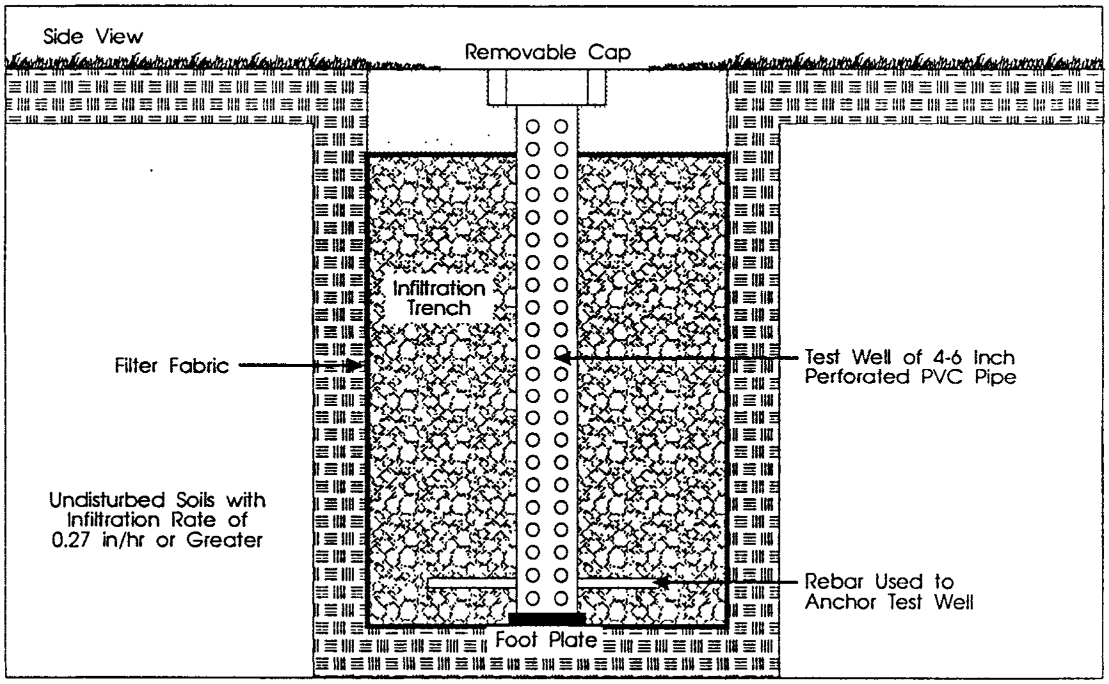


Figure 28. **Infiltration trench with observation well.** ***Source:*** **Schuler, T. R. 1987.** ***Controlling urban runoff: A practical manual for planning and designing urban BMPs.*** **Washington, D.C.: Metropolitan Washington Council of Governments.**

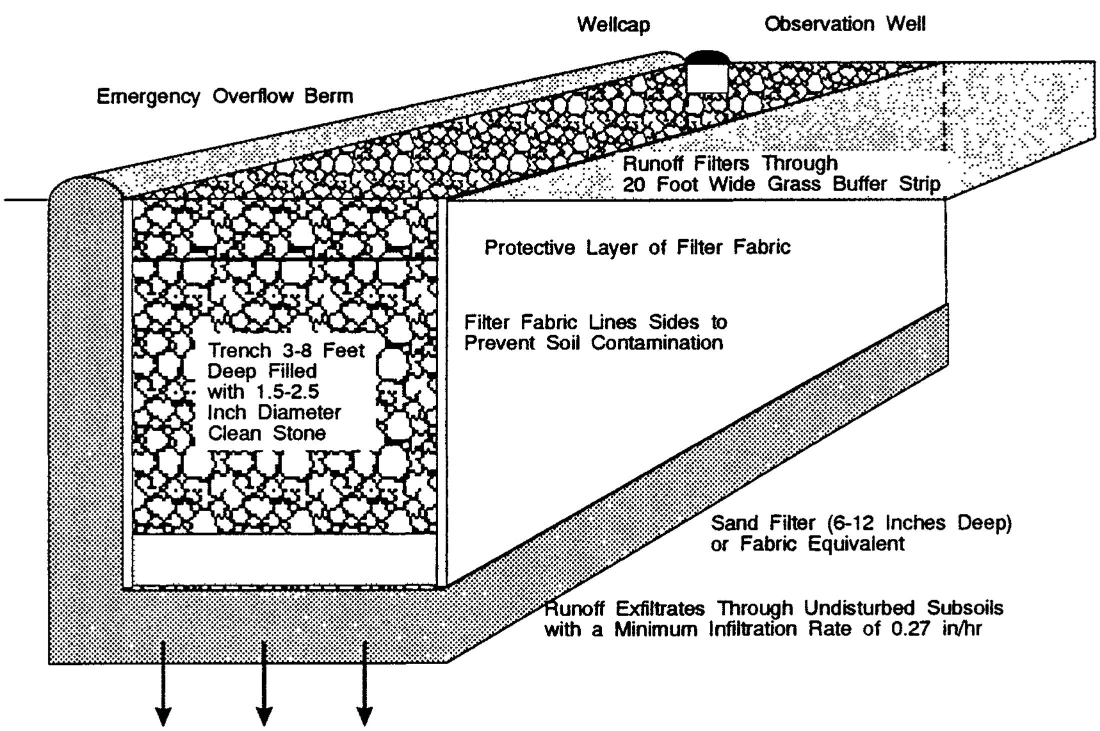


Figure 29. **Infiltration trench.** ***Source:*** **Schuler, T. R. 1987.** ***Controlling urban runoff: A practical manual for planning and designing urban BMPs.*** **Washington, D.C.: Metropolitan Washington Council of Governments.**

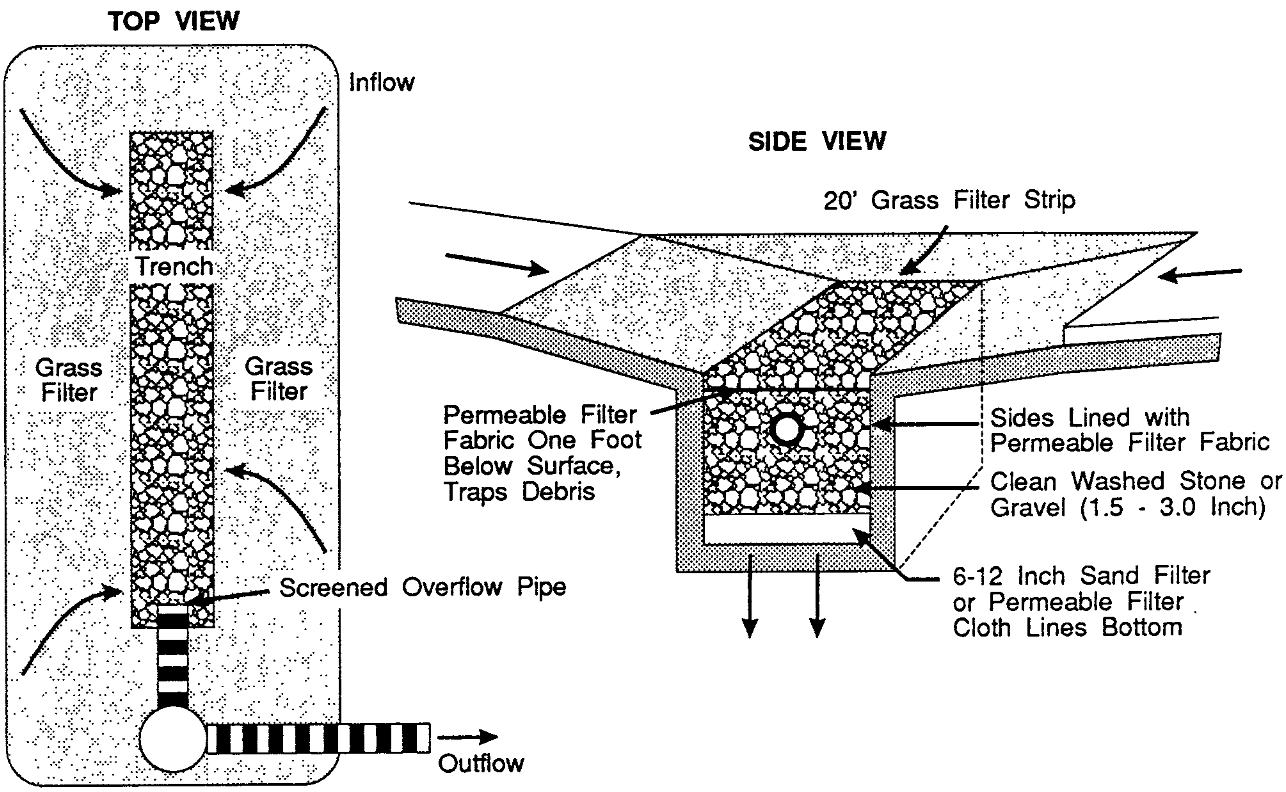


Figure 30. Median strip infiltration trench. *Source:* Schuler, T. R. 1987. *Controlling urban runoff: A practical manual for planning and designing urban BMPs.* Washington, D.C.: Metropolitan Washington Council of Governments.

are vulnerable to clogging, thereby reducing their effectiveness. Therefore, a vegetated buffer strip filtering the runoff is recommended as part of an infiltration facility. The strip would decrease the amount of suspended solids in the stormwater and thus increase the useful life of the infiltration facility. The filter strip should be at least 20 feet wide. It should also be sloped from 2% to 5% to prevent water from ponding and to ensure a slow velocity.

To protect the quality of the groundwater, a filter fabric is usually placed around the stone reservoir to reduce the amount of pollutants escaping from the trench. If this material becomes clogged, the effectiveness of the facility will be reduced. A study by Yim and Sternberg[13] examined the use of granular filters to reduce the clogging of facilities. Their test yielded four equations for determining the optimum filter medium. These equations are based on the fact that soils with a higher infiltration rate need finer filters:

$$D_{10} = \ln(e^{0.126} I^{-0.459}) \quad [3]$$

$$D_{90} = \ln(e^{0.131} I^{-1.045}) \quad [4]$$

$$D_{0} = e^{[\ln(D_{10}) - 0.125 \ln(\frac{D_{90}}{D_{10}})]} \quad [5]$$

$$D_{100} = e^{[\ln(D_{10}) + 0.125 \ln(\frac{D_{90}}{D_{10}})]} \quad [6]$$

where D_{10}, D_{90}, D_{0}, and D_{100} = the diameter (millimeters) of the filter medium below which 10%, 90%, 0%, and 100%, respectively, are smaller

I = the maximum infiltration rate (centimeters per second).

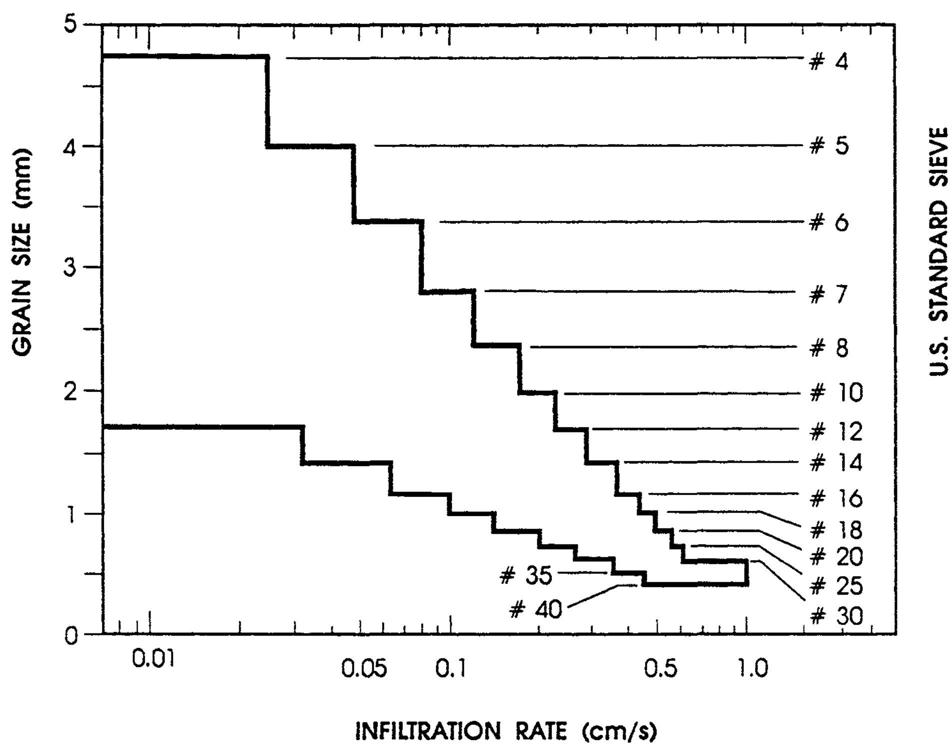


Figure 31. Relation between infiltration and filter grain sizes. *Source:* Yim, C. S., and Sternberg, Y. M. 1987. *Development and testing of granular filter design criteria for stormwater management infiltration structures.* Baltimore: Maryland Department of Transportation.

From these equations, Figure 31 was developed, which can be used to determine the characteristics of the filter medium. It is also suggested that the filter medium be about 6 inches deep.

The filter is usually placed on the bottom of the trench to intercept particles before they clog the soil below the trench. This filter will eventually become clogged, and maintenance will have to be performed by reexcavation of the trench and replacement of the filter. This can be fairly costly, but the study by Yim and Sternberg[13] showed that using a filter will almost double the useful life of the trench.

• *Quantity.* Because of the large size of the trench that would be required to control a 10-year storm, it is suggested that trenches not be used for large drainage areas or areas where the increase in peak flow, and, therefore, the amount of storage required, is very large.

A trial and error process of routing the design storms through the facility can be used to determine the amount of storage required for quantity control. Although the methods used to determine the amount of storage required for the ponds are not derived for infiltration BMPs, they can still be used to obtain an initial estimate of the required storage.

After a storage volume has been determined, the dimensions of the facility can be estimated. The depth should be designed such that the bottom is 4 feet above the bedrock and high water table and below the frost line. The surface area can be manipulated to suit the site conditions so long as it yields the required storage volume. The amount of surface area required is

$$S_a = \frac{Vol_s}{V_r \times d} \qquad [7]$$

where S_a = surface area (square feet)
Vol_s = storage volume (cubic feet)
V_r = void ratio (= 0.4 for 1.5- to 3-inch aggregate)
d = depth (feet).

The inflow hydrograph can be calculated by a number of methods, and the outflow versus storage curve can be found from a falling head test. Thus, the storms can be routed through the facility and the size of the trench can be changed to reduce the peak outflows to the preconstruction levels of a 2- and a 10-year design storm. When routing the storm through the trench, one can determine whether and how much flow will bypass the trench when it is filled with stormwater. The overflow from the trench is regulated by the SWMR and must also be contained in an adequate channel.

• *Other considerations.* Detention time is an important factor in determining the pollutant removal efficiency of a trench facility. Some sources recommend a detention time of up to 72 hours. The actual detention time can be estimated by:

$$T_s = \frac{d \times V_r}{f} \qquad [8]$$

where T_s = storage time (hours) or detention time
d = depth of storage in the trench (inches)
V_r = void ratio of stone reservoir
f = steady infiltration rate (inches per hour).

From this equation, it can be seen that detention time is directly related to trench depth. Since the WQV will most likely be much smaller than the storage required for a 10-year storm, the depth of the WQV will be very small in the trench. Therefore, infiltration trenches are much better suited for small drainage areas where the change in peak flow between pre-and postconstruction is small. Modifications can be made to the trench design to increase the depth of the WQV storage, but these will increase the cost and could make this BMP option infeasible.

4.4.4.2 Infiltration Basin

An infiltration basin looks very similar to a dry pond (see Figure 32). Stormwater from smaller, more frequent storms is infiltrated through the bottom of the basin. Larger storms can be controlled through infiltration and/or by a "peak shaving" outlet. The most important consideration for an infiltration basin is keeping the bottom from clogging with sediment. The clogging of basins, along with the overestimating of their infiltration rates, has led to the failure of many infiltration basins.[7]

- *Quality.* To protect groundwater quality, the bottom of the infiltration basin must be 4 feet or more above the bedrock and the seasonably high groundwater table. The WQV should be infiltrated within 48 hours. The primary removal mechanisms in infiltration basins are sedimentation, filtration, and biological uptake. Filtering is provided by the vegetation at the bottom of the pond and, preferably, also by a buffer strip before the stormwater runoff enters the facility. The filter strip should be at least 20 feet wide and should also be sloped from 2% to 5% to prevent water from ponding and to ensure a slow velocity. Vegetation can also contribute to the removal of pollutants through biological uptake. As the stormwater leaves, it is filtered again by the underlying soil.

The only quality requirement in the SWMR for infiltration basins is that the WQV be infiltrated within 48 hours. For pollutant removal, the stormwater should be detained for as long as possible, some sources[7,14] recommend up to 72 hours, with a minimum of 24 hours. An estimation of the depth can be found with equation 9:

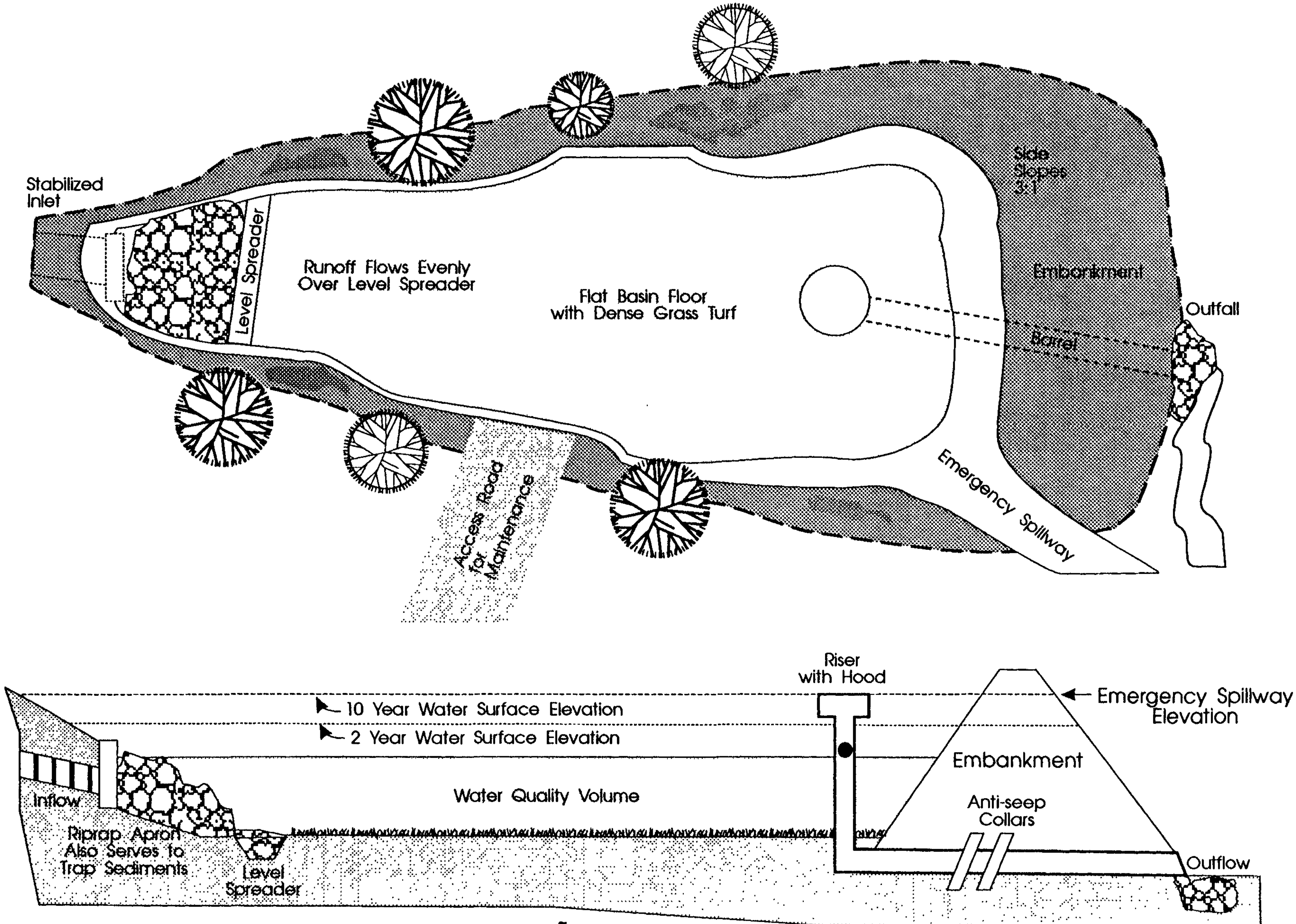


Figure 32. Infiltration basin. Data from Schueler.[7]

$$d = f \times T_s \qquad [9]$$

where d = depth (inches)
f = steady infiltration rate (inches per hour)
T_s = time of storage (hours).

The maximum allowable storage time is 48 hours. Considering the fact that basins may fail because of clogging and an infiltration rate that is lower than expected, a shorter time of storage, say 40 hours, might be used to compensate for inaccuracies in estimating infiltration rates. On the other hand, 48 hours could be used because infiltration through the sides of the basin is ignored and would be an added safety factor.

After the required depth for the basin is determined, the surface area can be found from equation 10:

$$S_a = \frac{WQV}{d} \qquad [10]$$

where S_a = surface area (square feet)
WQV = water quality volume (cubic feet)
d = depth (feet).

There are several other considerations that can help enhance the pollutant removal of these facilities. First, vegetation should be established on the basin floor. A dense stand of water-tolerant grass with a deeply penetrating root system would help stabilize the bottom of the basin and help keep the soil open. Vegetation would also provide biological uptake of nutrients.

Second, the pond bottom should be sloped as close to zero as possible in order to obtain a uniform depth of stormwater over the basin. The side slopes should be sloped at 3:1, or flatter, to allow for easy maintenance access and prevent erosion.

A third consideration has to do with the incoming stormwater. A combination of a level spreader/sediment forebay can be constructed to spread the stormwater evenly, thereby reducing erosion, and trap sediments before they clog the basin. Riprap should also be placed at the inlet to help reduce erosion.

• *Quantity.* For an infiltration basin, quantity can be controlled very similarly to a detention basin. The basin should be designed to reduce the peak flow from a 2- and a 10-year storm (considered individually) and be able to pass a 100-year storm safely.

After a required storage volume is estimated, the design storms should be routed through the basin to determine if the estimated value is correct. The outflow regulated by the SWMR is the overflow from the basin (the stormwater that is not infiltrated).

4.4.4.3 *Porous Pavement*

Porous pavement is an infiltration practice in which a stone "reservoir" is placed under a layer of open-graded asphalt concrete that contains no fines, yielding a pavement with about 16% voids that allows water to infiltrate. Under the asphalt are filters surrounding the stone reservoir that stores and detains stormwater. Figure 33 shows a cross section of a typical design. Porous pavement is generally not recommended for highway uses but is more appropriate for parking lots and other low-traffic areas. There have also been structural problems and clogging problems in some applications. Because the stone reservoir is located under the asphalt layer, maintenance can be difficult and costly. Winter salts and other abrasives should not be applied to the facility because they may cause clogging. Vacuuming on a regular basis is recommended.

