National Catalog of Erosion and Sediment Control and Stormwater Management Guidelines for Community Assistance

U.S. Department of Agriculture
Natural Resources Conservation Service
Community Assistance and Resource Development

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National Catalog of Erosion and Sediment Control and Storm Water Management Guidelines for Community Assistance

I. Introduction And Purpose

Since the early 1960's, the development and distribution of technical information for soil erosion and sediment control and storm water management on developing sites has grown tremendously. There has been little coordinated national effort to gather and catalog this valuable information. Historically, those developing state and local publications have spent a great deal of their own resources to gather and review the most current information.

The intent of this publication is to begin to inventory available materials for the planning, design, and installation of measures for urban erosion, sediment control, and storm water management. To assist others in the development or updating of materials specific to a locale, an inventory of existing publications has been compiled. The materials represent publications compiled totally by the Natural Resources Conservation Service or those where NRCS provided major input in a cooperative effort. The compilation includes titles of publications along with addresses of contacts. **An appendix to this document includes representative examples of planning procedures, technology, sample ordinances, practice measure implementation guidelines and specifications, and operation and maintenance measures.**

The document is separated into four parts as follows:

Part I	Introduction and Purpose
Part II	Reference List of Source Publications and Major Technical Materials
Part Ill	Catalog of Guideline Materials
Part IV	**Appendix I: Representative Examples**

Many practice standards are still in a developmental stage for protecting air and water quality. Because of the limited selection of completed guidelines and standards, most of these are not included at this time. Related air quality practices have only been addressed through the inclusion of dust control guidelines under construction guidelines. Additional measures will be added as they are developed. This collection is intended to give the user a sense of the state of the science and does not represent judgment of the available information. Future direction of this publication may also include electronic access to this information.

Your comments on this effort and suggestions for improvement are invited. Please direct comments to:

Director
Community Assistance and Resource Development Division
Natural Resources Conservation Service
U.S. Department of Agriculture
P.O. Box 2890
Washington, DC 20013-2890

Urban Conservation Standards Task Force

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User Response Questionnaire

In an effort to continuously present and maintain the most current and useful technical information, the Community Resource and Development Division of the USDA, Natural Resource Conservation Service is seeking to maintain a resource data base to be used for the purpose of gathering and disseminating information.

By completing and returning the following information, individuals will become part of a comprehensive network whose primary purpose is to facilitate technology transfer in the areas of published standards, specifications, guidelines and other documents.

Please mail the attached form to:

Director
Community Assistance Resource and Development Division
USDA, Natural Resources Conservation Service
P.O. Box 2890
Washington, DC 20013-2890

User Response Questionnaire

Name: _____ Job title: _____

Organization, agency/affiliation: _____

Address: _____

City: _____ State/Province: _____

Zip/Postal Code: _____

Area of Employment:

Private Sector_____
Consultant_____
Contractor_____
Academic_____
Professional Society_____
Product/Manufacturing_____

Public Sector_____
Federal_____
State
DOT_____
DNR _____
Other_____
Local
Municipal _____
Resource District _____
Watershed/Drainage District_____
Other_____

Major area of responsibility:
Regulatory_____
Engineering Design/Specifications_____
Technical Assistance/Planning _____ Construction/Inspection _____

Would you like to:

	Yes	No
To be listed as a resource for others to contact	___	___
To receive additional updates	___	___
To review future updates	___	___

What areas would you feel comfortable reviewing?

Other suggestions for improving this publication:

II. Reference List Of Source Publications And Major Technical Materials

State	Doc. No.	Name Of Document (Owner Of Document)
ALABAMA	*AL-1*	Alabama Handbook for Erosion Control Sediment Control and Stormwater Management on Construction Sites and Urban Areas. 1993. Alabama Soil and Water Conservation Committee - Hillwood Office Center, Bldg. 200, Suite 200-9 & 200 10, Montgomery, AL 36106-2686. Ph: (205) 242-2620.
ALASKA		None Available
ARIZONA		None Available
ARKANSAS		None Available
CALIFORNIA	*CA-1*	Volume II, Handbook of Best Management Practices. 1988. Tahoe Regional Planning Agency, P.O. Box 1038, Zephyr Cove, NV 89448. Ph: (702) 588-4547
	CA-2	County of Shasta, Erosion and Sediment Control Standards, Design Manual. 1992. Western Shasta Resource Conservation District, 3179 Bechelli Lane, Suite 107, Redding, CA 96002. Ph: (916) 246-5252
	CA-3	Erosion and Sediment Control Guidelines For Developing Areas Of The Sierra Foothills and Mountains. 1991. High Sierra RC&D Council, 251 Auburn Ravine Road, Auburn, CA 95603. Ph: (916) 823-5687

State	Doc. No.	Name Of Document (Owner Of Document)
	CA-4	Marin County Resource Conservation District Groundwork: A Handbook For Erosion Control In North Coastal California. 1987. Marin County Resource Conservation District, 1301 Redwood Way, Suite 170, Petaluma, CA 94954-1136. Ph: (707) 794-1242
	CA-5	Groundcover: A Planting Guide For Erosion Control And Site Improvement On The Central Coast. 1992. Santa Cruz County Resource Conservation District, 3233 Valencia Ave., Suite B-6, Aptos, CA 95003. Ph: 688-1562
	CA-6	Placer County Grading Ordinance. 1990. Placer County Public Works,11444 "B" Avenue, Auburn, CA 95603. Ph: (916) 889-7584
	CA-7	County of El Dorado Grading, Erosion and Sediment Control Ordinance. 1991. El Dorado County Building Department, 2850 Fairlane Court, Placerville, CA 95667. Ph: (916) 621-5315
COLORADO	*CO-1*	Erosion and Sediment Control in Urbanizing Areas of Colorado (Interim Guide). 1979. Natural Resources Conservation Service, 655 Parfet Street, Room E200C, Lakewood, CO 80215-5517. Ph: (303) 236-2913
CONNECTICUT	*CT-1*	Connecticut Guidelines for Soil Erosion and Sediment Control. 1985 (Revised 1988). The Connecticut Council on Soil and Water Conservation. Connecticut Department of Environmental Protection, Maps and Publication Division, 79 Elm Street, Hartford, CT 06106-5127. Ph: (203) 424-3533

State	Doc. No.	Name Of Document (Owner Of Document)
	CT-2	Connecticut Erosion and Sediment Control Pocket Guide. Connecticut Department of Environmental Protection, Water Management Bureau. Maps and Publication Division, CT-DEP, 79 Elm Street, Hartford, CT 06106-5127. Ph: (203) 424-3533
DELAWARE	*DE-1*	Delaware Erosion and Sediment Control Handbook. 1989. Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation. New Castle Conservation District, 6 Peoples Plaza, Newark, DE 19702. Ph: (302) 834-3560
	DE-2	Delaware Sediment and Stormwater Regulations. 1991. Department of Natural Resources and Environmental Control, Division of Water Resources, Division of Soil and Water Conservation, Dover, Delaware. (Included with Erosion and Sediment Control Handbook).
DISTRICT OF COLUMBIA	*DC-1*	A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone. 1992. Anacosta Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, 777 North Capitol St., Suite 306, Washington DC 20002. Ph: (202) 260-2090
FLORIDA	*FL-1*	The Florida Development Manual A Guide to Sound Land & Water Management. 1988. The State of Florida, Department of Environmental Protection, 2600 Blair Stone Rd.,Tallahasee, FL 32399-2400. Ph: (904) 488-4805
GEORGIA	GA-1	Manual of Erosion and Sediment Control in Georgia. 1992.

State	Doc. No.	Name Of Document (Owner Of Document)
		Georgia Soil and Water Conservation Commission, P.O. Box 8024, Athens, GA 30603. Ph: (706) 5423065.
HAWAII	*HI-1*	Erosion and Sediment Control Guide for Hawaii. 1981.
		USDA Natural Resources Conservation Service, P.O. Box 50004, 300 Ala Moana Blvd., Suite 4316, Honolulu, Hl 96850-0050. Ph: (808) 541-2603
IDAHO		None Available
ILLINOIS	*IL-1*	Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois. Revised 1988.
		Association of Illinois Soil and Water Conservation Districts, Suite 305A, 3085 Stevenson Drive, Springfield, IL 62703. Ph: 217-529-7788.
	IL-2	Standards and Specifications for Soil Erosion and Sediment Control. 1987.
		Illinois Environmental Protection Agency, Division of Water Pollution Control, 2200 Churchill Road, Springfield, IL 62794-9276.
	IL-3	1995 lllinois Urban Manual
		Illinois Environmental Protection Agency, Division of Water Pollution Control, 2200 Churchill Road Springfield, IL 62794-9276
INDIANA	*IN-1*	Indiana Handbook for Erosion Control in Developing Areas—Guidelines for Protecting Water Quality Through the Control of Soil Erosion and Sedimentation on Construction Sites. 1992.
		Urban Conservation Program, Division of Soil Conservation, Indiana Departmenl: of Natural Resources, 402 West Washington Street, Room W 265, Indianapolis, IN 46204-2748. Ph: 317-233-3870.

State	Doc. No.	Name Of Document (Owner Of Document)
IOWA	None Available	
KANSAS	*KS-1*	Kansas Urban Conservation Handbook. 1990. USDA Natural Resources Conservation Service, 760 South Broadway, Salina, KS 67401-4642.
KENTUCKY	*KY-1*	Best Management Practices for Cc,nstruction Activities.1994. Kentucky Division of Conservation and Division of Water, 691 Teton Trail, Frankfort, KY 40601. Ph: (502) 564-3080.
LOUISIANA	*LA-1*	Erosion and Sedimentation Control Guide for Developing Areas in Louisiana. 1989. Louisiana Department of Transportation and Development and Soil & Water Conservation Committee, Baton Rouge, LA Copies available: USDA - Natural Resources Conservation Service, RC&D Offic:e, 1402 Hawn Ave., Shreveport,LA 71107. Ph: (318~226-5335.
MAINE	*ME-1*	Maine Erosion and Sediment Control Handbook for Construction: Best Management Practices. March,1991. Cumberland County SWCD, Department of Environmental Protection, 1 A Karen Drive, Westbrook, ME 04092. Ph: (207) 871-9247
MARYLAND	*MD-1*	Maryland Standards and Specifications for Soil Erosion and Sediment Control. 1991 (Rev. 1994). Maryland Department of the Environment: Water Management Administration. In association with Natural Resources Conservation Service and State Soil Conservation Committee.

State	Doc. No.	Name Of Document (Owner Of Document)
		Maryland Department of the Environment, 2500 Broening Hwy., Baltimore, MD 212.25. Ph: (410) 6313000
	MD-2	Maryland Standards and Specifica:ions for Infiltration Practices in Stormwater Management. 1983.
		Maryland Department of Natural Resources, Erosion and Sediment Control Division, Water Resources Administration, TAWES State Offic:e Building, Annapolis, MD 21401.
		Stormwater Management Division, Water Resources Administration, Maryland Department of Natural Resources, Annapolis, Maryland.
	MD-3	1983 Maryland Standards and Specifications for Erosion and Sediment Control.
		Erosion and Sediment Control Division, Water Resources Administration, TAWES, State Office Building, Annapolis, MD 21401.
MASSACHUSETTS	*MA-1*	Massachusetts Nonpoint Source Management Manual - "The Megamanual": A Guidance Document for Municipal Officials. May, 1994.
		Massachusetts Department of Environmental Protection, Office of Watershed Management, Nonpoint Source Program, Boston, Massachusetts.
	MA-2	Massachusetts Conservation Guide: Volume 1 - Erosion and Sediment Control in Site Development. 1983.
		USDA- Natural Resources Conservation Service, 451 West Street, Amherst, MA 01002-2995.. Ph: (413) 2534350
	MA-3	Massachusetts Conservation Guide: Volume 2 Vegetative Practices in Site Development. 1983.

State	Doc. No.	Name Of Document (Owner Of Document)
		USDA, Natural Resources Conservation Service, 451 West Street, Amherst, MA 01002-2995. Ph: (413) 253-4350
MICHIGAN	*MI-1*	Guidebook of Best Management Practices for Michigan Watersheds. 1993.
		Michigan Department of Natural Resources, Surface Water Quality Division, P.O. Box 33028, Lansing, MI 48909. Ph: (517) 335-4623.
MINNESOTA	*MN-1*	Protecting Water Quality in Urban Areas — Best Management Practices for Minnesota. 1989.
		Minnesota Pollution Control Agency, Division of Water Quality, 520 Lafayette Road North, St. Paul, MN 55155. Ph: (612) 296-6300.
MISSISSIPPI	*MS-1*	Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater. 1994.
		Department of Environmental Quality, Office of Pollution Control, Water Quality Management Branch, ATTN: Stormwater Manual P.O. Box 10385, Jackson, MS 39289-0385. Ph: (601) 961-5171.
MISSOURI	*MO-1*	Erosion and Sediment Control Specifications. City of Kansas City, Missouri. Approved by Missouri Department of Natural Resources, 1992.
		Public Works Department, Engineering Division, 19th Floor, City Hall, 414 E. 12th Street, Kansas City, MO 64106.
	MO-2	Model Stormwater Runoff Management Ordinance and Commentary. 1980.
		Mid-America Regional Council, 300 Rivergate Center 600 Broadway, Kansas City, MO 64105-1536. Ph: (816) 474-4240.

State	Doc. No.	Name Of Document (Owner Of Document)
	MO-3	Model Grading and Sediment Conlrol Ordinance, With a Procedure to Estimate Soil Loss Resulting from Water Erosion on Development Areas and Conservation Practice Standards and Specifications for Urban Areas. 1977. Mid-America Association of Conservation Districts, 301 W. Lexington, Room 225, Independence, MO 64050.
	MO-4	Field Manual for Protecting Urban Water Quality. St. Charles County Soil and Water Conservation District, #1 Westbury Square, Bldg. D, St. Charles, MO 63301. Ph: (314) 724-2237.
	MO-5	Model Sediment & Erosion Control Regulations. St. Charles County Soil and Water Conservation District, #1 Westbury Square, Bldg. D, St. Charles, MO 63301. Ph: (314) 724-2237.
	MO-6	Urban Conservation Tips. USDA, Natural Resources Conservation Service, 555 Vandiver Drive, Columbia, MO 65202. Ph: (314) 875-5227.
	MO-7	Hold Your Ground—A Practical Guide For Protecting Your Natural Resources. St. Louis County Soil and Water Conservation District.
	MO-8	Delineating Watersheds - A First Step Towards Effective Management. 1993. Terrene Institute, 1717 K Street, NW, Suite 801, Washington, DC, 20006. Ph: 202-833-8317.
MONTANA		None Available
NEBRASKA	*NE-1*	City of Omaha Soil Erosion and Sediment Control Manual. HDR Engineering, Inc., Omaha, Nebraska. 1993.

State	Doc. No.	Name Of Document (Owner Of Document)
NEVADA	*NV-1*	Handbook of Best Management Practices, Draft. 1994. Department Of Conservation and Natural Resources, Bureau of Water Quality Planning, 333 West Nye Lane, Carson City, NV 89710. Ph: (702) 687-5883
NEW HAMPSHIRE	*NH-1*	Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire. March, 1992. New Hampshire Department of Environmental Services, Rockingham County Conservation District and USDA, Natural Resources Conservation Service, 32 Front Street, Exeter, NH 03833-2705. Ph: (603) 772-4385
NEW JERSEY	*NJ-1*	Standards for Soil Erosion and Sediment Control in New Jersey. 1987. New Jersey State Soil Conservation Committee, Division of Rural Resources, New Jersey Department of Agriculture, Trenton, New Jersey.
	NJ-2	New Jersey Construction Specifications and Material Specifications for Conservation Practices. USDA, SCS, January 1988. USDA, NRCS, P.O. Box 1088, Somerset, NJ 08625. Ph: (908) 246-1977 New Jersey State Soil Conservation Committee, State Health & Agricultural Building, P.O. Box CU330, Trenton, NJ 08625.
NEW MEXICO	*NM-1*	Manual for Urban Erosion and Sediment Control, Draft.1994.

State	Doc. No.	Name Of Document (Owner Of Document)
		USDA, Natural Resources Conservation Service, 517 Gold Avenue, SW., Room 3301, Albuquerque, NM 87102-3157. Ph: (505) 761 -4400
NEW YORK	*NY-1*	New York Guidelines for Urban Erosion and Sediment Control. 1991.
		Empire State Chapter Soil and Water Conservation Society, P.O. Box 1686, Syracuse, NY 13261-7172. Ph: (315) 477-6541.
NORTH CAROLINA	*NC-1*	Erosion and Sediment Control Planning and esign Manual. 1988.
		Department of Natural Resources and Community Development, Land Quality Section, P.O. Box 27687, Raleigh, NC 27611-7687. Ph: (913) 733-4574.
NORTH DAKOTA		None Available
OHIO		None Available
OKLAHOMA	*OK-1*	Erosion and Sediment Control on lJrban Areas. 1987.
		Oklahoma County Conservation District, 1000 W. Wilshire, Suite 223 A, Oklahoma City, OK 73116. Ph: (405) 848-1933.
OREGON		None Available
PENNSYLVANIA	*PA-1*	Commonwealth of Pennsylvania Erosion and Sediment Pollution Control Program Manual. April, 1990.
		Department of Environmental Resources, Office of Resources Management, Bureau of Soil and Water Conservation, Division of Soil Resources and Erosion Control, Harrisburg, Pennsylvania.

State	Doc. No.	Name Of Document (Owner Of Document)
	PA-2	Commonwealth of Pennsylvania Erosion and Sedimentation Control Plan Development Checklist and Worksheets. November, 1990. Department of Environmental Resources, Office of Resources Management, Bureau of Soil and Water Conservation, Division of Soil Resources and Erosion Control, One Ararat Blvd., Room 214, Harrisburg, PA 17110. Ph: (717) 471-5080
	PA-3	Erosion and Sedimentation Pollution Control Plan Guide for Small Projects. June, 1992 Southeast Pennsylvania Association of Conservation Districts, Delaware County, Conservation District, Media, Pennsylvania. Berks County Conservation District, 924 Torone Center, New Britain, PA 18901. Ph: (215) 345-7577
	PA-4	A Guide on Soil and Water Management for Local Officials. 1993. Natural Resources Conservation Service, USDA, 160 East 7th Street, Chester, PA 19013-6092. Ph: (610) 490-6065
PUERTO RICO	*PR-1*	Standards and Specifications for 'ioil Erosion and Sediment Control in Developing Areas. 1977. USDA, Natural Resources Conservation Service, Caribbean Area State Office, U.S. Federal Building, Rm. 639,150 Carlos A. Chardon Ave., Hato Rey, PR 00918-7013. Ph: (809) 766-5206.
RHODE ISLAND	*H1-1*	Rhode Island Soil Erosion and Sediment Control Handbook. 1989.

State	Doc. No.	Name Of Document (Owner Of Document)
		Rhode Island Department of Environmental Management, USDA, Natural Resources Conservation Service and Rhode Island State Conservation Committee, 9 Hayes Street, Providence, Rl. Ph: (401) 277-3162
SOUTH CAROLINA	*SC-1*	Erosion and Sediment Control in Developing Areas. 1977. USDA - Natural Resources Conservation Service, Strom Thurmond Federal Bldg., 1935 Assembly St., Rm. 950, Columbia, SC 29201. Ph: (803) 765-5681.
SOUTH DAKOTA	*SD-1*	Urban Soil Erosion and Sediment. 1974. USDA- Natural Resources Conservation Service, Federal Building, 200 Fourth Street S.W., Huron, SD 57350-2475. Ph: (605) 352-1200.
TENNESSEE	*TN-1*	Erosion and Sediment Control Handbook for Urban Areas and Construction Sites in Tennessee. 1974. USDA- Natural Resources Conservation Service, 675 U.S. Courthouse, 801 Broadway, Nashville, TN 37203. Ph: (615) 736-5471.
TEXAS	*TX-1*	Erosion and Sediment Guidelines for Developing Areas in Texas. 1976. USDA, Natural Resources Conservation Service, W.R. Poage Federal Building, 101 South Main, Temple, TX 76501 -7682. Ph: (817) 774-1214.
UTAH		None Available
VERMONT	*VT-1*	Vermont Handbook for Erosion Control and Sediment Control on Construction Sites. Special Publication No. 3. 1982 (Revised September, 1987). Vermont Geological Survey, Department of Water Resources and Environmental Engineering, Agency of Environmental Conservation, Heritage Building, River Road, Montpelier, VT. Ph: (802) 828-3341

State	Doc. No.	Name Of Document (Owner Of Document)
	VT-2	Soil Erosion and Sediment Control Manual - A Supplement to Vermont Handbook for Erosion Control and Sediment Control on Construction Sites - Special Publication No. 3. February, 1989. Vermont Association of Conservation Districts.
VIRGINIA	VA-1	Commonwealth of Virginia Best Management Practices Handbook - Urban. 1979. Virginia State Water Control Board, Planning Bulletin 321, Richmond Virginia.
	VA-2	Virginia Erosion and Sediment Control Handbook. 1992. Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, P.O. Box 721, Richmond, VA 23206-0721. Ph: (804) 786-1798
	VA-3	Northern Virginia BMP Handbook - A Guide to Planning and Designing Best Management Practices in Northern Virginia. November 6, 1992. Northern Virginia Planning District Commission, 7535 Little River Turnpike, Suite 100, Annandle, VA 22003. Ph: (703) 642-0700
	VA-4	Commonwealth of Virginia, Virginia Erosion and Sediment Control Law and Regulations, Department of Conservation and Recreation. 1993. Division of Soil and Water Conservation, 203 Governor Street, Suite 206, Richmond, VA 23216-2094. Ph: (804) 786-2064 Northern Virginia Planning District Commission.
WASHINGTON	WA-1	Construction and Water Quality: A Guide To Recommended Practices For The Control of Erosion and Sedimentation On Construction Sites. 1981.

State	Doc. No.	Name Of Document (Owner Of Document)
		King County Conservation Districl, Technical Center Building #19, 35 Powell Ave., S.\/\l., Renton, WA 98055-2908. Ph: (206) 764-3325
WEST VIRGINIA	WV-1	West Virginia Erosion and Sediment Control Handbook for Developing Areas. May, 1993. USDA, Natural Resources Conservation Service, 75 High Street, Morgantown, WV 26505. Ph: (304) 2914151
WISCONSIN		None Available
WYOMING		None Available

Additional References:

USDA, SCS, National Engineering Handbook, Drainage of Agricultural Land, 1971, Hydraulics 1975, Hydrology, SCS, Washington, DC

USDA, SCS, National Engineering Field Handbook, 1969, SCS, Washington, DC

USDA, SCS, National Planning Procedures Handbook, 1994, SCS, Washington, DC

USDA, SCS, Technical Release 55, Urban Hydrology for Small Watersheds, SCS, January 1975, Washington, DC

USDA, ARS, Predicting Rainfall Erosion Losses, A Guide to Conservation Planning, AH 537, ARS, Washington, DC

III. Catalog of Guideline Material

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III. Catalog Of Guideline Materials

Category	Doc. No.	Title Of Item
A. Planning		
1. Assessment and problem identification		
a. Miscellaneous		
	GA-1	Sediment And Erosion Control Processes, Principles And Practices
	GA-1	Soils Information
	KS-1	Controlling Urban Site Erosion
	OK-1	Erosion And Sedimentation In The Urban Setting
	OK-1	General Guideline For Urban Erosion Prevention During Construction
	SD-1	Use Of Soil Surveys And Soil Information
2. Planning procedures		
a. Plan development		
	AL-1	Developing Plans For Erosion And Sediment Control And Storm Water Management
	CA-1	Development Site Plan
	CA-2	Erosion And Sediment Control Plans
	CA-3	Principles Of Reduced Erosion And Sedimentation From Developing Areas
	CA-3	Standard Map Symbols For Erosion & Sediment Control Plans
	FL-1	The Planning Process (Chapter 8)
	GA-1	Land-Disturbing Activity Plan
	GA-1	Planning And Plans
	IL-1	Site Planning Process (Principles And Procedures)
	IL-3	Principles And Processes
	IN-1	Contents Of An Erosion And Sediment Control Plan
	IN-1	Symbols For Use On Erosion And Sediment Plan Site Maps
	KS-1	Site Planning Process
	KY-1	Resource Conservation Planning

Category	Doc. No.	Title Of Item
	LA-1	Site Planning Process
	Ml-1	Steps To Take To Address Urban Nonpoint Sources At The Watershed Level
	Ml-1	Steps To Take To Develop A Site Plan
	MN-1	Implementing Bmps To Prevent Nonpoint Source Pollution - Site Planning
	MS-1	Erosion, Sediment, And Stormwater Control Plan Guideline
	MS-1	Sample Erosion, Sediment And Stormwater Control Plan
	NC-1	Preparing The Erosion And Sediment Control Plan
	NC-1	Sample Erosion And Sediment Control Plan
	NE-1	Erosion And Sediment Control Plan
	OK-1	Step-By-Step Approach For Erosion Control On Small Urban Sites
	SD-1	General Guidelines For Land Treatment
	SD-1	Plan Development To Fit The Land
b. Plan implementation		
	IN-1	Developing And Using A Construction Sequence Schedule To Enhance Erosion And Sediment Control
	MN-1	Implementing BMPs To Prevent Nonpoint Source Pollution — Correcting A Water Quality Problem
	MN-1	Implementing BMP To Prevent Nonpoint Source Pollution — BMP Selection Process
	MN-1	Implementing BMPs To Prevent Nonpoint Source Pollution — Planning For Erosion And Sediment Control
	MN-1	Implementing BMPs To Prevent Nonpoint Source Pollution — Storm Water Management
	NE-1	Implementation And Sequencing Of Erosion And Sediment Controls

Category	Doc. No.	Title Of Item
3. Plan review and approval process		
a. Plan review		
	KS-1	Procedure For Review Of Preliminary Subdivision Plans
b. Plan approval and enforcement		
	FL-1	Local Planning Implementation (Chapter 8)
	IL-1	Plan Approval And Enforcement
	LA-1	Plan Approval And Enforcement
B. Technical information		
1. Materials		
a. Soil		
	AL-1	Soil Characteristics
	AL-1	Soil Considerations
	KS-1	Soils
	MO-6	Soils
	MS- 1	Soils
	NC-1	Soils Information
	TN-1	Predicting Soil Losses For Urbanizing Areas
	TX-1	Predicting Soil Erosion Loss On Construction Sites
	TX-1	Soil Data And Interpretations
2. Processes		
a. Erosion and sedimentation		
	CA-3	Statement Of The Problem - Erosion, Sedimentation
	CO-1	Urban Erosion/Sediment Yield Determination
	IL-1	The Erosion And Sedimentation Process
	KS- l	Soil Erosion - Water
	LA-1	The Erosion And Sedimentation Process
	MO-6	Soil Erosion - Water

Category	Doc. No.	Title Of Item
	MS- 1	Effects of Vegetation on Erosion and Sedimentation
	NC-1	Effects of Vegetation on Erosion and Sedimentation
	NC-1	Processes and Principles of Erosion and Sedimentation
	NE-1	The Erosion and Sedimentation Process; Soil Erosion - Water, Factors Influencing Erosion
	NM-1	Urban Erosion/Sediment Yield Determ ination
	SC-1	Guidelines for Controlling Erosion and Sediment
	WA-1	Urban Erosion/Sediment Yield Determination
b. Nonpoint source pollution		
	FL-1	Abatement of Nonpo~nt Source Pollution
	Ml-1	Detention and Infiltration to Address Urban Nonpoint Sources of Pollution
	Ml-1	Sources of Nonpoint Pollution; Impacts of Nonpoint Source Pollution on Surface Waters
	MN-1	The Effects of Urbanization on Water Quality; Characterist cs of Urban Runoff
c. Erosion prediction		
	CO-1	Urban Wind Erosion Estimates
	GA-1	Soil Loss Prediction
	Ml-1	Use of the Universal Soil Loss Equation in Developing Areas
	MO-3	A Procedure to Estimate Soil Loss
d. Hydrology		
	CO-1	Urban Hydrology Determination
	FL-1	Calculations of Estimated Runoff
	GA-1	Estimating Runoff from URBAN Areas
	GA- 1	Peak Discharges
	Hl-1	Urban Hydrology Determination
	Ml-1	One Method of Calculating Runoff-Computing Flood Discharges for Small Ungaged Watersheds

Category	Doc. No.	Title Of Item
	MN-1	Urban Hydrology
	MS-1	Hydrology
	NC-1	Estimating Roughnecs Coefficients
	NC-1	Estimating Runoff
	NM-1	Urban Hydrology Determination
	TN-1	Estimating Runoff
	WA-1	Urban Hydrology Determination

e. Erosion and sediment control

CA-2	Principles of Erosion and Sediment Control
CA-4	Groundwork: A Handbook for Erosion Control in North Coa,tal California
CA-5	Groundcover: A Planting Guide for Erosion Control and Site Improvement on the Central Coast
FL-1	Erosion and Sediment Control Principles
IL-1	Principles of Erosion and Sedimentation Control
IL-2	Basic Principles of Erosion and Sediment Control
IN-1	Ten General Principles of Erosion and Sediment Control
KS- 1	Stormwater Management, Erosion, and Sediment Control
NC-1	Vegetation Tables
NE-1	Principles of Erosion and Sediment Control
TN-1	Guidelines for Minimizing Erosion and Sediment in Urban Development
TX-1	Principles for Controlling Erosion and Sediment

f. Stormwater management

AL-1	Information for Designing Stormwater Management Measures
AL- 1	Managing Stormwater
FL-1	Principles of Stormwater
IL-1	Urban Stormwater Management
TX-1	Principles of Stormwater Management

g. Fertilizer and pesticide application

CO-1	Soil Sampling for Fertilizer and Amendments

Category	Doc. No.	Title Of Item
	Ml-1	Supplemental Fertilizer and Pesticide Application Procedures
	SC-1	Lime and Fertilizer for Plant Growth

i. Point source pollution

	FL-1	Individual Treatment and Disposal (Chapter 7)

C. State laws, permits and model ordinances

1. Model plan

AL-1	Erosion and Sediment Control Plans
FL-1	Excerpt from Martin County Comprehensive Plan
IL-1	Model Erosion and Sedimentation Control Plan
KY-1	Model Erosion and Sediment Control Plans
LA-1	Model Erosion and Sedimentation Control Plan

2. Model ordinances

AL-1	Model Ordinances
CA-6	Placer County Grading Ordinance
CA-7	County of El Dorado Grading, Erosion and Sediment Control Ordinance
FL-1	A Model Flood Management Ordinance
FL-1	City of Sanibel Ordinance
FL-1	Collier County Ordinance
FL-1	Franklin County Critical Shoreline Ordinance
FL-1	Orange County Lakeshore Protection Ordinance
FL-1	Ordinances for Nonpoint Source
FL-1	Two Draft Wetland Protection Ordinances
GA-1	Local Program Principles and Processes
GA-1	Model Soil Erosion and Sedimentation Control Ordinance
IL-1	Model Ordinances
Ml-1	Ordinances
MO-2	Model Stormwater Runoff Management Ordinance and Commentary

Category	Doc. No.	Title Of Item
	MO-3	Model Grading and Sediment Control Ordinance
	MO-5	Model Sediment & Erosion Control Regulations, St. Charles County SWCD, MO
	NC-1	The Sediment Control Law

3. Miscellaneous

	GA-1	Erosion and Sedimentation Act Georgia
	GA-1	Sources of Assistance and Resource Information
	GA-1	Uniform Coding System for Erosion and Sediment Control Practices
	Ml-1	Applicable State and Federal Regulations

D. Implementation measures

1. Construction procedures

	CA-2	Construction Schedules and Sequencing
	CA-2	Wet Weather Interim Plan
	IL-3	Construction Specifications

2. Practice categories (functional)

a. Site preparation

(1) Standards

	AL-1	Construction Exit/Entrance
	AL-1	Steam Crossing
	AL-1	Tree Preservation and Protection
	CA- 1	Grading Season
	CA-1	Winterization
	CA-1	Boundary Fencing
	CA-1	Traffic Control
	CA-1	Stabilized Construction Entrance
	CA-1	Protection of Trees and Other Vegetation
	CA-2	Land Grading for Minimizing Erosion
	CA-2	Topsoiling
	CA-2	Construction Road Stabilization
	CA-2	Temporary Gravel Construction Entrance/Exit
	CA-3	Protection of Trees in Urbanizing Areas

Category	Doc. No.	Title Of Item
	CO-1	Access Road
	CO-1	Land Clearing and Grading
	CO-1	Saving a Young Girdled Tree
	CO-1	Preserving Natural Vegetation
	CT-1	Land Grading
	CT-1	Stabilization Construction Entrance (Temp)
	CT-1	Temporary Stream Crossing
	CT-1	Topsoiling
	DE-1	Land Grading
	DE-1	Stabilization Construction Entrance (Temp)
	DE-1	Temporary Stream Crossing
	DE-1	Topsoiling
	FL-1	Construction Road Stabilization
	FL-1	Surface Roughening
	FL-1	Temporary Gravel Construction Entrance
	FL-1	Tree Preservation and Protection
	GA-1	Construction Exit
	GA-1	Temporary Stream Crossing
	Hl-1	Access Road
	Hl-1	Land Clearing and Grading
	IL-2&3	Land Grading
	IL-2&3	Protection of Trees in Urbanizing Areas
	IL-2&3	Stabilized Construction Entrance
	IL-2&3	Temporary Access Water Crossing
	IL-2&3	Topsoiling
	IL-3	Sump Pit
	IN-1	Temporary Gravel Construction Entrance/Exit Pad
	IN-1	Temporary Stream Crossing
	IN-1	Topsoil (Salvage and Utilization)
	IN-1	Tree Conservation
	KY-1	Construction Entrance
	KY-1	Construction Road Stabilization
	KY-1	Land Grading
	KY-1	Temporary Stream Crossing
	LA-1	Land Grading
	LA-1	Stabilized Construction Entrance
	MD-1	Land Grading and Structural Stabilization
	MD-1	Stabilization Construction Entrance (Temp)
	MD-1	Topsoiling
	ME-1	Stabilization Construction Entrance (Temp)
	ME-1	Temp Access Waterway Crossings

Category	Doc. No.	Title Of Item
	ME-1	Temporary Stream Crossing
	ME-1	Topsoiling
	Ml-1	Access Road
	Ml-1	Construction Barriers
	Ml- 1	Grading Practices
	Ml-1	Land Clearing
	Ml-1	Spoil Piles
	Ml-1	Staging and Scheduling
	Ml-1	Tree Protection
	Ml-1	Watercourse Crossings
	Ml-1	Wetland Crossings
	MO-1	Land Grading
	MO-1	Temporary Construction Entrance
	MO-1	Topsoiling
	MO-1	Tree Preservation ard Protection
	MO-3	Land Grading
	MS-1	Construction Entrance/Exit
	MS-1	Construction Road Stabilization
	MS-1	Land Grading
	MS-1	Stream Crossing
	MS-1	Tree Preservation and Protection
	NC-1	Construction Road Stabilization
	NC-1	Construction Sequence Schedule
	NC- 1	Surface Roughening
	NC-1	Temporary Gravel Construction Entrance/Exit
	NC- 1	Temporary Stream Crossing
	NC-1	Tree Preservation and Protection
	NE-1	Protection of Trees in Urbanizing Areas
	NE-1	Stabilized Construction Entrance
	NE-1	Topsoiling
	NH-1	Land Grading
	NH-1	Stabilization Construction Entrance (Temp)
	NH-1	Topsoiling
	NJ-1	Land Grading
	NJ- 1	Stabilization Construction Entrance (Temp)
	NJ-1	Temporary Stream Crossing
	NJ-1	Topsoiling
	NJ-2	Temp Access Road
	NM-1	Fencing
	NM-1	Land Clearing and Grading

Category	Doc. No.	Title Of Item
	NM-1	Stabilization of Roads, Entrance and Traffic During Construction
	NM-1	Topsoiling
	NV- 1	Access Road
	NV-1	Slope Shaping
	NV-1	Topsoiling
	NY-1	Topsoiling
	NY-1	Conservation Road Stabilization
	NY-1	Land Grading
	NY-1	Stabilization Construction Entrance (Temp)
	NY-1	Temp Access Bridge
	NY-1	Temp Access Waterway Crossings
	OK-1	Site Preparation and Grading
	OK- 1	Tree Conservation
	PA-2	Access Road (temp/perm)
	PR-1	Land Grading
	PR-1	Protection of Trees in Urbanizing Areas
	PR-1	Stabilized Construction Entrance
	RI-1	Stabilization Construction Entrance (Temp)
	RI-1	Temporary Stream Crossing
	SC-1	Land Grading
	SC- 1	Tem porary Construction Entrance
	TN-1	Land Grading
	TX-1	Access Roads
	TX-1	Land Grading
	VA-2	Access Road (temp/perm)
	VA-2	Conservation Road Stabilization
	VA-2	Stabilization Construction Entrance (Temp)
	VA-2	Temp Vehicular Stream Crossing
	VT- 1	Stabilization Construction Entrance (Temp)
	VT-2	Conservation Road Stabilization
	VT-2	Land Grading
	WA-1	Land Clearing and Grading
	WA- 1	Topsoiling
	WA-1	Preserving Natural Vegetation
	WV- 1	Conservation Road Stabilization
	WV-1	Land Grading
	WV- 1	Stabilization Construction Entrance (Temp)
	WV-1	Temporary Stream Crossing

Category	Doc. No.	Title Of Item

(2) Design Information/Fact Sheets

IL-1	Stabilized Construction Entrance
KS-1	Dust and Traffic Control
KS-1	Stabilized Entrance
MN- 1	Lot Benching
MN-1	Temporary Rock Construction Entrance
MN-1	Temporary Stream Crossing
MS-1	Construction Sequence
MS-1	Land Grading
MS-1	Tree Preservation and Protection
NC-1	Construction Road Stabilization
NC-1	Construction Sequence Schedule
NC-1	Land Grading
NC-1	Temporary Gravel Construction Entrance
NC-1	Temporary Stream Crossing
NC-1	Tree Presentation and Protection
TX-1	Benches and Berms
TX-1	Land Grading

b. Vegetative establishment — permanent

(1) Standards

AL-1	Buffer Zone
AL-1	Mulching
AL-1	Permanent Seeding
AL-1	Shrub, Vine and Ground Cover Planting
AL- 1	Sodding
AL- 1	Top Soil
AL-1	Tree Planting and Disturbed Areas
CA-1	Recommended Grass Species
CA-1	Recommended Shrub Species
CA-1	Recommended Tree Species
CA-1	Recommended Flowers and Legumes
CA-1	Wattling
CA-1	Brush Layering
CA- 1	I rrigation
CA-2	Permanent Seeding
CA-2	Hydroseeding
CA-2	Mulching
CA-3	Standards and Specifications for Seeding of Grasses or Grasses and Legumes
CO- 1	Critical Area Planting

CO-1 Grasses for Non Irrigated Areas

Category	Doc. No.	Title Of Item
	CO-1	Permanent Vegetation/Sodding
	CO-1	Seeding of Grasses cr Grasses and Legumes
	CO-1	Water Conserving Grasses
	CT-1	Permanent Vegetative Cover
	CT-1	Trees, Shrubs, Vines and Ground Covers
	DE-1	Stabilization - Bermuda Grass/Zoysia
	DE-1	Stabilization - Permanent Seeding
	DE-1	Stabilization - Temporary Seeding
	DE-1	Trees, Shrubs, Vines and Ground Covers
	FL-1	Bermuda Grass Establishment
	FL-1	Mulching
	FL-1	Permanent Seeding
	FL-1	Sodding
	FL-1	Top Soiling
	FL-1	Trees, Shrubs, Vines and Ground Cover
	GA-1	Topsoiling
	Hl-1	Environmental Planting
	IL-2	Vegetative Stabilization Permanent Seedings
	IL-2	Vegetative Stabilization of Channels and Steep Slopes
	IL-3	Mulching
	IL-3	Sodding
	IL-3	Vegetative Streambank Stabilization
	IL-3	Permanent Seeding
	IL-3	Tree and Shrub Planling
	IN-1	Dormant and Frost Seeding
	IN-1	Farmstead and Feedlot Windbreak
	IN-1	Mulching
	IN-1	Permanent Seeding
	IN-1	Sodding
	IN-1	Tree Planting (SCS, 612)
	KY-1	Ground Cover
	KY-1	Mulching
	KY- 1	Permanent Seeding
	KY- 1	Sodd ing
	KY-1	Top Soiling
	LA-1	Mulching
	MA-1	Seeding & Mulching
	MA-1	Trees, Shrubs, Vines and Ground Covers
	ME-1	Trees, Shrubs, Vines and Ground Covers
	Ml-1	Critical Area Stabilization
	Ml-1	Dune/Sand Stabilization

Ml-1	Mulching
Ml-1	Seeding (Includes Dormant Seeding)
Ml-1	Sodding

Category	Doc. No.	Title Of Item
	Ml-1	Soil Management (includes pH control)
	Ml-1	Trees, Shrubs, and Ground Covers
	MO-1	Mulching
	MO-1	Permanent Seeding
	MO-1	Sodding
	MO-1	Trees, Shrubs, Vines and Ground Cover
	MO-1	Vegetative Streambank Protection
	MO-3	Mulching
	MO-3	Seeding Permanent \/egetation
	MO-3	Sodding
	MS-1	Mulching
	MS- 1	Permanent Seeding
	MS-1	Sodding
	MS-1	Topsoiling
	MS-1	Trees, Shrubs, Vines, and Ground Cover
	NC-1	Mulching
	NC-1	Permanent Seeding
	NC-1	Sodding
	NC-1	Top Soiling
	NC-1	Trees, Shrubs, Vines, and Ground Cover
	NE-1	Vegetative Stabilization Permanent Seedings
	NE-1	Vegetative Stabilization of Channels and Steep Slopes
	NE-1	Vegetative Stabilization With Sod
	NE-1	Vegetative Stabilization With Trees and Shrubs
	NH-1	Permanent Vegetative Cover
	NH-1	Stabilization - Permament Seeding
	NH-1	Stabilization - Tempcrary Seeding
	NJ-1	Temporary Vegetative Cover
	NJ-1	Trees, Shrubs, Vines and Ground Covers
	NM-1	Permanent Vegetation/Sodding
	NM-1	Seeding of Grasses or Grasses and Legumes
	NV- 1	Hydromulch
	NV-1	Wattling
	NY-1	Trees, Shrubs, Vines and Ground Covers
	NY-1	Wattling
	OK-1	Erosion Protection w th Trees, Shrubs, and Ground Cover
	OK-1	Establishing Vegetat ve Cover
	OK-1	Mulching
	OK-1	Topsoiling

PR-1	Bermuda Grass
PR-1	Mulching
PR- 1	Permanent Seeding

Category	Doc. No.	Title Of Item
	PR-1	Sodding
	PR-1	Trees, Shrubs, Vines, and Ground Cover
	Rl-1	Trees, Shrubs, Vines and Ground Covers
	SC-1	Mulching
	SC-1	Planting for Erosion Control
	SC- 1	Sodding
	SC-1	Top Soiling
	TN-1	Critical Eroding Area Planting - Urban Areas Permanent Cover - Seeded, Sodding, Sprigging and Transplanting
	TN-1	Fibrous Netting Materials
	TN-1	Mulching
	TX-1	Critical Area Planting
	TX-1	Critical Area Planting with Sod
	VA-2	Stabilization - Bermuda Grass/Zoysia
	VA-2	Stabilization - Permanent Seeding
	VA-2	Stabilization - Temporary Seeding
	VA-2	Trees, Shrubs, Vines and Ground Covers
	VT-2	Permanent Vegetative Cover
	WA-1	Permanent Vegetation/Sodding
	WV-1	Permanent Vegetative Cover

(2) Design information/fact sheets

	AL-1	Information on Installing Vegetative Measures
	AL-1	Vegetation for Erosion and Sediment Control
	I L- 1	Non-Vegetative Stabilization(temporary and permanent mulching)
	IL-1	Vegetative Stabilization
	KS- 1	Dormant Seeding
	KS-1	Establishing Lawns - Cool Season
	KS-1	Establishing Lawns - Warm Season
	KS-1	Ground Cover
	KS- 1	Permanent Seeding
	KS-1	Sodding
	KS-1	Sodding and Mulching
	LA-1	Establishing Permanent Vegetation with Seed
	LA-1	Mulching
	LA-1	Sodding
	MN-1	Mulching
	MN-1	Sodding

MN-1 Vegetative Stabilization

Category	Doc. No.	Title Of Item
	MO-6	Establishing Lawns
	MO-6	Seeding and Mulchirg
	MS- 1	Permanent Seeding
	MS-1	Sodding
	MS-1	Topsoiling
	MS-1	Trees, Shrubs, Vines, and Ground Cover
	MS-1	Vegetative Dune Stabilization
	MS- 1	Vegetative Streambank
	NC-1	Mulching
	NC- 1	Permanent Seeding
	NC-1	Sodding
	NC-1	Topsoiling
	NC-1	Trees, Shrubs, Vines, and Ground Cover
	NC-1	Vegetative Dune Stabilization
	NC-1	Vegetative Streambank Stabilization
	TX-1	General Guidelines for Establishing Vegetative Cover

c. Vegetative establishment — temporary

(1) Standards

	CA-2	Temporary Seeding and Mulching
	CA-3	Standards and Specifications for Seeding of Grasses or Grasses and Legumes
	CO-1	Seeding of Grasses or Grasses and Legumes
	CO-1	Temporary Seeding
	CT-1	Temporary Vegetative Cover
	FL-1	Temporary Seeding
	IL-2	Vegetative Stabilizatian Temporary Seedings
	IL-3	Temporary Seeding
	IN-1	Mulching
	IN-1	Temporary Seeding
	KY-1	Temporary Seeding
	Ml-1	Mulching
	Ml-1	Soil Management (includes pH control)
	MO-1	Mulching
	MO-1	Temporary Seeding
	MO-3	Mulching
	MO-3	Seeding Temporary Vegetation
	MS- 1	Temporary Seeding

NC-1	Temporary Seeding
NE-1	Vegetative Stabilization Temporary Seedings

Category	Doc. No.	Title Of Item
	NM-1	Seeding of Grasses or Grasses and Legumes
	NV- 1	HydromuIch
	PA-1	Temporary Vegetative Cover
	PR- 1	Temporary Seeding
	Rl-1	Temporary Vegetative Cover
	TN-1	Critical Eroding Area Planting - Urban Areas Temporary Cover
	VT-2	Temporary Vegetative Cover
	WA-1	Temporary Seeding
	WV-1	Temporary Vegetative Cover

(2) Design information/fact sheets

IL-1	Non-Vegetative Stabilization(temporary and permanent mulching)
IL-1	Vegetative Stabilization
KS- 1	Temporary Seeding
LA-1	Establishing Temporary Vegetation with Seed
MN-1	Mulching
MN-1	Temporary Seeding
MS-1	Mulching
MS-1	Temporary Seeding
NC- 1	Temporary Seeding

d. Restoration

(1) Standards

NV-1	Brush Layering
NV-1	Brush Matting
NV-1	Wattling

(2) Design information/fact sheets

MA-1	Shading and Sediment Covers
ME-1	Gravel Pit Restoration
NJ-1	Channel Stabilizatior

e. Surface stabilization

(1) Standards

Category	Doc. No.	Title Of Item
	AL-1	Measures for Stabilizing Coastal Dunes
	AL-1	Surface Roughening
	CA-1	Straw Mulch
	CA-1	Hydromulch
	CA-1	Pine Needle Mulch
	CA-1	Jute Netting
	CA-1	Plastic Netting
	CA-1	Wood Excelsior Blanker
	CA-1	Erosion Control Blankets or Geotextiles
	CA-1	Chemical Mulches and Tackifiers
	CA-1	Wood Chip and Bark Mulches
	CA-2	Surface Roughening
	CO-1	Chemical Mulches and Tackifiers
	CO-1	Jute Netting
	CO-1	Synthetic Netting - Plastic., Geotextiles, Etc.
	FL-1	Concrete Grid and Modular Pavement
	GA-1	Coastal Dune Stabilization (with Vegetation)
	GA-1	Disturbed Area Stabilization Mulching only, Temporary Seeding, Permanent Vegetation)
	GA-1	Surface Roughening
	Hl-1	Jute Netting
	Hl-1	Synthetic Netting, Geotextiles, Etc.
	IL-2	Vegetative Stabilization With Mulching Only
	IL-3	Erosion Blanket
	IN-1	Erosion Control Blanket (Surface Applied)
	IN-1	Mulching
	IN-1	Rip rap
	IN-1	Surface Roughening
	IN-1	Turf Reinforcement Mat (Buried)
	LA-1	Armor Plating
	Ml-1	Dune/Sand Stabilizalion
	Ml-1	Modular Pavement
	Ml-1	Mulching
	Ml-1	Rip rap
	MO-1	Mulching
	MO-1	Rip rap
	MO-1	Surface Roughening
	MO-3	Mulching
	MS-1	Concrete Grid and Modular Pavement
	MS-1	Surface Roughening

MS-1 Vegetative Dune Stabilization

Category	Doc. No.	Title Of Item
	NC-1	Sand Fence (Wind Fence)
	NC-1	Vegetative Dune Stebilization
	NE-1	Rip rap
	NE-1	Vegetative Stabilization With Mulching Only
	NM-1	Chemical Mulches and Tackifiers
	NV-1	Hydromulch
	NV-1	Jute Netting
	NV- 1	Synthetic Netting, Geotextiles, Etc.

(2) Design information/fact sheets

	CT-1	Permanent Mulching
	CT-1	Precast Cellular Blocks
	CT-1	Rip rap
	CT-1	Temporary Mulching
	DE-1	Erosion Control Matting
	DE-1	Stabilization (Mulch only)
	I L- 1	Non-Vegetative Stabilization (temporary and permanent mulching)
	KS-1	Aggregate Cover
	KS-1	Mulching
	KS-1	Paving
	KS-1	Rip rap
	MA-1	Dune Stabilization
	MA-1	Sand/Wind Fence
	MA-1	Slope Protection Structures
	MA-1	Stabilization (Mulch only)
	MA-2	Mechanical Stabilizalion Techniques
	MD-1	Erosion Control Matting
	MD-1	Land Grading and Structural Stabilization
	MD-1	Stabilization (Mulch only)
	ME-1	Dune Stabilization
	ME-1	Permanent Mulching
	ME-1	Rip rap
	ME- 1	Temporary Mulching
	MN-1	Mulching
	MN-1	Rip rap
	MO-6	Controlling Construction Site Erosion
	MO-6	Rip rap
	MS-1	Concrete Grid and Modular Pavement
	MS-1	Surface Roughening
	NC-1	Surface Roughing
	NH-1	Concrete Grid & Modular Pavement

NH- 1	Erosion Control Matting
NH-1	Permanent Mulching

Category	Doc. No.	Title Of Item
	NH-1	Rip rap
	NH-1	Stabilization (Mulch only)
	MH-1	Temporary Mulching
	NJ-1	Dune Stabilization
	NJ-1	Rip rap
	NJ-1	Slope Protection Structures
	NJ-1	Stabilization (Mulch only)
	NY-1	Dune Stabilization
	NY- 1	Rip rap
	NY-1	Stabilization (Mulch only)
	NY-1	Surface Roughening
	OK-1	Erosion Control with Man-made Materials
	PA-1	Rip rap
	PA-1	Slope Protection Structures
	Rl-1	Precast Cellular Blocks
	Rl-1	Rip rap
	Rl-1	Slope Protection Structures
	VA-1	Concrete Grid & Modular Pavement
	VA-2	Stabilization - Blankets & Matting
	VA-2	Rip rap
	VA-2	Stabilization (Mulch only)
	VA-2	Surface Roughening
	VT-1	Surface Roughening
	VT-2	Rip rap
	VT-2	Stabilization (Mulch only)
	WV- 1	Erosion Control Matting
	WV-1	Stabilization (Mulch only)

f. Sediment traps and barriers

(1) Standards

	AL-1	Sediment Barrier/Fence
	AL-1	Sediment Basin
	CA-1	Straw Bale Sediment Barrier
	CA-1	Filter Fence
	CA-1	Straw Bale Drop Inlet Sediment Barrier
	CA-1	Sandbag Curb Inlet Sediment Barrier
	CA-1	Filter Berm
	CA-1	Siltation Berm
	CA-1	Sediment Trap
	CA-1	Sediment Basin
	CA-2	Minimize Disturbance and Buffer Strips

CA-2 Temporary Sediment Basin

Category	Doc. No.	Title Of Item
	CA-2	Temporary Sedimenl: Traps
	CA-2	Temporary Excavated Impoundment
	CA-2	Straw Bale Dike
	CA-2	Straw Bale Sedimen1: Barriers
	CA-2	Semi-pervious Sediment Barriers
	CA-2	Rock, Log, and Straw Bale Check Dams
	CA-2	Silt Fence
	CA-2	Drop Inlet Sediment Barriers
	CA-2	Curb Inlet Sediment Barriers
	CA-3	Straw Bale Dike
	CA-3	Sediment Basin
	CA-3	Sediment Trap
	CO- 1	Sediment/Debris Trap, Pond, or Basin
	CO- 1	Terracing
	CT- 1	Sediment Barrier
	CT-1	Sediment Basin (Permanent/Temporary)
	DE-1	Rock Check Dam
	DE-1	Sediment Basin (Permanent/Temporary)
	DE- 1	Sediment Tanks (Permanent/Temporary)
	DE-1	Sediment Traps (Permanent/Temporary)
	DE-1	Straw/Hay Bale Dikes/Barriers
	FL-1	Brush Barrier
	FL-1	Sediment Basin
	FL-1	Silt Fence
	FL-1	Straw Bale Barrier
	FL-1	Temporary Sediment Basin
	FL-1	Temporary Sediment Trap
	GA-1	Rock Filter Dam
	GA-1	Sediment Barrier
	GA-1	Temporary Sediment Basin
	Hl-1	Perimeter Dike
	Hl-1	Sediment Barrier - Hay Bales, Gravel or Fabric
	Hl-1	Sediment/Debris Trap, Pond, or Basin
	Hl-1	Terracing
	Hl-1	Vegetative Fiiter Strip
	IL-2&3	Portable Sediment Tank
	IL-2	Sediment Basin
	IL-2&3	Sediment Trap
	IL-2&3	Silt Fence
	IL-2&3	Straw Bale Dikes
	IL-3	Urban Filter Strip
	IN-1	Pond
	IN-1	Rock Check Dam

IN-1 Rock Dam

Category	Doc. No.	Title Of Item
	IN-1	Sediment Basin
	IN-1	Silt Fence (Sediment Fence)
	IN-1	Straw Bale Dam (Straw Bale Filter)
	IN-1	Temporary Sediment Basin
	IN-1	Temporary Sediment Trap
	IN-1	Vegetative Filter Strip
	IN-1	Water and Sediment Control Basin (SCS, 638)
	KY-1	Filter Strip
	KY-1	Sediment Basins
	KY-1	Silt Fence
	KY-1	Straw Bale Barrier
	LA-1	Hay Bale Dike
	LA-1	Sediment Basin
	LA-1	Sediment Trap
	LA-1	Silt Fence
	MA-1	Sediment Basin (Permanent/Temporary)
	MA-1	Sediment Removal
	MA-1	Sediment Traps (Permanent/Temporary)
	MA-1	Vegetative Filter Strip
	MD-1	Sediment Basin (Permanent/Temporary)
	MD-1	Sediment Tanks (Permanent/Temporary)
	MD-1	Sediment Traps (Permanent/Temporary)
	MD-1	Stone Check Dams (PermanenttTemporary)
	MD-1	Straw/Hay Bale Dike,/Barriers
	MD-1	Super Silt Fences
	MD-2	Vegetative Filter Strip
	ME-1	Sediment Barrier
	ME-1	Sediment Basin (Permanent/Temporary)
	ME-1	Sediment Traps (Per nanent/Temporary)
	ME-1	Stone Check Dams (Permanent/Temporary)
	ME-1	Vegetative Filter Strip
	Ml-1	Buffer/Filter Strips
	Ml-1	Catch Basins
	Ml-1	Check Dams
	Ml-1	Filters (includes filter fencing)
	Ml-1	Sediment Basin
	Ml-1	Wet Detention Basins
	MN-1	Sediment Barrier- Hay Bales, Gravel or Fabric
	MO-1	Sediment (Silt) Fence
	MO-1	Sediment Basin

MO-1	Temporary Sedimen: Trap
MO-1	Temporary Straw Bale Barrier

Category	Doc. No.	Title Of Item
	MO-3	Sediment Basin
	MS-1	Constructed ~Netland
	MS-1	Detention Basin
	MS-1	Sand Fence
	MS-1	Sediment Basin (Temporary)
	MS- 1	Silt Fence
	MS-1	Straw Bale B,arrier
	NC-1	Rock Dam
	NC- 1	Sediment Basin
	NC- 1	Sediment Ba sin Design
	NC-1	Sediment Fence (Silt Fence)
	NC-1	Temporary Sediment Trap
	NE-1	Fabric Silt Fence
	NE-1	Hay Bale Silt Check
	NE-1	Pond
	NE-1	Sediment Control Storage Devices
	N E- 1	Terrace
	NH-1	Sediment Basin (Permanent/Temporary)
	NH-1	Sediment Trcaps (Permanent/Temporary)
	NH-1	Straw/Hay Bale Dike/Barriers
	NH-1	Vegetative Filter Strip
	NJ-1	Sediment Barrier
	NJ-1	Sediment Basin (Permanent/Temporary)
	NM-1	Sediment Barrier- Hay Bales, Gravel or Fabric
	NM-1	Sediment/Debris Trap, Pond, or Basin
	NM-1	Vegetative Filter Strip
	NV-1	Gravel or Rock Filter Berm
	NV- 1	Sediment/Debris Trap, Pond, or Basin
	NV-1	Storm Drain/Curb Inlet Sediment Barriers
	NV-1	Vegetative Filter Strip
	NY-1	Debris Basin
	NY-1	Rock Check Dam
	NY-1	Sediment Basin (Permanent/Temporary)
	NY-1	Sediment Traps (Permanent/Temporary)
	NY-1	Straw/Hay Bale Dikes/Barriers
	OK-1	Diversion Terrace - Level (Temporary)
	OK-1	Sediment Detention F'ond
	OK-1	Sediment Detention F'ond with Rock Spillway (Temporary)
	OK-1	Silt Fence
	OK-1	Straw Bale Barrier
	PA-1	Sediment Barrier
	PA-1	Sediment Basin (Permanent/Temporary)

PA-1	Sediment Traps (Permanent/Temporary
PA-1	Straw/Hay Bale Dikes/Barriers

Category	Doc. No.	Title Of Item
	PR-1	Perimeter Dike
	PR-1	Straw Bale Dike
	Rl-1	Rock Check Dam
	Rl-1	Sediment Basin (Permanent/Temporary)
	SC-1	Debris (or Sediment) Basin Design
	SC-1	Temporary Perimeter Dike
	SC-1	Temporary Sediment Trap
	SC-1	Temporary Straw (or Hay) Bale Barrier
	TN-1	Debris Basin
	TN-1	Sediment Control Measure, Dike
	TX-1	Debris and Sediment Basins
	TX-1	Temporary Straw (or day) Bale Barrier
	VA-1	Straw/Hay Bale Dikes/Barriers
	VA-1	Vegetative Filter Strip
	VA-2	Brush Barrier
	VA-2	Rock Check Dam
	VA-2	Sediment Basin (Perrmanent/Temporary)
	VA-2	Sediment Traps (Permanent/Temporary)
	VA-2	Stone Check Dams (Permanent/Temporary)
	VA-2	Straw/Hay Bale Dikes/Barriers
	VT-1	Interceptor
	VT- 1	Sediment Traps (Permanent/Temporary)
	VT-1	Vegetative Filter Strip
	VT-2	Sediment Basin (Permanent/Temporary)
	VT-2	Straw/Hay Bale Dikes/Barriers
	WA-1	Buffer Zone
	WA-1	Gravel or Rock Filter Berm
	WA-1	Natural Vegetative Buffering
	WA-1	Perimeter Dike
	WA-1	Sediment Barrier- Hay Bales, Gravel or Fabric
	WA- 1	Sediment/Debris Trap, Pond, or Basin
	WV-1	Rock Check Dam
	WV- 1	Sediment Basin (Permanent/Temporary)
	WV-1	Straw/Hay Bale Dikes/Barriers
	WV- 1	Vegetative Filter Strip
	WV- 1	Water and Sediment Control Basin

g. Pollution prevention

(1) Standards

AL-1	Dust Control
CA-1	Dust Control
CA-1	Fertilizer Management

Category	Doc. No.	Title Of Item
	CA-1	Road Salt Storage and Related Practices
	CA-1	Street Cleaning Pract ces
	CA-1	Underground Storage Tanks
	CA-1	Livestock Facilities
	CT-1	Dust Control
	CT-1	Silt Curtain
	CT-1	Temporary Stream Crossing
	DE-1	Dust Control
	DE-1	Silt Fence
	DE-1	Temporary Stream Crossing
	DE-1	Toxic Salt Reduction
	FL-1	Dust Control
	FL-1	Fertilizer Application Control
	FL-1	Pesticide Use Contro
	FL-1	Solid Waste Collection and Disposal
	FL-1	Source Control on Construction Sites
	FL-1	Street Cleaning
	GA-1	Dust Control on Disturbed Areas
	IL-1	Dust and Traffic Control
	IL-2&3	Dust Control
	IL-2	Temporary Access \/\ ater Crossing
	IN-1	Dust Control
	IN-1	Pond
	KS-1	Dust and Traffic Control
	KY-1	Dust and Pollutants C,ontrol
	KY-1	Fertilizer Application Control
	KY-1	Pesticide and Chemical Application
	MA-1	Algaecide Application
	MA-1	Aquatic Week Harvesting and Hydro-raking
	MA-1	Artificial Circulation
	MA-1	Deep Stagnant Water Layer Aeration
	MA-1	Deep Stagnant Water Layer Withdrawal
	MA-1	Herbicide Application
	MA-1	Permanent Stream Crossing
	MA-1	Road Salt Storage Facility
	MA-1	Sediment Removal
	MA-1	Shallow Marsh Creation
	MA-1	Vegetative Filter Strip
	MD-1	Dust Control
	MD-2	Vegetative Filter Strip
	ME-1	Dust Control
	ME-1	Permanent Stream Crossing
	ME-1	Temporary Stream Crossing

ME-1	Vegetative Filter Strip
MI-1	Dust Control

Category	Doc. No.	Title Of Item
	Ml-1	Equipment Maintenance/Storage Area
	Ml-1	Extended Detention E, Basin
	Ml-1	Fertilizer Managemert
	Ml-1	Household Hazardous Waste Disposal
	Ml-1	Infiltration Basin
	Ml-1	Infiltration Trench
	Ml-1	Oil/Grit Separators
	Ml-1	Organic Debris Disposal
	Ml-1	Pesticide Management
	Ml-1	Street Sweeping
	Ml-1	Watercourse Crossings
	Ml-1	Wet Detention Basins
	Ml-1	Wetland Crossings
	Ml-1	Winter Road Management
	MN-1	Street Sweeping
	MN-1	De-lcing Chemical Use
	MN-1	Detention Pond
	MN-1	Extended Detention F'ond
	MN-1	Fertilizer Management
	MN-1	Filter Strips
	MN-1	Floatable Skimmers
	MN-1	Litter Control
	MN-1	Oil/Grit Separators
	MN-1	Vegetated Swales
	MN-1	Wetland Treatment
	MS-1	Dust Control
	NC-1	Dust Control
	NE-1	Dust Control
	NE-1	Pond
	NH-1	Deicing Chemical Use & Storage
	NH-1	Dust Control
	NH-1	Extended Detention Dry/Wet Basin
	NH-1	Fertilizer Management
	NH-1	Litter Control
	NH-1	Silt Fence
	NH-1	Vegetative Filter Strip
	NH-1	Street Sweeping
	NJ-1	Silt Fence
	NJ-1	Temporary Stream Crossing
	NJ-2	Dust Control
	NM-1	Fertilizer Management
	NV-1	Fertilizer Management
	NV- 1	Household Hazardous Waste Management

	NV- 1	Pesticide/Herbicide Management
	NV-1	Road Salt Storage and Related Practices

Category	**Doc. No.**	**Title Of Item**
	NV-1	Solid Waste Disposal Management
	NV-1	Street Cleaning Practices
	NV-1	Welihead Protection
	NY-1	Dust Control
	NY-1	Silt Fence
	OK-1	Dust Control
	Rl-1	Dust Control
	Rl-1	Filter Fabric Basin for Pumped Dewatering Discharge
	Rl-1	Perimeter Sediment E3arrier
	Rl-1	Silt Curtain
	Rl-1	Temporary Stream Crossing
	VA-1	Deicing Chemical Use & Storage
	VA-1	Fertilizer Management
	VA-1	Nonpoint Pollution Control on Construction Sites
	VA-1	Pesticide Use Contrcl
	VA-1	Reduction of Traffic Generated Pollutants
	VA-1	Sewer System Control
	VA-1	Solid Waste Collection and Disposal
	VA-1	Vegetative Filter Strip
	VA-2	Dust Control
	VA-2	Silt Fence
	VA-2	Street Cleaning
	VA-2	Turbidity Curtain
	VA-3	Street Sweeping
	VA-3	WQ Inlets/Oil Grit
	VT-1	Vegetative Filter Strip
	VT-1	WQ Inlets/Oil Grit
	VT-2	Permanent Stream Crossing
	VT-2	Silt Fence
	WV-1	Dust Control
	WV-1	Perimeter Sediment Barrier
	WV-1	Protecting Trees During Construction
	WV-1	Silt Fence
	WV-1	Temporary Stream Crossing
	WV-1	Vegetative Filter Strip

(2) Design information/fact sheets

	IL-1	Dust and Traffic Control

	KS-1	Dust and Traffic Control
	MN-1	De-Icing Chemical Use
	MN-1	Detention Pond
	MN-1	Extended Detention Pond
	MN-1	Fertilizer Management

Category	**Doc. No.**	**Title Of Item**
	MN-1	Filter Strips
	MN- 1	Floatable Skimmers
	MN-1	Litter Control Street Sweeping
	MN-1	Oil/Grit Separators
	MN-1	Vegetated Swales
	MN-1	Wetland Treatment
	MS-1	Dust Control
	NC- 1	Dust Control

h. Water Management

(1). Runoff control

(a.) Standards

AL-1	Diversion
AL-1	Stormwater Retention Structure
CA-1	Diversion Dike
CA-1	Diversion Swale
CA-1	Perimeter Dike
CA-1	Perimeter Swale
CA-1	Interceptor Dike
CA-1	Interceptor Swale
CA-1	Interception Trench
CA-1	Infiltration Trench
CA-1	Dry Well
CA-1	French Drain
CA-2	Temporary Dike
CA-2	Temporary Swale
CA-2	Grassed Waterways Swales and Dikes
CA-2	Rock Lined Channel
CA-2	Rip rap
CA-2	Water Bars and Rolling Dips
CA-3	Diversion Dike
CA-3	Cross Road Drain
CA-3	Perimeter Dike
CA-3	Interceptor Swale
CA-3	Perimeter Swale

CA-3	Diversion
CA-3	Level Spreader
CA-3	Infilitration Trench
CA-3	Slope Terracing
CO-1	Diversion
CO-1	Terracing
CT-1	Detention Basin/Ponds

Category	Doc. No.	Title Of Item
	CT-1	Diversions (Temporary/Permanent)
	CT-1	Grade Stabilization Structure (Permanent/Temporary)
	CT-1	Grassed Vegetative Waterway
	CT-1	Lined Waterway (Permanent)
	CT-1	Outlet Protection/Structure
	CT-1	Rip rap
	CT-1	Temporary Channel Lining
	DE-1	Diversions (Temporary/Permanent)
	DE-1	Earth Dikes
	DE-1	Grassed Vegetative Waterway
	DE-1	Outlet Protection/Structure
	DE-1	Perimeter Dike/Swale
	DE-1	Pipe Drop Structure
	DE-1	Storm Drain Inlet Protection
	DE-1	Sump Pits
	DE-1	Temporary Swale
	FL-1	Detention Basins
	FL-1	Diversion
	FL-1	Exfiltration Trenches
	FL-1	Parking Lot Storage
	FL-1	Porous Asphalt Pavement
	FL-1	Retention Basins
	FL-1	Right-of-Way Diversion
	FL-1	Rooftop Runoff Disposal
	FL-1	Temporary Diversion Dike
	FL-1	Temporary Fill Diversion
	GA-1	Buffer Zone
	GA-1	Diversion
	Hl-1	Diversion
	Hl-1	Dry Well/Vertical Drain
	Hl-1	Interceptor Swale/Drainage Ditch
	Hl-1	Perimeter Dike
	Hl-1	Terracing
	IL-2&3	Diversion
	IL-2&3	Earth Dikes
	IL-2	Perimeter Dike/Swale
	IL-2&3	Sump Pit
	IL-2&3	Temporary Storm Drain Diversion
	IL-2&3	Temporary Swale
	IL-3	Infiltration Trench
	IL-3	Right-of-Way Diversion
	IN-1	Diversion
	IN-1	Diversion Dike (Temporary Perimeter

Protection)
IN-1 Permanent Diversion

Category	Doc. No.	Title Of Item
	IN-1	Pond
	IN-1	Rock Check Dam
	IN-1	Temporary Diversion
	IN-1	Water Bar (Right-of-Way Diversion)
	KY-1	Diversion
	KY-1	Storm Water Retention Basins
	KY-1	Water Bar
	LA-1	Dikes
	LA-1	Earthen Diversions
	LA-1	Pipe Slope Drain
	LA-1	Swales
	MA-1	Block & Gravel Inlet Dike
	MA-1	Diversions (Temporary/Permanent)
	MA-1	Grade Stabilization Structure (Permanent/Temporary)
	MA-1	Grassed Vegetative Waterway
	MA-1	Grasslined Channels
	MA-1	Lined Waterway (Permanent)
	MA-1	Retention Basin
	MA-1	Rock Dam
	MA-1	Shallow Marsh Creation
	MA-1	Sod Drop Inlet Protection
	MA-1	Storm Drain Inlet Protection
	MA-1	Temporary Excavated Drop Inlet Protection
	MA-1	Underground Tanks
	MA-2	Bare Channels
	MA-2	Diversions (Temporary/Permanent)
	MA-2	Enclosed Drainage
	MA-2	Infiltration Basin/Pit
	MA-2	Storm Drains
	MD-1	Earth Dikes
	MD-1	Infiltration Trench
	MD-1	Lined Waterway (Permanent)
	MD-1	Pipe Slope Drains
	MD-1	Removable Pump Stations
	MD-1	Rip rap Channels
	MD-1	Rock Outlet Protection
	MD-1	Sump Pits
	MD-2	Dry Well
	MD-2	Porous Pavement
	MD-2	Vegetated Swales
	ME-1	Diversions (Temporary/Permanent)
	ME-1	Grassed Vegetative Waterway

	ME-1	Infiltration Basin/Pit
	ME-1	Level Spreader

Category	**Doc. No.**	**Title Of Item**
	ME-1	Lined Waterway (Permanent)
	ME-1	Paved Flume/Chutes
	ME-1	Pipe Inlet Protection
	ME-1	Pipe Outlet Protection
	ME-1	Pond Construction
	ME-1	Rip rap
	ME-1	Road Ditch Turnout
	ME-1	Storm Drain Inlet Protection
	ME-1	Temporary Slope Drain
	ME-1	Temporary Stream Diversion
	ME-1	Vegetated Swales
	ME-1	Water Conveyance Conduits
	Ml-1	Check Dams
	Ml-1	Dewatering
	Ml-1	Diversion
	Ml-1	Infiltration Basin
	Ml-1	Infiltration Trench
	Ml-1	Parking Lot Storage
	Ml-1	Porous Asphalt Pavement
	Ml-1	Roof Top Storage
	Ml-1	Wet Detention Basins
	MO-1	Permanent Diversion Dike
	MO-1	Right-of-Way Diversion
	MO-1	Temporary Diversion Dike
	MO-1	Temporary Perimeter Dike
	MO-3	Diversion
	MS-1	Buffer Zone
	MS-1	Diversion
	MS-1	Diversion (Temporary)
	MS-1	Exfiltration Trench
	MS-1	Parking Lot Storage
	MS-1	Stormwater Retention Basins
	MS-1	Water Bar
	NC-1	Diversion Dike (Perimeter Protection)
	NC-1	Permanent Diversions
	NC-1	Right-of-Way Diversions (Water Bars)
	NC-1	Temporary Diversions
	NE-1	Diversion
	NE-1	Pond
	NE-1	Terrace
	NH-1	Detention Basin/Ponds

NH-1	Diversions (Temporary/Permanent)
NH-1	Dry Well
NH-1	Earth Dikes
NH-1	Extended Detentior Dry/Wet Basin

Category	Doc. No.	Title Of Item
	NH-1	Grade Stabilization Sructure (Permanent/Temporary)
	NH-1	Grassed Vegetative Waterway
	NH-1	Infiltration Trench
	NH-1	Level Spreader
	NH-1	Outlet Protection/Structure
	NH-1	Parking Lot Storage
	NH-1	Paved Flume/Chutes
	NH-1	Pipe Slope Drains
	NH-1	Retention Basin
	NH-1	Rip rap
	NH-1	Storm Drain Inlet Protection
	NH-1	Storm Drains
	NH-1	Sump Pits
	NH-1	Vegetated Swales
	NJ-1	Diversions (Temporary/Permanent)
	NJ-1	Conduit Outlet Protection
	NJ-1	Detention Basin/Ponds
	NJ-1	Grade Stabilization Structure (Permanent/Temporary)
	NJ-1	Grassed Vegetative Waterway
	NJ-1	Lined Waterway (Permanent)
	NJ-1	Parking Lot Storage
	NJ-1	Rip rap
	NJ-1	Storm Drain Inlet Protection
	NJ-1	Subsurface Drain
	NJ-1	Temporary Channel Lining
	NJ-1	Underground Tanks
	NM-1	Diversion
	NV-1	Diversion
	NV-1	Diversion Dam
	NV-1	Dry Well/Vertical Drain
	NV-1	French Drain
	NV-1	Infiltration Trench
	NV-1	Interceptor Swale/Drainage Ditch
	NV-1	Snow Disposal From Roads and Developed Areas
	NV-1	Underground Storage Tanks
	NV-1	Waterbreaks or Waterbars
	NY-1	Diversions (Temporary/Permanent)
	NY-1	Drain Diversion
	NY-1	Earth Dikes
	NY-1	Grade Stabilization Structure (Permanent/Temporary)

Category	Doc. No.	Title Of Item
	NY-1	Grassed Vegetative Waterway
	NY-1	Level Spreader
	NY-1	Lined Waterway (Permanent)
	NY- 1	Paved Channel (Conc.)
	NY-1	Perimeter Dike/Swale
	NY-1	Rip rap
	NY-1	Storm Drain Inlet Protection
	NY-1	Water Bars
	OK-1	Diversion Terrace Graded
	OK-1	Right-of-Way Diversion (Temporary)
	PA-1	Lined Waterway (Permanent)
	PA-1	Rip rap
	PA-1	Rock Apron Outlet Protection
	PA-1	Vegetated Swales
	PR-1	Diversion
	PR-1	Diversion Dike (Temporary)
	PR-1	Interceptor Dike (Temporary)
	PR-1	Interceptor Swale (Temporary)
	PR-1	Perimeter Swale (Temporary)
	Rl-1	Detention Basin/Ponds
	Rl-1	Diversions (Temporary/Permanent)
	Rl-1	Grade Stabilization Structure (Permanent/Temporary)
	Rl-1	Grassed Vegetative Waterway
	Rl-1	Level Spreader
	Rl-1	Lined Waterway (Permanent)
	Rl-1	Rip rap
	Rl-1	Storm Drain Inlet Protection
	SC-1	Diversion
	SC-1	Diversion Design
	SC-1	Temporary Diversion Dike
	SC-1	Temporary Intercepl:or Dike
	TN-1	Diversion
	TX-1	Diversions
	VA-2	Rip rap
	VA-1	Cistern Storage
	VA-1	Conventional Flow Regulators
	VA-1	Conveyance System Storage
	VA-1	Fluidic Flow Regulators
	VA-1	Grassed Vegetative Waterway
	VA-1	Infiltration Basin/Pit
	VA-1	Level Spreader
	VA-1	Parking Lot Storage
	VA-1	Paved Flume/Chutes

	VA-1	Porous Pavement
	VA-1	Rooftop Detention
	VA-1	Rooftop Runoff Disposal
	VA-1	Seepage Areas
	VA-2	Culvert Inlet Protection

Category	**Doc. No.**	**Title Of Item**
	VA-2	Dewatering Structure
	VA-2	Diversions (Temporary/Permanent)
	VA-2	Pipe Slope Drains
	VA-2	Rock Outlet Protection
	VA-2	Storm Drain Inlet Protection
	VA-2	Stormwater Conveyance Channel
	VA-2	Subsurface Drain
	VA-2	Temporary Fill Diversion
	VA-2	Temporary ROW Diversion
	VA-2	Temporary Slope Drain
	VA-3	Infiltration Trench
	VA-3	Porous Pavement
	VA-3	Underground Tanks
	VA-3	Vegetated Swales
	VT-1	Dikes/Swales
	VT-1	Snow Fencing
	VT-2	Conduit Outlet Protection
	VT-2	Diversions (Temporary/Permanent)
	VT-2	Lined Waterway (Permanent)
	VT-2	Rip rap
	VT-2	Storm Drain Inlet Protection
	VT-2	Subsurface Drain
	WA-1	Diversion
	WA-1	Gradient Terrace
	WA-1	Interceptor Dike
	WA-1	Interceptor Swale/Drainage Ditch
	WA-1	Perimeter Dike
	WA-1	Swale Crossing
	WA-1	Trapezoidal Channel Diversion
	WV-1	Diversions (Temporary/Permanent)
	WV-1	Grade Stabilization Structure (Permanent/Temporary)
	WV-1	Grassed Vegetative Waterway
	WV-1	Infiltration Basin/Pit
	WV-1	Infiltration Trench
	WV-1	Lined Waterway (Permanent)
	WV-1	Open Channel
	WV-1	Outlet Protection/Structure