- *Quality.* For quality purposes, porous pavement is designed similarly to an infiltration trench. The WQV must be infiltrated within 48 hours, and the bottom of the facility must be 4 feet above the seasonably high water table and bedrock and below the frost line. Surface area is usually controlled by the size of the parking lot, and depth is controlled by the time of storage and the infiltration rate. The following equations can be used to determine the required depth and surface area, respectively:

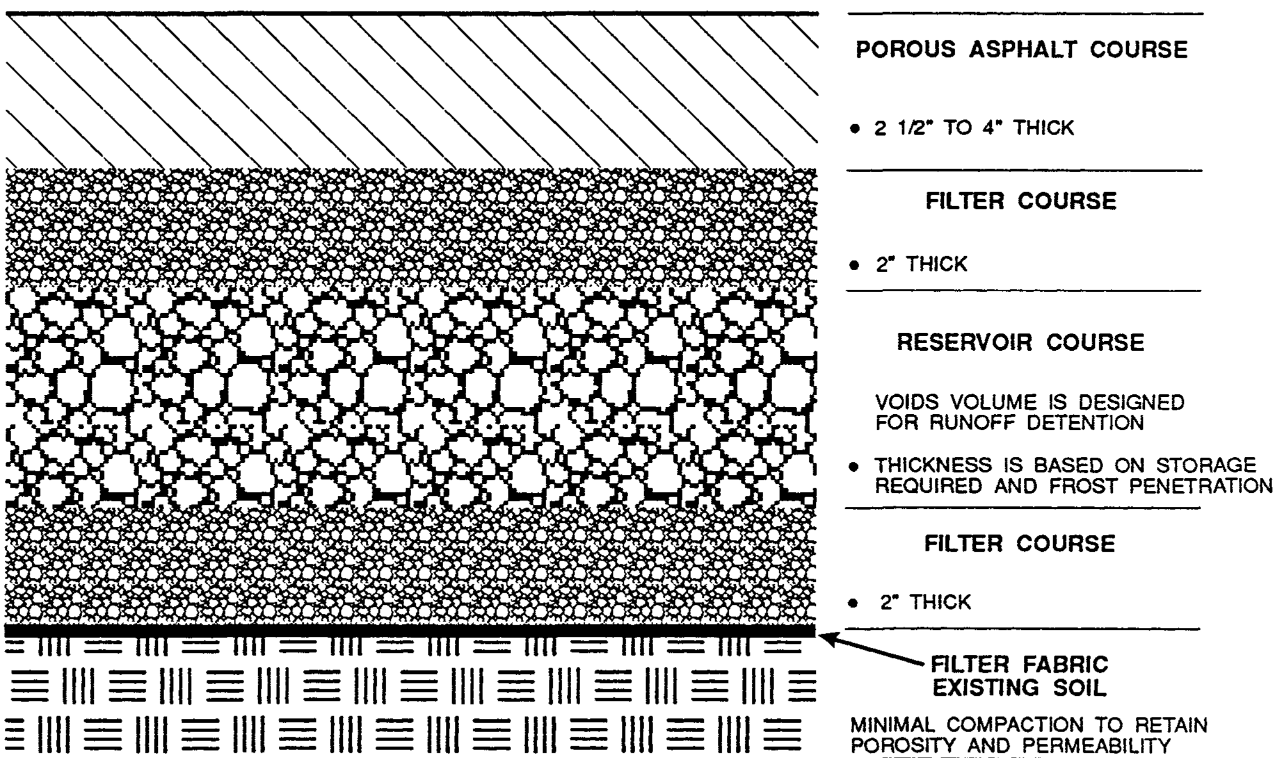


Figure 33. Porous pavement. *Source:* Northern Virginia Planning District Commission. 1987. *BMP handbook for the Occoquan watershed.* Annandale.

101b

$$D = \frac{T_s \times f}{V_r} \qquad [11]$$

where d = depth (inches)
T_s = storage time (hours)
f = steady infiltration rate (inches per hour)
V_r = void ratio

$$S_a = \frac{WQV}{V_r \times d} \qquad [12]$$

where S_a = surface area (square feet)
WQV = water quality volume (cubic feet)
V_r = void ratio
d = depth (feet).

• *Quantity.* For quantity purposes, the peak flows from a 2- and a 10-year storm must be reduced to predevelopment levels. The reduction can be accomplished by using the storage reservoir under the pavement to store the increased runoff from the developed area.

After a storage volume has been estimated, the design storms should be routed through the facility to determine if the estimated storage volume is adequate. Adjustments should be made if necessary.

Some designs may include an outlet pipe from the stone reservoir to drain excess stormwater and therefore provide control of the larger storms.

4.4.5 Vegetative Controls

Vegetative controls can be used to reduce the size and cost of the discussed structural controls. The SWMR encourage their use in conjunction with structural controls to reduce the size of a project and improve its controlling of runoff quantity and quality.

4.4.5.1 Filter Strip

• *Description.* A filter strip is a vegetated area that is designed to accept sheet flow. While flowing over the strip, stormwater is filtered by the vegetation, infiltrated, and detained. The most common cause for failure of filter strips is runoff bypassing the strip through eroded channels. If the stormwater is not evenly distributed over the entire strip, a channel could form and the strip would lose its effectiveness. To prevent the channelization, a level spreader can be used, as shown in Figure 34.

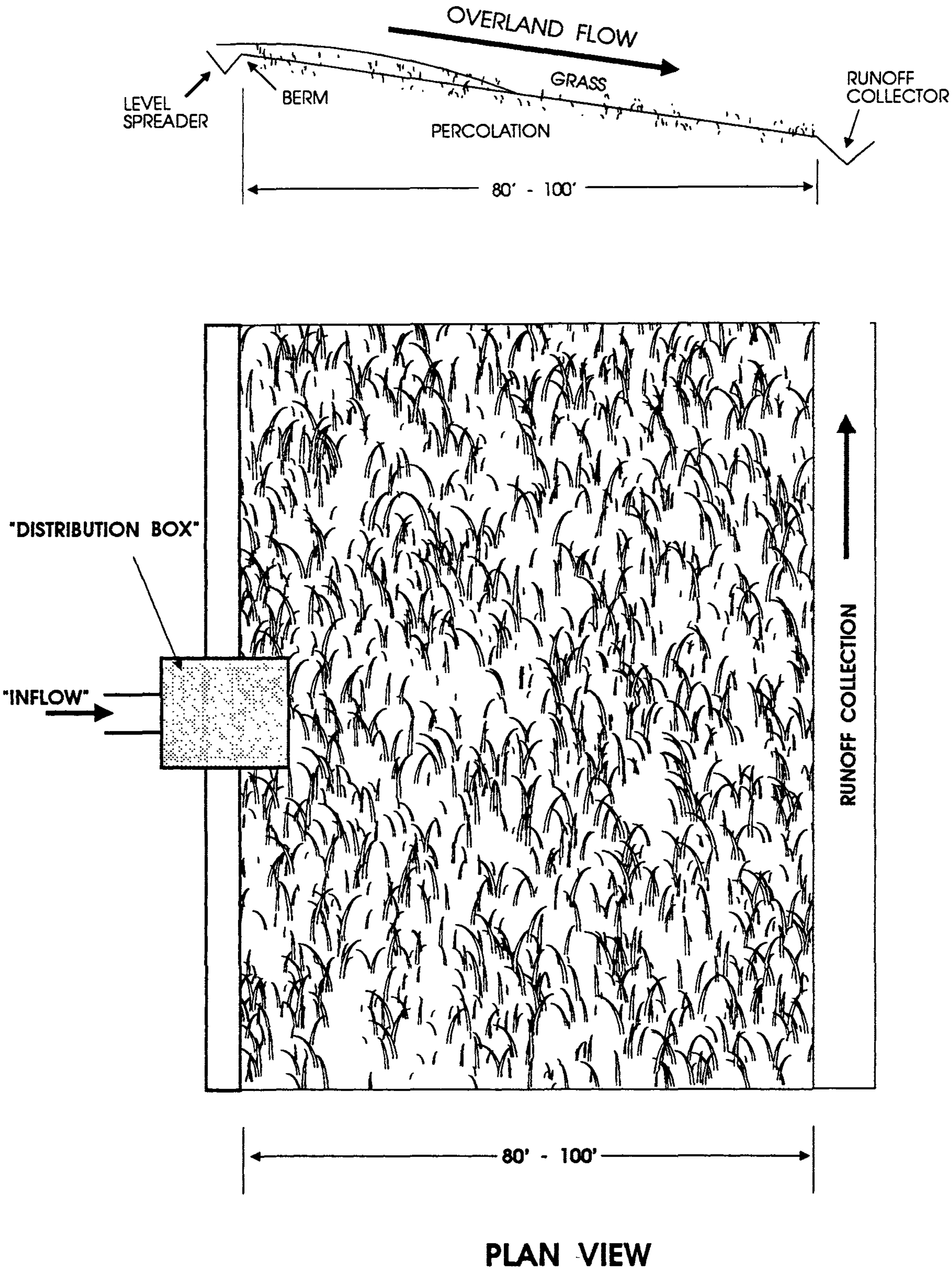


Figure 34. Level spreader system.

Filter strips can be used to filter runoff before it enters a structural (infiltration) facility, or they could be used alone. A study by Yu et al.[15] found that the level spreader was at least as cost-effective as a wet pond for pollutant removal in stormwater. However, its use for quantity control is limited to small drainage areas, with small increases in peak flows.

- *Design.* Filter strips should be constructed of dense, soil-binding, deep-rooted, water-resistant plants. They are usually constructed of grass, but forested strips are also feasible (they can have higher pollutant removal rates but should be longer because of their lack of cover and susceptibility to erosion).[7] For the filter strips to be effective, their slope should be no more than 5% and their length should be at least 20 feet.

Figure 35 was developed by Wong and McCuen[16] for determining the required length of a grassed filter strip. If the slope of the strip, roughness coefficient (Manning's n), and desired trap efficiency are known, the length required can be found by using Figure 35. The example in Figure 35 is for a slope of 2%, an n of 0.20, and a trap efficiency of 95%; the required filter strip length is 200 feet. In their study, Yu et al.[15] recommended that the filter strip be 80 to 100 feet long. As the filter length increases further, the removal efficiencies tend to level out, as can be seen in Figure 36.

As previously stated, the use of a level spreader is intended to spread runoff evenly and prevent the formation of channels in the filter strip. Several designs have been developed, with the main consideration being that the overflow from the level spreader be distributed equally across the filter strip. This can be done through the use of a rock-filled trench or a plastic-lined trench that acts as a small detention pond. The bottom and filter-side lip should have a zero slope to ensure an even distribution of runoff onto the strip. Figure 34 depicts a level spreader.

4.4.5.2 Grassed Swale

- *Description.* Grassed swales are roadside stormwater conveyances that can store, filter, and infiltrate runoff. Originally, they were an inexpensive way of rapidly transporting runoff from a site. On the other hand, runoff should be slowed down and detained for SWM purposes.

Some studies have been conducted on the use of swales for runoff quality control, and a wide variety of estimates of their effectiveness have been reported. From these studies, design guidelines have been developed for constructing swales so that the pollutant removal efficiency is improved.

- *Design.* Several studies conducted by Wanielista and Yousef[17] for the Florida Department of Transportation found roadside swales to be effective in removing many highway pollutants. Equation 13 was developed[17] to calculate the length of a swale that allows all of the stormwater to infiltrate for a given runoff flow rate:

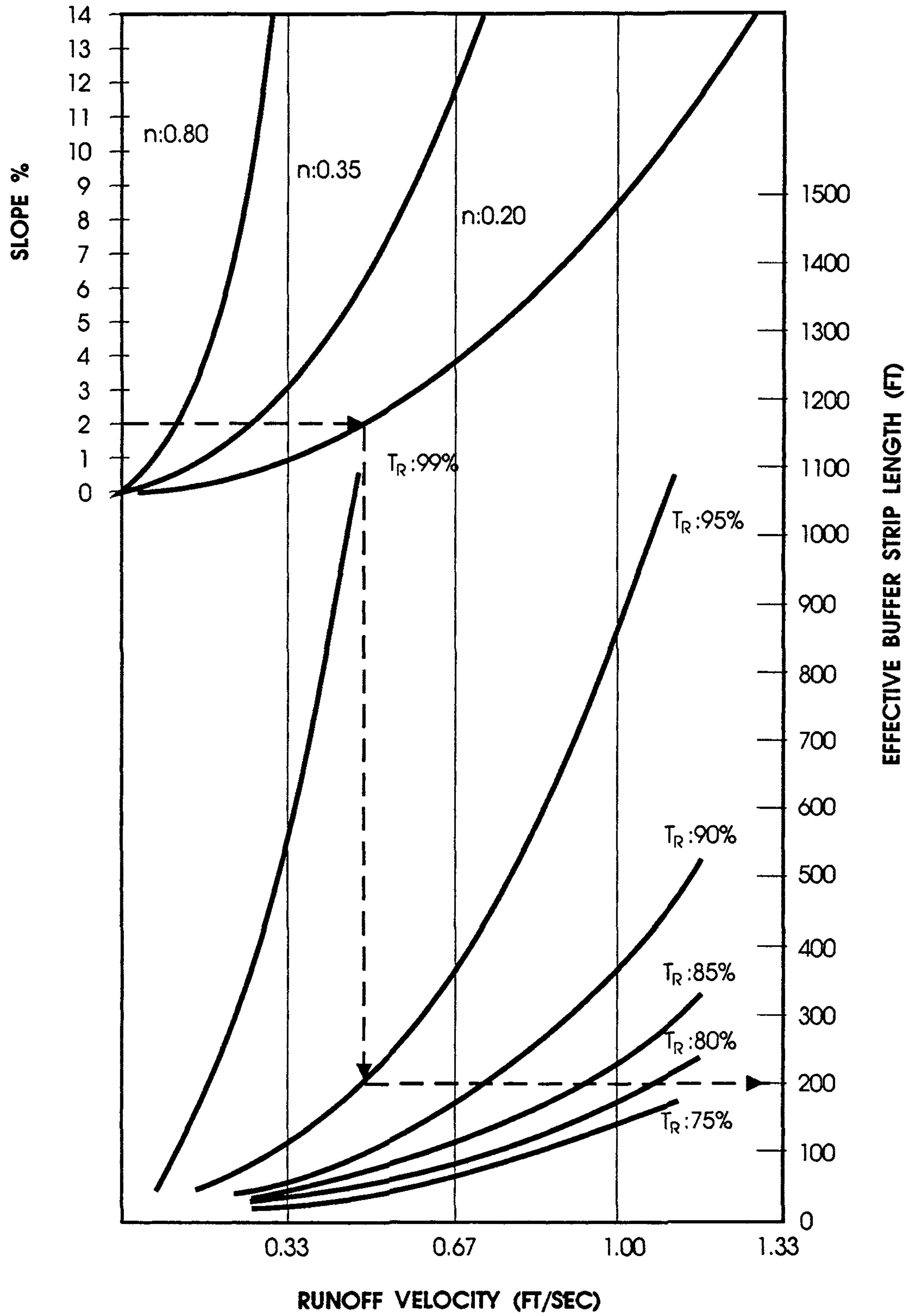


Figure 35. Removal rates (T_R) for buffer strips. *Source:* Wong, S. L., and McCuen, R. H. 1982. *The design of vegetative buffer strips for runoff and sediment control in stormwater management in coastal areas.* Annapolis: Maryland Department of Natural Resources.

10.30

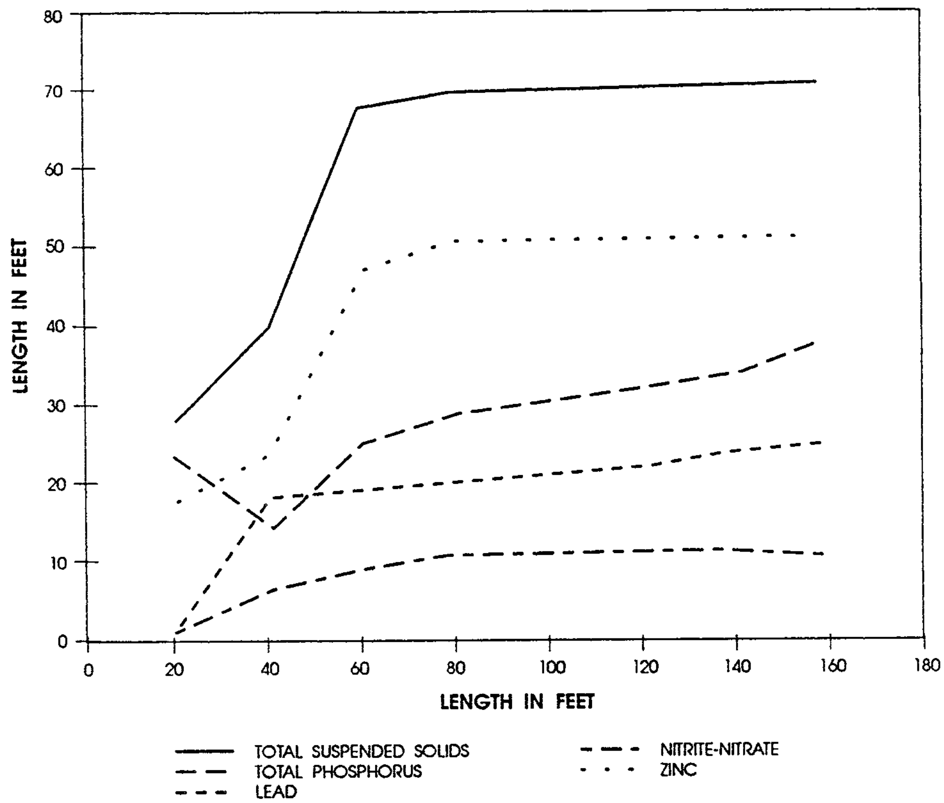
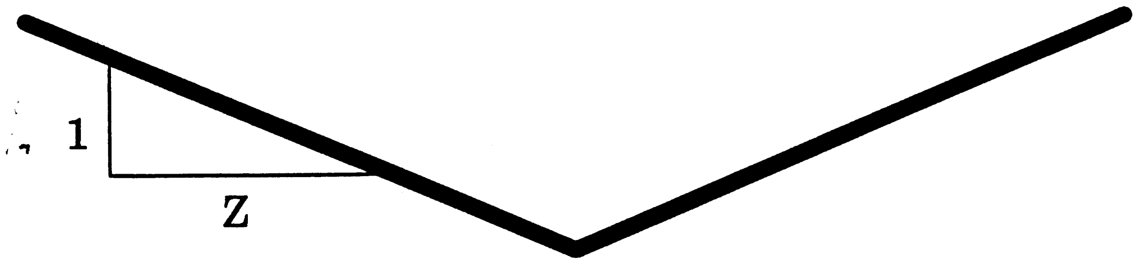


Figure 36. Level spreader removal efficiency vs. strip length. *Source:* Yu, S. L.; Norris, W. K.; and Wyant, D. C. 1987. *Urban BMP demonstration project of the Albemarle / Charlottesville area.* Report No. UDA/530358/ CZ88/102. Charlottesville: University of Virginia.

$$L = \frac{KQ^{5/8}S^{3/16}}{n^{3/8}f} \qquad [13]$$

where L = length of swale (feet or meters)
K = constant (see Figure 37)
Q = average runoff flow rate (cubic feet per second or cubic meters per second)
S = longitudinal slope (feet/feet or meters/meters)
n = Manning's roughness coefficient
f = infiltration rate (inches per hour or centimeters per hour).

If this equation leads to a swale that is too long, another equation may be used to determine the placement of swale blocks, or check dams, to compensate for the reduction in length where required because of site limitation etc.[17] By modifying equation 13, the volume of storage in the swale can be determined by:



Z (Side slope) (1 vertical/Z horizontal)	K (SI units)	I (US units)
1	98,100	13,650
2	85,400	11,900
3	71,200	9,900
4	61,200	8,500
5	54,000	7,500
6	48,500	6,750
7	44,300	6,150
8	40,850	5,680
9	38,000	5,255
10	35,760	4,955

Figure 37. Values of K for different swales. K = swale length formula constant (equation 13); Z = side slope parameter. *Source:* Wanielista, M. P., and Yousef, Y. A. 1990. *Swale designs: Stormwater quality.* Orlando: The Florida Engineering Society and State Department of Environmental Regulation.

$$Vol = Q(\Delta t) - \left(\frac{Ln^{3/8}f}{KS^{3/16}}\right)^{8/5}(\Delta t) \qquad [14]$$

where $Q(\Delta t)$ = volume of runoff at the end of time interval Δt (seconds)

$\left(\frac{Ln^{3/8}f}{KS^{3/16}}\right)^{8/5}$ = the volume of runoff percolated during time interval Δt by a certain swale with length L, which is shorter than the length calculated by equation 13

Δt = time interval (seconds).

Units of all other variables are the same as defined in equation 13. The answer obtained by solving the equation is, therefore, the volume that must be stored behind the check dam in the swale so that all of the stormwater is allowed to infiltrate.

The pollutant removal efficiency of a swale can be improved through enhancing filtering by grass in the channel. To enhance grass filtering, the swale should be designed as a triangle, with at least 3:1 side slopes, or a parabola, with a 6:1 top width–to–depth ratio. The grass in the swale should also be dense, deep rooted, and water tolerant. The grass should be high enough to cover the depth of runoff in the swale but not so high that it is flattened by the flowing stormwater.

4.4.6 Wetlands and Other Control Practices

Wetlands have the ability to remove many pollutants and detain stormwater. However, the processes that occur in wetlands are not fully understood, and the amount of wetland area required to treat stormwater can be very large. It has been recommended that wetlands and marshes be used in conjunction with other BMPs, such as on the bottom of dry ponds and on the fringes of wet ponds.

Although a substantial amount of information is available on using wetlands as a final treatment process of waste water, very little is known on using wetlands for treating stormwater. A recent report by Marble[18] provided guidelines for designing replacement wetlands.

With regard to using wetlands for SWM, Marble[18] reported that urban runoff is a good source of nutrients for the development of wetlands and that wetlands downstream of an impoundment may have reduced aquatic diversity because of reductions in the outflow detritus. Marble further stated that wetlands have the ability to remove sediments and toxins through sedimentation. However, the loadings of toxins and sediments should be low to moderate, and the ratio of wetland area to watershed area should be kept high. The functions of wetlands with regard to water quality are very complex. Hemond and Benoit[19] pointed out the following:

> The wetland is not a simple filter; it embodies chemical, physical, and biotic processes that can detain, transform, release, or produce a wide variety of substances. Because wetland water quality functions result from the operation of many individual, distinct, and quite dissimilar mechanisms, it is necessary to consider the nature of each individual process (p. 12).

The very limited number of studies undertaken on the use of wetlands for SWM indicate a wide disparity in the efficiency of wetlands to remove pollutants. A recent study by Martin[33] suggested that wetlands, when used in conjunction with another BMP such as a wet detention pond, can be quite effective in treating highway stormwater runoff.

Because VDOT, like other state transportation departments, is required to replace wetlands on a routine basis, the idea of using these constructed wetlands for SWM appears to be a prudent one. However, more field test and monitoring data need to be collected and analyzed before appropriate design guidelines can be developed.

Other methods have been cited in the literature as potential BMPs for controlling stormwater runoff. However, at the present time, information is sketchy on their effectiveness and on design guidelines.

Chapter 5

MAINTENANCE AND SAFETY

5.1 INTRODUCTION

Maintenance and safety are two factors that need to be considered when a control is designed. These factors should be considered over the expected service life of the facility.

5.2 EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION

5.2.1 Maintenance

The construction phase controls described in Chapters 3 and 4 will need to be maintained to continue working properly. When designing and placing a control structure, one should consider its future maintenance needs. The facility should be designed to allow for the easy access of maintenance equipment, including a maintenance entrance and right of way, or easement. Slide slopes with a slope of at least 3:1 should be developed for easy access and placed so that the facility can be inspected easily. Maintenance will be necessary if the facility is damaged in some way or is filled with sediment.

Other maintenance inspections include the following:

- *Daily inspection*. At the end of each day, the entire site should be inspected to ensure that all of the facilities, such as silt fences and dikes, have not been damaged during the day's activities. If sediment has been tracked onto public roads, it should be removed as stated in the ESCR (see Chapter 2).

- *Poststorm inspection*. After every significant rainfall, all of the management facilities should be inspected to determine if they functioned properly, were damaged from the storm, or need to be repaired or maintained. Larger storms can wash away fences, straw bales, and even berms. Also, vegetation should be checked to ensure that it is still established and therefore preventing erosion.

The control facilities tend to fill with sediment after storms. When they are half filled with sediment, the sediment should be removed so that the facility can function properly. Stakes can be placed in the facility marking the halfway point to signify the need for maintenance. In sediment basins, marks can be made on the riser to determine when maintenance is required.

- *Additional inspections*. Some of the facilities described in the preceding chapters have a useful life of only a few months. When their time for replacement draws near, they should be inspected more frequently to ascertain if they are functioning properly.

5.2.2 Safety

The public should be kept away from construction sites to prevent injury. However, children often wander onto sites and could become injured. Considerations should be given to fencing sediment basins and other potentially dangerous structures in populated areas to reduce the possibility of injury or drowning. Signs can also be posted to warn of the danger of drowning. Large ponds can be constructed with a safety ledge a few feet deep and several feet wide around the perimeter of the pond.