WV-1	Storm Sewers
WV-1	Underground Outlet
WV-1	Waterways

(2) Design information/fact sheets

IL-1	Diversions (temporary and permanent)
KS-1	Cistern Storage

Category	Doc. No.	Title Of Item
	K S-1	Constricted Downspouts of Roofs
	K S-1	Contoured Landscape
	K S-1	Detention Basin
	K S-1	Detention Reservoir
	K S-1	Diversion Measures
	K S-1	Diversions
	K S-1	Gravel Trenches
	K S-1	Groundwater Recharge
	K S-1	Increased Roof Roughness
	K S-1	Mulched Planters
	K S-1	Pool or Fountain Storage
	K S-1	Porous Pavement
	K S-1	Rooftop Gardens
	K S-1	Sod Roof Cover
	K S-1	Vegetated Ponding Areas
	MN-1	Detention Pond
	MN-1	Diversions
	MN-1	Extended Detention Pond
	MN-1	Infiltration Basin
	MN- 1	Infiltration Trench
	MN- 1	Temporary Diversion
	MN-1	Temporary Right-of-Way Diversion
	MN-1	Vegetated Swales
	MO-6	Diversions
	MS-1	Diversion
	MS-1	Diversion (Perimeter Protection)
	MS-1	Diversion (Temporary)
	MS-1	Parking Lot Storage
	MS-1	Stormwater Retention Basins
	MS-1	Water Bar
	NC-1	Diversions Dike
	NC-1	Permanent Diversiors
	NC-1	Right-of-Way Divisions (Water Bars)
	NC-1	Temporary Diversions
	SC- 1	Vegetation
	TX-1	Diversions
	TX-1	Ponds and Retarding Structures

b. Water conveyance

(1) Standards

	AL-1	Down Drain Structure
	AL-1	Paved Flume

AL-1 Water Conveyance Channel

Category	Doc. No.	Title Of Item
	AL-1	Waterway or Storm
	CA-1	Flexible Downdrain
	CA-1	Pipe Slope Drain
	CA-1	Sectional Downdrain
	CA-1	Chutes, Flumes, or Spillways
	CA-1	Permanent Waterways
	CA-2	Temporary Slope Drain
	CA-3	Stone Center Grassed Waterway
	CA-3	Access Road Rock Lined Ditch
	CA-3	Lined Ditch
	CO-1	Chutes, Flumes, or Spillways
	CO-1	Grassed Waterway
	CO-1	Rock, Lined or Paved Waterway/Ditch
	CO-1	Sod Chute Spillway
	CO-1	Stone Center Grassed Waterway
	FL-1	Grassed Waterways and Swales
	FL-1	Paved Flume
	FL-1	Stormwater Conveyance Channel
	FL-1	Temporary Slope Drain
	GA-1	Level Spreader
	GA-1	Permanent Down Drain Structure
	GA-1	Storm Drain Outlet Protection
	GA-1	Temporary Down Drain Structure
	GA-1	Vegetated Waterway or Stormwater
	Hl-1	Chutes, Flumes, or Spillways
	Hl-1	Flexible Downdrain Structure
	Hl-1	Grassed Waterway
	IL-2&3	Grassed Waterway
	IL-2	Lined Waterway or Outlet
	IN-1	Concrete Block Chute?
	IN-1	Grass-Lined Channel
	IN-1	Grassed Waterway
	IN-1	Lined Waterway or Outlet
	IN-1	Open Channel
	IN-1	Reinforced Vegetated Chute
	IN-1	Rip rap-Lined Channel
	IN-1	Rock Chute
	IN-1	Temporary Slope Drain
	IN-1	Underground Outlet
	KY-1	Paved Flume
	KY-1	Waterway
	LA-1	Grassed Waterway
	Ml-1	Grassed Waterway
	Ml-1	Stormwater Conveyance Channels

	MO-1	Grass-Lined Channel
	MO-1	Paved Flume or Chule

Category	**Doc. No.**	**Title Of Item**
	MO-1	Rip rap and Paved Channels
	MO-1	Temporary Slope Drain
	MO-3	Grassed Waterway
	MO-3	Roadside Erosion Control and Drainage
	MO-3	Underground Drains
	MS-1	Grassed Waterway
	MS-1	Grassed Waterway
	MS-1	Level Spreading
	MS-1	Lined Waterway or Outlet
	MS-1	Paved Flume
	MS-1	Slope Drain
	MS-1	Slope Drain (Temporary)
	NC-1	Design of Stable Channels and Diversions
	NC-1	Grass-Lined Channels
	NC-1	Paved Flumes (Chutes)
	NC-1	Rip rap-Lined and Paved Channels
	NC-1	Temporary Slope Drains
	NE-1	Grassed Waterway
	NM-1	Grassed Waterway
	NM-1	Rock, Lined or Paved Waterway/Ditch
	NM-1	Stone Center Grassed Waterway
	NV-1	Chutes, Flumes, or Spillways
	NV-1	Culverts
	NV- 1	Grassed Waterway
	NV-1	Rock, Lined or Paved Waterway/Ditch
	OK-1	Level Spreader
	OK-1	Waterway or Outlet
	PR-1	Grassed Waterway Cesign
	PR-1	Level Spreader
	TN-1	Grassed Waterway Outlet
	TX-1	Cleaning and Snagging
	TX-1	Concrete Chute or Flume
	TX-1	Grassed Waterway or Outlets
	TX-1	Lined Water or Outlet
	TX- 1	Open Channel
	TX- 1	Storm Sewers
	TX-1	Stream Channel Construction
	WA-1	Flexible Downdrain S ructure
	WA- 1	Grassed Waterway
	WA-1	Pipe Slope Drain

(2) Design information/fact sheets

IL-1	Enclosed Drainage Structures (storm sewers)

Category	Doc. No.	Title Of Item
	IL-1	Pipe Spillways
	IL-1	Waterways
	IL-1	Weir Spillways
	KS-1	Bare Channel
	KS-1	Box Inlet Drop Spillway
	KS-1	Chute Spillway
	KS-1	Drop Inlet Pipe Spillway
	KS-1	Drop Spillway
	KS-1	Lined Channel
	KS-1	Rock Chute
	KS-1	Storm Drains
	KS-1	Straight Pipe Spillwcy
	KS-1	Underground Drain Pipes
	KS-1	Underground Drains
	KS-1	Vegetative Channel
	KS-1	Waterways and Lined Channels
	MN-1	Storm Water Conveyance Channel
	MN-1	Temporary Slope Drain
	MO-6	Rock Chute
	MO-6	Underground Drain Pipes
	MO-6	Waterways and Lined Channels

(3) Inlet protection

(a) Standards

	AL- 1	Inlet Protector
	AL- 1	Retrofitting
	CA-1	Drop Inlet
	GA-1	Inlet Sediment Trap
	GA-1	Retrofitting
	IL-2	Storm Drain Inlet Protection
	IL-3	Inlet Protection - Block and Gravel
	IL-3	Inlet Protection - Excavated Drain
	IL-3	Inlet Protection - Fabric Drop
	IN-1	Basket Curb Inlet Protection
	IN-1	Block and Gravel Curb Inlet Protection
	IN-1	Block and Gravel Drop Inlet Protection
	IN-1	Excavated Drop Inlet Protection
	IN-1	Fabric Drop Inlet Protection
	IN-1	Gravel Curb Inlet Protection
	IN-1	Gravel Donut Drop Inlet Protection
	IN-1	Sandbag Curb Inlet Protection
	IN-1	Slotted Barrel Drop Inlet Protection

IN-1 Straw Bale Drop Inlet Protection

Category	Doc. No.	Title Of Item
	KY-1	Storm Drain Inlet Protection
	MO-1	Block and Gravel Inlet Protection (Temporary)
	MO-1	Excavated Drop Inlet Protection (Temporary)
	MO-1	Fabric Drop Inlet Protection (Temporary)
	MS-1	Protection (Block and Gravel, Straw Bale, Silt Fence, Excavated Inlet, Sod Inlet)
	MS-1	Storm Drain Inlet
	MS-1	Storm Drain Inlet Protection
	NC-1	Block and Gravel Inlet Protection
	NC-1	Excavated Drop Inlet Protection
	NC-1	Fabric Drop Inlet Protection
	NC-1	Sod Drop Inlet Protection
	NE-1	Gravel Curb Inlet Sediment Filter
	NV-1	Drop Inlet/Catch Basin
	TN-1	Urban Gutter Drain Sediment Barrier

(b) Design information/fact sheets

	MN-1	Storm Drain Inlet Protection

(4) Outlet protection

(a) Standards

	AL-1	Outlet Protection
	CA-1	Curb and Gutter
	CA-1	Culverts
	CA-1	Storm Drains
	CA-1	Paved Driveways
	CA-1	Slotted Drains
	CA-1	Outlet Protection
	CA-2	Energy Dissipator
	CA-2	Permanent Storm Drain Outlet
	CA-3	Stone Outlet Structure
	CA-3	Storm Drain Outlet Protection
	FL-1	Level Spreader
	FL-1	Outlet Protection
	IL-2	Grade Stabilization Structure (Slope Protection)
	IL-2&3	Rock Outlet Protection
	IL-3	Grassed Lined Channel
	IL-3	Level Spreader

	IN-1	Grade Stabilization Structure
	KY-1	Outlet Protection

Category	**Doc. No.**	**Title Of Item**
	LA-1	Level Spreader
	LA-1	Stone Outlet Structure
	Ml-1	Grade Stabilization Structure
	Ml-1	Stabilized Outlets
	MO-1	Level Spreader
	MO-1	Outlet Stabilization Structures
	MO-3	Grade Stabilization Structure
	MS-1	Level Spreader
	MS-1	Rock Outlet Protection
	NC-1	Design of Rip rap Outlet Protection
	NC-1	Level Spreader
	NC-1	Outlet Stabilization Structure
	NE-1	Grade Stabilization Structure (Slope Protection)
	NM-1	Storm Drain Outlet Protection
	NV-1	Level Spreader
	NV- 1	Storm Drain Outlet P rotection
	OK-1	Outlet Protection
	PR-1	Stone Outlet Structure
	PR-1	Storm Drain Outlet Protection
	SC-1	Level Spreader (Temporary)
	SC-1	Temporary Gravel Outlet Structure
	WA-1	Level Spreader
	WA-1	Stone Outlet
	WA-1	Storm Drain Outlet Protection

(b) Design information/fact sheets

IL-1	Outlet Protection Structures (lined apron)
MN-1	Outlet Protection

(5) Drainage

(a) Standards

CA-1	Subsurface Drain
CA-3	Subsurface Drain
FL-1	Subsurface Drains
FL-1	Underdrains and Stormwater Filter Systems
IL-2&3	Subsurface Drain
IL-3	Temporary Slope Drain

IN-1	Subsurface Drain
KY-1	Subsurface Drain

Category	Doc. No.	Title Of Item
	LA-1	Subsurface Drain
	Ml-1	Dewatering
	Ml-1	Subsurface Drain
	MS-1	Filtration Systems
	MS-1	Subsurface Drain
	NC-1	Subsurface Drain
	NV-1	French Drain
	NV-1	Infiltration Trench
	OK-1	Permanent Undergrcund Drain
	PR-1	Subsurface Drainage
	TN-1	Drains
	TX-1	Drainage

(b) Design information/fact sheets

KS-1	Draining Wet Areas
KS-1	Underground Drains
MN-1	Subsurface Drain
MO-6	Draining Wet Areas

(6) Irrigation

(a) Standards

AL- 1	Irrigation
NM-1	Irrigation
NV-1	Irrigation
NV-1	Water Spreading
TX-1	Irrigation

(7) Grade control

(a) Standards

AL-1	Channel Stabilization
AL-1	Check Dam
AL-1	Drop Structure
CA-1	Check Dams
CA-3	Grade Stabilization Structure (Paved Chute or Flume)
CA-3	Grade Stabilization Structure (Pipe Slope Drain)
CA-3	Grade Stabilization Structure (Gabion Drop Structure)
CO-1	Grade Stabilization Structure

FL-1	Check Dams
FL-1	Waterway Drop Structures

Category	Doc. No.	Title Of Item
	GA-1	Channel Stabilization
	GA-1	Check Dams
	GA-1	Grade Stabilization Structures
	Hl-1	Grade Stabilization Structure
	IN-1	Rock Check Dam
	IN-1	Stream Channel Stabilization
	KY-1	Check Dams
	KY-1	Structures
	LA-1	Chute Grade Stabilization Structure
	LA-1	Grade Stabilization Structure
	Ml-1	Check Dams
	MS-1	Check Dam
	MS-1	Grade Stabilization Structure
	NC-1	Check Dam
	NC-1	Grade Stabilization Structure
	NV-1	Check Dam - Rock, Timber, Concrete, Metal, Etc.
	OK-1	Check Dam
	OK-1	Grade Stabilization Dam and Sediment Basin
	PR-1	Grade Stabilization Structure (Paved Chute or Flume) (Pipe Slope Drain)
	SC-1	Grade Stabilization Structure
	TN-1	Grade Stabilization Structure
	TX-1	Grade Stabilization Structure
	WA-1	Check Dam - Rock, Timber, Concrete, Metal, Etc.

(b) Design information/fact sheets

K S-1	Box Inlet Drop Spillway
K S-1	Chute Spillway
K S-1	Drop Inlet Pipe Spill~vay
K S-1	Drop Spillway
K S-1	Rock Chutes
K S-1	Straight Pipe Spillway
MN-1	Grade Stabilization Structure

i. Bank and slope protection

(a) Standards

AL-1	Retaining Wall

CA-1	Rock Retaining Wall
CA-1	Gabion Wall

Category	Doc. No.	Title Of Item
	CA-1	Wood Retaining Wall
	CA-1	Rock Rip rap
	CA-1	Slope Shaping
	CA-1	Surface Roughening
	CA-1	Brush Matting
	CA-3	Flexible Pipe Slope Drain
	CA-3	Rip rap
	CT-1	Gabions
	CT-1	Prefabricated Retaining Wall
	CT-1	Reinforced Concrete Retaining Wall
	CT-1	Rip rap
	CT-1	Temporary Channel Lining
	CT-1	Vegetative Streambank Stabilization
	GA-1	Retaining Wall
	IL-2&3	Vegetative Stabilizalion of Channels and Steep Slopes
	IL-3	Structural Streambank Stabilization
	IN-1	Rip rap
	IN-1	Stream Channel Stabilization
	IN-1	Streambank and Shoreline Protection
	KY-1	Structural Streambank Stabilization
	KY-1	Vegetative Streambank Stabilization
	LA-1	Concrete Block Retaining Wall
	MA-1	Slope Protection Structures
	MA-1	Streambank Protection (Structural)
	MA-1	Vegetative Streambank Stabilization
	MD-1	Gabions
	MD-1	Rip rap Channels
	ME-1	Gabions
	ME-1	Retaining Walls
	ME-1	Rip rap
	ME-1	Vegetative Streambank Stabilization
	Ml- 1	Rip rap
	Ml-1	Slope/Shoreline Stabilization
	Ml-1	Stream Bank Stabilization
	MO- 1	Rip rap
	MO-1	Structural Streambank Protection
	MO-1	Vegetative Streambank Protection
	MS-1	Rip rap
	MS-1	Structural Streambank Stabilization
	NC- 1	Structural Streambank Stabilization
	NC-1	Vegetative Streambank Stabilization
	NE-1	Rip rap
	NE-1	Vegetative Stabilization of Channels

	and steep Slopes
NH-1	Gabions

Category	Doc. No.	Title Of Item
	NH-1	Rip rap
	NJ-1	Rip rap
	NJ-1	Slope Protection Structures
	NJ-1	Temporary Channel Lining
	NV-1	Retaining Wall - Masonry, Timber, Gabion, Etc.
	NV-1	Streambank/Shoreline Rip rap
	NY-1	Retaining Walls
	NY-1	Rip rap
	NY-1	Streambank Protection (Structural)
	OK-1	Rip rap
	OK-1	Streambank Stabilization
	PA-1	Gabions
	PA-1	Rip rap
	PA-1	Slope Protection Structures
	PA-1	Streambank Protectian (Structural)
	RI-1	Gabions
	RI-1	Prefabricated Retaining Wall
	RI-1	Reinforced Concrete Retaining Wall
	RI-1	Rip rap
	RI-1	Slope Protection Structures
	RI-1	Vegetative Streambank Stabilization
	SC-1	Streambank Protection
	TN-1	Streambank Protection
	TX-1	Streambank Protection
	VA-2	Rip rap
	VA-2	Vegetative Streambank Stabilization
	VA-2	Streambank Protection (Structural)
	VT-2	Rip rap
	WA-1	Retaining Wall- Masonry, Timber, Gabion, Etc.
	WA-1	Streambank/Shoreline Rip rap
	WV-1	Retaining Walls
	WV-1	Streambank Protection (Structural)

(b.) Design information/fact sheets

	KS-1	Retaining Walls
	KS-1	Rip rap
	MN-1	Rip rap
	MN-1	Structural Streambank Protection
	MO-6	Retaining Walls
	MO-6	Rip rap

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	CA-1	Snow Disposal Praclices
	CA-3	Lot Grading
	CO-1	Noxious Weed Control
	IL-3	Urban Stormwater \//etlands
	MS-1	Buffer Zone
	MS-1	Construction Road Stabilization
	MS-1	Exfiltration Trench
	MS-1	Stream Crossing
	NC-1	Permanent Stream C:rossing
	NC-1	Practical Selection Guide for Recommended Practices
	NV-1	Snow Disposal from Roads and Developed Areas
(9) Materials		
(a) Standards		
	AL-1	Gabion
	AL-1	Rip rap
	FL-1	Rip rap
	GA-1	Fiberglass Blanket
	GA-1	Gabion
	GA-1	Organic Material Fiber Blanket
	GA-1	Permanent Soil Reinforcing Mat
	GA-1	Rip rap
	KY-1	Rip rap
	ME-1	Geotextiles
	ME-1	Topsoil Substitutes/Soil Amendments
	Ml-1	Pond Sealing and Lining
	NY-1	Recreation Area Improvement
	NY-1	Topsoil Substitutes / Soil Amendments
	NC-1	Rip rap
	PA-2	Topsoil Substitutes/ Soil Amendments
	PR-1	Protective Materials for Channels
	PR-1	Rip rap

Category	Doc. No.	Title Of Item
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	IN-1	Guide for the Use of Geotextiles
	IN-1	INDOT Coarse Aggregate (CA) Size Specifications
(10) Shorezone practices		
	(a) Standards	
	CA-1	Protection of Shorezone Vegetation
	CA-1	Revetments
	CA-1	Bulkheads
	CA-1	Jetties
	CA-1	Breakwaters
	CA-1	Beach Replenishment
	CA-1	Dredging
	CA-1	Turbidity Curtain
	CA-1	Pump-out Facilities
	CA-1	Boat and Marina Maintenance
E. Operation and maintenance measures		
	(a) Standards	
	Ml-1	Equipment/Maintenance Storage Area
	Ml-1	Fertilizer Management
	Ml-1	Lawn Maintenance
	Ml-1	Pesticide Management
	Ml-1	Pond Construction and Management
	Ml-1	Soil Management (includes pH control)
	Ml-1	Winter Road Management
	OK-1	Construction Road Management
	(b) Design Information/fact sheets	
	MN-1	Catch Basin Cleaninc
	MN-1	De-lcing Chemical Use
	MN-1	Fertilizer Managemert
	MN-1	Street Sweeping

IV. Appendix I: Representative Examples

(To be developed)

DRAFT

National Catalog of Erosion and Sediment Control and Stormwater Management Guidelines for Community Assistance

Appendix - 1
Representative Examples

U.S. Department of Agriculture
National Resources Conservation Service
Community Assistance and Resource Development
February 1996

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A. Planning

A. Planning

1) Site Planning Process -
   Source: Illinois, IL-1

2) Model Erosion and Sediment Control Plan
   Source: Illinois, IL-1

3) Preparing the Erosion and Sedimentation Control Plan
   Source: North Carolina, NC-1

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3
site planning process

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1. INTRODUCTION TO PLANNING

When urban planning is begun, the area for development is often an environment that has been exposed for a very long time to the effects of many natural modifying factors. Development of new communities must, therefore, take this into account. Land use planning encompasses many disciplines. Ideally, the atmospheric, hydrologic, topographic, soil, geologic, biologic, and cultural data should mesh and provide the basis for a plan that cooperates with nature, yet is livable for man. This means recognizing the suitability and limitations of a site for a specific development, analyzing any conflicts with existing land use and, finally, determining appropriate constraints and then planning the proposed use. The objective is to encourage compatible land use and to discourage land use that conflicts with natural limitations and balances.

2. PLANNING PRINCIPLES

Over the years the following principles have been proven to contribute to appropriate urban land development and to provide effective soil erosion and sedimentation control. Builders and developers will find that these principles, when skillfully applied, are effective planning guidelines for land being converted to urban uses.

1. Select land that has desirable natural drainage and soils with good potential for the intended development. Suitability for different uses will vary with topography, drainage pattern, and soil types. Knowledge of these characteristics will be invaluable in identifying and evaluating potential problems. Detailed soil surveys and geological investigations should be made on questionable soils to assess their suitability for the intended development.

2. Delineate areas with severe limitations such as floodplains, steep slopes, drainageways, existing bodies of water, and unstable soils for appropriate open space uses.

3. Delineate natural vegetation to be retained and protected during construction whenever possible. Naturally-existing areas of grass, shrubs, and trees help to control soil erosion while enhancing the attractiveness of the project. Ultimately the total value of the development is increased.

4. Orient the development plan to the site so that minimum earth grading and other site preparation is required. Phase the development plan in workable units and plan a construction sequence to keep disturbed areas small and bare for the shortest period of time.

5. Plan for the safe disposal of increased water runoff caused by rooftops, pavement, and straightened waterways. Complete storm drainage facilities and make them operational as soon as possible.

6. Plan the development's streets to fit the contour of the land, avoiding long stretches of steep grades. Complete all designated paving as soon as possible.

7. Stockpile topsoil where practical, protect it adequately from erosion, and later spread it over the areas to be permanently vegetated.

8. Plan, install, and maintain temporary and permanent measures appropriate for controlling runoff, providing drainage, and reducing sedimentation to off-site areas during and after development.

9. Sprinkle water or apply dust suppressors on construction sites and haul roads frequently to minimize dust leaving the construction site.

10. Avoid disposal of fill or other material in floodplains or drainageways unless adequate means are developed to store and discharge normal flood flows safely.

3. GENERAL SITE PLANNING PROCEDURES

Natural Resource and Environmental Inventory

All of the urban site inventory data should be assembled in a readily understood form since many people of varying backgrounds will be reviewing and acting on the information submitted. A site location map, a site topographic map, a soil map, an existing vegetation map, and an off-site land use map are all valuable planning resources.

Site Location Map

Besides the obvious purpose of giving the position of a property in legal terms of Principal Meridian, Township, Range, and Section, a site location map shows the site's relationship to roads and other environmental features such as major drainageways, drainage divides.

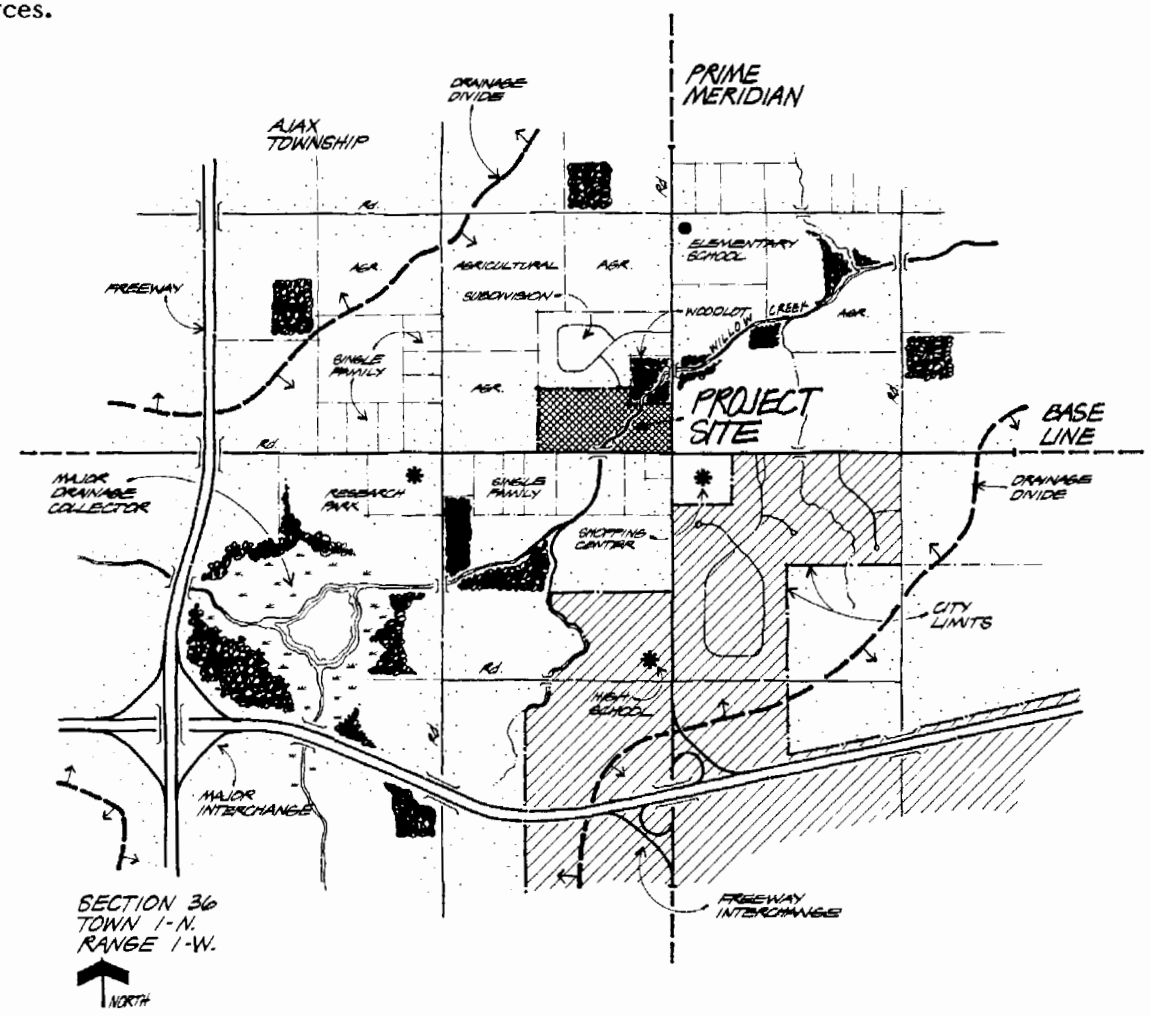


Figure 3-1: Site Location Map

Topographic Map

A detailed topographic map is required by most governmental agencies regulating developmental planning. These topographic maps are usually prepared at a scale of 1"=100' or 50' with a contour interval of 1-2'. The maps are typically correlated with the site's boundary survey and are usually referenced to USGS datum. This facilitates analysis and evaluation of floodplain data and drainage patterns both on-site as well as off-site at both spectrums of the tributary watershed.

Field Survey - Traditional manually accomplished survey. Time consuming. Most expensive for large land parcels.

Aerial Survey - Existing conditions and topography interpreted from aerial photographs. Very accurate. Flights limited to certain times of the year.

USGS Maps - Valuable for evaluating drainage patterns and development trends for large areas. Usually not enough detail for site specific planning.

By analyzing the contour elevations, such physical features as grades, drainage patterns, drainage divides, and depressional areas can be identified. Additional topographic information of a more general nature is available from various sources as listed in Appendix.

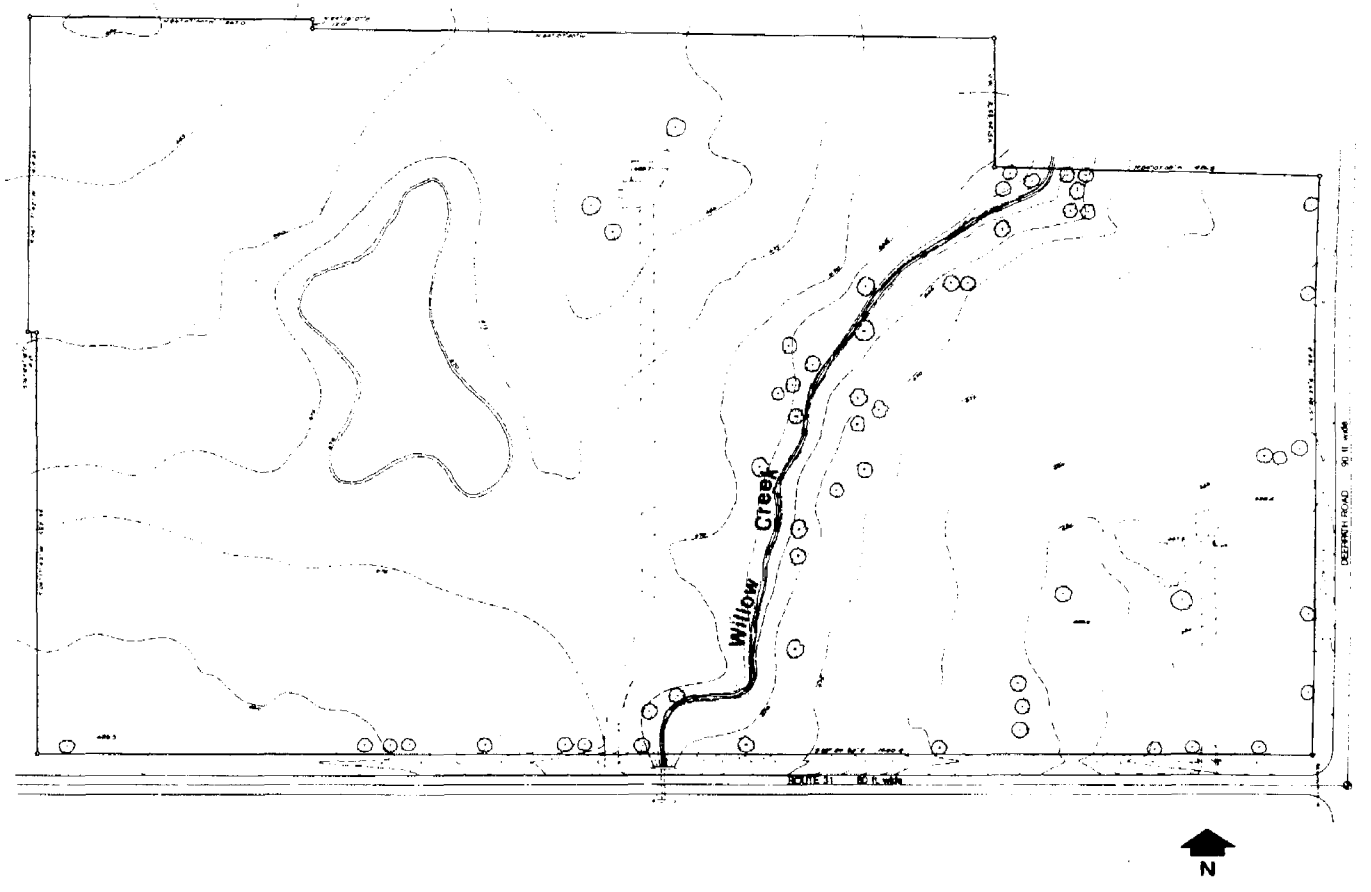
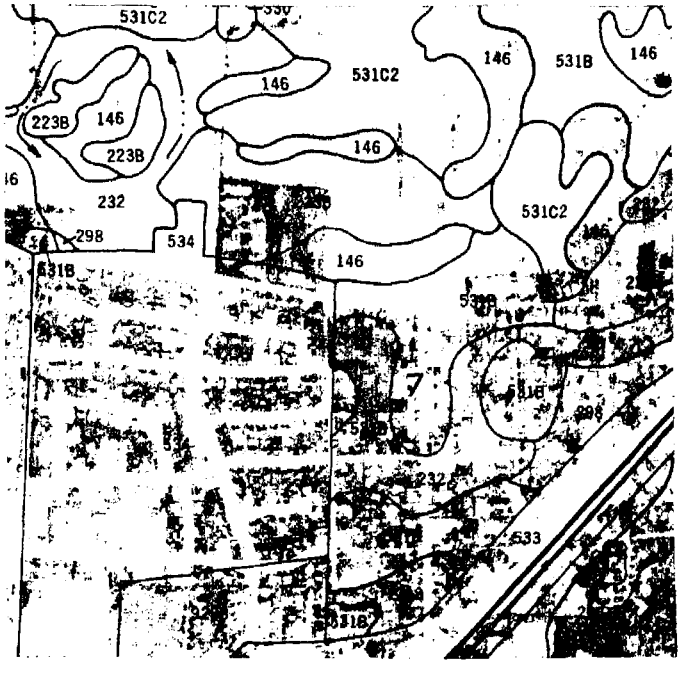


Figure 3-2: Topographic Map

Soils Map

The standard soil map as produced by the S.C.S. is usually superimposed on an aerial photograph flown at a scale of 4":1-mile with subdivision development. There should be an accompanying soil description which provides tabulations of basic data and interpretations of the various soils identified on the map. This should include soil limitations or potential ratings for the proposed uses.

Soils do not generally change abruptly from one mapping unit to another but tend to change gradually. In order to simplify the maps and because an area may be too small to delineate on a particular scale of map, small areas of similar soils are included in the dominant soil type. Soil maps, therefore, must be used within the limitations imposed by these conditions. They are not meant to pinpoint the soil conditions on areas smaller than about three acres. Enlarging the scale of a soil map in no way increases its accuracy. Additional field soil borings and onsite investigations performed by qualified soil professionals are often needed to determine soil conditions for intensive uses such as individual septic design. The soil map is an excellent guide, however, to determine where additional soil borings are needed.



A Typical SCS Soils Map

Current soil surveys are complete or will be completed in the near future for all of Illinois except Marshall and Fulton counties. Contact your local SCS office for current status of soil surveys in your area.

NATURAL DRAINAGE

In general, darker soils (like muck or peat) are the wettest or most poorly drained. The lighter colored soils (like sand) are drier and have better drainage. The presence of water-tolerant vegetation (like willows and cattails) indicates a poorly drained soil. Hardwoods, including red oak and sugar maple, can indicate the presence of a well drained soil. Poorly drained soils are often found in depressions that are subject to the collection of surface water runoff, while well drained soils are more often found at higher elevations.

There are five basic drainage classes for soils as follows:

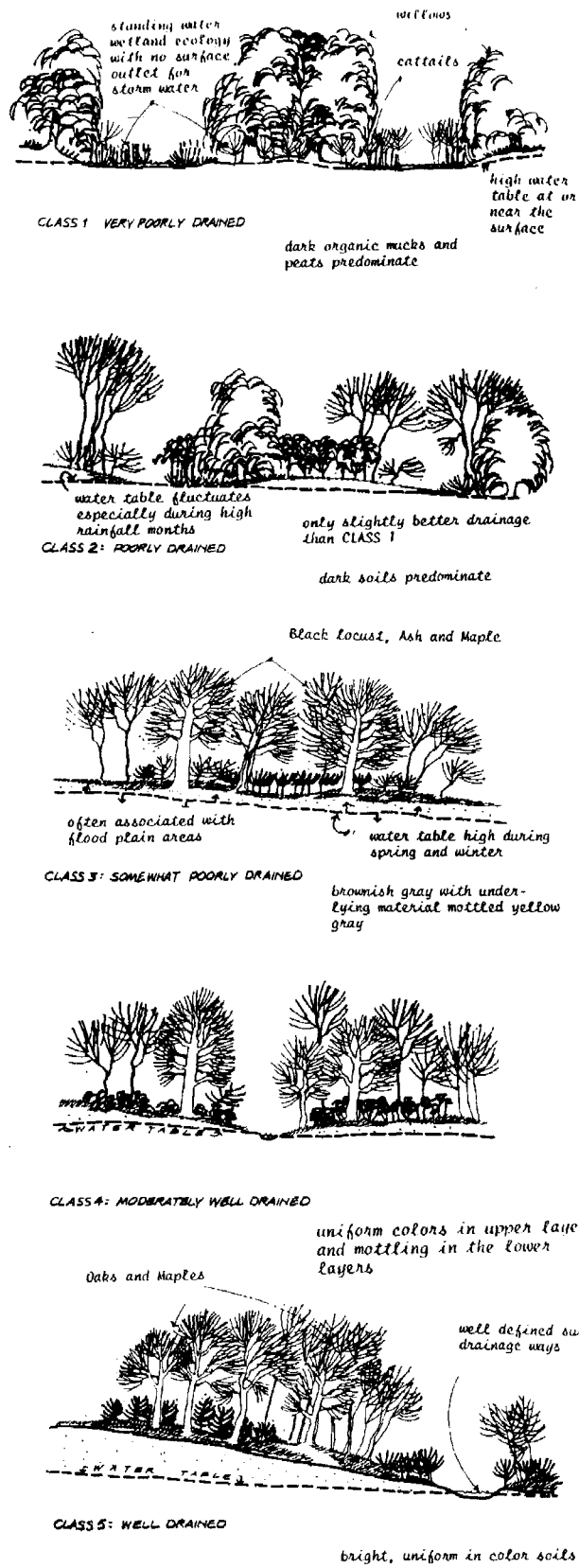
Very poorly drained - These soils tend to appear very dark and, for the most part, are composed of organic matter, muck, and/or peat. They are found frequently in low areas, in swampy or bog conditions, with no outlet for storm water. For very poorly drained soils, the water table remains at or near the surface of the ground for the greater part of the year.

Poorly drained - For these soils, the water table remains at or near the surface for a considerable part of the year, particularly during months with the highest precipitation rates. These soils exhibit only slightly better natural drainage characteristics than the very poorly drained class.

Somewhat poorly drained - These soils remain wet and exhibit a high water table for portions of the year (commonly during spring and winter months). Their color is brownish gray with an underlying yellow, brown, reddish, and gray mottled appearance.

Moderately well drained - These soils remain wet for only a small portion of the year. They exhibit uniform colors in the upper layers and some mottling in layers beneath.

Well drained - Well drained soils tend to be bright, uniform in color, and free of mottling. Water passes readily from the soil. Except for periods of intense rainfall, wetness is seldom evident.



TEXTURE

The "feel" of a soil determines its texture. To identify soil textures in the field, rub a sample of earth between the thumb and finger. There are three easily distinguishable extremes: sand feels gritty, silt feels floury, and clay feels smooth. For best results in identification, perform this "feel" test on both dry and moist soil samples. The test groups soil textures into six classes.

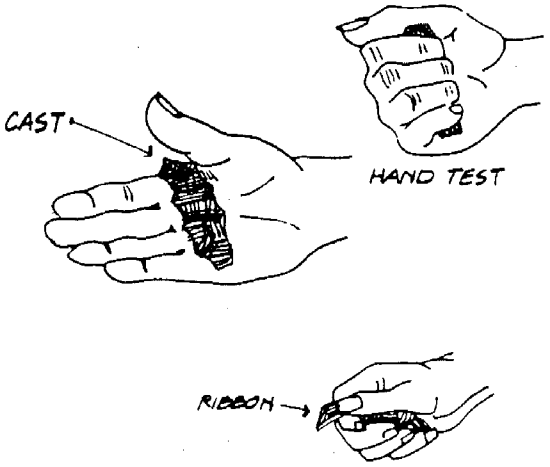
Sand - Individual grains are readily distinguished by sight and feel. Squeezed in the hand when dry, sand falls apart as soon as the hand is opened. Squeezed when moist, sand forms a cast. The shape holds as the hand opens, but crumbles when touched.

Sandy loam - This texture consists primarily of sand, but contains some silt and clay. Individual sand grains are, again, distinguished by sight and feel. Squeezed in the hand when dry, sandy loam falls apart once the hand opens. Squeezed when moist, it forms a cast and holds its shape, withstanding careful handling without crumbling.

Loam - Loam consists of a mixture of sand, silt, and clay. Squeezed in the hand when dry, it forms a cast that holds its shape and withstands careful handling without crumbling. The cast formed with moist soil can be handled freely without breaking. When rolled between the hands, loam can be pointed as fine as pencil lead, but is easily broken.

Silt loam - Silt loam consists of a moderate amount of sand, a small amount of clay, and a large amount of silt. When wet, silt loam runs together and puddles. Either dry or moist, casts formed by squeezing can be handled freely without breaking. When a ball of moist soil is pressed between the thumb and finger, it displays a broken appearance. When wet silt is vibrated in the hand, a surface sheen of water appears. When rolled between the hands, silt loam forms a thick, soft, easily broken thread.

Clay loam - This is a fine-textured soil. It breaks into clods or lumps which harden as they dry. A ball of moist soil pressed between the thumb and finger forms a thin ribbon that breaks readily, barely sustaining its own weight. Moist casts formed by squeezing withstand considerable handling. Clay loam can be formed to a pin point when rolled between the hands.



Clay - Clay is a fine-textured soil. It breaks into very hard clods or lumps when dry. When wet, it is plastic and unusually sticky. A ball of moist soil pressed between the thumb and finger produces a long ribbon. When rolled between the hands, clay forms a strong, plastic thread that can be shaped to a pin point. Cracking of the ground surface when it dries is a good indication of a high clay content in the soil.

Vegetation Map

An on-site investigation of existing vegetation is necessary to determine the type, variety, size, condition, and extent of vegetation on a site. Areas containing natural wetlands, native prairie plants, or stands of desirable trees should be identified so that later planning can incorporate these areas into the overall design of the development. Areas which are currently protected by vegetative ground cover can be developed with a minimum of erosion problems if the existing vegetative ground cover is preserved commensurate with the development phasing of construction program. Conversely, areas which are currently used for agricultural row crops or are void of vegetative ground cover need to be identified due to their higher potential for erosion and sedimentation.

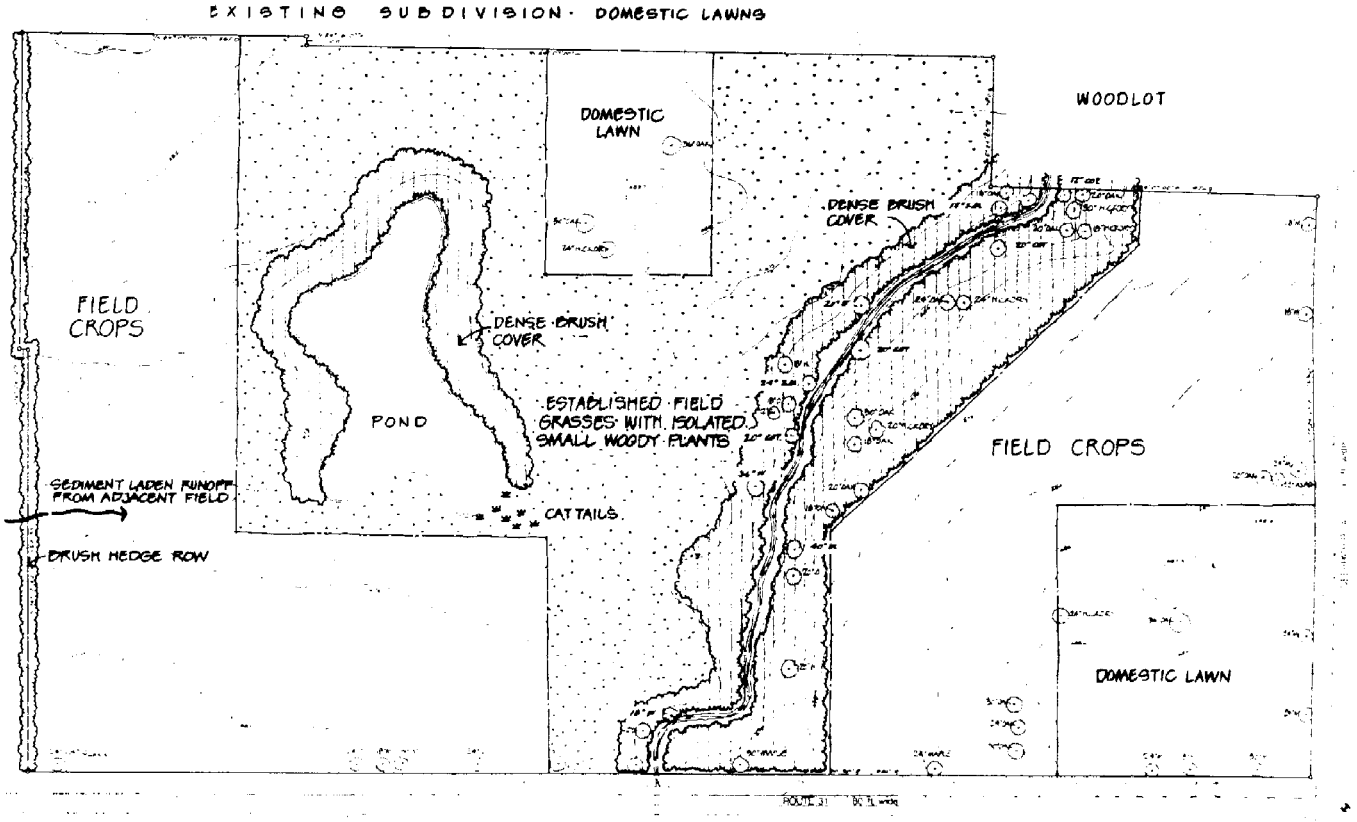


Figure 3-3: Vegetation Map

Off-Site Conditions

The adjacent land uses of a site, both existing and future, have a direct bearing on planning. Consideration must be given to the points of discharge of surface water onto adjacent property as well as to the size and condition of watersheds which are tributary to the site being developed. Applicable drainage laws governing the acceptance of drainage from higher land must be adhered to. Adjacent areas of particular environmental importance which are likely to be damaged by the proposed development should be identified and protected during the development process.

Since many of the areas being developed are presently or were once used for farming purposes, there are likely to be complex networks of drain tile which were used to provide subsurface drainage. These subsurface tiles often served several farms and if broken or disrupted by construction activities can cause severe drainage problems to adjoining land and to individual development sites near these tiles. Every effort should be made to locate these tile lines before construction starts and to reroute them when located during construction. Tile lines were not installed to function as storm sewers and therefore should not be used as outlets for storm water runoff. Such use often exceeds the capacity of the tile causing the tile to fail or the downstream properties to suffer drainage problems.

Site Analysis

The main purpose of the site analysis is to display all pertinent information about the existing conditions of the site that will influence preparation of a site plan to limit soil erosion and sedimentation problems. In general, all data gathered in the natural resource and environmental inventory (site analysis) should be included on the site analysis drawing.

Identification of Erosion and Sedimentation Hazards

Areas where the potential for erosion and sedimentation is high can be identified by incorporating all of the natural resource and environmental inventory information. Information can be used to identify areas with high erosion potentials.

Slopes can be grouped by grade and degree of potential erosion hazard as follows:

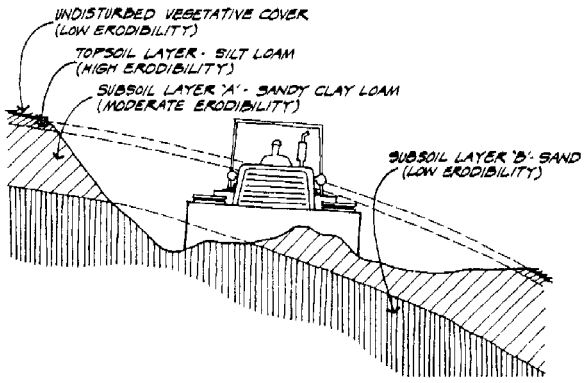
- 0-2% gradient - low erosion hazard
- 2-8% gradient - moderate erosion hazard
- Over 8% gradient - high erosion hazard

However, a slope with a low erosion hazard may still require soil erosion control measures because of its length, the highly erosive nature of the soil, the size of the drainage area, or the lack of vegetative protection. In addition to indicating slopes, the topographic map also indicates where runoff concentrates into drainageways.

The relative erodibility of the various soils can be determined from the soil map and the soil descriptions. In addition, the soil map symbols show slope ranges which relate to topography. The soil map also indicates drainageways, depressions, severity of previous erosion, exposed subsoil, gravel pits, and many other physical conditions. Every symbol on the soil map should be carefully identified so that potential problem areas can be recognized.

Particle size and gradation, percentage of organic matter, soil structure, and soil permeability on a construction site can be measured in the laboratory and a factor or rating assigned to each soil based on these tests. This is called the "K" or soil erodibility factor. The higher number the "K" factor, the more erodible the soil. Soils are commonly grouped by their soil erodibility for the purpose of soil erosion control planning. A list of the "K" factors for the soils of Illinois is given in the Appendix. Assistance in determining soil erodibility and assessing other site conditions during the site analysis is available from the local Soil and Water Conservation District as shown in the Appendix and at many county planning, health, highway, zoning, and building departments, as well as from the Soil Conservation Service. It is suggested that the erodibility of all sites be documented in the investigative phase of development planning, for this information is an important factor in preparing a development plan.

The residential development soil investigations, mapping, and interpretations ordinarily apply to the upper five feet of soil material. On a site where borings will be taken to determine subsurface conditions, the developer should ascertain if the soil is erodible. This is important because the erodibility of subsurface soils which are likely to be encountered may differ from the erodibility of surface soils, on which published erodibility ratings are based.



Erosion Hazard Varies With Extent of Grading

Information about off-site conditions can also be useful. Since the ultimate goal is to minimize the amount of sediment leaving the development site, the actual points of discharge onto adjacent property should be identified and protected. Likewise, sources of sediment from adjoining land must also be identified, and consideration given to this additional volume of sediment during planning and design phases.

The Composite Site Analysis

The composite site analysis includes three general types of information; existing conditions including natural and man-made elements, soils classification, and surface hydrology.

EXISTING CONDITIONS

Figure 3-4 shows the vegetation, topography, water bodies, and present land use on the development site. The majority of this particular site is cultivated. A creek flows through the site from south to north. A pond is located on the west half of the parcel. Several trees and areas of grass are scattered throughout the parcel. The low areas adjacent to the creek contain softwood trees such as cottonwood, silver maple, and willow together with various water-tolerant grasses. Further up on the slope are scattered hardwoods such as elm, hickory and oak. Cattle grazing has been allowed on the north side of the creek. A farmstead is present on the north side of the parcel. In the southeast corner of the parcel is an abandoned residence overgrown with trees, shrubs, and grasses. Steep slopes occur along the creek and on the north edge of the pond. To the south off-site is a state highway; to the east is a local road; to the north is County Forest Preserve, a single-family subdivision and a park; and to the west is tilled cropland.

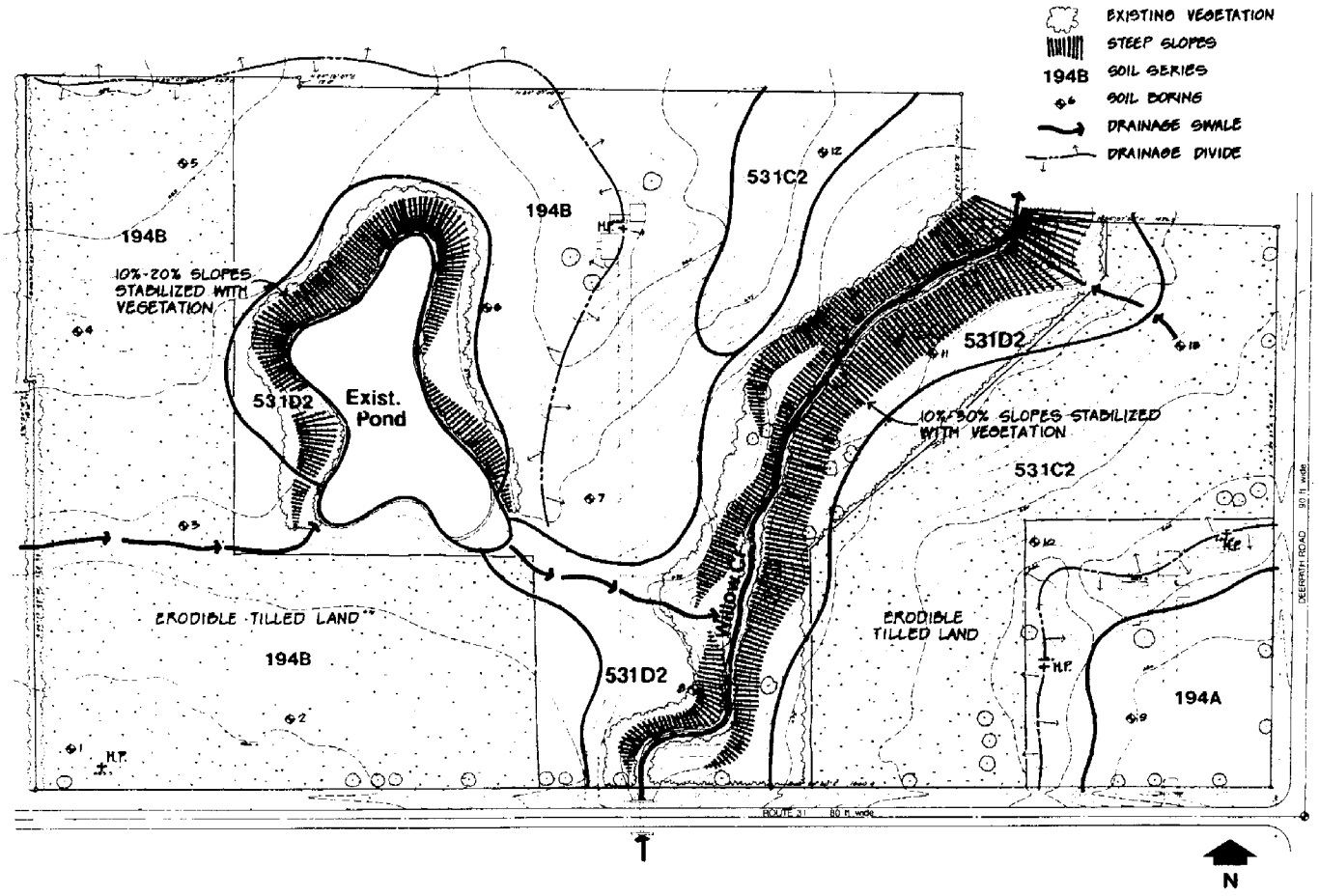


Figure 3-4: Composite Site Analysis

SOIL CLASSIFICATION

The composite site analysis also includes those soils found on the property from a soil survey. Morley (194B) i.e. located on the fairly gentle slopes and does not present a wetness problem. Morley (194A) soil represents the same soil located on flat topography. The soils on the slopes leading down to the creek and pond are Markham (531C2) and Markham (531D2). The "C" and "D" symbols indicate that the areas are sloping and steeply sloping, respectfully. The number "2" indicates that some of the topsoil has eroded from these areas and that some subsoil is mixed with the surface layer.

SURFACE HYDROLOGY

The composite site analysis also shows the important hydrologic features on the site. The different watersheds are separated by major ridge lines which are shown on the drawing. The elevations of low points and high points are noted, as is the location of the pond and creek. The direction of surface water flow and natural swales are indicated by arrows. The floodplain along the creek is also noted.

The surface hydrology is a very important consideration when determining the future locations of buildings, roads, parking lots and other features.

Planning Determinants

The documentation of planning determinants is a valuable step in the site planning process. The purpose is to draw certain basic conclusions about how the site should be developed to preserve important natural features and minimize the hazards of soil erosion and sedimentation. By studying the existing conditions shown on the composite site analysis and evaluating the cumulative effects of surface development conditions, it is possible to identify those areas of the site that exhibit high erosion potential, that are critical to proper on-site storm water management, or that would be extremely unstable if the natural cover were disturbed. These portions of the site can be identified as preservation areas. The remaining areas of the site can be identified as development areas. An illustration of how preservation and development areas can be shown in plan form is included on Fig. 3-5. For the site under consideration, the areas were determined as follows:

PRESERVATION AREAS

Three areas of the site are critical to watershed storm water management for both the site and adjacent areas and should be maintained in development of the plan. Willow Creek is part of a regional drainage system and must be maintained. The agricultural areas west of the site presently discharge runoff during storm periods to a drainage swale that runs through the site to a discharge at Willow Creek. This drainage course must be maintained to avoid flooding of the adjacent property. The pond functions as a collection basin for runoff from the north portions of the site. Since storm water retention capabilities will be required for the developed site, and since the soils in the pond area would be difficult to build on, this area should be considered for a permanent storm water retention facility.

Control of erosion on the site can be simplified by maintaining the vegetation on the steeper slopes adjacent to the creek and pond. In total, the preservation areas form a linked open space system which, if preserved, will allow for appropriate storm water management and control of erosion in the most critical areas. In addition, the open space system provides a significant natural aesthetic feature for development of an interesting planned environment.

DEVELOPMENT AREAS

In this case, there are three distinct development areas formed by the open space preservation system. Each area has different characteristics in terms of orientation inward to the open space system and orientation outward to adjacent properties and circulation routes. In addition, topography and soils vary from one area to another. These characteristics become important criteria for determining land use distribution and circulation systems in development of the final site plan.

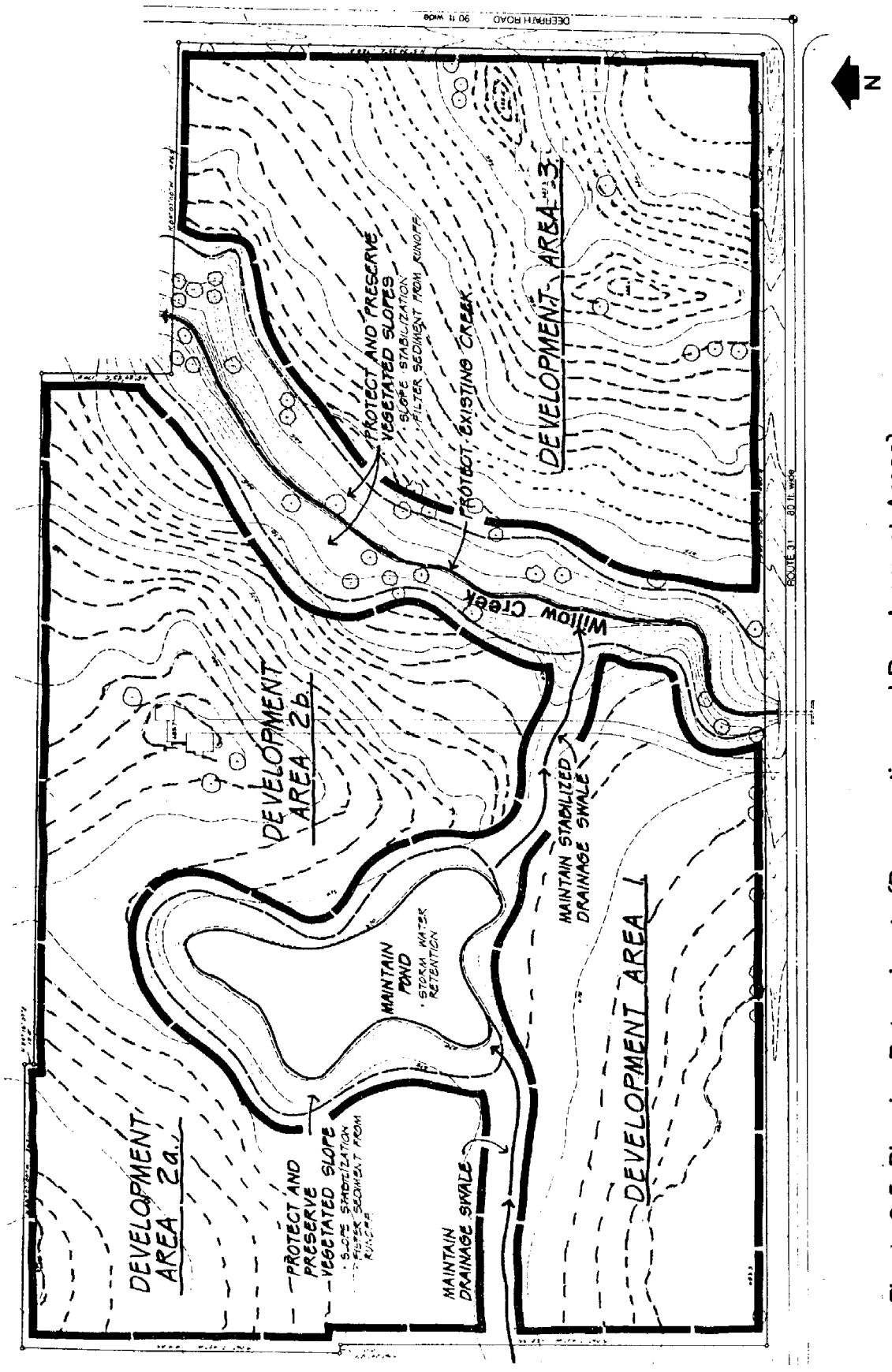


Figure 3-5: Planning Determinants (Preservation and Development Areas)

SITE PLAN DEVELOPMENT

Within the framework of the appropriate development areas identified in the previous step, the site can be planned to accommodate a variety of different uses from low density single-family residential to more intensive commercial or office uses. For purposes of illustration, A P.U.D. (planned unit development) is used as an example. This development, including townhouses, apartments, duplexes and commercial structures is typical of development trends in today's urbanizing areas.

After analyzing the data, determining the site limitations, and developing the planning determinants, the planner can develop a site plan. The buildings, roads, and parking lots and landscaping should be located to exploit the strengths and overcome the limitations of the site. The following are some points to consider in making these decisions:

A. Fit development to terrain. The development of an area should be tailored to the existing site conditions. This will avoid unnecessary land disturbance, minimizing the erosion hazards and costs.

B. Confine construction activities to the least critical areas. Any land disturbance in the critically erodible areas will necessitate the installation of more costly control measures.

C. Cluster buildings together. This can minimize the amount of disturbed area, concentrate utility lines and connections in one area, and provide more open natural space. The cluster concept can not only lessen the erodible area, but may reduce runoff, and generally reduce development costs.

D. Minimize impervious areas. Keep paved areas such as parking lots and roads to a minimum. The more land that is kept in vegetation cover, the more water will infiltrate thus minimizing runoff and erosion.

E. Utilize the natural drainage system. If the natural drainage system of a site can be preserved instead of being replaced with storm sewers or concrete channels, the potential for downstream damages due to increased runoff can be minimized.

The Final Site Plan shown on Figure 3-7 was developed through a balanced evaluation of such factors as land use compatibility, convenience, drainage, maintenance, costs, aesthetics, erosion potential during construction, and storm water runoff and management after construction. Following are the major site plan considerations.

Surface Features

BUILDINGS

Buildings have been located in areas where the soils provided good bearing strength and did not present wetness problems. Natural swales have been avoided, as well as steep slopes to reduce the amount of cut and fill that would be required. Large individual trees and groups of trees were left standing where feasible.

ROADS, WALKS AND PATHS

Topography of the development site and soil conditions were used to determine the location of roads. As with the buildings, roads were designed for construction in areas that are not steeply sloping in order to reduce the amount of cut and fill required and at the same time reduce the potential for erosion. Soils with a high water table and low bearing strength were also avoided.

PARKING LOTS

Parking lots have been located on the most level areas available next to the apartments and commercial buildings on the south side of the creek. This limits the amount of cutting and filling required and minimizes the area that must be disturbed.

Parking lots are located on Morley (194) and Markham (531C2) soils, which have good bearing strength and no wetness problems.

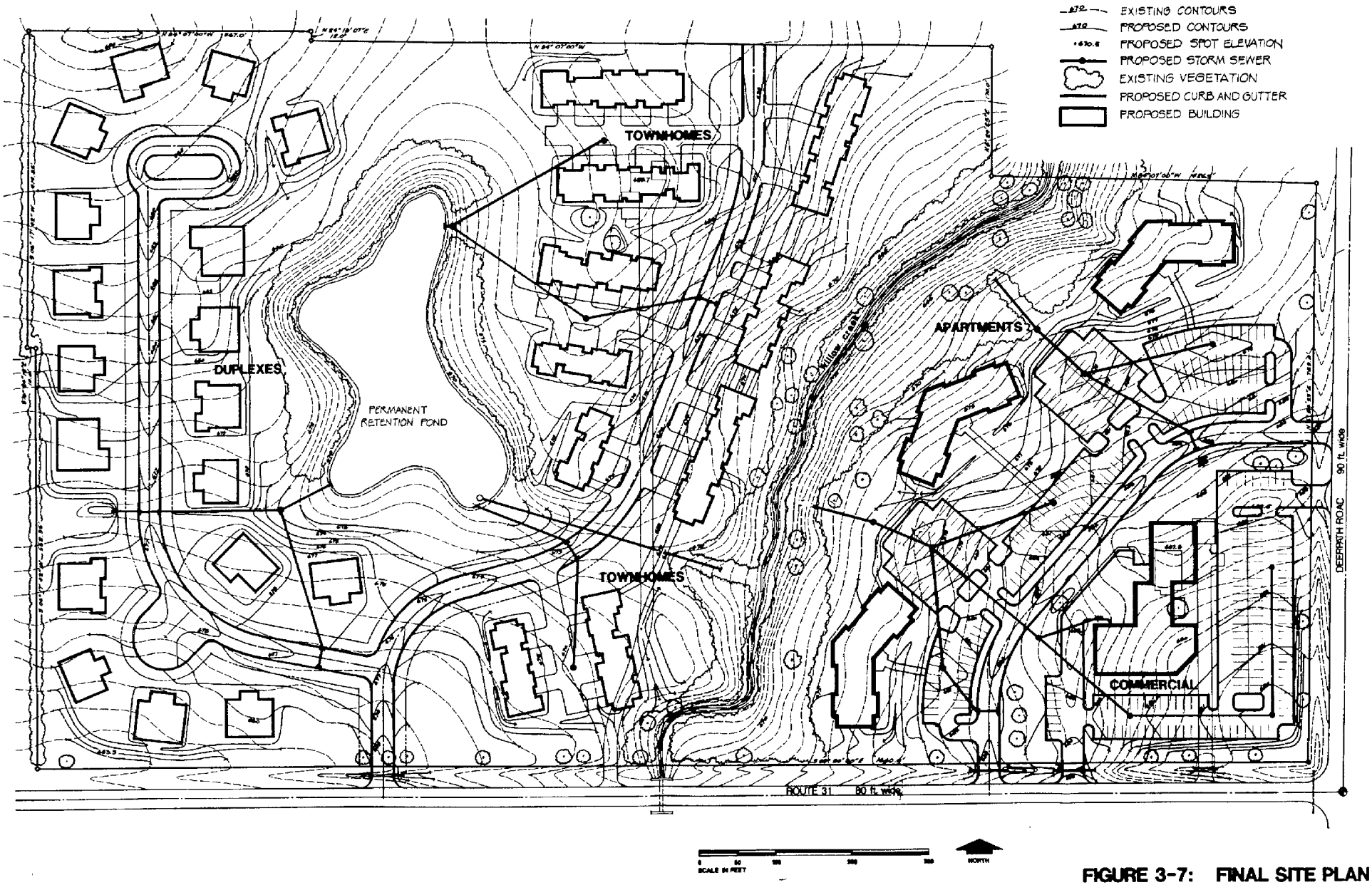


FIGURE 3-7: FINAL SITE PLAN

Grading and Drainage

The grading concept has been developed to preserve the natural drainage system of the site. Building elevations and road grades have been set to minimize cuts and fills in order to limit the extent of the disturbed areas. While this approach to grading is important to limit erosion problems, it normally also results in less earthwork and, therefore, reduced development costs.

In areas where cutting or filling is necessary, the slopes have been designed with relatively shallow grades to minimize the velocity of storm water runoff. Whenever possible, overland runoff is utilized in vegetated areas where velocities can be kept to a minimum. An underground storm sewer system is used to convey runoff from paved areas such as roads and parking areas. Several systems have been developed for the different development areas. These systems discharge either to the pond or directly to the creek.

The plan illustrates that the existing pond west of Willow Creek will be used as a retention basin for storage of storm water runoff. In addition, parking areas have been designed to provide depressional areas for temporary storm water storage.

Preservation and Open Space

Open space has been provided along the creek, in the natural swales, and around the pond. The location of this open space was very critical from the erosion control aspect. By providing open space along the creek, a vegetative buffer was allowed to remain, which will filter out any sediment running down slope toward the creek and reduce the velocity of surface water runoff which reduces the potential for erosion. Also the soils along the creek have a high water table and low bearing strength, as well as occurring in a floodplain, still another reason for avoiding construction here and leaving the area as open space. In addition to avoiding development along the creek for erosion control, there are other reasons for open space in this area and around the pond. The habitat around water bodies tends to provide a desirable environment for wildlife. This gives the public a good opportunity to observe wildlife. The pond and creek also provide other recreational opportunities such as fishing, paddling, and canoeing.

4

model erosion and sedimentation control plan

1. PLAN DEVELOPMENT CRITERIA 1

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Establishment of Permanent Vegetation
Protection of Adjacent Properties
Timing and Stabilization of Sediment Trapping Measures
Sediment Basins
Cut and Fill Slopes
Stormwater Management
Stabilization of Waterways and Outlets
Stormwater Inlet Protection
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1. PLAN DEVELOPMENT CRITERIA

Effective erosion control planning requires a working knowledge of both the application of control measures in terms of their selection and location and the design of the control measure in terms of its configuration, size, and construction. Of utmost importance, however, is a familiarity with the basic criteria that should guide the preparation of all erosion control plans regardless of their scale or complexity. These criteria are as follows:

STABILIZATION OF DENUDED AREAS AND SOIL STOCKPILES

Permanent or temporary soil stabilization should be applied to denuded areas within 15 days after final grade is reached on any portion of the site. Soil stabilization should also be applied within 15 days to denuded areas which may not be at final grade but will remain undisturbed for longer than 60 days.

Soil stabilization refers to measures which protect soil from the erosive forces of raindrop impact and flowing water. Applicable practices include vegetative establishment, mulching, and the early application of gravel base on areas to be paved. Soil stabilization measures should be selected to be appropriate for the time of year, site conditions and estimated duration of use.

Soil stockpiles should be stabilized or protected with sediment trapping measures to prevent soil loss.

ESTABLISHMENT OF PERMANENT VEGETATION

A permanent vegetative cover should be established on denuded areas not otherwise permanently stabilized. Permanent vegetation should not be considered established until a ground cover is achieved which is mature enough to control soil erosion satisfactorily and to survive severe weather conditions.

PROTECTION OF ADJACENT PROPERTIES

Properties adjacent to the site of a land disturbance should be protected from sediment deposition. This may be accomplished by preserving a well vegetated buffer strip around the lower perimeter of the land disturbance, by installing perimeter controls such as sediment barriers, filters or dikes, or sediment basins, or by a combination of such measures.

Vegetated filter strips may be used alone only where runoff in sheet flow is expected. In general, filter strips should be at least 15 feet in width. If at any time it is found that a vegetated filter strip alone is ineffective in stopping sediment movement onto adjacent property, additional perimeter controls must be provided.

TIMING AND STABILIZATION OF SEDIMENT TRAPPING MEASURES

Sediment basins, diversions, sediment barriers and other measures intended to trap sediment on-site must be constructed as a first step in grading and be made functional before upslope land disturbance takes place. Earthen structures such as dams, dikes, and diversions must be seeded and mulched within 15 days of installation.

SEDIMENT BASINS

Stormwater runoff containing sediment from drainage areas should pass through a sediment basin or other suitable sediment trapping facility.

CUT AND FILL SLOPES

Cut and fill slopes should be designed and constructed in a manner which will minimize erosion. Consideration should be given to the length and steepness of the slope, the soil type, upslope drainage area, groundwater conditions and other applicable factors. Slopes which are found to be eroding excessively within one year of construction should be provided with additional slope stabilizing measures until the problem is corrected.

STORMWATER MANAGEMENT

Properties and waterways downstream from development sites should be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff.

Concentrated stormwater runoff leaving a site should be discharged directly into a well defined natural or man-made off site receiving channel or

pipe. If no off site channel or pipe exists, the stormwater should be detained on site in a suitable retention/detention facility.

STABILIZATION OF WATERWAYS AND OUTLETS

All on-site stormwater conveyance channels should be designed and constructed to withstand the expected velocity of flow from a 10-year frequency storm without erosion. Stabilization adequate to prevent erosion should also be provided at the outlets of all pipes and paved channels.

STORM SEWER INLET PROTECTION

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

WORKING IN OR CROSSING WATERCOURSES

Construction vehicles should be kept out of watercourses to the extent possible. Where in-channel work is necessary, precautions should be taken to stabilize the work area during construction to minimize erosion. The channel (including bed and banks) should always be restabilized immediately after in-channel work is completed.

Where a live watercourse must be crossed by construction vehicles regularly during construction, temporary stream crossing should be provided.

CONSTRUCTION ACCESS ROUTES

Wherever construction vehicle access routes intersect paved public roads, provisions should be made to minimize the transport of sediment (mud) by runoff or vehicle tracking onto the paved surface.

DISPOSITION OF TEMPORARY MEASURES

All temporary erosion and sediment control measures should be disposed of within 30 days after final site stabilization is achieved or after the temporary measures are no longer needed. Trapped sediment and other disturbed soil areas resulting from the disposition of temporary measures should be permanently stabilized to prevent further erosion and sedimentation.

MAINTENANCE

All temporary and permanent erosion and sediment control measures should be maintained and repaired as needed to assure continued performance of their intended function.

2. EVALUATING EROSION AND SEDIMENTATION CONTROL MEASURES

There are three ways to accomplish urban soil erosion and sedimentation control:

- Stop erosion in the watershed, by soil stabilization or runoff control measures.
- Allow erosion to take place and then control sediment before it leaves a site.
- A combination of the two.

Every opportunity to provide protection to the soil surface should be taken. This helps prevent erosion and makes sediment control measures more efficient, effective, and less expensive as well as providing for a more attractive environment.

Sediment-trapping facilities should be used on large developments with mass grading. In this situation, erosion is allowed to take place and any sediment produced is trapped before it leaves the site. A minimum cost for sediment and erosion control for a construction site is usually accomplished by using a combination of erosion control and sediment-trapping measures.

Control Measure Selection Process

The accompanying flow chart and planning matrix is intended to simplify the selection of soil erosion and sedimentation control (SE & SC) measures. Following the flow chart from left to right, the user is guided to the group or groups of measures that will solve a specific SE & SC problem. Use of the flow chart and planning matrix (Fig. 4-1) follows five basic steps:

1. Identify the control problem.
2. Identify potential SE & SC problem areas on the construction site.
3. Identify what strategy or strategies are required to solve each potential problem.
4. Identify the group or groups of measures that will accomplish the required strategy.
5. Select the specific control measures within a group that can best be adapted to the site to solve the problem.

Step 1 : Identify Control Problem

On any construction site the objective in SE & SC is to prevent off-site sedimentation damage. The three basic methods useful to control on construction sites are soil stabilization, runoff control, and sediment control. Controlling erosion should be used as the first line of defense where soil properties and topography of the site make the design of sediment trapping facilities impractical or where much of the site will not be disturbed and much of the existing vegetation can be preserved. Controlling erosion is very effective for small disturbed areas such as single lots or small areas of a development that do not drain to a sediment trapping facility.

Sediment trapping facilities should be used on large developments where mass grading is planned, where it is impossible or impractical to control erosion, and where sediment particles are relatively large. A minimum of cost for SE & SC is usually accomplished by using a combination of erosion control and sedimentation control measures.

Step 2 : Identify Problem Areas

Once a method of control is selected, potential SE & SC problem areas are identified. Areas where erosion is to be controlled will usually fall into categories of slopes, graded areas or drainageways. Slopes include graded rights-of-way, stockpile areas, and all cut or fill slopes. Graded areas include all stripped areas other than slopes. Drainageways are areas where concentrations of water flow naturally or artifically, and the potential for gully erosion is high. Problem areas where sediment is to be controlled fall into categories of large or small drainage areas. Small areas are usually considered to be areas of one acre or less where filtering of sediment can be accomplished. Large areas include any drainage area larger than one acre where sediment must usually be trapped.

Step 3 : Identify Required Strategy

The third step in SE & SC planning is to follow the planning matrix from the problem area to the strategy that can be taken to solve the problem. There may be several strategies used individually or in combination to provide the solution. For example, if there is a cut slope to be protected from erosion, the strategies may be to protect the ground surface, divert water from the slope or shorten it. Any combination of the above can be used. If no rainfall except that which falls on the slope has the potential to cause erosion and if the slope is relatively short, protecting the soil surface is often all that is required to solve the problem.

Step 4 : Identify Control Measure Group

Once required strategies to solve the SE & SC problem are identified, the planning matrix leads to the group or groups of control measures that will accomplish one strategy. Control measures within each group have similar purpose, scope, application, design criteria, standard plans, and construction specifications. Therefore, any measure within a group will solve the problem in question.

Step 5 : Select Specific Control Measure

The final step in SE & SC planning can be accomplished by completing final design. This involves adaptation of any control measure within a group to solve the specific SE & SC problem. From descriptions given to the right of each control measure, the one measure which is most economical, practical, efficient, and adaptable to the site can be chosen.

Once the specific control measure has been selected, the plan key symbol given in the matrix can be placed on the SE & SC site plan to show where control measures will be used. Standardized design, plan, and construction specification sheets can then be completed for each control measure. This completes the planning for soil erosion and sedimentation control as a part of the total natural resource plan.

Grouping SE & SC Measures

Almost every SE & SC measure can be classified into one of the following types of control measures: soil stabilization, diversions, waterways, enclosed drainage, spillways, outlets, sediment basins, sedimentation filters, and mud and dust control. Each group of measures have similar design criteria, plans, and specifications. The only difference among specific measures is how each is adapted to a specific problem area.

Grouping control measures eliminates the repetition typically encountered in handbooks, manuals, and regulations. It further allows for only one set of design criteria to be used for a variety of specific SE & SC measures. The designer can adapt a measure any number of ways to best solve a specific problem instead of worrying about whether his adaptation will meet a very specific, perhaps restrictive, set of criteria for that particular measure. The only requirement of the design is that it solves the problem and follows sound engineering principles.

The concept of grouping measures was used as the basis for development of the SE & SC Control Measure Selection Process. Streambank protection measures such as revetments, jacks, and jetties were not included in the planning matrix because their design is beyond the scope of normal SE & SC measures and would not normally be required on construction sites if major streams are left undisturbed.

ILLINOIS SOIL EROSION AND SEDIMENTATION CONTROL
CONTROL MEASURE SELECTION PROCESS

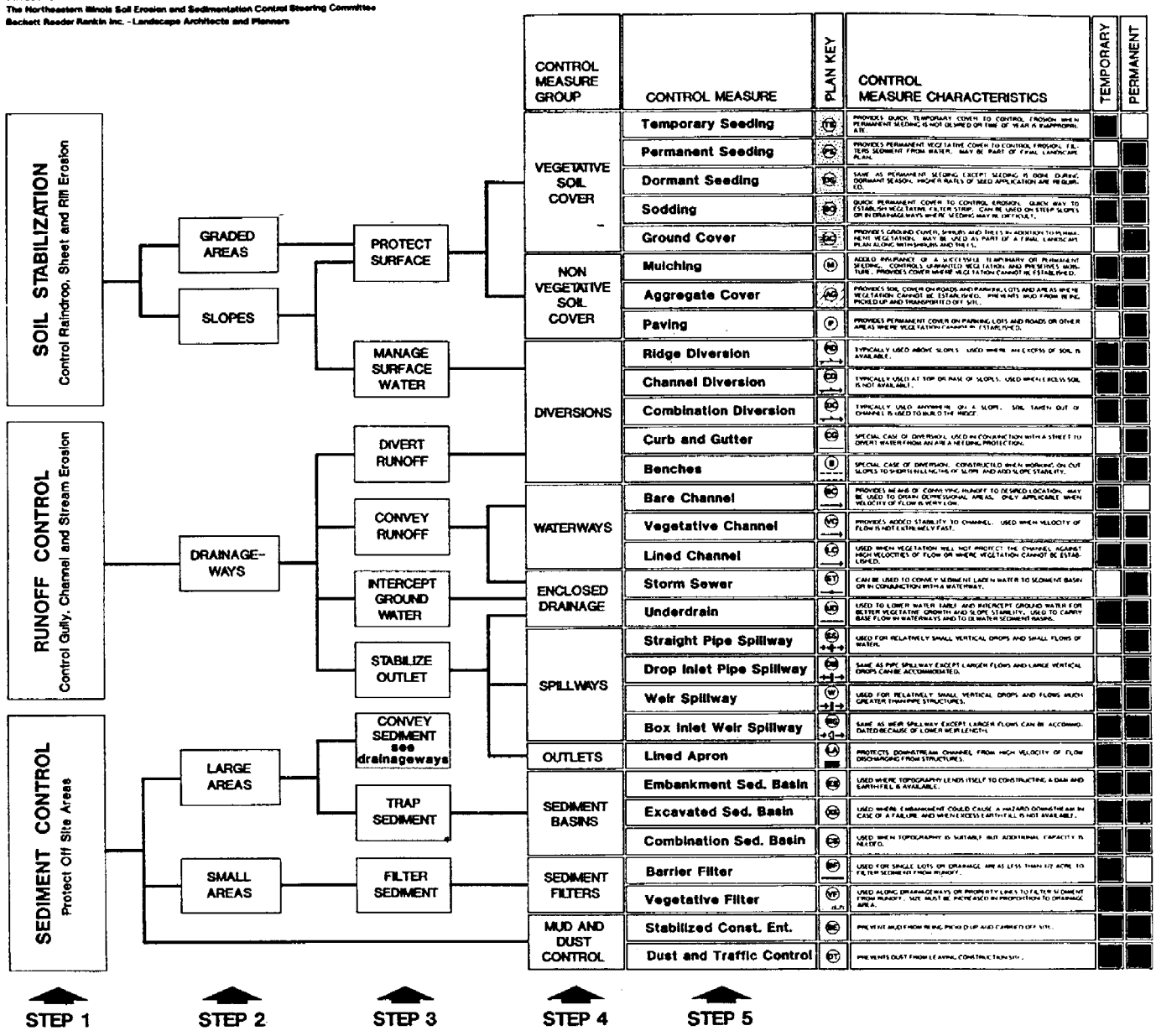


FIGURE 4-1: PLANNING MATRIX

STEPS IN THE SELECTION OF CONTROL MEASURES

STEP 1: IDENTIFY CONTROL PROBLEM

On any construction site the objective in SE & SC is to prevent off site sedimentation damage. The three basic methods useful to control on construction sites are soil stabilization, runoff control, and sediment control. Controlling erosion should be used as the first line of defense where soil properties and topography of the site make the design of sediment trapping facilities impractical or where much of the site will not be disturbed and much of the existing vegetation can be preserved. Controlling erosion is very effective for small disturbed areas such as single lots or small areas of a development that do not drain to a sediment-trapping facility.

Sediment trapping facilities should be used on large developments where mass grading is planned, where it is impossible or impractical to control erosion, and where sediment particles are relatively large. A minimum of cost for SE & SC is usually accomplished by using a combination of erosion control and sedimentation control measures.

STEP 2: IDENTIFY PROBLEM AREAS

Once a method of control is selected, potential SE & SC problem areas are identified. Areas where erosion is to be controlled will usually fall into categories of slopes, graded areas or drainageways. Slopes include graded rights-ofway, stockpile areas, and all cut or fill slopes. Graded areas include all stripped areas other than slopes. Drainageways are areas where concentrations of water flow naturally or artifically and the potential for gully erosion is high. Problem areas where sediment is to be controlled fall into categories of large or small drainage areas. Small areas are usually considered to be areas of 1 acre or less where filtering of sediment can be accomplished. Large areas include any drainage area larger than 1 acre where sediment must usually be trapped.

STEP 3: IDENTIFY REQUIRED STRATEGY

The third step in SE & SC planning is to follow the planning matrix from the problem area to the strategy that can be taken to solve the problem. There may be several strategies used individually or in combination to provide the solution. For example, if there is a cut slope to be protected from erosion, the strategies may be to protect the ground surface, divert water from the slope or shorten it. Any combination of the above can be used. If no rainfall except that which falls on the slope has the potential to cause erosion and if the slope is relatively short, protecting the soil surface is often all that is required to solve the problem.

STEP 4: IDENTIFY CONTROL MEASURE GROUP

Once required strategies to solve the SE & SC problem are identified, the planning matrix leads to the group or groups of control measures that will accomplish one strategy. Control measures within each group have similar purpose, scope, application, design criteria, standard plans, and construction specifications. Therefore, any measure within a group will solve the problem in question.

STEP 5: SELECT SPECIFIC CONTROL MEASURE

The final step in SE & SC planning can be accomplished by completing final design. This involves adaptation of any control measure within a group to solve the specific SE & SC problem. From descriptions given to the right of each control measure the one measure which is most economical, practical, efficient, and adaptable to the site can be chosen.

Once the specific control measure has been selected, the plan key symbol given in the matrix can be placed on the SE & SC site plan to show where control measures will be used. Standardized design, plan, and construction specification sheets can then be completed for each control measure. This completes the planning for soil erosion and sedimentation control as a part of the total natural resource plan.

3. CONTROL MEASURE CHARACTERISTICS

The following discussion of individual control measures as presented in the planning matrix is divided into three major areas, soil stabilization, runoff control, and sediment control. Each measure is described in more detail in Chapter 6.

Soil Stabilization

Soil stabilization measures are intended to provide protection of the soil surface from the erosive action of falling rain and runoff. The prime function of these measures is to prevent sheet and rill erosion. The two main groups include vegetative soil stabilization measures and nonvegetative soil stabilization measures.

Vegetative Soil Stabilization Measures

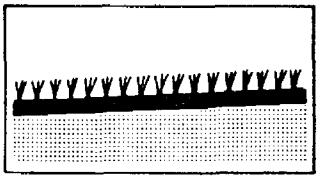
Vegetative soil stabilization measures refer to establishing vegetative cover on areas subject to erosion by rainfall. The purpose is to stabilize the soil, reduce damages from sediment and runoff to downstream areas, improve wildlife habitat and enhance natural beauty. Such measures are used in graded or cleared areas subject to erosion and where a permanent or temporary vegetative cover is needed.

The different types of vegetative soil stabilization measures given in the unified keying system matrix are selected on the basis of when seeding is to be done or what type of vegetative stabilization is required. Basic selection principles are as follows:

- Retain and protect as much existing vegetation as possible.
- Save existing on-site topsoil.
- Establish temporary protection as rapidly as possible.
- Select permanent vegetative methods and plant material that are best adapted to the site for the purpose of controlling erosion and sedimentation.

With these 4 principles in mind, slope stabilization, topsoil management, and maintenance measures are necessary in order to achieve vegetative control.

TEMPORARY SEEDING (TS)

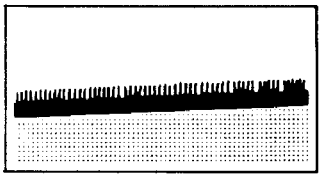


Temporary seeding is a common erosion control measure. It is less expensive than other planting methods such as permanent seeding or sodding and serves to hold the soil in place until permanent cover is provided at the time of final development. At varying times of the year, in accordance with construction schedules, an appreciable amount of temporary seeding may be done on subsoil subsequent to topsoil stripping and stockpiling. As a result, the seed selection, seeding operations, fertilizer applications, seed mixtures, mulch material or chemical soil stabilizer, and maintenance program must be conducive to the establishment of a dense vegetative cover under difficult conditions. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover.

Temporary seeding may prevent costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Diversions will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

PERMANENT SEEDING (PS)



Areas which must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

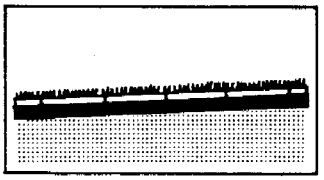
Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right seed mixture for the site, good seedbed preparation, and conscientious maintenance are important.

DORMANT SEEDING (DS)

When it is impossible to make permanent seedings at the optimum time of year for successful turf establishment, it may be necessary to make dormant or winter seeding. Dormant seeding is accomplished when seasonal temperatures have dropped below the level necessary to initiate seed germination. As soon as soil temperatures and moisture content in the spring are favorable, the seed will germinate and provide an early turf cover.

SODDING (SO)

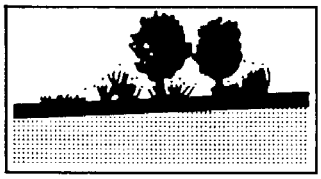


Sodding is desirable where it is necessary to achieve an instant turf cover and where it may be difficult to establish a cover by seeding. The advantages of sod include immediate erosion control, less seasonal installation limitations, greater chance of success, instant usability of the area, and immediate visual effect.

It is initially more costly to install sod than to seed. However, this cost is justified in places where sod can perform better than seed in controlling erosion. In swales and waterways where concentrated flow will occur, properly pegged sod is preferable to seed because there is no lag time between installation and the time when the channel is protected by vegetation. Drop inlets which will be placed in grassed areas can be kept free of mulch, seed, and mud, and the grade immediately around the inlet can be maintained by framing the inlet with sod strips.

Sod can be laid during times of the year when seeded grass may fail, so long as there is adequate water available for irrigation in the early weeks.

GROUND COVER (GC)



Ground covers, individually or collectively with woody plants, can provide erosion control on banks or slopes where maintenance of turf would be difficult or impossible and provides soil stabilization at property boundaries, stream banks, and waterway outlets. Trees, shrubs, and ground covers take longer to establish than grasses. The soils usually encountered for planting purposes in urban developments tend to be disturbed, making vegetative establishment more difficult. Recommended procedures and practices for establishing plants on such difficult sites can be obtained from professional landscape architects and the local Soil and Water Conservation District offices.

The following situations are examples of ways in which trees, shrubs, vines and ground covers may be used:

- On cut and fill slopes adjacent to paved areas of shopping centers, schools, industrial parks, or other non-residential projects, woody plants and ground covers can be used on these slopes to control erosion. They will also help to control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover.

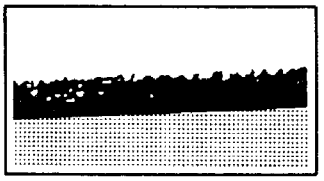
- In residential areas, slopes too steep to be mowed and areas along rights-of-way or easements may be planted in trees, shrubs, vines, or ground covers to reduce maintenance and improve appearance.

- The interested homeowner or small project developer may choose to use ornamental plants in problem areas--shade, steep slopes, inaccessible places--as alternatives to grass. Ground covers may be used to reduce or eliminate the need for mowing grass on level areas.

Non - Vegetative Soil Stabilization Measures

Non-vegetative soil stabilization measures refer to the application of plant residues or other suitable material to the soil surface. The purpose in some cases is to conserve moisture, prevent surface compaction, reduce runoff and erosion, control weeds, and help establish plant cover. In other cases, the purpose is to provide a compacted and stabilized surface that resists erosion and provides for vehicular traffic.

MULCHING (M)



The use of mulches has become standard measure in carrying out vegetative soil cover measures. A mulch protects against rain and wind while seeds are germinating and helps to insure a vegetative stand. Mulch increases aeration of heavy clay soils as it gradually becomes mixed with the basic soil. It also prevents surface soil erosion, minimizes damage to soil structure due to compaction from heavy rains or walking on it when the soil is wet, and conserves soil moisture by reducing the amount of soil water evaporation. In most cases, mulching is not so effective as live covers, but it can provide substantial protection, particularly as temporary cover. It can be applied at any time soil and site conditions are suitable for spreading and anchoring.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, and economics. It is especially important to mulch liberally in mid-summer and prior to winter, and on cut slopes and southern slope exposures.

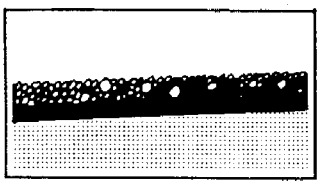
There are generally three categories of mulching materials:

Organic mulches include hay or straw, corn stalks, wood chips, bark chips or shredded bark.

Synthetic mulches include a wide range of emulsions or dispersions of vinyl compounds, asphalt, rubber or other substances which are mixed with water and applied to the soil.

Net and mats include a variety of materials installed directly on the soil surface and secured with staples or pegs.

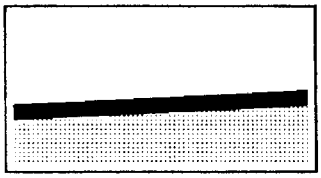
AGGREGATE COVER (AG)



Layers of gravel or crushed stone, such as marble, granite, quartzite, or lava chips, are an excellent inorganic mulch for short, low, to moderately steep slopes. Aggregate cover provides immediate erosion protection for the ground surface (often where vegetation cannot be established) and allows infiltration of rainfall for vegetative growth.

An aggregate cover can provide immediate stabilization of future paved roads and parking lots, and has the added advantage of preventing mud from being picked up by construction vehicles and equipment and transported off site.

PAVING (P)



Where roads, parking lots, and driveways are to have permanent cover, the ground surface is usually paved with asphalt or concrete. Paving can be used in other places where vegetation cannot be established or aggregate cover maintained. Since the natural on-site filtration capability is substantially reduced by paving, care must be taken that the paving does not contribute to off-site erosion problems.

Runoff Control

Runoff control measures are intended to provide for management of concentrated flows of runoff. The prime function of these measures is to control gully erosion. The main groups of control measures include diversions, waterways, enclosed drainage, spillways, and outlet protection.

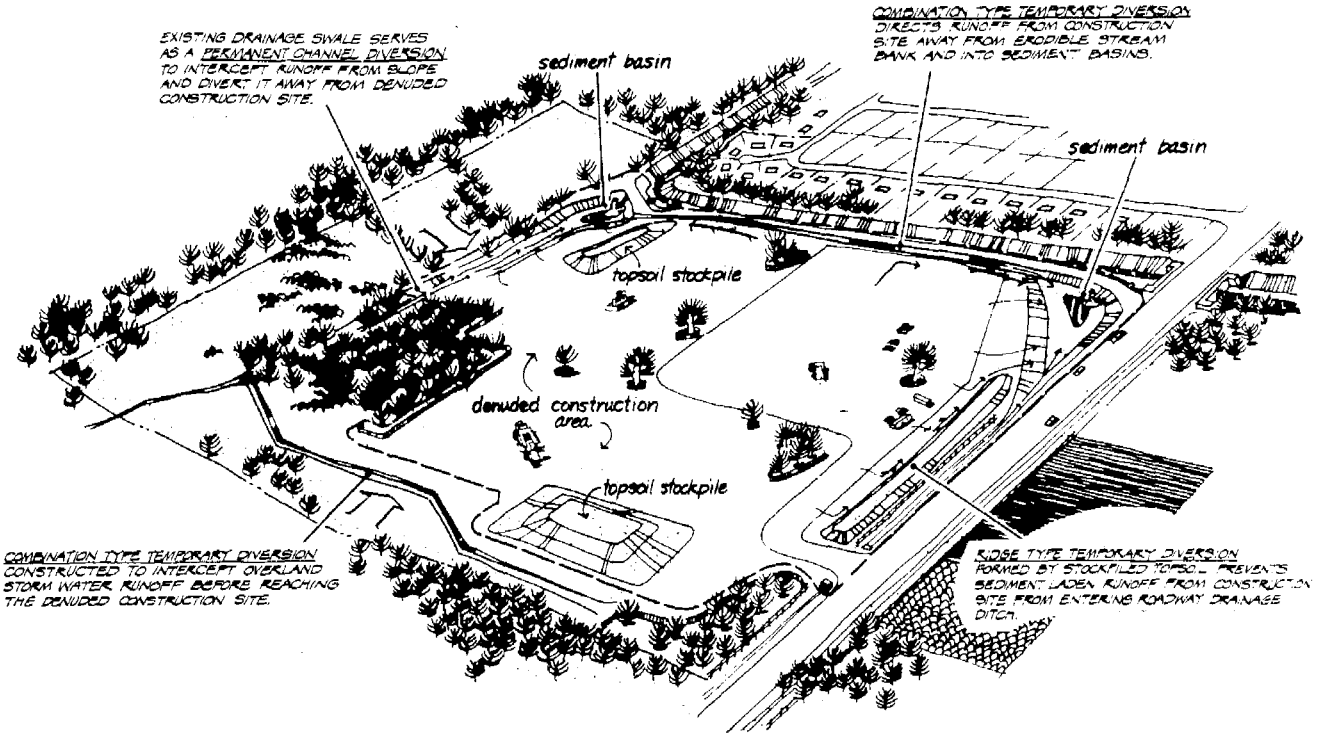
Diversion Measures

A diversion is a channel with a supporting ridge on the lower side constructed across the slope. Its purpose is to divert excess water from areas where it is not wanted to sites where it can be used or disposed of safely. For example, a diversion can be used to stop erosion by diverting runoff from a highly erosive area, to manage storm water runoff so that it minimizes wetness and/or flooding either on or off site, and to keep runoff polluted with sediment from leaving the site and/or causing damage on structures already built on the site.

Uses of diversions include:

- Prevent water from running across erodible areas
- Protect active gully heads by directing water away from them
- Protect buildings, residences, or streets from runoff water containing sediment
- Move or direct runoff to a desired location such as a sediment basin
- Constructed completely around a site to keep sediment laden water from leaving the site
- Used where runoff from higher areas is or has a potential to damage property, cause erosion, contribute to pollution, flooding, or interfere with or prevent the establishment of vegetation on lower areas
- Shortening the length of graded slopes such as spoil slopes or roadway grade thereby protecting lower portions of a hillside or roadway from highly erosive flow

Diversions can be useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of



Use of Diversions on Construction Sites

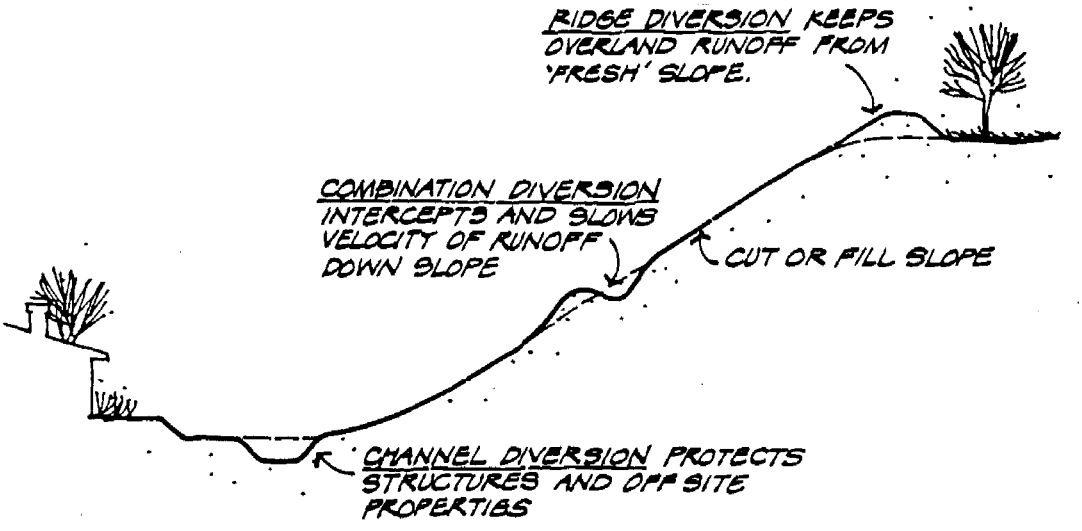
cut or fill slopes to keep runoff from upland drainage areas of the slope. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.

Permanent diversions are preferable to other types of man-made stormwater conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum. When properly coordinated into the landscape design of a site, diversions can be visually pleasing as well as functional.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is equally important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

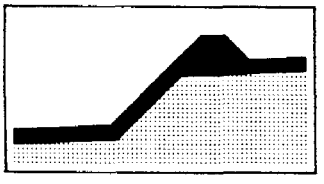
A temporary diversion is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the structure with vegetation.



Common Uses of Diversions

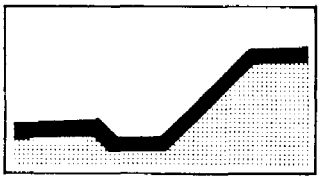
RIDGE DIVERSION (RD)



This is also called berm or dike, diversion dike, inceptor dike or perimeter dike. It consists of a ridge of compacted earth or other material forming a channel behind the ridge.

A ridge type diversion is most commonly used at the tops of slopes, perimeters of construction areas, and across disturbed rights-of-way. It can also be used around the base of spoil piles or around areas within the construction site that must be protected or are vulnerable to erosion. It is most easily constructed concurrent with major earth moving activities.

CHANNEL DIVERSION (CD)



This is also called diversion swale, interceptor swale, perimeter swale, or drainage dip. An excavated type diversion is constructed by cutting a channel across the slope. The depth (or height) is measured from bottom of channel to low bank of the channel. The width of the channel is determined by the amount of water that the channel intercepts plus a small additional oversizing to insure that the water does not overflow the channel.

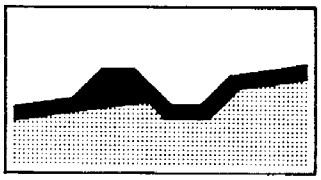
The diversion can be constructed at the same time that overall site grading is taking place at a minimum of time and expense as long as plans and location of the diversions are known. If fill materials are not readily available and additional cut is required for fill material, the excavated type of diversion would be used instead of the fill type.

The most common uses for an excavated type diversion is at the base of hills, slopes, or spoil piles, where it diverts water from permanently settling on low-lying areas and provides positive surface drainage. This type of diversion is also used at the tops of slopes, perimeters of construction areas, and across disturbed rights-of-way especially where fill is not available to construct a ridge type diversion and additional excavation is needed to provide additional fill material.

An excavated diversion may be more erosion resistant since it is cut directly into existing stabilized soil. However, it may be more difficult to establish vegetation. The excavated type of diversion does not work well on slopes. It may be

the most aesthetically pleasing type of diversion, especially if it is widened out and made shallower.

COMBINATION DIVERSION (DC)

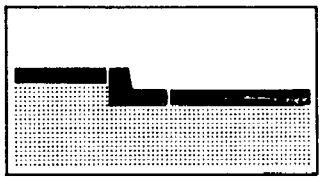


Other names include diversion terrace or interceptor channel. This type of diversion has an excavated channel and a constructed ridge. The distance from the bottom of the channel to the top of the ridge (height of ridge) is great enough to insure that the water will be conveyed along the diversion channel. The material excavated for the channel is used to build the ridge.

A combination-type diversion is usually constructed across long slopes or at intervals across disturbed erodible areas. However, it is applicable everywhere that an excavated or ridge type diversion is used. Since all cut from the channel is used in the ridge, cuts and fills will balance.

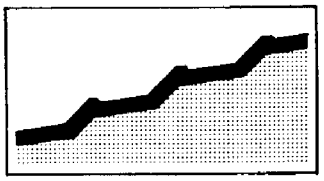
One type of temporary combination diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This practice can be constructed by the use of a motor grader or one of the smaller dozers. To shape the diversion, the piece of machinery used may run near the edge of the fill with its blade tilted to form the channel. This work would be done at the end of the working day and provide a channel with a ridge on the lower side to protect the slope. Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause more problems than it solves by concentrating water at a single point.

CURB AND GUTTER (CG)



A curb and gutter is actually a combination diversion; the curb being the same as a filled ridge and the gutter the same as the excavated channel. The curb and gutter may be used separately or in combination with each other to form any of the three types of diversions previously discussed. The curb and gutter is typically used instead of having side ditches along a road right-of-way. When the road runs across the slope (i.e., along the contour), the curb and gutter will intercept water and act in the same manner as a regular diversion. When roadway fills are subject to erosion due to concentrations of water running off the paved surface, curbs and gutters are sometimes installed at the top of the road fill and at the edge of the roadway to intercept the water and convey it to a safe outlet where it will not cause erosion.

BENCHES (B)



Benches are constructed on long-cut slopes to increase slope stability. They can, however, serve a dual purpose when constructed similar to any of the three types of diversions already discussed. They break up the length of slope, intercept runoff, and slow the velocity, thus minimizing erosion of the slope. Benches are built as a wide flat area on the slope. Instead of continuing a cut slope from the top to the bottom without a break, a flat area is constructed at certain intervals down the slope to intercept runoff before it can cause erosion. The flat areas are generally made wide enough to accommodate construction and maintenance equipment and usually backsloped to intercept and convey water to a suitable outlet.

Waterway Measures

A waterway is a natural or constructed channel designed and shaped for the safe disposal of runoff. The channel may be bare or may have a protective lining of vegetation or erosion resistant materials such as concrete, stone, or other permanent material. Waterways as discussed in this handbook do not include permanent or intermittent streams.

The purpose of waterway measures is to provide for the disposal of excess surface water from diversions or natural concentrations of flow without causing erosion or flooding.

The place where waterway measures are typically used is on all sites where added capacity, channel protection, or both are required to control erosion resulting from concentrated runoff. Examples include:

- To dispose of water from erosion and sediment control measures such as a diversion.
- To dispose or convey natural concentrations of runoff across a construction site without causing erosion or flooding.
- To dispose of concentration of water which exceeds the capacity of a storm sewer (as a component of a storm water removal system).

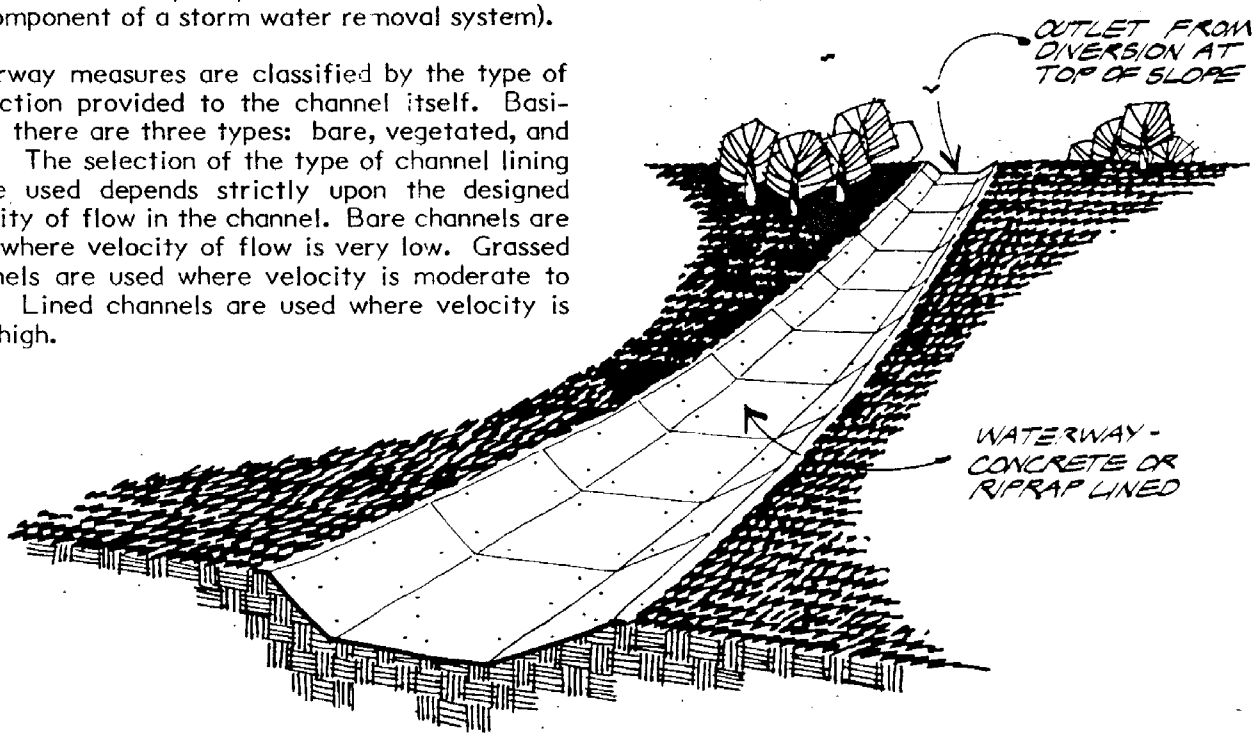
Waterway measures are classified by the type of protection provided to the channel itself. Basically, there are three types: bare, vegetated, and lined. The selection of the type of channel lining to be used depends strictly upon the designed velocity of flow in the channel. Bare channels are used where velocity of flow is very low. Grassed channels are used where velocity is moderate to slow. Lined channels are used where velocity is very high.

Typical waterway cross sections are vee-shaped, parabolic, and trapezoidal.

Vee-shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A grass or sod lining will suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a concrete or bituminous concrete lining may be appropriate.

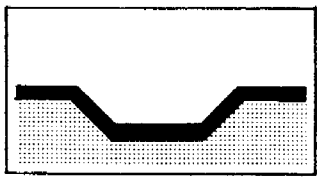
Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass and riprap are also useful where there is a continuous low flow in the channel.

Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches are generally lined with concrete or riprap.



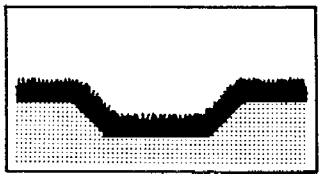
Typical Use of a Lined Waterway on a Slope

BARE CHANNEL (BC)



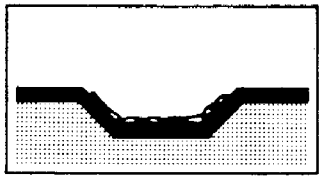
A bare channel is a temporary measure constructed by excavating a channel below the existing grade. Since the surface is unprotected, this type of channel is extremely vulnerable to erosion. Use of a bare channel should be limited to instances where the velocity of flow is very low.

VEGETATIVE CHANNEL (VC)



A vegetative channel can be either a temporary or permanent measure. Grass can be established by either seeding and mulching or sodding. Where immediate stabilization is required, sodding is recommended. A vegetative channel can be used where the velocity of flow is greater than with a bare channel.

LINED CHANNEL (LC)



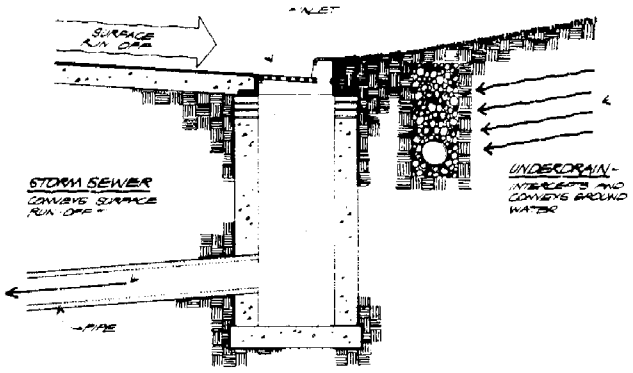
A lined channel is a permanent waterway measure. The lining material may be rock riprap, concrete, or flagstone. A lined channel provides an armored waterway and is applicable in situations of extremely high flow velocities.

For almost every application, a sand and gravel filter, filter cloth, or bedding will be required under the lining material. The filter prevents soil particles from moving through the riprap and into the stream under forces of seepage flow.

Enclosed Drainage Measures

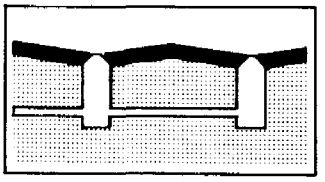
The two types of enclosed drainage measures are storm sewers and underdrains. Storm sewers are usually used to convey storm water runoff, whereas underdrains are typically used to collect and convey subsurface water.

The needs for both surface and subsurface drainage are commonly overlooked in planning a development. In many cases, drainage problems are complicated by the grading plan, which does not recognize the need for drainage. Natural drainageways must be maintained as a sort of emergency spillway for storm sewers and they are required to carry a capacity in excess of their designed flow. Many soils which are naturally wet and in the need of subsurface drainage can be identified by use of soil maps and soil use interpretive data.



Typical Enclosed Drainage Measures

STORM SEWER (ST)

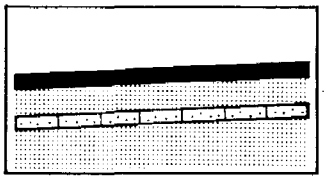


Storm sewers, in addition to traditional uses, may be used as an outlet structure for diversions or sediment basins. They are used to convey sediment laden water to basins or to convey storm water to storm water detention basins. They may also be used in conjunction with waterway measures as follows:

- Where erosive velocities exist in the channel, it may be more economical to use a storm water sewer than to line the channel.
- Usually base flow will occur in a grassed waterway. This destroys vegetation. Storm sewers can intercept this flow and convey it underground, so that the vegetation in the channel does not drown out.

Storm sewers may convey some of the smaller storms underground so that surface water will not be flowing in the grassed waterway so often. They can also be used as slope drains instead of a spillway structure. Furthermore, storm sewers can be used as an outlet for foundation drains, gutter downspouts, or sump pumps, depending upon local ordinances. Even if a local ordinance prohibits hook-up to the storm sewer, a second smaller underground pipe may be used as an outlet at an appropriate place. Since storm sewers are typically used in developments, it is particularly advantageous to also use them as a method of conveyance for sediment and erosion control during construction.

UNDERDRAIN (UD)



The purpose of underdrains is to improve the soil environment for vegetative growth by regulating the water table and ground water flow; intercept and prevent water movement into a wet area; remove water from around buildings, roads, play areas, sediment basins, or other physical improvements; intercept seep areas at the top of a slope; and regulate water to control health hazards.

Subsurface drainage utilizes buried pipes to remove free water from the soil and subsoil and lower the water table. Often times, underdrains are needed in waterways established in grass to intercept base flow and ground water so that it will not kill the grass in the channel.

Underdrain systems are of two types, relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern.

Interceptor drains are used to remove water as it seeps down a slope, to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout.

Spillway Measures

A spillway is a designed device, constructed or manufactured, used in a soil and water conservation or management system to retain, regulate, or control the flow of water.

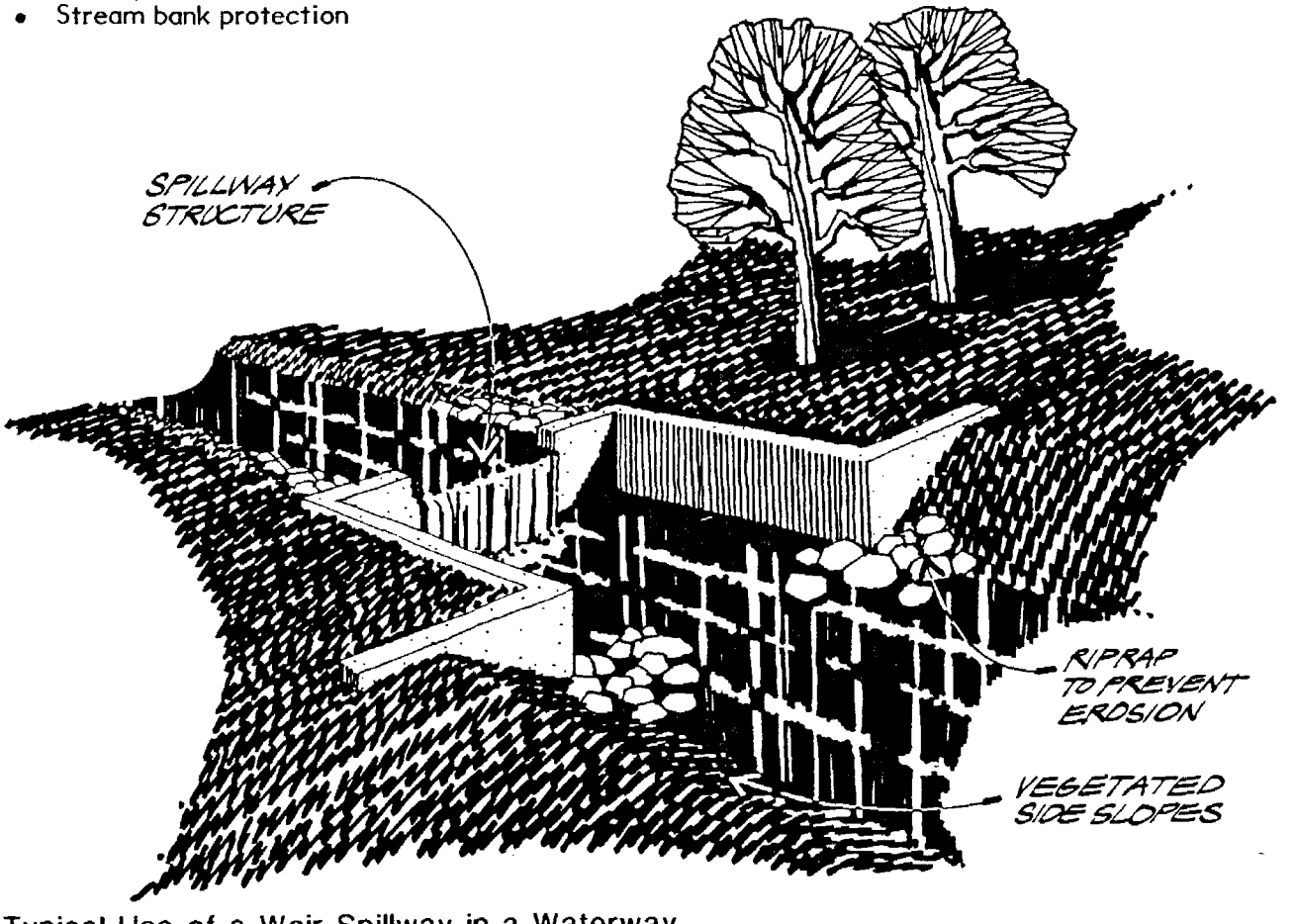
The purpose of spillway structures is to stabilize the grade and control erosion in natural or artificial channels, prevent the formation or advance of gullies, reduce environmental and pollution hazards, and provide for the safe conveyance of storm water runoff.

Structures are normally used in the following situations:

- Grade and gull control in waterways
- Sediment trapping
- Storm water detention
- Storm water retention
- Outlet protection
- Shore protection
- Stream bank protection

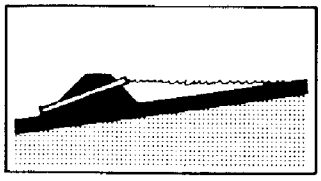
Structures can be classified into the following groups: pipe structures, weir structures, chute structures, and outlet protection structures.

For all except outlet protection structures, an earthen embankment is usually incorporated as a part of the structure and may be used to choose between pipe, weir, and chute types of structures. Outlet protection structures may be used in combination with any of the other types of structures to protect the outlet channel from excessive velocities generated in the structures. Within each type of control measure, structures are further classified by the type of inlet. For example, pipe structures may have a straight inlet, a flared inlet, or a drop inlet. Weir and chute structures may have a straight or a box inlet.



Typical Use of a Weir Spillway in a Waterway

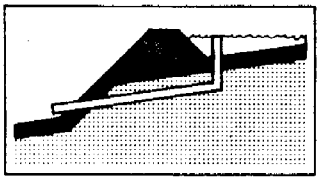
STRAIGHT PIPE SPILLWAY (SS)



Pipe spillways can be used for a large range of overfalls, but have a limited capacity for conveying runoff. They are typically used as slope drains, culvert crossing under roads, and can be used as outlet spillways for retention, detention, or sediment basins. Plain pipe spillways have the disadvantage of requiring a substantial depth of ponded water behind the spillway before it flows to its full capacity.

The specifications for pipe structures in this book contain guidelines primarily for flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the span is capable of withstanding the expected loads from heavy construction equipment which may cross the structure. The designer must also be aware that such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers or Illinois Department of Transportation Division of Water Resources.

DROP INLET PIPE SPILLWAY (DIS)

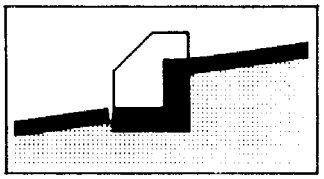


A drop inlet pipe spillway is similar to a plain pipe spillway except that the inlet is modified with a vertical pipe manhole or constructed box. The vertical inlet serves two purposes:

- It improves the hydraulic efficiency of the pipe spillway by decreasing the depth of water that must pond behind the structure before the pipe flows completely full.
- The vertical inlet may serve for grade and gully control of water course leading to the spillway.

The uses of a drop inlet pipe spillway are the same as the plain pipe spillway. In addition, if there is an overfall at the entrance to an existing culvert, a vertical inlet made of reinforced concrete may be attached to the existing culvert to control the overfall and thus eliminate fully erosion in the water course. The vertical inlet will also improve the hydraulic efficiency of the culvert. An existing culvert may be modified to function as a drop inlet pipe spillway. By adding a reinforced concrete vertical inlet to the culvert any overfall which exists at the entrance to the culvert is eliminated and the water course is stabilized. Sometimes this type of modified vertical inlet is called a drop box.

WEIR SPILLWAY (W)

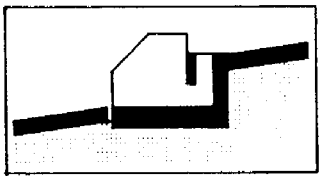


Weir spillways are used typically at the lower reaches of waterways and natural channels to drop water from one elevation to another, thus controlling gully erosion at that point.

Weir spillways are usually built of reinforced concrete or they can be obtained as prefabricated metal structures.

Weir spillways may be used as the outlet spillway to retention basins, but do not function well as outlet spillways to detention and sediment basins because of the large outflow capacity. Weir spillways will control somewhat less vertical drops than pipe spillways. However, the capacity of weir spillways is much greater than that of pipe spillways. The inlet to a weir spillway may be straight or modified with a box to provide even greater capacity.

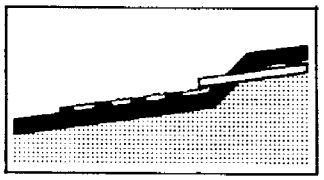
BOX INLET WEIR SPILLWAY (BS)



A box inlet weir spillway differs from a weir spillway only in terms of the inlet configuration. The box inlet type will handle a considerably greater amount of flow.

Outlet Measures

LINED APRON (LA)



The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. For extremely high velocity of flows special energy dissipation structures need to be designed.

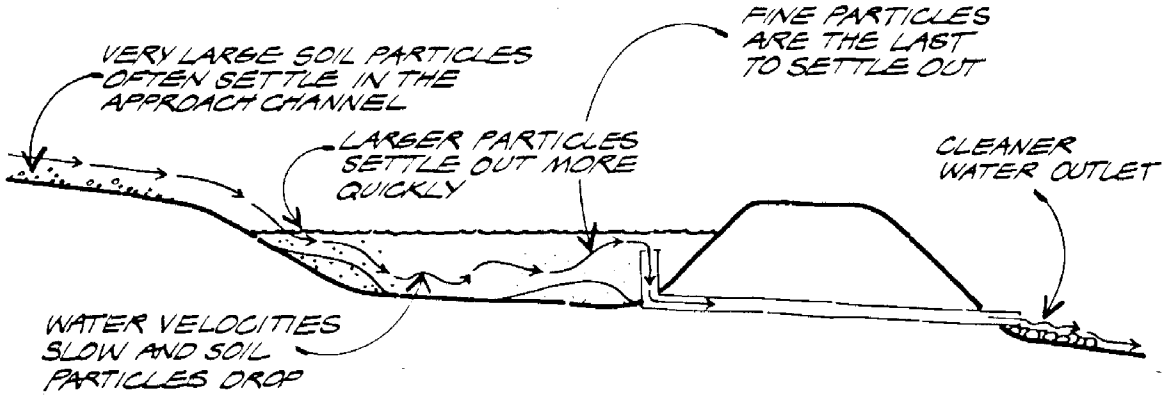
Sediment Control

Sediment control measures are intended to provide for the management of sediment on-site to avoid damage to adjacent properties and/or waterways. The main groups of measures include sediment basins, sediment filters, and mud and dust control.

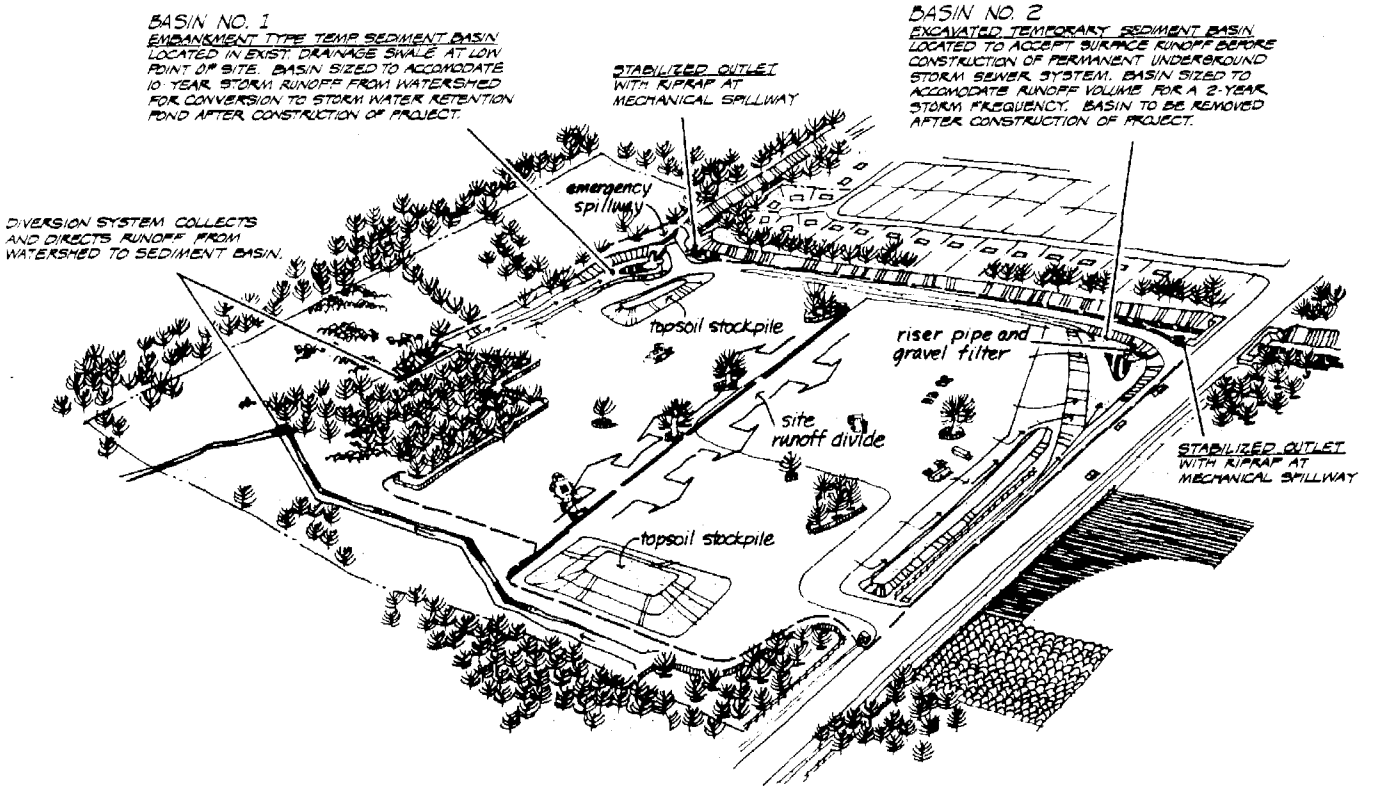
Sediment Basin Measures

A sediment basin is a barrier or dam constructed across a waterway or at other suitable locations to form a basin for catching and storing sediment. The purpose of using sediment basins is to preserve the capacity of reservoirs, ditches, waterways and streams; to prevent undesirable deposition on developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for the depositions and storage of silt, sand, gravel, and other detritus. The size of a sediment basin will depend upon the location, size of drainage area, soils, and rainfall pattern. Sufficient space for sediment is provided to store the expected sediment yield from the construction site. An additional volume of storage must be provided to temporarily store and detain the volume of runoff from the designed storm, since the outflow rate is decreased from the inflow rate in order to attain the proper amount of detention time for sediment to settle out. The basin has a constructed earth spillway, called an emergency spillway, to convey flows in excess of the designed storm safely around the sediment basin. In the design of some sediment basins, an additional volume of water may be designed into the basin for the retention or permanent storage of water.

Sediment basins are not always 100% effective in trapping sediment which flows into them. Therefore, they should be used in conjunction with erosion control measures such as temporary seeding, mulching, diversions, etc., to reduce the amount of sediment flowing into the basin.



How a Sediment Basin Works



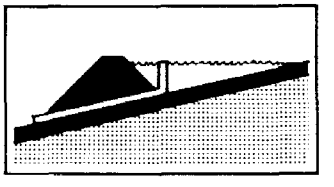
Use of Sediment Basins on a Construction Site

To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas and natural drainageways below disturbed areas. Drainage into the basin can be improved by the use of diversion, and waterways. The basin must not be located in a live stream but should be located to trap sediment-laden runoff before it enters the stream. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

There are two classes of basins. Class I is used for drainage areas five acres or less with embankments no higher than five feet. These basins require very little formal design and are relatively inexpensive to build. Many times existing storm sewer inlets can be temporarily modified to serve as the outlet structure for these basins and little or no other land grading is required.

Class II basins are for large drainage areas and for greater heights of embankment. These basins require formal engineering design

EMBANKMENT SEDIMENT BASIN (ES)

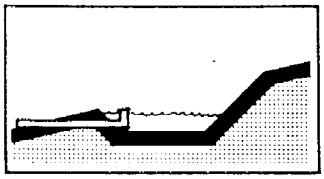


An embankment type basin is one of the most common types used on construction sites. These basins are particularly applicable on sites with drainage courses or swales which are depressed enough to allow construction of a dam across them to create a ponding area. This type of basin requires the availability of fill material for construction of a dam.

A checkdam may be considered a special case of an embankment type sediment basin. It is usually constructed of rock, straw bales, sandbags, wire

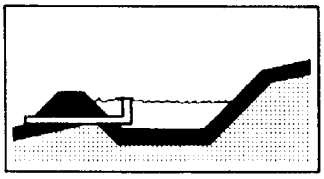
fence, timber, or other materials. It is usually installed along gullies, ditches, or small water courses in an effort to slow runoff velocities and prevent gully erosion. Generally, no provision is made for conveying water through a checkdam so it frequently fails by washing out under the dam, thus releasing any trapped sediment and creating even more erosion. Too often a checkdam is used on channels having drainage areas greater than recommended. In general, a checkdam is not recommended unless the drainage area is very small (less than one-half acre), and it is properly constructed and maintained to store all of the runoff from the drainage area. A better alternative to a checkdam would be to design non-erosive channel linings while construction or establishment of vegetation is taking place.

EXCAVATED SEDIMENT BASIN (XS)



Excavated sediment basins are located at low points on a site's drainage area. They are constructed by digging a pit to collect and hold runoff. With capacity obtained exclusively by excavation, this type of basin is recommended for use on relatively flat land where natural valleys or depressions do not exist, or where the drainage area is small. These basins often need to be pumped out after a storm event to ready them for the next storm. Furthermore, excavated basins cannot be rebuilt in poorly drained soils because they will fill with ground water instead of stormwater runoff.

COMBINATION SEDIMENT BASIN (CS)

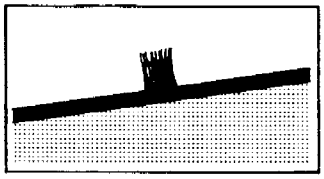


A combination excavated and embankment type basin is constructed with a balance of cut and fill. The material from the excavated pit is conveniently used to build the dam. This basin type is most applicable on sites with gentle to moderately sloping areas where natural depressions exist, but are not deep enough to provide required storage capacity by damming alone.

Sediment Filter Measures

Sediment control measures based on filtering fall into two categories: those which form sediment barriers and those which form vegetative filter strips. With the present state of the art, it is difficult to assign an accurate universal effectiveness to sediment control measures which are based on filtering. This is because accurate design criteria have not yet been established nor the effectiveness of such measures completely evaluated. In general, filtering measures should only be used on very small areas such as individual lots to control sheet erosion so that sediment does not leave the property or used as a "last resort" measure.

BARRIER FILTER (BF)



A barrier filter is a temporary barrier installed below small disturbed areas, at the toe of a slope, or at a storm sewer inlet to intercept and detain sediment. It is typically used at storm drain inlets where as much sediment is kept out as possible and at property lines of single-lot developments to prevent sediment from leaving the site. Types of barrier filters include straw bale barriers and silt fences.

Based on observations made in Virginia, Pennsylvania, Maryland, and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be.

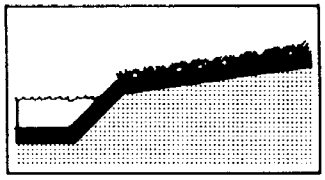
Improper use of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water velocities and volumes have destroyed or impaired their effectiveness. Improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal

or entrenchment, has allowed undercutting and end flow.

Proper installation procedures must be followed for straw bale barriers to be effective. Therefore, use of straw bale barriers should be contingent upon significant improvement in the installation and maintenance procedures applied to their use.

Silt fences composed of a wire support fence and an attached synthetic filter fabric slow the flow rate significantly. Both woven and nonwoven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the non-woven fabrics. Research has shown that silt fences can trap a much higher percentage of suspended sediments than can straw bales, and silt fences may be preferable to straw barriers in many cases. The finer the mesh of the fabric, the greater the filtering capability.

VEGETATIVE FILTER (VF)



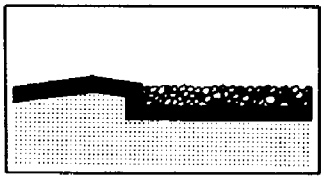
A vegetative filter strip is a grassed area through which storm water must flow before it enters streams, storm sewers, conduits, and the like. As water containing sediment flows through the filter strip, some sediment is removed by filtering and by deposition as the flow velocity is reduced. The vegetative filter can be either existing vegetation or the vegetation can be planted or sodded before construction starts. A tall, dense, sturdy turf makes the best vegetative filter.

Vegetative filters can be used to trap small amounts of sediment before it leaves the construction site, such as around storm sewer inlets, from a small lot, or along streams or newly established channels to help reduce sedimentation in the channel. On long slopes, strips are used at intervals to break up and slow over-land flow.

Mud and Dust Control Measures

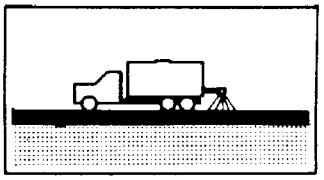
The purpose of these measures is to prevent the loss of soil from a construction site by tracking from vehicles or transport by wind. The two most commonly used measures are construction entrance stabilization and dust and traffic control.

STABILIZED CONSTRUCTION ENTRANCE (SE)



A stabilized construction entrance is a stone stabilized pad located at any point where traffic will be entering or leaving a construction site, to or from a public right-of-way, street, alley, sidewalk, or parking area. The purpose of the entrance is to reduce or eliminate the transport of mud from the construction area onto public rights-of-way by construction vehicles or by run-off. This practice is used at all appropriate points of construction ingress or egress.

DUST AND TRAFFIC CONTROL (DT)



Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in "heavy" construction activities, such as road and street construction and subdivision, commercial or industrial development, which involve disturbance of significant areas of soil surface.

In planning for dust control, it should be obvious that the less soil is exposed at any one time, the less potential there will be for dust generation. Therefore, phasing a project and utilizing temporary stabilization practices upon the completion of grading can significantly reduce dust emissions.

4. DEVELOPING THE EROSION CONTROL PLAN

The model Soil Erosion and Sedimentation Control Plan, shown on Figure 4-4, has been designed to include all of the items that should be considered when planning for soil erosion and sedimentation control. This plan, however, does not by any means contain every erosion control measure that can be used. Different areas may require different erosion control techniques based on the topography, climate, surface cover, and soils. For illustrative purposes, a number of erosion control measures have been used. In reality, further information may be required such as surface and subsurface soil investigations which provide a check on the soil survey.

Development of an erosion and sedimentation control plan involves three steps: determination of grading limits, determination of drainage areas, and selection of specific control measures.

Determine Grading Limits

Grading limits are indicated by outlining on the plan the extent of all areas where the soil will be disturbed or existing vegetative cover removed exposing bare soil. These areas will require one or more temporary or permanent soil stabilization measures.

Determine Drainage Areas

Outline all separate drainage areas that occur on the site (Fig. 4-2). In the case of the site plan that was prepared in Chapter 3, there are three separate drainage areas as follows:

Area 1 - Includes approximately 18.2 acres of the western portion of the site. All stormwater is discharged to the existing pond. Stormwater includes that which falls directly on the areas as well as runoff from adjacent properties to the west. Draw down for the pond is via an enclosed conduit easterly to Willow Creek.

Area 2 - Includes approximately 15.7 acres of the eastern portion of the site. All storm water is discharged to Willow Creek from both enclosed drainage and overland flow. Since Willow Creek is part of the regional watershed drainage pattern, protection of the creek from sediment disposition is particularly critical.

Area 3 - Includes approximately 1.3 acres of land adjacent to Deerpath Road and a portion of Route 31. All stormwater is discharged directly to the roadside drainage ditches, with off-site discharge points on the north and south. The prevention of sediment from entering the drainage ditches is particularly important.

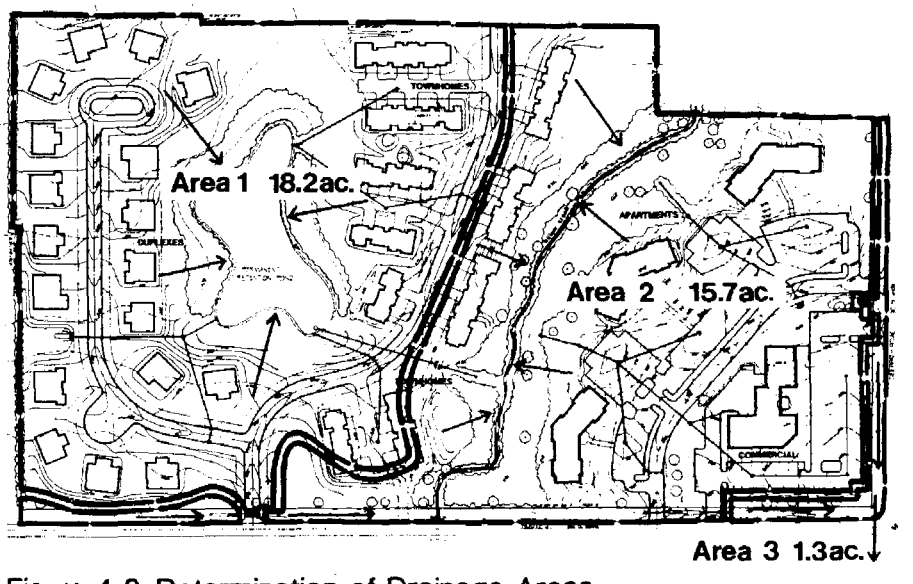


Figure 4-2: Determination of Drainage Areas

Selection of Specific Control Measures

In order to develop the most effective erosion control strategy, the three areas of concern, soil stabilization, runoff control, and sediment control, should be evaluated for each drainage area. This evaluation assures the most comprehensive strategy for the entire project. As control measures are selected for each area, their corresponding plan key symbols from the planning matrix should be placed on the final Erosion and Sedimentation Control Plan. For the subject site plan, the selection of control measures is made as follows:

Soil Stabilization

1. Topsoil Stockpiling - Strip topsoil from graded areas and stockpile for later use. Stockpiles should be located in safe areas and be adequately protected by temporary seeding and mulching.

2. Temporary Seeding - Certain portions of the project will be rough-graded as a first stage of construction with finish grading to follow near project completion. Seed these areas with fast germinating temporary grasses to reduce erosion potential.

3. Permanent Seeding - Immediately following finish grading establish permanent seeding.

4. Sodding - Sod may be installed in high activity areas such as building entrance zones for immediate stabilization. In Area 3, sod is required on the slopes adjacent to the public rights-of-way to prevent sedimentation in the drainage ditches.

5. Paved Areas - All roads and parking areas will be paved. Install the aggregate base as soon as possible in the construction sequence to provide required stabilization.

Runoff Control

1. Diversions - In areas 1 and 2 construct diversions at the lower end of graded areas to intercept sediment laden runoff and direct it to a controlled discharge point at the creek.

2. Enclosed Drainage - Drain, paved roads and parking lots by an underground storm sewer system.

3. Waterways - Construct a lined channel at the outlet of the pond discharge pipe to conduct water to Willow Creek. Construct vegetative channels at the outlets of diversions on the west side of Willow Creek to conduct runoff to the creek.

4. Outlet Protection - Build lined aprons at all storm sewer outlets discharging to the pond area.

Sediment Control

1. Sediment Basins - Construct sediment basins adjacent to the creek in area 2. These should be permanent structures designed to receive runoff from the diversion berms.

2. Sediment Barriers - During construction filter sediment laden water through straw bales before it enters storm inlets.

3. Sediment Filters - Provide barriers where surface drainage discharges to the creek or to off-site areas without being treated in a sediment basin. Such drainage areas must be less than one acre. Install a vegetative filter to stabilize the edge of the pond and filter sediment from surface runoff entering the pond.

4. Construction Entrances - Stabilize all entrance drives to the site should be stabilized during construction and prior to final paving.

5. Dust Control - All haul roads will be watered continuously while grading is taking place.

THE DEVELOPER WILL ASSUME RESPONSIBILITY FOR MAINTENANCE OF ALL SOIL EROSION CONTROL AND ON-SITE DETENTION MEASURES DURING AND AFTER CONSTRUCTION. THIS RESPONSIBILITY WILL BE TURNED OVER TO THE PROPERTY OWNERS AFTER 80% OF THE DEVELOPMENT IS COMPLETED AND OCCUPANCY PERMITS ISSUED FOR UNTIL SUCH TIME AS 80% OF THE LOTS IN THE DEVELOPMENT HAVE BEEN SOLD. HOWEVER, THE DEVELOPER SHALL NOT TRANSFER THESE IMPROVEMENTS FOR THE PURPOSE OF MAINTENANCE UNTIL HE HAS COMPLIED WITH THE ABOVE AND UNTIL HE HAS RECEIVED FINAL APPROVAL, FINAL INSPECTION, AND A CERTIFICATE OF COMPLIANCE FROM THE DEPARTMENT ENGINEER FOR THE BUILDING AND ZONING DEPT.

Inspection Schedule

1. DIVERSION AND STRUCTURAL MEASURES - WILL BE INSPECTED AT 7/8 DAY INTERVALS OR AFTER EVERY RAINSTORM PRODUCING RUNOFF.
2. SEDIMENT BASINS AND PONDS - WILL BE CHECKED AFTER EACH MAJOR PHASE OF THE DEVELOPMENT FOR SEDIMENT ACCUMULATION.
3. VEGETATIVE PLANTINGS - SPRING PLANTINGS WILL BE CHECKED DURING SUMMER OR EARLY FALL.
4. REPAIRS - ANY EROSION CONTROL MEASURES, STRUCTURAL MEASURES, OR OTHER RELATED ITEMS IN NEED OF REPAIR, WILL BE MADE WITHIN 15 DAYS.
5. MOWING - DRAINAGEWAYS, DITCHES AND OTHER AREAS THAT SUPPORT A DESIGNED FLOW OF WATER, WILL BE MOWED REGULARLY TO MAINTAIN THAT FLOW.
6. FERTILIZATION - SEEDED AREAS WHERE THE SEED HAS NOT PRODUCED A GOOD COVER, WILL BE INSPECTED AND FERTILIZED AS NECESSARY.

Soil Protection Chart

STABILIZATION TYPE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PERMANENT SEEDING			A									
DORMANT SEEDING	B											B
TEMPORARY SEEDING			C				D					
SODDING			E**									
MULCHING	F											

A KENTUCKY BLUEGRASS 90 LBS/AC. MIXED WITH PERENNIAL RYEGRASS 30 LBS/AC.

B KENTUCKY BLUEGRASS 135 LBS/AC MIXED WITH PERENNIAL RYEGRASS 45 LBS/AC. + 2 TONS STRAW MULCH PER AC.

C SPRING OATS 100 LBS/AC.

D WHEAT OR CEREAL RYE 150 LBS/AC.

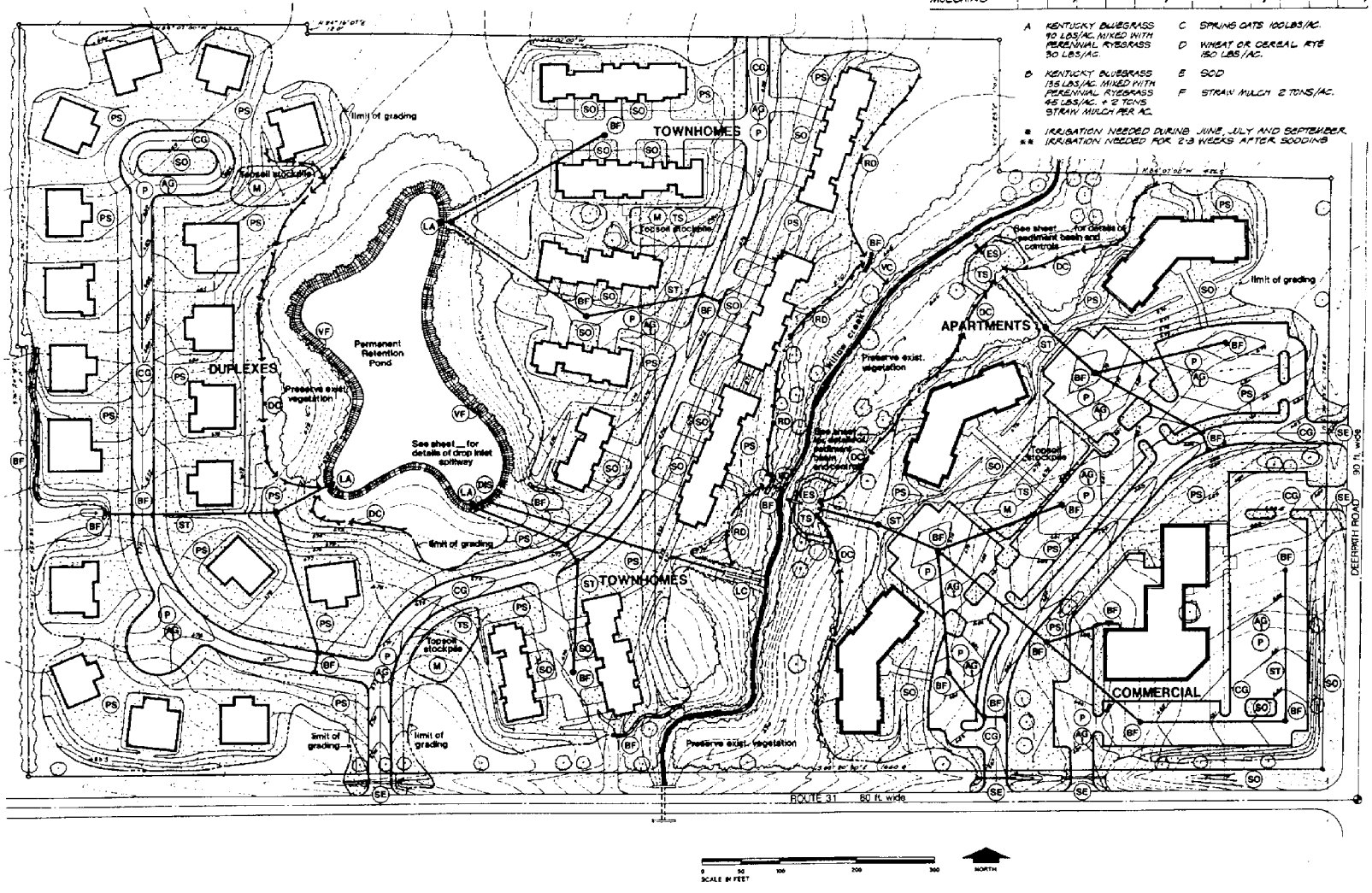
E SOD

F STRAW MULCH 2 TONS/AC.

* IRRIGATION NEEDED DURING JUNE, JULY AND SEPTEMBER.
** IRRIGATION NEEDED FOR 2-3 WEEKS AFTER SODDING

Legend

- EXISTING CONTOUR
- PROPOSED CONTOUR
- PROPOSED STORM SEWER
- PROPOSED CURB AND GUTTER
- LIMIT OF GRADING
- (M) PROPOSED CONTROL MEASURE
- PROPOSED DIVERSION MEASURE
- PROPOSED SED FILTER MEASURE



Construction Sequence and Responsible Contractor

	GRADING CONTRACTOR	UNDERGROUND CONTRACTOR	PAVING CONTRACTOR	LANDSCAPE CONTRACTOR
1. INSTALL SEDIMENT CONTROL MEASURES				
RD RIDGE DIVERSION	■			
DC COMBINATION DIVERSION	■			
VC VEGETATIVE CHANNEL	■			■
SS STRAIGHT PIPE SPILLWAY	■			
LA LINED APRON		■		
ES EMBANKMENT SEDIMENT BASIN	■			
BF BARRIER FILTER	■			
SE STABILIZED CONSTRUCTION ENT.	■			
2. GRADE SITE/STOCKPILE TOPSOIL	■			
3. PRESERVE AND PROTECT EXIST. VEG.				
4. INSTALL STORMWATER MGM'T. MEASURES				
ST STORM SEWER		■		
BF BARRIER FILTER (INLET PROTECTION)		■		
DIS DROP INLET SPILLWAY		■		
LC LINED CHANNEL		■		
5. TEMPORARY VEGETATIVE STABILIZATION OF CONTROL MEASURES				
TS TEMPORARY SEEDING				■
VF VEGETATIVE FILTER				■
M MULCHING				■
6. INSTALL ROAD AND PARKING SUBGRADE				
AG AGGREGATE COVER			■	
7. SITE CONSTRUCTION WORK				
CG CURB AND GUTTER			■	
P PAVING (WALKS, PLAZAS, ETC.)			■	
8. VEGETATIVE COVER ON ALL AREAS TO BE EXPOSED LONGER THAN 60 DAYS				
TS TEMPORARY SEEDING				■
9. SURFACE ROADS AND PARKING				
P PAVING			■	
10. PERMANENT VEGETATIVE STABILIZATION OF ALL EXPOSED AREAS				
PS PERMANENT SEEDING				■
SO SODDING				■
11. INSTALL PERMANENT LANDSCAPING				■
12. PERFORM CONTINUING MAINTENANCE	■	■	■	■

FIGURE 4-4: SOIL EROSION AND SEDIMENTATION CONTROL PLAN

Scheduling Construction Activities

Scheduling of construction activities should include sequence of construction, construction techniques, landscaping, and future operations and maintenance considerations. By properly scheduling the construction, both the extent of exposed ground and the duration of exposure can be minimized. Phasing, which allows for clearing, grading, and the stabilization of one portion of the site before clearing and grading begin on another, will limit the number and severity of erosion problems.

Construction phased so that a vegetated buffer is above or below critical areas, such as slopes, stream banks and surface drainageways under construction, will reduce the amount of runoff reaching the critical exposed area. A phased operation is especially valuable in dealing with long slopes, for stabilizing the upper portion will protect the lower portion.

The amount of rainfall and runoff during different periods of the year influences erosion vulnerability. In Illinois 80% of erosive rains occur from May 1 to October 1 with 50% of the erosive rains falling during the months of May, June, and July. Erosive rains, not rainfall, is the key factor to erosion control. In Illinois the growing season extends from April to mid-October. The recommended seeding schedule for both temporary and permanent seeding during this growing period are given in Chapter 6.

Temperature as well as precipitation influences seed germination. The cool, moist periods of early spring and fall are the most favorable for establishing a stabilizing vegetative cover. Planting during the late summer and early fall insures that soil will be well protected from erosion during the high risk period of the following spring through early summer when erosive rainfall is the greatest. Where feasible it is recommended that stabilizing vegetation be established in critical areas, such as drainageways and stream banks, before major clearing and grading begin on the rest of the site. The scheduling of site preparation work in the late summer and establishing vegetation over the fall period assures critical areas will be well protected for the period of major construction during the following summer.

When installation of permanent measures are not possible prior to winter shut-down, temporary seeding and mulching should be installed to protect the site during winter and early spring months.

Sequence of control measure installation is a critical factor in controlling erosion and sedimentation on the construction sites. Sediment basins and associated conveyance system, whether temporary or permanent, should be installed before construction begins on the rest of the site.

Immediately after grading is completed, permanent surface cover should be established. Where areas without sediment traps are to be left for extended period before they are brought up to final grade and permanently stabilized, temporary surface cover and/or mulch should be used to stabilize the exposed soil surface.

Developing The Schedule

The three main items required are a construction sequence, soil protection chart, and an inspection and maintenance schedule. Used in conjunction with the SE and SC Plan, this provides a system that will explain what and when it is going to happen.

On the SE and SC Plan is a chronological listing of the construction sequence. Each item in the list is a symbol referring to the specific erosion control measures to be used. This Construction Schedule explains in an orderly fashion what will occur from first to last. This gives plan reviewers and job superintendents a simple explanatory system to demonstrate the sequence of construction items.

The Soil Protection Chart (Fig. 4-3) provides a schedule for seeding, sodding or mulching. This chart can be used to schedule erosion control activities even if the anticiapted construction schedule falls behind.

The type of soil protection measure can be permanent, dormant and temporary seeding, sodding or mulch. Across the top of the soil protection chart are the months of the year. The arrows show the time of year the type of soil protection can be applied for seeding Zone 1. The seeding mixtures for the model SE and SC-plan were selected from information given in Chapter

6 and are represented by the letters A through F. In the case of mulch, the letter indicates the type of mulch and rate per acre. For sod, the letter states sod.

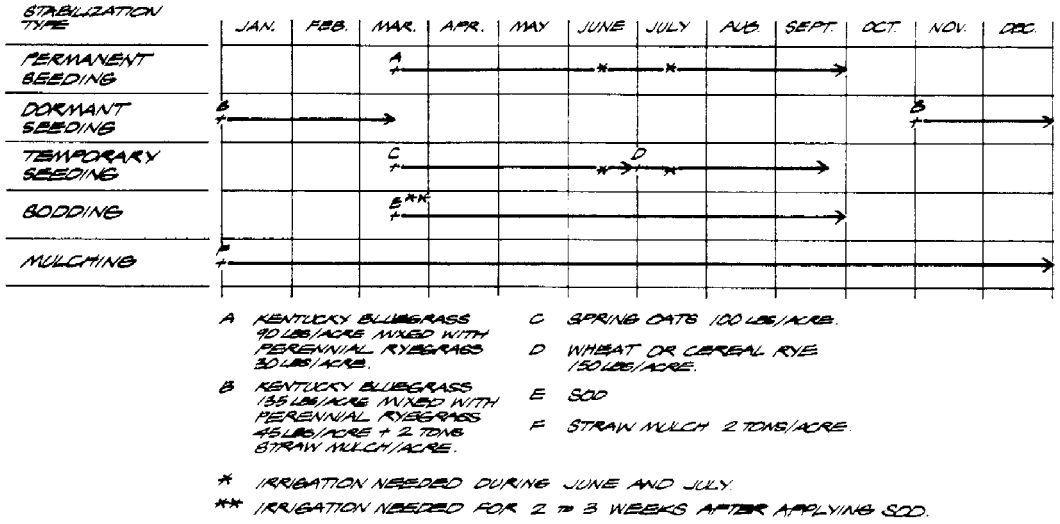


Figure 4-3: Typical Soil Protection Chart

Operation and Maintenance Plan

The final step in urban site planning is the development and implementation of an operation and maintenance plan for all temporary and permanent soil erosion control measures. This written plan should contain information covering the work program, materials, and equipment to be used, parties responsible for the maintenance, and the anticipated schedule of the maintenance program.

Follow-up inspections, immediately after each phase of construction, as well as periodic inspection and maintenance, are necessary to assure the proper functioning of erosion control measures. Runoff conveyance and storage measures and structural measures require inspection after every rain that produces runoff. Any channel obstructions should be removed and any damages repaired immediately. Sediment basins and ponds may require cleaning out on a regular basis in order to remain effective.