5.3 POSTCONSTRUCTION STORMWATER MANAGEMENT CONTROLS

5.3.1 Maintenance

Most facilities should be inspected at least once a year. A facility's need for maintenance is usually much less frequent than for construction phase controls (years instead of months). However, it will need to be maintained to continue to work properly.

5.3.1.1 Ponds

Ponds will need to be inspected at least once a year, preferably during wet weather, to ensure that they are functioning as designed. The area around ponds will need to be mowed at least twice a year to prevent woody growth. This is especially important on the embankment, where trees can lead to failure of the embankment.

The frequency of cleaning sediment from the pond will vary from site to site. Dry ponds usually need to be cleaned every 5 to 10 years. The cleaning schedule depends on the sediment loading to the pond and whether unsightliness is a problem. For pond maintenance, it is important to include a right of way for the heavy equipment that will be used to clean the pond. The side slopes around the pond should be 3:1 or flatter to allow for easy access.

Usually, sediment needs to be removed every 10 to 20 years from wet detention ponds, depending on the sediment loading. As in the case of dry ponds, it is important to include a right of way for the heavy equipment and keep the side slopes of the pond 3:1 or flatter. A release valve should be included in the design to drain the permanent pool so that access to the sediment for removal can be accomplished. Aquatic vegetation around the perimeter, if included in the design, will have to be harvested yearly to prevent a buildup of decaying organic matter on the bottom of the pond, which would increase the frequency of maintenance.

Removed sediment will have to be disposed of properly. Because of the possible presence of toxins in the sediment, it should not be placed indiscriminately or in a sanitary landfill.

5.3.1.2 *Infiltration Facilities*

Infiltration facilities will need to be inspected at least once a year, preferably during wet weather. Trenches and porous pavement can be inspected through the use of an observation well in the facility. The purpose of the inspection is to determine if the facility is draining properly and ensure that the WQV infiltrates within 48 hours. If the facility is not draining fast enough, maintenance will be required. This is generally required every 5 to 10 years.

When necessary, trenches and porous pavement must be excavated and new filters and stone reservoirs installed. It may also be necessary to remove the layer of soil directly below the trench if the trench has become clogged. Basins will need to have sediment removed, and the bottom of the basin may need to be tilled to re-open the soil. Removed materials should be disposed of properly.

To maintain a filter strip, it is important to mow it at least twice a year to discourage woody growth. Grass clippings should be removed because they can clog the facility. Fertilizers and pesticides should also be used with extreme caution because runoff passing over a strip may go directly into the groundwater.

5.3.1.3 *Vegetative Controls*

Vegetative controls will need to be mowed at least twice a year to discourage woody growth, and more frequently if the species requires. These controls should be inspected once a year to ensure that they are working properly. The grass should be tall enough to filter the entire depth of flow, but not so tall that it falls over and creates a mat. If sediment accumulates in an unwanted place, it should be removed and disposed of properly. Fertilizers and pesticides should be applied with care and only where necessary.

Level spreaders will need to be inspected at least once a year to determine if they are filled with sediment. The overflow lip should be checked to determine if it is still level. Any channels that have been eroded in the strip should be repaired.

5.3.2 Safety

Safety should be always be considered in planning or designing an SWM control. The most hazardous element in a facility is ponded stormwater and its potential to cause drownings. To prevent drownings, the facility should be designed to keep the public away from ponded water and facilitate their escape if they should happen to fall in. Wet ponds are especially dangerous because they are constantly ponding water. Other controls, such as infiltration basins and dry ponds, are designed to pond water for a day or longer and are also a risk. These facilities can be designed with fences, perimeter ledges, and flat side slopes to reduce the chance of injury. They should also be designed to allow an easy escape for anyone who falls into the ponded water.

1026

Chapter 6

COMPUTER MODELS

6.1 INTRODUCTION

The SWM models discussed in this chapter are limited to those models that describe both stormwater quantity and quality. These models range in their complexity from simple, single-purpose equations to complicated, multiple-featured computer programs. Properly calibrated and verified models provide an accurate description of the changes in stormwater quantity and quality for given conditions. By using the models, one can investigate and compare design options and choose an optimal design. Models can also be used, for example, to estimate the impact of particular growth patterns on strategies for local stormwater master planning. The designer can assume various growth patterns and use the model to simulate their consequences so that a desirable scenario could be chosen.

In SWM studies, models can be categorized into the following:

1. models for predicting stormwater runoff pollution loadings
2. models for describing the transformation and transport of stormwater-generated pollutants
3. models for describing BMP pollutant-removal mechanisms
4. models for SWM strategies, for example, models for strategically locating detention ponds.

Models are developed based on the knowledge of the basic stormwater quantity and quality processes and, therefore, are not a substitute for actual field data that describe these processes directly.

6.2 DESCRIPTION AND COMPARISON OF MODELS

6.2.1 Models for Predicting Stormwater Runoff Pollutant Loadings

One of the key elements of an SWM strategy is the estimation of stormwater pollution loadings that will, for example, provide the information needed for comparing the impact of various development subareas. This is a rather difficult matter in view of the fact that in many cases only a finite number of storms are sampled and only discrete grab sampling data are obtained. Moreover, the mass loadings of pollutants in stormwater runoff are affected not only by the drainage basin characteristics such as land use, slope, and imperviousness, but also by various hydrometeorological factors such as rainfall intensity and duration, flow rate, and antecedent conditions. It would therefore be desirable to have a substantial amount of data, taken at short time intervals and under various "environmental" conditions, to enable one to differentiate the aforementioned factors and obtain definitive estimates of stormwater runoff pollution loadings. However, budgetary and time constraints usually make detailed sampling infeasible, if not impossible. Consequently, it is frequently necessary to employ less sophisticated methods for the computation of pollution loadings.

6.2.1.1 Levels of Prediction

Several levels of analysis can be used to estimate stormwater runoff pollution loads. They range from a rather simplistic average annual loading to a complete distribution of loadings over the entire hydrograph for a single storm, i.e., the pollutograph analysis. In general, three levels of prediction can be defined:

1. *Level I: Total annual load or average annual load.* The total annual load is defined as the cumulative yield for a given year of a certain pollutant in stormwater runoff for a given area, usually expressed in terms of pounds per unit area per year. The average annual load may be defined as the long-term average of total annual loads. The average annual load can be converted to either average daily load for the entire year (wet and dry weather combined) or average daily load for the wet periods only.

2. *Level II: Mean event load or mean event concentration.* The average load for a specific event can be obtained by taking the average of the temporal distribution of pollution loads. Similar analysis can be made with regard to the pollutant concentration.

3. *Level III: Pollutographs.* The pollutograph depicts the continuous variation of pollution loadings with respect to time. Therefore, the within-event distribution of loads can be obtained.

Level I prediction may be used for the purpose of preliminary screening of SWM alternatives. Long-term loadings are useful in assessing long-term or steady-state impacts of stormwater runoff on receiving water quality. Siltation of river channels is a good example. The relative importance of stormwater runoff pollution, as compared to waste treatment effluents, is another. On the other hand, analysis of short-term "shock-loading" effects of stormwater runoff would require data on within-event distribution of pollution loadings. An example is the evaluation of the depletion of dissolved oxygen levels in a receiving stream after a storm.

6.2.1.2 The Simple Method

In rainfall-runoff analysis using the rational method, one uses a "runoff coefficient"[27] to "convert" the rainfall rate into an estimate of the peak rate of runoff from a particular area. The same approach can be used to estimate the average pollutant loading rate in stormwater runoff. An average, or "representative," pollutant concentration is obtained and then used together with the average runoff to give the average loading estimate as shown in the following equation:

$$L = C \times R \quad [15]$$

where L = average loading rate (pounds or kilograms per hour)
C = average or representative concentration (milligrams per liter)
R = runoff (cubic feet per second or cubic meters per second).

The method called the simple method[7] is crude and can provide only approximate estimates of event or long-term average loadings, such as average annual loading. However, it is easy to apply and its accuracy will be enhanced when the C value is modified when more stormwater quality data are available. If runoff is computed, then the average concentration can be obtained by the following methods:

1. *Using values obtained by sampling storms*. The average of flow-weighted average concentrations are computed from storm data. More accurate loading estimates can be made if the sampling program covers a variety of storms with different intensity/durations and frequencies. Examples of this approach are given in Whipple et al.[20] and Schueler.[7] Table 19 presents the average, flow-weighted C values for selected pollutants measured during the EPA's Nationwide Urban Runoff Project (NURP) study and several other studies.[7]

Table 19
URBAN *C* VALUES FOR USE WITH SIMPLE METHOD (mg/l)

Pollutant	New Suburban NURP Sites (Wash., DC)	Older Urban Areas (Baltimore)	Central Business District (Wash., DC)	National NURP Study Average	Hardwood Forest (Northern Virginia)	National Urban Highway Runoff
Phosphorus						
Total	0.26	1.08	–	0.46	0.15	–
Ortho	0.12	0.26	1.01	–	0.02	–
Soluble	0.16	–	–	0.16	0.04	0.59
Organic	0.10	0.82	–	0.13	0.11	–
Nitrogen						
Total	2.00	13.6	2.17	3.31	0.78	–
Nitrate	0.48	8.9	0.84	0.96	0.17	–
Ammonia	0.26	1.1	–	–	0.07	–
Organic	1.25	–	–	–	0.54	–
TKN	1.51	7.2	1.49	2.35	0.61	2.72
COD	35.6	163.0	–	90.8	>40.0	124.0
BOD (5-day)	5.1	–	36.0	11.9	–	–
Metals						
Zinc	0.037	0.397	0.250	0.176	–	0.380
Lead	0.018	0.389	0.370	0.180	–	0.550
Copper	–	0.105	–	0.047	–	–

TKN = total kjeldahl nitrogen; COD = chemical oxygen demand; BOD = biochemical oxygen demand.
Source: Schueler, T. R. 1987. *Controlling urban runoff: A practical manual for planning and design of urban BMPs.* Washington, D.C.: Metropolitan Washington Council of Government.

2. *Using a statistically developed equation relating the average concentration to various watershed characteristics and hydrological parameters considered to affect pollutant concentration.* For example, AVCO[21] developed regression equations relating average pollutant concentrations to variables such as length of main stream, average land slope, sewered area, and residential density. Heaney et al.[22] proposed the following loading factors for predicting the annual average loading rates as a "desktop" procedure.

6.2.1.3 U.S. Geological Survey Nationwide Regression Equations

Recently, the U.S. Geological Survey (USGS), using the EPA's NURP study and the USGS data bases, derived regional regression equations relating 11 stormwater runoff pollutant loads to watershed demographic and physical characteristics and storm-specific and climatic variables.[23] The pollutants covered included solids, chemical oxygen demand, nitrogen and phosphorus species, cadmium, copper, lead, and zinc.

Regression models were developed for mean concentrations of stormwater runoff and mean seasonal and mean annual pollutant loads for urban areas throughout the United States.

These models, together with the simple method, provide straightforward, simple tools for the preliminary planning and designing of SWM facilities.

6.2.2 Comprehensive Stormwater Management Models

These SWM models not only generate stormwater pollutant loads but also describe the fate and transport of the pollutants in the overland or conveyance systems. Many SWM models have been developed during the past two decades, and they exhibit many variations in terms of complexity in simulation algorithms, solution techniques, data requirements, etc.

The physical processes that are typically simulated by an SWM model can be seen in Figure 38. As seen in Figure 38, the major components of an SWM model are as follows:

1. *Overland flow component*: quantity and quality, including pollutant accumulation and washoff and transport over land surface
2. *Drainage system component*: quantity and quality, including channel or pipe flow transport, storage routing (such as detention ponds), etc.
3. *Receiving water component*: quantity and quality, including fate and transport of pollutants and receiving water response (most SWM models do not include this component).

A schematic diagram of the various components of an SWM model is shown in Figure 39. To date, the most commonly used or referenced SWM models are SWMM,[25–27] STORM,[27] and HSPF.[28]

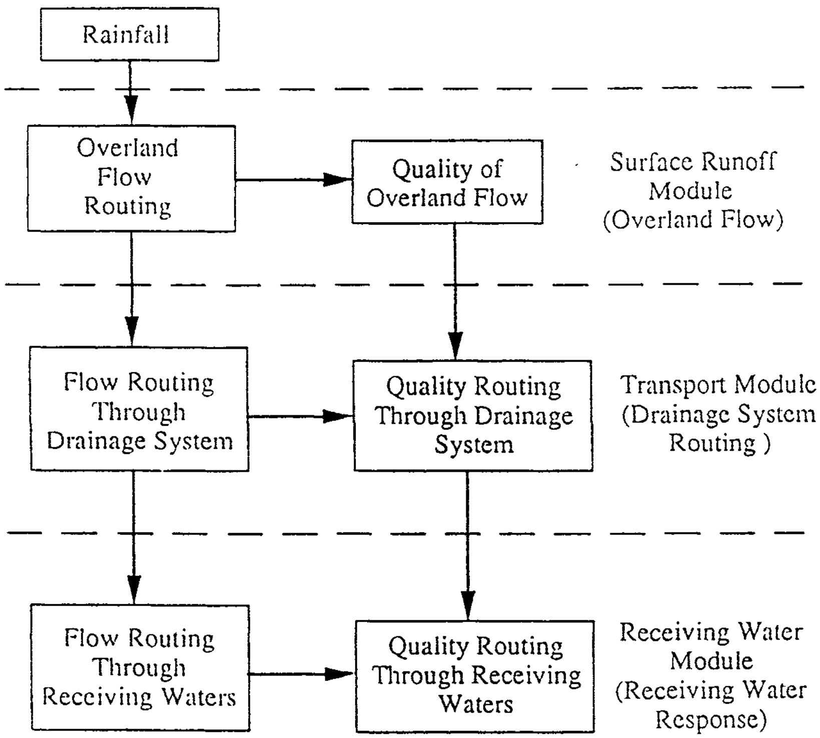


Figure 38. Schematic diagram of components of SWM model.

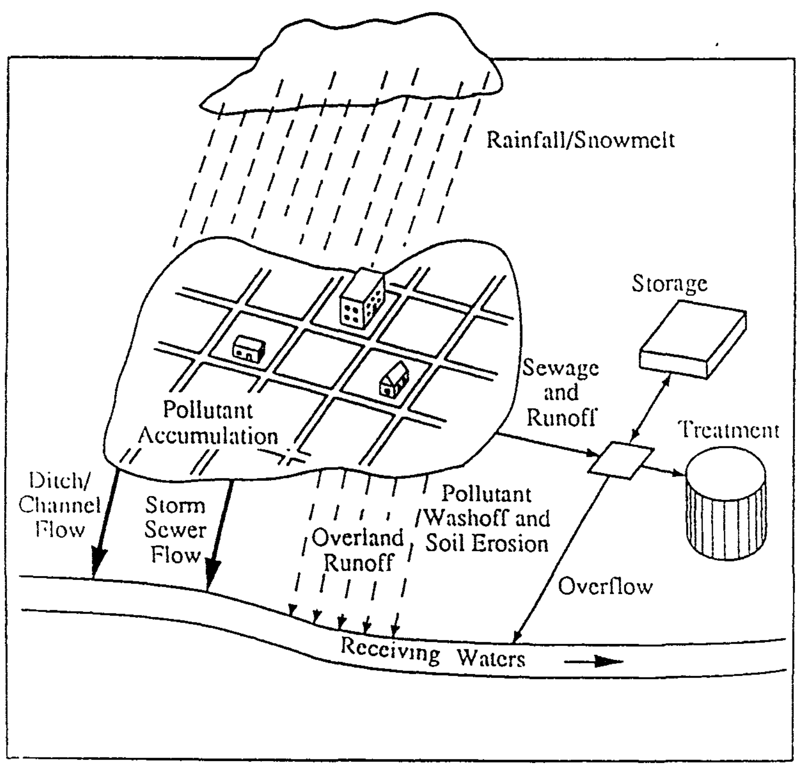


Figure 39. Conceptual view of urban drainage system. Data from U.S. Corps of Engineers.[27]

1. *SWMM (Stormwater Management Model). SWMM* is one of the most comprehensive models for planning and design. The model is the best documented and supported program, and user group meetings have continued to be held on a regular basis. SWMM essentially simulates all the quantity/quality processes shown in Figure 39. The model can handle complex sewer networks, including pumps, gates, etc. It can also simulate backwater and surcharging conditions. The quality simulation in SWMM is based on a pollutant buildup and wash-off mechanism. Major conventional pollutants, such as solids, nutrients, organics, oil, and grease, are simulated.

2. *STORM (Storage, Treatment, Overflow, Runoff Model).* STORM is a watershed model that simulates the processes depicted in Figure 38 except the sewer hydraulics component. The model computes runoff based on a runoff coefficient scheme and simulates six conventional pollutants: (1) suspended and (2) settleable solids, (3) BOD, (4) total nitrogen, (5) orthophosphorous, and (6) fecal coliform. STORM is a continuous simulation model and can be used to estimate overflow event statistics based on a given treatment level for the stormwater runoff generated. The pollutant simulation algorithm is similar to that of SWMM. The model is easy to implement and is less data intensive than SWMM.

3. *HSPF (Hydrologic Simulation Program, Fortran).* HSPF was developed based on the Stanford watershed model. The quality algorithm was based on sediment detachment and transport mechanisms. Pollutants are related to the sediment. HSPF is a comprehensive model and is highly data intensive. It can be run as either an event model or a continuous model.

Another model, called the *V*irgini*A ST*orm *M*odel, or VAST, was recently developed at the University of Virginia.[29] The VAST model is an event model and can be applied to multiple catchment basins. It combines techniques used in STORM, SWMM, and other commonly used hydrologic models to compute rainfall abstractions, generate overland flow hydrographs, combine and route outflow from upstream subbasins through the channel downstream, and compute pollutant washoff from subbasins. VAST is composed of three primary and two auxiliary computer programs. The primary program simulates stormwater runoff, pollutant loadings of suspended solids, settleable solids, BOD, total nitrogen, orthophosphate, fecal coliforms, and loadings for an additional four user-specified pollutants.

The auxiliary programs present results generated by VAST in graphical form on a computer video monitor. These programs can optionally present field data with simulation results to assist users in the calibration and verification processes.

A comparison of the various features in HSPF, STORM, SWMM, and VAST is presented in Table 20.

Table 20
COMPARISON OF MODELING CAPABILITIES

Capability	HSPF	STORM	SWMM	VAST
Event (E) or continuous (C) model	E,C	C	E,C	E
Infiltration loss techniques	Stanford watershed model, infiltration as function of soil moisture and permeability	Runoff coefficient	(1) Horton model (2) Modified Green-Ampt model	(1) Horton model (2) HEC-1 variable loss rate model (3) Initial abstraction-constant loss rate model
Runoff modeling techniques	Manning's equation and storage routing	Modified rational formula	Storage routing using Manning's equation and continuity equation	(1) Input unit hydrograph (2) Clark unit hydrograph
Sewer routing	Yes	No	Yes	No
Non–point source pollutant accumulation and washoff modeling techniques	Sediment detachment transport; pollutant is related to sediment	Based on pollutant accumulation and washoff	Based on pollutant accumulation and washoff	Based on pollutant accumulation and washoff
Number of pollutants	10	6	10	6 plus 4 user specified
Storage/treatment analysis	Yes	Yes	Yes	Being added
Executable on a microcomputer	Yes	Yes	Yes	Yes
Program output can be graphically presented	Line printer	Line printer	Line printer	Line printer and video monitor
Level of program documentation	High	Moderate	High	Moderate

continues

Table 20 (continued)

Capability	HSPF	STORM	SWMM	VAST
Ease of program implementation	Difficult	Easy	Difficult	Easy
Data requirement	Very high	Moderate	High	Moderate
Source	EPA	COE	EPA	UVA

EPA = Environmental Protection Agency; COE = Corps of Engineers; UVA = University of Virginia.

6.2.3 Models for BMP Evaluation

In order to simulate the effect of instituting various BMPs, Kuo et al.[30] modified the ILLUDAS model[31] to make it a continuous model capable of simulating water quality. The algorithm used by STORM was incorporated into ILLUDAS. Several BMP features were considered. An optimization routine was also included in the model for the purpose of sizing and locating detention basins in a watershed.

More recently, the Northern Virginia Planning District Commission developed a computer program to perform regional STM and BMP analyses.[32] The program uses an optimization routine to select the most cost-effective locations for regional SWM and BMP facilities in small undeveloped watersheds.

6.3 CALIBRATION AND VERIFICATION OF MODELS

A model needs to be calibrated and verified before it can be used as a planning or design tool. Calibration involves minimization of differences between observed data and computer results by adjusting particular model "parameters." Verification is the process of checking the model calibration using a different set of data. Usually, the verification results will provide feedback for further adjustment.

The objective of both the quantity and quality calibration is to fit the model to "average" watershed conditions. Therefore, the emphasis will be on results integrated over the entire calibration data (three or four storms) rather than on any single storm.

The standard error of estimate (SEE) is a commonly used statistic to measure the goodness of fit between observed and predicted data. It is computed from predicted and observed data points.

The criteria for acceptable SEE values depend on factors such as density of monitoring network, equipment accuracy, and subjective decision of the model. Ordinarily, an SEE of less than 10% is desirable.

The calibration process, a set of model parameters that yields the best SEE for all storms, will be accepted as calibrated model parameters. On the other hand, the verification of a model will usually involve filling one or two storms.

In general, model reliability increases when the amount of data for calibration and verification increases. However, resource limitations usually dictate the amount of data that can be gathered. It is not uncommon to find monitoring efforts of a year in duration and produce five or six sets of stormwater runoff data. In such a case, the common practice is to use three or four storms for model calibration and one or two for model verification.

Chapter 7

EXAMPLES

7.1 INTRODUCTION

This chapter provides examples of how to design control practices for E&S control and SWM. The entire design procedure will not be discussed, only the procedures emphasized in this manual.

7.2 EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION (SEDIMENT BASIN)

Because the sediment basin is the only control associated with a distinct design procedure, it is the only E&S control presented here.

> *Situation:* A VDOT project will disturb 3.2 acres, including 1 acre of new pavement. Since this area is greater than 3 acres, a sediment basin is required. The total required storage is 67 cubic yards per acre, or 5,789 cubic feet. (The total drainage area is 14 acres, so even if only 1 acre is disturbed, a sediment basin is still required because of the other 13 acres contributing runoff. The need for a sediment basin can be avoided if diversion dikes are put around the 1-acre project so that the other 13 acres do not contribute runoff.)

Although a rock check dam outlet could be used, a sediment basin can later be used as an SWM detention basin, and thus a riser pipe will be used. This riser will be designed by its use in the detention basin. To provide the required storage, the WQV outlet will be blocked off during the construction phase of the project. However, if the sediment basin will not be used later as a detention basin, calculations as described in Section 2.2 would be required to control a 2- and a 10-year flow.

Other considerations include marking of the riser to show when cleanout is needed and the adequacy of the downstream channel (riprap may be required for erosion control purposes).

7.3 POSTCONSTRUCTION STORMWATER MANAGEMENT CONTROLS

The examples given in this section are provided to give the reader a better understanding of the previously described SWM practices. Although all of them are not described here, the ones that are described may aid in the understanding of others. Some calculations have been omitted because they are beyond the scope of this manual.

7.3.1 Detention Basin

Situation: The area previously described for the sediment basin example must control stormwater because it is larger than 1 acre. The WQV required for this area is 1,815 cubic feet per acre, or 5,808 cubic feet. (This volume should be very close to the storage volume required for the sediment basin because 67 cubic yards is approximately 0.5 acre-inches.)