The use of vegetative material for erosion control purposes also required a regularly scheduled maintenance program. A follow-up maintenance program includes repair of seeded, sodded, or other vegetatively stabilized areas where the desired degree of stabilization has not been achieved. Spring plantings should be inspected during the summer or early fall so that any corrective measures that may be needed can be performed during the fall planting season. Maintenance of common areas in subdivisions is normally assumed by a park district or a homeowners' association. This should be considered in planning and designing permanent erosion and sedimentation control structures and practices. By making slopes 4:1 or flatter and designing for low maintenance, mowing and cleaning is more likely to take place, reducing the chance of poor maintenance and resulting structural failures. The operations and maintenance schedule should be written down for future reference by the land owners. If items such as timing, inspections, minor repairs, and grounds maintenance are clearly spelled out, they are more likely to be followed.

5. CONCLUSIONS

The preparation of a document that graphically illustrates and clearly describes the erosion and sedimentation control measures to be utilized on urban construction sites is a first step in preventing erosion and sedimentation damage. This plan, when properly implemented, lessens or eliminates the need for remedial erosion control.

Clear, concise documentation of all pertinent site conditions, erosion control measures, timing of construction, keys and legends will result in a site plan that can be implemented, inspected, and maintained.

There are three steps in effective erosion and sedimentation control. The first involves identifying probable critically erodible areas. This is done by analyzing site conditions and characteristics; such as: topography, soils, drainage, vegetation, etc. The second step is to determine what types of erosion and sedimentation control measures are necessary and where they are to be applied. The third step is the development and implementation of an operation and maintenance plan for all permanent erosion control measures. This written plan should contain information covering the schedule of maintenance, the extent of work, materials and equipment to be used, and parties responsible for the maintenance.

By using the planning matrix to help plan, apply, and maintain erosion control measures, urban development can be accomplished with reduced environmental damage, minimal extra cost, and can result in an increased property value for the site.

4

Preparing the Erosion and Sedimentation Control Plan

GENERAL CONSIDERATIONS

Before preparing an erosion and sedimentation control plan, the designer should have a sound understanding of the requirements of the North Carolina Sedimentation Control Law (*Chapter 1*), erosion and sedimentation control principles (*Chapter 2*), the role of vegetation and other surface protection in the erosion process (*Chapter 3*), and the appropriate uses of the principal erosion and sedimentation control practices *(Chapter 5)*.

Developers and builders can minimize erosion, sedimentation, and other construction problems by selecting areas appropriate for the intended use. Tracts of land vary in suitability for development. Knowing the soil type, topography, natural landscape values, drainage patterns, flooding potential, and other pertinent data helps identify both beneficial features and potential problems of a site.

Purpose of the Plan

The purpose of an erosion and sedimentation control plan is to establish clearly which control measures are intended to prevent erosion and off-site sedimentation. The plan should serve as a blueprint for the location, installation, and maintenance of practices to control all anticipated erosion and prevent sediment from leaving the site.

The approved erosion and sedimentation control plan—showing location, design, and construction schedule for all erosion and sedimentation control practices—should be a part of the general construction contract. State specifically the method of payment for implementing this plan in the contract and consider erosion and sedimentation control an early pay item.

Elements of the Plan

An erosion and sedimentation control plan must contain sufficient information to describe the site development and the system intended to control erosion and prevent off-site damage from sedimentation. As a minimum, include in the plan:

- a site location or vicinity map,
- a site development drawing,

- a site erosion and sedimentation control drawing,
- drawings and specifications of practices designated with supporting calculations and assumptions,
- vegetation specifications for temporary and permanent stabilization,
- a construction schedule,
- a financial/ownership form, and
- a brief narrative.

Although a narrative is not specifically required by the law, it can clarify details of the plan as an aid for the inspector and the contractor. The narrative should be concise but should describe:

- the nature and purpose of the proposed development,
- pertinent conditions of the site and adjacent areas, and
- the proposed erosion and sedimentation control measures.

The designer should assume that the plan reviewer has not seen the site and is unfamiliar with the project. Map scales and drawings should be appropriate for clear interpretation.

Data Collection and Preliminary Analysis

The base map for the erosion control plan is prepared from a detailed topographic map. If available, a soils map should be obtained from the local office of the USDA Soil Conservation Service. Transferring soil survey information to the topographic map is helpful for site evaluation.

The design engineer responsible for the plan should inspect the site to verify the base map with respect to natural drainage patterns, drainage areas, general soil characteristics, and off-site factors.

The base map should reflect such characteristics as:

- soil type and land slopes,
- natural drainage patterns,
- unstable stream reaches and flood marks,
- watershed areas,
- existing vegetation (noting special vegetative associations),
- critical areas such as steep slopes, eroding areas, rock outcroppings, and seepage zones,
- unique or noteworthy landscape values to protect,
- adjacent land uses—especially areas sensitive to sedimentation or flooding,
- critical or highly erodible soils that should be left undisturbed.

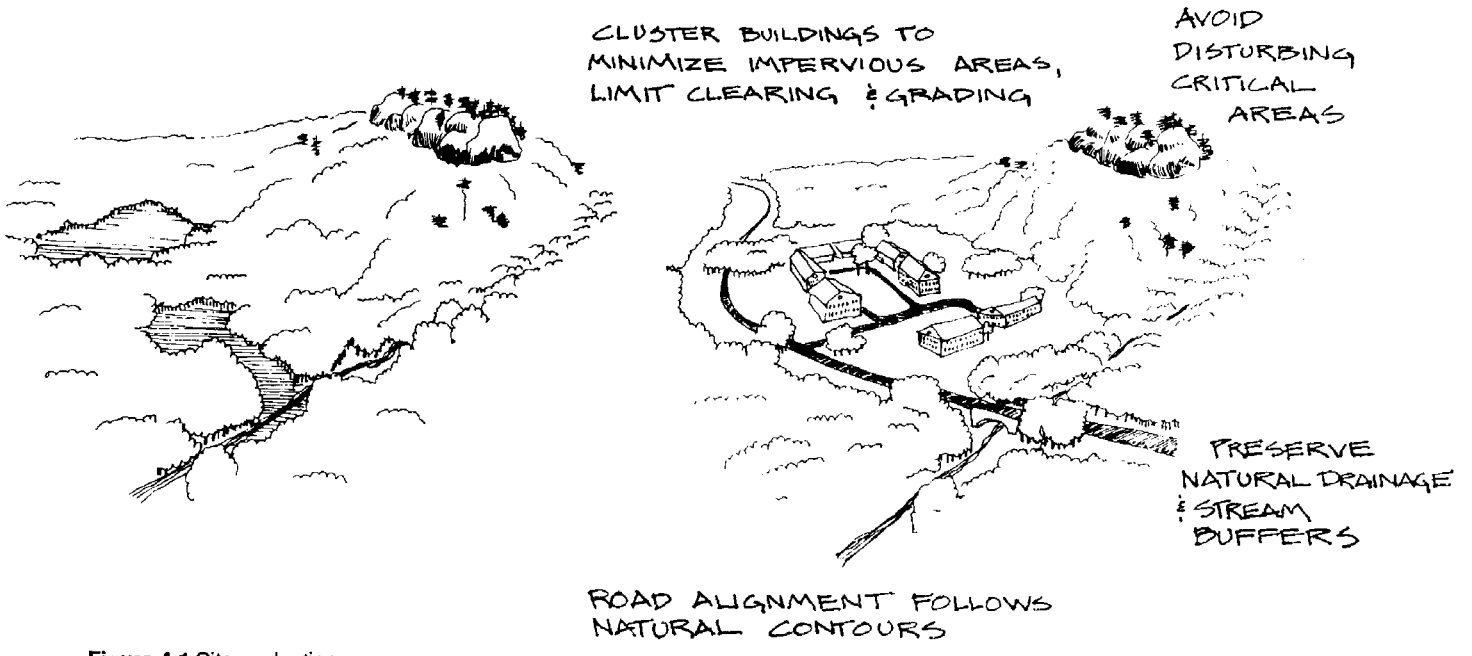


Figure 4.1 Site evaluation.

In the analysis of these data, identify:

- buffer zones,
- suitable stream crossing areas,
- access routes for construction and maintenance of sedimentation control devices,
- borrow and waste disposal areas, and
- the most practical sites for control practices.

The analysis of the topography, soils, vegetation, and hydrology should define the limitations of the site and identify locations suitable for development.

Principles of Site Development

The site evaluation data and the information shown on the field map serve as the basis for both the site development plan and the erosion and sedimentation control plan (Figure 4.1). Plan development to fit the proposed site, recognizing constraints determined in the site analysis. To determine the best layout of the site, observe the following principles:

Fit the development to the site—Follow natural contours as much as possible. Preserve and use natural drainage systems.

Limit clearing and grading—Clearly define work limit lines. Grade to minimize cut-and-fill slopes, preserve natural buffer areas, and limit the time that bare soil is exposed.

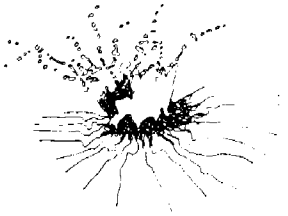
Minimize impervious areas—Build in clusters to provide more open space, minimize parking areas and reduce disturbance for utility line construction. Use porous paving materials when practical. Maintain existing vegetation where possible.

Avoid disturbing critical areas—Identify and avoid areas vulnerable to concentrated runoff.

Maintain and enhance existing site values—Retain significant trees and other plant groups. Avoid disturbing unique land forms, very steep slopes, and rock outcroppings.

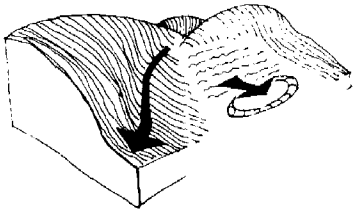
Strategy

The erosion and sedimentation control plan should seek to protect the soil surface from erosion, control the amount and velocity of runoff, and capture all sediment on-site during each phase of the construction project. Strategies for controlling erosion and sedimentation should consider the following elements:



Schedule activities—Coordinate the installation of erosion and sedimentation control practices to coincide with the construction activities as the most cost-effective control strategy. Many sedimentation control practices should precede grading activities.

Protect the soil surface—Limit the extent of disturbance and stabilize the soil surface immediately. Once the surface has been disturbed, it is subject to accelerated erosion and should be protected with appropriate cover, such as mulch or vegetation, in an expedient manner.



Control surface runoff—Divert water from undisturbed areas to avoid disturbed areas. Break up long slopes with temporary diversions to reduce the velocity of runoff. Divert sediment-laden water to sediment impoundments. Make all outlets and channels stable for the intended flow.

Capture sediment on-site—Divert runoff that transports sediment to an adequate sediment-trapping device to capture sediment on the site.

Chapter 5 provides a practice selection guide (Table 5.1) for the selection of appropriate control practices. *Chapter 6* contains standards and specifications for the implementation of recommended erosion and sedimentation control practices.

WRITING THE PLAN

Phase I: Runoff-Erosion Analysis

Development of the erosion and sedimentation control plan can be viewed as a series of phases that occur in approximate chronologic order. The phases overlap considerably and so are not presented as steps.

Landscape —Evaluate proposed changes in the landscape to determine their effect on runoff and erosion. Note all physical barriers to surface runoff, such as roads, buildings, and berms. Check slope grades and lengths for potential erosion problems. Designate intended collection points for concentrated flow

and specify controls to dissipate energy or stabilize the surface. Designate areas to be protected or used as buffer zones in this phase (Figure 4.2).

Runoff yield—Evaluate surface runoff for the entire contributing drainage area—on-site and off-site. Delineate small subwatersheds on-site and estimate peak runoff rates and volumes at selected collection points identified. Base runoff determinations on the peak discharge from the 10-year storm with site conditions during and after development—**not predisturbance conditions**. See *Appendix 8.03* for procedures for estimating peak runoff.

Sediment yield—Estimate sediment yield by subwatersheds. This aids in identifying preferred locations for sediment traps and barriers and can be used to estimate the expected cleanout frequency. An area that is subject to excessive erosion may call for extra storage capacity in traps or additional precautions during construction.

Phase II: Sediment Control

Erosion control practices reduce the amount of sediment generated, but they do not eliminate the need for sediment control devices such as barriers and traps. Sediment control practices operate by reducing flow velocity and creating shallow pools that reduce the carrying capacity of runoff. Thus sedimentation occurs on-site rather than off-site. Sediment is generally not controlled by filtering but by deposition. The designer should locate all traps and barriers recognizing

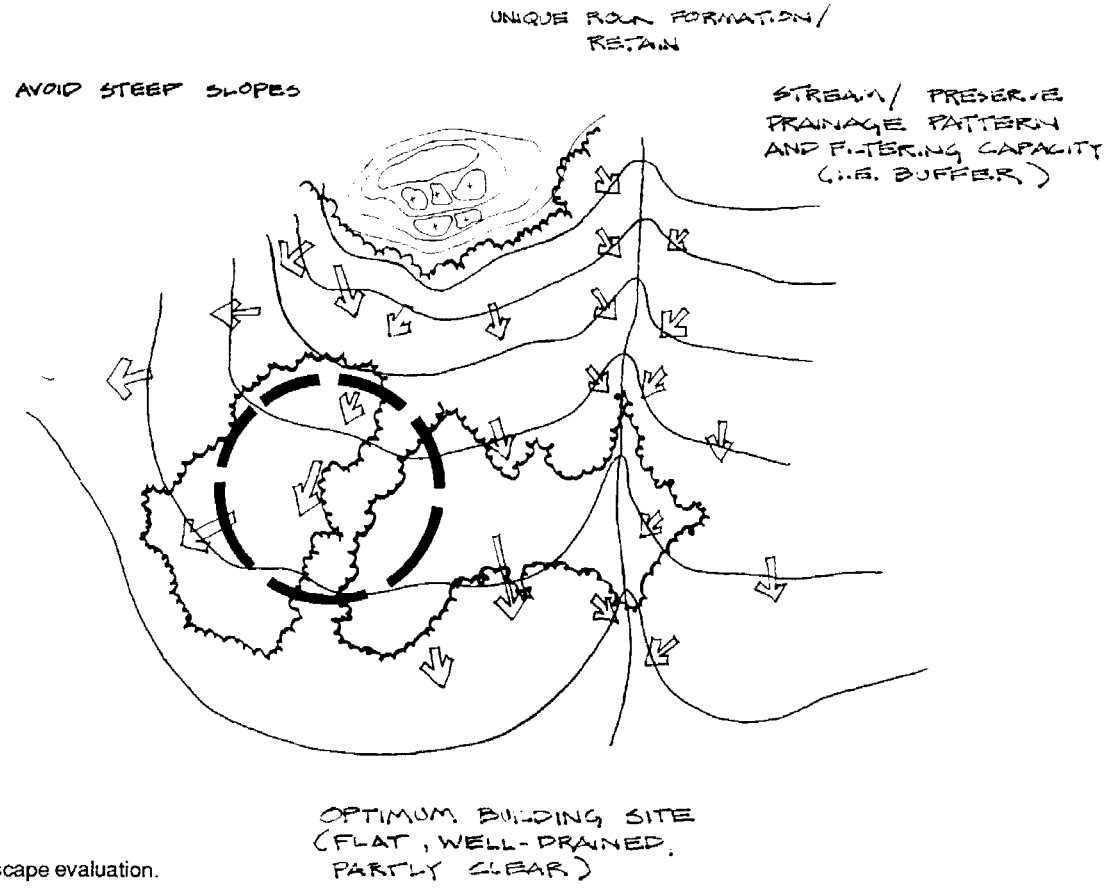


Figure 4.2 Landscape evaluation.

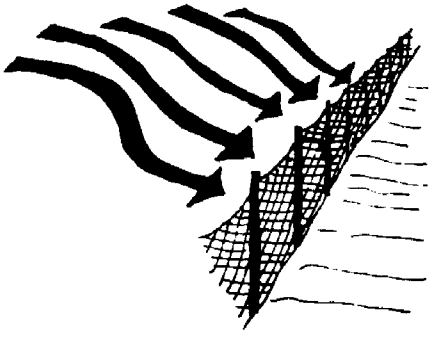
that they represent deposition points where access for maintenance will be necessary.

Sediment basins and traps—Select sites and install sediment basins and traps before other construction activities are started. Also consider locations for diversions, open channels, and storm drains at this time so that all sediment-laden runoff can be directed to an impoundment structure before leaving the construction site.

Divert sediment-free water away from sediment basins and release it through stable outlets. This reduces construction costs and improves basin efficiency.

The plan should show access points for cleanout of all traps and basins and indicate sediment disposal areas. Maintenance of storage capacity is essential throughout the construction period.

Practice standards in *Chapter 6* provide design criteria and construction specifications for sediment traps (Practice 6.60) and sediment basins (Practice 6.61). Procedures for the design of sediment basins are contained in *Appendix 8.07*.



Sediment fences—Sediment fences (Practice 6.62) provide effective control of sediment carried in sheet flow. They are particularly useful where there is limited space to work such as near property lines, among trees, or near sidewalks or streets.

Sediment fences should never be used across streams, ditches, channels, or gullies.

The sediment fence operates primarily by reducing flow velocity and causing a shallow pool to form. If filtering action is required, the designer should assume that the barrier will clog rapidly so that all runoff must be retained behind the fence or released through a designated outlet. Any outlet points must be reinforced and stabilized and should be designated in the plan.

Place sediment fences on relatively flat ground with sufficient area for a pool to develop without putting unnecessary strain on the fence. If a level area is not available at the fence location, excavate a trench directly upslope from the fence.

Show sediment fences on the topographic map and clearly indicate deposition areas and needed overflow or bypass outlet points. Also show access routes for maintenance.

Inlet protection—Inlet protection devices for storm sewers, conduits, slope drains, or other structures make effective, low-cost deposition areas for trapping and holding sediment. A shallow excavation in conjunction with a sediment barrier can be effective at many locations. In the plan, show where these measures will be located, what type of device will be used, and how these devices will be constructed and maintained. Practice standards for the design of several types of inlet protection devices are included in *Chapter 6* (Practices 6.50, 6.51, 6.52, and 6.53).

Phase III: Protection of Disturbed Areas

Once an area is disturbed, it is subject to accelerated erosion. In the plan, show how erosion will be controlled on these disturbed areas. Erosion control can be achieved by:

- limiting the size of clearing and time of exposure by proper scheduling,
- reducing the amount of runoff over the disturbed surface,
- limiting grades and lengths of slopes, and
- re-establishing protective cover immediately after land-disturbing activities are completed or when construction activities are delayed for 30 or more working days.

Cut-and-fill slopes—Steep cut or fill slopes are particularly vulnerable to erosion. Protect such slopes by temporary or permanent diversions just above the proposed slope before it is disturbed. Provide a stable channel, flume, or slope drain, where it is necessary to carry water down a slope. Flow conveyances may have vegetative, mechanical, or combined vegetative and mechanical liners, depending on slope and soil conditions.

Shorten long slopes by installing temporary diversions across the slope to reduce flow velocity and erosion potential. Install permanent diverions with slope drains and protected outlets on long steep slopes (over 20%) as the slopes are constructed.

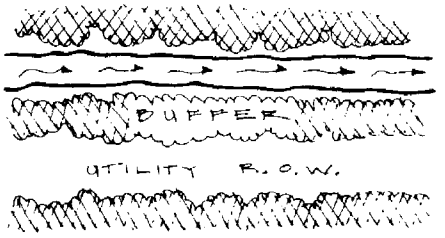
Finish final slope grades without delay and apply the appropriate surface stabilization measures as soon as possible. Roughen slope surfaces to improve the success of vegetative stabilization. Consider both the stabilization measures and how they will be maintained before planning the steepness of the finished slope. For example, if the finished slope is to have smooth grass cover, it should be constructed on a grade of 3:1 or flatter to allow mowing.

Surface covers—Riprap, gravel, straw and other land covers can provide immediate surface protection to disturbed soil areas. Riprap is especially useful where concentrated runoff over steep slopes occurs. Riprap should be installed on a gravel or filter fabric bed.

Construction traffic—Carefully plan stabilization of construction access areas, construction roads, and parking areas. Ensure that traffic patterns follow site contours and limit the length of routes up steeper slopes. Generally, road grades should not exceed 12%. Controlling surface runoff is necessary to prevent serious roadside erosion. Proper grading of the road surface, stable channel design, and use of water bars, other diversions, and culverts help prevent erosive flows. Where water tables are high, subsurface drainage may be needed to stabilize the subgrade. Storm drains should be considered for water disposal where channel grade exceeds 5%. Plans should show all stabilization measures needed to control surface runoff from all roads.

Borrow and waste disposal areas—Clear borrow and waste disposal areas only as needed and protect them from surface runoff. Maintain berms as fill slopes are constructed to reduce slope length and control runoff. Slope all areas to provide positive drainage, and stabilize bare soil surfaces with permanent

vegetation or mulch as soon as final grades are prepared. Direct all runoff that contains sediment to a sediment-trapping device. In large borrow and disposal sites, shape and deepen the lower end to form an in-place sediment trap, if site conditions warrant it. Off-site borrow areas may be governed by the N.C. Mining Act.



Utilities—Use the spoil from utility trench excavations to divert flow from upslope areas, but use care in spoil placement to avoid blocking natural surface outlets. Diversions and water bars can reduce erosion when properly spaced across utility rights-of-way. When utilities are located near a stream, maintain an undisturbed buffer zone wherever possible. If site dewatering is necessary, pump or divert muddy water to sediment traps before discharging it to the stream. If streams must be crossed, make sure all necessary materials and equipment are on-site before construction begins, and complete work quickly. Finish all disturbed surfaces to design grade and immediately stabilize them with permanent vegetation or other suitable means. When utilities cross the stream, you must specify the plans to prevent sedimentation.

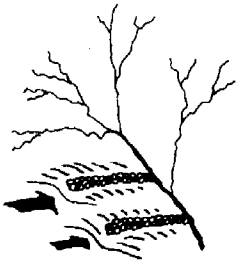
Perimeter protection—Consider diversion dikes for perimeter protection for all proposed developments and install them where appropriate before clearing the site. Exercise care not to create flooding or erosion by blocking the natural drainage pattern. Be sure to provide an adequate outlet.

Dust control—Exposed soil surfaces that are nearly level have little potential for runoff erosion but may be subject to severe wind erosion. Keeping the disturbed surface moist during windy periods is an effective control measure, especially for construction haul roads.

Preserving vegetation—Preserve existing vegetation on the site as long as possible as a cost-effective way to prevent on-site erosion and off-site sedimentation.

Phase IV: Runoff Conveyance

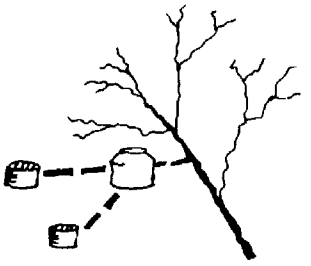
The safe conveyance of runoff water from a construction site is achieved by: (1) utilizing and supplementing existing stable watercourses, (2) designing and constructing stable open channels, or (3) installing storm drains with stable outlets. The plan should indicate locations and designs for these facilities. Complete and stabilize outlets for channels, diversions, slope drains, or other structures before installing the conveyance measure.



Existing watercourses—When using existing watercourses, either show that flow velocities are acceptable for increased runoff conditions or indicate how necessary stabilization will be achieved.

Excavated channels—When channels are to be excavated, base a stability analysis on allowable velocity or tractive force procedures. Include all calculations as part of the plan documentation.

Wide, shallow channels with established grass linings are usually stable on slopes up to 5%. These channels must be protected with temporary liners until grass is established. If channel gradients are too steep to use vegetation, riprap or concrete linings may be required, and in some instances grade stabilization structures may be needed.



Storm drains—Where the site plan calls for a system of storm drains, the drains may be used effectively in the erosion and sedimentation control plan. Build junction boxes or inlets early in the construction sequence, and grade the adjacent area to drain toward the inlet. Install an inlet protection device at all open pipe inlets and excavate a shallow basin in the approach to the inlet for sediment storage. The storm drain flow from the protected inlets may be diverted to a sediment basin for additional sediment control. Restrict the drainage area for inlets to less than 1 acre, and frequently inspect inlet protections for needed maintenance.

Standards for runoff conveyance (Practices 6.30, 6.31, 6.32, and 6.33) and outlet protection measures (Practices 6.40 and 6.41) in *Chapter 6* provide the criteria necessary for the design of these practices. Design procedures for channels and outlet structures are contained in *Appendices 8.05, 8.06,* and *8.07*. Standards for the design of storm drains are not included.

Phase V: Stream Protection

Streambanks, streambeds, and adjoining areas are susceptible to severe erosion if not protected. Include sufficient detail to show that streams are stable for the increased velocities expected from the development activity. At a minimum, all streams should be stable for flows from the peak runoff from the 10-year storm.

When stability analysis shows that the stream requires protection, vegetation is usually the preferred approach because it maintains the stream nearest to its natural state. When flow velocities approach 4-6 ft/sec, or if frequent periods of bankful flows are expected, structural measures such as riprap lining or grade stabilization structures are usually necessary. In the plan, show where stream protection is needed and how it will be accomplished.

Runoff into stream—Only sediment-free runoff may be discharged from construction sites directly into streams. Ensure that all other flows enter from desilting pools formed by sediment traps or barriers.

Velocity control—Keep the velocity of flow discharged into a stream within acceptable limits for site conditions. Control velocity by installing an appropriate outlet structure. Standards for two types of outlet protection devices are given in *Chapter 6* (Practices 6.40 and 6.41). Design procedures for riprap outlet structures are contained in *Appendix 8.06*.

Buffer zone—Areas adjoining streams should be left undisturbed as buffers (Figure 4.3). Existing vegetation, if dense and vigorous, will reduce flow velocities and trap sediment from sheet flow. However, the principal benefit of leaving natural buffer zones along streams is that they prevent excessive erosion in these sensitive areas. Maintaining stream canopies also protects fish and wildlife habitats; provides shade, windbreaks, and noise barriers; protects the bank from out-of-bank flood flows; and generally preserves natural site aesthetics.

Indicate stream buffer zones in plans that involve natural streams. The width is determined by site conditions but generally should not be less than 25 feet on each side of the stream. Where natural buffers are not available, provide artificial buffers. **Where work is required along a stream, you must provide a mechanical or artificial buffer.**

Figure 4.3 Wooded buffer zone.

Off-site stream protection—Increased rate and volume of runoff from development activities may cause serious erosion at points some distance downstream. The developer should work with downstream property owners to stabilize sensitive downstream channel areas.

Stream crossing—Minimize the number of stream crossings. Construct crossings during dry periods; if necessary, divert water during construction. The plan should show the type of crossing to be used and the associated control measures to minimize erosion from surface runoff such as diversions, outlet structures, riprap stabilization, etc. Design guidelines are given in *Chapter* 6 (Practices 6.70, 6.71, 6.72, and 6.73) for stream protection practices.

Phase VI: Construction Scheduling

Appropriate sequencing of construction activities can be the most effective means for controlling erosion and sedimentation. Consequently, present the construction activity schedule of the general contract as part of the erosion and sedimentation control plan. **Put into place the primary erosion and sedimentation control practices for the site, i.e., sediment basins and traps, and a water conveyance system before undertaking major land-disturbing activities.**

Install sediment basins and primary sedimentation control practices as the first structural measures. Next install the overall water disposal outlet system for the site.

Stabilize all construction access routes, including the construction entrance/exit and the associated drainage system, as the roads are constructed. Install storm drains early in the construction sequence and incorporate them in the sedimentation control plan. Then install low-cost inlet protection devices for efficient sedimentation control in the area around the inlets. This allows early use of the inlets and the drain system.

Install diversions above areas to be disturbed and, where appropriate, locate diversion dikes along boundaries of areas to be graded before grading takes place.

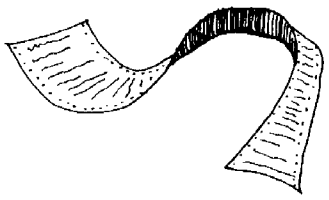
After all principal erosion and sedimentation control measures are in place, perform the land clearing and rough grading. Clear areas only as needed and com-

plete final grading and surface stabilization in an expedient manner and within the construction schedule. Minimize the time of exposure and select temporary ground cover according to the location and season. Temporary surfaces should be stabilized as soon as active grading is suspended, and must be stabilized within 30 working days or 120 calendar days, regardless of the time of year.

Phase VII: Maintenance

In the erosion and sedimentation control plan, indicate who is responsible for maintenance and when it will be provided. The maintenance schedule should be based on site conditions, design safeguards, construction sequence and anticipated weather conditions. Specify the amount of allowable sediment accumulation, design cross-section, and required freeboard for each practice and what will be done with the sediment removed. The plans should also state when temporary practices will be removed and how these areas and waste disposal areas will be stabilized.

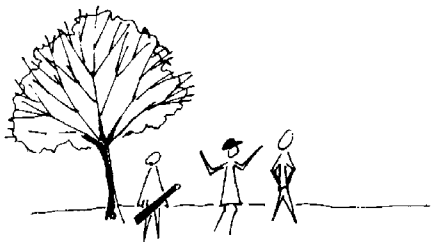
Phase VIII: Performance Requirement



Even though the developer may have an approved plan that is properly installed and maintained, he is not relieved of responsibility for off-site sediment damage resulting from his construction activities. Therefore, frequently inspect the property boundary for evidence of sedimentation. If off-site damage occurs, the developer may be responsible for immediate corrective measures. Modification of the plan and re-approval may also be necessary.

The erosion and sedimentation control plan should be flexible enough to allow for modification to correct problems. It is common for unanticipated events or construction changes to occur during project development that may require major alterations in the plan. Resubmit significant changes for approval before they are implemented.

Phase IX: Preconstruction Conference



A preconstruction conference with the owner, contractor, and erosion control personnel at the site is recommended as a means of assuring proper implementation of the erosion and sedimentation control plan. This conference is required by some local ordinances. A preconstruction conference allows all parties to meet, review the plans and construction schedule, and agree on responsibility and degree of control expected. Discuss maintenance requirements, phasing of operations, and plan revisions at this time.

A preconstruction meeting is especially important for large, complex jobs or when the contractor and/or developer has had little experience in this type of work.

If the job foreman assigned responsibility for on-site sediment control cannot be present at the conference, give his name to the erosion control representative at this time.

5
plan approval and enforcement

1. PLAN REVIEW AND APPROVAL	1
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1. PLAN REVIEW AND APPROVAL

Once the enforcement agency is given the necessary ordinances and regulations, it must have the ability to review, approve, and inspect the actual on-site process to meet these requirements. The process must assure that the public interest in effective soil erosion and sedimentation control is protected, while not hampering the property owner unnecessarily in the productive use of his land.

Reviewing Personnel

Once a plan is designed incorporating all available data and concepts which are site specific to the project, it may be reviewed by the enforcement agency. This agency -- generally the planning, building or zoning office of the municipality or county -- will have one or more persons on its staff to review and recommend action on the plan. Reviewing personnel should have experience and educational background in the science of soils, groundwater, soil and water conservation, and stormwater management, and should be aware of good site planning and landscaping techniques. Personnel must be able to apply this knowledge and experience to the specifics of each site, since a soil erosion and sediment control plan is unique to each development.

If an agency cannot include a person with all these qualifications on its staff, existing personnel can be trained for this position. Several training courses and seminars are available through the Soil Conservation Service, Environmental Protection Agency, and the American Public Works Association. Short courses are usually offered at local colleges and universities through cooperative eduction programs. The local soil and water conservation district is always available to offer information and advice.

Under Illinois law, counties and municipalities have extensive authority to enter into intergovernmental agreements in performing their responsibilities. Such agreements may include provisions for sharing of personnel. Communities which, individually, can not support a full-time staff person may find it advantageous to develop such an agreement. The Northeastern Illinois Planning Commission can provide examples of such agreements and technical assistance in their development.

The Review Process

The land developer must be well informed on the needs and requirements of controlling soil erosion and sedimentation for the development. He must also understand the relationship between good site management, sediment and erosion control and stormwater management, both on a temporary and permanent basis. An excellent feasible and economical plan can be developed if the property owner is aware of these concepts during initial discussion of the plan layout. Once the designer is familiar with the requirements of the plan the review and enforcement procedure should be thoroughly discussed with him.

Approval of the Plan

As previously mentioned, each soil erosion and sediment control plan is unique for each site. However, there are certain aspects of a plan which must be submitted with each proposal. These include:

- The existing topography of the site and adjacent areas
- A complete physical survey of the site, including such land features as rivers, swamps, type and location of plant life, tree groups, wells, and any existing structures
- A soil survey analysis
- A proposed grading plan including elevations of building, manhole covers, street profiles, sidewalks, ditches, driveways, stormwater and sediment basins and berms

The soil erosion and sediment control plan is finalized after developing the grading plan. In many cases soil erosion and sediment control plans are made part of the grading plan. However, in developments requiring several temporary and permanent controls this is not recommended. The plan should be a composite of existing and proposed grading plans, and the proposed controls incorporated on a separate plan so that the procedures that will be required in the field can be readily understood.

The plan should clearly point out the following:

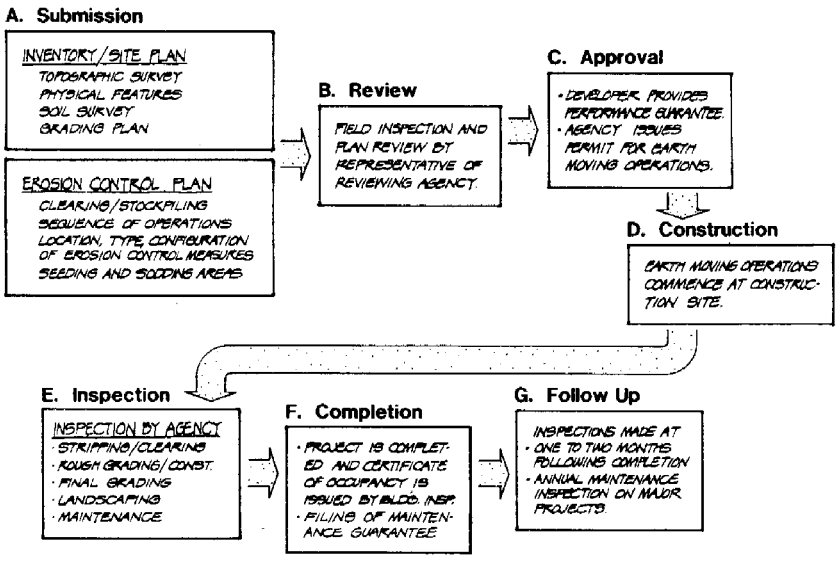
- Required initial clearing and stockpiling operations
- Sequence of all operations during construction
- Location, type, configuration of such controls as swales, berms, dams, sediment basins, and release mechanisms detailed on construction drawings and in specifications
- Areas to be sodded and/or seeded, including kind of seed, rates and dates of application

Before approval of any plan a physical inspection of the site should be made by the reviewing agency. If necessary, alternatives could be considered as development progresses.

Consideration should be given to the development of a permit system concerning earth-moving operations. A permit application should be submitted along with plans.

Governmental agencies should require the developer to provide a performance guarantee in the form of either a bond, letter of credit or cash escrow in an amount not less than the cost of constructing the public improvements. The guarantee should include costs for implementing all phases of a Soil Erosion and Sedimentation Control Plan from clearing and stockpiling operations to final grading and landscaping. An agreement would be a part of this guarantee which would give the governmental agency authority to use the funds to complete the project if the developer defaults or does not properly implement the approved plan. This guarantee should be effective for a sufficient time period to perform the acitivities required, inspect and approve the final installation after completion. Along with stating the notification process, the agency should be given the authority to extend the agreement beyond its original expiration date if necessary.

The Performance Guarantee should be replaced with a Maintenance Guarantee for a stated period of time and in an amount equal to a percentage of the cost of constructing the improvement, usually between 10% and 15%. This prevents unnecessary costs and problems for the agency due to poor workmenship and defective materials.



2. ENFORCEMENT

Once a soil erosion and sediment control plan is submitted and approved, the responsibility to enforce the ordinance and to insure compliance with the plan will be given to the reviewing agency, either a county or municipal government. The most important factor in having a good enforcement system is to have a very complete soil erosion and sediment control plan. The more complete the erosion control plan the easier and more efficient the inspection process will be. The information that is contained in the plan is what must be complied with and enforced.

Inspections

The inspection process can vary. Some agencies may want to hire a person trained in soil conservation to inspect various sites, or the building inspector or building commissioner can do the job. Either way, the system will be effective if the inspector has a properly organized system by which to make inspections. The system can start in the office by having a visual display of those projects that are under development within the boundaries of the agency's jurisdiction. A map of the county or municipality may be on display with the various projects coded to indicate their stage of progress. These stages can vary from the sketch stage to final landscaping and maintenance. Along with this map could be a chart listing the various projects and the dates written on it to show when approval was given for the planning stages and inspections. These visual displays can be a very effective day-to-day reminder of what projects are going on within the jurisdiction. They are also a quick way to check if a project is underway that does not have a permit.

In addition to visual displays, a complete file including copies of the soil erosion and sediment control plan should be kept on each project for future reference. A master list of the project names, owners, locations, type of projects, and permit numbers should also be kept on file.

Once the system is organized in the office, a permit can then be issued with the assurance that efficient inspections will be made. The applicant should be made aware that it is his responsibility to have the permit posted and to call for inspections. It is also suggested to require a stamped, approved soil erosion and sediment control plan on the site for inspectors to refer to during inspections.

The five stages in which inspections are made should be listed on the permit:

- Stripping and/or clearing
- Rough grading and construction
- Final grading
- Landscaping
- Maintenance

Their purpose is as follows:

1. The stripping and/or clearing inspection includes the removal of any trees, stumps, brush, stones, buildings or other items on the surface that need to be removed before grading can begin.

2. The rough grading and construction inspection includes topsoil removal, grading for roads, sediment basins, diversions, and home, commercial and industrial sites. The actual construction of buildings will occur very near this stage of grading.

3. The final grading inspection includes grading completed to the point where topsoil placement and seeding or sodding will begin.

4. The landscaping inspection is made after all sod, seed, trees and/or shrubs are planted.

5. The maintenance inspections are made during the construction process to make sure that any erosion control measures that have been installed are functioning properly. An inspection is also made one or two months after the project is completed. In addition to this, a system should be set up on a year-to-year basis to make maintenance inspections, especially on all major projects.

The stages of construction will vary somewhat depending on the nature of the project, size of the project, whether it is developed in units or for

various other reasons. For subdivisions the responsibility for soil erosion and sediment control many times includes not only the developer who does the major improvements, but the individual homeowner who buys a lot and contracts to have the house built. This situation may require one site development permit for the entire subdivision, including roads, rough grading, sediment basins, and other aspects from the developer and other additional permits or erosion control provisions in the building permit. This may be necessary in order to control erosion over a period of time.

As each inspection is made, pictures should be taken and a progress report written and filed with the project file. If the progress of the project does not follow the erosion control plan, the developer or responsible party should be notified and given a certain time to comply. If at the end of the time limit no effort has been made to correct the situation, the entire project should be stopped.

The system used to stop the project can be the same one used to stop building construction when it does not comply with the code. In extreme cases cooperation with local law enforcement agencies may be necessary to enforce the ordinance. Situations will also arise where earthwork is being done for a project for which no soil erosion and sediment control plan has been submitted and no site development permit has been obtained. The same system of stopping further work on the project should be used as for those that do have permits. In this situation, however, it will be required that a soil erosion and sediment control plan be submitted and approved and a permit obtained before work resumes.

Expiration of Permit

If a permit is obtained and work is not resumed within a given period of time, the permit should expire and a new one obtained. The time given will vary according to the local ordinance. If this situtation does occur, the project developer should be required to obtain a new permit under the requirements of any amendments to the ordinances or any new ordinances.

Revocation of Permit

Authority: If any project affects the health, safety, or welfare of persons residing or working in the vicinty of the project, or if any person holding a permit conducts or carries on the project so that it is materially detrimental to the public welfare or injurious to adjacent property or improvements, the permit should be revoked or suspended. The exact method of permit revocation should be stated in the ordinance. The responsibility for revoking the permit is usually that of the enforcing agency.

Procedure for Revoking Site Development Permit: The procedure for revoking a permit will be explained in the ordinance. The procedure will most likely involve hearings and take an extended period of time. The actual committee or group responsible for revoking the permit may not be the same as the enforcement agency. The inspector's responsibility will be to give timely reports on the progress of the project to the proper authority until the matter is resolved.

3. DEVELOPMENT OF A LOCAL SOIL EROSION AND SEDIMENTATION CONTROL ORDINANCE

The previous two sections dealt with the mechanics of preparing and reviewing a soil erosion and sediment control plan and implementing the plan out in the field. However, the one tool needed prior to doing any of these measures is an ordinance. The legality for requiring such a plan must be firmly established and understood in order for the plan and implementation to be effective. The appendix includes three sample ordinances. These documents include all pertinent articles required by most governmental agencies. They are to be used as a reference guide for development of an ordinance to meet the specific needs of any community.

B. Technical Information

B. Technical Information

1) Soils and Soil Related Processes

a. Soils Information
Source: North Carolina, NC-1

b. Processes and Principles of Erosion and Sedimentation
Source: North Carolina, NC-1

c. Procedure for Computing Sheet and Rill Erosion
on Project Areas
Source: Georgia, GA-1

d. Effects of Vegetation on Erosion, Sedimentation,
and Property Value
Source: North Carolina: NC-1

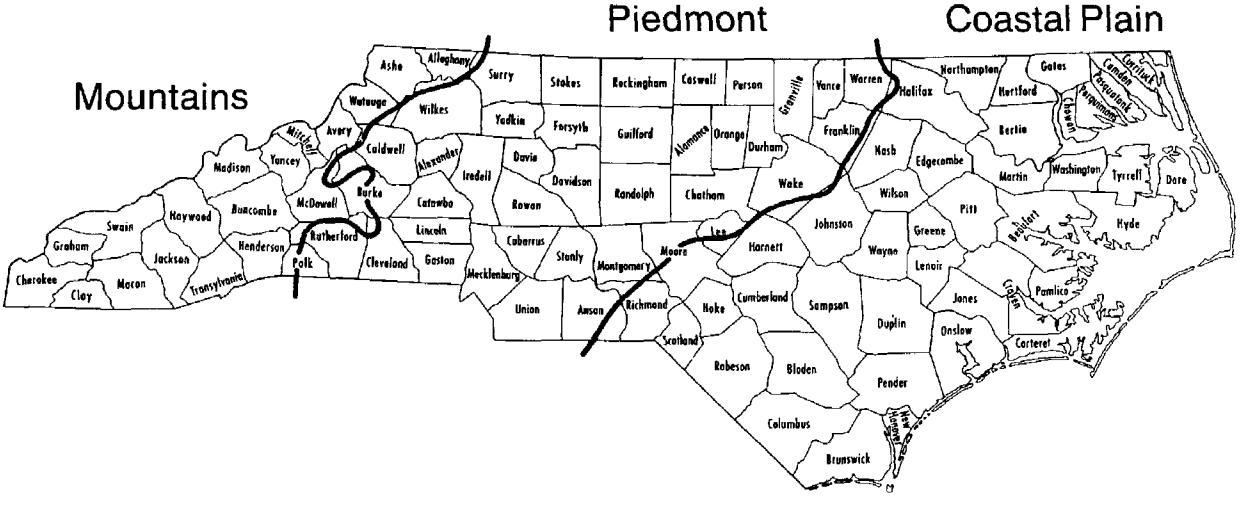
8.01 SOILS INFORMATION

A basic knowledge of soils can aid in preparing development plans. Selection of vegetation to be grown on the site for landscaping and erosion control also requires knowledge of the soils, and selection of other erosion control practices may depend on soil characteristics. In general, erosion control can be designed more cost effectively if soils are considered.

North Carolina is divided into three major soil regions (Coastal Plain, Piedmont, and Mountains) in which geology, geomorphology, and climate are the major factors determining soil characteristics (Figure 8.01a). Other site- specific factors such as moisture, temperature, organic matter, and vegetation also influence these characteristics.

About 45% of the land area of North Carolina is in the Coastal Plain. Elevations range from sea level to about 650 ft. Topography is flat to rolling, with soils that vary from sandy, droughty sandhills to large, wet pocosins, which are composed of sandy to clayey unconsolidated marine and fluvial deposits. About 39% of the state is in the Piedmont, in a rolling to hilly area between the Coastal Plain and the Mountains. Elevations range from 300 ft to 1500 ft. About 16% of the state is in the Mountains, with elevations ranging from 1500 to 6680 ft. Within each region the soils are numerous and often complex. Transition zones between the major regions are composed of mixed soils with variable characteristics.

Figure 8.01a Major soil regions of North Carolina.



USING SOIL SURVEYS

Information on soils may be obtained from soil surveys but should be verified by on-site investigation. Soil surveys are available for most counties and can be obtained from the local Soil Conservation Service. The survey includes soil maps, soil descriptions, and soil interpretations.

A soil survey map is shown in Figure 8.01b. Boundaries of the different kinds of soils are delineated, showing their location and extent in relation to streams, roads, buildings, and other landscape features. Soil properties are determined from soil samples taken throughout the survey area and from laboratory analyses of selected samples.

Soils are named according to a nationwide uniform procedure. The classification system discussed here is that developed by the Soil Survey Staff of the U.S. Department of Agriculture (1975), published as Soil Taxonomy. The primary bases for identifying different classes in this system are the properties of soils as found in the field—properties that can be measured quantitatively. Another significant feature of this system is the nomenclature employed. The family names, for instance, define the major soil characteristics. Families are divided into lower-level groups called series. Soil series are commonly named for towns or other geographic features near the place where they were first observed and mapped. A soil series is made up of soils that have similar profiles, major horizons, or layers that are similar in thickness, arrangement, and other important characteristics. A description of each soil type commonly found in North Carolina is given in Table 8.01d (found at the end of this appendix).

A series is divided into phases based on differences in surface layer texture, slope, stoniness, and other characteristics that affect use of the soils. The phase name indicates a feature that affects management. A Cecil sandy loam, 3 to 5% slope, and a Wedowee sandy loam, 8 to 15% slope, stony, are examples of soils in which phase distinctions are made.

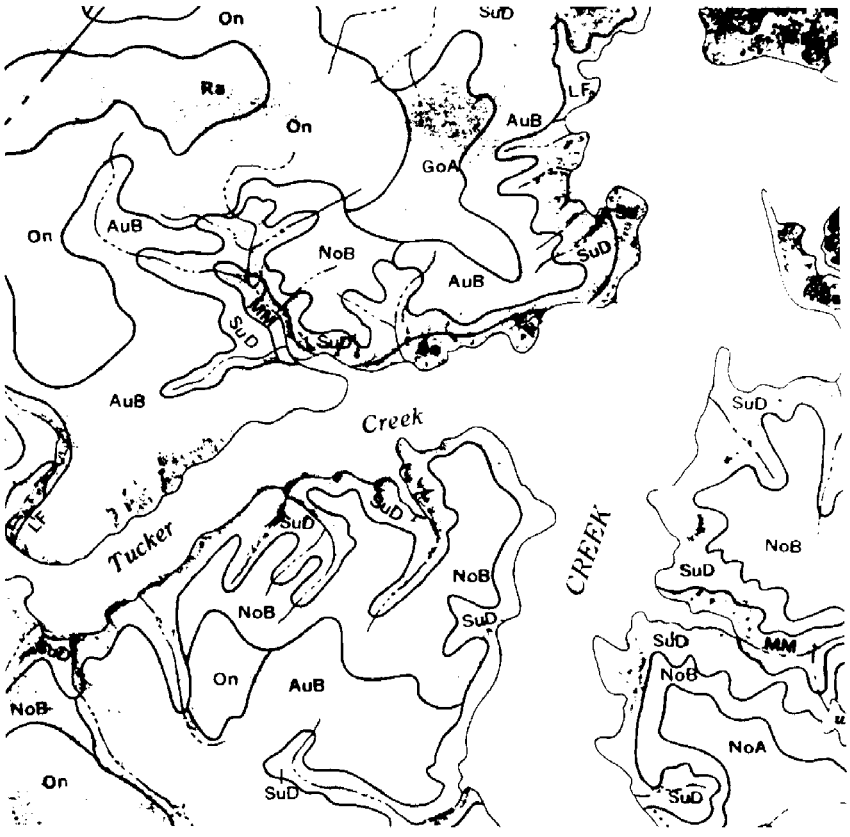


Figure 8.01b Detail of soil survey map of Craven County.

NC0069 S O I L I N T E R P R E T A T I O N S R E C O R D

MLRA(S): 133A, 136, 153A, 148, 153B, 153C WICKHAM SERIES
REV. RAG,WEH, 7-87
TYPIC HAPLUDULTS, FINE-LOAMY, MIXED, THERMIC

THE WICKHAM SERIES CONSISTS OF NEARLY LEVEL TO MODERATELY STEEP, WELL DRAINED SOILS ON STREAM TERRACES IN THE PIEDMONT AND STREAM TERRACES AND LOW MARINE TERRACES IN THE COASTAL PLAIN. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS BROWN SANDY LOAM ABOUT 9 INCHES THICK. THE SUBSOIL IS YELLOWISH RED AND STRONG BROWN. IT EXTENDS TO 51 INCHES AND IS SANDY CLAY LOAM IN THE UPPER PART; SANDY CLAY LOAM AND SANDY LOAM IN THE MIDDLE PART; SANDY LOAM AND LOAMY SAND IN THE LOWER PART. THE UNDERLYING LAYER TO 70 INCHES IS GRAVELLY LOAMY SAND. SLOPES RANGE FROM 0 TO 25 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT 3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-9	SL, FSL, L	SM, SM-SC, ML, CL-ML	A-4	0	95-100	90-100	70-100	45-80	25	NP-7
0-9	LS, LFS	SM	A-2	0	95-100	90-100	55-80	15-30	-	NP
0-9	SCL, CL	CL-ML, CL, SC, SM-SC	A-2, A-4, A-6, A-7-6	0	95-100	90-100	75-100	30-70	20-41	5-15
9-40	SCL, CL, L	CL-ML, CL, SC, SM-SC	A-2, A-4, A-6, A-7-6	0	95-100	90-100	75-100	30-70	20-41	5-15
40-70	VAR									

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND EROD. GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-9	8-15	1.45-1.65	2.0-6.0	0.11-0.16	4.5-6.0	-	LOW	.24	5	-	.5-2	MODERATE	HIGH
0-9	4-10	1.60-1.70	2.0-6.0	0.05-0.08	4.5-6.0	-	LOW	.15	5	-	.5-1		
0-9	18-35	1.30-1.50	0.6-2.0	0.12-0.17	4.5-6.0	-	LOW	.24	4	-	.5-1		
9-40	18-35	1.30-1.50	0.6-2.0	0.12-0.17	4.5-6.0	-	LOW	.24					
40-70													

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	THYDIC GRP	POTENTIAL FROST ACTION
NONE-RARE			6.0			-		60		-	-	B	-

	SANITARY FACILITIES (B)		CONSTRUCTION MATERIAL (B)
SEPTIC TANK ABSORPTION FIELDS	0-8% NONE: MODERATE-PERCS SLOWLY 8-15% NONE: MODERATE-SLOPE,PERCS SLOWLY 0-8% RARE: MODERATE-FLOODING,PERCS SLOWLY 8-15% RARE: MODERATE-FLOODING,PERCS SLOWLY 15+%: SEVERE-SLOPE	ROADFILL	0-15%: GOOD 15+%: FAIR-SLOPE
SEWAGE LAGOON AREAS	0-2%: MODERATE-SEEPAGE 2-7%: MODERATE-SEEPAGE,SLOPE 7+%: SEVERE-SLOPE	SAND	IMPROBABLE-EXCESS FINES
SANITARY LANDFILL (TRENCH)	0-8% NONE: MODERATE-TOO CLAYEY 8-15% NONE: MODERATE-SLOPE,TOO CLAYEY 0-8% RARE: MODERATE-FLOODING,TOO CLAYEY 8-15%RARE:MODERATE-FLOODING,SLOPE,TOO CLAYEY 15+%: SEVERE-SLOPE	GRAVEL	IMPROBABLE-EXCESS FINES
SANITARY LANDFILL (AREA)	0-8% NONE: SLIGHT 8-15% NONE: MODERATE-SLOPE 0-8% RARE: MODERATE-FLOODING 8-15% RARE: MODERATE-FLOODING,SLOPE 15+%: SEVERE-SLOPE	TOPSOIL	0-8%: FAIR-TOO CLAYEY,SMALL STONES 8-15%: FAIR-TOO CLAYEY,SMALL STONES,SLOPE 15+%: POOR-SLOPE

Figure 8.01c Typical soil interpretation sheet describing soil properties and suitability for various uses.

Each soil series is described on an interpretation sheet, such as that shown in Figure 8.01c. Interpretation sheets list properties and typical site conditions that are important in erosion and sedimentation control planning for construction sites: texture, erodibility, slope, plasticity, permeability, and depth to and hardness of bedrock. The interpretation sheet also lists other ratings and limitations that are important for site selection and development, such as shrink-swell potential, risk of corrosion, engineering properties, and hydrologic soil group.

Limitations of the survey must also be understood to make accurate interpretations. First, data generally do not represent soil material below 5 or 6 ft. Also, small soil areas that differ from the dominant soil may not be delineated in the map because the map scale limits the size of areas that can be shown. The ranges given for soil properties are often too wide for the design needs of a small

development. Therefore, on-site investigation is needed in conjunction with a soil survey to evaluate many specific soil characteristics.

Properties included on the soils interpretation sheet that affect erosion most are soil texture, soil erodibility factor, slope, plasticity index, liquid limit, permeability, depth to bedrock, soil reaction, seasonal high water table, hydrologic group, and engineering classification. A description of each follows.

Soil Texture

Soil survey interpretation sheets indicate the USDA texture class for each soil, expressed as a relative proportion by weight of soil particle size classes finer than 2 mm. The basic texture classes, in decreasing particle size are sands, loams and clays. On the basis of these classes, additional class names are used such as loamy sand, sandy clay, and silty clay. Sands, loamy sands, and sandy loams may be further subdivided as very coarse, coarse, fine, or very fine. Soil description by particle size analysis, which is used by USDA as a guide to textural classifications, is shown in Figure 8.01d. Symbols used in classifying soils according to texture are provided at the bottom of the figure with corresponding description.

Soil texture is defined by the proportions of different size groups of particles. The size limits of different soil particles are listed in Table 8.01a.

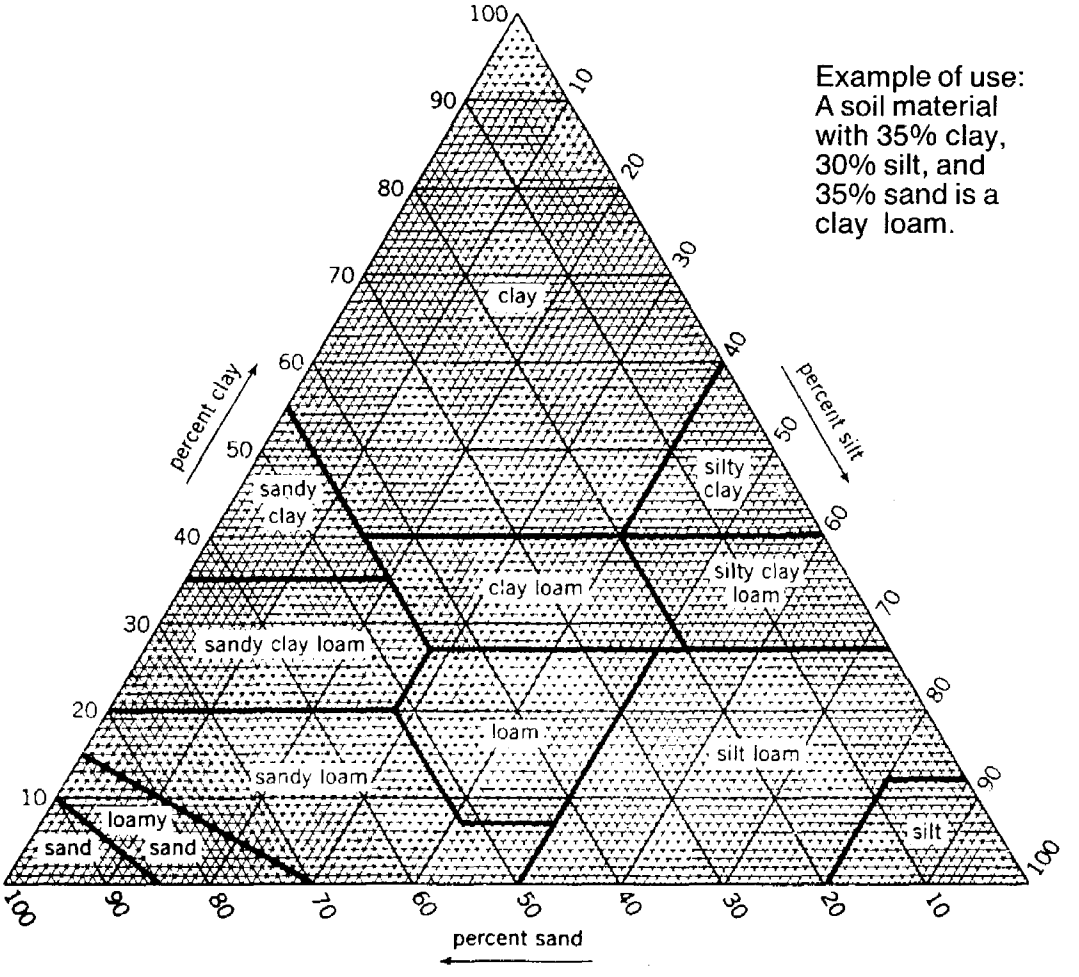
Table 8.01a Size Limits of Soil Particles

Soil Particle	Size
Cobble	0.3 - 0.15 m
Gravel	0.15 - 2.0 mm
Sand	2.0 - 0.05 mm
Silt	0.05 - 0.002 mm
Clay	< 0.002 mm

The physical properties and chemical composition of large soil particles differ from small soil particles. Since most physical and chemical reactions occur on the surface of small particles, clay (which has much more surface per unit mass than silt or sand) affects soil properties to a much greater extent than do coarser particles. Sand and rock fragments retain water and nutrients poorly, because the voids between particles allow water and air to move freely. Therefore, soils with a large percentage of sand-size particles are generally poorly aggregated, well-drained, and well-aerated.

Silt particles are barely visible to the naked eye and are intermediate in many properties between sand and clay. Silt is characterized by its plasticity and stickiness. Silt content is an important characteristic for determining erodibility because silt-sized particles are small enough to reduce the water intake or infiltration rate, and because they are easily detached and transported in runoff. The small particle size makes silt difficult to capture in traps or basins.

There are two major types of clays, kaolinite and montmorillonite. Kaolinite (referred to as a 1:1 clay) is the most common clay in North Carolina soils. It is relatively inactive and fairly stable. Montmorillonite (referred to as a 2:1 clay) is a very active clay that shrinks when dry and swells when wet. These characteristics affect the permeability of soils and are very important to their use and management. Clayey soils retain water that is available for plant growth, but



Texture modifier:		Texture terms:		Terms used in lieu of texture:	
CB	Cobbly	COS	Coarse sand	G	Gravel
CBA	Angular cobbly	S	Sand	MARL	Marl
CBV	Very cobbly	FS	Fine sand	MPT	Mucky-peat
CBX	Extremely cobbly	VFS	Very fine sand	MUCK	Muck
CN	Channery	LCOS	Loamy coarse sand	PEAT	Peat
CNV	Very channery	LS	Loamy sand	SG	Sand and gravel
CNX	Extremely channery	LFS	Loamy fine sand	UWB	Unweathered bedrock
GR	Gravelly	LVFS	Loamy very fine sand	VAR	Variable
GRC	Coarse gravelly	COSL	Coarse sandy loam	WB	Weathered bedrock
GRF	Fine gravelly	SL	Sandy loam		
GRV	Very gravelly	FSL	Fine sandy loam		
GRX	Extremely gravelly	VFSL	Very fine sandy loam		
MK	Mucky	L	Loam		
PT	Peaty	SIL	Silt loam		
SH	Shaly	SI	Silt		
SHV	Very shaly	SCL	Sandy clay loam		
SHX	Extremely shaly	CL	Clay loam		
SR	Stratified	SICL	Silty clay loam		
ST	Stony	SC	Sandy clay		
STV	Very stony	SIC	Silty clay		
STX	Extremely stony	C	Clay		

Note: These are boundary classifications. Soils possessing characteristics of two or more groups are designated by combinations of group symbols. For example, SR-S-FS is a stratified sand fine sand.

Figure 8.01d Guide for USDA Textural Classification and symbols (source: National Soils Handbook).

these soils are often dense, hard, wet, airtight, acidic and infertile. They may restrict root growth even though water holding capacity and potential rooting depth are adequate. Urban uses of clayey soils may be limited due to cracking of foundations and failure of septic drain fields.

Soil texture information for soils commonly found in North Carolina is given in Table 8.01d.

Soil Erodibility Factor, (K)

The soil erodibility factor, K, provides a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. The principal factors affecting K are texture, organic matter, structure, and permeability. If minimal grading or compaction is expected, K from the soil interpretation sheet, which provides K for a range of depths, can be used (Table 8.01d). Erodibility increases with increasing K. Subsoils exposed during construction, however, may be too deep to be included on the survey. In this case, on-site investigation is necessary to flag erosion-prone areas. The soil erodibility nomograph in Figure 8.01e can be used to estimate K from the percentage of sand, percentage of organic matter, soil structure, and soil permeability.

Slope

The erosion potential increases with slope length and gradient. Long and steep slopes have high potential for soil loss due to surface runoff.

Plasticity Index and Liquid Limit

Both the plasticity index and the liquid limit indicate the effect of water on the strength and consistency of soil and are most important in fine-grained soils. Soils with greater plasticity generally have higher cohesion and resistance to erosion than soils with lower plasticity. These indexes are used in both the Unified and the American Association of State Highway and Transportation Officials (AASHTO) soil classification systems, which are described in more detail later. They are also used as indicators in making general predictions of soil behavior.

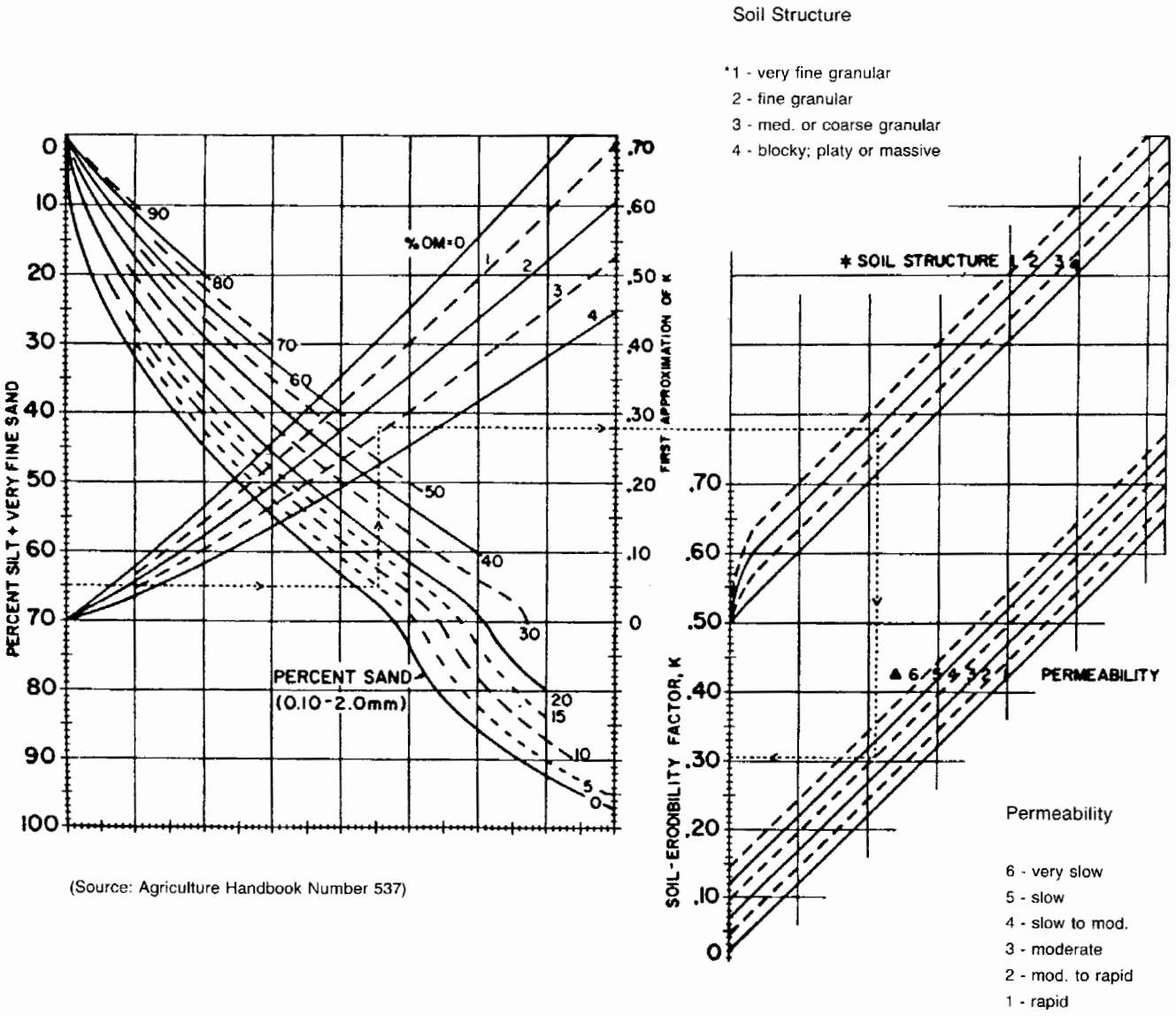
Information on plasticity of soils commonly found in North Carolina is given in Table 8.01d.

Permeability

Permeability is a major factor influencing erosion. It refers to the soil's ability to transmit water or air and depends on both the size and volume of pores. Deep, permeable soils are less erodible because more rainfall soaks in, reducing surface runoff. Because permeability varies with depth, excavation may expose layers that are more or less permeable than the original surface. Compaction reduces permeability.

Depth to Bedrock

Soil survey interpretation sheets generally provide an estimate of depth to and hardness of bedrock, the solid (fixed) rock underlying soil. This information is helpful in determining time and cost of excavation as well as potential erodibility of the subsoil material. Hardness classes, "soft" and "hard", indicate the ease of excavating into the bedrock. "Soft" rock is likely to be sufficiently soft, thinly bedded, or fractured so that excavation can be made with trenching machines, backhoes, small rippers, or other equipment common in construction of pipelines, sewer lines, cemeteries, dwellings, or small buildings. "Hard" rock is like-



(Source: Agriculture Handbook Number 537)

Procedure: With appropriate data, enter scale at left and proceed to points representing the soil's % sand (0.10-2.0 mm), % organic matter, structure and permeability, **in that sequence.** Interpolate between plotted curves. The dotted line illustrates procedure for a soil having: silt + vfs 65%, sand 5%, OM 2.8%, structure 2, permeability 4. Solution: K = 0.31.

Figure 8.01e Soil-erodibility nomograph.

ly to require blasting or special equipment beyond what is considered normal in this type of construction.

Bedrock at shallow depths limits plant growth by restricting root penetration. There is frequently a correlation between bedrock depth and water holding capacity.

Soil Reaction, (pH)

Soil reaction represents the degree of acidity or alkalinity of a soil, expressed as pH. The pH in soils is directly related to parent material. The principal value of soil pH measurement is the knowledge it gives about associated soil characteristics, such as phosphorus availability or base saturation. A pH of approximately 6 to 7 indicates readily available plant nutrients.

Leaching removes bases, causing a pH decline. Therefore, the amount of rainfall, rate of percolation, return movement of moisture by capillary action and evaporation affect pH. The pH is higher in soils of arid regions than in humid regions, higher in younger soils than older soils, higher on steep slopes than on flat topography, and higher under prairie than under timber.

Soil reaction is also used as an indicator of corrosivity or dispersivity. In general, soils that are either very alkaline or very acid are likely to be highly corrosive to steel. Soils that are acid are likely to be corrosive to concrete.

The range of pH for soils commonly found in North Carolina is given in Table 8.01d.

Seasonal High Water Table

A seasonal high water table is a zone of saturation at the highest average depth during the wettest season of the year. It is at least 6 inches thick, persists in the soil for more than a few weeks, and is within 6 ft of the soil surface. Soils that have a seasonal high water table are classified according to depth to the water table, kind of water table, and time of year when the water table is highest. Depth and duration of high water may limit soils for uses such as septic tank absorption fields, roadfill, and topsoil. A water table near the surface during the growing season is detrimental to many plants and must be considered in vegetation plans.

Hydrologic Group

Hydrologic group identifies soils as having the same runoff potential under similar storm and cover conditions. Soil properties that determine the hydrologic groups include the following: seasonal high water table, water intake rate and permeability after prolonged wetting, and depth to the slowly permeable layer. The influence of ground cover is not considered. The soils in the U.S. and Caribbean area are placed into four groups (A, B, C, and D) and three dual classes (A/D, B/D, C/D). In the definition of classes, infiltration rate is the rate at which water enters the soil at the surface, controlled by surface conditions. Transmission rate is the rate water moves in the soil, controlled by the permeability of deeper horizons. The hydrologic group for soils commonly found in North Carolina is given in Table 8.01d. Definitions of the groups are listed below.

- **Group A** (low runoff potential)—Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well-drained to ex-

cessively drained sands or gravels. These soils have a high rate of water transmission.

- **Group B**—Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- **Group C**—Soils having slow infiltration rates when thoroughly wetted. Group C soils often have a layer that impedes downward movement of water or may consist of moderately fine to fine-textured particles. These soils have a slow rate of water transmission.
- **Group D** (high runoff potential)—Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of clay soils with high swelling potential. These soils frequently have a permanent high water table or a claypan or clay layer at or near the surface. Other soils in this group consist of shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.
- **Dual hydrologic groups**, A/D, B/D, and C/D, are indicated for certain wet soils that can be drained. The first letter applies to the drained condition, the second to the undrained condition. Only soils that are rated D in their natural condition are assigned to a group.

Engineering Classification

Soils are classified according to engineering properties by two classification systems in the soil survey: (1) the AASHTO system and (2) the Unified Soil Classification System. Engineering classification for soils commonly found in North Carolina is given in Table 8.01d.

AASHTO System

The AASHTO system classifies soils according to the properties that affect roadway construction and maintenance. The fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in silt and clay. Soils in group A-7 are fine grained. Highly organic soils in Group A-8 are classified on the basis of visual inspection. The AASHTO classification system is summarized in Table 8.01b.

Unified System

The Unified System classifies soils according to suitability for construction material: grain-size distribution, plasticity index, liquid limit, and organic matter content. This classification is based on that portion of soil having particles smaller than 3 inches in diameter. Classes include coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC), fine-grained soils (ML, CL, OL, MH, CH, OH), and highly organic soils (PT). Borderline soils require a dual classification symbol. Table 8.01c provides classification descriptions for each class in the Unified System.

Table 8.01b
AASHTO Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing 0.075 mm)							Silt-Clay Materials (More than 35% passing 0.075 mm)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, Percent Passing: 2.00 mm (No. 10)	50 max										
0.425 mm (No. 40)	30 max	50 max	51 min								
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of Fraction Passing 0.425 mm (No. 40)											
Liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[a]
Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand		Fine Sand	Silty or Clayey Gravel Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

[a]Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30.
Plasticity index of A-7-6 subgroup is greater than LL minus 30.

FIELD TESTS

Although soil textures are defined in terms of the particle-size distribution determined by mechanical analysis in the laboratory, it is often desirable and necessary to estimate the textural class in the field. Field estimates of texture are influenced by consistency, structure, organic matter content, kind of clay and adsorbed cations, and particle size.

Classification of soils in the field involves several different tests. Screening and weighing the samples are not necessary. Field tests described here include tests to (1) determine texture as coarse- or fine-grained, (2) classify coarse-grained materials, (3) classify fine-grained materials, and (4) determine if the soil has high organic matter content, high plasticity, or high clay content.

Determining Texture as Coarse- or Fine-grained

TEST 1
Spread the sample on a flat surface and examine the particles to determine approximate grain size by visual inspection. If more than 50% of the sample has individual grains that are visible to the naked eye, the material is coarse; if less than 50%, it is fine.

Aggregated dry particles may appear to be sand-sized. Saturating the sample will break these aggregated particles down. By rubbing the wetted soil between the thumb and forefinger, sand-sized grains can be detected as they will feel rough and gritty. Practice with samples with known percentages of sand is helpful in estimating sand content.

TEST 2
Fill a straight-sided glass bottle to approximately 0.4 of its height with the sample, then nearly fill the bottle with water. Shake until all the material is in suspension. Estimate the percentage that settles in 25 seconds. If more than 50%

Table 8.01c
Classification of Materials for the Unified System

Group Symbol	Description of Material Classification
Coarse-grained	
GW	Well-graded gravels and gravel-sand mixture little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
GM	Silty gravels, gravel-sand-silt mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
GC	Clayey gravels, gravel-sand-clay mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
SW	Well-graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
SP	Poorly graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
SM	Silty sands, sand-silt mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.
SC	Clayey sands, sand-clay mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.
Fine-grained	
OL	Organic silts and organic silty clays of low plasticity. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CH	Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
OH	Organic clays of medium to high plasticity. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
Highly organic	
PT	Peat, muck, and other highly organic soils.

NOTE: These are boundary classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC is a well-graded, gravel-sand mixture with clay binder.

All sieve sizes on this table are U. S. Standard.

of the material settles in 25 seconds, the material is coarse-grained; if less than 50% of the material settles in 25 seconds, the material is fine-grained.

Classifying Coarse-Grained Materials

Spread a representative sample on a flat surface. Determine whether more than one-half of the visible grains by weight are pea size or larger. If they are, it is a gravel; if not, it is a sand.

After determining if the material is a gravel or a sand, it is further classified according to the properties of the fine content of the material. Remove the coarse material by spreading a thin layer of material on a sheet of paper and tapping the coarse material to the edge. Saturate the remaining material and work it into the hands. The hands will not be stained if there is less than 5% fines. It will be GW or GP if the material is a gravel, or SW or SP if the material is a sand. The hands will be stained if there is more than 12% fines. Weak casts can be formed from moist material. It will be GM or GC if the material is a gravel or SM or SC if the material is a sand.

Dual symbol materials (5 to 12% fines) cannot be readily classified by field procedures.

Use a second sample if there is less than 5% fines. Spread it out and observe the grain size distribution. If the coarse material consists of fairly well-distributed particles, the material is a well-graded gravel or sand (GW or SW). If the coarse material consists chiefly of single-sized particles or of large and small particles with in-between sizes missing, the material is a poorly graded gravel or sand (GP or SP).

When there are more than 12% fines in a coarse-grained material, make the plasticity tests on the fines described below under **Classifying Fine-grained Materials** to determine whether the material is clayey or silty.

The material will be GC or SC if clayey and GM or SM if silty.

Classifying Fine-Grained Materials

TEST 1

Prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water to make the soil soft but not sticky. Place pat in the open palm of the hand and shake it horizontally. Presence of fine-grained material is indicated by the appearance of water on the surface of the pat, giving the sample a glossy appearance. The water and gloss will disappear from the surface when the pat is squeezed between thumb and forefinger. The rapidity of the appearance of water during shaking and its disappearance when squeezed identifies the character of the fines. An ML will have a rapid reaction; an MH and CL, a slow reaction; and a CH, no reaction.

TEST 2

Dry crushing strength is estimated by crushing a dry clod between the fingers. A block of soil at least 3/4-inch in smallest dimension should be used, as smaller samples may give erroneous results. CH material is almost impossible to break. Easily crushed material of low strength is classified ML. Medium strength material is either CL or MH.

TEST 3
The toughness test uses the same procedures that are used in the laboratory to determine the plastic limit (PL). Wet and mold a soil sample so that it can be rolled into a thread without crumbling. The material will not stick to the hands if the correct amount of water is added. Roll the moist soil with the palm of the hand on any clean, smooth surface such as a piece of paper, to form a 1/8-inch diameter thread. Gradually reduce the moisture content by breaking up the sample and remolding and rolling it until the 1/8-inch thread breaks into approximately 3/4-inch long pieces. The material is then at its plastic limit. Circumferential breaks in the thread indicate a CH or CL material. Longitudinal cracks and diagonal breaks indicate an MH material.

Remold the sample into a coarse thread and pull it apart. A tough thread indicates high plasticity (CH or CL). A medium tough thread indicates an MH material. A weak thread indicates an ML material.

TEST 4
The ribbon test uses a sample with moisture content at or slightly below the plastic limit. The ribbon is formed by squeezing and working the sample between thumb and forefinger.

A weak ribbon that breaks easily indicates an ML soil. A hard ribbon that breaks fairly readily indicates an MH soil. A flexible ribbon with medium strength indicates a CL soil. A strong, flexible ribbon indicates a CH soil.

TEST 5
A test for stickiness can be made by saturating the material and letting it dry on the hands. An ML soil will brush off with little effort. A CL or MH soil rubs off with moderate effort when dry. A CH soil requires rewetting to completely remove it from the hands.

TEST 6
The Liquid Limit (LL) test takes a pat of moist soil with volume about one-half cubic inch and enough water to make the soil soft but not sticky. Rapidly add enough water to cover the surface. Break the pat open immediately. If water penetrates, the LL is low. If water does not penetrate, LL is high. Visual observation of this phenomenon is much easier in direct sunlight.

Determining Other Conditions

Tests are also available to identify high organic matter content, plasticity, and clay content, as described below.

- **Odor test**—to determine high organic matter content. Fresh, damp organic soils have a distinctive, pungent, musty odor.
- **Shine test**—to determine plasticity. In making the shine test, be sure soil is not micaceous. Rub a small clod of air-dry soil with a knife blade. A shiny surface indicates high plasticity. You are seeing the shine of the dry, highly plastic fines.
- **Malachite-green test**—to determine clay content. The staining agent used is a saturated nitrobenzene solution of malachite green. Clay minerals of the kaolinite group merely absorb the dye, becoming blue to green-blue after application of this solution. Montmorillonite becomes yellow-red, and illite becomes purple-red to purple.

Table 8.01d
Soil Characteristics for Common Soils in North Carolina.

Name	Depth	pH	K	Hydrology Group	Plasticity	Textural Classification[1] USDA	Unified	AASHTO
ALAGA	0-6	4.5-6.0	0.17	A	NP	LS, LFS, FS	SM, SW-SM, SP-SM	A-2, A-1-B
	6-80	4.5-6.0	0.17	A	NP-4	LS, LFS, FS	SM, SW-SM, SP-SM	A-2
ALAMANCE	0-11	4.5-7.3	0.43	B	NP-10	L, SIL, VFSL	ML	A-4
	0-11	4.5-7.3	0.28	B	NP-5	GR-L, GR-SIL, GR-VFSL	ML	A-4
	11-35	4.5-5.5	0.43	B	7-20	CL, SICL, SIL	CL, ML	A-4, A-6, A-7
	35-46	4.5-5.5	0.43	B	5-15	L, SIL, VFSL	CL, ML, CL-ML	A-4, A-6, A-7
	46-64	4.5-6.0	0.32	B	NP-12	VFSL	ML	A-4, A-6
	64-80			B		Var		
ALBANY	0-48	3.6-6.5	0.10	C	NP	S, FS	SM	A-2
	0-48	3.6-6.5	0.10	C	NP	LS	SM	A-2
	48-56	4.5-6.0	0.20	C	NP	SL	SM	A-2
	56-88	4.5-6.0	0.24	C	NP-17	SCL, SL, FSL	SC, SM, SM-SC	A-2, A-4, A-6
ALTAVISTA	0-12	4.5-6.0	0.20	C	NP	LS, SL	SM	A-2
	0-12	4.5-6.0	0.24	C	NP-7	FSL, L	ML, CL-ML, SM, SM-SC	A-4
	12-42	4.5-6.0	0.24	C	5-28	CL, SCL, L	CL, CL-ML, SC, SM-SC	A-4, A-6, A-7
	42-60			C	NP	Var		
AMERICUS	0-7	4.5-5.5	0.10	A	NP	LS, S, LFS	SM, SP-SM	A-2
	7-47	4.5-5.5	0.17	A	NP	LS, LFS	SM	A-2
	47-72	4.5-5.5	0.20	A	NP-7	SL, LS, FSL	SM, SM-SC	A-2
APPLING	0-9	4.5-5.5	0.24	B	NP-5	FSL, SL, LS	SM, SM-SC	A-2
	0-9	4.5-5.5	0.15	B	NP	GR-SL, GR-COSL	GM, GP-GM, SM, SP-SM	A-1
	0-9	4.5-5.5	0.20	B	6-20	SCL	CL, SC, CL-ML, SM-SC	A-6, A-4
	9-35	4.5-5.5	0.20	B	15-30	SC, CL, C	MH, ML	A-7
	35-46	4.5-5.5	0.24	B	8-22	SC, CL, SCL	SC, CL	A-4, A-6, A-7
	46-65			B	NP	Var		
ARAPAHOE	0-17	3.6-5.5	0.15	B/D	NP	LFS, LS	SM	A-2, A-4
	0-17	3.6-5.5	0.15	B/D	NP-4	FSL, L	SM	A-2, A-4
	17-42	3.6-7.8	0.15	B/D	NP	FSL, L, SL	SM	A-2, A-4
	42-80	5.6-7.8	0.10	B/D	NP-4	SR-LS-S	SM, SP-SM	A-2, A-3, A-4
ASHE	0-7	4.5-6.0	0.24	B	NP-7	L, SL, FSL	SM, SM-SC, ML, CL-ML	A-4
	0-7	4.5-6.0	0.17	B	NP-7	GR-L, GR-SL, GR-FSL	SM, SM-SC	A-2, A-4
	0-7	4.5-6.0	0.17	B	NP-7	ST-L, ST-SL, ST-FSL	SM, SM-SC	A-2, A-4
	7-25	4.5-6.0	0.17	B	NP-7	L, SL, FSL	SM, SM-SC	A-4
	25-30	4.5-6.0	0.17	B	NP	SL	SM	A-2, A-4
	30			B		UWB		
AUGUSTA	0-9	4.5-6.0	0.24	C	NP-10	SIL, L	ML, CL-ML	A-4
	9-60	4.5-6.0	0.24	C	5-25	SCL, CL, L	CL, CL-ML	A-4, A-6, A-7
	60-70	4.5-6.0	0.24	C	NP-5	COSL, L, GR-LS	SM, SP-SM,ML, SM-SC	A-2, A-4, A-1
AUTRYVILLE	0-26	4.5-6.5	0.10	A	NP	S, LS, LFS	SP-SM, SM	A-2, A-3
	26-41	4.5-5.5	0.10	A	NP-3	SL, SCL, FSL	SM	A-2
	41-58	4.5-5.0	0.10	A	NP	S, LS, LFS	SP-SM, SM	A-2, A-3
	58-85	4.5-5.5	0.17	A	NP-10	SL, SCL, FSL	SM, SC, SM-SC	A-2, A-4
AYCOCK	0-12	4.5-6.0	0.37	B	NP-10	VFSL, L, SIL	ML, CL-ML, CL	A-4
	12-80	4.5-5.5	0.43	B	8-30	CL, SICL, L	CL	A-4, A-6, A-7

[1]See Tables 8.01b, 8.01c and Figure 8.01d for definition of symbols.

2

Processes and Principles of Erosion and Sedimentation

When land is disturbed at a construction site, the erosion rate accelerates dramatically. Since ground cover on an undisturbed site protects the surface, removal of that cover increases the site's susceptibility to erosion. Disturbed land may have an erosion rate 1,000 times greater than the pre-construction rate. Even though construction requires that land be disturbed and be left bare for periods of time, proper planning and use of control measures can reduce the impact of man-induced accelerated erosion.

The major problem associated with erosion on a construction site is the movement of soil off the site and its impact on water quality. Millions of tons of sediment are generated annually by the construction industry in the United States. The rate of erosion on a construction site varies with site conditions and soil types but is typically 100 to 200 tons per acre and may be as high as 500 tons per acre. In N. C., 15% to 32% of eroded soil is transported to valuable water resources (SCS, 1977).

Identifying erosion problems at the planning stage and noting highly erodible areas, helps in selecting effective erosion control practices and estimating storage volumes for sediment traps and basins. This manual focuses primarily on the prevention of sedimentation problems associated with water-generated soil erosion.

THE EROSION AND SEDIMENTATION PROCESS

Types of Erosion

Erosion is a natural process by which soil and rock material is loosened and removed. Erosion by the action of water, wind, and ice has produced some of the most spectacular landscapes we know. Natural erosion occurs primarily on a geologic time scale, but when man's activities alter the landscape, the erosion process can be greatly accelerated. Construction-site erosion causes serious and costly problems, both on-site and off-site.

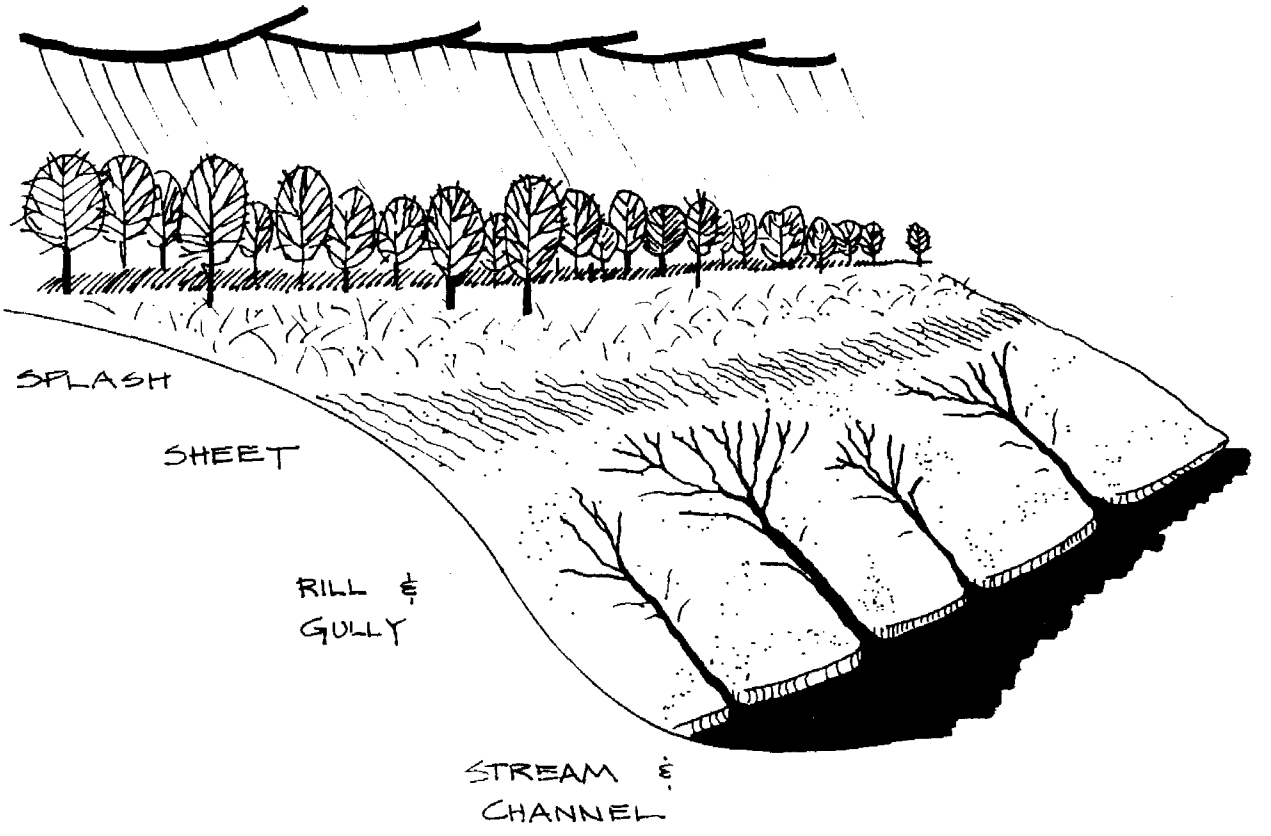


Figure 2.1 The four types of soil erosion on an exposed slope.

The soil erosion process begins by water falling as raindrops and flowing on the soil surface. Figure 2.1 illustrates the four types of soil erosion on exposed terrain: **splash, sheet, rill and gully,** and **stream and channel.** Splash erosion results when the force of raindrops falling on bare or sparsely vegetated soil detaches soil particles. Sheet erosion occurs when these soil particles are easily transported in a thin layer, or sheet, by water flowing. If this sheet runoff is allowed to concentrate and gain velocity, it cuts rills and gullies as it detaches more soil particles. As the erosive force of flowing water increases with slope length and gradient, gullies become deep channels and gorges. The greater the distance and slope, the more difficult it is to control the increasing volume and velocity of runoff and the greater the resultant damage.

Sedimentation

Sedimentation is the deposition of soil particles that have been transported by water and wind. The quantity and size of the material transported increases with the velocity of the runoff. Sedimentation occurs when the water in which the soil particles are carried is sufficiently slowed for a long enough period of time to allow particles to settle out. Heavier particles, such as gravel and sand, settle out sooner than do finer particles, such as clay. The length of time a particle stays in suspension increases as the particle size decreases. The colloidal clays stay in suspension for very long periods and contribute significantly to water turbidity.

Factors that Influence Erosion

The potential for an area to erode is determined by four principal factors: soils, surface cover, topography, and climate. These factors are interrelated in their effect on erosion potential. The variability in North Carolina's terrain, soils, and vegetation makes erosion control unique to each development.

Understanding the factors that effect the erosion process enables us to make useful predictions about the extent and consequences of on-site erosion. An empirical model developed for agricultural applications, the Universal Soil Loss Equation (USLE), predicts soil loss resulting from sheet and rill erosion. It considers both the effects of erosion control practices and the factors that influence erosion, so it is useful for evaluating erosion problems and potential solutions. The factors that influence erosion are soil characteristics, surface cover, topography, and climate.

Soils

A soil is a product of its environment. The vulnerability of a soil to erosion, known as its erodibility, is a result of a number of soil characteristics, which can be divided into two groups: those influencing infiltration, the movement of water into the ground; and those affecting the resistance to detachment and transport by rainfall and runoff. The soil erodibility factor (K) is a measure of a soil's susceptibility to erosion by water. Key factors that affect erodibility are soil texture, content of organic matter, soil structure, and soil permeability.

Soil texture is described by the proportions of sand, silt, and clay in the soil. High sand content gives a coarse texture, which allows water to infiltrate readily, reducing runoff. A relatively high infiltration rate coupled with resistance to transport by runoff results in a low erosion potential. Soils containing high proportions of silt and very fine sand are most erodible. Clay acts to bind particles and tends to limit erodibility; however, when clay erodes, the particles settle out very slowly.

Because **organic matter**, such as plant material, humus, or manure, improves soil structure, increases water-holding capacity, and may increase the infiltration rate, it reduces erodibility and the amount of runoff.

Soil structure is determined by the shape and arrangement of soil particles (Figure 2.2). A stable, sharp, granular structure absorbs water readily, resists erosion by surface flow, and promotes plant growth. Clay soils or compacted soils have slow infiltration capacities that increase runoff rate and create severe erosion problems.

Soil permeability refers to a soil's ability to transmit air and water. Soils that are least subject to erosion from rainfall and shallow surface runoff are those with high permeability rates, such as well-graded gravels and gravel-sand mixtures. Loose, granular soils reduce runoff by absorbing water and by providing a favorable environment for plant growth.

Surface Cover

Vegetation is the most effective means of stabilizing soils and controlling erosion. It shields the soil surface from the impact of falling rain, reduces flow velocity, and disperses flow. Vegetation provides a rough surface that slows the runoff velocity and promotes infiltration and deposition of sediment. Plants

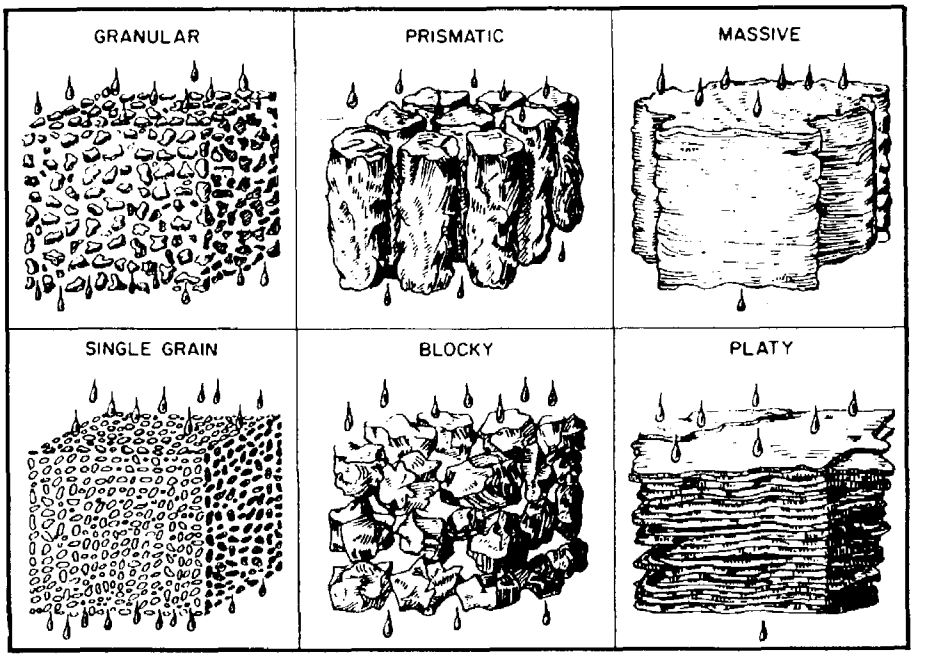


Figure 2.2 Soil structure influences the infiltration rate and movement of water in a soil. (Source: USDA and U.S. Department of the Interior, Agr. Inf. Bul. No. 199, 1959)

remove water from the soil and thus increase the soil's capacity to absorb water. Plant leaves and stems protect the soil surface from the impact of raindrops, and the roots help maintain the soil structure.

The type and condition of ground cover influence the rate and volume of runoff. Although impervious surfaces protect the area covered, they prevent infiltration and thereby decrease the time of concentration for runoff. The result is high peak flow and increased potential for stream and channel erosion (Figure 2.3).

Nonvegetative covers such as mulches, paving, and stone aggregates also protect soils from erosion.

Topography

Topographic features distinctly influence erosion potential. Watershed size and shape, for example, affect runoff rates and volumes. Long, steep slopes increase runoff flow velocity. Swales and channels concentrate surface flow, which results in higher velocities. Exposed south-facing soils are hotter and drier, which makes vegetation more difficult to establish.

Climate

North Carolina has considerable diversity of climate. A hurricane season along the coastal region and snow and ice in the mountains are examples of the extremes in weather. High-intensity storms that are common in North Carolina produce far more erosion than low-intensity, long-duration storms with the same runoff volume.

The frequency, intensity, and duration of rainfall and the size of the area on which the rain falls are fundamental factors in determining the amount of runoff produced. Seasonal temperature changes also define periods of high erosion risk. For example, precipitation as snow creates no erosion, but repeated freez-

ing and thawing breaks up soil aggregates, which can be transported readily in runoff from snowmelt.

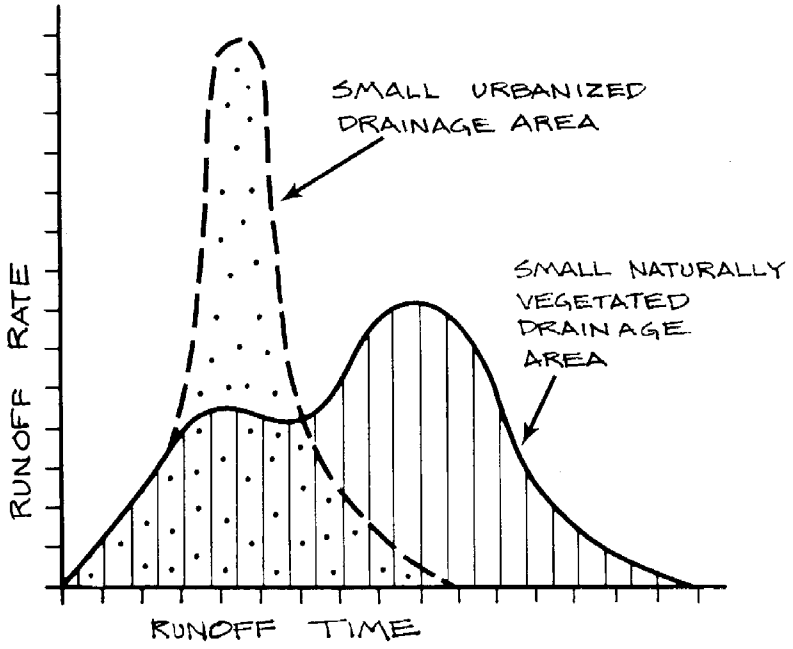


Figure 2.3 Comparison of runoff in natural and urbanized drainage areas.

Impacts of Erosion and Sedimentation

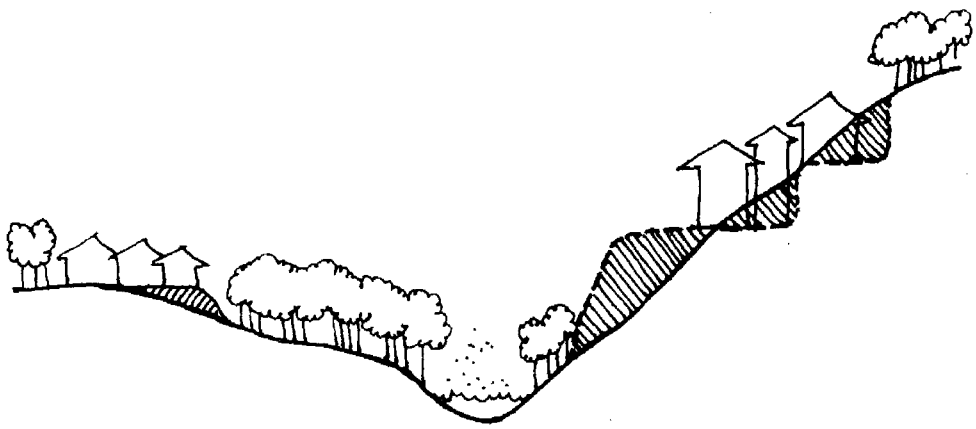
Damage from sedimentation is expensive both economically and environmentally. Sediment deposition destroys fish spawning beds, reduces the useful storage volume in reservoirs, clogs streams, may carry toxic chemicals, and requires costly filtration for municipal water supplies. Suspended sediment can reduce in-stream photosynthesis and alter a stream's ecology. Many environmental impacts from sediment are additive, and the ultimate results and costs may not be evident for years. The consequences of off-site sedimentation can be severe and should not be considered as just a problem to those immediately affected.

On-site erosion and sedimentation can cause costly site damage and construction delays. Lack of maintenance often results in failure of control practices and expensive cleanup and repairs.

PRINCIPLES OF EROSION AND SEDIMENTATION CONTROL

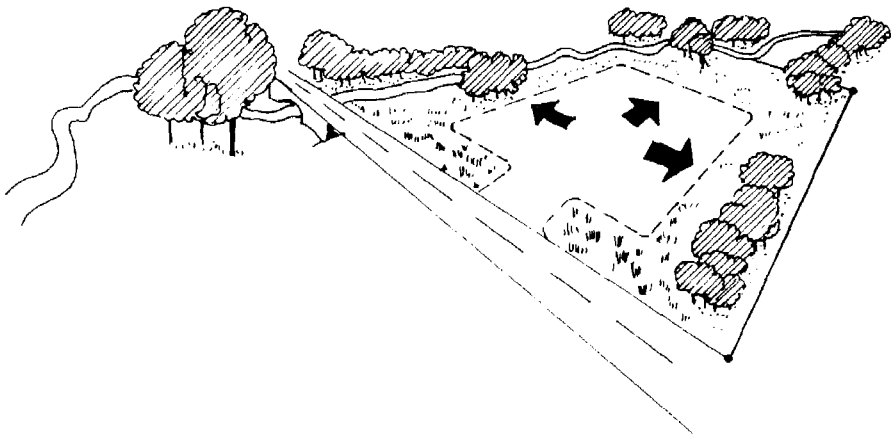
Effective erosion and sedimentation control requires first that the soil surface be protected from the erosive forces of wind, rain, and runoff, and second that eroded soil be captured on-site. The following principles are not complex but are effective. They should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

Fit the Development to Existing Site Conditions



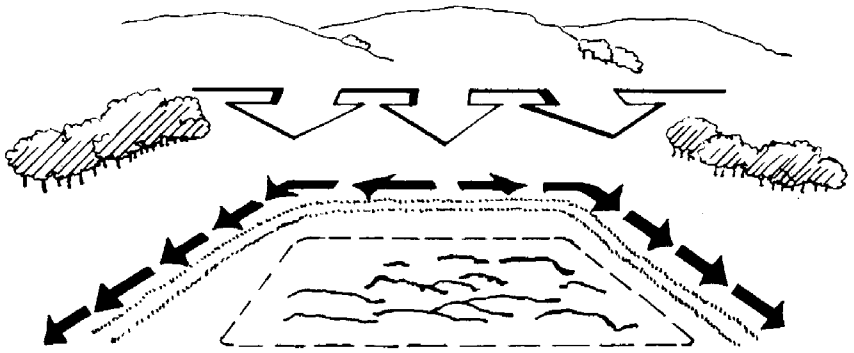
Review and consider all existing conditions in the initial site selection for the project. Select a site that is suitable rather than force the terrain to conform to development needs. Ensure that development features follow natural contours. Steep slopes, areas subject to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. **Any modification of a site's drainage features or topography requires protection from erosion and sedimentation.**

Minimize the Extent and Duration of Exposure



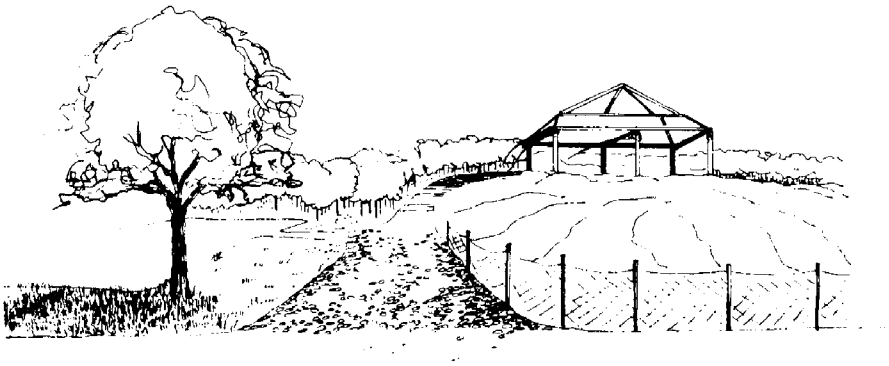
Scheduling can be a very effective means of reducing the hazards of erosion. Schedule construction activities to minimize the exposed area and the duration of exposure. In scheduling, take into account the season and the weather forecast. Stabilize disturbed areas as quickly as possible.

Protect Areas to be Disturbed from Stormwater Runoff



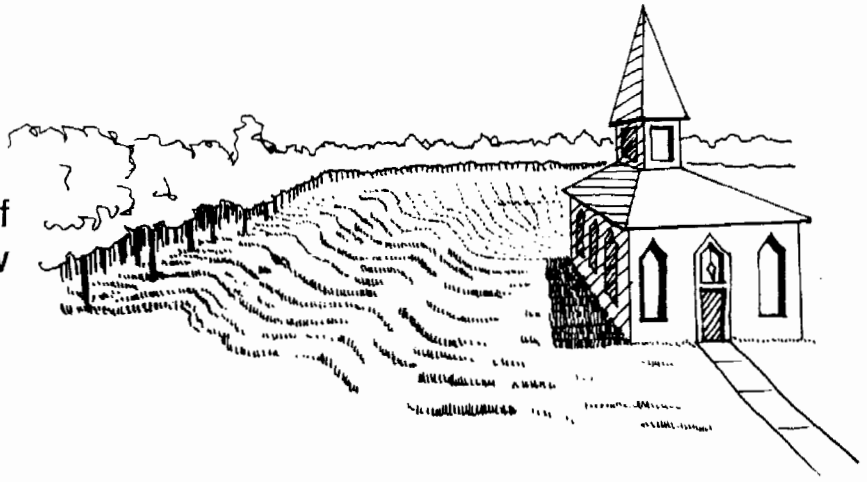
Use dikes, diversions, and waterways to intercept runoff and divert it away from cut-and-fill slopes or other disturbed areas. To reduce on-site erosion, install these measures before clearing and grading.

Stabilize Disturbed Areas



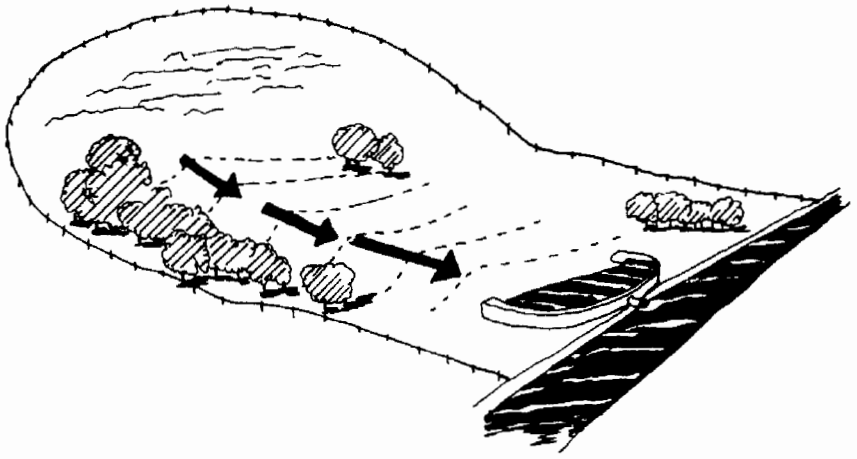
Removing the vegetative cover and altering the soil structure by clearing, grading, and compacting the surface increases an area's susceptibility to erosion. Apply stabilizing measures as soon as possible after the land is disturbed. Plan and implement temporary or permanent vegetation, mulches, or other protective practices to correspond with construction activities. Protect channels from erosive forces by using protective linings and the appropriate channel design. Consider possible future repairs and maintenance of these practices in the design.

Keep Runoff Velocities Low



Clearing existing vegetation reduces the surface roughness and infiltration rate and thereby increases runoff velocities and volumes. Use measures that break the slopes to reduce the problems associated with concentrated flow volumes and runoff velocities. Practical ways to reduce velocities include conveying stormwater runoff away from steep slopes to stabilized outlets, preserving natural vegetation where possible, and mulching and vegetating exposed areas immediately after construction.

Retain Sediment on the Site



Even with careful planning some erosion is unavoidable. The resulting sediment must be trapped on the site. Plan the location where sediment deposition will occur and maintain access for cleanout. Protect low points below disturbed areas by building barriers to reduce sediment loss. **Whenever possible, plan and construct sediment traps and basins before other land-disturbing activities.**

Inspect and Maintain Control Measures

Inspection and maintenance is vital to the performance of erosion and sedimentation control measures. If not properly maintained, some practices may cause more damage than they prevent. Always evaluate the consequences of a measure failing when considering which control measure to use, since failure of a practice may be hazardous or damaging to both people and property. For example, a large sediment basin failure can have disastrous results; low points in dikes can cause major gullies to form on a fill slope. It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop. Assign an individual responsibility for routine checks of operating erosion and sedimentation control practices.

APPENDIX B-2

PROCEDURE FOR COMPUTING SHEET AND RILL EROSION ON PROJECT AREAS

INTRODUCTION

Since the late 1940's, Soil Conservation Service (SCS) geologists, who are responsible for estimating sediment yields, have been using the Musgrave Equation to compute the amount of sheet and rill erosion occurring in a watershed. The Musgrave Equation has been a part of one of several procedures used to estimate sediment yields. Additional research on erosion has resulted in the development of the Universal Soil Loss Equation (USLE) by the Agricultural Research Service (ARS) in cooperation with the SCS and certain state experiment stations. The USLE has been used only on cropland, hayland, and pastures in rotation. Erosion factors reflecting the effect of cover on uncultivated land areas have been lacking. Since the USLE has been used throughout much of the country as a tool in planning land treatment on individual operating units, it was recommended that the use of this equation with its refined data be extended to urban watersheds and other project areas. In order to do this, additional plant cover factors (C) were needed for permanent pastureland, rangeland, woodland, and idle land to estimate the effect of these types of cover on soil losses.

During a conference of SCS and ARS personnel in November of 1971, needed factors for types of cover on uncultivated lands were discussed and tentatively agreed upon. Subsequent analyses by the ARS provided values for these factors as presented in Tables B-2.3 and B-2.4 These factors are for use in the USLE to estimate sheet and rill erosion for project work such as watersheds, river basin studies, and resource conservation and development (RC&D) projects.

The complete USLE is:

$$A = RKLSCP \qquad \text{(Eq. B-1)}$$

where,

A is the computed soil loss (sheet and rill erosion) in tons per acre per year. A *is not the sediment yield;*

R, the rainfall factor, is the number of erosion-index units in a normal year's rain;

K, the soil-erodibility factor, is the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow, on a 9-percent slope 72.6 feet long;

L, the slope-length factor, is the ratio of the soil loss from the field slope length to that from a 72.6 ft. length on the same soil type and gradient;

S, the slope-gradient factor, is the ratio of soil loss from the field gradient to that from a 9-percent slope;

C, the cropping management factor, is the ratio of soil loss from a field with specified cropping and management to that from the fallow condition on which the factor K is evaluated;

P, the erosion-control practice factor, is the ratio of soil loss with contouring, stripcropping, or contour irrigated furrows to that with straight-row farming, up and down slope.

RAINFALL FACTOR (R)

The energy of moving water detaches and transports soil materials. The energy-intensity (EI) parameter measures total raindrop energy of a storm and its relation to the maximum 30-minute intensity. Soil losses are linearly proportional to the number of EI units. The EI values are summed to obtain an annual rainfall-erosivity index for a given location. This annual index serves as the R factor and has been estimated for the state of Georgia and can be obtained from table B-2.1.

SOIL-ERODIBILITY FACTOR (K)

The capability of a soil surface to resist erosion is a function of the soil's physical and chemical properties. The most significant soil characteristics affecting soil erodibility are texture, organic matter content, soil structure and permeability. The K values are assigned to named kinds of soil and may be obtained from the Soil Conservation Service published lists.

SLOPE LENGTH (L) AND SLOPE GRADIENT (S)

Soil loss is affected by both length and degree of slope. For convenience in the field application of these factors they are combined into a single topographic factor, LS.

The LS factor for gradients up to 60% and slope lengths to 2000 feet is obtained from the Slope-Effect Chart, Figure B-2.2. Similar data in tabular form is shown in Table B-2.2. Values shown on the chart and table for slopes of less than 3%, greater than 20%, or longer than 400 feet, represent extrapolations of the formula beyond the range of research data. Computed soil loss obtained using such LS values may require adjustment based on experience and judgment.

Table B-2.1. — Rainfall-Erosion Index Factor "R" Values

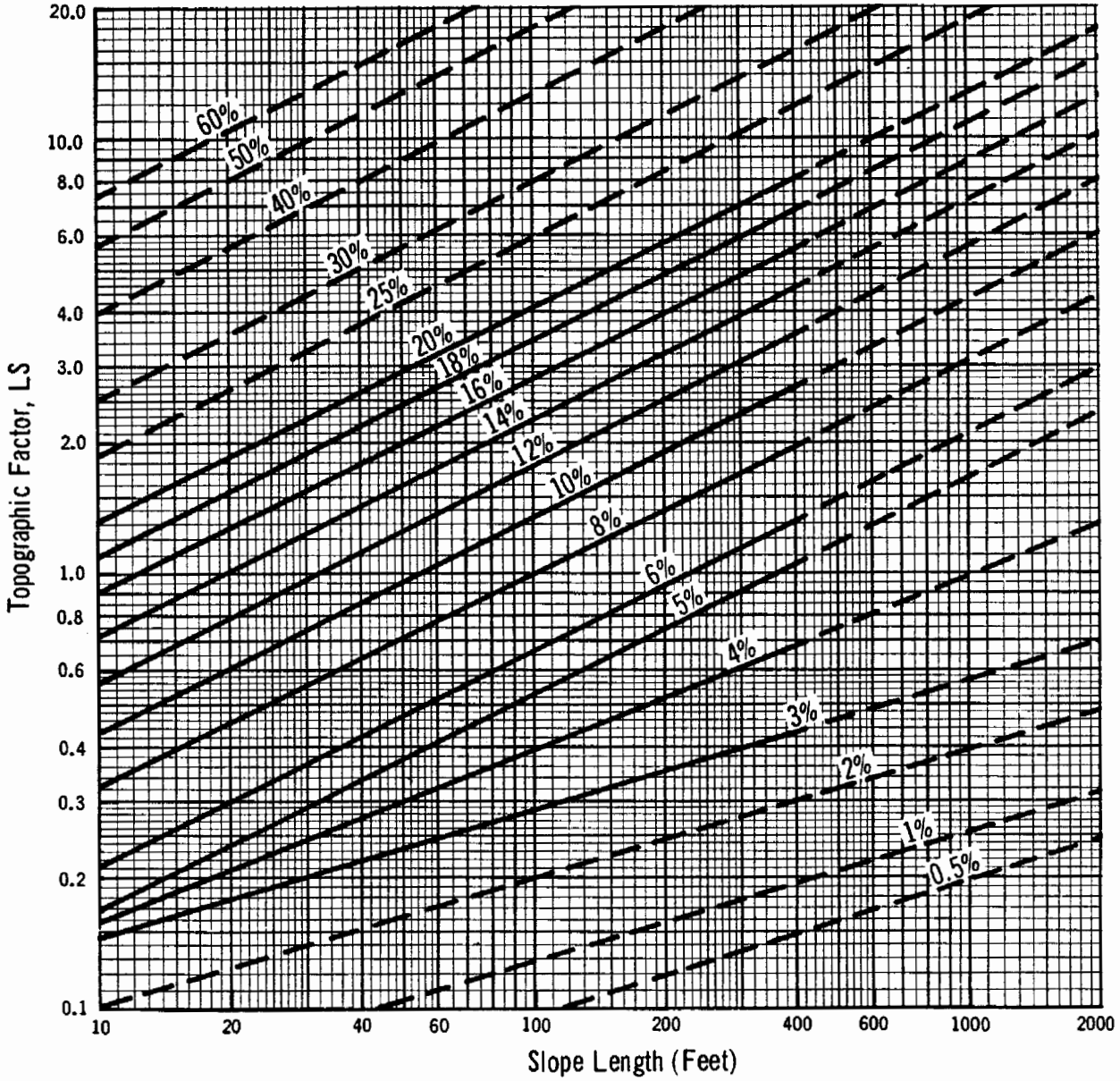
County	R	County	R	County	R
Appling	350	Clay	375	Franklin	300
Atkinson	325	Clayton	300	Fulton	300
Bacon	350	Clinch	350	Gilmer	275
Baker	375	Cobb	300	Glascock	250
Baldwin	275	Coffee	325	Glynn	400
Banks	300	Colquitt	350	Gordon	300
Barrow	275	Columbia	250	Grady	400
Bartow	300	Cook	350	Greene	250
Ben Hill	325	Coweta	325	Gwinnett	300
Berrien	350	Crawford	300	Habersham	300
Bibb	300	Crisp	325	Hall	275
Bleckley	300	Dade	275	Hancock	250
Brantley	375	Dawson	275	Haralson	325
Brooks	375	Decatur	425	Harris	325
Bryan	350	DeKalb	300	Hart	275
Bulloch	325	Dodge	300	Heard	275
Burke	275	Dooly	325	Henry	300
Butts	300	Dougherty	350	Houston	300
Calhoun	375	Douglas	300	Irwin	325
Camden	400	Early	400	Jackson	275
Candler	300	Echols	350	Jasper	275
Carroll	325	Effingham	350	Jeff Davis	325
Catoosa	275	Elbert	250	Jefferson	275
Charlton	375	Emanuel	300	Jenkins	300
Chatham	350	Evans	325	Johnson	300
Chattahoochee	350	Fannin	275	Jones	275
Chattooga	300	Fayette	300	Lamar	300
Cherokee	300	Floyd	300	Lanier	350
Clarke	275	Forsyth	275	Laurens	300

County	R
Lee	350
Liberty	350
Lincoln	250
Long	350
Lowndes	350
Lumpkin	275
McDuffie	250
McIntosh	400
Macon	325
Madison	275
Marion	325
Meriwether	325
Miller	400
Mitchell	375
Monroe	300
Montgomery	300
Morgan	275
Murray	275
Muscogee	325
Newton	300
Oconee	275
Oglethorpe	250
Paulding	300
Peach	300
Pickens	275
Pierce	350
Pike	325
Polk	300
Pulaski	300

County	R
Putnam	275
Quitman	375
Rabun	300
Randolph	350
Richmond	250
Rockdale	300
Schley	325
Screven	300
Seminole	425
Spalding	300
Stephens	300
Stewart	350
Sumter	325
Talbot	325
Taliaferro	250
Tattnall	325
Taylor	325
Telfair	325
Terrell	350
Thomas	400
Tift	350
Toombs	325
Towns	300
Treutlen	300
Troup	325
Turner	325
Twiggs	300
Union	300
Upson	325

County	R
Walker	275
Walton	275
Ware	350
Warren	250
Washington	275
Wayne	375
Webster	350
Wheeler	300
White	300
Whitfield	275
Wilcox	325
Wilkes	250
Wilkinson	275
Worth	350

Figure B-2.1 —Slope-Effect Chart (Topographic Factor, LS)[2].



[2] The dashed lines represent estimates for slope dimensions beyond the range of lengths and steepnesses for which data are available. The curves were derived by the formula:

$$LS = \left(\frac{\lambda}{72.6}\right)\left(\frac{430\,x^2 + 30x + 0.43}{6.575415}\right)^m$$

where λ = field slope length in feet and m = 0.5 if s = 5% or greater, o.4 if s = 4%, and 0.3 if s = 3% or less; and x = sin θ. θ is the angle of slope in degrees.

Table B-2.2. — Slope Effect Table (Topographic Factor, LS) — Sheet 1 of 2

Percent Slope	Slope Length in Feet													
	10	20	40	60	80	100	110	120	130	140	150	160	180	200
0.2	0.04	0.05	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10
0.3	0.04	0.05	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11
0.4	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11
0.5	0.05	0.06	0.08	0.08	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12
1.0	0.06	0.08	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16
2.0	0.10	0.12	0.15	0.17	0.19	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.25
3.0	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.30	0.31	0.32	0.32	0.33	0.34	0.35
4.0	0.16	0.21	0.28	0.33	0.37	0.40	0.42	0.43	0.44	0.46	0.47	0.48	0.51	0.53
5.0	0.17	0.24	0.34	0.41	0.48	0.54	0.56	0.59	0.61	0.63	0.66	0.68	0.72	0.76
6.0	0.21	0.30	0.43	0.52	0.60	0.67	0.71	0.74	0.77	0.80	0.82	0.85	0.90	0.95
8.0	0.31	0.44	0.63	0.77	0.89	0.99	1.04	1.09	1.13	1.17	1.21	1.25	1.33	1.40
10.0	0.43	0.61	0.87	1.06	1.23	1.37	1.44	1.50	1.56	1.62	1.68	1.73	1.84	1.94
12.0	0.57	0.81	1.14	1.40	1.61	1.80	1.89	1.98	2.06	2.14	2.21	2.28	2.42	2.55
14.0	0.73	1.03	1.45	1.78	2.05	2.29	2.41	2.51	2.62	2.72	2.81	2.90	3.08	3.25
16.0	0.90	1.27	1.80	2.20	2.54	2.84	2.98	3.11	3.24	3.36	3.48	3.59	3.81	4.01
18.0	1.09	1.54	2.17	2.66	3.07	3.43	3.60	3.76	3.92	4.06	4.21	4.34	4.61	4.86
20.0	1.29	1.82	2.58	3.16	3.65	4.08	4.28	4.47	4.65	4.83	5.00	5.16	5.47	5.77
25.0	1.86	2.63	3.73	4.56	5.27	5.89	6.18	6.45	6.72	6.97	7.22	7.45	7.90	8.33
30.0	2.52	3.56	5.03	6.16	7.11	7.95	8.34	8.71	9.07	9.41	9.74	10.06	10.67	11.25
40.0	4.00	5.66	8.00	9.80	11.32	12.65	13.27	13.86	14.43	14.97	15.50	16.01	16.98	17.90
50.0	5.64	7.97	11.27	13.81	15.94	17.82	18.69	19.53	20.32	21.09	21.83	22.55	23.91	25.21
60.0	7.32	10.35	14.64	17.93	20.71	23.15	24.28	25.36	26.40	27.39	28.36	29.29	31.06	32.74

Table B-2.2. — Slope Effect Table (Topographic Factor, LS) — Continued Sheet 2 of 2

Percent	Slope Length in Feet													
Slope	300	400	500	600	700	800	900	1000	1100	1200	1300	1500	1700	2000
0.2	0.11	0.12	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.20
0.3	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.18	0.19	0.20	0.21	0.22
0.4	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.20	0.21	0.22	0.23
0.5	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.24
1.0	0.18	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.30	0.32
2.0	0.28	0.31	0.33	0.34	0.36	0.38	0.39	0.40	0.41	0.42	0.43	0.45	0.47	0.49
3.0	0.40	0.44	0.47	0.49	0.52	0.54	0.56	0.57	0.59	0.61	0.62	0.65	0.67	0.71
4.0	0.62	0.70	0.76	0.82	0.87	0.92	0.96	1.01	1.04	1.08	1.12	1.18	1.24	1.33
5.0	0.93	1.07	1.20	1.31	1.42	1.52	1.61	1.69	1.78	1.86	1.93	2.07	2.21	2.40
6.0	1.17	1.35	1.50	1.65	1.78	1.90	2.02	2.13	2.23	2.33	2.43	2.61	2.77	3.01
8.0	1.72	1.98	2.22	2.43	2.62	2.81	2.98	3.14	3.29	3.44	3.58	3.84	4.09	4.44
10.0	2.37	2.74	3.06	3.36	3.62	3.87	4.11	4.33	4.54	4.74	4.94	5.30	5.65	6.13
12.0	3.13	3.61	4.04	4.42	4.77	5.10	5.41	5.71	5.99	6.25	6.51	6.99	7.44	8.07
14.0	3.98	4.59	5.13	5.62	6.07	6.49	6.88	7.26	7.61	7.95	8.27	8.89	9.46	10.26
16.0	4.92	5.68	6.35	6.95	7.51	8.03	8.52	8.98	9.42	9.83	10.24	11.00	11.71	12.70
18.0	5.95	6.87	7.68	8.41	9.09	9.71	10.30	10.86	11.39	11.90	12.38	13.30	14.16	15.36
20.0	7.07	8.16	9.12	9.99	10.79	11.54	12.24	12.90	13.53	14.13	14.71	15.80	16.82	18.24
25.0	10.20	11.78	13.17	14.43	15.59	16.66	17.67	18.63	19.54	20.41	21.24	22.82	24.29	26.35
30.0	13.78	15.91	17.79	19.48	21.04	22.50	23.86	25.15	26.38	27.55	28.68	30.81	32.80	35.57

PLANT COVER OR CROPPING MANAGEMENT FACTOR (C)

The C factor values relate to the effect of cover. These average values may be for a period as long as 100 years, if that is the evaluation period of a project area.

The erosion equation, as used on cropland and hayland, employs established factor relationships to estimate a basic soil-loss that is determined by the soil properties, topographic features, certain conservation practices, and expected rainfall patterns for a specific field. The basic soil loss is the rate at which the field would erode if it were continuously in tilled fallow. The equation's factor C indicates the percentage of this potential soil loss that would occur if the surface were partially protected by some particular combination of cover and management. The Musgrave cover factors cannot be directly substituted for the C factor in the USLE because the base conditions from which the cover factors were developed are different, (continually tilled fallow for USLE as opposed to up-and-down hill row crops for Musgrave).

Extension of the factor C to completely different situations is based upon three separate and distinct but interrelated zones of influence: (a) the vegetative cover in direct contact with the soil surface; (b) canopy cover; and (c) effects at and beneath the surface.

Factor (C) for Pasture, Range and Idle Land

The effects of the three zones of influence were used in the estimation of factor C for pastureland, rangeland and idle land as shown in Table B-2.3.

Table B-2.3. — "C" Values for Permanent Pature, Rangeland, and Idle Land[3]

Vegetal Canopy			Cover That Contacts the Surface					
Type and Height of Raised Canopy[4]	Canopy Cover[5] %	Type[6]	Percent Ground Cover					
			0	20	40	60	80	95-100
Column No.:	2	3	4	5	6	7	8	9
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds	25	G	.36	.17	.09	.038	.012	.003
or short brush		W	.36	.20	.13	.082	.041	.011
(0.5 m (1.6 ft.) fall ht.)	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush	25	G	.40	.18	.09	.040	.013	.003
or brushes		W	.40	.22	.14	.085	.042	.011
(2 m 6.6 ft. fall ht.)	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appre-	25	G	.42	.19	.10	.041	.013	.003
ciable low brush		W	.42	.23	.14	.087	.042	.011
(4 m (13.1 ft.) fall ht.)	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

[3]All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years.

[4]Average fall height of waterdrops from canopy to soil surface: m = meters.

[5]Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

[6]G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.
W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface, and/or undecayed residue).

Factor (C) for Woodland

Permanent woodland differs in several respects from the situations covered by Table B-2.4. A layer of compacted decaying duff or litter several inches thick is extremely effective against water erosion. Existing research data, though limited, supports a C value as low as .001 for woodland with a 100% cover of such duff. Computed values of the erosion equation's factor C for some woodland situations are presented in Table B-2.4.

Factor (C) for Cropland and Hayland

This factor is a measure of the effects of cropping sequences, cover and management on soil losses from cropland and hayland. Factors have been computed, on a local basis, for conventional and conservation (minimum) tillage systems of farming.

Table B-2.4. — "C" Factors for Woodland

Tree Canopy[7] % of Area	Forest Litter[8] % of Area	Undergrowth[9]	"C" Factor
100-75	100-90	Managed[10]	.001
		Unmanaged[10]	.003-.011
70-40	85-75	Managed	.002-.004
		Unmanaged	.01- .04
35-20	70-40	Managed	.003-.009
		Unmanaged	.02- .09[11]

[7]When tree canopy is less than 20%, the area will be considered as grassland, or cropland for estimating soil loss. See Table B-2.2.

[8]Forest litter is assumed to be at least two inches deep over the percent ground surface area covered.

[9]Undergrowth is defined as shrubs, weeds, grasses, vines, etc., on the surface area not protected by forest litter. Usually found under canopy openings.

[10]Managed — grazing and fires are controlled.
Unmanaged — stands that are overgrazed or subjected to repeated burning.

[11]For unmanaged woodland with litter cover of less than 75%, C values should be derived by taking 0.7 of the appropriate values in Table B-2.2. The factor of 0.7 adjusts for the much higher soil organic matter on permanent woodland.

Table B 2.5. — Generalized values of the cover and management factor, C, in the 37 states east of the Rocky Mountains[12]

Line no.	Crop, rotation, and management[14]	Productivity level[13]	
		High	Mod.
		C value	
Base value: continuous fallow, tilled up and down slope		1.00	1.00
CORN			
1	C, RdR, fall TP, conv (1)	0.54	0.62
2	C, RdR, spring TP, conv (1)	.50	.59
3	C, RdL, fall TP, conv (1)	.42	.52
4	C, RdR, wc seeding, spring TP, conv (1)	.40	.49
5	C, RdL, standing, spring TP, conv (1)	.38	.48
6	C, fall shred stalks, spring TP, conv (1)	.35	.44
7	C(silage)-W(RdL, fall TP) (2)	.31	.35
8	C, RdL, fall chisel, spring disk, 40-30% rc (1)	.24	.30
9	C(silage), W wc seeding, no-till pl in c-k W (1)	.20	.24
10	C(RdL)-W(RdL, spring TP) (2)	.20	.28
11	C, fall shred stalks, chisel pl, 40-30% rc (1)	.19	.26
12	C-C-C-W-M, RdL, TP for C, disk for W (5)	.17	.23
13	C, RdL, strip till row zones, 55-40% rc (1)	.16	.24
14	C-C-C-W-M-M, RdL, TP for C, disk for W (6)	.14	.20
15	C-C-W-M, RdL, TP for C, disk for W (4)	.12	.17
16	C, fall shred, no-till pl, 70-50% rc (1)	.11	.18
17	C-C-W-M-M, RdL, TP for C, disk for W (5)	.087	.14
18	C-C-C-W-M, RdL, no-till pl 2d & 3rd C (5)	.076	.13
19	C-C-W-M, RdL, no-till pl 2d C (4)	.068	.11
20	C, no-till pl in c-k wheat, 90-70% rc (1)	.062	.14
21	C-C-C-W-M-M, no-till pl 2d & 3rd C (6)	.061	.11
22	C-W-M, RdL, TP for C, disk for W (3)	.055	.095
23	C-C-W-M-M, RdL, no-till pl 2d C (5)	.051	.094
24	C-W-M-M, RdL, TP for C, disk for W (4)	.039	.074
25	C-W-M-M-M, RdL, TP for C, disk for W (5)	.032	.061
26	C, no-till pl in c-k sod, 95-80% rc (1)	.017	.053
COTTON[15]			
27	Cot, conv (Western Plains) (1)	0.42	0.49
28	Cot, conv (South) (1)	.34	.40
MEADOW			
29	Grass & Legume mix	0.004	0.01
30	Alfalfa, Lespedeza or Sericia	.020	
31	Sweet clover	.025	
SORGHUM, GRAIN (Western Plains)[15]			
32	RdL, spring TP, conv (1)	0.43	0.53
33	No-till pl in shredded 70-50% rc	.11	.18

Table B-2.5. — Generalized values of the cover and management factor, C, in the 37 states east of the Rocky Mountains[12] — Continued

Line no.	Crop, rotation, and management[14]	Productivity level[13]	
		High	Mod.
		C value	
SOYBEANS[15]			
34	B, RdL, spring TP, conv (1)	0.48	0.54
35	C-B, TP annually, conv (2)	.43	.51
36	B, no-till pl	.22	.28
37	C-B, no-till pl, fall shred C stalks (2)	.18	.22
WHEAT			
38	W-F, fall TP after W (2)	0.38	
39	W-F, stubble mulch, 500 lbs rc (2)	.32	
40	W-F, stubble mulch, 1000 lbs rc (2)	.21	
41	Spring W, RdL, Sept TP, conv (N & S Dak) (1)	.23	
42	Winter W, RdL, Aug TP, conv (Kans) (1)	.19	
43	Spring W, stubble mulch, 750 lbs rc (1)	.15	
44	Spring W, stubble mulch, 1250 lbs rc (1)	.12	
45	Winter W, stubble mulch, 750 lbs rc (1)	.11	
46	Winter W, stubble mulch, 1250 lbs rc (1)	.10	
47	W-M, conv (2)	.054	
48	W-M-M, conv (3)	.026	
49	W-M-M-M, conv (4)	.021	

[12]This table is for illustrative purposes only and is not a complete list of cropping systems or potential practices. Values of C differ with rainfall pattern and planting dates. These generalized values show approximately the relative erosion-reducing effectiveness of various crop systems, but locationally derived C values should be used for conservation planning at the field level. Tables of local values are available from the Soil Conservation Service.

[13]High level is exemplified by long-term yield averages greater than 75 bu. corn or 3 tons grass-and-legume hay; or cotton management that regularly provides good stands and growth.

[14]Numbers in parentheses indicate number of years in the rotation cycle. No. (1) designates a continuous one-crop system.

[15]Grain sorghum, soybeans, or cotton may be substituted for corn in lines 12, 14, 15, 17-19, 21-25 to estimate C values for sod-based rotations.

Abbreviations defined:

B	soybeans	F	fallow
C	corn	M	grass & legume hay
c-k	chemically killed	pl	plant
conv	conventional	W	wheat
cot	cotton	wc	winter cover

lbs rc — pounds of crop residue per acre remaining on surface after new crop seeding
% rc — percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc — 70% cover for C values in first column; 50% for second column
RdR — residues (corn stover, straw, etc.) removed or burned
RdL — all residues left on field (on surface or incorporated)
TP — turn plowed (upper 5 or more inches of soil inverted, covering residues)

Table B-2.6. — "C" factors for different types of temporary ground cover

	Application Rate T/Ac.	C
Straw or hay, tied by anchoring or by tracking equipment used across slope	1.0	.20
	1.5	.10
	2.0	.05
	4.0	.02
Woodchips	7.0	.08
	12.0	.05
	25.0	.02
Wood cellulose fiber	2.0	.10
Fiberglass (1,000 lbs./ac.)		.05
Asphalt emulsion (1,250 gallons/ac.)		.02
Crushed stone	60.0	.17
	135.0	.05
	240.0	.02
Bare areas	—	1.0
Annual cover	—	0.15

EROSION-CONTROL PRACTICE FACTOR (P)

This factor accounts for control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration, and runoff velocity. Practices for which factors have been established are contouring, contour stripcropping, and contour irrigated furrows. Terraces and diversions, where used, reduce the length of slope only.

The practice values for contouring, contour stripcropping (strips of sod or meadow alternated with strips of row crop or small grain), and contour irrigated furrows are:

Land Slope %	P Values			
	Contouring	Contour Stripcropping	Contour Irrigated Furrows	Terracing[16]
2.0 to 7	0.50	0.25	0.25	0.10
8.0 - 12	0.60	0.30	0.30	0.12
13.0 - 18	0.80	0.40	0.40	0.16
19.0 - 24	0.90	0.45	0.45	0.18

[16] For prediction of contribution to off-field sediment load.

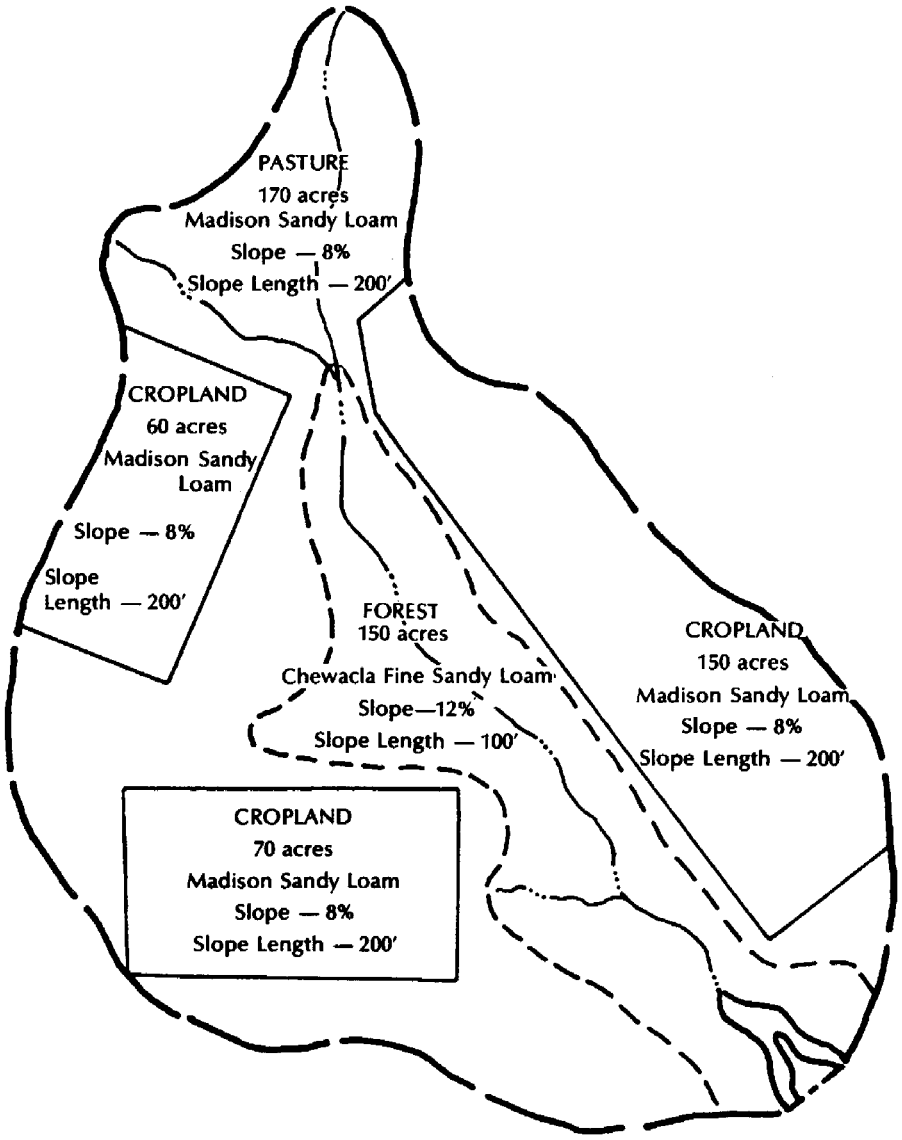


Figure B-2.2 — A Hypothetical 600-Acre Watershed for Use in Example.

EXAMPLE OF USE OF UNIVERSAL SOIL LOSS EQUATION IN WATERSHED PLANNING

Assume a watershed area of 600 acres above a proposed floodwater retarding structure in Hancock County, Georgia. Compute the average annual soil loss from sheet erosion for present conditions and for future conditions after recommended land treatment is applied on all land in the watershed.

Present Conditions

Cropland — 280 acres

Continuous corn with residue removed — average yield — 70 bu./ac.

Cultivated up and down slope

Soil — Madison sandy loam

Slope — 8 percent

Slope length — 200 feet

R = 250	Figure B-2.1
K = 0.32	Appendix B-1
LS = 1.4	Figure B-2.2
C = 0.50	Table B-2.5
P = 1.00	

A = 250 x .32 . 1.4 x .50 x 1.0
= 56.0 Tons/Acre/Year Soil Loss

Pasture — 170 acres

Canopy of short brush — 0.5 m fall height

Percent cover provided by canopy — 50 %

Surface cover — grass and grasslike plants

Percent of surface or ground cover — 80%

Soil — Madison sandy loam

Slope — 8 percent

Slope length — 200 feet

R = 250
K = 0.32
LS = 1.4
C = 0.012

A = 250 x .32 . 1.4 x .012 - 1.34 Tons/Acre/Year

Forest — 150 acres

Percent of area covered by tree canopy — 30%

Percent of area covered by litter — 50%

Undergrowth — unmanaged

Soil — Chewacla fine sandy loam

Slope — 12 percent

Slope length — 100 feet

R = 250
K = 0.32
LS = 1.8
C = 0.05

A = 250 x .32 x 1.8 x .05 = 7.2 Tons/Acre/Year

Future Conditions

Cropland — 280 acres

Rotation of wheat, meadow, corn, corn with residue left

Contour stipcropped

Soil — Madison sandy loam

Slope — 8 percent

Slope length — 200 feet

R = 250
K = 0.32
LS = 1.4
C = 0.095
P = 0.3

A = 250 x .32 x 1.4 x 0.095 x .3 = 3.2 Tons/Acre/Year

Pasture — 170 acres

With improved management:

Canopy cover decreased to 25 percent with 4 m fall height

Ground cover increased to 95 percent (for area not protected by canopy)

Soil — Madison sandy loam

Slope — 8 percent

Slope length — 200 feet

R = 250
K = 0.32
LS = 1.4
C = 0.003

A = 250 x .32 x 1.4 x .003 = 0.34 Tons/Acre/Year

Forest — 150 acres

With improved management:

Canopy cover increased to 60 percent

Litter cover increased to 80 percent

Undergrowth — managed

Soil — Chewacla fine sandy loam

Slope — 12 percent

Slope length — 100 feet

R = 250
K = 0.32
LS = 1.8
C = 0.003

A = 250 x .32 x 1.8 x .003 = 0.43 Tons/Acre/Year

SUMMARY OF AVERAGE ANNUAL SOIL LOSSES

Present Conditions

Cropland — 280 acres x 56.0 tons/ac.	= 15,680 tons/year
Pasture — 170 acres x 1.34 tons/ac.	= 228 tons / year
Forest — 150 acres x 7.2 tons/ac.	= 1,080 tons/year

Future Conditions

Cropland — 280 acres x 3.2 tons/ac.	= 896 tons/year
Pasture — 170 acres x .34 tons/ac.	= 59 tons/year
Forest — 150 acres x .43 tons/ac.	= 65 tons/year

GUIDE FOR DEVELOPING THE SOIL ERODIBILITY FACTOR (K) IN THE UNIVERSAL SOIL LOSS EQUATION

The soil erodibility factor (K) used in the universal soil loss equation is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It is a value determined experimentally for selected benchmark soils. Based on a knowledge of the behavior of soil properties and their interactions, these data are synthesized and values assigned to other kinds of soil.

A single K value can be given the dominant textural phase of a soil series if the erosion potential is about the same for all horizons and textural phases of that series. Where horizons or textural phases of a series differ greatly in erosion potential, say two or more K value classes, more than one K value needs to be assigned to the named kind of soil.

K values that have been obtained experimentally range from .01 to .64. For ease of use, twelve K value classes are used as follows: .10, .15, .17, .20, .24, .28, .32, .37, .43, .49, .55 and .64.

In developing K values for soils, use all applicable data. In addition, consider the following soil properties that have been found to affect soil erodibility:

1. Soil texture, especially percent of silt plus very fine sand.
2. Percent of sand greater than 0.10 mm.
3. Soil organic matter content.
4. Soil structure (type, grade).
5. Soil permeability.
6. Clay mineralogy.
7. Coarse fragments in soil layer being evaluated.

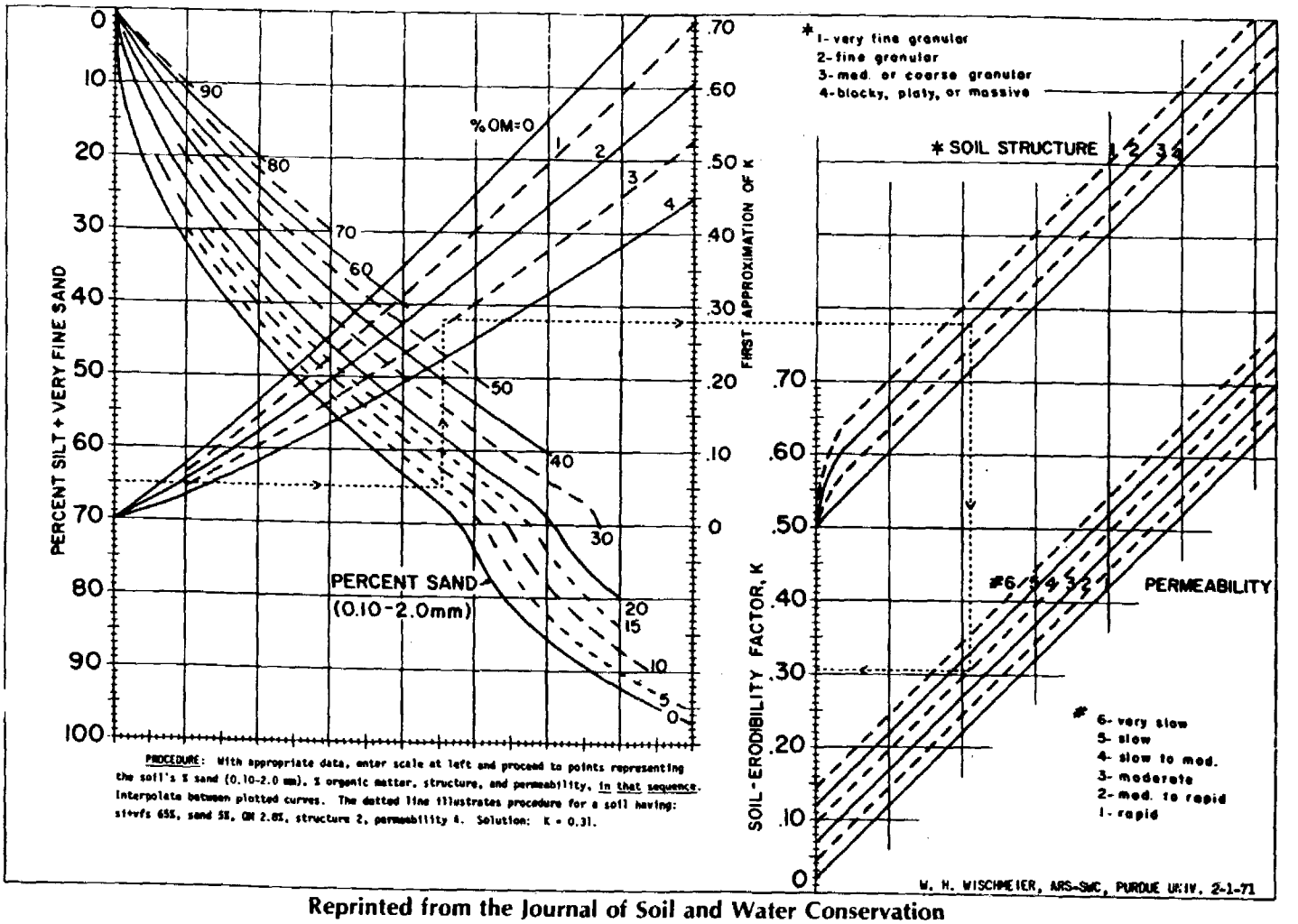
Rainfall intensity, distribution, amount, length and steepness of slope, vegetative cover and erosion control practices all influence soil erodibility but these are taken care of by other variables in the equation.

The Agricultural Research Service has developed a nomograph which shows the influence of various selected soil properties on K values (42). A copy of this nomograph is attached for information and guidance.

When using the nomograph, care should be taken to select those soil properties that are most representative of the horizon being considered. For horizons having organic matter in excess of 4 percent, do not

Figure B-2.3

SOIL ERODIBILITY NOMOGRAPH



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extrapolate—use the 4 percent curve.

The K values derived from the nomograph must be adjusted for coarse fragments. K values for soils high in coarse fragments (gravelly, chanery, shaly, slaty, cherty, cobbly, or flaggy) are reduced by one or two classes. Soils that are very gravelly, very chanery, very shaly, very slaty, very cherty, very cobbly, or very flaggy are reduced by two or three classes.

Soil scientists using the ARS nomograph have noted that for some soils, the K values obtained from the nomograph differ from those they have been using for many years. The nomograph commonly gives higher K values for silty soils and lower values for soils high in clay and in sand than values now in use. Where these values differ more than two K value classes, there is need to study the soils carefully and see how they behave under field conditions. For some soils, the best value may be somewhere between these two values. For other soils, the original estimated value may be more representative; in others the nomograph value may be more representative. The nomograph is based on a limited number of different kinds of soil and experience with its use is limited. Therefore, it should be used only as a guide at this time.

SEDIMENT YIELD AND COMPUTATIONS FOR SEDIMENT STORAGE STRUCTURES

General

The results of the investigations to determine gross erosion and sediment sources should be used to compute the sediment storage requirements for any structure.

Sediment yield is dependent upon gross erosion from a watershed and the transport of the eroded material to a given point of measurement. *In almost all watersheds the sediment yield to any point during any period will be less than 100 percent of the gross erosion occurring above that point.* Since only a part of the material set in motion by erosion processes is moved out of a watershed, the gross erosion figure must be adjusted downward to arrive at the sediment yield. This adjustment factor is the ratio of sediment yield to gross erosion and is termed the sediment delivery ratio. It is dependent upon several interrelated physical, hydrologic, hydraulic, and other watershed characteristics. If significant relationships between sediment delivery ratios and certain watershed characteristics can be established for a group of watersheds in a relatively homogeneous area, it is then possible to develop a procedure for making sound estimates of expected sediment yields from gross erosion data and the sediment delivery ratio characteristics of other watersheds within this area.

Sediment Delivery Ratio

A study of the characteristics of the size of the watershed variable, when used in a regression analysis with sediment delivery ratio, showed that the net influence of several watershed factors are represented in the derived equation for estimating sediment delivery ratio. For example, plottings on log-log paper revealed that watershed size is significantly related to the following measurable characteristics of the sample watersheds:

1. LENGTH OF ALL CHANNELS. In this relatively homogeneous area total channel length was found to increase with an increase in size of watershed.
2. CHANNEL DENSITY. In contrast to the large watersheds, small watersheds are found to have more linear feet of channels per unit of area.
3. MAIN STEM CHANNEL LENGTH. The length of a main stem channel is directly related to the area of the watershed it serves.
4. RELIEF. Total relief increases with increasing watershed size.
5. RELIEF-LENGTH RATIO. Large watersheds usually have lower relief-length ratio values than smaller watersheds in the same area.
6. ALLUVIAL SOILS AREA. In contrast to small watersheds, larger watersheds usually have a greater proportion of their total area in alluvial soils, indicating an inverse relationship between watershed area and downstream delivery of erosional material.

The most significant variable has proved to be watershed area. The empirical relationship of sediment delivery ratio to watershed area is presented in the two delivery ratio curves in Figures B-2.4 and B-2.5. It is recommended that Figure B-2.4 be used where a majority of the eroded material is medium to coarse texture. A delivery ratio curve, based on the relationship of Relief-Length (R/L) Ratio, is included in Figure B-2.6. It is recommended that this curve be used where a majority of the eroded material is medium to coarse texture.

Methods of Determining Sediment Yield

There are several ways to determine the sediment yield of a watershed depending on the environment and the data available. The following two methods are recommended:

1. Gross erosion and sediment delivery ratios.
2. Measured reservoir sediment accumulation.

Using gross erosion and sediment delivery ratios is well suited for estimating sediment yields in the southeastern United States. The estimate of sediment yield is made by use of the following equation:

$$Y = E(DR) \qquad \text{(Eq. B-2)}$$

where,

Y = Sediment yield (tons/unit area/year)
E = gross erosion (tons/unit area/year)
DR = sediment delivery ratio (in percent)

The gross or total erosion in the drain age area is the summation of all the erosion taking place. It includes sheet and rill erosion and channel type erosion (gullies, valley trenches, streambank erosion, etc.). The product of the gross erosion and sediment delivery ratio is the sediment yield.

Measured reservoir sediment accumulation in reservoirs of known age and history is an excellent source of data for establishing sediment yields. Reservoir deposition and sediment yield are not synonymous. The amount of accumulated sediment must be divided by the reservoirs trap efficiency to obtain the sediment yield. This takes into account the amount of sediment that passed through the reservoir. A detailed procedure for measuring sediment and accumulation in reservoirs is contained in Section 3, chapter 7 of the National Engineering Handbook (31).

The sediment yield of an unmeasured watershed may be estimated from that of a measured watershed in the same major land resource area where the topography, soils, and land use are similar. In order to directly transpose sediment yield data, *the size of the drainage area of the surveyed reservoir should not be less than one half nor more than twice that of the watershed under consideration.* Beyond these limitations the annual sediment yield may be adjusted on the basis of the ratio of the drainage areas raised to the 0.8 power:

$$S_e = S_m \frac{A_e^{0.8}}{A_m} \qquad \text{(Eq. B-3)}$$

where,

S_e = sediment yield of unmeasured watershed, in tons per year
S_m = sediment yield of measured watershed in tons per year (measured annual sediment deposition/ trap efficiency of surveyed reservoir)
A_e = drainage area of unmeasured watershed
A_m = drainage area of measured watershed

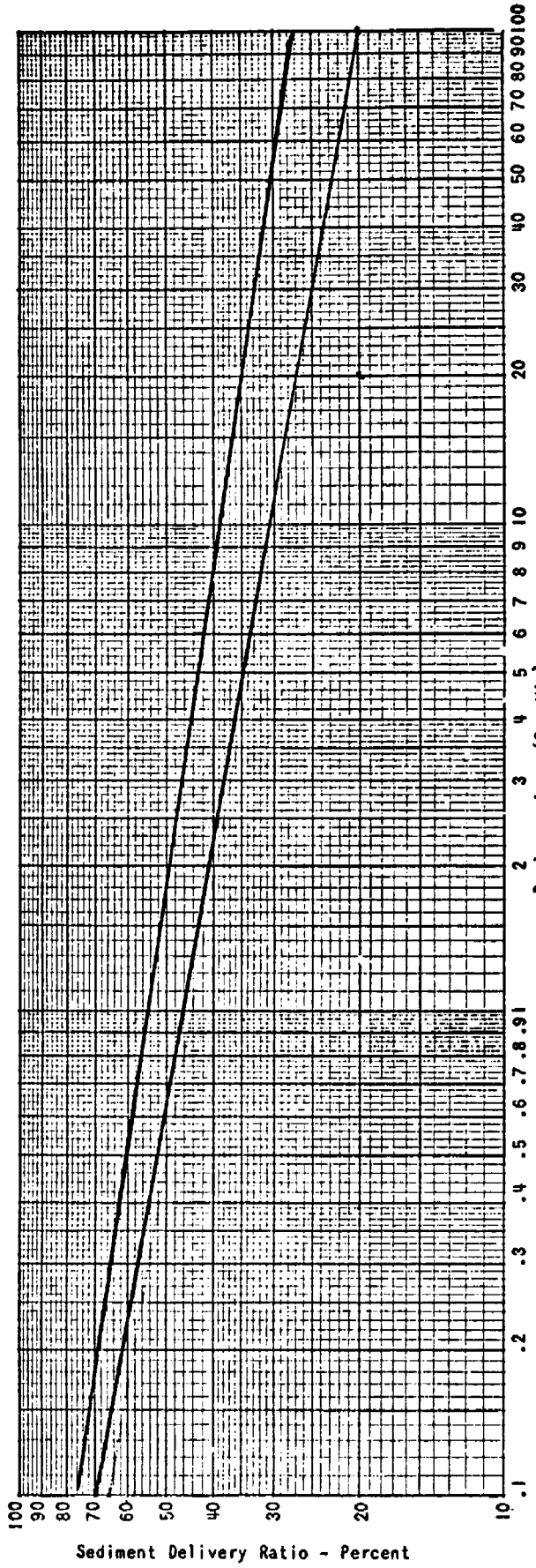


Figure B-2.4 — Sediment delivery ratio curve for fine and medium textured soils.