For quantity purposes, the required storage volume is the difference between the pre- and postconstruction hydrographs. It has been determined that the time of concentration is 30 minutes and the pre- and postconstruction flows (Q) for a 2-, a 10-, and a 100-year storm are (in cubic feet per second):

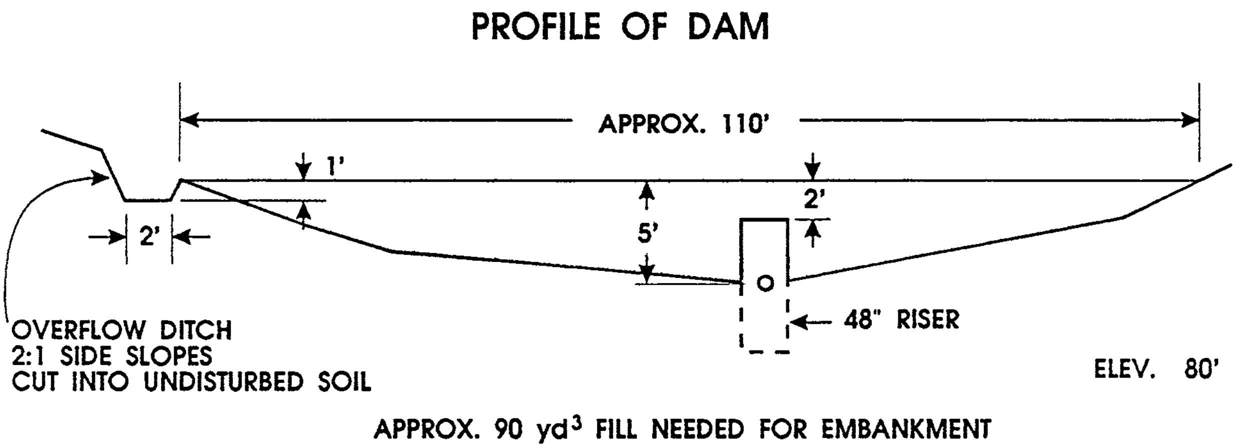
Pre	Post
$Q_2 = 15.1$	$Q_2 = 16.2$
$Q_{10} = 20.2$	$Q_{10} = 21.6$
$Q_{100} = 35.7$	$Q_{100} = 38.3$

For an estimate of the needed storage, the Pagan method[10] (Figure 22) yields a percentage of peak inflow of 94%, a storage/inflow of 300 seconds, and storage of 6,480 cubic feet for a 10-year storm. Using a first estimate of 7,000 cubic feet and a maximum depth of 3 feet with a 3:1 length-to-width ratio yields a basin approximately 28 by 84 feet. The first trial run will be done with a natural basin (no excavation) and embankment. Table 21 shows storage volumes from basin contours. A riser 3 feet high gives 5,887 cubic feet of storage, which is more than what is needed for the sediment basin and WQV. A 3-inch orifice will be used to detain the WQV (the orifice that should be used to detain the WQV for 30 hours is less than the minimum 3 inches). The diameter of the riser is 48 inches, and the riser connects to a 30-inch culvert. The embankment will be 5 feet high for this first trial.

Table 21
STORAGE CONTOURS FOR EXAMPLE BASIN
Detention Basin from Contours (Storage Volumes)

Contour Elevation	Depth at Lowest Point	Area (ft^2)	Incremental Volume (ft^3)	Total Volume (ft^3)
84.0	0.0	0	0.0	0.0
85.0	1.0	200	100.0	100.0
86.0	2.0	2,375	1,287.5	1,387.5
➞ 87.0	3.0	6,625	4,500.0	➞ 5,887.5
88.0	4.0	10,250	8,437.0	14,325.0
89.0	5.0	13,375	11,812.5	26,137.5

Note: Areas measured from contours. Required volume for water quality = 5,808 cubic feet. Required volume for sediment = 5,789 cubic feet. Volume provided by basin at elevation 87.0 is 5,888 cubic feet at the maximum desirable depth of 3 ft. Basin is OK for sediment storage and water quality. Numbers next to arrows indicate the design features selected.



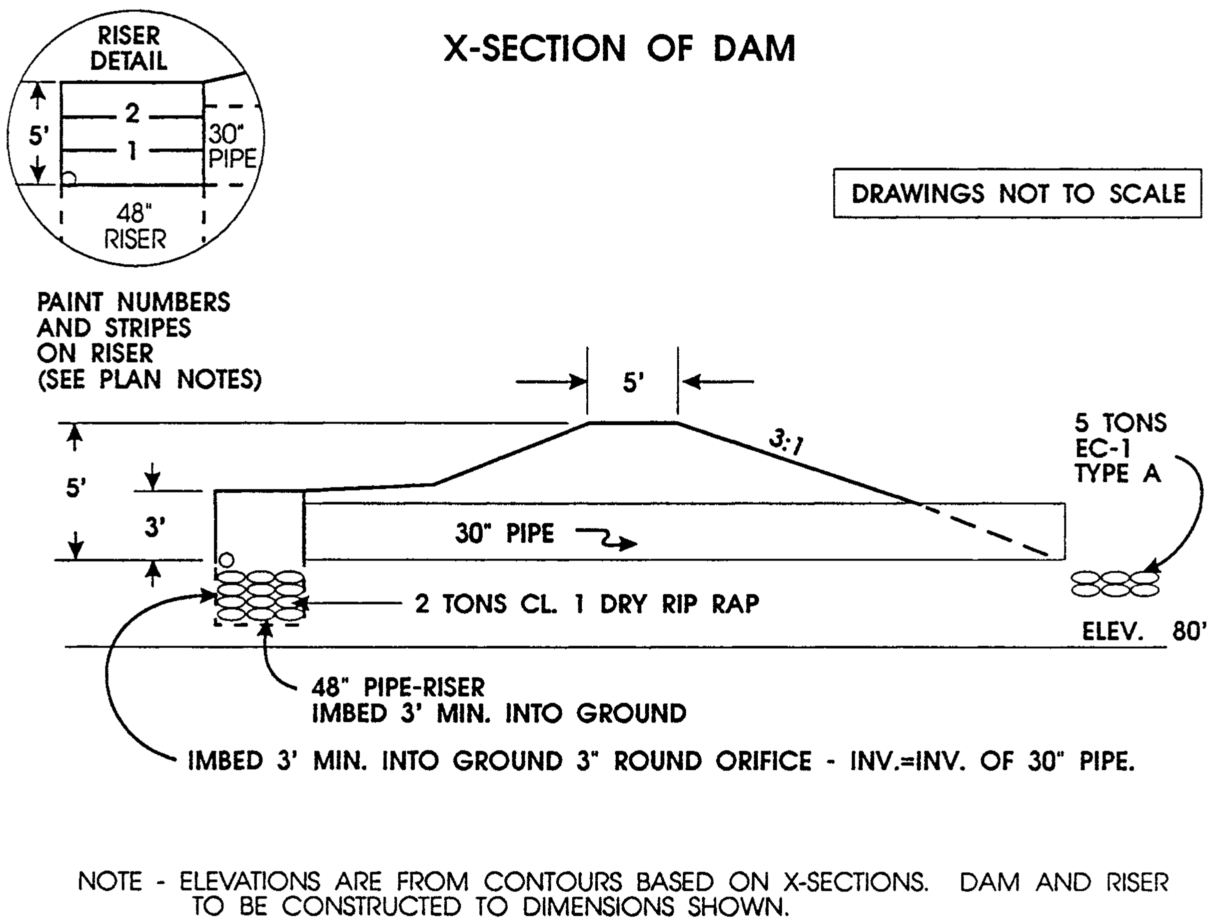


Figure 40. Example basin embankment.

Now that a trial basin has been determined, the design storms may be routed through the basin. The first estimates used in this case were accurate, and no further iterations are required. The peak flows from the basin were below predevelopment levels for both a 2- and a 10-year storm, and a 100-year storm safely passed without the use of an emergency spillway. However, a spillway should still be included in the design in case the riser becomes clogged. Figure 40 illustrates the embankment determined using these calculations.

Riprap should also be placed at the end of the outlet pipe to prevent erosion. The channel that receives the outflow should be adequate (i.e., not be eroded by the flows from the basin). Other considerations include the need for fencing and the maintenance access.

7.3.2 Infiltration Basin

Situation: At the site, it is desired to use an infiltration basin. The site selected has more than the 4-foot minimum depth to bedrock and the seasonably high groundwater table and more than the minimum infiltration rate of 0.27 inch per hour.

The designer should be cautious when designing a sediment basin to become an infiltration basin. While the sediment basin is functioning, infiltration will tend to clog the soil below the basin with sediment. Thus, more maintenance than just the removal of accumulated sediment may be required.

For the infiltration basin, the WQV is the same as in the previous example: 5,808 cubic feet. The infiltration rate is given as 0.5 inch per hour. The depth of the basin can be determined from equation 9, where the storage time used is 48 hours. This yields a depth of 2 feet. A basin 39 by 75 feet and 2 feet deep would give 5,850 cubic feet of WQV storage.

For quantity purposes, the basin must also store stormwater to reduce the postconstruction peak flows. This storage as estimated by the Pagan method[10] was 6,480 cubic feet. Since this is close to the WQV, the size of the pond will not be modified. An earthen spillway will be used as the outlet for the basin, 2 feet above the basin's floor, 2 feet wide, and with 3:1 side slopes. Next, the design storms must be routed through the basin. In this case, the values assumed were accurate, and the peak flows were reduced below preconstruction levels. If this was not the case, new assumptions would have to be made and the storms rerouted until the peak flows were appropriate. When the storms are routed through the basin, it is important to include the infiltration of stormwater.

In this example, an earthen spillway was used. It is very important that this spillway be erosion resistant. The downstream channel must also be adequate to prohibit erosion. Both of these criteria can be met with the use of riprap. If an earthen spillway was not adequate for some reason, a riser spillway similar to that in the detention basin example could be used.

Other considerations would include the design of a buffer strip before the basin (swales could be used for this purpose) to remove large suspended solids before they clogged the bottom, use of a level spreader at the inlet to reduce erosion and remove more of the suspended solids, and placement of an appropriate grass at the bottom of the basin to help infiltration and pollutant removal.

REFERENCES

1. U.S. Department of Agriculture, Soil Conservation Service. 1975. *Standards and specifications for soil erosion and sediment control in developing areas.* College Park, Md.
2. Thurow, T., and Duncan, E. 1975. *Performance controls for sensitive lands: A practical guide for local administrators.* Chicago: American Society of Planning Officials.
3. Maestri, B.; Dorman, D. E.; and Hartigan, J. 1988. *Managing pollution from highway storm water runoff.* Report No. TRR 1166. Washington, D.C.: Transportation Research Board.
4. Virginia Soil and Water Conservation Commission. 1982. *Virginia erosion & sediment control field manual.* Richmond.
5. Virginia Department of Transportation. 1988. *Landscape manual.* Richmond.
6. Virginia Soil and Water Conservation Commission. 1980. *Virginia erosion & sediment control handbook.* Richmond.
7. Schueler, T. R. 1987. *Controlling urban runoff: A practical manual for planning and designing urban BMPs.* Washington, D.C.: Metropolitan Washington Council of Governments.
8. Oakland, P. 1983. An evaluation of urban storm water pollutant removal through grassed swale treatment. In *1983 international symposium on urban hydrology, hydraulics and sediment control,* pp. 183–185. Lexington: University of Kentucky.
9. Transportation Research Board. 1980. *Design of sedimentation basins.* NCHRP Synthesis 70. Washington, D.C.
10. Pagan, A. R. 1975. Usefulness of the storage parameter. *Civil Engineering,* 45(10): 82–83.
11. Federal Highway Administration. 1979. *Design of urban highway drainage: The state-of-the-art.* Publication No. FHWA-TS-79-225. Washington, D.C.
12. McBride, M. C., and Sternberg, Y. M. 1983. *Storm water management infiltration structures.* Publication No. FHWA-MS-83/04. Baltimore: Maryland Department of Transportation.
13. Yim, C. S., and Sternberg, Y. M. 1987. *Development and testing of granular filter design criteria for stormwater management infiltration structures (SWMIS).* Publication No. FHWA/MD-87/03. Baltimore: Maryland Department of Transportation.
14. Northern Virginia Planning District Commission. 1987. *BMP handbook for the Occoquan watershed.* Annandale.

15. Yu, S. L.; Norris, W. K.; and Wyant, D. C. 1987. *Urban BMP demonstration project in the Albemarle / Charlottesville area.* Report No. UVA/530358/CE88/ 102. Charlottesville: Department of Civil Engineering, University of Virginia.

16. Wong, S. L., and McCuen, K. H. 1982. *The design of vegetative buffer strips for runoff and sediment control in stormwater management in coastal areas.* Annapolis, Md.: Department of Natural Resources.

17. Wanielista, M. P., and Yousef, Y. A. 1990. Swale designs. *Stormwater quality.* Orlando: The Florida Engineering Society and State Department of Environmental Regulation.

18. Marble, A. D. 1990. *A guide to wetland functional design.* McLean, Va.: Federal Highway Administration.

19. Hemond, H. F., and Benoit, J. 1988. *Cumulative impacts on water quality functions of wetlands.* Report No. EPA/600/J-88/498. Corvallis, Ore.: U.S. Environmental Protection Agency.

20. Whipple, W., Jr.; Yu, S. L.; and Hunter, J. V. 1978. Runoff pollution from multiple family housing. *Journal of American Water Resources Association* 14(2): 288–301.

21. AVCO Economics Systems Corp. 1970. *Storm water pollution from urban land activity.* Federal Water Quality Administration Publication No. 11034FKL07/70. Washington, D.C.

22. Heaney, J.; Hubber, W. W.; and Nix, S. J. 1976. *Storm water management model: Level I preliminary screening procedures.* Report No. EPA-600/2-76-275. Cincinnati, Oh.: Environmental Protection Agency.

23. Driver, N., and Tasker, G. D. 1988. *Techniques for estimation of storm-runoff loads, volumes and selected constituent concentrations in urban watersheds in the U.S.* USGS Open-File Report 88-191. Denver: U.S. Geological Survey.

24. Metcalf & Eddy, Inc.; University of Florida; and Water Resources Engineers, Inc. 1971. *Stormwater management model for EPA.* EPA Report No. 11024DOC07/71-10/71. Washington, D.C.

25. Huber, W. C.; Heaney, J. P.; Nix, S. J.; Dickinson, R. E.; and Polmann, D. J. 1981. *Storm water management model user's manual: Version III.* Report No. EPA-600/2-84-109a. Athens, Ga.: Environmental Protection Agency.

26. Roesner, L. A.; Shubinski, R. P.; and Aldrich, J. A. 1981. *Storm water management model user's manual: Version III: Addendum I, EXTRAN.* Report No. EPA-600/2-84-109b. Athens, Ga.: Environmental Protection Agency.

27. U.S. Corps of Engineers. 1974. *Urban storm water runoff, STORM.* Computer Program 723-S8-L2520. Davis, Calif.: Hydrologic Engineering Center.

28. Environmental Protection Agency. 1980. *Hydrocomp simulation package—FORTRAN: User's manual.* Athens, Ga.

29. Yu, S. L., and Tisdale, T. 1986. *A new microcomputer model for stormwater management.* Paper presented at the Conference on Stormwater and Water Quality Modeling, Environmental Protection Agency, Toronto, Canada.

30. Kuo, C. Y.; Loganathan, G. V.; Cox, W. E.; Shregtha, S. P.; and Ying, K. J. 1987. *Effectiveness of BMPs for stormwater management in urbanized watersheds.* Bulletin No. 159. Blacksburg: Virginia Water Resources Research Center.

31. Terstriep, M. L., and Stall, J. B. 1974. *The Illinois urban drainage area simulator, ILLUDAS.* Bulletin No. 58. Urbana: Illinois State Water Survey.

32. Northern Virginia Planning District Commission. 1990. *Evaluation of regional BMPs in the Occoquan watershed.* Annandale.

33. Martin, G. H. 1988. Effectiveness of an urban runoff detention pond–wetlands system. *Journal of Environmental Engineering,* 114(4): 810–827.

Appendix

STORMWATER REGULATIONS

Virginia Erosion and Sediment Control Regulations

Virginia Stormwater Management Regulations

Chesapeake Bay Preservation Area Designation and Management Regulations

NPDES Permit Application Requirements for Storm Water Discharges:
Final Regulation—A Summary

1049

Virginia

Erosion and Sediment Control Regulations

Virginia Department of Conservation and Recreation
Division of Soil and Water Conservation
203 Governor Street, Suite 206
Richmond, VA 23219

E&SREGS.PM3

Reprinted 1991

VIRGINIA SOIL AND WATER CONSERVATION BOARD

Title of Regulation: VR 625-02-00.
Erosion and Sediment Control Regulations.

Effective Date: September 13, 1990

TABLE OF CONTENTS

SECTION

VR 625-02-00. EROSION AND SEDIMENT CONTROL REGULATIONS

§1.1. Definitions.

The following words and terms, when used in these regulations, shall have the following meaning, unless the context clearly indicates otherwise. In addition, some terms not defined herein are defined in §10.1-560 of the Erosion and Sediment Control Law.

"Act" means the Erosion and Sediment Control Law, Article 4 (§10.1-560 et seq.) of Chapter 5 of Title 10.1 of the Code of Virginia.

"Adequate channel" means a watercourse that will convey a chosen frequency storm event without overtopping its banks or causing erosive damage to the bed, banks and overbank sections of the same.

"Applicant" means any person submitting an erosion and sediment control plan for approval or requesting the issuance of a permit, when required, authorizing land-disturbing activities to commence.

"Board" means the Virginia Soil and Water Conservation Board.

"Causeway" means a temporary structural span constructed across a flowing watercourse or wetland to allow construction traffic to access the area without causing erosion damage.

"Channel" means a natural stream or manmade waterway.

"Cofferdam" means a watertight temporary structure in a river, lake, etc., for keeping the water from an enclosed area that has been pumped dry so that bridge foundations, dams, etc., may be constructed.

"Dam" means a barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or to retain soil, rock or other debris.

"Denuded" means a term applied to land that has been physically disturbed and no longer supports vegetative cover.

"Department" means the Department of Conservation and Recreation.

"Development" means a tract of land developed or to be developed as a single unit under single ownership or unified control which is to be used for any business or industrial purpose or is to contain three or more residential dwelling units.

"Dike" means an embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; levee.

"District" means a political subdivision of the Commonwealth organized in accordance with the provisions of Article 3 (§10.1-506 et seq.) of Chapter 5 of Title 10.1 of the Code of Virginia.

"Diversion" means a channel with a supporting ridge on the lower side constructed across or at the bottom of a slope for the purpose of intercepting surface runoff.

"Dormant" refers to denuded land that is not actively being brought to a desired grade or condition.

"Erosion and Sediment Control Plan" means a document containing material for the conservation of soil and water resources of a unit or group of units of land. It may include appropriate maps, an appropriate soil and water plan inventory and management information with needed interpretations, and a record of decisions contributing to conservation treatment. The plan shall contain all major conservation decisions to assure that the entire unit or units of land will be so treated to achieve the conservation objectives.

"Flume" means a constructed device lined with erosion-resistant materials intended to convey water on steep grades.

"Live watercourse" means a definite channel with bed and banks within which concentrated water flows continuously.

"Locality" means a county, city or town.

"Natural stream" means nontidal waterways that are part of the natural topography. They usually maintain a continuous or seasonal flow during the year and are characterized as being irregular in cross-section with a meandering course. Constructed channels such as drainage ditches or swales shall not be considered natural streams.

"Nonerodible" means a material, e.g., riprap, concrete, plastic, etc., that will not experience surface wear due to natural forces.

"Person" means any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, county, city, town or other political subdivision of the Commonwealth, any interstate body, or any other legal entity.

"Plan approving authority" means the board, the district or a county, city, or town, or a department of a county, city, or town, responsible for determining the adequacy of a conservation plan submitted for land-disturbing activities on a unit or units of land and for approving plans.

"Post-development" refers to conditions that may be reasonably expected or anticipated to exist after completion of the land development activity on a specific site or tract of land.

"Pre-development" refers to conditions at the time the erosion and sediment control plan is submitted to the plan approving authority. Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing conditions at the time the erosion and sediment control plan for the initial phase is submitted for approval shall establish pre-development conditions.

"Sediment basin" means a depression formed from the construction of a barrier or dam built to retain sediment and debris.

"Sheet flow" (also called overland flow) means shallow, unconcentrated and irregular flow down a slope. The length of strip for overland flow usually does not exceed 200 feet under natural conditions.

"Single family residence-separately built" means a noncommercial dwelling that is occupied exclusively by one family and not part of a residential subdivision development.

"Slope drain" means tubing or conduit made of nonerosive material extending from the top to the bottom of a cut or fill slope.

"Stabilized" means an area that can be expected to withstand normal exposure to atmospheric conditions without incurring erosion damage.

"Storm sewer inlet" means a structure through which stormwater is introduced into an underground conveyance system.

"Stormwater detention" means the process of temporarily impounding runoff to reduce flood peaks.

"Stormwater retention" means the process by which an impoundment structure stores the total runoff of a given storm and then releases the flow at a controlled rate over an extended period.

"Subdivision" unless otherwise defined in a local ordinance adopted pursuant to §15.1-465 of the Code of Virginia, means the division of a parcel of land into three or more lots or parcels of less than five acres each for the purpose of transfer of ownership or building development, or, if a new street is involved in such division, any division of a parcel of land. The term includes resubdivision and, when appropriate to the context, shall relate to the process of subdividing or to the land subdivided.

"Temporary stream crossing" means a temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes or pipe arches.

"Ten-year frequency storm" means a storm that is capable of producing rainfall expected to be equaled or exceeded on the average of once in 10 years. It may also be expressed as an exceedence probability with a 10 % chance of being equaled or exceeded in any given year.

"Two-year frequency storm" means a storm that is capable of producing rainfall expected to be equaled or exceeded on the average of once in two years. It may also be expressed as an exceedence probability with a 50 % chance of being equaled or exceeded in any given year.

§1.2. Authority.

The authority for these regulations is contained in Article 4 (§10.1-560 et seq.) of Chapter 5 of Title 10.1 of the Code of Virginia.

§1.3. Purpose.

The purpose of these regulations is to form the basis for the administration, implementation and enforcement of the Act. The intent of these regulations is to establish the framework for compliance with the Act while at the same time providing flexibility for innovative solutions to erosion and sediment control concerns.

§1.4. Scope and Applicability.

A. These regulations set forth minimum standards for the effective control of soil erosion, sediment deposition and nonagricultural runoff that are required to be met in erosion and sediment control programs adopted by districts and localities under the Act.

B. The standards contained in these regulations also apply to:

1. Erosion and control plans that may be submitted directly to the board pursuant to §10.1-563 A of the Act;
2. Annual general erosion and sediment control specifications that electric and telephone utility companies and railroad companies are required to file with the board pursuant to §10.1-563 D of the Act;
3. Conservation plans and annual specifications that state agencies are required to file with the department pursuant to §10.1-564 of the Act; and
4. Federal agencies that enter into agreements with the board.

C. The submission of annual specifications to the board or the department by any agency or company does not eliminate the need for a project specific Erosion and Sediment Control Plan.

§1.5 Minimum Standards.

An erosion and sediment control program adopted by a district or locality shall contain regulations that are consistent with the following criteria, techniques and methods:

1. Permanent or temporary soil stabilization shall be applied to denuded areas within seven days after final grade is reached on any portion of the site. Temporary soil stabilization shall be applied within seven days to denuded

areas that may not be at final grade but will remain dormant (undisturbed) for longer than 30 days. Permanent stabilization shall be applied to areas that are to be left dormant for more than one year.

2. During construction of the project, soil stock piles shall be stabilized or protected with sediment trapping measures. The applicant is responsible for the temporary protection and permanent stabilization of all soil stockpiles on site as well as soil intentionally transported from the project site.

3. A permanent vegetative cover shall be established on denuded areas not otherwise permanently stabilized. Permanent vegetation shall not be considered established until a ground cover is achieved that, in the opinion of the local program administrator or his designated agent, is uniform, mature enough to survive and will inhibit erosion.

4. Sediment basins and traps, perimeter dikes, sediment barriers and other measures intended to trap sediment shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

5. Stabilization measures shall be applied to earthen structures such as dams, dikes and diversions immediately after installation.

6. Surface runoff from disturbed areas that is comprised of flow from drainage areas greater than or equal to three acres shall be controlled by a sediment basin. The sediment basin shall be designed and constructed to accommodate the anticipated sediment loading from the land-disturbing activity. The outfall device or system design shall take into account the total drainage area flowing through the disturbed area to be served by the basin.

7. Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. Slopes that are found to be eroding excessively within one year of permanent stabilization shall be provided with additional slope stabilizing measures until the problem is corrected.

8. Concentrated runoff shall not flow down cut or fill slopes unless contained within an adequate temporary or permanent channel, flume or slope drain structure.

9. Whenever water seeps from a slope face, adequate drainage or other protection shall be provided.

10. All storm sewer inlets that are made operable during construction shall be protected so that sediment-laden water cannot enter the conveyance system without first being filtered or otherwise treated to remove sediment.

11. Before newly constructed stormwater conveyance channels are made operational, adequate outlet protection and any required temporary or permanent channel lining shall be installed in both the conveyance channel and receiving channel.

12. When work in a live watercourse is performed, precautions shall be taken to minimize encroachment, control sediment transport and stabilize the work area to the greatest extent possible during construction. Nonerodible material shall be used for the construction of causeways and cofferdams. Earthen fill may be used for these structures if armored by nonerodible cover materials.

13. When a live watercourse must be crossed by construction vehicles more than twice in any six-month period, a temporary stream crossing constructed of nonerodible material shall be provided.

14. All applicable federal, state and local regulations pertaining to working in or crossing live watercourses shall be met.

15. The bed and banks of a watercourse shall be stabilized immediately after work in the watercourse is completed.

16. Underground utility lines shall be installed in accordance with the following standards in addition to other applicable criteria:

a. No more than 500 linear feet of trench may be opened at one time.

b. Excavated material shall be placed on the uphill side of trenches.

c. Effluent from dewatering operations shall be filtered or passed through an approved sediment trapping device, or both, and discharged in a manner that does not adversely affect flowing streams or off-site property.

d. Restabilization shall be accomplished in accordance with these regulations.

e. Applicable safety regulations shall be complied with.

17. Where construction vehicle access routes intersect paved public roads, provisions shall be made to minimize the transport of sediment by vehicular tracking onto the paved surface. Where sediment is transported onto a public road surface, the road shall be cleaned thoroughly at the end of each day. Sediment shall be removed from the roads by shoveling or sweeping and transported to a sediment control disposal area. Street washing shall be allowed only after sediment is removed in this manner. This provision shall apply to individual subdivision lots as well as to larger land-disturbing activities.

18. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization or after the temporary measures are no longer needed, unless otherwise authorized by the local program administrator.

Trapped sediment and the disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion and sedimentation.

19. Properties and waterways downstream from development sites shall be protected from sediment deposition, erosion and damage due to increases in volume, velocity and peak flow rate of stormwater runoff for the stated frequency storm of 24-hour duration in accordance with the following standards and criteria:

a. Concentrated stormwater runoff leaving a development site shall be discharged directly into an adequate natural or man-made receiving channel, pipe or storm sewer system. For those sites where runoff is discharged into a pipe or pipe system, downstream stability analyses at the outfall of the pipe or pipe system shall be performed.

b. Adequacy of all channels and pipes shall be verified in the following manner:

(1). The applicant shall demonstrate that the total drainage area to the point of analysis within the channel is one hundred times greater than the contributing drainage area of the project in question.

(2). Natural channels shall be analyzed by the use of a two-year frequency storm to verify that stormwater will not overtop channel banks nor cause erosion of channel bed or banks.

(3). All previously constructed man-made channels shall be analyzed by the use of a ten-year frequency storm to verify that stormwater will not overtop its banks and by the use of a two-year storm to demonstrate that stormwater will not cause erosion of channel bed or banks.

(4). Pipes and storm sewer systems shall be analyzed by the use of a ten-year frequency storm to verify that stormwater will be contained within the pipe or system.

c. If existing natural receiving channels or previously constructed man-made channels or pipes are not adequate, the applicant shall:

(1). Improve the channels to a condition where a ten-year frequency storm will not overtop the banks and a two-year frequency storm will not cause erosion to the channel bed or banks; or

(2). Improve the pipe or pipe system to a condition where the ten-year frequency storm is contained within the appurtenances; or

(3). Develop a site design that will not cause the pre-development peak runoff rate from a two-year storm to increase when runoff outfalls into a natural channel or will not cause the pre-development peak runoff rate from a ten-year storm to increase when runoff outfalls into a man-made channel.

(4). Provide a combination of channel improvement, stormwater detention/retention or other measures which is satisfactory to the plan approving authority to prevent downstream erosion.

d. The applicant shall provide evidence of permission to make the improvements.

e. All hydrologic analyses shall be based on the existing watershed characteristics and the ultimate development condition of the subject project.

f. If the applicant chooses an option that includes stormwater detention/retention, he shall obtain approval from the locality of a plan for maintenance of the detention facilities. The plan shall set forth the maintenance requirements of the facility and the person responsible for performing the maintenance.

g. Increased volumes of sheet flows that may cause erosion or sedimentation on adjacent property shall be diverted to a stable outlet, adequate channel or detention facility.

h. In applying these stormwater management criteria, individual lots in a residential subdivision development shall not be considered to be separate development projects. Instead, the residential subdivision development, as a whole, shall be considered to be a single development project. Hydrologic parameters that reflect the ultimate subdivision development shall be used in all engineering calculations.

i. Proposed commercial or industrial subdivisions shall apply these stormwater management criteria to the development as a whole. Hydrologic parameters that reflect the ultimate subdivision development shall be used in all engineering calculations.

§1.6. Variances.

The plan approving authority may waive or modify any of the regulations that are deemed inappropriate or too restrictive for site conditions, by granting a variance. A variance may be granted under these conditions:

1. At the time of plan submission, an applicant may request a variance to become part of the approved erosion and sediment control plan. The applicant shall explain the reasons for requesting variances in writing. Specific variances which are allowed by the plan approving authority shall be documented in the plan.

2. During construction, the person responsible for implementing the approved plan may request a variance in writing from the plan approving authority. The plan approving authority shall respond in writing either approving or disapproving such a request. If the plan approving authority does not approve a variance within 10 days of receipt of the request, the request shall be considered to be disapproved. Following disapproval, the applicant may resubmit a variance request with additional documentation.

3. The plan approving authority shall consider variance requests judiciously, keeping in mind both the need of the applicant to maximize cost effectiveness and the need to protect off-site properties and resources from damage.

§1.7 Maintenance and Inspections.

A. All erosion and sediment control structures and systems shall be maintained, inspected and repaired as needed to insure continued performance of their intended function. A statement describing the maintenance responsibilities of the permittee shall be included in the approved erosion and sediment control plan.

B. Periodic inspections are required on all projects by the enforcement authority. An inspection shall be made during or immediately following initial installation of erosion and sediment controls, at least once in every two-week period, within 48 hours following any runoff producing storm event, and at the completion of the project prior to the release of any performance bonds.

§1.8. Residential Subdivision Development.

A. An erosion and sediment control plan shall be filed for a residential development and the buildings constructed within, regardless of the phasing of construction.

B. If individual lots or sections in a residential development are being developed by different property owners, all land-disturbing activities related to the building construction shall be covered by an erosion and sediment control plan or an "Agreement in Lieu of a Plan" signed by the property owner.

C. Land-disturbing activity of less than 10,000 square feet on individual lots in a residential development shall not be considered exempt from the provisions of the act and these regulations.

D. The construction of permanent roads or driveways that disturb in excess of 10,000 square feet and that serve more than one single-family residence separately built is not exempt from the requirements of the Act and these regulations.

§1.9 Criteria for Determining Status of Land-disturbing Activity.

A. A property owner who disturbs 10,000 square feet, or more, of land and claims that the activity is exempted from the requirements of the Act as shown in 10.1-560 of the Code of Virginia shall have one year from the date of commencement of the activity to demonstrate to the erosion and sediment control enforcement authority that the activity is exempt. As soon as a nonexempt status is determined, the requirements of the Act shall be immediately enforced.

B. Should a land-disturbing activity cease for more than 180 days, the plan approval authority or the permit issuing authority shall evaluate the existing approved erosion and sediment control plan to determine whether the plan still satisfies local and state erosion and sediment control criteria and to verify that all design factors are still valid. If the authority finds the previously filed plan to be inadequate, a modified plan shall be submitted and approved prior to the resumption of land-disturbing activity.

§1.10. State Agency Projects.

A. All state agency land-disturbing activities that are not exempt and that have commenced without an approved erosion and sediment control plan shall immediately cease until an erosion and sediment control plan has been submitted to and approved by the department. A formal "Notice of Permit Requirement" will be sent to the state agency under whose purview the project lies since that agency is responsible for compliance with the Act.

B. Where inspections by department personnel reveal deficiencies in carrying out an approved plan, the person responsible for carrying out the plan, as well as the state agency responsible, will be issued a notice to comply with specific actions and the deadlines that shall be met. Failure to meet the prescribed deadlines can result in the issuance of a stop work order for all land-disturbing activities on the project at the discretion of the director of the department or his designee who is authorized to sign such an order. The stop work order will be lifted once the required erosion and sediment control measures are in place and inspected by department staff.

C. Whenever the Commonwealth or any of its agencies fails to comply within the time provided in an appropriate final order, the director of the department may petition for compliance as follows: For violations in the Natural Resources

Secretariat, to the Secretary of Natural Resources; for violations in other secretariats, to the appropriate secretary; for violations in other state agencies, to the head of such agency. Where the petition does not achieve timely compliance, the director shall bring the matter to the Governor for resolution.

D. Where compliance will require the appropriation of funds, the director shall cooperate with the appropriate agency head in seeking such an appropriation; where the director determines that an emergency exists, he shall petition the Governor for funds from the Civil Contingency Fund or other appropriate source.

106

Virginia
Stormwater Management Regulations

Virginia Department of Conservation and Recreation
Division of Soil and Water Conservation
203 Governor Street, Suite 206
Richmond, VA 23219

1990

TREGS.PM3

PART I.

GENERAL.

§ 1.1. Definitions.

The following words and terms used in these regulations have the following meanings, unless the context clearly indicates otherwise.

"Act" means Article 1.1 (§10.1-603.1 et seq.) of Chapter 6 of Title 10.1 of the Code of Virginia.

"Adequate channel" means a channel that will convey the designated frequency storm event without overtopping the channel banks nor causing erosive damage to the channel bed or banks.

"Applicant" means any person submitting a stormwater management plan for approval.

"Channel" means a natural stream or manmade waterway.

"Department" means the Department of Conservation and Recreation.

"Development" means a tract of land developed or to be developed as a unit under single ownership or unified control which is to be used for any business or industrial purpose or is to contain three or more residential dwelling units.

"Director" means the Director of the Department of Conservation and Recreation.

"Flooding" means a volume of water that is too great to be confined within the banks or walls of the stream, water body or conveyance system and that overflows onto adjacent lands, causing or threatening damage.

"Floodplain" means those areas adjoining a river, stream, channel, ocean, bay or lake which are likely to be covered by flooding.

"Infiltration facility" means a stormwater management facility which temporarily impounds runoff and discharges it via infiltration through the surrounding soil. While an infiltration facility may also be equipped with an outlet structure to discharge impounded runoff, such discharge is normally reserved for overflow and other emergency conditions. Since an infiltration facility impounds runoff only temporarily, it is normally dry during non-rainfall periods.

"Inspection" means an on-site review of the project's compliance with the approved plan, the local stormwater management program, and any applicable design criteria.

"Land development" or "land development project" means a manmade change to the land surface that potentially changes its runoff characteristics.

"Local stormwater management program" or "local program" means a statement of the various methods employed by a locality to manage the runoff from land development projects and may include such items as local ordinances, policies and guidelines, technical materials, inspections, enforcement and evaluation.

"Locality" means a county, city, or town.

"Nonpoint source pollution" means pollution whose sources cannot be pinpointed but rather is washed from the land surface in a diffuse manner by stormwater runoff.

" Onsite stormwater management facilities" means facilities which are designed to control stormwater runoff emanating from a specific site.

"Person" means any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, county, city, town or other political subdivision of the Commonwealth, any interstate body or any other legal entity.

"Post-development" refers to conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land.

"Pre-development" refers to the land use that exists at the time that plans for the land development are submitted to the locality. Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing land use at the time the first item is submitted shall establish pre-development conditions.

"Regional (watershed wide) stormwater management facility" or "regional facility" means a facility or series of facilities designed to control stormwater runoff from a large contributing area, although only portions of the watershed may experience land development.

"Regional stormwater management plan" or "regional plan" means a document containing material describing how runoff from open space, existing development and future planned development areas within a watershed will be controlled by coordinated design and implementation of regional stormwater management facilities.

"Runoff" or "stormwater runoff" means that portion of precipitation that is discharged across the land surface or through conveyances to one or more waterways.

"State project" means the construction of any facility or expansion of an existing facility including, but not limited to land clearing, soil movement, or land development, which is undertaken by any state agency, board, commission, authority or any branch of state government, including state supported institutions of higher learning, which disturbs more than one acre of land area.

"Stormwater detention basin" or "detention basin" means a stormwater management facility which temporarily impounds runoff and discharges it through a hydraulic outlet structure to a downstream conveyance system. While a certain amount of outflow may also occur via infiltration through the surrounding soil, such amounts are negligible when compared to the outlet structure discharge rates and are, therefore, not considered in the facility's design. Since a detention facility impounds runoff only temporarily, it is normally dry during non-rainfall periods.

"Stormwater management facility" means a device that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release or the velocity of flow.

"Stormwater management plan" or "plan" means a document containing material for describing how existing runoff characteristics will be maintained by a land development project and comply with the requirements of the local program or these regulations.

"Stormwater retention basin" or "retention basin" means a stormwater management facility which, similar to a detention basin, temporarily impounds runoff and discharges its outflow through a hydraulic outlet structure to a downstream conveyance system. Unlike a detention basin, however, a retention basin also includes a permanent impoundment and, therefore, is normally wet, even during non-rainfall periods. Storm runoff inflows are temporarily stored above this permanent impoundment.

"Subdivision" unless otherwise defined in a local ordinance adopted pursuant to § 15.1-465 of the Code of Virginia, means the division of a parcel of land into three or more lots or parcels of less than five acres each for the purpose of transfer of ownership or building development, or, if a new street is involved in such division, any division of a parcel of land. The term includes resubdivision and, when appropriate to the context, shall relate to the process of subdividing or to the land subdivided.

"Water quality volume" means the volume equal to the first 0.5 inch of runoff multiplied by the total area of the land development project.

"Watershed" means the total drainage area contributing runoff to a single point.

§ 1.2. Authority.

Article 1.1 (§10.1-603.1 et seq.) of Chapter 6 of Title 10.1 of the Code of Virginia authorizes the department to promulgate these regulations.

§ 1.3. Purposes.

The purposes of these regulations are to:

1. Inhibit the deterioration of existing waters and waterways of the Commonwealth by requiring that state agency and local stormwater management programs maintain post-development runoff characteristics, including both water quantity and quality, as nearly as practicable, equal to or better than the pre-development runoff characteristics;

2. Control nonpoint source pollution, localized flooding and stream channel erosion, by establishing minimum acceptable technical criteria that must be met by state agencies and all stormwater management programs implemented by localities;

3. Establish minimum acceptable administrative procedures that must be met by all local stormwater management programs implemented by localities;

4. Require the provision of long-term responsibility for, and maintenance of, stormwater management facilities and other techniques specified to manage the quality and quantity of runoff;

5. Provide for the integration of stormwater management programs with erosion and sediment control, site plan review, flood insurance, floodplain management and other land development related programs and laws and regulations requiring compliance prior to authorizing construction; and

6. Provide for the periodic review and evaluation of local stormwater management programs and state agency compliance and for annual reporting to the General Assembly of the extent to which the state stormwater management program has reduced nonpoint source pollution and mitigated the detrimental effects of localized flooding.

§ 1.4. Applicability.

A. These regulations are applicable to:

1. Every locality that establishes a local stormwater management program; and
2. Every state agency that, after January 1, 1991, undertakes any land clearing, soil movement, or construction activity involving soil movement or land development.

B. The following activities are exempt from these regulations:

1. Permitted surface or deep mining operations and projects, or oil and gas operations and projects conducted under the provisions of Title 45.1 of the Code of Virginia.
2. Tilling, planting or harvesting of agricultural, horticultural, or forest crops.
3. Single-family residences separately built and not part of a subdivision, including additions or modifications to existing single-family detached residential structures.

4. Land development projects that disturb less than one acre of land area, except that the governing body of a locality that has adopted a local stormwater management program may exempt a smaller area of disturbed land or may qualify the conditions under which this exemption shall apply.

PART II.

TECHNICAL CRITERIA.

§ 2.1. Applicability.

Except as provided for in § 1.4.B. of these regulations, all local stormwater management programs and state projects must comply with the general requirements and water quality requirements in this Part.

§ 2.2. General requirements.

A. A stormwater management plan for a land development project shall be developed so that from the site, the post-development peak runoff rate from a two-year storm and a 10-year storm, considered individually, shall not exceed their respective pre-development rates.

B. These design storms shall be defined as either a 24-hour storm using the rainfall distribution recommended by the U.S. Soil Conservation Service when using U.S. Soil Conservation Service methods or as the storm of critical duration that produces the greatest required storage volume at the site when using a design method such as the Rational Method.

C. For purposes of computing runoff, all lands in the site shall be assumed prior to development to be in good condition (if the lands are pastures, lawns, or parks), with good cover (if the lands are woods), or with conservation treatment (if the lands are cultivated); regardless of conditions existing at the time of computation.

D. Construction of stormwater management facilities or modifications to channels shall comply with all applicable laws and regulations. Evidence of approval of all necessary permits shall be presented.

E. Localities shall require impounding structures that are not covered by the Virginia Dam Safety Regulations to be checked for structural integrity and floodplain impacts for the 100-year storm event.

F. Pre-development and post-development runoff rates shall be verified by calculations that are consistent with good engineering practices and are acceptable to the locality.

G. Outflows from a stormwater management facility shall be discharged to an adequate channel, or velocity dissipators shall be placed at the outfall of all detention and retention basins and along the length of any outfall channel as necessary to provide a non-erosive velocity of flow from the basin to a channel.

H. Proposed residential, commercial, or industrial subdivisions shall apply these stormwater management criteria to the land development as a whole. Individual lots in new subdivisions shall not be considered separate land development projects, but rather the entire subdivision shall be considered a single land development project. Hydrologic parameters shall reflect the ultimate land development and shall be used in all engineering calculations.

I. New construction, including construction of stormwater management facilities, should be avoided in floodplains. When this is unavoidable, a special examination to determine adequacy of proposed stormwater management facilities during the 10-year flood shall be required. The purpose of this analysis is to ensure that the stormwater management facility will operate effectively.

J. In addition, such construction shall be in compliance with all applicable regulations under the National Flood Insurance Program.

K. To prevent flooding or stream erosion downstream of the development site, it may be necessary to increase the detention storage requirements and reduce peak outflow rates to levels that exceed the requirements of § 2.2.A. of these regulations. This requirement can be imposed only if a watershed analysis has been made by the locality.

L. Land development projects must comply with the Virginia Erosion and Sediment Control Act and attendant regulations.

§ 2.3. Water quality requirements.

The water quality volume shall be treated by one of the following methods.

A. For a detention basin, the water quality volume shall be detained and released over 30 hours.

1. The detention time is a brim-drawdown time and therefore, shall begin at the time of peak storage of the water quality volume in the detention basin.
2. If the above requirement would result in an outlet opening smaller than three inches in diameter or the equivalent cross sectional area, the period of detention shall be waived so that three inches will be the minimum outlet opening used.

B. For a retention basin, the volume of the permanent pool must be at least three times greater than the water quality volume.

C. For an infiltration facility, the water quality volume must be completely infiltrated within 48 hours.

1. The invert of the infiltration facility must be at least four feet above the seasonal high groundwater elevation.
2. A detailed soils analysis and report shall be required.
3. Approvals will be on a case-by-case basis after technical review by the designated authority. The object of this review will be to avoid groundwater contamination.

D. Design calculations verifying compliance with the water quality requirements shall be submitted.

§ 2.4. Nonstructural measures.

It is not necessary that basic requirements for water quality and quantity control be satisfied by means of structural methods. Non-structural practices including, but not limited to, cluster land use development, minimization of impervious surface and curbing requirements, open space acquisition, floodplain management, and protection of wetlands, steep slopes and vegetation should be coordinated with structural requirements. Such changes in land use often decrease the runoff coefficients, thus reducing the scope and cost of structural practices.

PART III.

LOCAL STORMWATER MANAGEMENT PROGRAMS.

§ 3.1. Applicability.

A. This Part specifies administrative procedures for all localities operating local stormwater management programs.

B. Except for regulations related to plan approval, which are set forth in §§ 3.5. and 3.6. of these regulations, a locality may adopt regulations that are more stringent than those necessary to ensure compliance with these regulations, provided that the more stringent regulations are based upon the findings of local comprehensive watershed management studies and that prior to adopting more stringent regulations a public hearing is held after giving due notice.

C. The department and a locality operating a stormwater management program are authorized to cooperate and enter into agreements with any federal or state agency in connection with stormwater management plans.

1. A locality that has adopted more stringent requirements or regional stormwater management plans may request, in writing, that the department consider these requirements in its review of state agency projects within that locality.
2. To the maximum extent practicable, the state agencies shall comply with these local program requirements.
3. Nothing in this Part shall be construed as authorizing a locality to regulate, or to require prior approval by the locality for, a state project.

D. Localities with existing stormwater management programs shall have one year from the effective date of these regulations to modify their programs to comply with the minimum requirements of these regulations.

§ 3.2. Requirements for local program and ordinance.

A. At a minimum, the local stormwater management program and implementing ordinance shall require compliance with the stormwater management technical criteria established in Part II of these regulations.

B. Each locality shall submit its stormwater management program, implementing ordinance, and amendments to the department for review. The department shall determine if the program and ordinance are consistent with the state stormwater management regulations and notify the locality of its findings within 60 days.

C. Each stormwater management program shall consider the unique character and limitations of the environment in the planning area.

D. Stormwater management programs shall refer to and be in compliance with requirements for the control of soil erosion. The stormwater management program and ordinance shall also be consistent with relevant federal and state laws, rules and regulations concerning stormwater management, dam safety, management and flood control. Additionally, such programs should be coordinated with any stormwater management plans prepared by any other locality in the watershed.

E. The local stormwater management program and ordinance shall be included in the periodic reexamination of the locality's comprehensive land use plan.

F. Except as provided for in § 1.4.B. of these regulations, no grading, building, or other permit shall be issued for land development unless a stormwater management plan has been submitted to the locality and approved.

G. Nothing in this regulation shall be construed as limiting the rights of other federal and state agencies from imposing stricter standards or other requirements as allowed by law.

§ 3.3. Watershed planning encouraged.

A. In developing a local stormwater management program, a locality should consider regional planning for the appropriate watershed. The objective of regional stormwater management planning is the achievement of greater economy and efficiency through the use of regional stormwater management facilities that can serve several land development projects, as opposed to the use of a multitude of facilities that are intended solely for individual land development projects. In addition to mitigating the impacts of new development, regional stormwater management facilities may also provide an opportunity to remediate flooding or water quality problems caused by uncontrolled existing development. Because watershed boundaries typically transcend political boundaries, localities are encouraged to develop cooperative regional stormwater management plans.

B. Regional stormwater management planning should include the following, as a minimum:

1. Consideration of the locality's comprehensive plan, zoning, government facility plans and similar planning tools.
2. An analysis of the impacts of development on the watershed based on hydrologic and hydraulic modeling. At a minimum, the 2-year, 10-year, and 100-year storms shall be studied. Ultimate development of the watershed shall be assumed.
3. Recommendations for locations, specified release rates, and required storage capacities of needed regional stormwater management facilities based on the modeling.
4. Consideration of future expansion of regional stormwater management facilities based on the possibility that development might exceed the anticipated level.
5. Requirements for necessary onsite stormwater management facilities and release rates.
6. An implementation schedule and financing requirements.

§ 3.4. Administrative procedures: Stormwater management plans.

A. A local stormwater management program and ordinance shall require a person who intends to initiate a land development project to submit a stormwater management plan and obtain the locality's approval of the plan prior to beginning the land development project.

B. The local stormwater management program and ordinance shall establish stormwater management plan submittal requirements. The stormwater management plan may include the appropriate maps, calculations, detail drawings, reports and a listing of the status of all major permit decisions to assure that the land development project achieves the objectives of the local program. Maps, plans, and designs shall be certified by a professional engineer or Class III B surveyor.

C. A locality may charge applicants a reasonable fee to defray the costs of program administration, including costs associated with plan review, issuance of permits, periodic inspection for compliance with approved plans and necessary enforcement, provided that charges for such costs are not made under any other law, ordinance or program. The fee shall not exceed an amount commensurate with the services rendered and expenses incurred or the amount established in § 10.1-603.10 of the Code of Virginia, whichever is less.