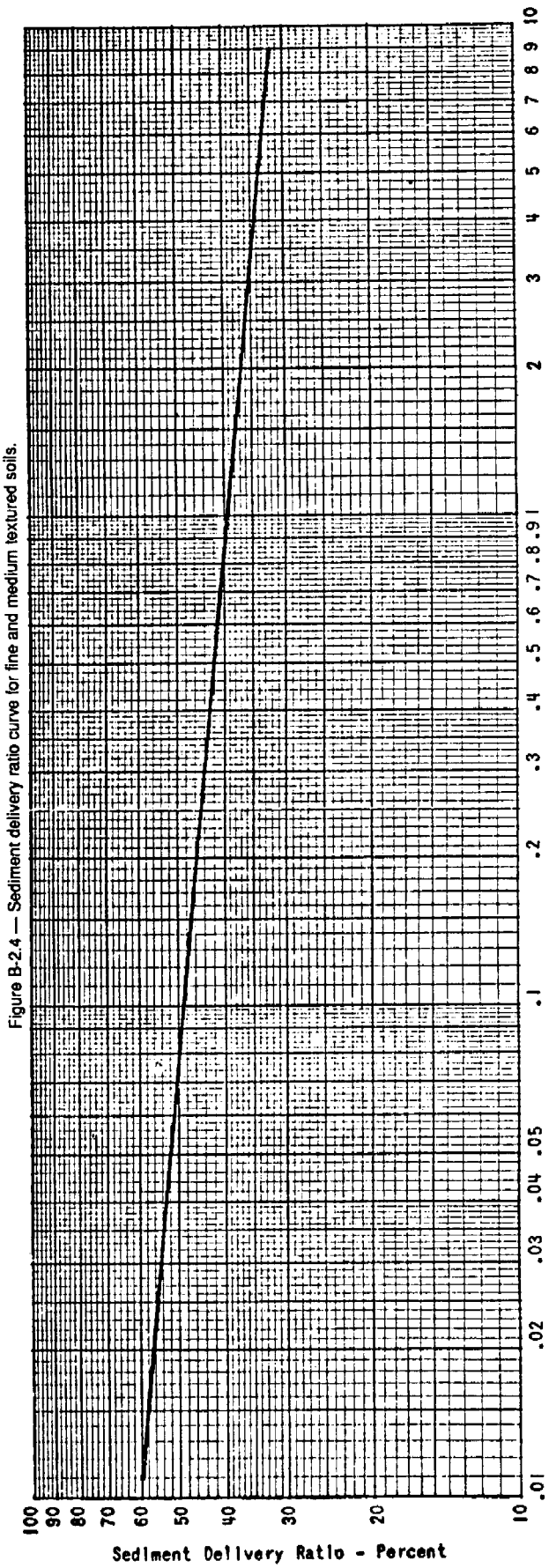


Figure B-2.5 — Sediment delivery ratio curve for medium and coarse textured soils.

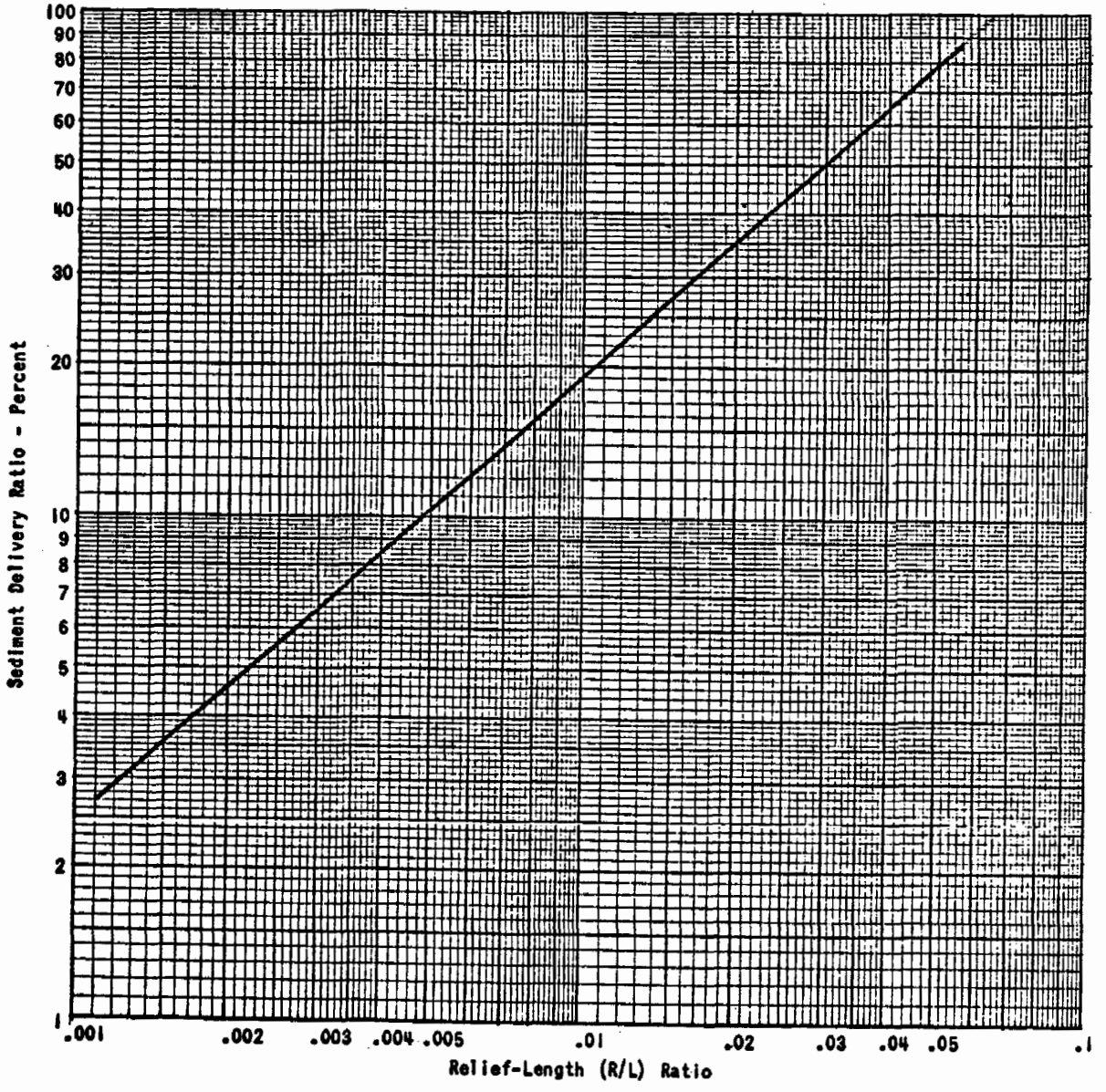
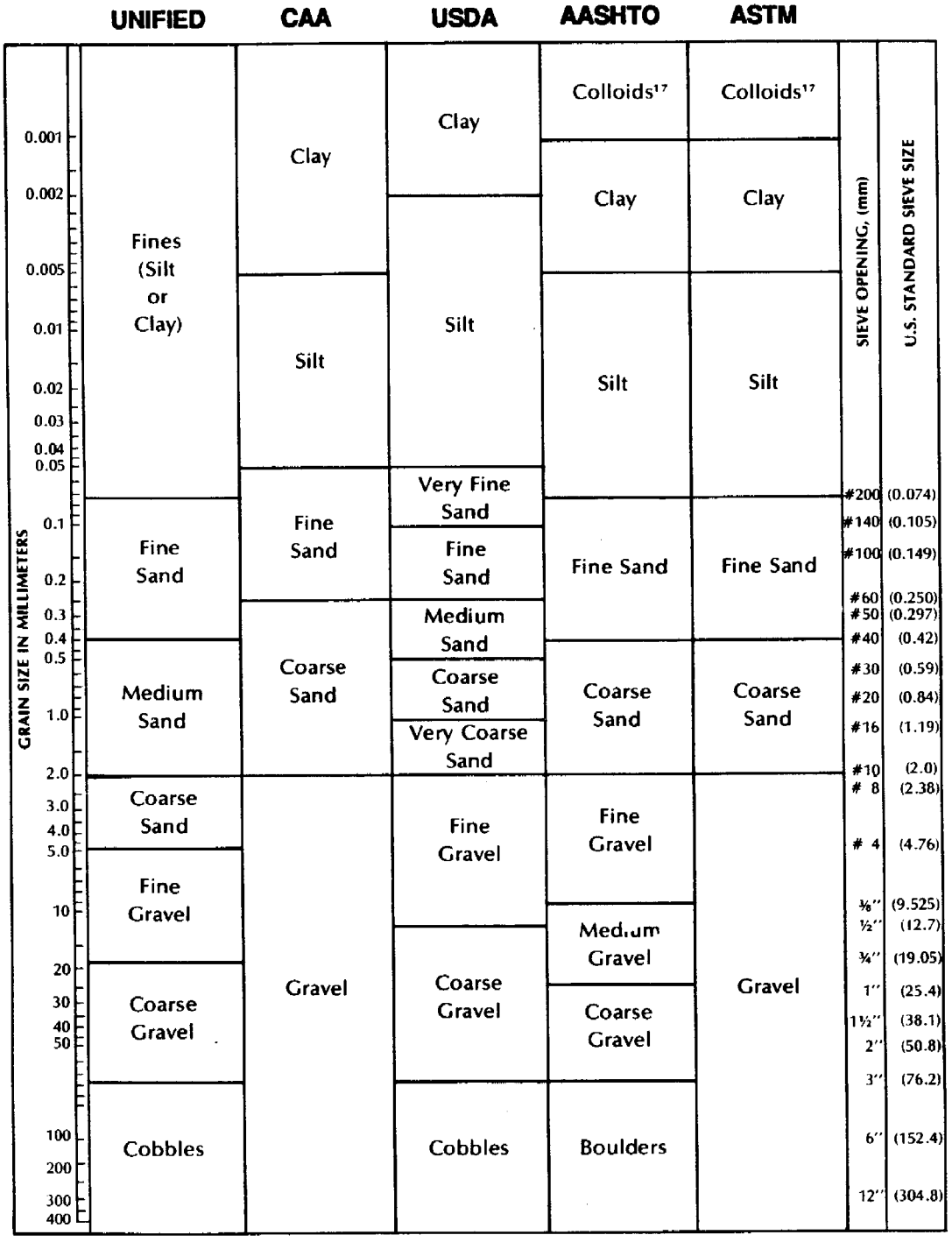


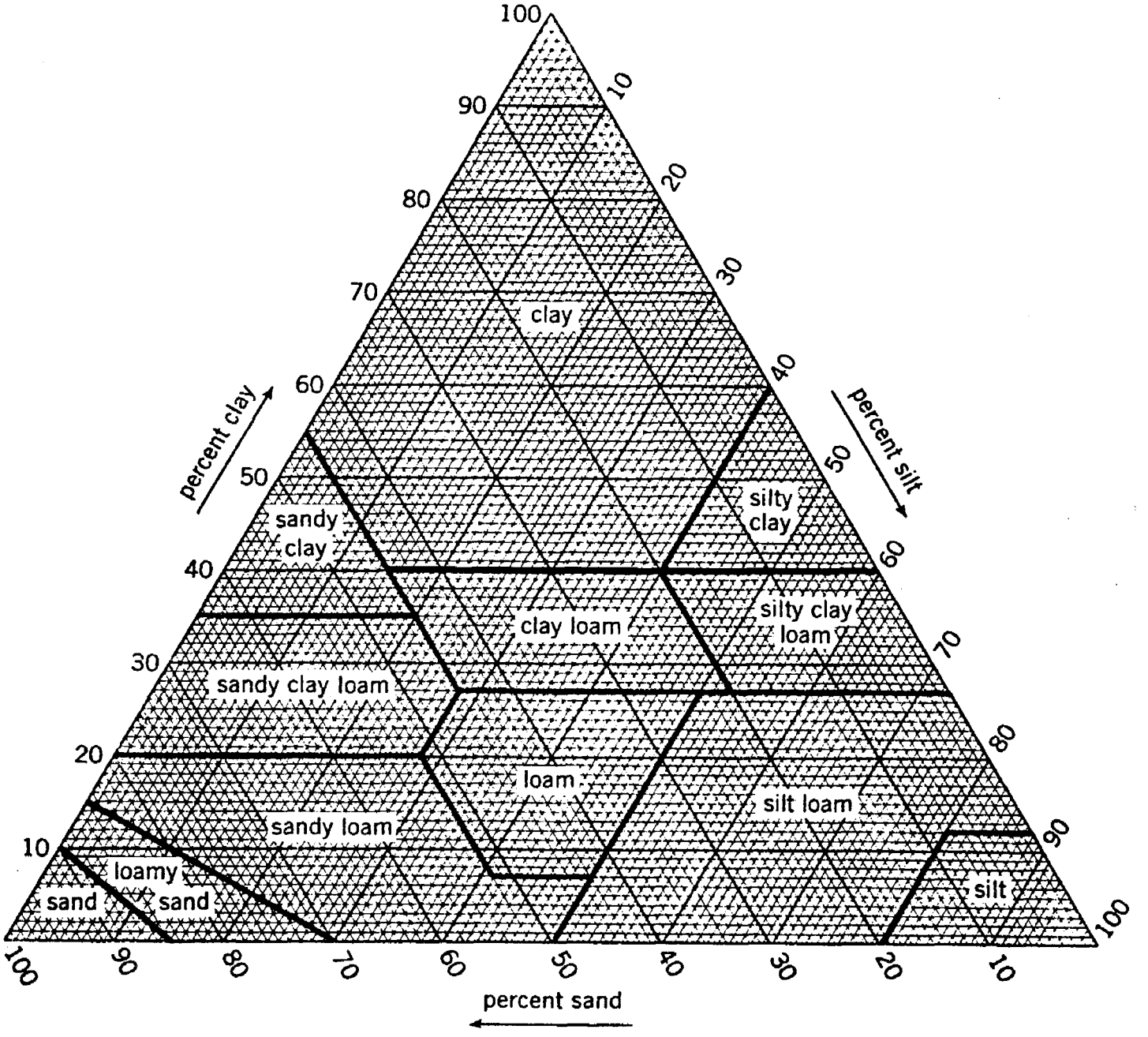
Figure B-2.6 — Sediment delivery ratio curve-erosion from all sources medium and course textured soils.

Figure B-2.7 — Comparison of Soil Classification Systems.
Soil Separates/Size Limits



[17]Included in clay fraction in test reports

Figure B-2.8 — Guide for Textural Classification.



3

Vegetative Considerations

EFFECTS OF VEGETATION ON EROSION, SEDIMENTATION, AND PROPERTY VALUE

Dense, vigorous vegetation protects the soil surface from raindrop impact, a major force in dislodging soil particles and moving them downslope. It also shields the soil surface from the scouring effect of overland flow and decreases the erosive capacity of the flowing water by reducing its velocity.

The shielding effect of a plant canopy is augmented by roots and rhizomes that hold the soil, improve its physical condition, and increase the rate of infiltration, further decreasing runoff. Plants also reduce the moisture content of the soil through transpiration, thus increasing its capacity to absorb water (Figure 3.1).

Suitable vegetative cover affords excellent erosion protection and sedimentation control and is essential to the design and stabilization of many structural erosion control devices. Vegetative cover is relatively inexpensive to achieve and tends to be self-healing; it is often the only practical, long-term solution to stabilization and erosion control on most disturbed sites in North Carolina.

Planning from the start for vegetative stabilization reduces its cost, minimizes maintenance and repair, and makes structural erosion control measures more effective and less costly to maintain. Post-construction landscaping is also less costly where soils have not been eroded, slopes are not too steep, and weeds are not allowed to proliferate. Natural areas—those left undisturbed—can provide low-maintenance landscaping, shade, and screening. Large trees increase property value if they are properly protected during construction.

Besides preventing erosion, healthy vegetative cover provides a stable land surface that absorbs rainfall, cuts down on heat reflectance and dust, restricts weed growth, and complements architecture. The result is a pleasant environment for employees, tenants and customers, and an attractive site for homes. Property values can be increased dramatically by small investments in erosion control. Even the final landscaping represents only a small fraction of total construction costs and contributes greatly to the marketing potential of a development.

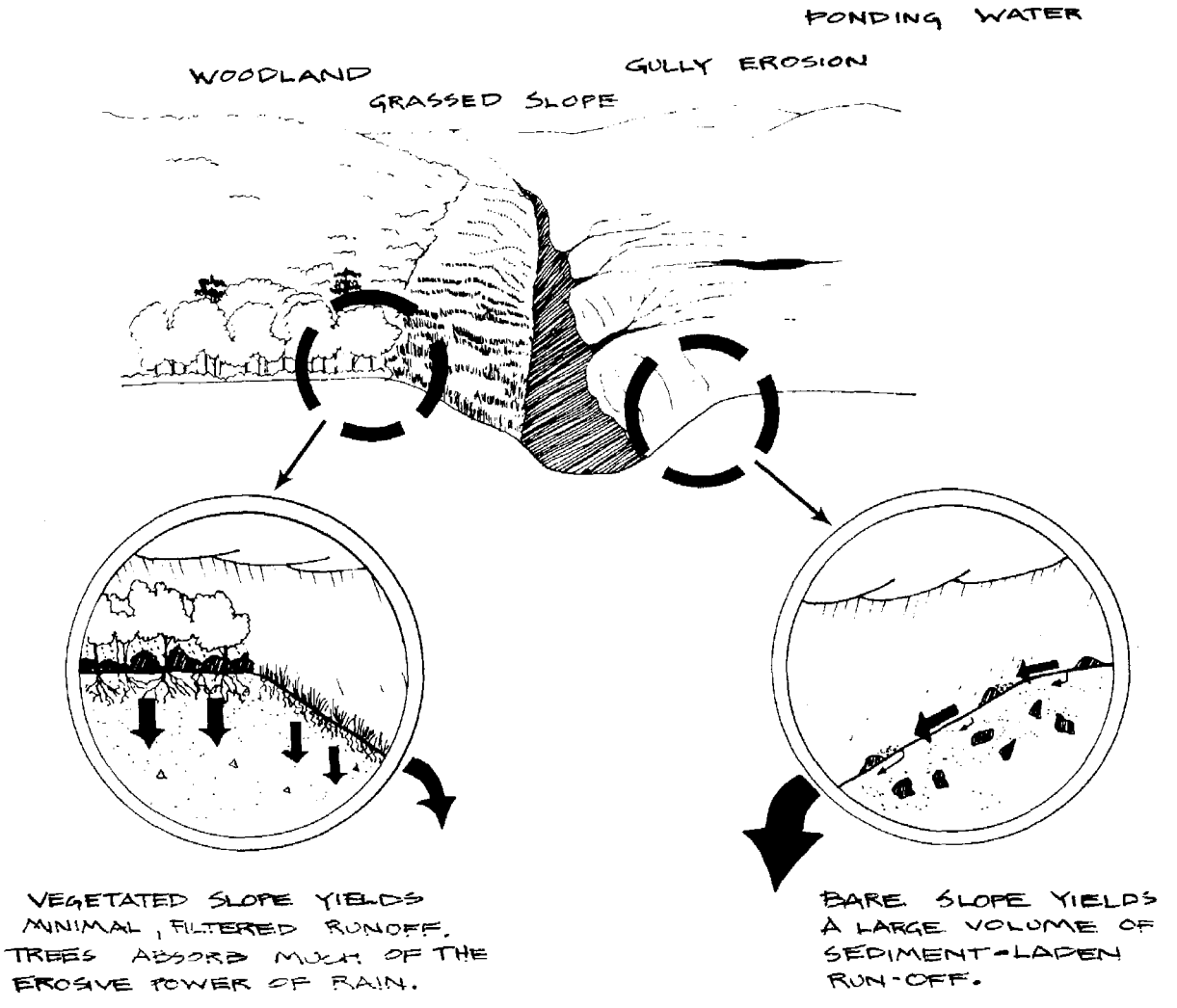


Figure 3.1 Effects of vegetation on erosion.

SITE CONSIDERATIONS

Species selection, establishment methods, and maintenance procedures should be based on site characteristics including soils, slope, aspect, climate, and expected management.

Slope

The steeper the slope, the more essential is a vigorous vegetative cover. Good establishment practices, including seedbed preparation, quality seed, lime, fertilizer, mulching and tacking are critical. The degree of slope may limit the equipment that can be used in seedbed preparation, planting, and maintenance; steep slopes also increase costs.

Aspect

Aspect affects soil temperature and available moisture. South- and west-facing slopes tend to be warmer and drier, and often require special treatment. For example, mulch is essential to retain moisture, and drought-tolerant plant species

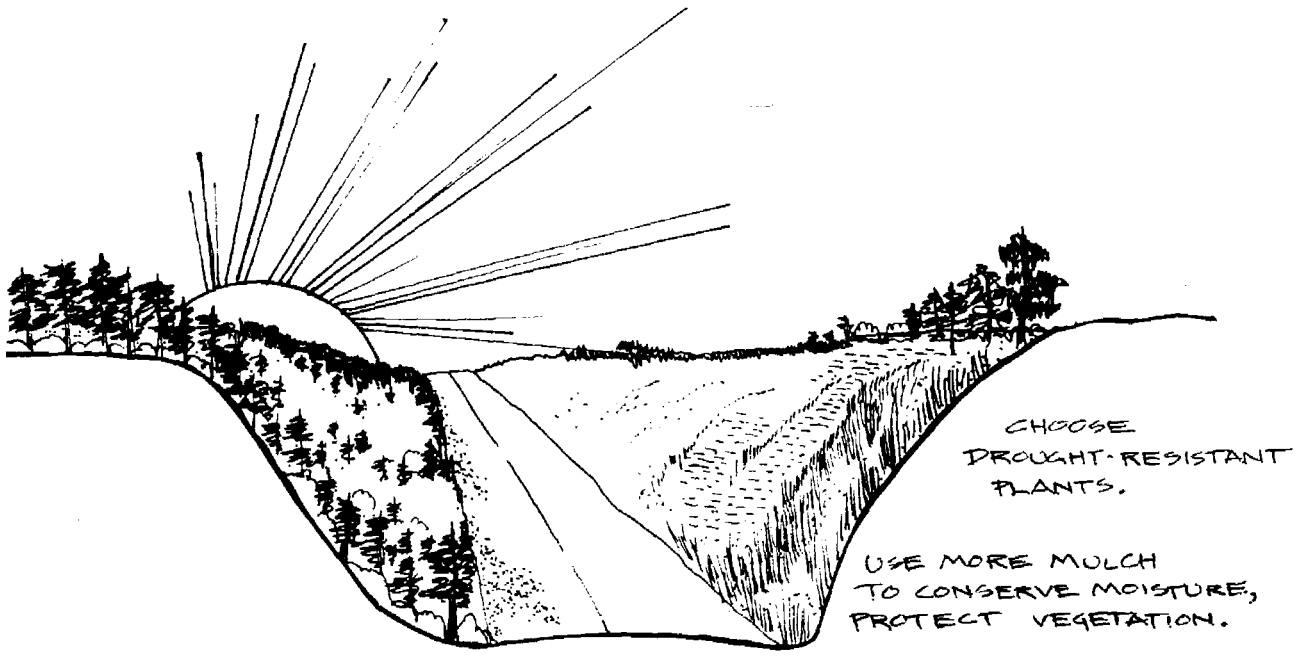


Figure 3.2 South- and west-facing slopes are hot and dry.

should be added to the seed mixture (Figure 3.2). South- and west-facing slopes also may be subject to more frost heaving due to repeated cycles of freezing and thawing.

Climate

The regional climate must be considered in selecting well-adapted plant species. North Carolina recommendations are usually based on three broad physiographic regions: Mountain, Piedmont, and Coastal Plain. Climatic differences determine the appropriate plant selections based on such factors as cold-hardiness, tolerance to high temperatures and high humidity, and resistance to disease.

Management

When selecting plant species for stabilization, consider post-construction land use and the expected level of maintenance. In every case, future site management is an important factor in plant selection.

Where a neat appearance is desired, use plants that respond well to frequent mowing and other types of intensive maintenance. Likely choices for quality turf in the west are tall fescue, Kentucky bluegrass, and Bermudagrass, or in the east, Bermudagrass, centipedegrass, zoysiagrass, and Bahiagrass.

At sites where low maintenance is desired, longevity is particularly important. Sericea lespedeza, tall fescue, annual lespedeza, and, in some cases, Bermudagrass, redtop, or crownvetch are likely choices. Other species may be appropriate to intermediate levels of maintenance.

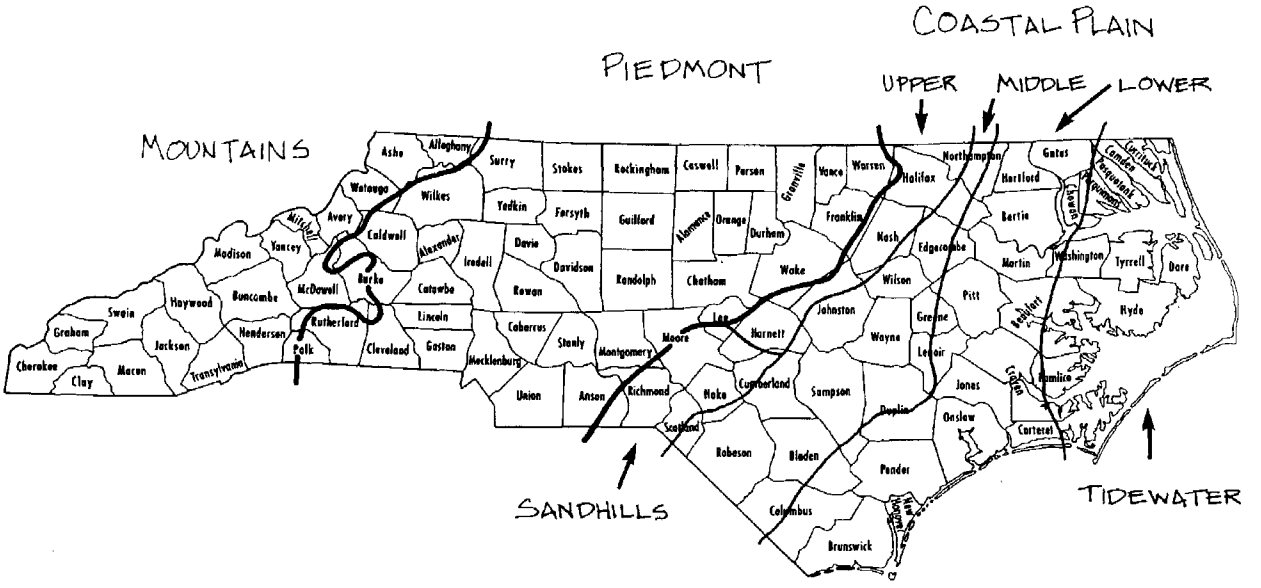


Figure 3.3 Major physiographic regions of North Carolina differ in relief, geology, climate, elevation, and major soil systems.

Soils

Many soil characteristics—including texture, organic matter, fertility, acidity, moisture retention, drainage, and slope—influence the selection of plants and the steps required for their establishment. The following is a very general description of North Carolina soils with respect to characteristics that affect stabilization of disturbed sites. Soil formation in North Carolina has been influenced primarily by parent materials and relief. As a result, soils differ among the major physiographic regions shown in Figure 3.3.

Mountain Region

Surface soils of the Mountain Region vary from sandy loam to clay loam, with shallow subsoils varying from silt loams to sandy loams. Steep slopes with shallow, stony, droughty soils are common. Many mountain soils have been severely eroded. On more level topography, deeper profiles provide greater water-storage capacity and room for root growth. Shallow, stony soils and steep slopes present major problems for vegetation establishment in this region. Permanent vegetation is normally selected from cool-season, winter-hardy perennials.

Piedmont Region

Piedmont soils are similar to those of the Mountains but, in general, are deeper, lower in organic matter, and have subsoils higher in clay. Deeper subsoils are typically silts, silt loams, and sandy loams. Surface soils vary from sandy loam to clay loam, and subsoils are commonly thick with heavy clay texture. While topography is gentler than in the Mountains, it is mostly rolling to hilly, with well-developed drainage patterns. Soils are generally well to excessively drained.

The sloping terrain and silty subsoils often result in severe erosion potential. As a result of previously poor management practices, many areas are moderately to severely eroded.

Piedmont soils generally support a wide variety of plants, including both cool- and warm-season species. Sites that are steep, shallow, stony, droughty, or severely eroded present problems for establishment of vegetation.

Coastal Plain Region

Coastal Plain soils include some of the easiest and some of the most difficult soils to vegetate. The Coastal Plain region has several different subregions to consider.

The Sand Hills region of the Coastal Plain is dominated by coarse, deep, excessively drained sand and rolling topography. These soils are extremely low in organic matter and plant nutrients. When disturbed, they are subject to both wind and water erosion. These are some of the most erodible soils in the State and need to be treated with the utmost caution. Due to their low water-holding capacity, revegetation requires highly drought-resistant species.

Upper and Middle Coastal Plain soils generally have well-drained sandy loam surface horizons underlain by sandy clay loam subsoils. Topography is undulating to nearly level. These soils retain more moisture and nutrients than the sands of the Sand Hills and coastal dunes, and support a wider variety of vegetation. However, they are still quite erodible when disturbed. The region also includes some poorly drained soils and some excessively drained "Sand Hills" soils.

Lower Coastal Plain soils vary from well-drained to poorly drained and from sand to silt loam in texture. The coarser soils are extremely erodible. Poorly drained soils ranging from sands to organics are limited in extent. Along the southern coast both old and young dune sands occur. Choice of species for revegetation is largely determined by moisture retention and drainage conditions. Dune sands require a unique group of species.

The Tidewater Region is dissected by sounds and numerous wide rivers. Soils may be wet and mostly organic or mineral soils with high clay content. Draining these soils can be difficult. The organic mucks and peats are most often underlain by sand, but may have silt or clay subsoils.

Nature of Disturbed Soils

Throughout the State, most disturbed sites end up, after grading, with a surface consisting of acid, infertile subsoil materials that are toxic to most plants (Figure 3.4). Such soils may not be capable of supporting the dense growth necessary to prevent erosion. Construction activities further decrease soil productivity by increasing compaction, making slopes steeper, and altering drainage patterns. Topsoiling, soil amendments, and special seedbed preparation are generally required to offset these problems.

Soil Sampling

A good sedimentation control plan should include thorough soil sampling in the area of planned construction. Different soils should be sampled separately. Containers for soil samples and instructions for sampling may be obtained from any local Agricultural Extension office or from the North Carolina Department of Agriculture. Analysis of soil samples is available from the NCDA soil testing lab. Test results include lime and fertilizer recommendations. Fertilizing ac-

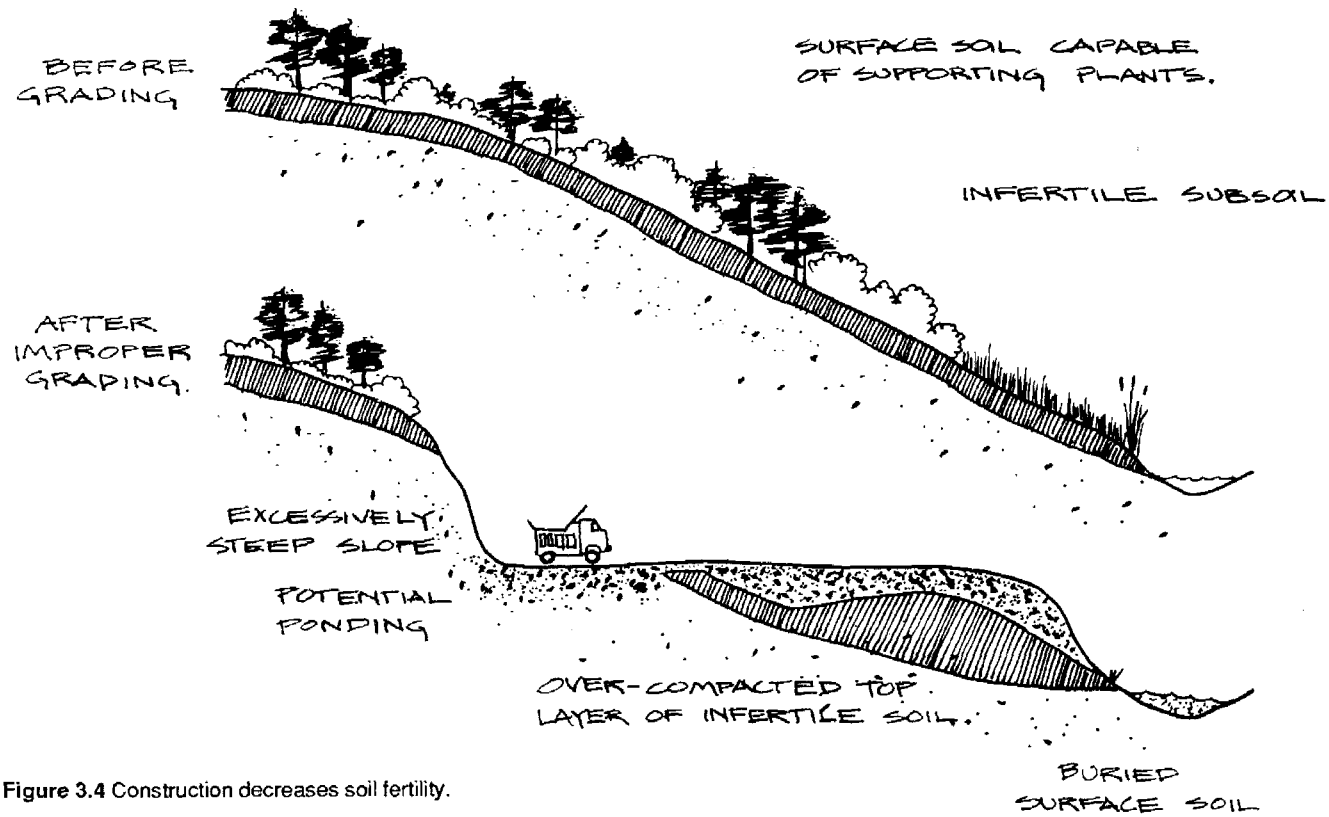


Figure 3.4 Construction decreases soil fertility.

cording to the soil test ensures the most efficient expenditure of money for fertilizer and a minimum of excess fertilizer to pollute streams or groundwater. Soil sampling should begin well in advance of planting because 1 to 6 weeks are required to obtain soil test results.

Soil Limitations

Certain soil factors are difficult to modify and can impose severe limitations on plant growth. These include such things as depth, stoniness, texture, and properties related to texture such as water- and nutrient-holding capacity. Extremely coarse textures result in droughtiness and nutrient deficiencies. Fine textures, on the other hand, impede infiltration and decrease permeability, thereby increasing the volume of runoff. Toxic levels of elements such as aluminum, iron, and manganese are limiting to plant growth. However, these become less soluble as the pH is raised, so that toxicity problems can usually be eliminated by liming. Toxicities from industrial waste could also make the soil unsuitable for plant growth.

Portions of this manual refer to "poor," "severe," "droughty," and "adverse" soils. These are subjective terms that require judgment based on experience in revegetating disturbed soils. They refer to soils that require special treatment beyond routine tillage and fertilization. *Appendix 8.01* provides guidance for identifying soils and predicting their characteristics.

SEASONAL CONSIDERATIONS

Newly constructed slopes and other unvegetated areas should be seeded and mulched, or sodded, as soon as possible after grading. Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for planting perennials generally extend from March through May and from August through October. Outside these dates the probability of failure is higher. If the time of year is not suitable for seeding permanent cover (perennial species), a temporary cover crop should be planted. Otherwise, the area must be stabilized with gravel or mulch. Temporary seeding of annual species (small grains, Sudangrass, or German millet) often succeeds at times of the year that are unsuitable for seeding permanent (perennial) species. Some annual species may be recommended for late winter through spring, summer, or late summer through late fall. Planting dates differ with physiographic region.

Seasonality must be considered when selecting species. Grasses and legumes are usually classified as warm- or cool-season in reference to their season of growth. Cool-season plants produce most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore fall is the most dependable time to plant them. Warm-season plants green-up late in the spring, grow most actively during the summer, and go dormant at the first frost in fall. Spring and early summer are preferred planting times for warm-season plants.

Variations in weather and local site conditions can modify the effects of regional climate. For this reason, mixtures including both cool- and warm-season species are preferred for low-maintenance cover, particularly in the Piedmont. Such mixtures promote cover adapted over a range of conditions. These mixtures are not desirable, however, for high-quality lawns, where variation in texture of the turf is inappropriate.

SELECTION OF VEGETATION

Species selection should be considered early in the process of preparing the erosion and sedimentation control plan. A diversity of vegetation can be grown in North Carolina, due to the variation in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, species selection should be made with care. Many widely occurring plants are inappropriate for soil stabilization because they do not protect the soil effectively, or because they are not quickly and easily established. Plants that are preferred for some sites may be poor choices for others; a few can become troublesome pests.

Initial stabilization of most disturbed sites requires grasses and legumes that grow together without gaps. This is true even where part or all of the site is planted to trees or shrubs. In landscape plantings, disturbed soil between trees and shrubs must also be protected either by mulching or by permanent grass-

legume mixtures. Although mulching alone is an alternative, it requires continuing maintenance.

Mixtures vs Single-Species Plantings

Single-species plantings are warranted in many cases, but they are more susceptible than mixtures to damage from disease, insects, and weather extremes. In addition, mixtures tend to provide protective cover more quickly. Consequently, the inclusion of more than one species should always be considered for soil stabilization and erosion control. Mixtures need not be elaborate. The addition of a quick-growing annual provides early protection and facilitates establishment of one or two perennials. More complex mixtures might include a quick-growing annual, one or two legumes, and one or two perennial grasses (*Practice Standards and Specification: 6.11, Permanent Seeding*).

Companion or "Nurse" Crops

The addition of a "nurse" crop (quick-growing annuals added to permanent mixtures) is a sound practice for soil stabilization, particularly on difficult sites—those with steep slopes; poor, stony, erosive soils; late seedings, etc.—or in any situation where the development of permanent cover is likely to be slow. The nurse crop germinates and grows rapidly, holding the soil until the slower-growing perennial seedlings become established (Figure 3.5). Nurse crop recommendations are included in *Practice Standards and Specifications: 6.11, Permanent Seeding*.

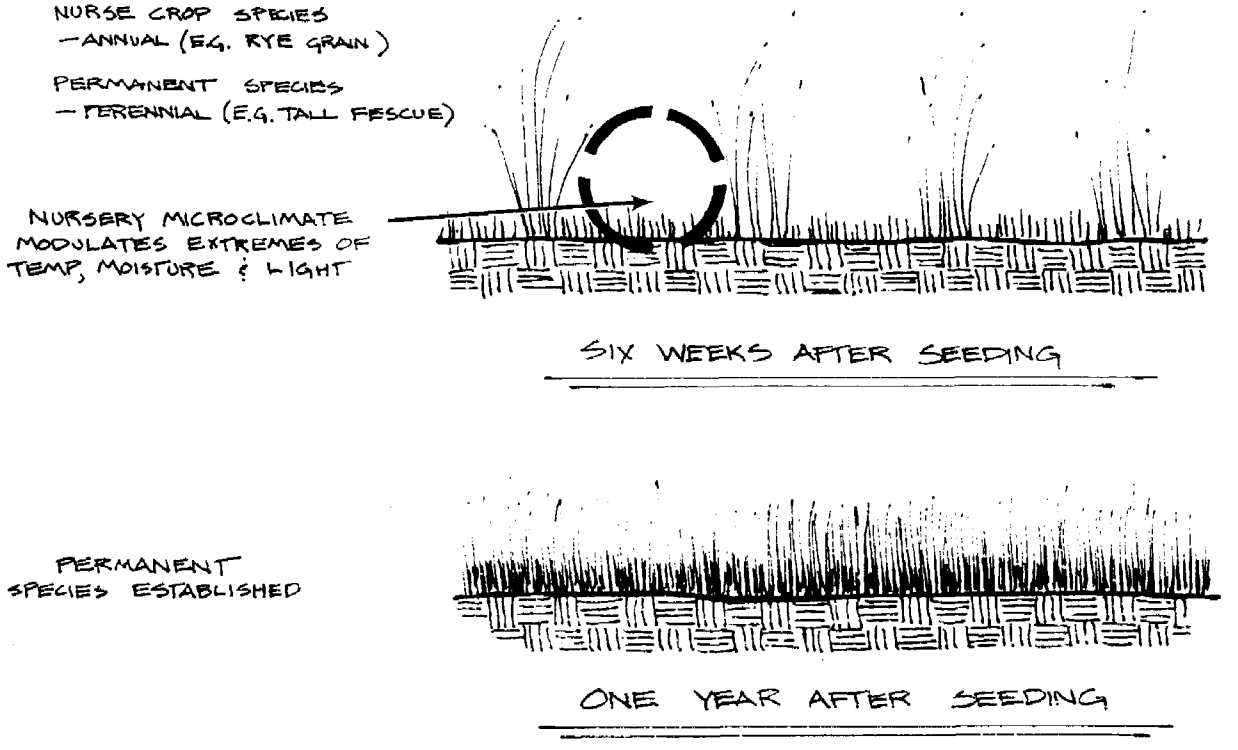


Figure 3.5 Nurse crops promote the establishment of permanent species.

Seeding rate of the nurse crop must be limited to avoid crowding, especially under optimum growing conditions. Seeding rates recommended in this manual are designed to avoid overcrowding. **Do not exceed the recommended rate.**

Plant Species Selection

Table 3.1 is a summary of the major plant species available for stabilization use in North Carolina. This summary is based on research and many years of field experience. Using this information makes plant selection straightforward for most situations. Recommended plants and some of more limited application are listed in Table 8.02a, *Appendix 8.02*, along with their botanical names. Specific seeding rates are given in *Practice Standards and Specifications: 6.10, Temporary Seeding*, and *6.11, Permanent Seeding*.

Annuals

Annual plants grow rapidly and then die in one growing season. They are useful for quick, temporary cover or as nurse crops for slower-growing perennials.

Winter rye (grain) is usually superior to other winter annuals (wheat, oats, crimson clover, etc.) both for temporary seeding and as a nurse crop in permanent mixtures. It has more cold-hardiness than other annuals and will germinate and grow at lower temperatures. By maturing early, it offers less competition during the late spring period, a critical time in the establishment of perennial species. Rye grain germinates quickly and is tolerant of poor soils. Including rye grain in fall-seeded mixtures is almost always advantageous, but it is particularly helpful on difficult soils and erodible slopes or when seeding is late. Overly thick stands of rye grain will suppress the growth of perennial seedlings. **Limit seeding rates to the suggested level.** About 50 lb/acre is the maximum for this purpose, and where lush growth is expected, that rate should either be cut in half, or rye grain should be eliminated from the mixture.

Table 3.1
Plants Recommended for Revegetating Disturbed Soils in North Carolina

	Annuals	Perennials
Cool-season grasses	Winter rye (grain)	Tall fescue Kentucky bluegrass Redtop
Warm-season grasses	German millet Sudangrass	Bermudagrass Bahiagrass Centipedegrass
Legumes	Annual lespedeza	Crownvetch Sericea lespedeza
Marsh plants		Smooth cordgrass Saltmeadow cordgrass Giant cordgrass
Dune plants		American beachgrass Sea oats Bitter panicum Saltmeadow cordgrass

Annual ryegrass is not recommended for use in North Carolina (Figure 3.6). It provides dense cover rapidly, but may be more harmful than beneficial in areas that are to be permanently stabilized. Annual ryegrass is highly competitive, and if included in mixtures, it crowds out most other species before it matures in late spring or early summer, leaving little or no lasting cover. It can be effective as a temporary seeding, but if allowed to mature the seed volunteers and seriously interferes with subsequent efforts to establish permanent cover. Winter rye (grain) is preferable in most applications.

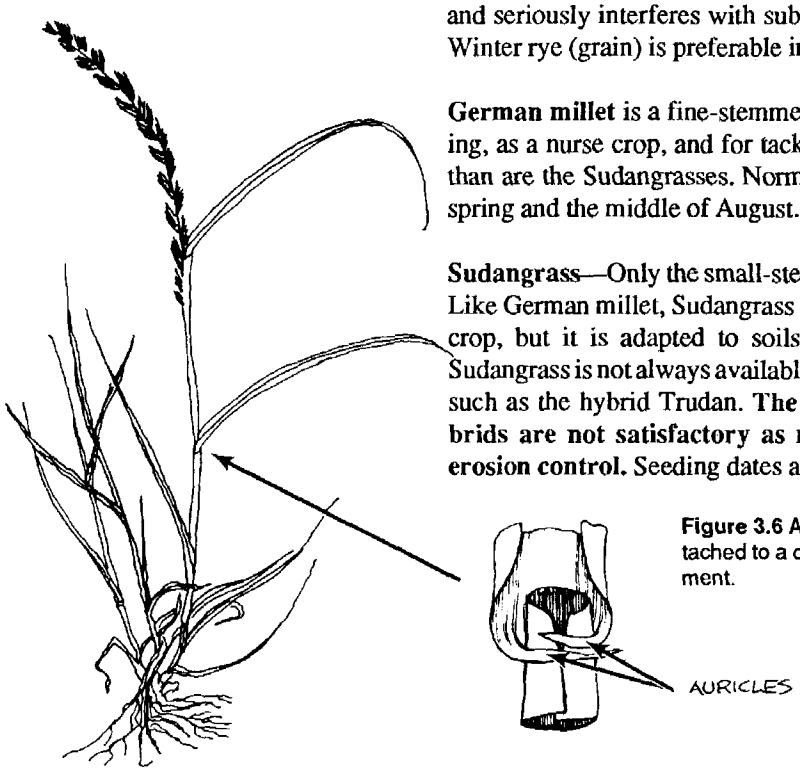


Figure 3.6 Annual ryegrass is recognized by flowers directly attached to a central stem and claw-like auricles at the leaf attachment.

German millet is a fine-stemmed summer annual, useful for temporary seeding, as a nurse crop, and for tacking mulch. It is better adapted to sandy soils than are the Sudangrasses. Normal seeding dates are between the last frost in spring and the middle of August.

Sudangrass—Only the small-stemmed varieties of Sudangrass should be used. Like German millet, Sudangrass is useful for temporary seeding and as a nurse crop, but it is adapted to soils higher in clay content. Seed for common Sudangrass is not always available, but other small-stemmed types may be used, such as the hybrid Trudan. **The coarse-stemmed sorghum-Sudangrass hybrids are not satisfactory as nurse plants and are not appropriate for erosion control.** Seeding dates are similar to those for German millet.

Annual lespedeza is a warm-season, self-reseeding annual legume that is tolerant of low fertility and is adapted to climate and most soils throughout the state. It is an excellent nurse crop in the spring, filling in weak or spotty stands the first season without suppressing the perennial seedlings. It is often seeded with sericea lespedeza. Annual lespedeza can heal damaged areas in the perennial cover for several years after initial establishment. Two varieties of annual lespedeza are generally available: Kobe and Korean. Kobe is superior on sandy soils and generally preferable in the Coastal Plain. Both Kobe and Korean are satisfactory in the Piedmont. Korean is better in the mountains as the seeds mature earlier.

The preferred seeding dates for annual lespedeza are in late winter to early spring. It can be mixed with fall seedings, in which case some seeds remain dormant over the winter and germinate the following spring. However, it is more effective to overseed with lespedeza in February or March.

Cool-Season Perennials

Perennial plants remain viable over winter and initiate new growth each year. Stands of perennials persist indefinitely under proper management and environmental conditions. They are the principal components of permanent vegetative cover.

Cool-season perennials produce most of their growth during the spring and fall and are more cold-hardy than most warm-season species. Descriptions of the species recommended for vegetating disturbed soils follow.

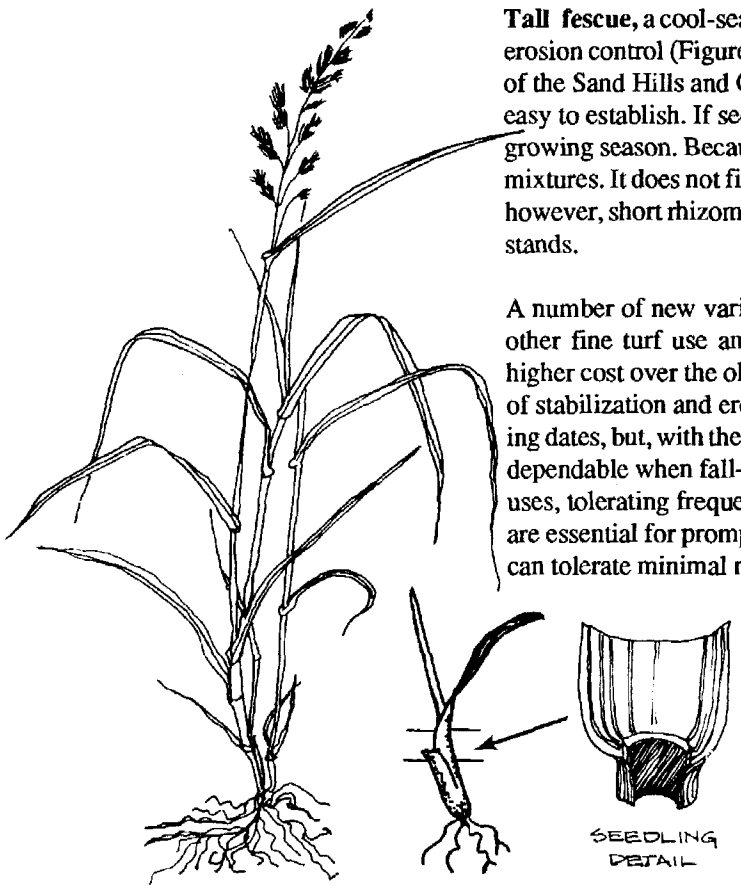


Figure 3.7 Tall fescue is a common perennial easily confused with ryegrass. Seedhead is branched, loose and open. Auricles are absent in young plants (compare with Figure 3.6).

Tall fescue, a cool-season grass, is the most widely used species in the state for erosion control (Figure 3.7). It is well-adapted to all but the most droughty soils of the Sand Hills and Coastal Plain. It thrives in full sun to partial shade and is easy to establish. If seeded in the fall, it provides stabilization early in the first growing season. Because of tall fescue's bunchy growth habit, it is best used in mixtures. It does not fill in well where areas are damaged by disease or weather; however, short rhizomes enable individual plants to expand substantially in thin stands.

A number of new varieties of tall fescue are becoming available for lawn and other fine turf use and several offer definite improvements. However, their higher cost over the old standby, KY31, is seldom justified solely for purposes of stabilization and erosion control. Tall fescue tolerates a wide range of seeding dates, but, with the possible exception of high mountain elevations, it is most dependable when fall-planted. It is adapted to both high- and low-maintenance uses, tolerating frequent or no mowing. Liberal fertilization and proper liming are essential for prompt establishment of tall fescue, but once firmly in place it can tolerate minimal maintenance almost indefinitely.

Kentucky bluegrass is the dominant lawn grass in the Mountains and Upper Piedmont. It has higher lime and fertility requirements than the other perennial grasses used in these regions. Bluegrass spreads by strong rhizomes and, where adapted, is an excellent soil stabilizer, readily filling in damaged spots. As with tall fescue, it has been the subject of intensive breeding activity in recent years, resulting in varieties with more heat tolerance and resistance to hot-weather diseases. Mixtures of these new varieties with improved types of tall fescue are becoming popular, particularly for Piedmont lawns, where they can be used in both sun and partial shade.

Redtop is a tough, cool-season perennial grass tolerant of infertile, droughty, somewhat acid soils. It can be a useful component of mixtures on dry, stony slopes in the western half of the state, particularly in the Mountain region.

Warm-Season Perennials

Warm-season perennials initiate growth later in the spring than cool-season species and experience their greatest growth during the hot summer months. Warm-season species are not generally used in the Mountains; most species

Figure 3.8 Common Bermudagrass.

thrive only in areas on the Coastal Plain. The following grasses have proven the most useful for soil stabilization.

Bermudagrass is an aggressive, sod-forming, warm-season perennial adapted to a wide range of well-drained to excessively drained soils throughout the Piedmont and Coastal Plain. It is very drought-resistant, has considerable salt-tolerance, and can be very useful for erosion control, particularly on deep sands in the Sand Hills and near the coast. Bermudagrass is not at all shade tolerant.

Common Bermudagrass (Figure 3.8) should be used with **extreme care** as it quickly becomes a pest in croplands, gardens, and landscape plantings, spreading rapidly both vegetatively and by seed. It is difficult to control and almost impossible to eradicate.

The turf- and hay-type hybrids do not produce viable seed and are less aggressive. Therefore, they are much easier to control and less likely to become pests. However, hybrid Bermudas are more costly to establish because they must be planted from sprigs or plugs. In fact, the cost involved in establishing turf-type hybrids makes them generally practical only for fine turf use.

Common Bermudagrass is normally seeded in late spring using "hulled" seed (seed from which the outer covering or bracts have been removed). Unhulled seed may be used in fall-seeded mixtures because it lies dormant over winter and germinates in the spring. Hybrid varieties are planted in early spring, while soil moisture is still adequate. They may be planted later if water is available for irrigation.

Bahiagrass is a warm-season perennial grass adapted to the lower Piedmont and Coastal Plain. It tolerates dry, acid, low-fertility soils. Bahiagrass produces a fairly dense sod suitable for low-maintenance lawns, were it not for the production of unsightly seedheads (1-2 ft high) throughout the growing season.

Unfortunately, the strain of Bahiagrass generally available, Pensacola, is occasionally subject to winter-kill at this latitude. Consequently, it should not be relied upon in pure stands. The Wilmington strain is more cold-tolerant, but seed is not generally available.

Centipedegrass is adapted to well-drained, medium- to coarse-textured soils in the eastern Piedmont and Coastal Plain. Generally used as a low- to moderate-maintenance turf, it is tolerant of infertile, low pH soils, heat, drought, and cold.

A serious problem with centipedegrass is its slow growth rate. Also, when grown on dry sands, irrigation is required to avoid severe pest injury (pearl bug). It is not tolerant to traffic or compaction.

Centipedegrass can be established from seeds or sprigs, but a nurse crop must be used to provide initial erosion control. The best planting months are March through July.

Weeping lovegrass seeds often germinate and become established under drier conditions than most other cultivated grasses, and it is quite drought-resistant.

It is a bunch grass, forming distinct clumps that spread very little. This makes perfect stands essential, otherwise erosion between clumps may become serious. Further, this species is usually rather short-lived in North Carolina. Lovegrass is sometimes mixed with sericea lespedeza, which fills in between the clumps and persists after the weeping lovegrass declines. However, it can be too competitive as a nurse crop. Where permanent cover is desired, it is usually best to start with species that provide more complete cover of a more permanent nature.

Weeping lovegrass is not recommended because its clumping growth habit and lack of persistence reduce its value for erosion control under North Carolina conditions.

Perennial Legumes

Crownvetch is a deep-rooted, perennial legume with spreading rootstocks, adapted to the Mountain region and to the cool slopes (north and east exposures) in the Piedmont. It is useful on steep slopes and rocky areas that are likely to be left unmowed. Crownvetch requires a specific *Rhizobium* inoculant, which may have to be obtained by special order. It can be seeded in the spring or fall. Crownvetch does not respond well to mowing.

Sericea lespedeza is a deep-rooted, drought-resistant perennial legume, adapted to all but the poorly drained soils of the state. It is long-lived, tolerant of low-fertility soils, and pest free, and it fixes nitrogen. It can be a valuable component in most low-maintenance mixtures. Sericea is a slow starter and should not be expected to contribute much to prevention of soil erosion the first year; however, it strengthens rapidly and persists indefinitely on suitable sites. Seedings that include sericea require mulch and should include nurse plants such as German millet, Sudangrass, or annual lespedeza. "Scarified," or roughened, seed should be used for spring seeding of sericea because it germinates more readily. Unscarified seed is recommended for fall-seed mixtures because many of the seeds will lie dormant over winter and germinate early the next spring.

Sericea does not tolerate frequent mowing and may be considered unsightly because the old top growth breaks down slowly.

Coastal Dune Vegetation

Revegetation of construction sites on the barrier islands of North Carolina requires special attention to selection of plant species. In the foredune area there are only a few plants that tolerate the stresses of the beach environment. They must be able to survive salt spray, sand blasting, burial by sand, saltwater flooding, drought, heat, and low nutrient supply. The species commonly planted in this environment is American beachgrass. Other well-suited plants are sea oats, bitter panicum, and coastal panicgrass. In areas behind the foredune, coastal Bermudagrass has been used effectively for stabilization. In low, moist areas saltmeadow cordgrass may be transplanted.

American beachgrass is a cool-season perennial dune grass. It is the principal species presently planted in North Carolina for dune building and as a stabilizer in the foredune zone. Easy to propagate, it establishes and grows rapidly, and is readily available from commercial nurseries. It is an excellent sand trapper capable of growing upward with 4 ft of accumulating sand in one season. New

plantings are usually effective at trapping wind-blown sand by the middle of the first growing season.

While extremely valuable for initial stabilization and dune building in disturbed areas, this grass has several serious problems under North Carolina conditions. It is a northern species, probably occurring naturally only as far south as Currituck Banks. It is severely affected by heat and drought and tends to deteriorate and die behind frontal dunes as the sand supply declines. Also, it is susceptible to a fungal disease (Marasmius blight) and a soft scale insect (*Eriococcus carolinae*). Consequently, beachgrass plantings should be reinforced by the inclusion of sea oats and bitter panicum. Dead patches should be replanted to sea oats, bitter panicum, or seashore elder. Sea oats and bitter panicum may be planted without beachgrass, but these plants are more expensive.

Figure 3.9 Sea oats.

The selection of adapted strains is important, as the southern limit of adaptation for this species is approached along the North Carolina coast. Hatteras, a North Carolina selection, has been used effectively for many years. Cape is a northern strain that looks good at first but does not persist well here. Bogue is a more recent selection, better than Cape but not as thoroughly tested as Hatteras.

Sea oats (Figure 3.9) is the primary native dune builder from Currituck Banks southward to Mexico. It is a warm-season grass, vigorous, drought- and heat-tolerant, and an excellent sand trapper once fully established. The seed heads, borne on 3 to 4 ft stalks, are quite decorative. This plant is much more tolerant of reduced sand and nutrient supply than American beachgrass and may persist in backdune areas indefinitely.

Sea oats is limited in commercial availability. Pot-grown seedlings may be transplanted to the dunes when 12 to 16 inches in height.

Early growth in the dunes is generally slower than American beachgrass, and transplants are not effective in trapping sand the first season. This, and the scarcity of commercial supplies, make planting in pure stands generally impractical. However, on the North Carolina coast enough sea oats plants should be included in American beachgrass plantings to assure a future seed supply if there is not already one nearby. This will provide for gradual replacement as the beachgrass stand weakens.

Bitter panicum is a warm-season, perennial grass occurring on and near sand dunes from New England southward to Mexico. It rarely, if ever, produces viable seed and must be propagated vegetatively. It is also highly palatable to grazing animals. These characteristics probably account for its scarcity on many beaches.

Bitter panicum is most useful for inclusion in American beachgrass plantings to encourage long-term stability. It is relatively pest-free, both under nursery conditions and on the dunes. Commercial supplies are limited, but could be readily expanded to meet demand.

When buried, this grass will root at most nodes. Place runners in trenches, leaving several inches of the tip exposed, or set small plants, as with American beachgrass. Stands respond vigorously to nitrogen fertilization.

Saltmeadow cordgrass is a warm-season perennial useful for transplanting on low areas subject to saltwater flooding. It is a heavy seed producer and is often the first plant on moist sand flats. It collects and accumulates blowing sand, creating an environment suitable for dune plants.

Saltmeadow cordgrass is easy to transplant on moist sites but does not survive on dry dunes. Plants should be dug from young, open stands. Survival of transplants from older, thick stands is poor. Nursery production from seed is relatively easy, and the pot-grown seedlings transplant well. Propagation by seed is possible, but the percentage of viable seed varies.

Intertidal Vegetation

There is often a need to transplant vegetation in the intertidal zone of estuaries to reduce shoreline erosion, to stabilize dredged material, or for mitigation. The concept of mitigation—permitting disturbance of natural marshes in return for establishing new marshes—is receiving attention and has been tested in North Carolina. Such a trade-off may be justified if a small inclusion of marsh in a construction site is a problem. Decisions on permits are made on an individual basis by personnel of the appropriate State and Federal regulatory agencies.

In saltwater areas, smooth cordgrass is transplanted in the intertidal zone from mean sea level to mean high water, and saltmeadow cordgrass from mean high water to the storm tide level. In brackish water areas (10 parts per thousand or less of soluble salts), giant cordgrass may be used in the intertidal zone. Greenhouse-grown seedlings of these plants can be obtained from commercial sources, but usually only on special order. Transplants may also be dug from young, open natural stands in the case of smooth and saltmeadow cordgrass.

Smooth cordgrass is the dominant plant in the regularly flooded intertidal zone of saltwater estuaries along the Atlantic and Gulf Coast of North America. The plant is adapted to anaerobic, saline soils that may be clayey, sandy, or organic. It will tolerate salinities of 35 parts per thousand (ppt) but grows best from 10 to 20 ppt. Plant height varies from 1 to 7 ft depending on environmental conditions and nutrient supply. It produces a dense root and rhizome mat that helps prevent soil movement. Transplants can be obtained by digging from new, open stands of the grass or may be grown from seed in pots. Seed are collected in September and stored, covered with seawater, and refrigerated. The plants and seedlings grow rapidly when transplanted on favorable sites.

Saltmeadow cordgrass is a fine-leaved grass, 1 to 3 ft in height, that grows just above the mean high tide line in regularly flooded marshes, and throughout irregularly flooded marshes. It can be propagated in the same way as smooth cordgrass except that seed may be stored dry under refrigeration. A stand of saltmeadow cordgrass provides good protection from storm wave erosion.

Giant cordgrass grows in brackish, irregularly-flooded areas. Stems are thicker and taller than in the other cordgrasses, growing to a height of 9 to 10 ft. Seed-

lings are easy to produce in pots and these can be successfully transplanted, but survival of plants dug from existing stands is poor.

ESTABLISHING VEGETATION

Topsoiling

The surface layer of an undisturbed soil is often enriched in organic matter and has physical, chemical, and biological properties that make it a desirable planting and growth medium. These qualities are particularly beneficial to seedling establishment. Consequently, **where practical, topsoil should be stripped off prior to construction and stockpiled for use in final revegetation of the site.** Planning such stabilization measures from the beginning of the project may eliminate costly amendments and repair measures later. Topsoiling may not be required for the establishment of less demanding, lower maintenance plants, but it is essential on sites having critically shallow soils or soils with other severe limitations. It is essential for establishing fine turf and ornamentals.

The need for topsoiling should be evaluated, taking into account the amount and quantity of available topsoil and weighing this against the difficulty of preparing a good seedbed on the existing subsoil. Where a limited amount of topsoil is available, it should be reserved for use on the most critical areas. In many cases topsoil has already been eroded away or, as in wooded sites, it may be too trashy.

Site Preparation

The soil on a disturbed site must be modified to provide an optimum environment for germination and growth. Addition of topsoil, soil amendments, and tillage are used to prepare a good seedbed. At planting the soil must be loose enough for water infiltration and root penetration, but firm enough to retain moisture for seedling growth. Tillage generally involves disking, harrowing, raking, or similar method. Lime and fertilizer should be incorporated during tillage.

Soil Amendments

Liming is almost always required on disturbed sites to decrease the acidity (raise pH), reduce exchangeable aluminum, and supply calcium and magnesium. Even on the best soils, some fertilizer is required. Suitable rates and types of soil amendments should be determined through soil tests. Limestone and fertilizer should be applied uniformly during seedbed preparation and mixed well with the top 4 to 6 inches of soil.

Organic amendments, in addition to lime and fertilizer, may improve soil tilth, structure, and water-holding capacity—all of which are highly beneficial to seedlings establishment and growth. Some amendments also provide nutrients. Examples of useful organic amendments include well-rotted sawdust, well-rotted animal manure and bedding, crop residue, peat, and sludge from municipal sewage or industrial waste.

Organic amendments are particularly useful where topsoil is absent, where soils are excessively drained, and where soils are high in clay. The application of several inches of topsoil usually eliminates the need for organic amendments.

Sludge is an inexpensive amendment that can be very beneficial to plant growth, but proper planning and careful management are essential to its use. Sludge adds nutrients, primarily nitrogen and phosphorus, improves soil structure, and increases organic matter. Types of sludge available include municipal sewage, and waste from textile, wood processing, and fermentation industries. Nutrient content of the sludge depends on the source, but is much lower than that of commercial fertilizers. Sewage sludge may be used in reclamation of disturbed sites, **but always check local or State regulations before attempting to use sewage sludge.**

Sludges may sometimes be high in heavy metals such as nickel and cadmium. North Carolina has published guidelines for the use of sludges which must be followed to maximize effectiveness and avoid pollution of streams. Runoff and erosion control are essential where sludge has been applied. Near residential areas odors can also be a problem. Sludge is available in either solid or liquid forms. Solid or semi-solid forms are broadcast on sod or soil and may or may not be incorporated. Liquid sludge is irrigated, broadcast, broadcast and incorporated, or injected directly beneath the surface.

Surface Roughening

A rough surface is especially important to seeding sloped areas. Contour depressions and loose surface soil help retain lime, fertilizer, and seed. A rough surface also reduces runoff velocity and increases infiltration.

Because slopes steeper than 3:1 are not usually mowed, they can be left quite rough by grooving, furrowing, tracking, or stairstep grading (*Practice Standards and Specifications: 6.03, Surface Roughening*). Stairstep grading is particularly helpful where there are large amounts of soft rock, because each step catches material in which vegetation can become established.

Slopes flatter than 3:1, which may be mowed, should be grooved by disking, harrowing, raking, or operating planting equipment on the contour. On gentle slopes with sufficient mulch, this is sufficient to retain seed and soil amendments and promote infiltration. Seed should be broadcast soon after surface roughening, before the surface is sealed by rainfall.

Planting Methods

Seeding is by far the fastest and most economical method that can be used with most species. However, some grasses do not produce seed and must be planted vegetatively. Seedbed preparation, liming, and fertilization are essentially the same regardless of the method chosen.

Seeding

Uniform seed distribution is essential. This is best obtained using a cyclone seeder (hand-held), drop spreader, conventional grain drill, cultipacker seeder, or hydraulic seeder. The grain drill and cultipacker seeders (also called grass seeder packer or Brillion drill) are pulled by a tractor and require a clean, even seedbed.

On steep slopes hydroseeding may be the only effective seeding method. Surface roughening is particularly important when preparing slopes for hydroseed-

ing. In contrast to other seeding methods, a rugged and even trashy seedbed gives the best results.

The "insurance" effect of extra seed has been taken into account in arriving at the rates recommended in this manual. **Rates exceeding those given are not recommended because over-dense stands are more subject to drought and competitive interference.**

Because uniform distribution is difficult to achieve with hand-broadcasting, it should be considered only as a last resort. When hand-broadcasting of seed is necessary, uneven distribution may be minimized by applying half the seed in one direction and the other half at right angles to the first. Small seed should be mixed with sand for better distribution.

A "sod seeder" (no-till planter) is used to restore or repair weak cover. It can be used on moderately stony soils and uneven surfaces. It is designed to penetrate the sod, open narrow slits, and deposit seed with a minimum of surface disturbance. Fertilizer is applied in the same operation.

Inoculation of legumes—Legumes have bacteria, rhizobia, which invade the root hairs and form gall-like "nodules." The host plant supplies carbohydrates to the bacteria, which supply the plant with nitrogen compounds fixed from the atmosphere. A healthy stand of legumes, therefore, does not require nitrogen fertilizer. *Rhizobium* species are host specific—a given species will inoculate some legumes but not others. Successful establishment of legumes, therefore, requires the presence of specific strains of nodule-forming, nitrogen-fixing bacteria on their roots. In areas where a legume has been growing, sufficient bacteria may be present in the soil to inoculate seeded plants, but in other areas the natural *Rhizobium* population may be too low.

In acid subsoil material, if the specific *Rhizobium* is not already present, it must be supplied by mixing it with the seed at planting. Cultures for this purpose are available through seed dealers.

Among the legumes suggested here, crownvetch is the only one generally requiring inoculation under North Carolina conditions. Lespedeza nodule bacteria are widely distributed in the soils of this state.

Sprigging and Plugging

Sprigging refers to planting stem fragments consisting of runners (stolons) or lateral, below-ground stems (rhizomes), which are sold by the bushel. This method can be used with most warm-season grasses and with some ground covers, such as periwinkle. Certain dune and marsh grasses are transplanted using vertical shoots with attached roots or rhizomes. Sprigs can be broadcast or planted in furrows using a tobacco transplanter. Under favorable conditions, the hay-type, hybrid Bermudagrasses will cover-over in one growing season from sprigs spaced on 6-ft centers. Lawn-type plants are usually sprigged much more thickly.

Broadcasting is easier but requires more planting material—3 to 10 bu/1,000 ft^2 for Bermudagrass. Broadcast sprigs must be pressed into the top 1/2 to 1 inch

of soil by hand or with a smooth disk set straight, special planter, cultipacker, or roller.

Plugging differs from sprigging only in the use of plugs cut from established sod, in place of sprigs. It is usually used to introduce a superior grass into an old lawn. It requires more planting stock, but usually produces a complete cover more quickly than sprigging.

Sodding

In sodding, the soil surface is completely covered by laying cut sections of turf. It is practiced in this region with turf-type Bermudas, Kentucky bluegrass, tall fescue, and bluegrass-tall fescue mixtures, and is limited primarily to lawns, steep slopes, and sod waterways. A commercial source of high-quality turf is required and water must be available. Plantings must be wet down immediately after planting, and kept well watered for a week or two thereafter.

Sodding, though quite expensive, is warranted where immediate establishment is required, as in stabilizing drainage ways and steep slopes, or in the establishment of high-quality turf. If properly done, it is the most dependable method and the most flexible in seasonal requirements. Sodding is feasible almost any time the soil is not frozen.

Irrigation

Irrigation, though not generally required, can extend seeding dates into the summer and insure seedling establishment. Damage can be caused by both under- and over-irrigating. If the amount of water applied penetrates only the first few inches of soil, plants may develop shallow root systems that are prone to desiccation. **If supplementary water is used to get seedlings up, it must be continued until plants become firmly established.**

Irrigation requirements depend upon current weather conditions—rainfall, temperature, humidity, etc. A statewide weather forecast including information on planting and growing conditions is available through the North Carolina Agricultural Extension Service by calling "Teletip" (1- 800-662-7301). This can be used to determine day-to-day watering needs.

Mulching

Mulch is essential to the revegetation of most disturbed sites, especially on difficult sites such as southern exposures, channels, and excessively dry soils. The steeper the slope and the poorer the soil, the more valuable it becomes. In addition, mulch fosters seed germination and seedling growth by reducing evaporation, preventing soil crusting, and insulating the soil against rapid temperature changes.

Mulch may also protect surfaces that cannot be seeded. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow. There are a number of organic and a few chemical mulches that may be useful, as well as nets and tacking materials (*Practice Standards and Specifications: 6.14, Mulching).*

Grain straw (wheat, oats, barley, rye) is the most widely used and one of the best mulches. However, there are other materials that work well but may be only

locally available. Mulching materials covered in this manual have their respective advantages and appropriate applications, and a material should not be selected on the basis of cost alone.

MAINTENANCE

Satisfactory stabilization and erosion control requires a complete vegetative cover. Even small breaches in vegetative cover can expand rapidly and, if left unattended, can allow serious soil loss from an otherwise stable surface. A single heavy rain is often sufficient to greatly enlarge bare spots, and the longer repairs are delayed, the more costly they become. Prompt action will keep sediment loss and repair cost down. New seedlings should be inspected frequently and maintenance performed as needed. If rills and gullies develop, they must be filled in, re-seeded, and mulched as soon as possible. Diversions may be needed until new plants take hold (Figure 3.10).

Maintenance requirements extend beyond the seeding phase. Damage to vegetation from disease, insects, traffic, etc., can occur at any time. Herbicides and regular mowing may be needed to control weeds--dusts and sprays may be needed to control insects. Herbicides should be used with care where desirable plants may be killed. **Weak or damaged spots must be relimed, fertilized, mulched, and reseeded as promptly as possible.** Refertilization may be needed to maintain productive stands.

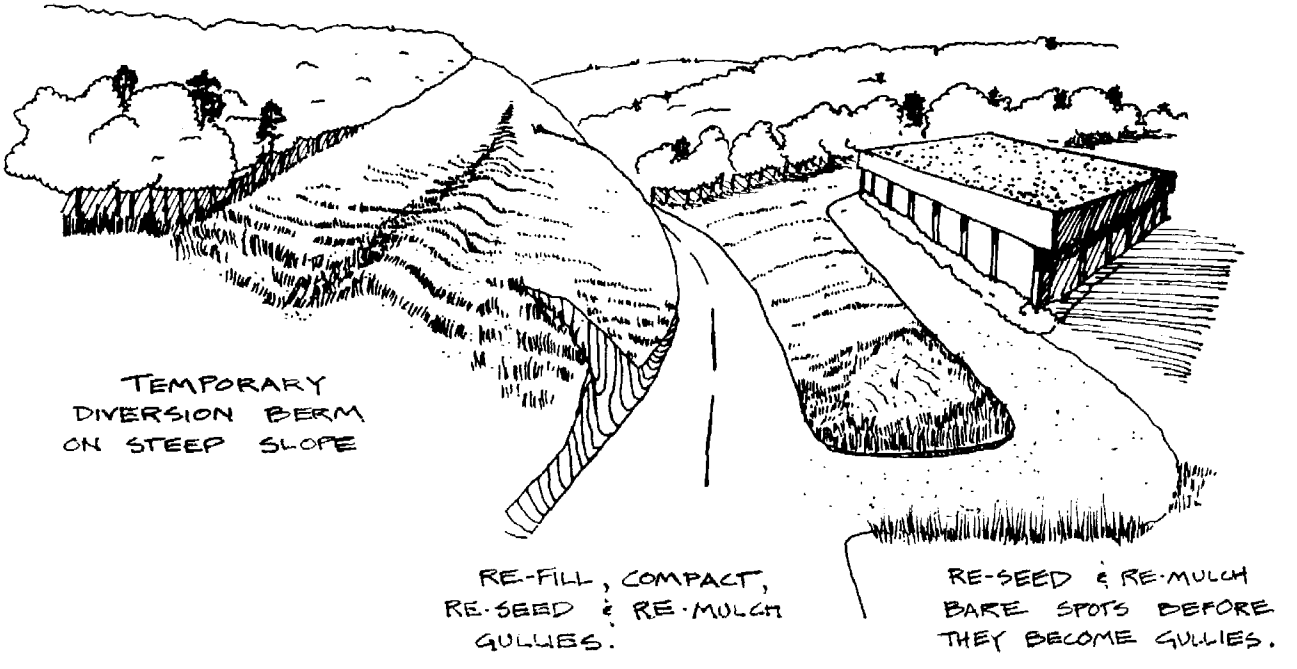


Figure 3.10 Maintenance of vegetative cover.

Vegetation established on disturbed soils often requires additional fertilization. Frequency and amount of fertilization can best be determined through periodic soil testing. Fertilization guidelines are also given in the seeding specifications (*Practice Standards and Specifications: 6.11, Permanent Seeding*). A fertilization program is required for the maintenance of fine turf and sod that is mowed frequently. Maintenance requirements should always be considered when selecting plant species for revegetation.

2) Hydrology and Water Quality

a. The Effects of Urbanization on Water Quality
Source: Minnesota, MN-1

b. Characteristics of Urban Runoff
Source: Minnesota, MN-1

c. Estimating Runoff - Rational Method
Source: North Carolina, NC-1

3) Stormwater Management

a. Urban Stormwater Management
Source: Illinois, IL-1

b. Principles of Stormwater Management
Source: Florida, FL-1

1. THE EFFECTS OF URBANIZATION ON WATER QUALITY

There are two main reasons why urbanization increases pollutant loads in runoff. First of all, the volume and rate of runoff are typically increased as an area is developed, providing a larger capacity to transport pollutants. The second reason is that some materials are typically made more available for loss in runoff as the intensity of the land use increases. The following section describes these hydrologic effects and the pollutants commonly associated with urban watersheds. Although many of the effects discussed here relate to surface water quality, it is important to remember that ground water quality can also be adversely affected by urbanization. The greatest potential for ground water pollution comes from pollutants that are soluble in water, and are not readily trapped or treated by the soil during percolation.

HYDROLOGIC CHANGES

When an undeveloped area changes to support urban land uses, drastic changes in the local hydrology result. As land is covered with roads, buildings, and parking lots, the amount of rainfall that can infiltrate into the soil is reduced. This increases the volume of runoff from the watershed. Figure 1.1 shows the relationship of runoff, infiltration, and evaporation for watersheds with varying degrees of impervious cover. Typical impervious cover percentages are shown in Table 1-1.

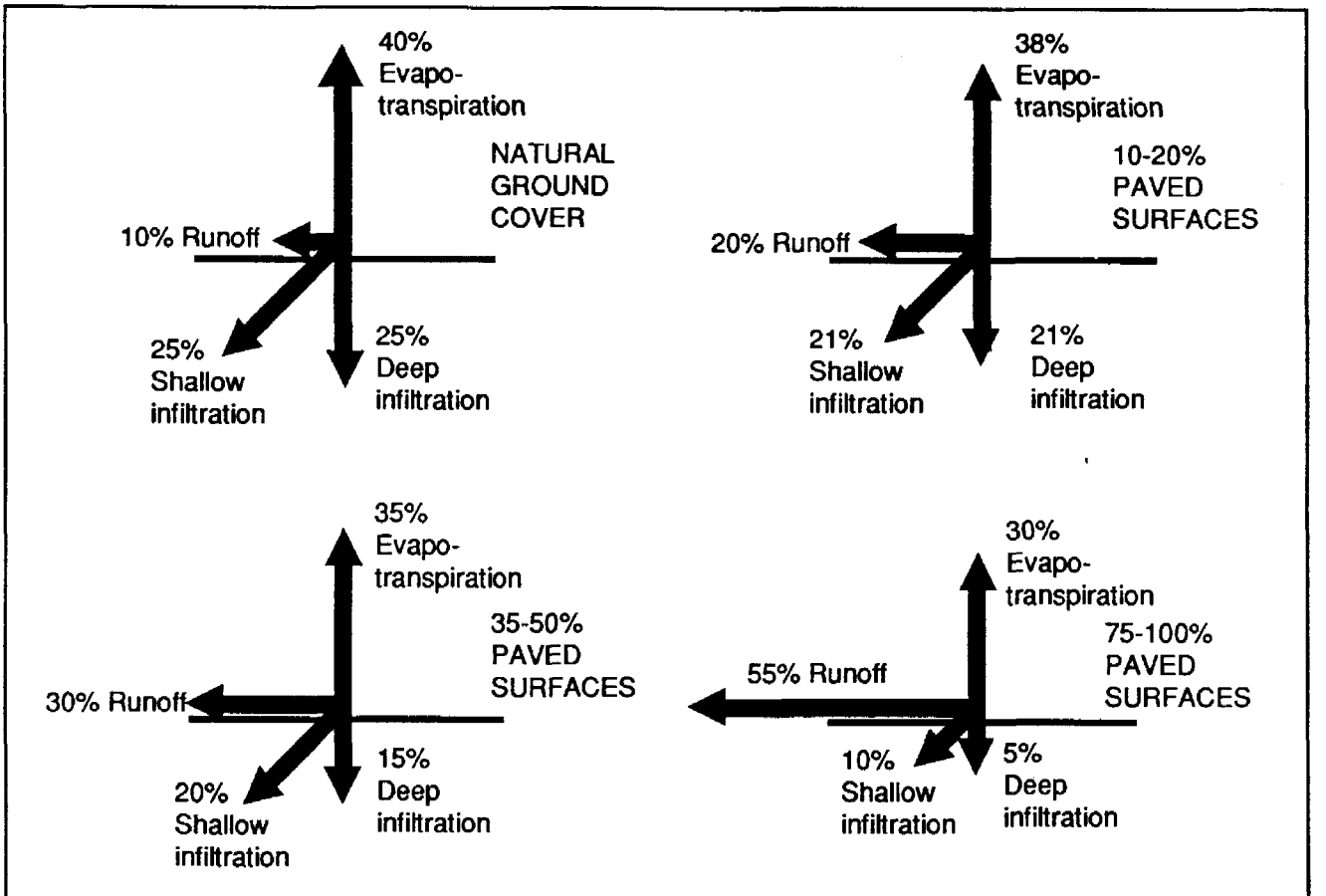


Figure 1-1: Typical changes in runoff flows resulting from paved surfaces

Table 1-1: Typical Impervious Area Percentages

Land Use	% Impervious Cover
Business District or Shopping Center	95-100
Residential, High Density	45-60
Residential, Medium Density	35-45
Residential, Low Density	20-40
Open Areas	0-10

When an urban area is developed, natural drainage patterns are modified as runoff is channeled into road gutters, storm sewers, and paved channels. These modifications increase the velocity of runoff, which decreases the time required to convey it to the mouth of the watershed. This results in higher peak discharges and shorter times to reach peak discharge. Figure 1-2 shows typical pre-development and post-development hydrographs for a watershed that is being developed for urban land uses. The area below the hydrographs represents the volume of runoff. The increased volume of runoff after development is significant because of the increased pollutant loading it can deliver as well as potential flooding and channel erosion problems.