D. Prior to issuance of any permit, the locality may also require an applicant to submit a reasonable performance bond in accordance with § 10.1-603.8.A of the Code of the Virginia.

§ 3.5. Administrative procedures: Approval and disapproval of plans.

A. A maximum of 30 calendar days from the receipt of an application will be allowed for preliminary review of the application for completeness. During this period, the locality will either accept the application for review, which will begin the 60-day review period, or reject the application for incompleteness and inform the applicant in writing of the information necessary to complete the application.

B. The 60-day review period begins on the day the complete stormwater management plan is accepted for review. At this time, an acknowledgement letter is sent to the applicant. During the 60-day review period, the locality shall either approve or disapprove the plan and communicate its decision to the applicant in writing. Approval or denial shall be based on the plan's compliance with the locality's stormwater management program.

C. A disapproval of a plan shall contain the reasons for disapproval.

D. The applicant or any aggrieved party authorized by law may appeal a locality's decision of approval or disapproval of a stormwater management plan application within 30 days after the rendering of such a decision of the locality, to the circuit court of the jurisdiction in which the land development project is located.

E. Judicial review shall be on the record previously established and shall otherwise be in accordance with the provisions of the Administrative Process Act (§ 9-6.14:1 et seq.).

§ 3.6. Administrative procedures: Conditions of approval.

Each plan approved by a locality shall be subject to the following conditions:

1. The applicant shall comply with all applicable requirements of the approved plan, the local program, these regulations and the Act, and shall certify that all land clearing, construction, land development and drainage will be done according to the approved plan.

2. The land development project shall be conducted only within the area specified in the approved plan.

3. The locality shall be allowed, after giving notice to the owner, occupier or operator of the land development project, to conduct periodic inspections of the project.

4. The person responsible for implementing the approved plan shall conduct monitoring and submit reports as the locality may require to ensure compliance with the approved plan and to determine whether the plan provides effective stormwater management.

5. No transfer, assignment or sale of the rights granted by virtue of an approved plan shall be made unless a written notice of transfer is filed with the locality and the transferee certifies agreement to comply with all obligations and conditions of the approved plan.

§ 3.7. Administrative procedures: Changes to an approved plan.

No changes may be made to an approved plan without review and written approval by the locality.

§ 3.8. Administrative procedures: Exceptions.

A. A request for an exception shall be submitted, in writing, to the locality. An exception from the stormwater management regulations may be granted, provided that: (i) exceptions to the criteria are the minimum necessary to afford relief, and (ii) reasonable and appropriate conditions shall be imposed as necessary upon any exception granted so that the purpose and intent of the Act is preserved.

B. Economic hardship is not sufficient reason to grant an exception from the requirements of this regulation.

§ 3.9. Administrative procedures: Maintenance and inspections.

A. Maintenance of stormwater management facilities is an integral aspect of a stormwater management program. Responsibility for the operation and maintenance of stormwater management facilities, unless assumed by a governmental agency, shall remain with the property owner and shall pass to any successor or owner. If portions of the land are to be sold, legally binding arrangements shall be made to pass the basic responsibility to successors in title. These arrangements shall designate for each project the property owner, governmental agency, or other legally established entity to be permanently responsible for maintenance.

B. In the case of developments where lots are to be sold, permanent arrangements satisfactory to the approving agency shall be made to insure continued performance of these obligations.

C. A schedule of maintenance inspections shall be incorporated into the local ordinance. Ordinances shall also provide that in cases where maintenance or repair is neglected, or the stormwater management facility becomes a danger to public health or safety, the locality has the authority to perform the work and to recover the costs from the owner.

D. Localities may require right of entry agreements or easements from the applicant for purposes of inspection and maintenance.

E. At a minimum, stormwater management facilities shall be inspected on a semi-annual basis and after any storm which causes the capacity of the facility to be exceeded.

F. During construction of the stormwater management facilities, localities shall make inspections on a regular basis.

G. Inspection reports shall be maintained as part of the land development project file.

§ 3.10. Compliance.

If the locality determines that there is a failure to comply with the plan, notice shall be served upon the applicant or person responsible for implementing the plan by registered or certified mail to the address specified in the application or plan certification, or by delivery at the site of development activities to the agent or employee supervising such activities. The notice shall specify the measures needed to comply with the plan and shall specify the time within which such measures shall be completed. Upon failure to comply within the time specified, the permit may be revoked and the applicant or person responsible for implementing the plan shall be deemed to be in violation of the Act and upon conviction shall be subject to the penalties provided in § 10.1-603.14 of the Code of Virginia.

§ 3.11. Review of plans by the department.

The department will review any stormwater management plan with real or potential interjurisdictional impacts, upon the request of one of the involved localities, to determine whether the plan is consistent with the provisions of the Act and these regulations. Any such review shall be completed and a report submitted to each locality involved within 90 days of such request.

PART IV.

STATE AGENCY PROJECTS.

§ 4.1. Stormwater management plans or standards required.

A. After January 1, 1991, a state agency shall not undertake any land clearing, soil movement or construction activity involving soil movement or land development unless the state agency has:

1. Submitted to the department a stormwater management plan for the state project and has obtained approval of the plan from the department; or
2. Submitted annually to the department stormwater management standards and specifications and has obtained approval of those standards and specifications.

B. Stormwater management plans prepared for state projects shall comply with the technical criteria established in Part II of these regulations and, to the maximum extent practicable, any local stormwater management requirements in accordance with § 3.1.C. of these regulations.

C. The following schedule for compliance with the state stormwater management regulations shall be applied to state projects.

1. As of January 1, 1991, state projects subject to the capital outlay process described in the Department of General Services, Division of Engineering and Buildings' Capital Outlay Manual that have received approval of preplanning studies or schematic drawings by the Art and Architectural Review Board, and those capital outlay projects not subject to the capital outlay manual that have completed 50% or more of final construction plans, shall make every effort to retrofit their projects with the appropriate measures. However, substantial redesign of the project or additional land acquisition will not be required. At a minimum, these projects must comply with the stormwater management criteria established in the state Erosion and Sediment Control Act and attendant regulations.
2. All other state projects must comply fully with these regulations as of January 1, 1991.

§ 4.2. Minimum requirements for stormwater management plans.

As a minimum, a stormwater management plan shall contain the following:

1. The location and the design of the proposed stormwater management facilities.
2. Overall site plan.
3. Comprehensive hydrologic and hydraulic computations for the pre-development and post-development two-year and 10-year storm events, considered individually.
4. Calculations verifying compliance with the water quality requirements.
5. A description of the requirements for maintenance of the stormwater management facilities and a recommended schedule of inspection and maintenance.
6. The identification of a person or persons who will be responsible for maintenance.
7. Certification of maps, plans and designs by a professional engineer or Class III B surveyor.

§ 4.3. Minimum requirements for submission of stormwater management standards and specifications.

A. A request for approval of stormwater management standards and specifications may be submitted to the department by a state agency on an annual basis. At a minimum, the following certifications shall accompany the request.

1. Individual stormwater management plans shall be prepared for all state agency projects.
2. The stormwater management plans shall comply with the technical requirements established in Part II of these regulations and, to the maximum extent practicable, any local stormwater management requirements in accordance with § 3.1.C. of these regulations.
3. An inspection and maintenance schedule shall be developed and implemented.

B. Copies of stormwater management specifications and standards including, but not limited to, design manuals, technical guides and handbooks, shall be submitted.

§ 4.4. Actions on plans or specifications by the department.

A. Not later than 30 days after receipt of a complete stormwater management plan submitted by a state agency, the department shall approve or disapprove the plan.

1. The department shall transmit its decision in writing to the state agency which submitted the plan.
2. Disapproved plans must be resubmitted to the department.

B. The department's recommendations shall be binding on the state agency and on the private business or businesses, if any, hired by the state agency.

C. A state agency shall not change an approved stormwater management plan without approval from the department.

§ 4.5. Compliance.

A. The state agency responsible for the land development shall ensure compliance with the approved plan or specifications, even if actual plan implementation is performed by a private business or businesses, hired by the state agency.

B. The department shall perform random site inspections of state projects to assure compliance with these regulations, the Erosion and Sediment Control Act and related regulations.

C. The department may require monitoring and reports from the state agency responsible for implementing the plan, to ensure compliance with the approved plan and to determine if the measures required in the plan provide effective stormwater management.

PART V.

REPORTING.

§ 5.1 Reporting on stormwater management.

A. Localities with stormwater management programs and state agencies shall submit an annual report to the department. The report shall cover the period from July 1 to June 30 and shall be submitted to the department by September 1.

B. For localities, an annual report shall include, at a minimum, the number and type of stormwater facilities installed in the locality during the preceding year; their storage capacities; the affected water body, watershed or basin; a summary of any water quality monitoring data associated with the facilities; and the number and reasons for any exceptions approved by the locality.

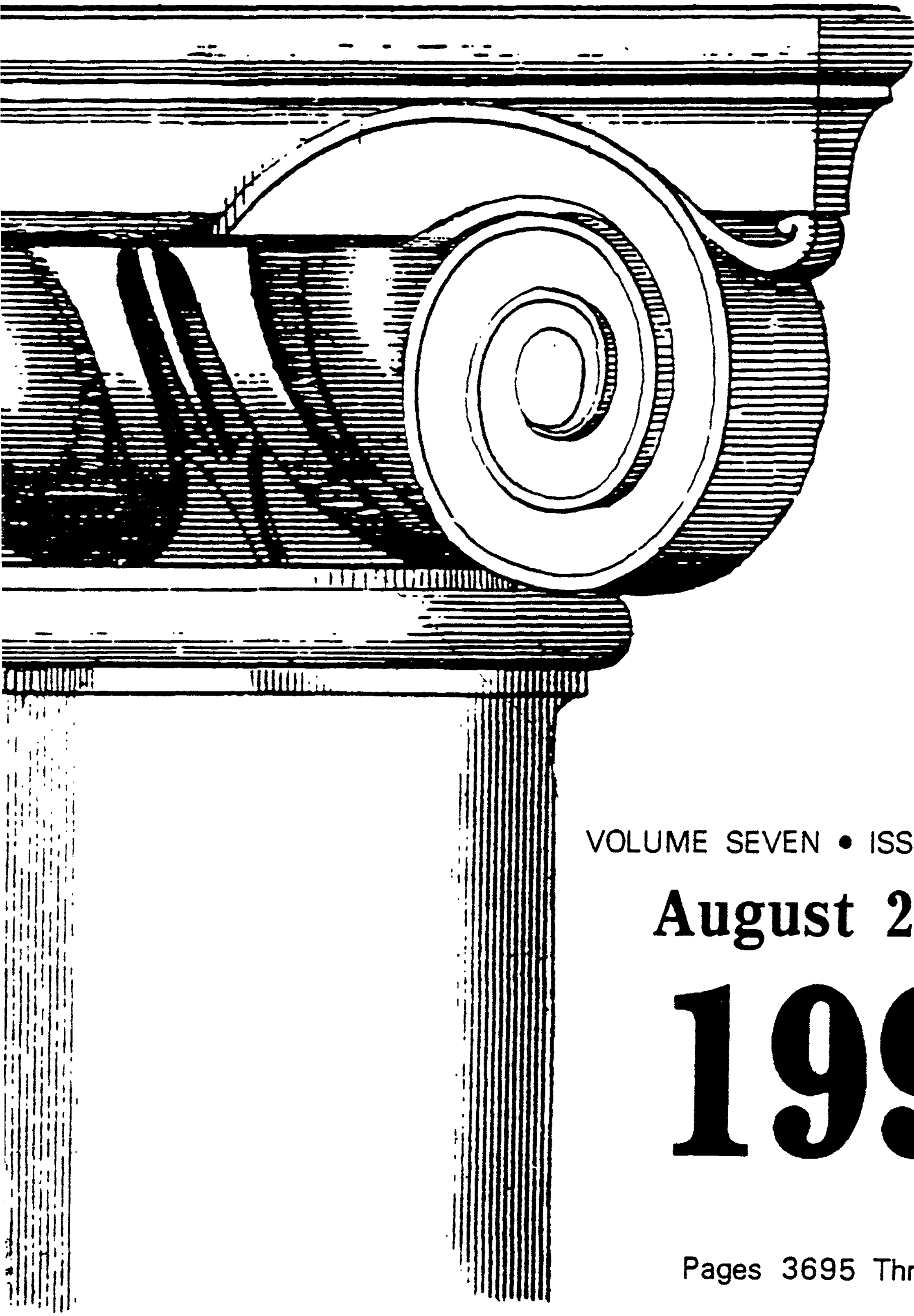
C. For state agencies, an annual report shall include, at a minimum, the location (locality), number and type of stormwater facilities installed during the preceding year; their storage capacities; the affected water body, watershed or basin; and a summary of any water quality monitoring data associated with the facilities.

D. The department will compile this information and report to the General Assembly on the extent to which stormwater management programs have reduced nonpoint source pollution to the Commonwealth's waters.

1089

THE VIRGINIA REGISTER

OF REGULATIONS



VOLUME SEVEN • ISSUE TWENTY-FOUR

August 26, 1991

1991

Pages 3695 Through 3984

STATE AIR POLLUTION CONTROL BOARD

REGISTRAR'S NOTICE: This regulation is excluded from Article 2 of the Administrative Process Act in accordance with § 9-6.14:4.1 C 2 of the Code of Virginia, which excludes regulations that establish or prescribe agency organization, internal practice or procedures, including delegations of authority. The Department of Air Pollution Control will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision.

Title of Regulation: **VR 120-01. Regulations for the Control and Abatement of Air Pollution: Delegation of Authority (Appendix F).**

Statutory Authority: § 10.1-1308 of the Code of Virginia.

Effective Date: October 1, 1991.

Summary:

The regulation amendments concern provisions covering delegation of authority (Appendix F) and are summarized below:

The amendments revise the delegation of authority from the board to the department (i) to change certain subsection designations as reflected in recent changes to Rules 4-3 and 5-3; and (ii) to add to the provisions covering exemptions from delegation to the department the approval of amendments to any policy or procedure approved by the board, except as may be provided by the board in the affected policy or procedure.

VR 120-01. Regulations for the Control and Abatement of Air Pollution: Delegation of Authority (Appendix F).

I. Restrictions upon delegation of authority.

The delegation of authority specified within this appendix is subject to the following restrictions:

A. The board reserves the right to exercise its authority in any of the following delegated powers should it choose to do so.

B. A party significantly affected by any decision of the executive director may request that the board exercise its authority for direct consideration of the issue. The request shall be filed within 30 days after the decision is rendered and shall contain reasons for the request.

C. The submittal of the request by itself shall not constitute a stay of decision. A stay of decision shall be sought through appropriate legal channels.

II. Substance of delegation of authority.

A. The executive director is delegated the authority to act within the scope of the Virginia Air Pollution Control Law and these regulations and for the board when it is not in session except for the authority to:

1. Control and regulate the internal affairs of the board;

2. Approve proposed regulations for public comment and adopt final regulations;

3. Grant variances to regulations;

4. Issue orders and special orders, except for consent orders and emergency special orders;

5. Determine significant ambient air concentrations under §§ 120-04-0304 ~~D~~ *E* and 120-05-0304 ~~D~~ *E* ;

6. Approve amendments to any policy or procedure approved by the board, except as may be provided therein;

~~6.~~ *7.* Appoint persons to the State Advisory Board on Air Pollution;

~~7.~~ *8.* Create local air pollution control districts and appoint representatives; and

~~8.~~ *9.* Approve local ordinances.

B. The board may exercise its authority for direct consideration of permit applications in cases where one or more of the following issues is involved in the evaluation of the application: (i) the stationary source generates public concern relating to air quality issues; (ii) the stationary source is precedent setting; or (iii) the stationary source is a major stationary source or major modification expected to impact on any nonattainment area or class I area.

C. The executive director shall notify the board chairman of permit applications falling within the categories specified in subsection B of this section and the board chairman shall advise the executive director of those permits the board wishes to consider directly.

D. The executive director has final authority to adjudicate contested decisions of subordinates delegated powers by him prior to appeal of such decisions to the circuit court or consideration by the board.

CHESAPEAKE BAY LOCAL ASSISTANCE BOARD

Title of Regulation: **VR 173-02-01. Chesapeake Bay Preservation Area Designation and Management Regulations.**

Statutory Authority: §§ 10.1-2103 and 10.1-2107 of the Code of Virginia.

Effective Date: October 1, 1991.

Summary:

These regulations are adopted by the Chesapeake Bay Local Assistance Board in accordance with provisions of §§ 10.1-2103 and 10.1-2107 of the Code of Virginia. The regulations are divided into six parts dealing with (i) introductory matters, (ii) local government requirements, (iii) Chesapeake Bay Preservation Area criteria, (iv) land use and development performance criteria, (v) implementation, assistance, and determination of consistency, and (vi) enforcement.

Amendments to these regulations clarify the definition of "public roads" and establish conditions which they must satisfy to cross preservation areas called Resource Protection Areas, establish a specific date of subdivision for exempting lots that cannot comply with buffer area and reserve septic system drainfield requirements, compress deadlines for adoption of local programs pursuant to the Act, and change the effective date in order to supersede emergency regulations (VR 173-02-01.1) which are currently in effect. The emergency regulations already incorporate the compression of local program adoption deadlines and the buffer and reserve drainfield effective date proposed.

In addition, minor editorial, form or style changes have been made to correct grammar and punctuation. None of these changes affect the content or intent of the regulations.

VR 173-02-01. Chesapeake Bay Preservation Area Designation and Management Regulations.

PART I.
INTRODUCTION.

§ 1.1. Application.

The board is charged with the development of regulations which establish criteria that will provide for the protection of water quality, and that also will accommodate economic development. All counties, cities, and towns in Tidewater Virginia shall comply with these regulations. Other local governments not in Tidewater Virginia may use the criteria and conform their ordinances as provided in these regulations to protect the quality of state waters in accordance with § 10.1-2110 of the Code of Virginia.

§ 1.2. Authority for regulations.

These regulations are issued under the authority of §§ 10.1-2103 and 10.1-2107 of Chapter 21 of Title 10.1 of the Code of Virginia (the Chesapeake Bay Preservation Act, hereinafter "the Act").

§ 1.3. Purpose of regulations.

The purpose of these regulations is to protect and improve the water quality of the Chesapeake Bay, its tributaries, and other state waters by minimizing the effects of human activity upon these waters and implementing the Act, which provides for the definition and protection of certain lands called Chesapeake Bay Preservation Areas, which if improperly used or developed may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries.

These regulations establish the criteria that counties, cities, and towns (hereinafter "local governments") shall use to determine the extent of the Chesapeake Bay Preservation Areas within their jurisdictions. These regulations establish criteria for use by local governments in granting, denying, or modifying requests to rezone, subdivide, or to use and develop land in Chesapeake Bay Preservation Areas. These regulations identify the requirements for changes which local governments shall incorporate into their comprehensive plans, zoning ordinances, and subdivision ordinances to protect the quality of state waters pursuant to §§ 10.1-2109 and 10.1-2111 of the Act.

§ 1.4. Definitions.

The following words and terms used in these regulations have the following meanings, unless the context clearly indicates otherwise. In addition, some terms not defined herein are defined in § 10.1-2101 of the Act.

"Act" means the Chesapeake Bay Preservation Act found in Chapter 21 (§ 10.1-2100 et seq.) of Title 10.1 of the Code of Virginia.

"Best management practice" means a practice, or combination of practices, that is determined by a state or designated area wide planning agency to be the most effective, practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

"Board" means the Chesapeake Bay Local Assistance Board.

"Buffer area" means an area of natural or established vegetation managed to protect other components of a Resource Protection Area and state waters from significant degradation due to land disturbances.

"Chesapeake Bay Preservation Area" means any land designated by a local government pursuant to Part III of these regulations and § 10.1-2107 of the Act. A Chesapeake Bay Preservation Area shall consist of a Resource Protection Area and a Resource Management Area.

"Department" means the Chesapeake Bay Local Assistance Department.

"Development" means the construction or substantial alteration of residential, commercial, industrial

institutional, recreation, transportation, or utility facilities or structures.

"Director" means the Executive Director of the Chesapeake Bay Local Assistance Department.

"Floodplain" means all lands that would be inundated by flood water as a result of a storm event of a 100-year return interval.

"Highly erodible soils" means soils (excluding vegetation) with an erodibility index (EI) from sheet and rill erosion equal to or greater than eight. The erodibility index for any soil is defined as the product of the formula RKLS/T, as defined by the "Food Security Act (F.S.A.) Manual" of August, 1988 in the "Field Office Technical Guide"of the U.S. Department of Agriculture Soil Conservation Service, where K is the soil susceptibility to water erosion in the surface layer; R is the rainfall and runoff; LS is the combined effects of slope length and steepness; and T is the soil loss tolerance.

"Highly permeable soils" means soils with a given potential to transmit water through the soil profile. Highly permeable soils are identified as any soil having a permeability equal to or greater than six inches of water movement per hour in any part of the soil profile to a depth of 72 inches (permeability groups "rapid" and "very rapid") as found in the "National Soils Handbook" of July, 1983 in the "Field Office Technical Guide"of the U.S. Department of Agriculture Soil Conservation Service.

"Impervious cover" means a surface composed of any material that significantly impedes or prevents natural infiltration of water into the soil. Impervious surfaces include, but are not limited to, roofs, buildings, streets, parking areas, and any concrete, asphalt, or compacted gravel surface.

"Infill" means utilization of vacant land in previously developed areas.

"Intensely Developed Areas" means those areas designated by the local government pursuant to § 3.4 of these regulations.

"Local governments" means counties, cities, and towns. These regulations apply to local governments in Tidewater Virginia, as defined in § 10.1-2101 of the Act, but the provisions of these regulations may be used by other local governments.

"Local program" means the measures by which a local government complies with the Act and regulations.

"Local program adoption date" means the date a local government meets the requirements of subsections A and B of § 2.2 of Part II.

"Nontidal wetlands" means those wetlands other than tidal wetlands that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, as defined by the U.S. Environmental Protection Agency pursuant to § 404 of the federal Clean Water Act, in 33 C.F.R. 328.3b, dated November 13, 1986.

"Plan of development" means any process for site plan review in local zoning and land development regulations designed to ensure compliance with § 10.1-2109 of the Act and these regulations, prior to issuance of a building permit.

"Public road" means a publicly-owned road designed and constructed in accordance with [~~policies, procedures and criteria of~~ water quality protection criteria at least as stringent as requirements applicable to] the Virginia Department of Transportation, including regulations promulgated pursuant to (i) the Erosion and Sediment Control Law (§ 10.1-560 et seq. of the Code of Virginia) and (ii) The Virginia Stormwater Management Act (§ 10.1-603 et seq. of the Code of Virginia). This definition includes those roads where the Virginia Department of Transportation exercises direct supervision over the design or construction activities, or both [, and cases where secondary roads are constructed or maintained, or both, by a local government in accordance with the standards of that local government].

"Redevelopment" means the process of developing land that is or has been previously developed.

"Resource Management Area" means that component of the Chesapeake Bay Preservation Area that is not classified as the Resource Protection Area.

"Resource Protection Area" means that component of the Chesapeake Bay Preservation Area comprised of lands at or near the shoreline that have an intrinsic water quality value due to the ecological and biological processes they perform or are sensitive to impacts which may result in significant degradation to the quality of state waters.

"Substantial alteration" means expansion or modification of a building or development which would result in a disturbance of land exceeding an area of 2,500 square feet in the Resource Management Area only.

"Tidal shore" or *"shore"* means land contiguous to a tidal body of water between the mean low water level and the mean high water level.

"Tidal wetlands" means vegetated and nonvegetated wetlands as defined in § 62.1-13.2 of the Code of Virginia.

"Tidewater Virginia" means those jurisdictions named in § 10.1-2101 of the Act.

"Tributary stream" means any perennial stream that is so depicted on the most recent U.S. Geological Survey

7-1/2 minute topographic quadrangle map (scale 1:24,000).

"Use" means an activity on the land other than development including, but not limited to, agriculture, horticulture, and silviculture.

"Water-dependent facility" means a development of land that cannot exist outside of the Resource Protection Area and must be located on the shoreline by reason of the intrinsic nature of its operation. These facilities include, but are not limited to (i) ports; (ii) the intake and outfall structures of power plants, water treatment plants, sewage treatment plants, and storm sewers; (iii) marinas and other boat docking structures; (iv) beaches and other public water-oriented recreation areas [; ;] and (v) fisheries or other marine resources facilities.