Higher flows can cause flooding and have adverse effects on natural streams. Under natural conditions and at bankfull capacity, studies have shown that streams can handle a flow approximately equal to the 2-year frequency peak discharge (Anderson, 1970; Leopold et al, 1964). After urbanization, increased flows can cause bank-full flow to be exceeded several times each year. In addition to regular flood damage, this condition causes previously stable channels to erode and widen. Much of the material that erodes becomes bed load and can smother benthic organisms. Sediment from streambank erosion eventually settles and silts in streams, rivers, and lakes.

Base flow in streams is also affected by changes in hydrology from urbanization because a large part of base flow is supplied by shallow infiltration. As shallow infiltration is reduced by increased impervious cover, the volume of water available for base flow in streams is reduced. These changes in hydrology, combined with increased pollutant loadings, can have a dramatic effect on the aquatic ecosystem in urban streams. Studies of streams affected by urbanization have shown that fish populations either disappear or are dominated by rough fish that can tolerate a lower level of water quality (Klein, 1979).

URBAN NONPOINT SOURCE POLLUTANTS

The major nonpoint source urban nonpoint source pollutants include sediment, nutrients, trace metals, oxygen-demanding substances, toxic chemicals, bacteria, hydrocarbons and chloride. Each of these pollutants is discussed below.

Sediment

Sediment is made up of tiny soil particles that are washed or blown into lakes and streams. It is considered to be one of the most damaging pollutants in Minnesota, and is the major pollutant by volume in state surface waters.

Sediment fills in road ditches, streams, lakes, rivers, wetlands, and road ditches, and can affect aquatic life by smothering fish larvae and eggs. Suspended soil particles can cause water to look cloudy or turbid. Excessive turbidity reduces light penetration in water, impairs sight feeding fish, clogs fish gills, and increases drinking water treatment costs. Fine sediment also acts as a vehicle to transport other pollutants including nutrients, trace metals, and hydrocarbons to nearby surface waters.

Runoff from construction sites is by far the largest source of sediment in urban areas under development. Average sediment-loading rates from construction sites vary from 36.5 to 1100 tons/acre/year. These rates for construction sites are 5 to 500

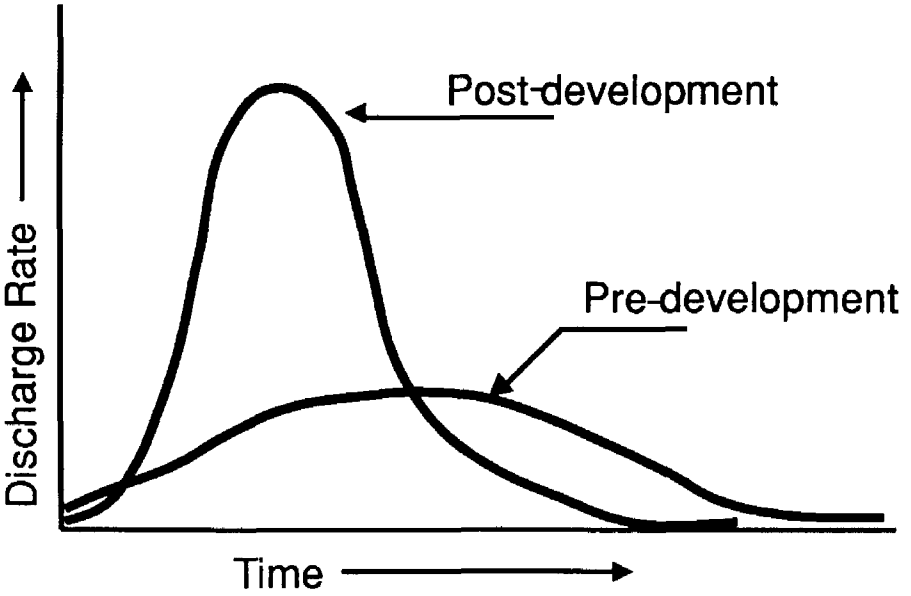


Figure 1-2: Pre- and post-development hydrographs

times greater than those from undeveloped land (USEPA, 1977). Another major source of sediment is streambank erosion, which is accelerated by increases in peak rates and volumes of runoff due to urbanization. In fully developed urban areas, sand that is applied to icy roads can also create a significant sediment load (Oberts, 1986).

Nutrients

In Minnesota, nutrients are a major concern for surface water quality because of the effect they can have on lakes. Nutrients, especially phosphorus and nitrogen, can cause algal blooms and excessive aquatic plant growth in lakes. Of the two, phosphorus is usually the limiting nutrient that controls the growth of algae in lakes. As phosphorus loadings rise, the potential for algal blooms and accelerated lake eutrophication also increases. The ammonium form of nitrogen can also have severe effects on surface water quality. The ammonium is converted to nitrate and nitrite forms of nitrogen in a process called nitrification. This process consumes large amounts of oxygen and can kill fish by lowering dissolved oxygen levels in water. These conditions can impair many important uses of these waters, including recreation, fish habitat, and water supply. Most of complaints received by the Minnesota Pollution Control Agency about lake water quality concern problems that are caused by excessive nutrient levels (Munson, 1988).

The nitrate form of nitrogen is very soluble and is found naturally at low levels in water. When nitrogen fertilizer is applied to lawns or other areas in excess of plant needs, nitrates can leach below the root zone, eventually reaching ground water. Water contaminated with high levels of nitrates presents a clear health hazard to young infants whose formula is prepared with it. Adults can tolerate higher levels of nitrates in drinking water; however, studies suggest that long term use of drinking water with elevated nitrate levels may cause some forms of cancer (Health and Environment Digest, 1988).

In urban areas, major sources of nutrients are organic matter such as lawn clippings and leaves and improper or excessive use of fertilizers. Orthophosphate from auto emissions also contributes phosphorus in areas with heavy automobile traffic (Shelly and Gaboury, 1986). Phosphorus in urban runoff has also been associated with the application of sand and salt on roads (Oberts, 1986).

Trace metals

Trace metals are a water quality concern because of the toxic effects they can have on aquatic life. The most common trace metals found in urban runoff are lead, zinc, and copper (USEPA, 1983). These metals were all found in more than 90 percent of the samples taken as part of the Nationwide Urban Runoff Program (NURP). Chromium, cadmium, and nickel were also detected frequently in the NURP sampling. These metals originate from galvanizing, chrome plating, and other metal sources in urban areas. Fallout from automobile emissions is also a major source of lead in urban areas. Lead and zinc in urban runoff have also been associated with application of road, sand and salt (Richards et al, 1973; Oberts, 1986).

As the metals corrode, dissolve, or settle out of the air, small amounts are carried away by wind or water, and concentrate in urban runoff. The toxicity of trace metals in runoff varies with the hardness of the receiving water. As total hardness of the water increases, the threshold concentration levels for adverse biological effects increases. Many of these metals become attached to fine sediment and are carried with it until the sediment settles out. When these metals settle out, they can accumulate over a period of time to levels that are harmful to aquatic life. Studies have shown that trace metals bioaccumulate in plants and aquatic life in areas where they are contained in sediment (Meiorin, 1986; USFWS, 1988).

Oxygen-demanding substances

While land animals extract oxygen from the air, aquatic life depends on oxygen dissolved in water. When organic matter is consumed by microorganisms, dissolved oxygen is consumed in the process. After it rains, urban runoff can deposit large quantities of oxygen-demanding substances in lakes or streams. The biochemical oxygen demand (BOD) of typical urban runoff is on the same order of magnitude as the effluent from an efficiently run secondary wastewater treatment plant (USEPA, 1983). This can create a pulse of high oxygen demand during storm runoff that can totally deplete oxygen supplies in shallow, slow moving, or poorly flushed waters. Oxygen depletion is a common cause of fish kills. In urban areas, pet wastes, street litter, and organic matter are common sources of oxygen-demanding substances.

Toxic chemicals

As part of the NURP study, residential runoff was sampled to determine the presence of more than 100 organic compounds. The most commonly detected compound was a plasticizer that is used in plastic products. NURP's analyses generally indicated that organic compounds are not normally found in residential runoff. When these chemicals were detected, the concentrations were low. However, there were two instances where the concentrations reached toxic levels. In those cases, one compound was a wood preservative, and the other was a pesticide (USEPA, 1983). This indicates that these materials can result in significant water quality problems if they are not handled and applied properly.

Bacteria

Bacteria levels are most severe in the summer when temperatures are most favorable for their reproduction. The NURP study found that total coliform counts exceeded EPA water quality criteria at almost every site and almost every time it rained (USEPA, 1983). The coliform bacteria that are detected may not be a health risk in themselves, but are often associated with other pathogens. Pet and other animal wastes are common sources of bacteria in urban areas.

Hydrocarbons

Petroleum-derived hydrocarbons are commonly found in urban runoff. These materials initially float on water and create the familiar rainbow-colored film. Hydrocarbons have a strong affinity for sediment and quickly become adsorbed to it. The hydrocarbons are then transported with sediment and settle out with it. Hydrocarbons are a concern

because they are known to be toxic to aquatic organisms at relatively low concentrations (Stenstrom et al, 1984). Common sources of hydrocarbons are spillage at oil storage and fueling facilities, leakage from crankcases, and improper disposal of drain oil (MacKenzie and Hunter, 1979).

Chloride

In Minnesota, a tremendous amount of salt is used each year to melt ice from roads, parking lots, and sidewalks. Because it is extremely soluble, almost all salt applied ends up in surface or ground water (Pitt, 1985). If the concentration of chloride becomes too high, it can be toxic to many freshwater organisms.

Normal application of salt to roads for de-icing is unlikely to create toxic conditions due to elevated chloride levels. However, there have been numerous documented cases of surface and ground water contamination caused by runoff from inadequately protected stockpiles of salt and sand-salt mixtures.

THE POLLUTANT DELIVERY PROCESS

Understanding the pollutant delivery process is fundamental to nonpoint source pollution control. There are three steps to the delivery process--availability, detachment, and transport. Most substances must go through this entire chain before they can become pollutants. Breaking this chain at any step will prevent a substance from being delivered to receiving waters. Some pollutants are more readily controlled at a particular step in the delivery process. A basic understanding of this process and the characteristics of the pollutants in question helps to target BMPs so they prevent delivery most effectively.

Availability

Obviously, a material must be available before it can become a potential pollutant. The quantity of a material in the environment and its characteristics determine the degree of availability. In an urban environment, the quantity of certain pollutants in the environment is a function of the intensity of the land use.

For instance, a high density of automobile traffic makes a number of potential pollutants, such as lead and hydrocarbons more available. Control methods such as street sweeping. which would reduce the availability of these pollutants, have been studied as part of NURP. The NURP studies concluded that street sweeping was ineffective for controlling very fine pollutants such as those associated with automobile traffic (USEPA, 1983). From a water quality BMP standpoint, these materials are best controlled later in the delivery process (Schaefer and Hey, 1983).

The availability of a material such as fertilizer is a function of the quantity and the manner in which it is applied. Applying fertilizer in quantities that exceed plant needs leaves the excess nutrients available for loss to surface or ground water. Reducing the availability of fertilizers through reduced use and proper application is the best way to control nonpoint source pollution from these materials.

Detachment

Detachment is the process in which materials are dislodged from their original location and become mobile. The detachment process can either be physical or chemical. Most physical detachment is the result of raindrop impact or overland flow. Chemical detachment involves dissolving soluble materials or ion exchange processes.

Control of pollutant delivery in the detachment phase is most practical for materials such as sediment when erosion control practices are used to prevent the detachment of soil particles. Once soil particles are detached, coarser particles can be trapped effectively by sediment control practices. However, fine soil particles are not readily trapped except by detention practices with very long detention times.

Transport

Transport is the final phase of the delivery process. Transport involves moving a material from its point of detachment to a receiving water. In urban areas, a large part of the runoff is transported to receiving waters over impermeable surfaces such as streets or in storm sewers. This results in very efficient transport of pollutants to receiving waters once they are detached.

For many urban nonpoint source pollutants, especially those associated with sediment, interrupting transport is the most practical way to prevent their delivery to receiving waters. Detention or infiltration practices can be effective for interrupting transport of many pollutants.

2. CHARACTERISTICS OF URBAN RUNOFF

GENERAL CHARACTERISTICS

A thorough understanding of the characteristics of urban runoff is needed to select BMPs to meet a water quality goal. For many situations in Minnesota, estimates of annual pollutant loadings or concentrations in runoff can be used to evaluate these characteristics. These estimates provide an indication of long-term effects on water quality such as nutrient loading to lakes, and trace metal build-up in sediments.

Table 2-1: Mean Pollutant Concentrations (mg/l)

Pollutant	Land Use			
	Residential	Mixed	Commercial	Open/ non-urban
COD	83	75	61	51
TSS	140	101	90	216
Pb	0.18	0.19	0.13	0.054
Zn	0.18	0.19	0.33	0.23
TKN	2.35	1.44	1.40	1.36
N/N	0.96	0.67	0.63	0.73
Total P	0.46	0.33	0.24	0.23
Soluble P	0.16	0.07	0.098	0.06

COD=chemical oxygen demand
TSS=total suspended solids
TKN=total Kjeldahl nitrogen
N/N=nitrate nitrogen

Source: Computed from USEPA, 1983, Table 6-12.

In other situations, the short-term effects on water quality may need to be considered. These effects are important when evaluating pollutants such as trace metals and oxygen-demanding substances, which can kill aquatic life through toxicity or oxygen depletion. The methodology used for evaluating these short-term effects is different from that used for annual loadings, and these two methods will be discussed separately.

The Nationwide Urban Runoff Program (NURP) sampled and studied urban runoff on a large scale throughout the United States. The final report of this study presented the results of statistical analysis of that data (USEPA, 1983).

One component of the NURP study involved the evaluation of the data based upon geographic location. The study did not show any distinct patterns in the data that could be attributed to geographic location. NURP concluded that individual site differences are far more significant than geographic differences for urban pollutant concentrations. This is important to remember when determining how transferable the data is from one location to another.

NURP also evaluated the impact of different land uses on urban runoff characteristics. Because of the variability of the data, they concluded that except for the open/non-urban land use, differences in pollutant concentrations were not statistically significant. In addition to this, the NURP data concluded that urban pollutant concentrations could not be correlated statistically with either storm runoff volume or storm intensity for most sites. The mean concentrations from the NURP study are included in Table 2-1.

The mean values for various land uses are shown even though the differences were not statistically significant. When estimating pollutant concentrations, the use of local water quality monitoring data for a watershed is preferable to

using NURP data. In the event that local data is not available, values from NURP can be used for a rough estimate of pollutant export from urban areas.

Some local data is available from a study that is based upon a smaller data set than NURP. During this study, the United States Geologic Survey and the Metropolitan Council collected water quality data from 19 monitoring sites in the Twin Cities area (USGS, 1982). This data shows considerable differences in pollutant loadings, which vary according to watershed land use characteristics. To provide a basis for judgment about local loadings, mean pollutant concentrations from four of these sites are included in Table 2-2. The characteristics of these watersheds are described in Table 2-3.

Table 2-2: Flow-Weighted Mean Pollutant Concentrations (mg/l) And Ranges

	Monitoring Site				
Pollutant	Yates	Iverson	Sandburg	Elm	
COD	90	38	138	65	mean
	24-879	1-597	10-850	45-157	range
TSS	133	740	337	10	mean
	2-758	17-26,610	7-4388	2-374	range
Pb	0.23	0.02	0.19	0.005	mean
	0.015-1.8	0.008-0.31	0.003-1.5	0.001-0.012	range
Zn	0.198	0.235	0.185	0.012	mean
	.02-2.2	0.028-0.53	0.02-0.81	0.005-0.019	range
TKN	3.6	1.2	2.5	2.1	mean
	0.6-28.6	1.0-29.2	0.4-16.0	1.2-5.4	range
N/N	0.79	0.07	0.42	0.27	mean
	0.05-4.5	0.05-2.45	0.05-2.4	0.05-1.35	range
Total P	0.63	0.62	0.63	0.35	mean
	0.10-3.85	0.2-13.1	0.07-4.3	0.11-2.23	range

COD= chemical oxygen demand
TSS= total suspended solids
TKN= total Kjeldahl nitrogen
N/N = nitrate nitrogen

Source: USGS, 1982

In Table 2-2, the range of the data is presented in addition to mean values to illustrate the extreme variability experienced in urban runoff water quality monitoring. It is important to keep this variation in mind when using the mean values. These mean values should always be used with caution and qualified to avoid the impression that they are absolute values. This data is provided to help a planner decide what range in values may be appropriate in a given situation. The Elm Creek data shows typical values for a watershed with a minimal amount of development. The Iverson and Yates data are included to provide a comparison of residential runoff for a stabilized watershed (Yates), and one under development (Iverson). Note the elevated total suspended solids (TSS) levels in the developing watershed. The Sandburg site provides data from an area with a commercial/industrial land use.

When comparing pollutant levels for present and future land uses, it is extremely important to understand the difference between pollutant loadings and concentrations. Tables 2-1 and 2-2 show mean concentrations of pollutants in runoff. In many

Table 2-3: Watershed Characteristics For Monitoring Sites In Table 2-1.

	Monitoring Site			
	Elm Creek	Iverson Avenue	Sandburg Road	Yates Avenue
Major Land Use	Relatively open, less than 25% farmed	Residential area under construction	Light industrial	Medium to high density residential
Drainage Area (square miles)	14.3	0.15	0.12	0.35
Drainage System	Low gradient stream	Curb and gutter with some in-stream wetlands	Curb and gutter	Curb and gutter
Typical Soils	Loamy, well drained soils	Gently sloping loamy soils	Moderately sloped loamy soils	Flat sandy soils

cases, the differences in concentrations for various land uses may not be significant. However, pollutant loadings are a function of both concentration and runoff volume. As an area develops and the percentage of impervious area increases, the volume of runoff can increase drastically. So, if the pollutant concentration stays constant while the volume of runoff triples, the annual pollutant loading will triple, also.

Table 2-4 illustrates typical pollutant export coefficients that have been reported for urban runoff. These export coefficients are expressed in values of pounds per acre, and are based upon assumed runoff volumes. It is apparent that pollutant loadings increase significantly as impervious area increases with development.

Table 2-4: Estimated Annual Pollutant Loadings (Pounds/Acre)

	Land Use		
Pollutant	Residential (R = 0.3)	Commercial (R = 0.8)	Open (R = 0.1)
COD	170	330	35
TSS	285	490	150
Pb	0.37	0.70	0.04
TKN	4.8	7.6	0.92
N/N	2.0	3.4	0.49
Total P	0.94	1.3	0.16
Soluble P	0.33	0.53	0.04

COD = Chemical oxygen demand
TSS = Total suspended solids
TKN = Total Kjeldahl nitrogen
N/N = Nitrate nitrogen
Assumptions: Mean concentrations from Table 2-1
Annual rainfall of 30 inches
Computed with equation 2-4

ESTIMATING ANNUAL POLLUTANT LOADINGS

The procedure presented here gives a planner the flexibility needed to develop a site-specific estimate of pollutant loadings for various conditions. This is a relatively simple procedure; however, the reader should be aware of its limitations. First of all, the results are very dependent upon the mean pollutant concentrations used. As mentioned previously, local monitoring data is the best source of this data for present conditions as long as sufficient data is available. Lacking that, estimates can be made from Tables 2-1 or 2-2, or other appropriate reference. For future conditions, an estimate must always be made based upon mean concentrations from other similar locations.

This procedure uses the product of the estimated annual runoff volume and mean concentrations to estimate annual loading. This is expressed in equation 2-1 and is only intended to provide a rough indication of loadings for an average year.

Mean pollutant concentrations can be converted to annual pollutant loadings with the following simple relationship:

$$L = (C)(V) \qquad \textbf{Eqn 2-1}$$

Where:
L = Annual pollutant loading
C = Mean pollutant concentration
V = Annual volume of runoff

The only factors needed to compute this are the watershed size, annual rainfall, watershed runoff coefficient, mean pollutant concentration, and a conversion factor. The watershed area is normally determined in the very early stages of any planning activity for storm water management considerations. The watershed size can be determined from local data, topographic maps, or field inspection. In urban areas, storm sewer drainage areas must also be checked.

The average annual precipitation for an area can be determined from local rainfall records. Figure 2-1 shows average annual rainfall values for Minnesota. The runoff coefficient (R) is the ratio of average runoff to average rainfall when both are expressed in watershed inches. Driscoll (1983) studied runoff coefficients from NURP data and found them related to watershed imperviousness. An analysis of that data resulted in the following relationship:

$$R = 0.05 + 0.009(I) \qquad \textbf{Eqn 2-2}$$

Where:
R = runoff coefficient (unitless)
I = impervious area in watershed (percent)

Rainfall events that do not produce runoff should not be considered in this equation. In order to be compatible with the rainfall values in Figure 2-1, an adjustment must be made to account for this. Schueler (1987) evaluated rainfall events in the Washington D.C. area and suggested that 10% of the rainfall events resulted in no appreciable runoff. To account for this, R should be reduced by 10%, and can be represented by:

$$R = 0.9\,[0.05 + 0.009(I)] \qquad \textbf{Eqn 2-3}$$

This equation only applies to surface runoff and does not consider base flow. If the site under consideration is large enough so that base flow is involved, that loading should be considered separately using site-specific data for base flow volume and pollutant concentrations.

The mean pollutant concentration is best determined from local monitoring data. Lacking that data, estimates of mean concentrations from the NURP studies or the USGS Twin Cities data can be used. It is important to realize the general nature of this data when it is used in place of site-specific information.

An annual pollutant loading (L) can be computed with this information using the following formula:

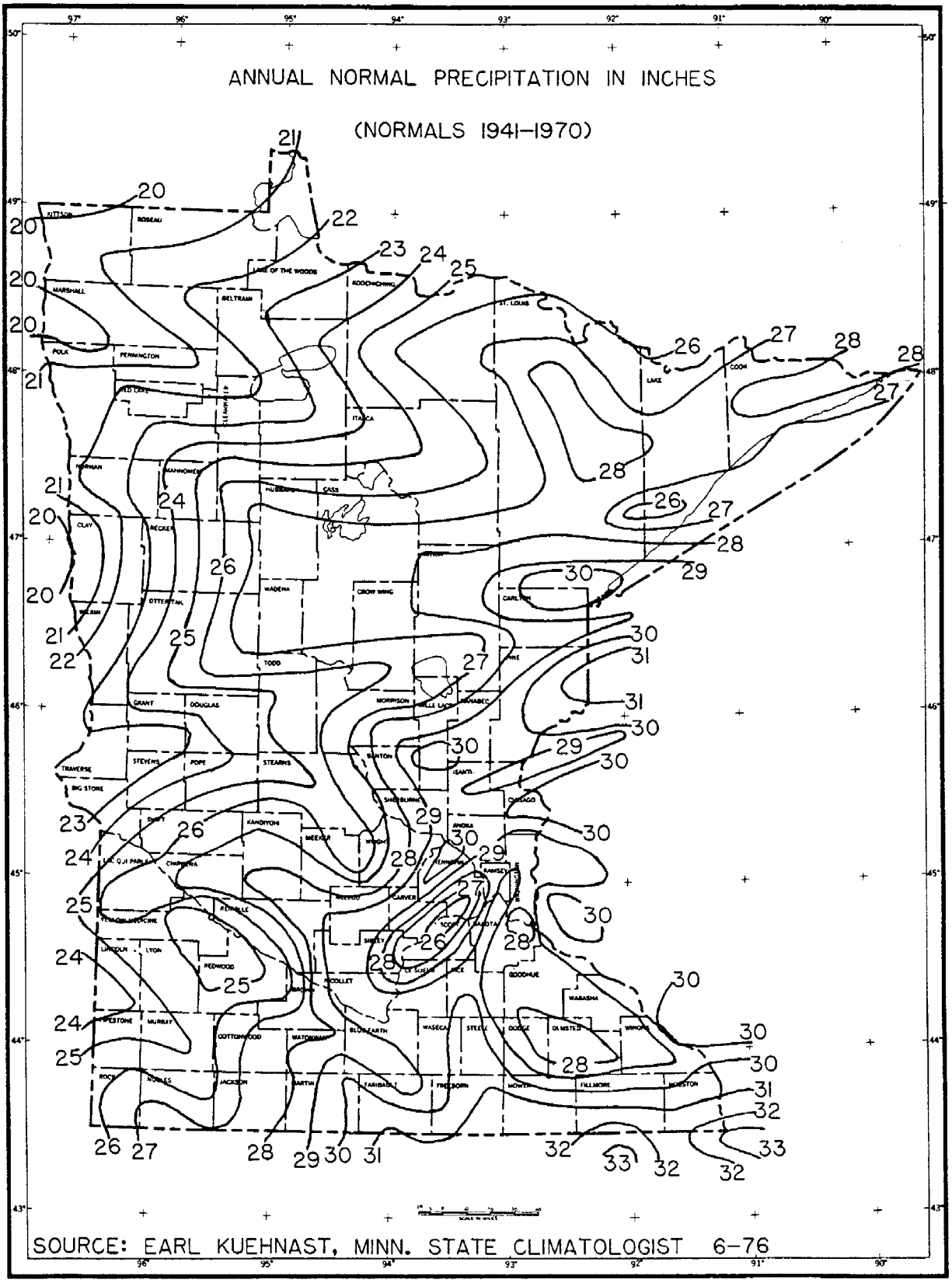


Figure 2-1: Average annual rainfall values in Minnesota

$$L = (A)(P)(R)(C)(0.226) \qquad \textbf{Eqn 2-4}$$

Where:
L = Annual pollutant loading, pounds
A = Watershed area, acres
P = Annual precipitation, inches
R = Runoff coefficient, unitless
C = Mean pollutant concentration, mg/l
0.226 = Conversion factor

This average annual pollutant loading can be useful for estimating changes in pollutant loadings and long-term impacts of urban pollutants on receiving waters such as lakes. It is also a useful tool for comparing the pollutant loadings for pre- and post-development land uses in order to have a basis for BMP selection. Table 2-4 lists some typical annual loadings that are estimated for various land uses.

The Metropolitan Council has developed another procedure for estimating pollutant loadings from urban watersheds. This information is presented in *Surface Water Management, Simplified Modeling for Watersheds* by Gary Oberts.

Example 2-1: Estimating pollutant loadings

A planner wishes to compare the pre-development and post-development pollutant loadings for a proposed commercial development. A detention pond that meets the criteria in this handbook is planned to reduce pollutant loadings as well as to reduce peak discharges from the site. The following procedure is used to evaluate the pollutant loadings:

1. Compile site data:

   Average Annual Rainfall-30 inches (from Figure 2-1)
   Pre-development impervious area-5%
   Post-development impervious area-80%

2. Compute runoff coefficient (R) using equation 2-3:

   Pre-development R = 0.0855
   Post-development R = 0.69

3. Estimate pre-development mean concentrations and compute annual loadings. In this case, monitoring data was not available, so values from Tables 2-1 and 2-2 were used. Equation 2-4 was used to compute annual loadings. Values for C were obtained from Table 2-2, Elm site.

Pollutant	Mean Concentration mg/liter	Annual Loading pounds
COD	65.0	6029.0
Pb	0.005	0.46
Zn	0.012	1.1
Total P	0.35	32.0
TKN	2.1	190.0

4. Estimate post-development mean concentrations and pollutant loadings using the same procedure as above. Values for C were obtained from Table 2-2, Sandburg site.

Pollutant	Mean Concentration (mg/liter)	Annual Loading (pounds)
COD	138.0	103,000
Pb	0.19	140
Zn	0.185	140
Total P	0.63	470
TKN	2.5	1900

5. Estimate post-development loadings after installation of the detention pond.

   Long-term removal efficiencies are based upon the performance data presented in the detention pond practice of this handbook.

Pollutant	Long-term Pollutant Removal (%)	Annual Loading With Pond (Pounds)
COD	95	5200
Pb	97	4.3
Zn	80	28
Total P	70	140
TKN	40	1100

SHORT TERM EFFECTS ON WATER QUALITY

If a planner wishes to assess the short-term effects of urban runoff on streams or rivers, a different method of analysis is more appropriate. An analysis that determines the probability of exceeding certain threshold levels of pollutants will provide a more meaningful representation of in-stream effects. To evaluate water quality in this manner, NURP developed a stochastic procedure for analysis of data. This method relates the median pollutant concentration and the coefficient of variation for the data to arrive at an expected concentration for any frequency of occurrence. This relationship is expressed by Equation 2-5.

$$x = (Cm)(\exp(Z\sqrt{\ln (1+(CV)}\ )) \qquad \textbf{Eqn 2-5}$$

Where:
x = Expected pollutant concentration for specified chance of occurrence
Z = Standard normal probability
Cm = Median pollutant concentration
CV = Coefficient of variation

Equation 2-5 can be used to estimate frequency of occurrence from data with a sufficiently large population set. This formula was used to determine expected concentrations of several pollutants based upon NURP median concentrations. Expected values for a 25, 10, and 1 percent chance of occurrence were computed. These values are summarized in Table 2-5.

To put the trace metal concentrations from Table 2-5 in perspective, toxicity data is reported in Table 2-6. This table lists toxicity criteria developed by EPA for ingestion and significant mortality (USEPA, 1983). The effect that urban runoff trace metal concentrations will have upon a stream or river depends upon factors such as dilution and total hardness of the water. For information on Minnesota water quality standards, contact the Minnesota Pollution Control Agency. As shown in the table, threshold levels for toxicity increase as the total hardness of the water increases. This toxicity data is based upon laboratory studies with the trace metals in the ionic form. Trace metal concentrations reported for urban runoff may contain a certain portion that is not in a toxicologically available form.

The effects of oxygen-demanding substances on a stream or river depend upon several factors. Some of the most important are the oxygen requirements of aquatic organisms that inhabit the water body, and the ability of the system to re-oxygenate itself. In a slow, sluggish or poorly flushed system, oxygen demand from urban runoff can totally deplete the dissolved oxygen supply.

Table 2-5: Pollutant Concentrations (mg/l) In Urban Runoff For Various Chances Of Occurrence

Pollutant	Residential Chance of Occurrence			Mixed Chance of Occurrence			Commercial Chance of Occurrence		
	25%	10%	1%	25%	10%	1%	25%	10%	1%
COD	103	141	241	93	130	228	63	97	199
Pb	0.23	0.34	0.68	0.23	0.42	1.22	0.16	0.23	0.44
Zn	0.22	0.34	0.47	0.25	0.37	0.77	0.41	0.69	1.7

COD= chemical oxygen demand

Computed from median values in USEPA, 1983, Table 6-12.

Table 2-6: Toxic Concentration Levels (mg/l)

Pollutant	Hardness mg/l	Chronic criterion[1]	Maximum criterion[2]
Zinc	50	0.055	0.11
	100	0.099	0.20
	200	0.18	0.36
	300	0.25	0.50
Lead	50	0.0018	0.031
	100	0.0044	0.074
	200	0.011	0.018
	300	0.018	0.30

[1]Chronic criteria protect aquatic life for long-term exposure

[2]Maximum criteria is 1/2 acute value for a sensitive organism. (EPA's final acute value)

Source: Appendix A in MPCA, 1988

8.03 ESTIMATING RUNOFF

Estimating peak rate of runoff, volume of runoff, and soil loss are basic to the design of erosion and sedimentation control facilities.

There are many methods of determining runoff. Two acceptable methods, the rational method and the Soil Conservation Service (SCS) peak discharge method, are described in this section.

The rational method is very simple in concept but relies on considerable judgment and experience to evaluate all factors properly. It is used primarily for small drainage areas (less than 50 acres). The SCS method is more sophisticated hydrologically and offers a more accurate approximation of runoff, particularly for areas larger than 20 acres. Choice of method for small areas depends primarily on the experience of the designer.

Rational Method

The rational formula is:

$$Q = CiA$$

where:

- Q = peak rate of runoff in cubic feet per second (cfs).
- C = runoff coefficient, an empirical coefficient representing the relationship between rainfall rate and runoff rate.
- i = average intensity of rainfall in inches/hour, for a storm duration equal to the time of concentration, Tc.
- Tc = time of concentration, in minutes; the estimated time for runoff to flow from the most remote part of the watershed to the point under consideration. It consists of the total time for overland sheet flow and concentrated flow (channel and/or pipe flow).
- A = drainage area in acres.

The general procedure for determining peak discharge using the rational formula is presented below and illustrated in Sample Problem 8.03a.

Step 1. Determine the drainage area in acres.

Step 2. Determine the runoff coefficient, C, for the type of soil/cover in the drainage area (Table 8.03a).

If the land use and soil cover is homogenous over the drainage area, a C value can be determined directly from Table 8.03a. If there are multiple soil cover conditions, a weighted average must be calculated, or the area may be subdivided.

Step 3. Determine the time of concentration, Tc, for the drainage area (i.e., the time of flow from the most remote point in the basin to the design point, in minutes).

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, ave., 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
Residential:		Heavy soil, flat, 2%	0.13-0.17
Single-family areas	0.30-0.50	Heavy soil, ave., 2-7%	0.18-0.22
Multi units, detached	0.40-0.60	Heavy soil, steep, 7%	0.25-0.35
Multi units, attached	0.60-0.75		
Suburban	0.25-0.40	Agricultural land:	
		Bare packed soil	
Industrial:		Smooth	0.30-0.60
Light areas	0.50-0.80	Rough	0.20-0.50
Heavy areas	0.60-0.90	Cultivated rows	
		Heavy soil no crop	0.30-0.60
Parks, cemeteries	0.10-0.25	Heavy soil with crop	0.20-0.50
		Sandy soil no crop	0.20-0.40
Playgrounds	0.20-0.35	Sandy soil with crop	0.10-0.25
		Pasture	
Railroad yard areas	0.20-0.40	Heavy soil	0.15-0.45
		Sandy soil	0.05-0.25
Unimproved areas	0.10-0.30	Woodlands	0.05-0.25
Streets:			
Asphalt	0.70-0.95		
Concrete	0.80-0.95		
Brick	0.70-0.85		
Drives and walks	0.75-0.85		
Roofs	0.75-0.85		

NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, Tc. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).

Sample Problem 8.03a
Determination of peak runoff rate using the rational method.

$Q = CiA$

Given:

Drainage area:	20 acres
Graded areas:	12 acres
Woodland:	8 acres
Maximum slope length:	400 ft
Average slope:	3%, area bare
Location:	Raleigh, NC

Find:

Peak runoff rate from 10-yr frequency storm

Solution:

(1) Drainage area: 20 acres (given)

(2) Determine runoff coefficient, C.
Calculate Weighted Average

	Area		C from Table 8.03a		
Graded[1]	12	x	0.45	=	5.4
Woodland	8	x	0.15	=	1.2
	20				6.6

$C = 6.6/20 = 0.33$

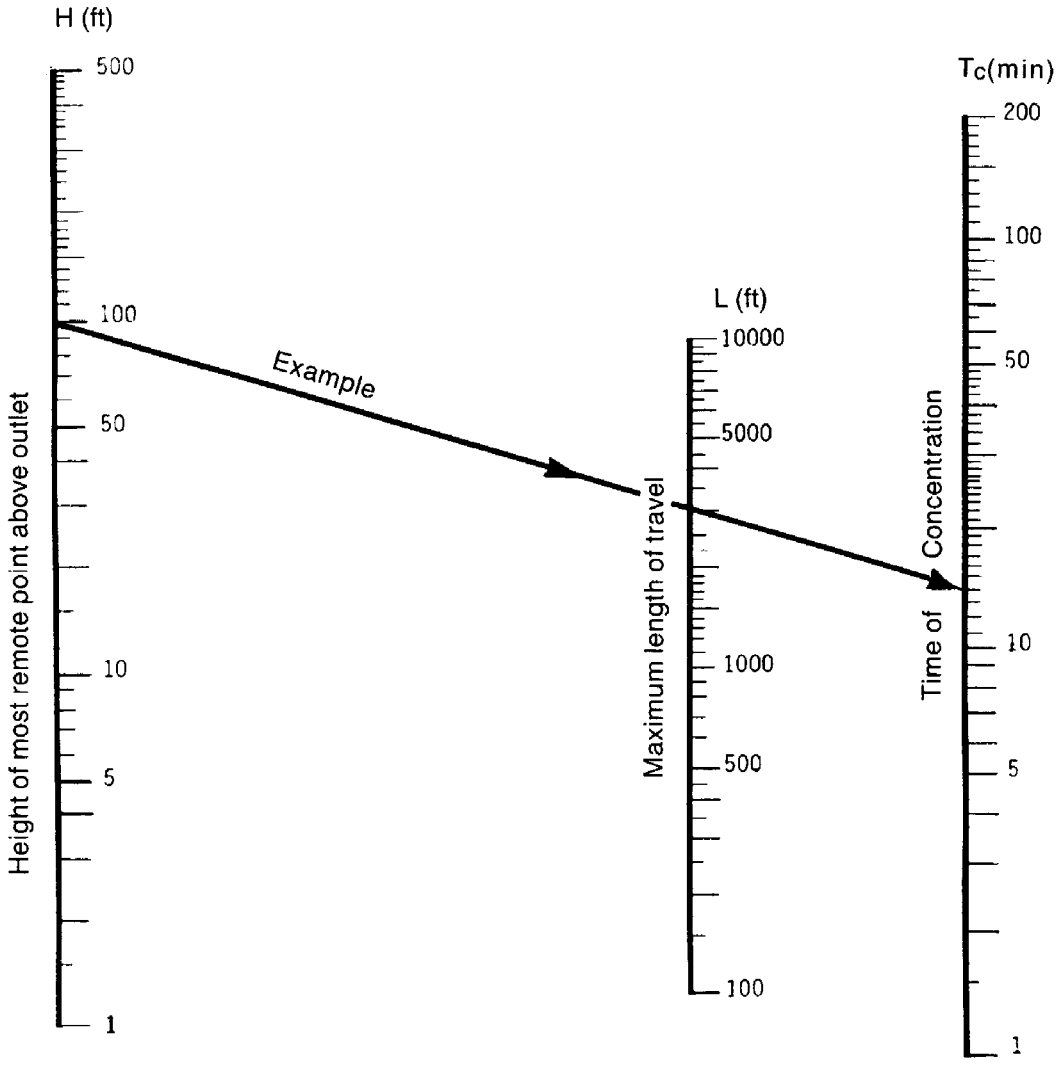
(3) Find the time of concentration, T_C, from Figure 8.03a using maximum length of travel = 400 ft and height of most remote point above outlet = 400 ft x 3% = 12 ft; assume overland flow on bare earth.
T_C = 3.2 minutes.

NOTE: Any time of flow in channel should be added to the overland flow to determine T_C.

(4) Determine the rainfall intensity factor, i.
i = 8.0 inches/hr (from Figure 8.03e) using 5-minute duration

(5) $Q = C(i)(A)$
$Q = 0.33(8.0)(20) = 52.8$ cfs; Use 53 cfs

[1]For graded areas use C value range for smooth, bare packed soil (Table 8.03a).



Note:
Use nomograph T_C for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply T_C by 2.

For overland flow, concrete or asphalt surfaces, multiply T_C by 0.4.

For concrete channels, multiply T_C by 0.2.

Figure 8.03a Time of concentration of small drainage basins.

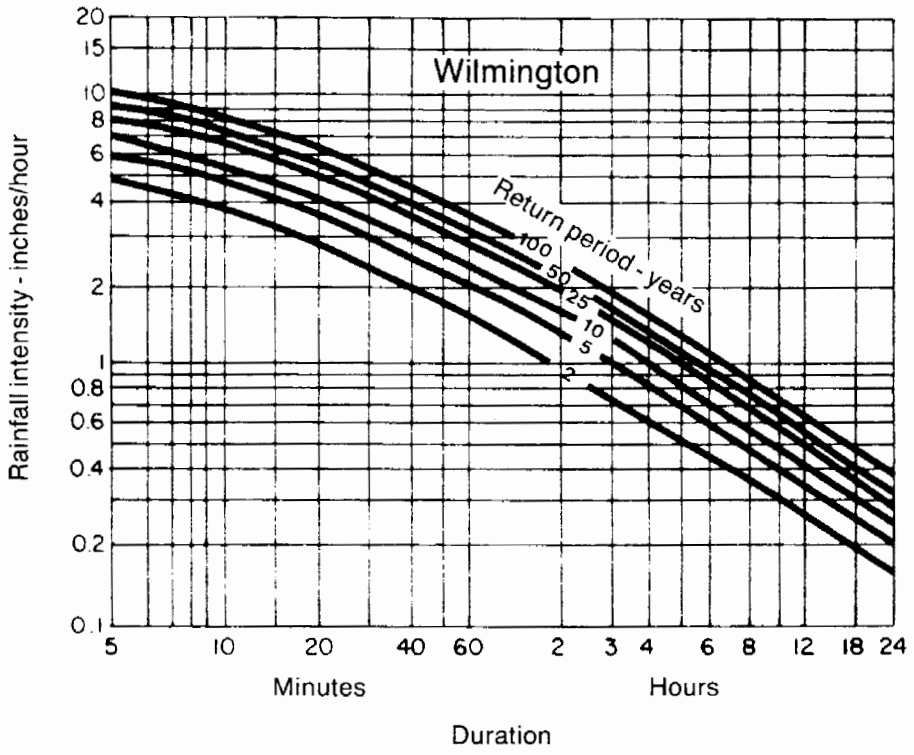


Figure 8.03b Rainfall intensity duration curves—Wilmington.

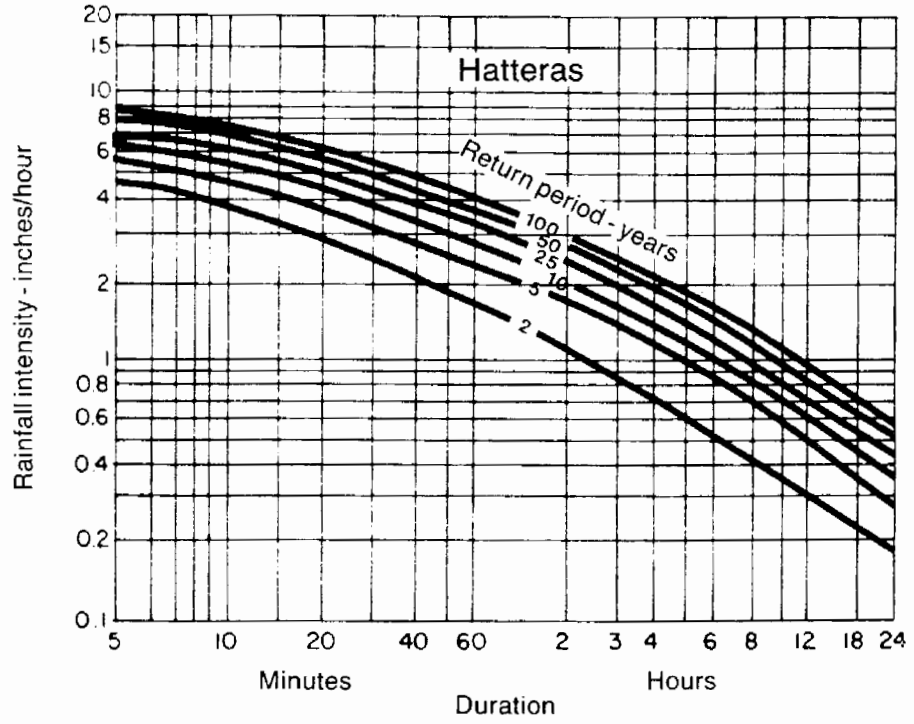


Figure 8.03c Rainfall intensity duration curves—Hatteras.

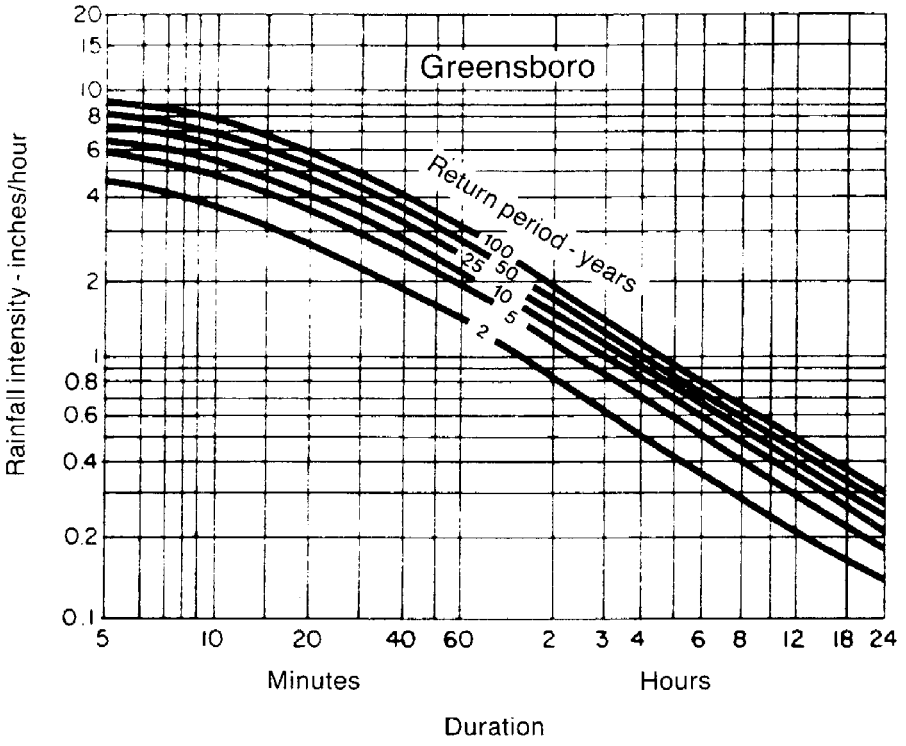


Figure 8.03d Rainfall intensity duration curves—Greensboro.

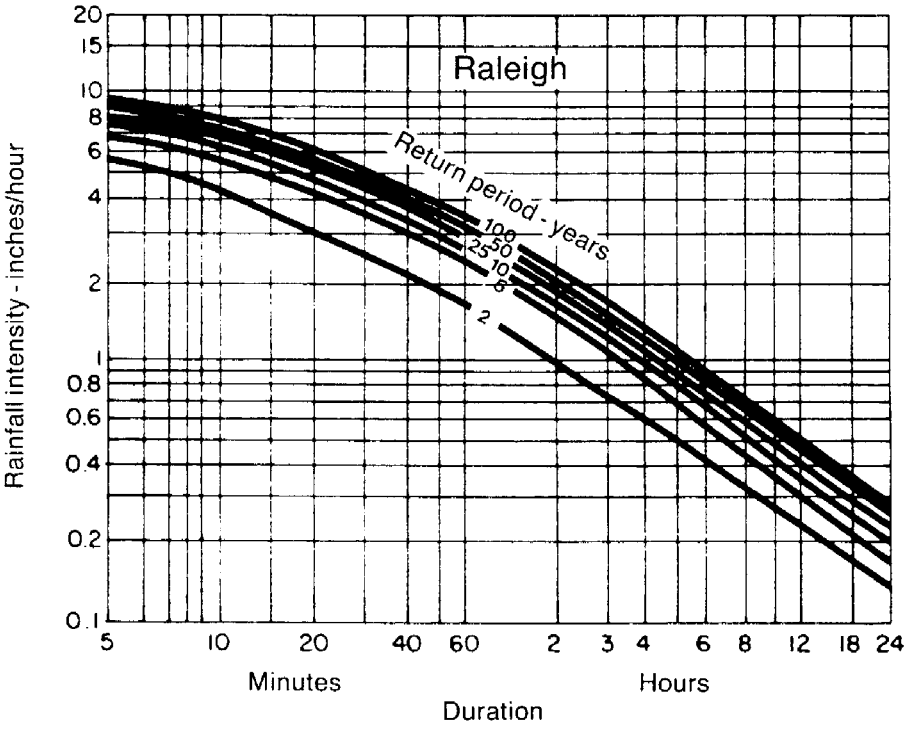


Figure 8.03e Rainfall intensity duration curves—Raleigh.

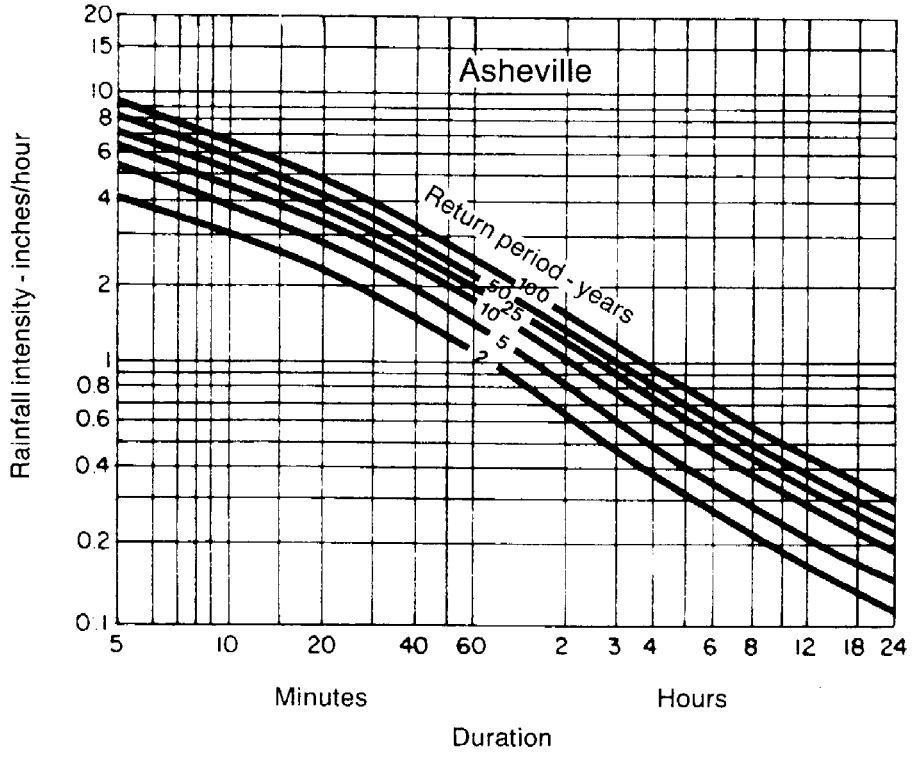


Figure 8.03f Rainfall intensity duration curves—Asheville.

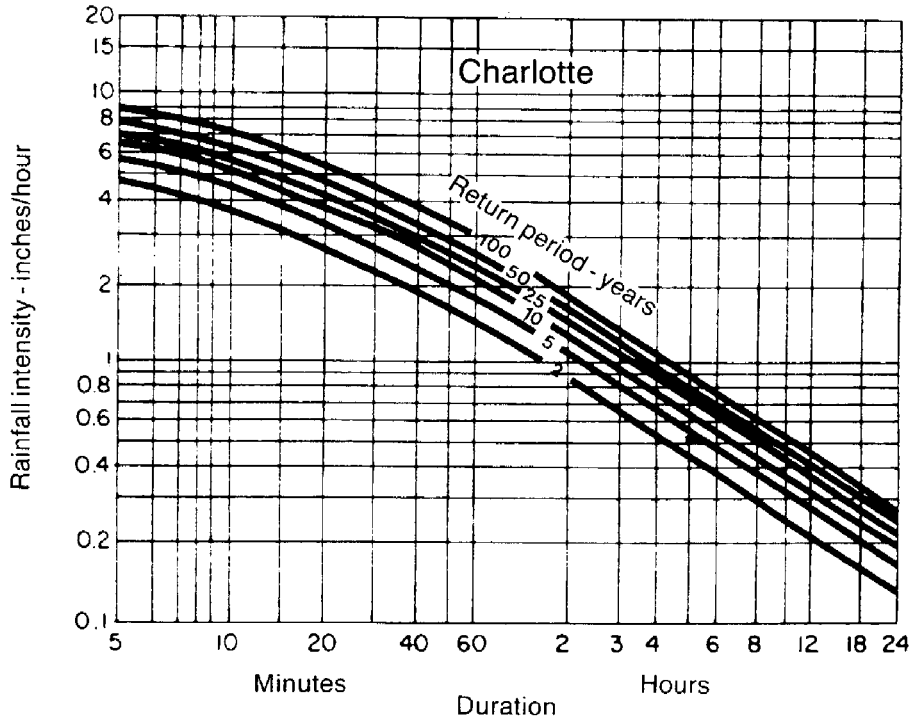


Figure 8.03g Rainfall intensity duration curves—Charlotte.

SCS Peak Discharge Method

The peak discharge method of calculating runoff was developed by the USDA Soil Conservation Service and is contained in SCS Technical Release No. 55 (TR-55) entitled Urban Hydrology for Small Watersheds. This method of runoff calculation yields a total runoff volume as well as a peak discharge. Use of the SCS method is illustrated in Sample Problem 8.03b and in *Chapter 7, Sample Erosion and Sedimentation Control Plan.*

Step 1. Measure the drainage area (in acres); the hydraulic length (distance from most remote point to design point, in feet); and the average slope (percent) of the watershed.

Step 2. Calculate a curve number, CN, for the drainage area.

The curve number, CN, is an empirical value, which establishes a relationship between rainfall and runoff based upon characteristics of the drainage area. Table 8.03b contains CN values for different land uses, cover conditions, and hydrologic soil groups. Hydrologic group assignments for most common soils in North Carolina are given in *Appendix 8.01*. If the soil name is not known, judge the soils based on the group description below:

- **Soil Group A**—Represents soil having a low runoff potential due to high infiltration rates. These soils consist primarily of deep, well-drained sands and gravels.
- **Soil Group B**—Represents soils having a moderately low runoff potential due to moderate infiltration rates. These soils consist primarily of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse textures.
- **Soil Group C**—Represents soils having a moderately high runoff potential due to slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water, or soils with moderately fine to fine texture.
- **Soil Group D**—Represents soils having a high runoff potential due to very slow infiltration rates. These soils consist primarily of soils with high water tables, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

If the watershed is homogeneous (i.e., uniform land use and soils) the CN value can be determined directly from Table 8.03b. Curve numbers for nonhomogeneous watersheds may be determined by dividing the watershed into homogeneous subareas and computing a weighted average.

Step 3. Select design storm and determine runoff depth and volume for erosion and sediment control using the 10-yr, 24-hr storm.

a. Determine rainfall amount, in inches, from Figures 8.03h through 8.03m for the selected design storm. (The design storm is based on an SCS Type II, 24-hr rainfall distribution.)

7

urban stormwater management

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1. PLANNING STORMWATER MANAGEMENT

As rural areas become urbanized, the resulting increases in peak discharges can adversely affect downstream flood plains. Increasingly, planners, developers, and the public want these downstream areas to be protected. Many local governments are adopting ordinances to control the type of development and its allowable impacts on the watershed. One of the most common controls requires that post-development peak discharges do not exceed present condition peak discharges for one or more storm frequencies at specified points along a channel. Urbanization will increase runoff volumes even when controls are installed to limit past development peak discharges.

This chapter discusses ways to manage peak discharges by delaying runoff. It also presents a procedure for estimating the storage capacity required to maintain the peaks within a specified level.

Efforts to reduce the effects of increased runoff from urban areas have been innovative and diverse. Many methods have been used effectively, such as infiltration trenches, porous pavement, rooftop storage, and cisterns. But these solutions can be expensive or require site conditions that cannot be provided.

The detention basin is the most widely used measure for controlling peak discharge. It can be designed to fit a wide variety of sites and can accommodate multiple-outlet spillways to meet requirements for multi-frequency control of flow. Measures other than a detention basin may be preferred in some locations. Any device selected, however, should be assessed as to its cost, function, maintenance needs and impact. Most stormwater management systems do not reduce the volume of runoff. The effects of measures such as detention basins can be easily identified when they discharge to small drainageways. However as drainage basins become larger, it is much more difficult to determine effects of an individual detention basin. Due to the timing of basin discharges some basins may have little or no impact on reducing flood flows.

It is recommended that stormwater management systems be analyzed on a watershed basis using a detailed hydrology-hydraulic model.

EFFECTS OF URBAN DEVELOPMENT

An urban or urbanizing watershed is one in which impervious surfaces cover or will soon cover a considerable area. Impervious surfaces include roads, sidewalks, parking lots, and buildings. Natural flow paths in the watershed may be replaced or supplemented by paved gutters, storm sewers, or other elements of artificial drainage.

Hydrologic studies to determine runoff and peak discharge should ideally be based on long-term stationary streamflow records for the area. Such records are seldom available for small drainage areas. Even when they are available, accurate statistical analysis of them is usually impossible because of the conversion of land to urban uses during the period of record. It therefore is necessary to estimate peak discharges with hydrologic models based on measurable watershed characteristics. Only through an understanding of these characteristics and experience in using these models can we make sound judgments on how to alter model parameters to reflect changing watershed conditions.

Urbanization changes a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff. Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, cover type, impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces.

Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of the development, the effect of any flood control works, or other natural or manmade storage, and the time distribution of rainfall during a given storm event.

RUNOFF RATES: BEFORE AND AFTER DEVELOPMENT

Comparisons of runoff rates prior to and following land development are described generally in Figure 7-1. Undesirable hydrologic products of development illustrated by Figure 7-1 are increased flow velocities and stages in downstream channels and pipe networks, often producing or compounding stormwater impacts in downstream areas, such as flooding, erosion, sedimentation, and pollution of receiving waters.

BENEFITS OF STORAGE

Temporarily storing or detaining excess stormwater runoff and then releasing it at a regulated rate is a fundamental principle in stormwater management. Using this approach, runoff is stored in constructed or natural basins from which it is released continually until the water elevation in the facility reaches its design dry-weather stage. Maximum discharge rates and outflow velocities should be regulated to conform to the capacities and physical characteristics of downstream drainage systems, both constructed and natural. Some of the captured water may be retained for aesthetic reasons, consumption, or other uses. A part of the retained volume may never be discharged to a natural watercourse, but it may be consumed by plants, or dispersed through evaporation or ground water recharge.

In areas having appreciable topographic relief, storage is extremely useful in lessening the high kinetic energy of surface runoff. Energy dissipation and flow attenuation can reduce soil erosion and the amounts of pollutants of various kinds that are assimilated and/or transported by urban runoff from ground, pavement, and other surface areas. While in storage, the pollutant concentrations in runoff will often be somewhat reduced through natural processes such as sedimentation, flotation, and oxidation. Before release, the stored runoff may be given special treatment as may be necessary or practical. By means of controlling release flows, the impacts of the pollutant loading of stored runoff on receiving water quality can be minimized.

Where existing combined sewers are used to transport stormwater runoff, the use of upstream off-line flow stabilization storage can relieve the peak loading on these sewers and treatment plants. This can reduce sewage overflows and backups and the pollution and flooding of basements, streets, land and bodies of water. Where storm sewers are used to convey runoff, a system of properly designed detention facilities can also be effective in

reducing pollution and flooding from stormwater discharges. In areas of flat terrain where hydraulic gradients are small, detention of runoff can be an important factor in reducing local flooding and in minimizing drainage channel sizes, storm sewer pipe diameters, and associated costs.

Stormwater detention facilities cause a distinct reduction of runoff flows. Much of the suspended solids transported by runoff can settle out in the facility. Thus sediments can be trapped before the flow enters the main drainage system and causes siltation in downstream channels and land areas.

The use of on-site detention facilities may be dictated by governmental ordinances or may be chosen by land developers, at their own discretion, as a means of reducing outfall drainage system construction costs. Sometimes detention ponds are built to form the core of grassed storage areas which may be used to store stormwater, commonly called blue-green areas in open space developments, parks, and other planned urban developments. Regardless of the type or reason for detention facilities, if they are carefully designed, built, operated and maintained, the result is attenuation of peak runoff flows.

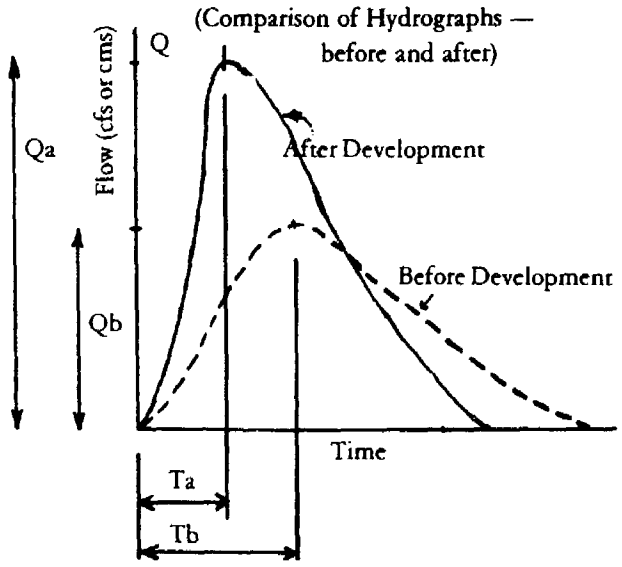


Figure 7-1
RUNOFF HYDROGRAPHS SHOWING EFFECTS OF URBANIZATION

THE STORAGE CONCEPT

The principle of detention storage of excess runoff is illustrated by Figure 7-2. A hydrograph of uncontrolled runoff produced by a rainfall event over a land area is represented by the solid line. The maximum ordinate depicts a peak flow that may exceed the design discharge capacity of the downstream conveyance system, possibly producing excessively high stages in open channels downstream and/or surcharging of downstream sewers. The total volume of runoff is represented by the area between the curve and the (horizontal) time axis.

One means of mitigating downstream problems and damages is to spread the runoff event over a longer time period, thereby reducing the peak rates of flow into the downstream system. This is accomplished by means of a temporary storage of a portion of the runoff upstream from areas subject to flooding. The hydrograph discussed above then becomes an inflow hydrograph to the storage facility.

The lower curve (shown as a broken line in Figure 7-2) is intended to portray an acceptable hydrograph of the same runoff, immediately downstream of the storage facility. The area between this curve and the time axis represents the same volume of runoff as does the solid line. The difference between these curves is in their shapes, i.e., the flow rates of the outflow hydrograph have been reduced, and the total time period for the entire event has been increased.

The area between the curves to the left of their intersection represents the volume of stored runoff, and the difference between the ordinates at a specific time is the rate at which runoff is entering storage. Similarly, the difference in the ordinates to the right of the intersection represents the rate at which stored runoff is being drained from storage. Assuming that infiltration and evaporation are not significant, these two volumes must be equal.

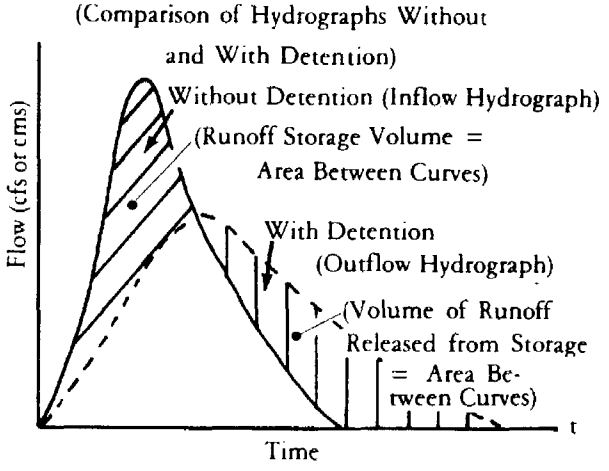


FIGURE 7-2
CONCEPT OF STORMWATER DETENTION

ON-SITE DETENTION

On-site detention of stormwater generally refers to storage, on a land development site, of excess runoff prior to its entry into a principal drainage system. Inflow to the storage facility is accompanied by controlled release of the stored runoff during inflow and after runoff has stopped. In some applications, the runoff may first be conducted short distances by collector sewers located on or adjacent to the site of the detention facility. Since collection sewers are usually designed for a low frequency storm, provisions must be made to allow for overland flow to occur without damage when the sewers overload. On-site detention facilities are often located in the upper and middle areas of a drainage basin. Usually storage capacities need not be as large as those of floodwater reservoirs sometimes constructed in downstream areas.

ALTERNATIVE MEANS OF STORING EXCESS RUNOFF

There are three principal places to store runoff:

1. at ground level - in ponds, basins, infiltration pits, and on paved areas such as parking lots, walkways, and street surfaces

2. underground - in oversized drains and sewers, caverns or tanks, dry wells, and within porous rock strata (recharge)

3. above ground - on rooftops

Some of the means of providing detention are single purpose, for runoff control; however, many other methods are multiple purpose. The latter are often the most favored, better accepted, and most feasible from a financing standpoint. Descriptions and discussions of both single purpose and multiple purpose facilities are given here. The opportunities and constraints associated with various detention methods and types of facilities are identified.

ON-SITE ON-STREAM AND OFF-STREAM FACILITIES

The advantages and disadvantages of detention facilities are largely dependent upon the location of the facilities - other on-site, on-stream, or off-stream. Advantages and disadvantages are identified here for each type.

ON-SITE DETENTION FACILITIES

Potential advantages

* attacks or prevents problems at their sources, permits small areas for detention sites to be feasible.

* permits construction cost of stormwater transport system to be less

* can permit ponds to serve as urban wildlife habitats

* may provide recreation opportunities, improves esthetics (if properly maintained)

* protects areas along entire length of drainage system from new stormwater problems and prevents compounding existing problems

* offers choice of methods (rooftop, parking lot, ground surface)

* can sometimes be incorporated into other local programs (parks) i.e., a good use of required open space

Potential Disadvantages

* may require use of expensive, desirable building sites

* may result in a proliferation of randomly located detention facilities

* may be hard to maintain if facilities are scattered

* may cause environmental detriments and safety hazards to develop when maintenance is insufficient

* could increase flows in remote downstream areas if upstream facilities are randomly located

ON-STREAM DETENTION

Potential Advantages

* may lessen runoff from short duration rainstorms satisfactorily

Potential Disadvantages

* is not a substitute for on-site detention - unless the volume of storage provided also allows for contributions from all tributary upstream areas

* long duration rainstorms may produce a condition in which inflow and outflow are comparable in magnitude, and the water level (stage) stabilizes. The increased in flow caused by urbanization will, therefore, be passed into downstream reaches

* may increase stream stages in upstream areas

* may contribute to surcharging of storm sewers in upstream areas

* will usually pose a downstream hazard

OFF-STREAM DETENTION

Potential Advantages

* adds flexibility to design -- location choices, depth and area alternatives, layout alternatives, hydraulic alternatives

* permits low flows to pass into downstream areas without using valuable storage capacity of the facility

* may hold stored runoff for whatever time period seems necessary and prudent, realizing the need to be prepared for the next runoff event

* enhances opportunities for multiple purpose use

Potential Disadvantages

* may require land that is prohibitively expensive or unavailable

* may generate large operation and/or maintenance expenses

TYPES OF DETENTION FACILITIES

OPEN SPACE AND GRASSED AREA DETENTION

An excellent opportunity for on-site detention is afforded where open space and grassed areas are provided in a land development to enhance the aesthetic appeal. Minimum grading is desirable to minimize the cost. Installation of stormwater release controls such as weirs, orifices, small diameter pipes, gates and other similar devices are commonly used to accomplish the desired peak-flow attenuation objective. Positive drainage toward the control devices is important to avoid entrapment of water which will cause

swampy conditions, weed growth, and increased maintenance costs. The initial flow through the control structure usually carries floating debris. It is essential that plans provide for the removal of this material to assure optimum operation of the structures.

BLUE-GREEN STORAGE

Incorporation of stormwater storage in urban drainageways traversing roadways is a version of detention ponding that has been identified as the blue-green concept. Most often, the drainageways are designed to utilize the roadway embankments as dams and control structures so that runoff will pond upstream of these points. The structures will normally pass small flows unimpeded, and ponding will be activated when flow rates approaching a control point exceed the pass-through rate used in the hydraulic design. Location and design of blue-green areas should maximize the ponding potential of built-up roadways where storage is needed. Roadway embankments at control points should be stabilized and protected to minimize erosional effects of rainfall and stream flows.

MAJOR STORMWATER DETENTION PONDS

Permanent ponds for detention of excess runoff can be incorporated into surface drainage systems. Such ponds should be built to accept peak flows and volumes of runoff from whatever design storm may be designated or computed, as required by the regulatory authorities. Overflow spillways must be provided to bypass or discharge flows into floodways on the peripheries of the ponds so that safe water storage elevations are not exceeded nor banks breached. For extremely large detention ponds, adequate design precautions should be taken to minimize possible shoreline erosion attributable to ice, wind, and wave action. In some locations, municipal, state, and federal agencies may require that specific safety standards be met by ponds impounding a significant depth or volume of water.

Restricting sediment accumulation and water pollution in large ponds is of particular importance, especially when recreational use of the pond is permitted or planned. The polluting effects of roadside accumulation of salts, copper, and asbestos from brake linings, grease, oil, and heavy metals are significant if allowed to enter a storage pond. Such deleterious material should be screened out of the drainage system by interception and disposition before it reaches stormwater storage ponds. Without such precautions, water quality can deteriorate to a point where a storage pond becomes a distinct detriment to the development.

PARKING LOT DETENTION

Storm runoff can be detained on parking lot sites by shallow basins or swales. With this type of control, excess runoff from a relatively small site can be detained on the site at low cost and with minor inconvenience to traffic. Arrangement of areas in a parking lot to accept ponding should be planned so that pedestrians are inconvenienced as little as possible. A 7-inch design depth is not unreasonable for parking locations in the remote areas of lots.

Design considerations should recognize the possible use of porous type asphalt in constructing parking lots, provided the subgrade has an adequate infiltration capability and climate allows use of such paving methods. A substantial reduction in runoff volume may be possible by providing for infiltration and surface storage volume requirements, and drainage structure needs may be thereby reduced. Expansive type soils may preclude this solution.

Instead of building one large parking lot detention facility, construction of a combination of smaller areas can be as effective. Storage in parking lots of commercial, industrial, and multi-family developments can be accomplished by constructing catch basins with inlet grates that cause water to pond. The accumulated effect of the ponds will serve the same purpose as one larger facility. A negative feature of this system is the inconvenience that the ponding water may

cause to the users of the parking facility, even though it is for a short period. The other negative feature is the potential to freeze in northern Illinois. Adequate warning signs should be posted in parking lots used for floodwater detention.

An alternative to impervious paving of parking areas is the substitution of turf grids (precast concrete slotted panels). A grid configuration prevents rutting of the grass turf, and the runoff coefficient of flow across a turf grid is only about half that of a paved area. Such grids provide architectural design treatment of hardened areas and permit infiltration of stormwater. Because grass can be planted in the slots or intersects of the concrete panels, a more aesthetic appearance results -- when properly maintained. Between 3 to 6 inches of sand ballast is usually placed over the cleared subgrade to serve as a base for the grids in order to carry vehicle loads heavier than normal. A detriment is that the initial cost of a turf-gridded area compared to the same area of asphalt pavement is about tripled. Carports, residential driveways, residential patio areas, and supplementary parking areas are potential applications where turf-grid surfacing can be accommodated easily to reduce excess runoff volumes and peak flows by infiltration. Areas subject to snow removal operations may find difficulty with the rough surface.

ROOFTOP PONDING

Low slope roofs are common for industrial, commercial, and apartment buildings. Building codes in many parts of the country specify that roofs be designed to sustain snow loads. Although the structural capability of a roof must be considered when designing a roof for temporary storage of rainwater, a roof designed for snow loads can usually accommodate an equivalent water load without need for major structural modifications. Roof surfaces should generally be cambered upward to compensate for vertical deflections produced by the stormwater load. This is needed to prevent excessive storage depths, or allowances may be made by considering deflections in storage computations.

Roof drains must be designed with proper outlet capacities to control release rates to the design level. Overflow mechanisms should be provided to preclude danger from overloading. Special considerations of roof water tightness may be necessary when water is to be detained for long time periods or where frequent freezing and thawing are prevalent. The discharge capacity of the roof drain is designed using a weir calculation. Additional maintenance should be anticipated on roofs subject to leaf accumulation.

UNDERGROUND STORAGE IN HOLDING TANKS

This type of on-site detention involves the underground construction of a holding tank or large size pipe as a means of providing controlled runoff from the site. This application should be limited to highly congested areas where surface ponding is prohibited due to the scarcity or high cost of available land, or areas where surface topography is not conductive to aboveground storage. Outflow control devices may consist of small gravity pipes, weirs, or proprietary devices. In some applications, pumping may be required to discharge stored runoff. Tanks under parking lots subject to freezing should not be used due to the potential for extensive structural damage.

MULTIPLE-PURPOSE USE OF DETENTION FACILITIES

The success and widespread popularity of employing on-site detention systems to detain storm runoff area based on the adaptable nature of this type control to fit other uses. In the minds of a community, the multi-purpose use of such a facility greatly improves the perception that such a facility is a justifiable expense by the public or by the private developer.

Detention ponds present prime examples of multiple use adaptability and, when artistically conceived and designed, can support year-round activities to maximize use of the space occupied. Ponds can be designed to develop aesthetically pleasing settings and, in many cases, they offer the

opportunity to accommodate various types of water sports. Ponds that are recharged by a fresh water source can be stocked with fish. This offers an excellent recreational diversion to both youngsters and adults living nearby. During winter months, detention ponds with a permanent pool of water provide opportunities for ice skating.

A detention basin that is dry between runoff events can be used for field sports such as football, soccer, baseball, and various passive recreational pursuits such as badminton, model airplane operation, shuffleboard, croquet, and picnicking. Some detention basins may double as tennis or basketball courts. It might be difficult to convince some taxpayers that the benefits derived from recreation outweighs the cost of the land plus construction costs. However, should the recreational area be redesigned as a multiple purpose recreational/detention basin, the cost would look insignificant compared to the cost of upgrading a storm drainage system or the amount of potential flood damages. However extensive care must be taken to assure that adequate drainage is provided or otherwise the recreational facility will be unusable. Design feature to improve recreation use of a basin are as follows:

1. Provide at least 2% slope on the bottom surface.
2. Provide a lined low flow channel throughout the basin.
3. Provide subsurface drainage under the playing areas.
4. Provide a separate basin for sediment storage upstream from primary basin that is easily accessible by heavy equipment.

Pedestrian plazas located in highly congested areas can be converted to provide detention storage as well as provide a pleasant rest stop for pedestrians to relax, or enjoy their meals outdoors.

Typically, detention basins in parks are designed to incorporate picnic tables, and ball fields with low flow channels or small pipes designed to bypass low flows and minimize subsequent maintenance requirements. Larger detention facilities holding a permanent pool of water may serve as a source of irrigation water for the development.