PART II.
LOCAL GOVERNMENT PROGRAMS.

§ 2.1. Local program development.

Local governments shall develop measures (hereinafter called "local programs") necessary to comply with the Act and regulations. Counties and towns are encouraged to cooperate in the development of their local programs. In conjunction with other state water quality programs, local programs shall encourage and promote: (i) protection of existing high quality state waters and restoration of all other state waters to a condition or quality that will permit all reasonable public uses and will support the propagation and growth of all aquatic life, including game fish, which might reasonably be expected to inhabit them; (ii) safeguarding the clean waters of the Commonwealth from pollution; (iii) prevention of any increase in pollution; (iv) reduction of existing pollution; and (v) promotion of water resource conservation in order to provide for the health, safety and welfare of the present and future citizens of the Commonwealth.

§ 2.2. Elements of program.

Local programs shall contain the elements listed below. Local governments shall adopt elements A and B concurrently and no later than 12 months after the adoption date of these regulations. Elements C through G shall *also* be in place within ~~24~~ *12* months after the adoption date.

A. A map delineating Chesapeake Bay Preservation Areas.

B. Performance criteria applying in Chesapeake Bay Preservation Areas that employ the requirements in Part IV.

C. A comprehensive plan or revision that incorporates the protection of Chesapeake Bay Preservation Areas and of the quality of state waters.

D. A zoning ordinance or revision that (i) incorporates measures to protect the quality of state waters in Chesapeake Bay Preservation Areas, and (ii) requires compliance with all criteria set forth in Part IV.

E. A subdivision ordinance or revision that (i) incorporates measures to protect the quality of state waters in Chesapeake Bay Preservation Areas, and (ii) assures that all subdivisions in Chesapeake Bay Preservation Areas comply with the criteria set forth in Part IV.

F. An erosion and sediment control ordinance or revision that requires compliance with the criteria in Part IV.

G. A plan of development process prior to the issuance of a building permit to assure that use and development of land in Chesapeake Bay Preservation Areas is accomplished in a manner that protects the quality of state waters.

PART III.
CHESAPEAKE BAY PRESERVATION AREA DESIGNATION CRITERIA.

§ 3.1. Purpose.

The criteria in this part provide direction for local government designation of the ecological and geographic extent of Chesapeake Bay Preservation Areas. Chesapeake Bay Preservation Areas are divided into Resource Protection Areas and Resource Management Areas that are subject to the criteria in Part IV and the requirements in Part V. In addition, the criteria in this part provide guidance for local government identification of areas suitable for redevelopment that are subject to the redevelopment criteria in Part IV.

§ 3.2. Resource Protection Areas.

A. Resource Protection Areas shall consist of sensitive lands at or near the shoreline that have an intrinsic water quality value due to the ecological and biological processes they perform or are sensitive to impacts which may cause significant degradation to the quality of state waters. In their natural condition, these lands provide for the removal, reduction, or assimilation of sediments, nutrients, and potentially harmful or toxic substances in runoff entering the Bay and its tributaries, and minimize the adverse effects of human activities on state waters and aquatic resources.

B. The Resource Protection Area shall include:

1. Tidal wetlands;

2. Nontidal wetlands connected by surface flow and contiguous to tidal wetlands or tributary streams;

3. Tidal shores;

4. Such other lands under the provisions of subsection A of § 3.2 of this part necessary to protect the quality of state waters;

5. A buffer area not less than 100 feet in width located adjacent to and landward of the components listed in subdivisions 1 through 4 above, and along both sides of any tributary stream. The full buffer area shall be designated as the landward component of the Resource Protection Area notwithstanding the presence of permitted uses or equivalent measures in compliance with Part IV of these regulations. Designation of this area shall not be subject to reduction unless based on reliable site-specific information as provided in subsection B of § 4.1, and subsections C and E of § 5.6 of these regulations.

§ 3.3. Resource Management Areas.

A. Resource Management Areas shall include land types that, if improperly used or developed, have a potential for causing significant water quality degradation or for diminishing the functional value of the Resource Protection Area.

B. A Resource Management Area shall be provided contiguous to the entire inland boundary of the Resource Protection Area. The following land categories shall be considered for inclusion in the Resource Management Area:

1. Floodplains;

2. Highly erodible soils, including steep slopes;

3. Highly permeable soils;

4. Nontidal wetlands not included in the Resource Protection Area;

5. Such other lands under the provisions of subsection A of § 3.3 of this part necessary to protect the quality of state waters.

C. Resource Management Areas shall encompass a land area large enough to provide significant water quality protection through the employment of the criteria in Part IV and the requirements in Parts II and V.

§ 3.4. Intensely Developed Areas.

At their option, local governments may designate Intensely Developed Areas as an overlay of Chesapeake Bay Preservation Areas within their jurisdictions. For the purposes of these regulations, Intensely Developed Areas shall serve as redevelopment areas in which development is concentrated as of the local program adoption date. Areas so designated shall comply with the performance criteria for redevelopment in Part IV.

Local governments exercising this option shall examine the pattern of residential, commercial, industrial, and institutional development within Chesapeake Bay Preservation Areas. Areas of existing development and infill sites where little of the natural environment remains may be designated as Intensely Developed Areas provided at least one of the following conditions [~~exist~~ *exists*]:

A. Development has severely altered the natural state of the area such that it has more than 50% impervious surface;

B. Public sewer and water is constructed and currently serves the area by the effective date. This condition does not include areas planned for public sewer and water;

C. Housing density is equal to or greater than four dwelling units per acre.

PART IV.
LAND USE AND DEVELOPMENT PERFORMANCE CRITERIA.

§ 4.1. Purpose.

The purpose of this part is to achieve the goals of the Act and § 2.1 of these regulations by establishing criteria to implement the following objectives: prevent a net increase in nonpoint source pollution from new development, achieve a 10% reduction in nonpoint source pollution from redevelopment, and achieve a 40% reduction in

In order to achieve these goals and objectives, these criteria establish performance standards to minimize erosion and sedimentation potential, reduce land application of nutrients and toxics, maximize rainwater infiltration, and ensure the long-term performance of the measures employed.

A. These criteria become mandatory upon the local program adoption date. They are supplemental to the various planning and zoning concepts employed by local governments in granting, denying, or modifying requests to rezone, subdivide, or to use and develop land in Chesapeake Bay Preservation Areas.

B. Local governments may exercise judgment in determining site-specific boundaries of Chesapeake Bay Preservation Area components and in making determinations of the application of these regulations, based on more reliable or specific information gathered from actual field evaluations of the parcel, in accordance with plan of development requirements in Part V.

§ 4.2. General performance criteria.

It must be demonstrated to the satisfaction of local governments that any use, development, or redevelopment of land in Chesapeake Bay Preservation Areas meets the following performance criteria:

1. No more land shall be disturbed than is necessary to provide for the desired use or development [~~;~~ .]

2. Indigenous vegetation shall be preserved to the maximum extent possible consistent with the use and development allowed [~~;~~ .]

3. Where the best management practices utilized require regular or periodic maintenance in order to continue their functions, such maintenance shall be ensured by the local government through a maintenance agreement with the owner or developer or some other mechanism that achieves an equivalent objective [~~;~~ .]

4. All development exceeding 2,500 square feet of land disturbance shall be accomplished through a plan of development review process consistent with § 15.1-491 (h) of the Code of Virginia [~~;~~ .]

5. Land development shall minimize impervious cover consistent with the use or development allowed [~~;~~ .]

6. Any land disturbing activity that exceeds an area of 2,500 square feet (including construction of all single family houses, septic tanks and drainfields, but otherwise as defined in § 10.1-560 of the Code of Virginia) shall comply with the requirements of the local erosion and sediment control ordinance [~~;~~ .]

7. On-site sewage treatment systems not requiring a Virginia Pollutant Discharge Elimination System (VPDES) permit shall:

a. Have pump-out accomplished for all such systems at least once every five years;

b. For new construction, provide a reserve sewage disposal site with a capacity at least equal to that of the primary sewage disposal site. This reserve sewage disposal site requirement shall not apply to any lot or parcel recorded prior to ~~the effective date of these regulations, and which~~ *October 1, 1989, if the* lot or parcel is not sufficient in capacity to accommodate a reserve sewage disposal site, as determined by the local health department. Building shall be prohibited on the area of all sewage disposal sites until the structure is served by public sewer or an on-site sewage treatment system which operates under a permit issued by the State Water Control Board. All sewage disposal site records shall be administered to provide adequate notice and enforcement.

8. Stormwater management criteria which accomplish the goals and objectives of these regulations shall apply. For development, the post-development nonpoint source pollution runoff load shall not exceed the pre-development load based upon average land cover conditions. Redevelopment of any site not currently served by water quality best management practices shall achieve at least a 10% reduction of nonpoin source pollution in runoff compared to the existin runoff load from the site. Post-development runof from any site to be redeveloped that is currentl served by water quality best management practice shall not exceed the existing load of nonpoint sourc pollution in surface runoff.

a. The following stormwater management option shall be considered to comply with this subsectio of these regulations:

(1) Incorporation on the site of best managemen practices that achieve the required control;

(2) Compliance with a locally adopted regiona stormwater management program incorporatin pro-rata share payments pursuant to the authorit provided in § 15.1-466(j) of the Code of Virginia tha results in achievement of equivalent water qualit protection;

(3) Compliance with a state or locally implemente program of stormwater discharge permits pursuan to § 402(p) of the federal Clean Water Act, as se forth in 40 C.F.R. Parts 122, 123, 124, and 504 dated December 7, 1988;

(4) For a redevelopment site that is completel impervious as currently developed, restoring a minimum 20% of the site to vegetated open space.

b. Any maintenance, alteration, use, or improvemen to an existing structure which does not degrade th quality of surface water discharge, as determined b the local government, may be exempted from th requirements of this subsection.

c. Stormwater management criteria fo redevelopment shall apply to any redevelopmen whether or not it is located within an Intensel Developed Area designated by a local government.

9. Land upon which agricultural activities are bein conducted, including but not limited to cro production, pasture, and dairy and feedlot operation shall have a soil and water quality conservation plan Such a plan shall be based upon the Field Offic Technical Guide of the U.S. Department of Agricultur Soil Conservation Service and accomplish water qualit protection consistent with the Act and thes regulations. Such a plan will be approved by the loca Soil and Water Conservation District by January 1 1995.

The board will request the Department o Conservation and Recreation to evaluate the existin state and federal agricultural conservation program for effectiveness in providing water quality protectio In the event that, by July 1, 1991, the Department o Conservation and Recreation finds that th implementation of the existing agricultural conservation programs is inadequate to protect water quality consistent with the Act and these regulations, the board will consider the promulgation of regulations to provide more effective protection of water quality from agricultural activities and may require implementation of best management practices on agricultural lands within the Chesapeake Bay Preservation Areas.

10. Silvicultural activities in Chesapeake Bay Preservation Areas are exempt from these regulations provided that silvicultural operations adhere to water quality protection procedures prescribed by the Department of Forestry in its "Best Management Practices Handbook for Forestry Operations." The Department of Forestry will oversee and document installation of best management practices and will monitor instream impacts of forestry operations in Chesapeake Bay Preservation Areas. In the event that, by July 1, 1991, the Department of Forestry programs are unable to demonstrate equivalent protection of water quality consistent with the Act and these regulations, the Department of Forestry will revise its programs to assure consistency of results and may require implementation of best management practices.

11. Local governments shall require evidence of all wetlands permits required by law prior to authorizing grading or other on-site activities to begin.

§ 4.3. Performance criteria for Resource Protection Areas.

The following criteria shall apply specifically within Resource Protection Areas and supplement the general performance criteria in § 4.2 of this part.

A. Allowable development.

A water quality impact assessment shall be required for any proposed development in accordance with Part V. Land development may be allowed only if it (i) is water dependent or (ii) constitutes redevelopment.

1. A new or expanded water-dependent facility may be allowed provided that:

a. It does not conflict with the comprehensive plan;

b. It complies with the performance criteria set forth in this part;

c. Any non-water-dependent component is located outside of Resource Protection Areas;

d. Access will be provided with the minimum disturbance necessary. Where possible, a single point of access will be provided.

2. Redevelopment shall conform to applicable stormwater management and erosion and sediment control criteria in this part.

3. Roads and driveways not exempt under subdivision 1 of subsection B of § 4.5 of these regulations may be constructed in or across Resource Protection Areas if each of the following conditions is met:

a. The local government makes a finding that there are no reasonable alternatives to aligning the road or driveway in or across the Resource Protection Area [~~;~~ ;]

b. The alignment and design of the road or driveway are optimized, consistent with other applicable requirements, to minimize (i) encroachment in the Resource Protection Area and (ii) adverse effects on water quality [~~;~~ ;]

c. The design and construction of the road or driveway satisfy all applicable criteria of these regulations, including submission of a water quality impact assessment [~~;~~ ;]

d. The local government reviews the plan for the road or driveway proposed in or across the Resource Protection Area in coordination with local government site plan, subdivision, and plan of development approvals.

B. Buffer area requirements.

To minimize the adverse effects of human activities on the other components of the Resource Protection Area, state waters, and aquatic life, a [~~100 foot~~ *100-foot*] buffer area of vegetation that is effective in retarding runoff, preventing erosion, and filtering nonpoint source pollution from runoff shall be retained if present and established where it does not exist. The [~~100 foot~~ *100-foot*] buffer area shall be deemed to achieve a 75% reduction of sediments and a 40% reduction of nutrients. Except as noted in this subsection, a combination of a buffer area not less than 50 feet in width and appropriate best management practices located landward of the buffer area which collectively achieve water quality protection, pollutant removal, and water resource conservation at least the equivalent of the [~~100 foot~~ *100-foot*] buffer area may be employed in lieu of the [~~100 foot~~ *100-foot*] buffer. The following additional performance criteria shall apply:

1. In order to maintain the functional value of the buffer area, indigenous vegetation may be removed only to provide for reasonable sight lines, access paths, general woodlot management, and best management practices, as follows:

a. Trees may be pruned or removed as necessary to provide for sight lines and vistas, provided that where removed [~~,~~] they shall be replaced with other vegetation that is equally effective in retarding runoff, preventing erosion, and filtering nonpoint source pollution from runoff.

b. Any path shall be constructed and surfaced so as to effectively control erosion.

c. Dead, diseased, or dying trees or shrubbery may be removed at the discretion of the landowner, and silvicultural thinning may be conducted based upon the recommendation of a professional forester or arborist.

d. For shoreline erosion control projects, trees and woody vegetation may be removed, necessary control techniques employed, and appropriate vegetation established to protect or stabilize the shoreline in accordance with the best available technical advice and applicable permit conditions or requirements.

2. When the application of the buffer area would result in the loss of a buildable area on a lot or parcel recorded prior to ~~the effective date of these regulations~~ *October 1, 1989* , modifications to the width of the buffer area may be allowed in accordance with the following criteria:

a. Modifications to the buffer area shall be the minimum necessary to achieve a reasonable buildable area for a principal structure and necessary utilities.

b. Where possible, an area equal to the area encroaching the buffer area shall be established elsewhere on the lot or parcel in a way to maximize water quality protection.

c. In no case shall the reduced portion of the buffer area be less than 50 feet in width.

3. Redevelopment within Intensely Developed Areas may be exempt from the requirements of this subsection. However, while the immediate establishment of the buffer area may be impractical, local governments shall give consideration to implementing measures that would establish the buffer in these areas over time in order to maximize water quality protection, pollutant removal, and water resource conservation.

4. On agricultural lands the agricultural buffer area shall be managed to prevent concentrated flows of surface water from breaching the buffer area and noxious weeds (such as Johnson grass, kudzu, and multiflora rose) from invading the buffer area. The agricultural buffer area may be reduced as follows:

a. To a minimum width of 50 feet when the adjacent land is enrolled in a federal, state, or [~~locally funded~~ *locally-funded*] agricultural best management practices program, and the program is being implemented, provided that the combination of the reduced buffer area and the best management practices [~~achieve~~ *achieves*] water quality protection, pollutant removal, and water resourc conservation at least the equivalent of the [~~100 fo~~ *100-foot*] buffer area;

b. To a minimum width of 25 feet when a soil an water quality conservation plan, as approved by th local Soil and Water Conservation District, has bee implemented on the adjacent land, provided that th portion of the plan being implemented for th Chesapeake Bay Preservation Area achieves wate quality protection at least the equivalent of tha provided by the [~~100 feet~~ *100-foot*] buffer area i the opinion of the local Soil and Water Conservatio District Board. Such plan shall be based upon th Field Office Technical Guide of the U.S. Departmen of Agriculture Soil Conservation Service an accomplish water quality protection consistent wit the Act and these regulations;

c. The buffer area is not required for agricultura drainage ditches if the adjacent agricultural lan has in place best management practices i accordance with a conservation plan approved b the local Soil and Water Conservation District.

§ 4.4. Local program development.

Local governments shall incorporate the criteria in thi part into their comprehensive plans, zoning ordinances subdivision ordinances, and such other police and zoning powers as may be appropriate, in accordance with §§ 10.1-2111 and 10.1-2108 of the Act and Part V of these regulations. The criteria may be employed in conjunction with other planning and zoning concepts to protect the quality of state waters.

§ 4.5. Administrative waivers and exemptions.

A. Nonconforming use and development waivers.

1. Local governments may permit the continued use, but not necessarily the expansion, of any structure in existence on the date of local program adoption. Local governments may establish an administrative review procedure to waive or modify the criteria of this part for structures on legal nonconforming lots or parcels provided that:

a. There will be no net increase in nonpoint source pollutant load;

b. Any development or land disturbance exceeding an area of 2,500 square feet complies with all erosion and sediment control requirements of this part.

2. It is not the intent of these regulations to prevent the reconstruction of pre-existing structures within Chesapeake Bay Preservation Areas from occurring as a result of casualty loss unless otherwise restricted by local government ordinances.

B. Public utilities, railroads, and facilities exemptions.

1. Construction, installation, operation, and maintenance of electric, gas, and telephone transmission lines, railroads, and public roads and their appurtenant structures in accordance with [*(i)*] *regulations promulgated pursuant to* [~~(i)~~] the Erosion and Sediment Control Law (§ 10.1-560 et seq. of the Code of Virginia) *and* [~~(ii)~~] *the Stormwater Management Act (§ 10.1-603.1 et seq. of the Code of Virginia),* [~~or~~ *(ii)*] an erosion and sediment control plan *and a stormwater management plan* approved by the Virginia ~~Soil and Water Conservation Board~~ *Department of Conservation and Recreation*, [*, or (iii) local water quality protection criteria at least as stringent as the above state requirements*] will be deemed to constitute compliance with these regulations. *The exemption of public roads is further conditioned on the following:*

a. Optimization of the road alignment and design, consistent with other applicable requirements, to prevent or otherwise minimize (i) encroachment in the Resource Protection Area and (ii) adverse effects on water quality;

b. Local governments may choose to exempt (i) all public roads as defined in § 1.4 of these regulations, or (ii) only those public roads constructed by the Virginia Department of Transportation.

2. Construction, installation, and maintenance of water, sewer, and local gas lines shall be exempt from the criteria in this part provided that:

a. To the degree possible, the location of such utilities and facilities should be outside Resource Protection Areas;

b. No more land shall be disturbed than is necessary to provide for the desired utility installation;

c. All such construction, installation, and maintenance of such utilities and facilities shall be in compliance with all applicable state and federal permits and designed and conducted in a manner that protects water quality;

d. Any land disturbance exceeding an area of 2,500 square feet complies with all erosion and sediment control requirements of this part.

C. Exemptions in Resource Protection Areas.

The following land disturbances in Resource Protection Areas may be exempt from the criteria of this part provided that they comply with subdivisions 1 and 2 below of this subsection: (i) water wells; (ii) passive recreation facilities such as boardwalks, trails, and pathways; and (iii) historic preservation and archaeological activities.

1. Local governments shall establish administrative procedures to review such exemptions.

2. Any land disturbance exceeding an area of 2,500 square feet shall comply with the erosion and sediment control requirements of this part.

§ 4.6. Exceptions to the criteria.

Exceptions to the requirements of these regulations may be granted , provided that: (i) exceptions to the criteria shall be the minimum necessary to afford relief, and (ii) reasonable and appropriate conditions upon any exception granted shall be imposed as necessary so that the purpose and intent of the Act [~~is~~ *are*] preserved. Local governments shall design an appropriate process or processes for the administration of exceptions, in accordance with Part V.

PART V.
IMPLEMENTATION, ASSISTANCE, AND DETERMINATION OF CONSISTENCY.

§ 5.1. Purpose.

The purpose of this part is to assist local governments in the timely preparation of local programs to implement the Act, and to establish guidelines for determining local program consistency with the Act.

§ 5.2. Local assistance manual.

A. The department will prepare a manual to provide guidance to assist local governments in the preparation of local programs in order to implement the Act and these regulations. The manual will be updated periodically to reflect the most current planning and zoning techniques and effective best management practices. The manual will be made available to the public.

B. The manual will recommend a schedule for the completion of local program elements and their submission to the board for its information, to ensure timely achievement of the requirements of the Act and timely receipt of assistance. The board will consider compliance with the schedule in allocating financial and technical assistance. Those elements of the manual necessary to assist local governments in meeting the ~~first year~~ requirements *of subsections A and B of § 2.2* will be completed by the effective date of these regulations.

C. The manual is for the purpose of guidance only and is not mandatory.

§ 5.3. Board to establish liaison.

The board will establish liaison with each local government to assist that local government in developing and implementing its local program, in obtaining technical and financial assistance, and in complying with the Act and regulations.

§ 5.4. Planning district comments.

Local governments are encouraged to enlist the assistance and comments of regional planning district agencies early in the development of their local programs.

§ 5.5. Designation of Chesapeake Bay Preservation Areas.

A. The designation of Chesapeake Bay Preservation Areas as an element of the local program should:

1. Utilizing existing data and mapping resources, identify and describe tidal wetlands, nontidal wetlands, tidal shores, tributary streams, [~~flood plains~~ *floodplains*], highly erodible soils including steep slopes, highly permeable areas, and other sensitive environmental resources as necessary to comply with Part III [. ;]

2. Determine, based upon the identification and description, the extent of Chesapeake Bay Preservation Areas within the local jurisdiction [. ;]

3. Prepare an appropriate map or maps delineating Chesapeake Bay Preservation Areas [. ;]

4. Prepare amendments to local ordinances which incorporate the performance criteria of Part IV or the model ordinance prepared by the board.

B. Review by the board.

The board will review a proposed program within 60 days. If it is consistent with the Act, the board will schedule a conference with the local government to determine what additional technical and financial assistance may be needed and available to accomplish the proposed program. If not consistent, the board will notify the local government and recommend specific changes.

C. Adoption of ~~first year program~~ *designation and performance criteria* .

After being advised of program consistency, local governments shall hold a public hearing, delineate Chesapeake Bay Preservation Areas on an appropriate map or maps, and adopt the performance criteria. Copies of the adopted program documents and subsequent changes thereto [,] shall be provided to the board.

§ 5.6. Preparation and submission of management program.

Local governments must adopt the full management program, including any revirions to comprehensive plans, zoning ordinances, subdivisic. ordinances, and other local authorities necessary to implement the Act, within ~~24~~ *12* months of the adoption date of these regulations. Prior to adoption, local governments may submit any proposed revisions to the board for comments. Guidelines are provided below for local government use in preparing local programs and the board's use in determining loc program consistency.

A. Comprehensive plans.

Local governments shall review and revise the comprehensive plans, as necessary, for compliance with 10.1-2109 of the Act. As a minimum, the comprehensiv plan or plan component should consist of the followin basic elements: (i) a summary of data collection an analysis; (ii) a policy discussion; (iii) a land use plan ma (iv) implementing measures, including specific objective and a time frame for accomplishment.

1. Local governments should establish an informatio base from which to make policy choices about futur land use and development that will protect the qualit of state waters. This element of the plan should b based upon the following:

a. Information used to designate Chesapeake Ba Preservation Areas;

b. Other marine resources;

c. Shoreline erosion problems and location c erosion control structures;

d. Conflicts between existing and proposed land use and water quality protection;

e. A map or map series [,] accurately representin the above information.

2. As part of the comprehensive plan, loca governments should clearly indicate local policy o land use issues relative to water quality protectio Local governments should ensure consistency amon the policies developed.

a. Local governments should discuss each componen of Chesapeake Bay Preservation Areas in relation t the types of land uses considered appropriate an consistent with the goals and objectives of the Ac these regulations, and their local programs.

b. As a minimum, local governments should prepar policy statements for inclusion in the plan on th following issues:

(1) Physical constraints to development, includin soil limitations, with an explicit discussion of soi suitability for septic tank use;

(2) Protection of potable water supply, includin groundwater resources;

(3) Relationship of land use to commercial an recreational fisheries;

(4) Appropriate density for docks and piers;

(5) Public and private access to waterfront areas and effect on water quality;

(6) Existing pollution sources;

(7) Potential water quality improvement through the redevelopment of Intensely Developed Areas.

c. For each of the policy issues listed above, the plan should contain a discussion of the scope and importance of the issue, alternative policies considered, the policy adopted by the local government for that issue, and a description of how the local policy will be implemented.

d. Within the policy discussion, local governments should address consistency between the plan and all adopted land use, public services, land use value taxation ordinances and policies, and capital improvement plans and budgets.

B. Zoning ordinances.

Local governments shall review and revise their zoning ordinances, as necessary, to comply with § 10.1-2109 of the Act. The ordinances should:

1. Make provisions for the protection of the quality of state waters;

2. Incorporate either explicitly or by direct reference [~~;~~] the performance criteria in Part IV;

3. Be consistent with the comprehensive plan within Chesapeake Bay Preservation Areas.

C. Plan of development review.

Local governments shall make provisions as necessary to ensure that any development of land within Chesapeake Bay Preservation Areas must be accomplished through a plan of development procedure pursuant to § 15.1-491(h) of the Code of Virginia to ensure compliance with the Act and regulations. Any exemptions from those review requirements shall be established and administered in a manner that ensures compliance with these regulations.

D. Subdivision ordinances.

Local governments shall review and revise their subdivision ordinances, as necessary, to comply with § 10.1-2109 of the Act. The ordinances should:

1. Include language to ensure the integrity of Chesapeake Bay Preservation Areas;

2. Incorporate, either explicitly or by direct reference, the performance criteria of Part IV.

E. Water quality impact assessment.

A water quality impact assessment shall be required for any proposed development within the Resource Protection Area consistent with Part IV and for any other development in Chesapeake Bay Preservation Areas that may warrant such assessment because of the unique characteristics of the site or intensity of the proposed use or development.

1. The purpose of the water quality impact assessment is to identify the impacts of proposed development on water quality and lands in Resource Protection Areas consistent with the goals and objectives of the Act, these regulations, and [~~their~~] local programs, and to determine specific measures for mitigation of those impacts. The specific content and procedures for the water quality impact assessment shall be established by local governments. Local governments should notify the board of all development requiring such assessment. Upon request, the board will provide review and comment on any water quality impact assessment within 90 days, in accordance with advisory state review requirements of § 10.1-2112 of the Act.

2. The assessment shall be of sufficient specificity to demonstrate compliance with the criteria of the local program.

F. Review by the board.

The board will review any proposed management program within 90 days. If it is consistent with the Act, the board will schedule a conference with the local government to determine what additional technical and financial assistance may be needed and available to accomplish the long-term aspects of the local program. If the program or any part thereof is not consistent, the board will notify the local government in writing stating the reasons for a determination of inconsistency and recommending specific changes. Copies of the adopted program documents and subsequent changes thereto shall be provided to the board.

§ 5.7. Certification of local program.

Upon request, the board will certify that a local program complies with the Act and regulations.

PART VI.
ENFORCEMENT.

§ 6.1. Applicablity.

The Act requires that the board ensure that local governments comply with the Act and regulations and that their comprehensive plans, zoning ordinances, and subdivision ordinances are in accordance with the Act. To satisfy these requirements, the board has adopted these regulations and will monitor each local government's compliance with the Act and regulations.

§ 6.2. Administrative proceedings.

Section 10.1-2103.8 of the Act provides that the board shall ensure that local government comprehensive plans, subdivision ordinances, and zoning ordinances are in accordance with the provisions of the Act, and that it shall determine such compliance in accordance with the provisions of the Administrative Process Act. When the board determines to decide such compliance, it will give the subject local government at least 15 days notice of its right to appear before the board at a time and place specified for the presentation of factual data, argument, and proof as provided by § 9-6.14:11. The board will provide a copy of its decision to the local government. If any deficiencies are found, the board will establish a schedule for the local government to come into compliance.

§ 6.3. Legal proceedings.

Section 10.1-2103.10 of the Act provides that the board shall take administrative and legal actions to ensure compliance by local governments with the provisions of the Act. Before taking legal action against a local government to ensure compliance, the board shall, unless it finds extraordinary circumstances, give the local government at least 15 days notice of the time and place at which it will decide whether or not to take legal action. If it finds extraordinary circumstances, the board may proceed directly to request the Attorney General to enforce compliance with the Act and regulations. Administrative actions will be taken pursuant to § 6.2.

§ 6.4. Adoption date.

The adoption date of these regulations shall be November 15, 1990.

§ 6.5. Effective date.

The effective date of these regulations shall be ~~the date of expiration of Emergency Chesapeake Bay Preservation Area Designation and Management Regulations (VR 173-02-01.1, effective when signed and filed with the Virginia Registrar of Regulations)~~ *October 1, 1991, at which date they shall supersede the Emergency Chesapeake Bay Preservation Area Designation and Management Regulations (VR 173-02-01.1)* .

DEPARTMENT OF HEALTH (STATE BOARD OF)

REGISTRAR'S NOTICE: This regulation is excluded from Article 2 of the Administrative Process Act in accordance with § 9-6.14:4.1 C 1 of the Code of Virginia, which excludes agency orders or regulations fixing rates or prices. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision.

Title of Regulation: **VR 355-39-01. Regulations Governi Eligibility Standards and Charges for Medical C Services (Schedule of Charges Only).**

Statutory Authority: § 32.1-12 of the Code of Virginia.

Effective Date: October 1, 1991.

Summary:

This regulation change is being sought to modify t Virginia Department of Health's schedule of charg Visit charges will be increased to new Medic maximum reimbursement levels which go into eff October 1. Activities of Daily Living charges are bei increased because Medicaid reimbursement w increase for this service. The basis for dental charg is being changed to allow a more complete char schedule. Since Medicaid does not pay for den services to adults, there is no Medicaid charge schedule on which to base adult services.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT APPLICATION REQUIREMENTS FOR STORM WATER DISCHARGES

FINAL REGULATION

A SUMMARY

United States Environmental Protection Agency

October 31, 1990

I. INTRODUCTION

Pollutants in storm water discharges from many sources are largely uncontrolled. The "National Water Quality Inventory, 1988 Report to Congress" (EPA, 1988), concluded that the States cite diffuse sources of water pollution as the leading cause of water quality impairment. In developing the National Water Quality Inventory, the States identified a number of major classes of diffuse sources of pollution, including, separate storm sewers, urban runoff, construction, waste disposal, and resource extraction, which correlate well with categories of discharges covered by the NPDES storm water program. Although many studies characterize these sources as a diffuse or nonpoint source of pollution, the majority of urban runoff and construction site runoff is discharged via separate storm sewers and, therefore, under the Clean Water Act (CWA), are discharges from point sources.

The National Urban Runoff Program (NURP), has shown that storm water from residential and commercial areas can contain a variety of pollutants including heavy metals, fecal coliforms, pesticides, suspended solids, nutrients and floatables. Runoff from industrial facilities can contain additional pollutants depending on the nature of industrial activity such as material management and waste disposal practices and activities which disturb soils. Other studies have shown that many storm sewers also receive illicit discharges of untreated non-storm water discharges, spills, and large amounts of improperly disposed wastes, particularly used oils. Removal of non-storm water discharges to storm sewers presents opportunities for dramatic improvements in the quality of storm water discharges.

II. SUMMARY OF THE RULE

This summary addresses amendments to 40 CFR 122 which establish NPDES permit application requirements for: storm water discharges associated with industrial activity; discharges from large municipal separate storm sewer systems (systems serving a population of 250,000 or more); and discharges from medium municipal separate storm sewer systems (systems serving a population of 100,000 or more, but less than 250,000).

III. DISCHARGES FROM LARGE AND MEDIUM MUNICIPAL SEPARATE STORM SEWER SYSTEMS

A. Defining Municipal Separate Storm Sewer System[1]

A "large municipal separate storm sewer system" is a system serving a population of 250,000 or more. A "medium municipal separate storm sewer system" is a system serving a population of

100,000 or more, but less than 250,000. These systems include separate storm sewers:

- o located in one of the 173 cities with a population of 100,000 or more;
- o located in one of the 47 counties identified by EPA as having large populations in unincorporated, urbanized areas;
- o that are designated by the Director of the NPDES program as part of the large or medium system due to the interrelationship with the large or medium systems described above; or
- o that are located within the boundaries of a region defined by a storm water management regional authority and are designated by the Director of the NPDES program as part of a large or medium system.

B. Storm Water Permits for Municipalities

The CWA requires that NPDES permits for discharges from municipal separate storm sewer systems include: a requirement to effectively prohibit non-storm water discharges into the storm sewers; and controls to reduce the discharge of pollutants to the maximum extent practicable (including management practices, control techniques and system, design and engineering methods, and other provisions appropriate for the control of such pollutants.)

EPA or authorized NPDES States may issue system-wide or jurisdiction-wide permits covering all discharges from a municipal separate storm sewer system.

C. Permit Application Requirements[2]

The permit application requirements for discharges from municipal separate storm sewer systems have been designed to facilitate development of site specific permit conditions. The permit application requirements provide municipal applicants an opportunity to propose appropriate management programs to control pollutants in discharges from their municipal systems. This increases flexibility to develop permit conditions and ensures input from municipalities in developing appropriate controls.

A two-part application process for discharges from large and medium municipal separate storm sewer systems has been established.

1. Part 1 of the application includes:

   - General information (name, address, etc.);
   - Existing legal authority and any additional authorities needed;
   - Source identification information;
   - Discharge characterization including:
     - monthly mean rain and snow fall estimates;
     - existing quantitative data on volume and quality of storm water discharges;
     - a list of receiving water bodies and existing information on the impacts on receiving waters;
     - Field screening analysis for illicit connections and illegal dumping;
   - Characterization plan identifying representative outfalls for further sampling in Part 2;
   - Description of existing management programs to control pollutants from the municipal separate storm sewer and to identify illicit connections; and
   - Description of financial budget and resources currently available to complete Part 2.

2. Part 2 of the application includes:

   - Demonstration of adequate legal authority to control discharges, prohibit illicit discharges, require compliance, and carry out inspections, surveillance, and monitoring;
   - Source identification indicating the location of any major outfalls and inventorying the principal products or services provided by each facility discharging storm water associated with industrial activity to the municipal separate storm sewer;
   - Discharge characterization data including:
     - quantitative data from 5-10 representative locations in approved sampling plans;
     - for selected conventional pollutants and heavy metals, estimates of the annual pollutant load and event mean concentration of system discharges;

1108

- proposed schedule to provide estimates of: seasonal pollutant loads; and the mean concentration for certain detected constituents in a representative storm event; and

- proposed monitoring program for representative data collection.

o Proposed management program including descriptions of:

- structural and source control measures that are to be implemented to reduce pollutants in runoff from commercial and residential areas including:

    - maintenance activities;
    - planning procedures to develop, implement, and enforce controls for areas of new development and significant redevelopment;
    - practices for operating and maintaining public streets and highways;
    - procedures to assure flood management projects assess impacts on water quality;
    - program to monitor pollutants in runoff from operating or closed municipal landfills (or other facilities for municipal waste); and
    - program to reduce pollutants in discharges associated with the application of pesticides, herbicides, and fertilizer;

- program to detect and remove illicit discharges including:

    - program to implement and enforce an ordinance or order;
    - procedures to conduct on-going field screening activities;
    - procedures to be followed to investigate potential illicit discharges;
    - procedures to prevent, contain, and respond to spills;
    - program to promote, publicize, and facilitate public reporting;
    - educational activities for management of used oil and toxic material; and
    - controls to limit infiltration of seepage from sanitary sewers;

- program to monitor and control pollutants from municipal landfills; hazardous waste treatment, disposal, and recovery facilities; SARA Section 313, Title III facilities; and other priority industrial facilities including:
  - priorities and procedures for inspection and enforcement;
  - monitoring program; and
  - program to implement and maintain structural and non-structural BMPs;
- program to control pollutants in construction site runoff including:
  - site planning requirements;
  - non-structural and structural management practices;
  - procedures for identifying priorities for inspecting sites and enforcement actions;
  - educational and training measures for construction site operators.

o Estimated reduction in loadings of pollutants as a result of the management program; and

o Fiscal analysis of necessary capital and operation and maintenance expenditures.

D. Effective Prohibition of Non-Storm Water Discharges[3]

For many municipalities, a first priority for reducing pollutants from municipal separate storm sewer systems is to effectively prohibit non-storm water discharges to their municipal separate storm sewer system. The permit application process implements this effective prohibition by establishing requirements for a field analysis to detect illicit connections and illegal dumping. In addition, applicants are required to submit a proposed program to control illicit connections and illegal dumping as part of their proposed management programs.

E. Application Deadlines[4]

For large municipal separate storm sewer systems, Part 1 must be submitted within 12 months of the date of publication of the final rule. The Director will then have 90 days from receipt of Part 1 to approve or deny a sampling plan. Part 2 must be submitted within 24 months of the date of publication of the final rule. Medium municipal separate storm sewer systems must submit Part 1 within 18 months from the date of publication of the final rule. The Director will have 90 days from receipt to approve or deny a sampling plan. Part 2 must be submitted within 30 months of the date of publication of the final rule.

IV. REQUIREMENTS FOR STORM WATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY

A. Industries Covered by Regulation[5]

The term "storm water discharge associated with industrial activity" means the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant including:

- Facilities subject to National effluent limitation guidelines;

- Facilities classified as Standard Industrial Codes (SIC) 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, and 373. (These codes include lumber; paper mills; chemical; petroleum; rubber; leather tanning and finishing; stone, clay, and concrete; metal; enameled iron and metal sanitary ware; and ship/boat manufacturing facilities);

- Facilities classified as SIC codes 10 through 14 including active and inactive mining and oil and gas operations with contaminated storm water discharges, except for areas of coal mining operations which have been reclaimed and the performance bond has been released by the appropriate SMCRA authority, or non-coal mining operations which have been released from applicable State or Federal reclamation requirements after 30 days after publication of the final regulation (see the description of special application provisions for mining operations and oil and gas operations below);

- Hazardous waste treatment, storage, or disposal facilities;

- Landfills, land application sites, and open dumps that receive industrial wastes;

- Recycling facilities classified as SIC codes 5015 and 5093. (These codes include metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards);

- Steam electric power generating facilities (including coal handling sites);

- Vehicle maintenance, equipment cleaning, or airport de-icing areas of railroad, mass transit, school bus, trucking and courier services, postal service, water transportation, and airport facilities, and petroleum bulk stations;

- Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of sewage (including land used for the disposal of sludge located within the confines of the facility) with a design flow of 1.0 mgd or more or required to have an approved pretreatment program. This does not include farm lands, domestic gardens or lands used for beneficial reuse of sludge which are not physically located in the confines of the facility;

- Construction activity (except for disturbances of less than 5 acres of total land area which are not part of a larger common plan of development or sale); and

- Facilities where materials are exposed to storm water classified under SIC codes 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, and 4221-25 (These codes include food; tobacco; textile; apparel; wood kitchen cabinets; furniture; paperboard containers and boxes; converted paper/paperboard products; printing; drugs; leather; fabricated metal products; industrial and commercial machinery and computer equipment; electronic equipment; transportation equipment; measuring, analyzing, and controlling instruments and photographic, medical, and optical goods, and watches and clocks; glass; and certain warehousing and storage manufacturing facilities).

Areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots are generally excluded from the definition of storm water discharge associated with industrial activity, as long as the drainage from the excluded areas is not mixed with storm water drained from areas with industrial activity.

B. Industrial Storm Water Permitting Strategy

EPA estimates that about 100,000 facilities are addressed by the regulatory definition of "storm water discharges associated with industrial activity". The large number of facilities addressed will place correspondingly large administrative burdens on EPA and States with authorized NPDES programs to issue and administer permits for these discharges. To provide a reasonable and rational framework to addressing this permitting task, EPA is developing a strategy for permitting storm water discharges associated with industrial activity. In developing this strategy, the Agency recognizes that the CWA provides flexibility in the manner in which NPDES permits are issued[6], and intends to use this flexibility in designing a workable and reasonable permitting system that emphasizes reduction of risk to human health and aquatic resources. The strategy is intended to establish a framework for developing permitting priorities based on reduction of risk to human health and aquatic resources, and includes the following four tier set of priorities for issuing permits over time:

- o <u>Tier I - Baseline Permitting</u>: One or more general permits[7] will be developed initially to cover the majority of storm water discharges associated with industrial activity;
- o <u>Tier II - Watershed Permitting</u>: Facilities within watersheds shown to be adversely impacted by storm water discharges associated with industrial activity will be targeted for individual or watershed-specific general permits.
- o <u>Tier III - Industry-Specific Permitting</u>: Specific industry categories will be targeted for individual or industry-specific general permits; and
- o <u>Tier IV - Facility-Specific Permitting</u>: A variety of factors will be used to target specific facilities for individual permits.

The industrial storm water permitting strategy also calls for the development of State storm water permitting plans as a mechanism to provide public participation and ensure appropriate implementation of storm water permitting activities within the various States. State strategies will also provide a foundation from which State storm water management programs required under section 402(p)(6) of the Clean Water Act can be developed.

C. Relationship of Strategy to Permit Application Requirements

The industrial storm water permitting strategy described above identifies several permitting approaches that the Agency anticipates will be used in addressing storm water discharges associated with industrial activity. The NPDES regulatory scheme provides three potential options for applying for permit coverage for storm water discharges associated with industrial activity: (1) individual permit applications; (2) group applications; and (3) notice of intent requirements developed for general permit coverage. Notices of intent will generally need to include only information such as the type of industry, location and name of receiving waters.

The following discussion summarizes regulatory requirements for individual permit applications and group applications. These requirements apply to discharges that are not covered by a general permit. Where a general permit has been issued for a discharge, individual or group applications are not required, as the general permit establishes alternative (and typically simplified) requirements for obtaining coverage under the general permit.

D. Individual Application Requirements for Storm Water Discharges Associated with Industrial Activity[8]

1. Generally Applicable Requirements (See Parts 2 and 3 below with Regard to Construction, Mining, and Oil and Gas Operations)

Individual application requirements for most storm water discharges associated with industrial activity are comprised of Form 1 (general information) and Form 2F (storm water discharges). The Form 2F requirements include:

- o Topographic map showing on-site drainage;
- o Estimate of impervious surfaces and the total area drained by each outfall;
- o Narrative description of material management practices and control measures;
- o Certification that separate storm water outfalls have been evaluated for non-storm water discharges;
- o History of leaks and spills; and
- o Test Data Parameters
  - Any pollutant with effluent guideline limitation;
  - Any pollutant in NPDES permit for process discharge;
  - Oil and grease, pH, TOC, BOD_5, COD, TSS, Nitrogen, Phosphorus;
  - Certain pollutant(s) known to be in the discharge;
  - Flow measurement(s) or estimate(s);
  - Date(s) and duration of storm event(s).

2. Application Requirements for Construction Activities[9]

Construction facilities which discharge storm water associated with industrial activity are not required to submit sampling data in permit applications. Instead, individual application requirements for these facilities include, in addition to Form 1:

- o Narrative description of the construction activity;
- o Total area of the site and area to be excavated under the permit;

- o Proposed measures to control pollutants in storm water discharges during and after construction operations;
- o Estimate of runoff coefficient and increase in impervious areas after construction; and
- o Name of receiving water.

3. Application Requirements for Mining Operations and Oil and Gas Operations[10]

Oil and gas facilities (active or inactive) are not required to submit a permit application unless the facility had a discharge of a reportable quantity[11] for which notice is required under CERCLA or CWA at any time since three years before the publication of the rule; or such facility has a discharge which contributes to a violation of a water quality standard.

Mining operations (active or inactive) are not required to submit permit applications unless the storm water discharge has come into contact with any overburden, raw material, intermediate or finished products, byproducts, or waste products located on site. Areas of coal mining operations which have been reclaimed and the performance bond has been released by the appropriate SMCRA authority, or non-coal mining operations which have been released from applicable State or Federal reclamation requirements after 30 days after publication of the final regulation are not subject to permitting requirements.

E. Group Application Requirements[12]

Certain facilities which discharge storm water associated with industrial activity have the option of participating in a group application in lieu of submitting a complete individual application. If dischargers are part of the same effluent guideline subcategory or are sufficiently similar as to be appropriate for general permit coverage, they may submit a group application. Group applications consists of two parts:

<u>Part 1</u> - Identifies participants and includes:

- o A summary of each participant's industrial activities;
- o An explanation of why the participants are sufficiently similar to make use of the group application;
- o A list of significant materials stored outside by participants and material management practices; and
- o A list of 10 percent of the dischargers that will submit test data in Part 2.

Part 2 - 10 percent of discharges must submit test data (a minimum of 10 and a maximum of 100 dischargers with either 2 from each precipitation zone[13] represented, or one discharger from each precipitation zone in which nine or fewer members of the group are located).

F. Storm Water Discharges Associated with Industrial Activity to Large and Medium Municipal Separate Storm Sewer Systems[14]

In addition to submitting permit applications, operators of storm water discharges associated with industrial activity which discharge through large or medium municipal separate storm sewers are required to submit to the operator of that municipal storm sewer: the name of the facility; a contact person and phone number; the location of the discharge; and a description of the principal products or services provided by the facility (including any SIC code). Such notice must be given no later than 180 days after the date of publication of the rule or 180 days prior to commencing an activity that could result in a storm water discharge associated with industrial activity.

G. Application Deadlines[15]

Individual applications for storm water discharges associated with industrial activity must be submitted within 12 months of the date of publication of the rule.

Part 1 of the group application must be submitted within 120 days of the date of publication of the rule. The Director will then have 60 days to approve or deny participation in the group. Part 2 must then be submitted no later than one year after the date of approval of Part 1. Facilities that are rejected as group members have 12 months from the date they received notice of rejection to file individual permit applications. Facilities may add on to group applications within 15 months of the date of publication of the rule at the Director's discretion but only upon a showing of good cause.

Where an applicable general permit has been issued, the general permit will establish a date for when a discharger must submit a notice of intent to be covered by the general permit. Dischargers obtaining coverage under a general permit are not required to submit an individual permit application or participate in a group application for the discharge covered by the general permit.

1. 122.26(b)(4) and 122.26(b)(7)

2. 122.26(d)

3. 122.26(b)(2), 122.26(b)(5), 122.26(d)(1)(iii)(a), 122.26(d)(1)(iv)(D), 122.26(d)(1)(iv)(E)(1), 122.26(d)(1)(v)(B), 122.26(d)(2)(i)(B), 122.26(d)(2)(i)(C), 122.26(d)(2)(iii)(A), and 122.26(d)(2)(iv)(B)

4. 122.26(e)

5. 122.26(b)(14)

6. The court in NRDC v. Train, 396 F.Supp. 1393 (D.D.C. 1975) aff'd, NRDC v. Costle, 568 F.2d 1369 (D.C.Cir. 1977), has acknowledged the administrative burden placed on the Agency by requiring individual permits for a large number of storm water discharges. In this decision, the court recognized EPA's discretion to use certain administrative devices, such as area permits or general permits to help manage its workload. In addition, the court recognized flexibility in the type of permit conditions that are established, including requirements for best management practices.

7. A general permit is a permit that covers discharges from more than one facility within a State. General permits are either issued by EPA or, in States with authorized NPDES programs, by the State.

8. 122.26(c)

9. 122.26(c)(1)(ii)

10. 122.26(a)(2) and 122.26(c)(1)(iii) and (iv)

11. Reportable quantities for hazardous substances are defined at 40 CFR 117.21 and 40 CFR 302.6. The reportable quantity for oil is defined at 40 CFR 110.6.

12. 122.26(c)(2)

13. The storm water permit application regulation defines nine precipitation zones for the purposes of developing and submitting group applications.

14. 122.26(a)(4)

15. 122.26(e)