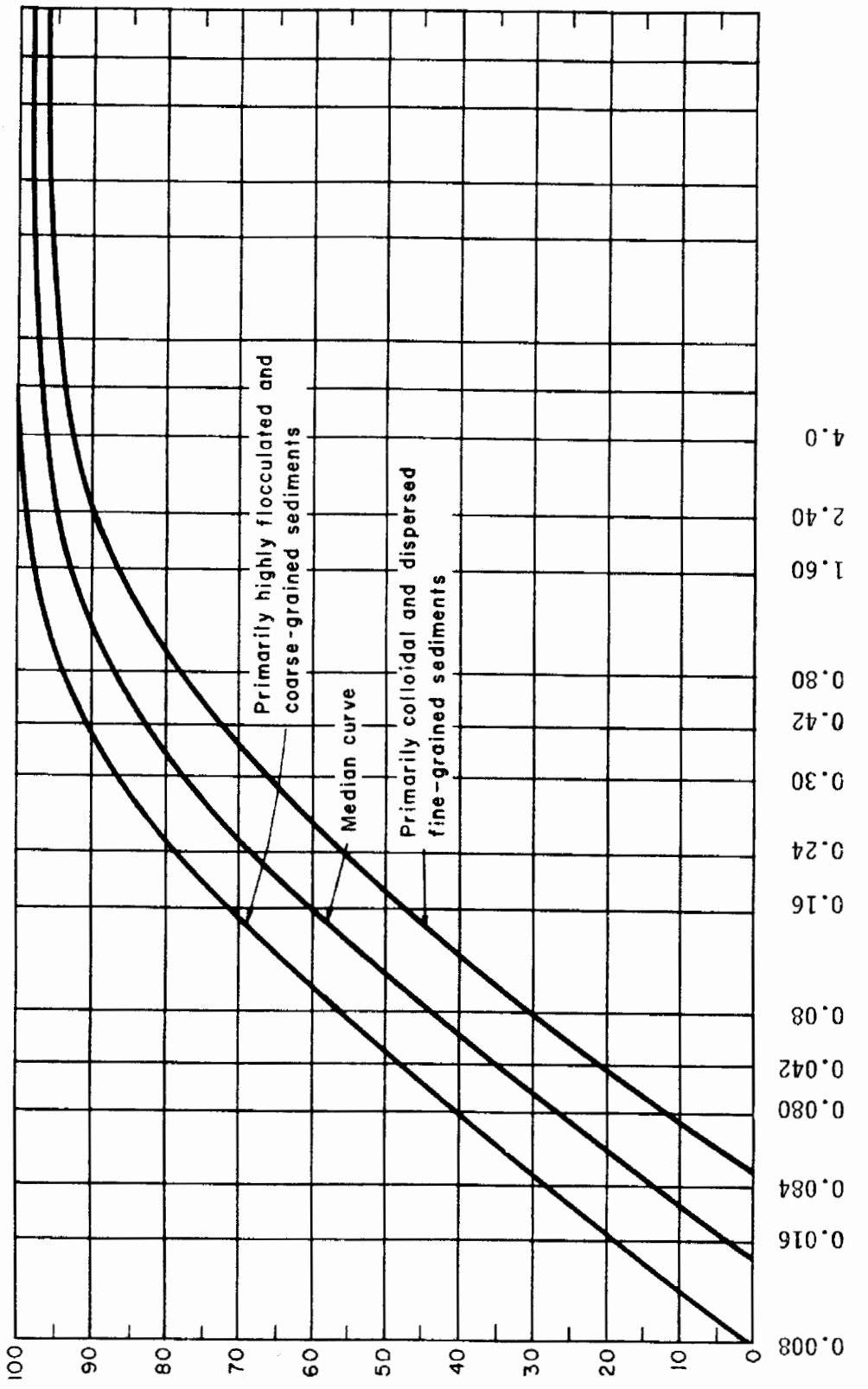
STORMWATER DETENTION FOR WATER QUALITY BENEFITS

Detention basins, either wet or dry, can be very effective in improving water quality by removing pollutants associated with sediment. A properly designed basin can remove 70 to 80 percent of the sediment entering the basin.

Page 7-9 is a summary of design considerations to consider when designing a basin for water quality. These enhancements often can be made for little or no extra capital or maintenance costs. Figure 7-2 shows the expected trap efficiencies of basins depending on the amount of storage capacity provided.

SUMMARY OF DETENTION BASIN DESIGN CONSIDERATIONS FOR WATER QUALITY

Design Consideration	Water Quality Enhancement Suggestion
1. Basin Size	Wet - Determine pool volume based on actual solids settling rate and runoff volumes, rates, and frequencies for the permanent pool. Typically, between 0.25 inches and 0.5 inches of water volume per acre of watershed depending on land cover characteristics and design settling velocity. Temporary storage needed for flood control is then added to this volume. Dry - Again, actual solids settling rates should be determined. Basin volume needed for flood control should be computed and then overflow rates should be checked for frequent runoff events to be sure that over flow rate or detention times do not exceed design criteria rate. If overflow rate is too large, the basin area needs to be increased while holding depth constant until satisfactory overflow rates are obtained.
2. Inlet/Outlet Orientation	Opposite ends of the basin.
3. Basin Shape	Elliptical, rectangular, or triangular with inlet and outlet at opposite longitudinal ends.
4. Length to Width Ratio	3:1 to 5:1 or greater
5. Velocity Dissipation	Baffles and pre-sedimentation basins located in flow path between inlet and outlet.
6. Outlets	Wet - Surface withdrawal controlled by a weir. Dry - Perforated riser, buried in gravel or blind underdrain system.
7. Depth	Wet - Deep enough to prevent resuspension of settled sediment due to wind or velocity currents. Typically at least 4 - 5 feet average depth.
8. Shorelines	Stabilized with vegetation or rip rap to prevent erosion. Safety ledge should be provided. Slope 5:1 or flatter.
9. Bank Slope	Wet - Saftey ledge should be provided. Slope may be important if fish life is to be maintained. Dry - 3:1 or flatter for safety and to encourage establishment of vegetative cover.
10. Maintenance	Provision for maintenance equipment access. Provision of a pre-sedimentation basin to localize sediment deposition. Provision of an alternate bottom outlet in wet basins to allow the pond to be drained for maintenance.



Trap Efficiency of Reservoirs

Figure 7-2

2. FACTORS AFFECTING RUNOFF

RAINFALL

Precipitation, whether it occurs as rain or snow, is the potential source of flooding in small watersheds. The extent of the storm and the distribution of rainfall during the storm are two major factors which affect the peak rate of runoff.

The storm distribution can be thought of as a measure of how the rate of rainfall (intensity) varies within a given time interval. For example, in a given 24-hour period, a certain amount of precipitation may have been measured. However, this precipitation may have occurred over the entire 24-hour period or in just one hour. These two situations represent two entirely different storm distributions.

The size of the storm is often described by the length of time over which precipitation occurs, the total amount of precipitation occurring and how often this same storm might be expected to occur (frequency). Thus, a 10-year, 24-hour storm can be thought of as a storm producing the amount of rain in 24 hours with a 10% chance of occurrence in any given year.

ANTECEDENT MOISTURE CONTENT

The runoff from a given storm is affected by the existing soil moisture content resulting from the amount of precipitation occurring during the preceding five days (antecedent moisture condition).

SOILS

In general, the higher the rate of infiltration, the lower the quantity of stormwater runoff. Fine textured soils such as clay produce a higher rate of runoff than do coarse textured soils such as sand. Sites having clay soils may require the construction of more elaborate drainage systems than sites having sandy soils.

SURFACE COVER

The type of cover and its condition affects runoff volume through its influence on the infiltration rate of soil. Fallow land yields more runoff than forested or grass land for a given soil type.

The foliage and its litter maintain the soils infiltration potential by preventing the sealing of the soil surface from the impact of the raindrops. Some of the raindrops are retained on the surface of the foliage, increasing their chance of being evaporated back to the atmosphere. Some of the intercepted moisture is so long draining from the plant down to the soil that it is withheld from the initial period of runoff. Foliage also transpires moisture into the atmosphere thereby creating a moisture deficiency in the soil which must be replaced by rainfall before runoff occurs. Vegetation, including its ground litter, forms numerous barriers along the path of the water flowing over the surface of the land which slows the water down and reduces its peak rate of runoff.

Covering areas with impervious material reduces surface storage and infiltration and thus increases the amount of runoff.

PONDING OR WETLAND AREAS

On very flat areas where ponding or wetland areas occur in the watershed, a considerable amount of the surface runoff may be retained in temporary storage, thus reducing the rate at which runoff will occur.

TIME OF CONCENTRATION

This is the time it takes water to travel from the most distant part of the watershed to the point of interest. The time of concentration effects the peak and shape of the hydrograph.

3. METHODS OF DETERMINING RUNOFF

Many different methods of computing runoff have been developed. Some of the methods and limitations of each are listed below.

1. The Rational Method establishes an empirical formula for computing peak rates of runoff that is commonly used in urban areas. It is useful for estimating runoff on relatively small areas such as roof tops, parking lots, or others. According to Reference 7-1, use of the rational equation should be limited to drainage areas less than 20 acres. However, some practitioners totally deplore the use of the Rational Method even on the smallest of drainage areas. The most serious drawback of the Rational Method is that it gives only the peak discharge and provides no information on the time distribution of the storm runoff. Furthermore the choice of "c" and "tc" when choosing "i" in the Rational Method is more an art of judgment than a precise account of the antecedent moisture condition or an aerial distribution of rainfall intensity (Reference 7-2). Modifications of the Rational Method have similar limitations (Reference 7-1).

2. The ILLUDAS computer program is another procedure developed in Illinois for computing runoff in urban areas (Reference 7-5). This uses a hydrograph to obtain the peak rate of discharge. It is only applicable for a fully developed urban watershed and should not be used for undeveloped or rural watersheds. The maximum storm event to be analyzed should be the 25-year frequency or 4% chance event and the maximum drainage area should not exceed five square miles.

3. The SCS-TR-20 computer program utilizes hydrologic soil-cover complexes (runoff curve numbers discussed in Reference 7-3 and 7-6 to determine runoff volumes and unit hydrographs to determine peak rates of discharge. Factors included in the method are 24-hour rainfall amount, a given rainfall distribution, runoff curve numbers, time of concentration, travel time, and drainage area. This procedure probably should not be used for drainage areas less than 50 acres or more than 20 square miles. It is very useful for larger drainage basins especially when there are a series of structures or several tributaries to be studied.

4. The SCS TR-55 (Reference 7-3) Tabular Method is a approximation of the more detailed SCS TR-20 method. The Tabular Method divides the watershed into subareas, completes an outflow hydrograph for each, and then combines and routes each subarea to the outlet. It is especially useful for measuring the effects of changed land use in a part of a watershed. It can also be used to determine the effects of structures and combinations of structures, including channel modifications, at different locations in a watershed. The Tabular Method should not be used when large changes in the curve number occur among subareas within a watershed and when runoff volumes are less than about 1.5 inches for curve numbers less than 60. For most watershed conditions, however this procedure is adequate to determine the effects of urbanization on peak rates of discharge for subareas up to approximately 20 square miles in size.

5. The SCS TR-55 Graphical Method (Reference 7-3) is the method discussed in this handbook. The method calculates peak discharge using an assumed unit hydrograph and a thorough, but rapid, evaluation of the soils, slope, and surface cover characteristics of the contributing watershed. The assumed unit hydrograph is based on design considerations rather than meteorological factors. Correction factor for swampy or ponding conditions can be used, if they are warranted. This method is recommended for use in the design of all SE & SC measures. When more detail and accuracy is required or when an accurate simulation of natural conditions is required, one of the other appropriate methods should be used.

6. The COE-HEC 1 provides similar evaluation as the the SCS TR-20. It is a rainfall-runoff model that can be calibrated to gauge records. Like TR-20, it can be used on both simple and complex watersheds.

Selection Criteria for Runoff Calculation Methods

OUTPUT REQUIREMENTS	DRAINAGE AREA	APPROPRIATE METHOD
PEAK DISCHARGE ONLY	UP TO 20 AC.	1 2 3 4 5 6
	UP TO 2000 AC.	2 3 4 5 6
	UP TO 5 SQ. MI.	2 3 4 6
	UP TO 20 SQ. MI.	3 4 6
PEAK DISCHARGE AND TOTAL RUNOFF VOLUME	UP TO 2000 AC.	2 3 4 5 6
	UP TO 5 SQ. MI.	2 3 4 6
	UP TO 20 SQ. MI.	3 4 6
RUNOFF HYDROGRAPH	UP TO 5 SQ. MI.	2 3 4 6
	UP TO 20 SQ. MI.	3 4 6

1 RATIONAL METHOD
2 ILLUDAS (ONLY FULLY DEVELOPED URBAN WATERSHEDS)
3 SCS TR-20 METHOD
4 SCS TR-55 TABULAR METHOD
5 SCS TR-55 GRAPHICAL METHOD
6 COE HEC-1 METHOD

4. SCS TR-55 GRAPHICAL METHOD

Estimating runoff is the process of determining the volume or peak rate of runoff from a given watershed for the specified design storm.

This section demonstrates a procedure for estimating depth and peak rates of runoff from small watersheds for use in designing sediment and erosion control measures.

This method is called TR-55 Graphical Method and is applicable for watershed areas of 2,000 acres or less. Adjustment factor is given to correct for ponding or swampy areas. A detailed discussion of this method is given in Urban Hydrology for Small Watersheds: Technical Release No. 55 (TR-55)(Reference 7-3).

PRECIPITATION

This method is based on a 24-hour duration rainfall with the most intense rainfall occurring during a six-hour period near the middle of that period. This storm distribution represents the most intense type of storm typically occurring in this part of the United States. The amount of rainfall that can be expected in a 24-hour period for selected frequencies is shown on Figure 7-3.

SOILS

Soils have been divided into groups called hydrologic soil groups to describe their potential to produce runoff. These groups are based on infiltration and transmission rates.

The four hydrologic soil groups used in measuring runoff potential are:

1. Group A: These are soils exhibit a high infiltration and low runoff rate. They are chiefly deep, well-drained sands or gravels.

2. Group B: When thoroughly wet, but not saturated, these soils display a moderate infiltration and runoff rate. They are well-drained soils, generally moderate in depth, moderately fine to moderately coarse in texture, including sandy loam, and silt.

3. Group C: These soils have a slow infiltration and rapid runoff rate when wet. They are distinguished by a layer that impedes downward movement of water and are moderately fine or finely textured. This group includes clay loam.

4. Group D: These soils have the slowest infiltration rate and the highest runoff rate. Chiefly clay soils with a high swelling potential, they have a permanent high water table. Other common characteristics include a claypan at or near the surface and shallowness over nearly impervious material.

The infiltration rates and runoff rates of all soils are affected by climatic conditions such as freezing. Regardless of its hydrologic soil group, all frozen soils exhibit a rapid runoff rate.

Low soil temperatures typical of the colder seasons decrease the rate of infiltration and thereby increase the volume of runoff to be expected. Rains on frozen ground may cause the largest runoff of the year.

Consideration should be given to whether heavy equipment has or will compact the soil significantly more than natural conditions, whether much of the pervious area is barren with little sod established and whether grading has mixed the surface and subsurface soils causing a completely different hydrologic condition. Any one of the above could cause a soil normally in hydrologic group B or C to be classified in group C or D.

Hydrologic soil groups for soils in Illinois are given in the appendix.

SURFACE COVER

The Soil Cover Complex Method uses a numerical rating called a runoff curve number (RCN) to describe the combined effects of soil type and surface cover conditions. This information is given in Figures 7-4 a, b, and c.

TIME OF CONCENTRATION AND TRAVEL TIME

Travel time (Tt) is the time it takes water to travel from one location to another in a watershed. Tt is a component of time of concentration (Tc) which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. Tc is computed by summing all the travel time for consecutive components of the drainage conveyance system.

Tc influences the shape and peak of the runoff hydrograph. Urbanization usually decreases Tc, thereby increasing the peak discharge. But Tc can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

FACTORS AFFECTING TIME OF CONCENTRATION AND TRAVEL TIME

SURFACE ROUGHNESS

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

CHANNEL SHAPE AND FLOW PATTERN

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

SLOPE

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

EXAMPLE WEIGHTED CURVE NUMBER COMPUTATION

Given: A 100 acre watershed with all soils in hydrologic soil group C. The proposed land use is 50 acres of detached houses with 1/4 acre lot size; 10 acres of townhouses on 1/8 acre lots; 25 acres of streets with curbs and gutters, schools, parking lots, plazas and 15 acres of open space, parks, school yards, etc., with good grass cover.

Find: the future runoff curve number.

Solution:

Land Use	Acres	RCN	Product
Detached houses w/lot size 1/4 acre	50	83	4150
Townhouses with lot size 1/8 ac	10	90	900
Streets with curbs, plazas	25	98	2450
Open space, parks, etc	15	74	1110
	100		8610

$$\text{Weighted RCN} = \frac{\text{Product}}{\text{Acres}} = \frac{8610}{100} = 86$$

USDA-SCS - 24-Hour Rainfall (Inches) for Illinois Counties

	County	Frequency (Yrs.)					
		2	5	10	25	50	100
1.	Adams	3.3	4.2	4.8	5.5	6.2	6.8
2.	Alexander	3.6	4.4	5.1	5.8	6.5	7.0
3.	Bond	3.4	4.2	4.8	5.5	6.2	6.7
4.	Boone	2.8	3.6	4.1	4.7	5.3	5.9
5.	Brown	3.3	4.2	4.8	5.4	6.1	6.7
6.	Bureau	3.0	3.8	4.4	5.0	5.6	6.2
7.	Calhoun	3.4	4.3	4.9	5.6	6.3	6.9
8.	Carroll	3.0	3.8	4.3	4.9	5.5	6.2
9.	Cass	3.3	4.2	4.7	5.4	6.0	6.6
10.	Champaign	3.0	3.9	4.4	5.2	5.7	6.2
11.	Christian	3.3	4.1	4.7	5.3	6.0	6.5
12.	Clark	3.1	4.0	4.6	5.1	5.8	6.2
13.	Clay	3.3	4.2	4.7	5.4	6.0	6.5
14.	Clinton	3.4	4.3	4.8	5.5	6.2	6.8
15.	Coles	3.1	4.0	4.6	5.2	5.8	6.3
16.	Cook	2.8	3.5	4.0	4.7	5.2	5.7
17.	Crawford	3.2	4.1	4.6	5.2	5.9	6.3
18.	Cumberland	3.2	4.1	4.6	5.2	5.9	6.3
19.	DeKalb	2.8	3.6	4.2	4.8	5.4	5.9
20.	DeWitt	3.1	4.0	4.5	5.1	5.8	6.3
21.	Douglas	3.1	4.0	4.5	5.1	5.8	6.3
22.	DuPage	2.8	3.5	4.1	4.7	5.3	5.8
23.	Edgar	3.1	3.9	4.4	5.0	5.7	6.2
24.	Edwards	3.3	4.2	4.7	5.4	6.1	6.5
25.	Effingham	3.3	4.1	4.7	5.3	6.0	6.5
26.	Fayette	3.3	4.2	4.7	5.4	6.1	6.6
27.	Ford	3.0	3.8	4.3	4.9	5.6	6.1
28.	Franklin	3.5	4.3	4.8	5.6	6.3	6.8
29.	Fulton	3.2	4.1	4.6	5.3	5.9	6.5
30.	Gallatin	3.4	4.3	4.8	5.5	6.2	6.7
31.	Greene	3.4	4.3	4.8	5.5	6.2	6.8
32.	Grundy	2.9	3.7	4.2	4.8	5.4	6.0
33.	Hamilton	3.4	4.3	4.8	5.5	6.2	6.7
34.	Hancock	3.3	4.2	4.8	5.5	6.1	6.7
35.	Hardin	3.4	4.3	4.8	5.6	6.3	6.7
36.	Henderson	3.2	4.1	4.7	5.3	5.9	6.6
37.	Henry	3.1	3.9	4.4	5.1	5.7	6.3
38.	Iroquois	2.9	3.7	4.2	4.9	5.5	6.0
39.	Jackson	3.5	4.4	5.0	5.7	6.4	6.9
40.	Jasper	3.2	4.1	4.6	5.2	5.9	6.4
41.	Jefferson	3.4	4.3	4.8	5.5	6.2	6.7
42.	Jersey	3.4	4.3	4.8	5.6	6.3	6.8
43.	Jo Daviess	3.0	3.8	4.3	4.9	5.5	6.2
44.	Johnson	3.5	4.4	5.0	5.7	6.4	6.9
45.	Kane	2.8	3.6	4.1	4.7	5.3	5.8
46.	Kankakee	2.9	3.7	4.2	4.8	5.4	5.9
47.	Kendall	2.8	3.6	4.2	4.8	5.4	5.9
48.	Knox	3.2	4.0	4.5	5.2	5.8	6.4
49.	Lake	2.7	3.4	3.9	4.6	5.2	5.7
50.	LaSalle	3.0	3.8	4.3	4.9	5.5	6.1
51.	Lawrence	3.2	4.1	4.6	5.2	5.9	6.4
52.	Lee	3.0	3.8	4.3	4.9	5.5	6.1

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Figure 7-3 Note: Other sources, such as the Illinois State Water Survey, will provide 24-hour rainfall amounts for Illinois locations.

USDA-SCS - 24-Hour Rainfall (Inches) for Illinois Counties (Cont.)

	County	Frequency (Yrs.)					
		2	5	10	25	50	100
53.	Livingston	3.0	3.8	4.3	4.9	5.6	6.1
54.	Logan	3.2	4.0	4.6	5.2	5.8	6.4
55.	McDonough	3.2	4.1	4.7	5.3	6.0	6.6
56.	McHenry	2.8	3.5	4.1	4.7	5.2	5.8
57.	McLean	3.1	3.9	4.4	5.0	5.7	6.2
58.	Macon	3.2	4.0	4.6	5.2	5.9	6.4
59.	Macoupin	3.4	4.2	4.8	5.5	6.2	6.7
60.	Madison	3.4	4.3	4.8	5.6	6.2	6.8
61.	Marion	3.4	4.2	4.7	5.5	6.1	6.6
62.	Marshall	3.0	3.9	4.4	5.0	5.6	6.2
63.	Mason	3.2	4.1	4.6	5.3	5.9	6.5
64.	Massac	3.5	4.4	5.0	5.7	6.4	6.9
65.	Menard	3.2	4.1	4.7	5.3	5.9	6.5
66.	Mercer	3.2	4.0	4.6	5.2	5.8	6.5
67.	Monroe	3.5	4.4	5.0	5.7	6.4	7.0
68.	Montgomery	3.4	4.2	4.7	5.4	6.1	6.6
69.	Morgan	3.3	4.2	4.7	5.4	6.1	6.7
70.	Moultrie	3.2	4.0	4.6	5.2	5.8	6.4
71.	Ogle	2.9	3.7	4.3	4.9	5.4	6.1
72.	Peoria	3.1	4.0	4.5	5.1	5.8	6.4
73.	Perry	3.5	4.3	4.9	5.6	6.3	6.9
74.	Piatt	3.1	4.0	4.5	5.1	5.8	6.3
75.	Pike	3.4	4.3	4.8	5.5	6.2	6.8
76.	Pope	3.5	4.3	4.9	5.7	6.3	6.8
77.	Pulaski	3.6	4.4	5.0	5.8	6.5	7.0
78.	Putnam	3.0	3.8	4.4	5.0	5.6	6.2
79.	Randolph	3.5	4.4	5.0	5.7	6.4	7.0
80.	Richland	3.2	4.1	4.7	5.3	6.0	6.4
81.	Rock Island	3.1	4.0	4.5	5.2	5.7	6.4
82.	St. Clair	3.5	4.4	4.9	5.6	6.3	6.9
83.	Saline	3.4	4.3	4.8	5.6	6.3	6.7
84.	Sangamon	3.3	4.1	4.7	5.3	6.0	6.5
85.	Schuyler	3.3	4.2	4.7	5.4	6.0	6.6
86.	Scott	3.3	4.2	4.8	5.5	6.1	6.7
87.	Shelby	3.2	4.1	4.7	5.3	6.0	6.5
88.	Stark	3.1	3.9	4.4	5.1	5.7	6.3
89.	Stephenson	3.0	3.7	4.3	4.9	5.4	6.1
90.	Tazewell	3.2	4.0	4.5	5.1	5.8	6.4
91.	Union	3.6	4.4	5.0	5.7	6.5	7.0
92.	Vermilion	3.0	3.8	4.3	4.9	5.5	6.0
93.	Wabash	3.3	4.1	4.7	5.3	6.0	6.4
94.	Warren	3.2	4.1	4.6	5.3	5.9	6.5
95.	Washington	3.5	4.3	4.8	5.6	6.3	6.8
96.	Wayne	3.4	4.2	4.7	5.4	6.1	6.6
97.	White	3.4	4.2	4.7	5.5	6.2	6.6
98.	Whiteside	3.0	3.8	4.4	5.0	5.6	6.2
99.	Will	2.8	3.6	4.2	4.8	5.4	5.8
100.	Williamson	3.5	4.3	4.9	5.6	6.3	6.8
101.	Winnebago	2.9	3.6	4.2	4.8	5.3	6.0
102.	Woodford	3.1	3.9	4.4	5.0	5.7	6.2

From U. S. Weather Bureau
Technical Paper #40

Figure 7-3 (continued) Note: Other sources, such as the Illinois State Water Survey, will provide 24-hour rainfall amounts for Illinois locations.

–Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group–			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) :					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94
Idle lands (CN's are determined using cover types).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

Figure 7-4a

Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Crop residue cover* applies only if residue is on at least 5% of the surface throughout the year.

[3]Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Figure 7-4b

Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

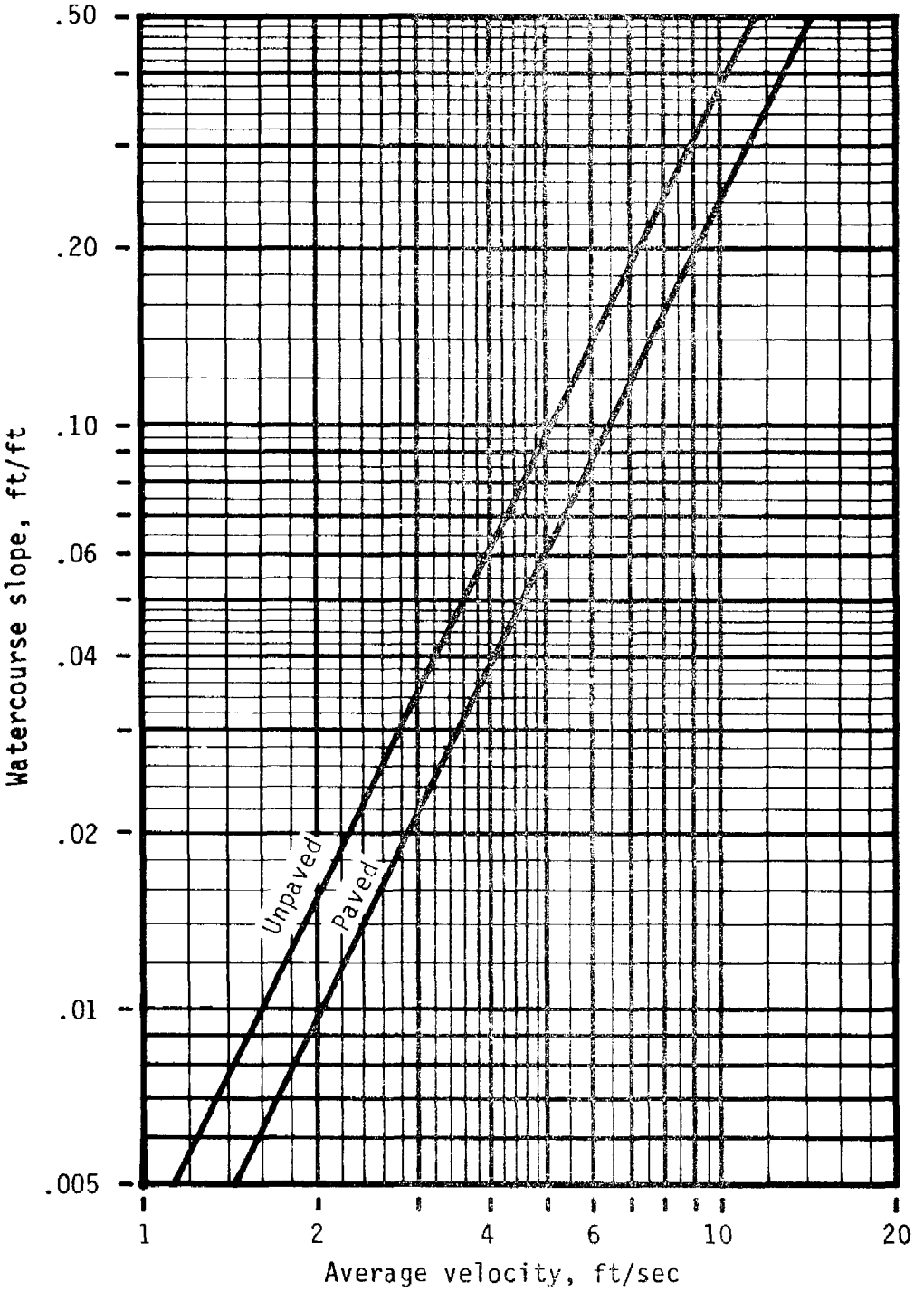
[3]*Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Figure 7-4c



Average velocities for estimating travel time for shallow concentrated flow.

Figure 7-5

COMPUTATION OF TRAVEL TIME AND TIME OF CONCENTRATION

Water moves through a watershed as sheet flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (Tt) is the ratio of flow length to flow velocity:

[Eq. 7-1] $$Tt = \frac{L}{3600\ V}$$

where

Tt = travel time (hr)
L = flow length (ft),
V = average velocity (ft/s), 3600 = conversion factor from seconds to hours.

Time of concentration (Tc) is the sum of Tt values for the various consecutive flow segments:

$$Tc = Tt_1 + Tt_2 + \ldots Tt_m$$

[Eq. 7-2]
where

Tc = time of concentration (hr) and
m = number of flow segments.

SHEET FLOW

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Figure 7-6 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute Tt:

$$Tt = \frac{0.007(nL)0.8}{(P_2)0.5\ S0.4}$$

[Eq. 7-3]
where

Tt = travel time (hr)

n = Manning's roughness coefficient (Figure 3-1)

L = flow length (ft)

P_2 = 2-year, 24-hour rainfall (in), and

s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from Figure 7-3.

Figure 7-6 Roughness coefficients (Manning's n) for sheet flow

Surface description	n1
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover <20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41

Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

SHALLOW CONCENTRATED FLOW

After a maximum of 300 feet, sheet flow usually becomes shallow, velocity for this flow can be determined from Figure 7-5, in which average velocity is a function of watercourse slope and type of channel. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in Figure 7-5, use equation 7-1 to estimate travel time for the shallow concentrated flow segment.

OPEN CHANNELS

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity is usually determined for bank full elevation.

Manning's equation is:

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$$

[Eq. 7-4]

V = average velocity (ft/s),
r = hydraulic radius (ft) and is equal to a/p_w,
a = cross section flow area (ft^2)
Pw = wetted perimeter (ft),
s = slope of the hydraulic grade lined (Channel slope, ft/ft), and
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Lindsey et al. (1982). After average velocity is computed using equation 7-4, Tt for the channel segment can be estimated using equation 7-3.

RESERVOIR OR LAKES

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

LIMITATIONS

* Manning's kinematic solution should not be used for sheet flow longer than 300 feet.

* In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate Tc. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

* The minimum Tc used in TR-55 is 0.1 hour.

* A culvert or bridge can act as a reservoir or outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 7-1

The sketch below shows an example watershed. The problem is to compute Tc at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute Tc, first determine Tt for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s)=0.01 ft/ft; and length (L)= 100 ft.
Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L= 1400
Segment CD: Channel flow; Manning's n = .05; flow area (a)=27 ft^2; wetted perimeter (Pw)= 28.2 ft; s=0.005 ft/ft; and L= 7300 ft.

See Figure 7-7 for the computations made on worksheet 1.

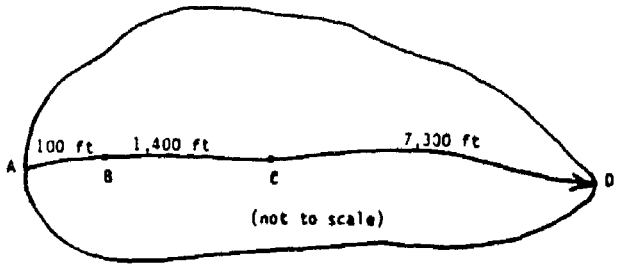


Figure 7-6

DETERMINING RUNOFF VOLUME

The following equation converts the amount of rainfall to inches of runoff based on the runoff curve number.

[Eq. 7-5]

$$\text{Runoff Volume} = \frac{(P-0.2s)^2}{P + 0.8S}$$

where $S = \frac{1000}{RCN} - 10$

P = precipitation (in)
RCN = runoff curve number

Solutions of the above equation are tabulated in Figure 7-8.

Worksheet 1: Time of concentration (T_c) or travel time (T_t)

Project Heavenly Acres By HM Date 12-12-87

Location Champaign Co, Checked BC Date 12-14-87

Circle one: Present (Developed)

Circle one: (T_c) T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)		Segment ID	AB			
1. Surface description (Figure 7-6)			Dense Grass			
2. Manning's roughness coeff., n (Figure 7-6)			0.24			
3. Flow length, L (total L ≤ 300 ft)	ft		100			
4. Two-yr 24-hr rainfall, P_2	in		3.0			
5. Land slope, s	ft/ft		0.01			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t	hr		0.32	+ —	=	0.32
Shallow concentrated flow		Segment ID	BC			
7. Surface description (paved or unpaved)			Unpaved			
8. Flow length, L	ft		1400			
9. Watercourse slope, s	ft/ft		0.01			
10. Average velocity, V (Figure 7-5)	ft/s		1.6			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		0.24	+ —	=	0.24
Channel flow		Segment ID	CO			
12. Cross sectional flow area, a	ft^2		27			
13. Wetted perimeter, p_w	ft		28.2			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		0.957			
15. Channel slope, s	ft/ft		0.005			
16. Manning's roughness coeff., n			0.05			
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s		2.05			
18. Flow length, L	ft		7300			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		0.99	+	=	0.99
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr					1.55

Figure 7-7

Runoff depth for selected CN's and rainfall amounts[1]

Rainfall	Runoff depth for curve number of—												
	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1]Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

Figure 7-8

DETERMINING PEAK DISCHARGE

This section presents the Graphical Peak Discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation -- Hydrology" (SCS 1983). The peak discharge equation used is:

[Eq. 7-6] $qp = qu\ Am\ Q\ Fp$

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
Am = drainage area (mi^2);
Q = runoff (in); and
Fp = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) Tc (hr), (2) drainage area (mi^2), (3) rainfall distribution (II), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the Tc computation, an adjustment for pond and swamp areas is also needed.

PEAK DISCHARGE COMPUTATION

For a selected rainfall frequency the 24-hour rainfall (P) is obtained from Figure 7-3 or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in this chapter. The CN is used to determine the initial abstraction (I_a) from Figure 7-9 Ia/P is then computed.

If the computed Ia/P ratio is outside the range shown in Figure 7-12 for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation.

Peak discharge per square mile per inch of runoff (q_u) is obtained from Figure 7-12 by using Tc, rainfall distribution type, and Ia/P ratio. The pond and swamp adjustment factor is obtained from Figure 7-10 (rounded to the nearest table value). Use worksheet 2 to aid in computing the peak discharge using the Graphical method.

I_a values for runoff curve numbers

Curve number	Ia (in)	Curve number	Ia (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.362
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Figure 7-9

Adjustment factor (Fp) for pond and swamp areas that area spread throughout the watershed

% of pond and swamp areas	Fp
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Figure 7-10

LIMITATIONS

The Graphical method provides a determination of the peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method. Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.

* The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.

* The watershed may have only one main stream or, if more than one, the branches must have nearly equal Tc's.

* The method cannot perform valley or reservoir routing.

* The Fp factor can be applied only for ponds or swamps that are not in the Tc flow path.

* Accuracy of peak discharge estimated by this method will be reduced if Ia/P values are used that are outside the range given in Figure 7-12. The limiting Ia/P values are recommended for use.

* This method should be used only if the weighted CN is greater than 40.

* When this method is used to develop estimates of of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating Tc.

* Tc values with this method may range from 0.1 to 10 hours.

Example 7-3

Compute the 25-year peak discharge for the 250-acre watershed described in example; Figure 7-11 shows how worksheet 2 is used to compute q_p as 265 cfs.

Worksheet 2 Graphical Peak Discharge method

Project Heavenly Acres By HM Date 12-12-87

Location Champaign Co. Checked BC Date 12-14-87

Circle one: Present (Developed)

1. Data:

   Drainage area ..... A_m = 0.39 mi^2 (acres/640)

   Runoff curve number .... CN = 75

   Time of concentration .. T_c = 1.55 hr (from Worksheet 1)

   Rainfall distribution type = II (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ..... = - - percent of A_m (— acres or mi^2 covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	25		
3.	Rainfall, P (24-hour)	in	5.2		
4.	Initial abstraction, I_a ..... 0.667 / 5.2 (Use CN with figure 7-9)	in	0.667		
5.	Compute I_a/P		0.13		
6.	Unit peak discharge, q_u ..... (Use T_c and I_a/P with figure 7-12)	csm/in	260		
7.	Runoff, Q ..... (From figure 7-8)	in	2.62		
8.	Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with figure 7-10 Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9.	Peak discharge, q_p ..... (Where $q_p = q_u A_m Q F_p$) 260 x 0.39 x 2.62 x 1.0	cfs	265		

Figure 7-11

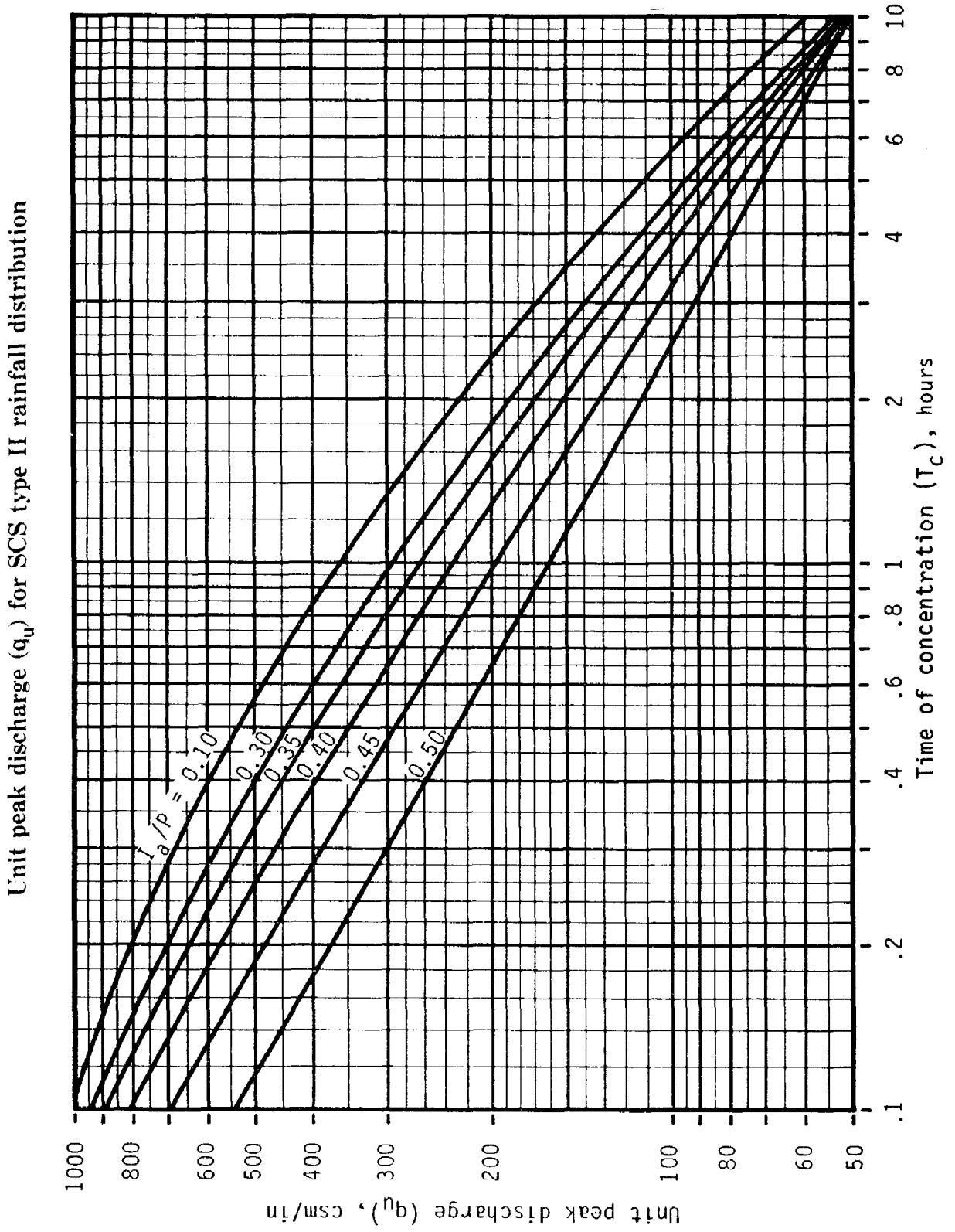

Unit peak discharge (q_u) for SCS type II rainfall distribution
Unit peak discharge (q_u), csm/in
1000
800
600
500
400
300
200
100
80
60
50
Time of concentration (T_c), hours
.1
.2
.4
.6
.8
1
2
4
6
8
10
I_a/P = 0.10
0.30
0.35
0.40
0.45
0.50

Figure 7-12

5. METHODS OF FLOOD ROUTING

Flood routing is analyzing the disposition of water from the design storm and is accomplished by various methods. The basic premise used in any flood routing procedure is that the total inflow is equal to the total outflow plus the change in storage.

Once a design inflow hydrograph has been developed, flood routing is straight forward and the volume of required storage can be determined. The method of determining the runoff and the inflow hydrograph is very important as the accuracy of routing results depend upon it. For this reason, inflow hydrographs derived from runoff methods intended only to predict peak discharge should not be used. Appropriate methods and limitations of methods of computing runoff are discussed in the previous section of this chapter.

STORAGE INDICATION METHOD

One of the most widely used methods of determining the required storage volume in detention or sediment basins is the Storage-Indication Method. This mathematical flow routing procedure consists of a trial and error process based upon the Continuity Equation. The basic premise is that the volume of water entering the basin minus the volume of water leaving the basin, over a given time interval, equals the required storage volume. The design procedure for implementing the Storage-Indication Method can be quite lengthy and time consuming when done manually. It is explained in Reference 7-2 and in most hydrology handbooks. This method is excellent for reservoir routing, but it should not be used for channel routing.

For a faster determination of routings, the computer program TR-20 can be used for both reservoir and channel routing. The Storage-Indication Method of routing is used for reservoir routing and the Convex Method of channel routing is used.

TR-55 GRAPHICAL METHOD

A short cut Storage-Indication Method of reservoir routing is described in Reference 7-3. It is more conservative but much faster. It is based on investigation of average storage and routing effects from many structures. Its use should be limited to drainage areas less than 250 acres and subject to same limitations listed in the scope of sediment basins.

ILLUDAS METHOD

A computer program called ILLUDAS will perform reservoir and storm water routings for a fully urbanized watershed (Reference 7-5). Limitations of ILLUDAS were given in the runoff section.

ESTIMATING TEMPORARY STORAGE

INPUT REQUIREMENTS AND PROCEDURES

Use Figure 7-13 to estimate storage volume (Vs) required or peak outflow discharge (q_o). The most frequent application is to estimate Vs, for which the required inputs are runoff volume (Vr), q_o, and peak inflow discharge (q_i). To estimate q_o, the required inputs are Vr, Vs, and q_i.

ESTIMATING Vs

Use worksheet to estimate Vs, storage volume required, by the following procedure.

1. Determine q_o. Many factors may dictate the selection of peak outflow discharge. The most common is to limit downstream discharges to a desired level, such as predevelopment discharge. Another factor may be that the outflow device has already been selected.

2. Estimate q_i by TR-55 graphical method. Do not use peak discharges developed by any other procedure. When using the Tabular Hydrograph method to estimate qi

for a subarea, only use peak discharge associated with Tt=0.

3. Compute q_o/q_i and determine Vs/Vr from Figure 7-13.

4. Q (in inches) was determined when computing q_i in step 2, but now it must be converted to the units in which Vs is to be expressed -- most likely, acre-feet or cubic feet. The most common conversion of Q to Vr is expressed in acre-feet:

[Eq. 7-6] $Vr = 53.33Q(Am)$

where Vr=runoff volume (acre-feet)
Q=runoff (in),
Am=drainage area (mi_2), and
53.33=conversion factor from in-mi^2 to acre-feet.

5. Use the results of steps 3 and 4 to compute Vs:

[Eq. 7-7] $$Vs = Vr \frac{Vs}{Vr}$$

where Vs = storage volume required (acre-feet).

6. The stage in the detention basin corresponding to Vs must be equal to the stage used to generate q_o. In most situations a minor modification of the outflow device has been preselected, repeat the calculations with a modified q_o value.

Estimating q_o

Use worksheet 3 to estimate q_o, required peak outflow discharge, by the following procedure.

1. Determine Vs. If the maximum stage in the detention basin is constrained, set Vs by the maximum permissible stage.

2. Compute Q (in inches) by the procedures in this chapter, and convert it to the same units as Vs (see step 4 in "Estimating Vs).

3. Compute Vs/Vr and determine q_o/qi from Figure 7-13.

4. Estimate qi by the procedures in this chapter. Do not use peak discharges developed by any other method. When using the Tabular Method to estimate qi for a subarea, use only the peak discharge associated with Tt = 0.

5. From steps 3 and 4, compute qo:

[Eq. 7-8] $$qo = qi \frac{qo}{qi}$$

6. Proportion the outflow device so that the stage at qo is equal to the stage corresponding to Vs. If qo cannot be calibrated except in discrete steps (i.e., pipe sizes), repeat the procedure until the stages for qo and Vs are approximately equal.

LIMITATIONS

* This routing method is less accurate as the qo/qi ratio approaches the limits shown in Figure 7-13. The curve in Figure 7-13 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (Vs) required is small, the shape of the outflow hydrograph is sensitive to the rate of rise of the inflow hydrograph. Conversely, when Vs is large, the inflow hydrograph has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (qo) approaches the peak inflow discharge (pi), parameters that affect the rate of rise of a hydrograph, such as rainfall volume, curve number, and the time of concentration, become especially significant.

* The procedure <u>should not be used</u> to perform final design if an error in storage of 25% cannot be tolerated. Figure 7-13 is biased to prevent undersizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and routing will often pay for itself through reduced construction costs.

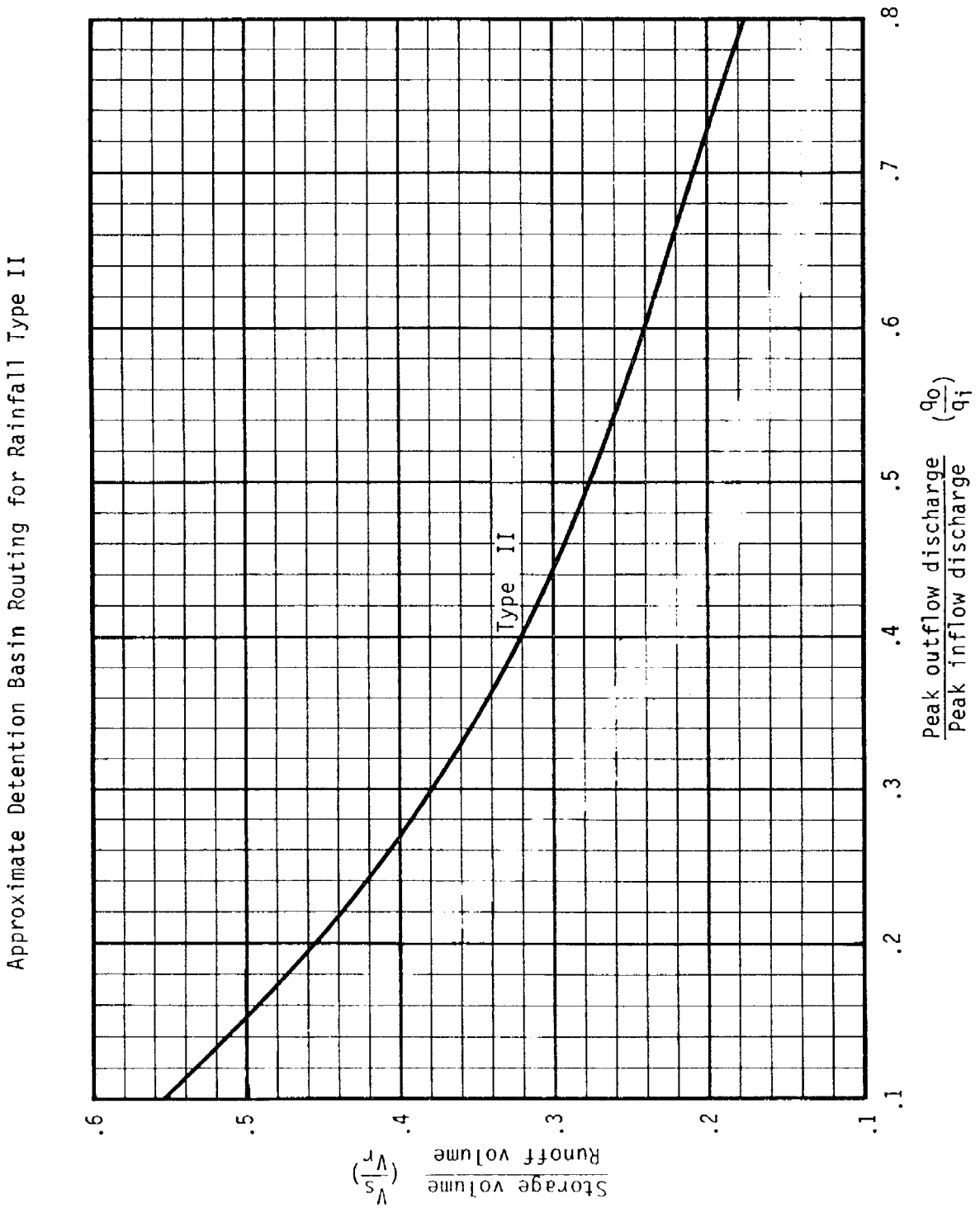

Approximate Detention Basin Routing for Rainfall Type II
Type II
.6
.5
.4
.3
.2
.1
.1
.2
.3
.4
.5
.6
.7
.8
Storage volume / Runoff volume ($\frac{V_s}{V_r}$)
Peak outflow discharge / Peak inflow discharge ($\frac{q_o}{q_i}$)

Figure 7-13

Example 7-4

Example: Estimating Vs, single-stage structure

A development is being planned in a 250 acre (0.39-mi^2) watershed that outlets into an existing concrete-lined channel designed for present conditions. If the channel capacity is exceeded, damages will be substantial. The present channel capacity, 180 cfs, was established by computing discharge for the 25-year frequency storm by the Graphical Peak Discharge Method.

The developed condition peak discharge (qi) computed by the same method is 360 cfs, and runoff (Q) is 2.6 inches. Since outflow must be held to 180 cfs, a detention basin having that maximum outflow discharge (qo) will be built at the watershed outlet.

How much storage (Vs) will be required to meet the maximum outflow discharge (qo) of 180cfs, and what will be the approximate dimensions of a rectangular weir outflow structure? Figure 7-14 shows how worksheet 3 is used to estimate required storage (Vs = 12.0 acre-feet) and maximum stage (Emax = 105.6 ft).

The rectangular weir was chosen for its simplicity; however, several types of outlets can meet the outflow device proportion requirement. Most hydraulic references, along with considerable research data that are available, provide more guidance on variations of outlet devices than can be summarized here.

An outlet device should be proportioned to meet specific objectives. A single-stage device was specified in this example because only one storm was considered. A weir is suitable here because of the low head. The weir crest elevation is 100.0 ft.

Using Vs = 12.0 acre-feet (Figure 7-14), step 3) and the elevation storage curve, the maximum stage (Emax) is 105.6 ft.

The rectangular weir equation is:
[Eq. 7-9]

$$qo = 3.2\ LwHw^{1.5}$$

where
qo = peak outflow discharge(cfs)
Lw = weir crest length (ft), and
Hw = head over weir crest (ft).

Hw and qo are computed as follows:

Hw = Emax - weir crest elevation
= 105.6 - 100.0 = 5.6 ft.

Since qo is known to be 180 cfs, solving equation 7-9 for Lw yields

$$Lw = \frac{qo}{3.2\ Hw^{1.5}}$$

$$= \frac{180}{3.2(5.6)^{1.5}} = 4.3 \text{ ft.}$$

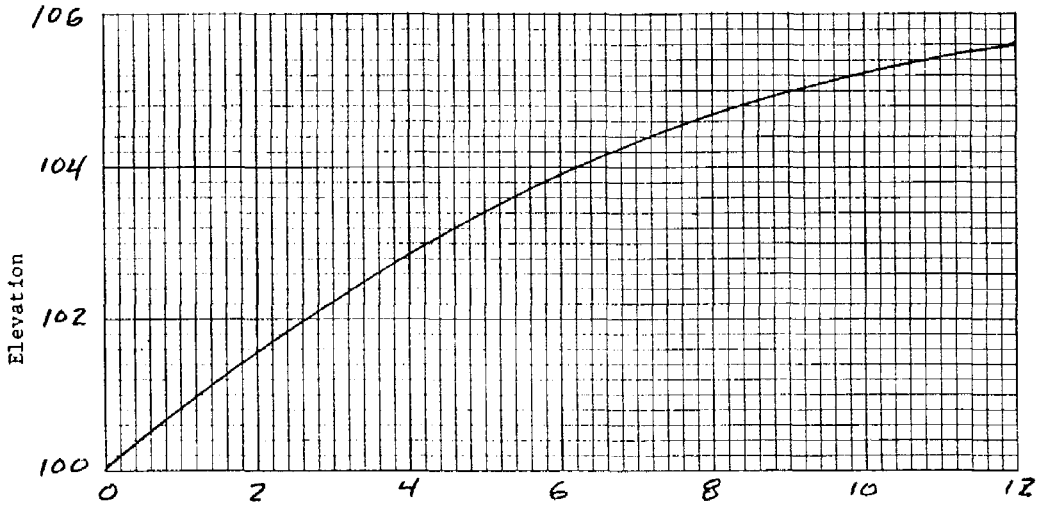
In summary, the outlet structure is a rectangular weir with crest length of 4.3 ft, Hw = 5.6 ft, and qo = 180 cfs corresponding to a
Vs = 12.0 acre-feet.

Worksheet 3 Detention basin storage, peak outflow discharge (q_o) known

Project Heavenly Acres By HM Date 12-12-87

Location Champaign Co. Checked BC Date 12-14-87

Circle one: Present (Developed)



1. Data:
   Drainage area ..... A_m = 0.39 mi^2
   Rainfall distribution type (I, IA, II, III) = II

		1st stage	2nd stage
2.	Frequency ..... yr	25	
3.	Peak inflow discharge, q_i .... cfs (From worksheet 2)	265	
4.	Peak outflow discharge, q_o .... cfs 1/	180	
5.	Compute $\frac{q_o}{q_i}$	0.68	
6.	$\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 7-13)	0.22	
7.	Runoff, Q ..... in	2.62	
8.	Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)	54.5	
9.	Storage volume, V_s ..... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	12.0	
10.	Maximum stage, E_{max} (From plot)	105.6	

1/ 2nd stage q_o includes 1st stage q_o.

Figure 7-14

Chapter 4

Principles of Stormwater Management

This chapter presents a broad overview of the stormwater problem and why a comprehensive stormwater management approach is needed to cost effectively provide solutions. Stormwater pollutants and attenuation mechanisms are discussed. Part 2 of Chapter 6 contains detailed information on stormwater BMPs that can be used to achieve stormwater management objectives.

CHAPTER 4

PRINCIPLES OF STORMWATER MANAGEMENT

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CHAPTER 4

PRINCIPLES OF STORMWATER MANAGEMENT

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CHAPTER 4

PRINCIPLES OF STORMWATER MANAGEMENT

THE STORMWATER PROBLEM

Water flowing over the land during and immediately following a rainstorm is called stormwater runoff. The runoff passing a particular point is equal to the total amount of rainfall upstream of that point less the amounts of infiltration, transpiration, evaporation, surface storage and other losses. The amount of these losses is a function of climate, soils, geology, topography, vegetative cover and, most importantly, land use.

There are four distinct yet interrelated effects of land use changes on the hydrology of an area: changes in peak flow characteristics, changes in total runoff, changes in water quality, and changes in the hydrologic amenities (Leopold, 1968). The hydrologic amenities are what might be called the appearance or the impression which the river, its channel and its valleys, leaves with the observer. Of all land use changes affecting the hydrology of an area, urbanization is the most forceful.

As an area becomes urbanized, the peak flow and the rate of runoff increase as the runoff is concentrated in peaks that are sharper, faster and higher than those produced under natural conditions (Figure 4-1). These effects are caused by: 1) a reduction in the opportunity for infiltration, evaporation, transpiration and depression storage; 2) an increase in the amount of imperviousness; and, 3) modification of the surface drainage patterns, including the associated development of stormwater management facilities.

The volume of stormwater runoff is governed primarily by infiltration characteristics and is related to the land use, soil type, topography and vegetative cover. Thus, runoff is directly related to the percentage of the area covered by roofs, streets and other impervious surfaces. Water intercepted by vegetation and evaporated or transpired is lost from runoff. Water infiltrated into the soil and groundwater is delivered to the stream as delayed flow and does not contribute directly to peak stormwater runoff. Impervious surfaces normally contribute almost all of the total rain immediately to stormwater runoff.

All forms of land use affect water quality (Figure 4-2). In an undeveloped area, many ongoing physical, chemical and biological processes interact to recycle most of the materials found in the runoff. As the human land use intensifies, these processes are disrupted. Man's activities add materials to the land surface (pesticides, fertilizers, animal wastes, oil, grease, heavy metals). These materials are then washed off by the rainfall and runoff, thereby increasing the pollutant load carried to receiving waters by stormwater runoff. Table 4-1 lists the ranges of several pollutants observed in rural and urban runoff.

Of primary importance to water quality is the "first flush". This term describes the washing action that stormwater has on accumulated pollutants in the watershed. In the early stages of runoff the land surfaces, especially impervious surfaces like streets and parking areas, are flushed clean by the

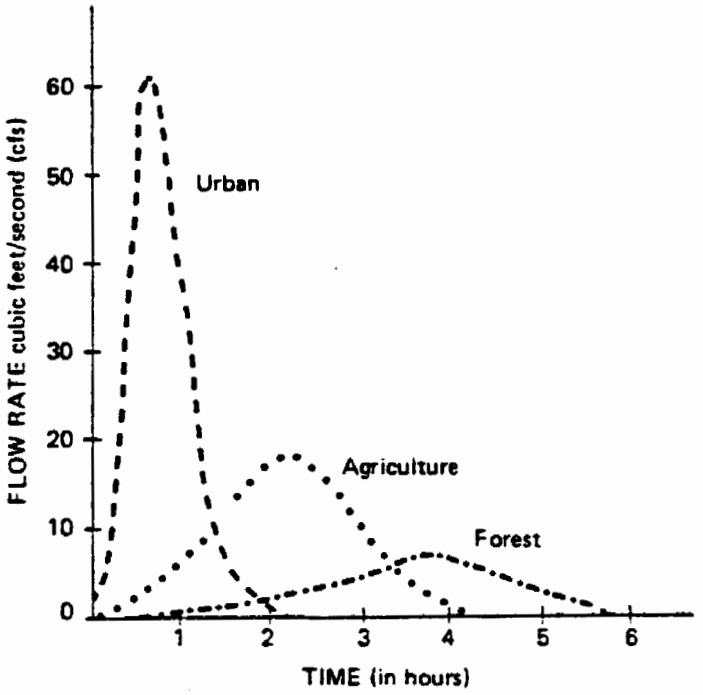

Figure 4-1. Changes in Land Use Affect the Rate and Volume of Runoff

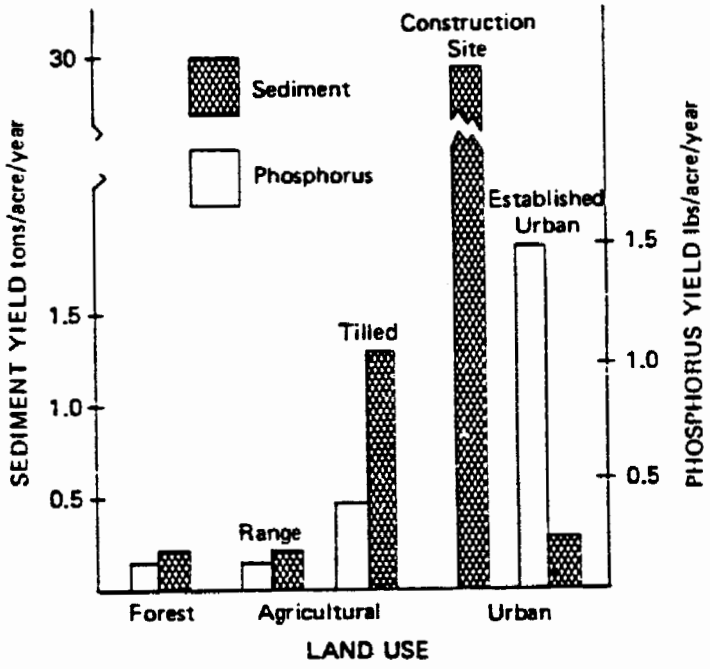

Figure 4-2. Land Use Affects the Quality of Runoff Water

TABLE 4-1

Characteristics of Different Pollution Sources

(1) PARAMETER	URBAN STORMWATER	RURAL STORMWATER	UNTREATED WASTEWATER	SECONDARY TREATED WASTEWATER
BOD_5	1-400	1-200	100-350	10-30
SS	2-7340	3-726	100-350	10-30
TN	1-49	3.7-15.5	35-100	15-35
TP	.1-16	.5-12.5	10-50	3-10
OP	.1-10.0	.1-10.0	6-35	.5-10
TOC	3-384	1-100	100-300	10-120
COD	5-3100	2-150	250-1000	25-150
LEAD	.1-10	.01-2.0	.05-1.27	.0005-.20
ZINC	.1-4.6	.01-1.5	.03-8.31	.047-.02
CADMIUM	0-.10	0-.05	.004-.14	.0002-.02
OILS/GREASE	0-110	0-50	50-150	5-15
FECAL COLIFORM	$55\text{-}112\times10^6$	$55\text{-}112\times10^6$	$10^7\text{-}10^9$	200
TOTAL COLIFORM	$200\text{-}146\times10^6$	$200\text{-}146\times10^6$	$10^9\text{-}10^{11}$	1000

(1) All parameters expressed in Mg/l except coliform which are number of organisms/100 m^1.

stormwater. This flushing creates a shock loading of pollutants. Extensive studies in Florida have determined that the first flush equates to the first one inch of runoff which carries 90% of the pollution load from a storm (USGS, 1984). Treatment of the first one inch of runoff will help ensure that the water quality effects of stormwater are minimized. First flush effects generally diminish as the size of the drainage basin increases and the amount of impervious area decreases.

Finally, the value of the hydrologic environment as an amenity is primarily affected by three factors: stability of the stream channel, accumulation of trash, and disruption of the stream community. A channel which is gradually enlarged because of increased floods caused by urbanization, tends to have unstable and unvegetated banks, scoured or muddy channel beds, and unusual accumumlations of sediment and debris. Together with the accumulation of trash in the channel and floodplain (beer cans, lumber scraps, lawn clippings, concrete, wire) these all tend to severely decrease the visual attractiveness of a stream. Ultimately these factors disrupt the natural balance in the streams' biota resulting from the addition of nutrients, organics, and sediment. These disruptions increase algal growth and turbidity, lower the oxygen content of the water, and thereby change the biological character of the stream, replaceing game fish with less desirable species.

In summary, each progression toward more intensive land use tends to disrupt the ongoing natural processes which protect and preserve water quality. Therefore, to ensure future protection of water resources, it is imperative that land uses be managed in a responsible way.

WHAT IS STORMWATER MANAGEMENT?

In an undeveloped area, stormwater runoff is managed by nature through the hydrologic cycle (see Figure 2-9). The cycle begins with rainfall. Rain either stands where it falls, on leaf or plant, and evaporates; or it is absorbed into the ground near the surface, to feed trees and vegetation, ultimately to be returned to the atmosphere by transpiration; or it percolates deeply into the ground replenishing the groundwater supply. The remainder of the rainfall collects into rivulets. This collected runoff increases in quantity and speed as it moves down the watershed, through drainageways and streams, to its ultimate destination, the river and then the sea. Evaporation from the sea surface begins the cycle again.

This simple explanation of the hydrologic cycle belies its complexity. Nature's inability to accommodate severe rainfalls without significant damage, even in undeveloped areas, is very apparent. Nature's stormwater management systems are not static but are constantly changing. Streams meander, banks erode, vegetation and soil permeabilities change with the seasons, lakes fill in with sediment and eventually disappear. The stripping of ground and tree cover by fire can change an entire system forcing new natural accommodations throughout the system.

Historically, urbanization has resulted in the development of "drainage" systems to lower the groundwater level, or to reduce flooding. These systems were required because man was unwilling to suffer inconvenience where it could be avoided and because he would not tolerate the loss of life or property. Typically such concerns have meant that stormwater management

systems were designed for safety and convenience without recognition of other important considerations. Therefore, no matter how large the rainfall or its duration, the stormwater system was expected to remove the runoff as quickly as possible, to restore maximum convenience in the shortest possible time. In other words, until recently, stormwater management was concerned with only the quantitative effects of runoff.

Today, however, stormwater management is far more comprehensive. An effective program involves the implementation of actions to control water in its hydrologic cycle with the objectives of providing: 1) surface drainage; 2) flood control; 3) erosion and sedimentation control; and,4) reduction of pollutants in runoff (SCS, 1975). Stormwater management applies to rural and urban areas alike; however, the techniques presented in this manual are most relevant to urban or urbanizing situations.

To accomplish the four objectives of stormwater management, it is necessary to ensure that the volume, rate, timing and pollutant load of runoff after development is similar to that which occurred prior to development. The approach suggested in this manual is to minimize the adverse impacts of stormwater through a coordinated system of source controls. Source controls emphasize the prevention and reduction of nonpoint pollution and excess stormwater flow before it ever reaches a collection system or receiving waters. Source control is the central tenet of the various management methods or Best Management Practices (BMPs) recommended in this manual.

FLORIDA'S STORMWATER PROBLEM

Increased stormwater generated by the clearing of land and creation of impervious sufaces associated with Florida's rapid growth and urbanization has resulted in flooding and water quality degradation. Stormwater is the largest contribution of pollutants to Florida's lakes, streams and estuaries. In many lake watersheds, stormwater and other nonpoint sources are the only sources of pollution loading. Stormwater is responsible for:

1. Virtually all of the sediment deposited in Florida waters. Parts of a Canoe Creek in Escambia County have been nearly filled with sediment from unpaved roads and farm fields.

2. Nine times the loading of oxygen demanding substances when compared to loads from point sources. Unless properly abated, these loads lead to fish kills, especially in the summer when hot temperatures and frequent rains combine to lower oxygen levels.

3. Nutrient loads comparable to those from wastewater discharges. As a result, many waters, especially lakes, are hampered by algae blooms and other undesirable aquatic plants. Nutrient enrichment from agricultural runoff has severely affected Lakes Apopka and Okeechobee.

4. Eighty to ninety-five percent of the heavy metals entering our waters. Lead, zinc, copper, cadimium and chromium are deposited on highways and parking areas along with oils and greases.

Besides environmental impacts, stormwater also causes adverse economic impacts. Each year brings millions of dollars in property damage from flooding,

frequently related to stormwater sediment deposition which clogs conveyances and reduces water storage. Stormwater pollutants also add to the cost of treating water used for drinking or by industry. Stormwater has also resulted in the closure of lakes to swimming and shellfish waters to harvesting, contributed to declining property values of waterfront homes and resulted in depressed fisheries.

In addition to the stormwater effects of new development, Florida's history of "ditching and draining" led to the proliferation of stormwater systems constructed solely for flood protection. These "drainage systems" were designed to carry stormwater away from developed areas as quickly as possible and deliver it to the nearest lake, river, sinkhole or bay. Today, these systems are major contributors of stormwater pollutants and to the decline of water quality in many Florida waters. A long term, carefully planned program to modify these systems to reduce their pollution loads will be an important element in Florida's efforts to provide clean and abundant water for future generations.

STORMWATER POLLUTANTS AND THEIR REMOVAL

To achieve the desired objectives of flood protection, water quality protection, erosion prevention and enhanced aesthetics and recreation, a stormwater management system must be an integral part of the site planning process for every project. Each site will contain natural attributes that should influence the type and configuration of the stormwater system. For example, sandy soils imply using infiltration practices such as retention areas integrated into the development's open space and landscaping while natural low areas and isolated wetlands offer opportunities for detention/wetland treatment. The variety of features contained on a site will often suggest which particular combination of Best Management Practices (BMPs) can be successfully integrated into an effective system. A stormwater management system should be viewed as a "treatment train" in which the individual BMPs are the cars. The more BMPs that are incorporated into the system, the better the performance of the train.

To effectively reduce stormwater pollution loads, the designer of a stormwater management system must also be aware of the pollutants typically found in stormwater and the biological, chemical and physical processes that remove the pollutants. The most common stormwater pollutants and amelioration mechanisms are summarized below:

1. Sediment is solid material that originates mostly from disintegrated rocks, or eroded soil or accumulated organic materials deposited on the land surface. The quantity, characteristics and causes of the occurrence of sediment are influenced by numerous factors including slope, length of slope, soil characteristics, land use and traffic volume. Sediment particles vary greatly in size and density. The settleability of a particular sediment particle depends directly on these two properties and these must be determined in order to build into the stormwater management system appropriate mechanisms to promote settling. Of course, the most effective control method for sedimentation is erosion control - prevent the production of sediment as much as possible.

2. Oxygen demanding substances include numerous organic materials which are decomposed by micro organisms thereby creating a need for oxygen. Consequently, a stormwater system such as a detention lake must include mechanisms to maintain high oxygen levels and prevent the formation of anaerobic conditions. Oxygenation mechanisms can be natural (such as shallow depths, sufficient length and width to induce wind mixing and orientation to maximize the opportunities for wind mixing, or mechanical (such as aerators).

3. Heavy metals in runoff from highways originate from the operation of motor vehicles, direct fallout and the degradation of highway materials. The most abundant heavy metals in stormwater are lead, zinc and copper which together account for about 90% of the dissolved heavy metals and 90-98% of the total metal concentrations (Harper, 1985). Except for copper and cadmium, most metal species are present in particulate form. Consequently, very good removal efficiencies (60-95%) can be obtained in properly designed stormwater management practices. To maximize heavy metal removal in retention or detention designs, designers should provide physical configurations which encourage a gradual reduction in flow velocity to promote particle sedimentation; maximize the flow length from inlets to the discharge point; prevent short circuiting of flows and hydraulically dead zones; and include suitable aquatic plants to promote removal of dissolved metals. To keep metals bound to sediment it is important that the sediment pH to be kept near 7 and that the sediments be aerobic. A decrease in pH and, to lesser extent, a reduction in redox potential will cause metals to become soluble and release from the sediment. For this reason, it is important to monitor the accumulation of sediment and decaying organic matter within detention ponds since this can result in lowered pH and possible anaerobic conditions. Failure to properly remove sediments could cause release of accumulated metals into the underlying groundwater or into surface waters.

4. Nutrients, such as nitrogen and phosphorus, stimulate the growth of algae and other aquatic plants and are common constituents of stormwater. These nutrients accelerlate the process of eutrophication in lakes and streams. Nutrients in stormwater may be either dissolved or particulate, with particulate forms slightly dominating (about 60%). Consequently, a stormwater management system, especially a detention system, must incorporate provisions for settling to remove particulate forms of nutrients and include nutrient assimilation for dissolved forms. A littoral zone planted with suitable aquatic plants should be concentrated near the discharge point to provide nutrient assimilation. Swale conveyance, sediment sumps or a perimeter swale and berm system can be used to reduce particulate nutrients.

FLORIDA'S STORMWATER MANAGEMENT PROGRAM

Recognition of the water quality problems caused by nonpoint sources led to the adoption in 1982 of Chapter 17-25, Florida Administrative Code, the Stormwater Rule. The objective of this regulation is to prevent the pollution of Florida waters from new stormwater discharges that were constructed after February 1, 1982. The vast number of new stormwater dischargers resulting

from Florida's rapid growth precluded the determination of an individual discharge limitation for each one and led to the creation of a performance standard based rule. Since the minimum treatment level for point sources was secondary treatment, a similar minimum treatment level was set for stormwater. This meant that the performance standards were selected so that the stormwater system would remove at least 80% of the annual pollution load. A copy of the current version of Chapter 17-25, F.A.C., can be found in Appendix 4-1.

In implementing the Stormwater Rule, it was the department's intent to delegate stormwater quality permitting to the water management districts so that it could be consolidated with their stormwater quantity permitting programs. The SFWMD received delegation in February, 1982 while the SWFWMD received delegation in March, 1984 with the SJRWMD and SRWMD obtaining delegation in April, 1986. Except within the SFWMD, permitting of wetland stormwater systems in accordance with Section 17-25.042, F.A.C., is conducted by the Department of Environmental Regulation. Appendix 4-2 summarizes delegation with respect to which agency issues a stormwater quality permit.

CHALLENGES FOR THE FUTURE

In addition to Florida's backlog of water quality problems and the increasing number of new resource degradation problems, Florida faces many institutional roadblocks that hinder effective, innovative resources management. State laws and rules still promote piecemeal, crisis solving approaches which are aimed at managing resources within political boundaries. Also, there are many overlapping agency and governmental authorities regulating stormwater and other environmental impacts which has often proven to be counterproductive.

There is a major need for re-evaluating regulatory approaches to shift the emphasis toward more comprehensive, prevention oriented strategies. This new management perspective is called "Watershed Planning" and stormwater management is a very important element in this approach.

The following comparison is provided to illustrate the basic differences between the current piecemeal approach and a comprehensive watershed approach to stormwater management. (CDM, 1985).

1. Piecemeal Approach: In the case of existing urban development, this option involves addressing local stormwater problems without evaluating the potential for the runoff control measure to cause adverse impacts in downstream areas. An example is the construction of a relief sewer in upstream areas without evaluating downstream impacts. In the case of future urban development, this option involves the delegation of stormwater management responsibilities to local land developers. Each developer is responsible for constructing stormwater management facilities on his development site to maintain post-development peak runoff and pollution loads from the site at predevelopment levels.

2. Comprehensive Approach: This option involves developing a comprehensive watershed plan, known as the "master plan", which identifies the most appropriate control measures and optimum locations to control watershed-wide impacts. This approach typically involves combinations of the following: (a) strategically locating a single stormwater

detention facility (i.e., stormwater pond) to control post-development runoff from several land development projects; (b) providing stream channel improvements (e.g., removal of obstructions to flow, riprap, widening, deepening) where necessary upstream of the stormwater detention facility; and (c) nonstructural measure such as parkland acquisition and floodproofing to supplement structural control measures. In addition, watershed management allows the coordination of infrastructure improvements, point source management and nonpoint source management and provides a vital linkage between land use management and water resources management.

While the piecemeal approach to urban stormwater management is relatively easy to administer, it offers the following disadvantages; greater risk of negative spillover effects, particularly in multi-juridictional watersheds; insignificant flood protection benefits due to the emphasis on minor flooding impacts; ineffective runoff control throughout the watershed due to the failure to evaluate locational differences in the benefits of detention facilities; relatively high local costs for facility maintenance activities; and unnecessary costs for the use of small-scale structural solutions instead of large-scale nonstructural solutions which are much cheaper. Included among the potential negative effects of a piecemeal stormwater management program are:

- The piecemeal program may only partially solve the major flooding problem(s).
- The piecemeal program may solve flooding problems in the upstream jurisdiction, but create a flooding problem(s) in the downstream jurisdiction;
- Randomly located detention basins may actually increase downstream peak flows, rather than reduce them;
- The piecemeal program may result in prohibitively high maintenance costs for the significant number of runoff control facilities;
- Significant capital and O&M expenditures may be wasted; and
- The costs of remedial structural solutions are likely to be much greater than the overall costs if an adequate management program had been implemented in the first place.

The master plan approach offers significant advantages over the piecemeal approach including: reductions in capital and O&M costs; reductions in the risk of downstream flooding and erosion, particularly in multi-jurisdictional watersheds; opportunities to manage existing stormwater problems; capability to consider nonstructural measures; increases in land development opportunities; increased opportunities for recreational uses of runoff controls; potential contributions to local land use planning; and popularity among land developers.

The major disadvantage of the master plan approach include: local governments must perform advance planning studies to locate and develop preliminary designs for regional stormwater management facilities; local governments must finance, design, and construct the regional stormwater

management facilities; local governments must finance, design, and construct the regional stormwater management facilities before the majority of future urban development occurs, with reimbursement by developers over a build-out period that can last 5-20 years; and, in some cases, local governments may be required to carry out extraordinary maintenance activities for regional stormwater management facilities which are perceived by the public to be primarily recreational facilities that merit water quality protection.

Local governments will play a particularly important role in watershed planning for several reasons. They determine zoning and land use, issue building permits, inspect projects, and have code enforcement powers. Also, because there is no statewide management framework in place, local governments have the choice to pursue master planning efforts on their own.

Development of any comprehensive watershed management program, whether on a statewide or local basis will require maximum cooperation, a "team approach" between all participating agencies and governments along with the private sector. More and more communities are shifting from the piecemeal to the comprehensive approach and ultimately the future of Florida's water resources will depend on the extent to which this leadership is followed.

PRINCIPLES OF STORMWATER MANAGEMENT

- It is much more efficient and cost-effective to prevent problems than to attempt to correct problems after the fact. Sound land use planning decisions based on the site planning principles discussed in Chapter 2 are essential as the first, and perhaps the most important, step in managing stormwater related problems. All new development plans (e.g., subdivisions, shopping centers, industrial parks, office centers, etc.) and redevelopment plans should include a comprehensive stormwater management system.

- Every piece of land is part of a larger watershed. A stormwater management system for each development project should be based on, and should support a plan for the entire drainage basin.

- Optimum design of the stormwater management system should mimic (and use) the features and functions of the natural drainage system which is largely capital, energy and maintenance cost free. Every site contains natural features which contribute to the management of stormwater under the existing conditions. Depending upon the site, existing features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. "Natural" engineering techniques should be used to preserve and enhance the natural features and processes of a site and to maximize the economic and environmental benefits. Natural engineering is particularly effective when combined with open space and recreational use of the site, or in "blue-green" developments using cluster techniques. Engineering design can and should be used to improve the effectiveness of natural systems, rather than negate, replace or ignore them.

- The volume, rate, timing and pollutant load of stormwater after development should closely approximate the conditions which occurred before development. To accomplish these objectives two overall concepts must be considered: (1) the perviousness of the site should be maintained to the greatest extent possible; and (2) the rate of runoff should be slowed. Preference should be given to stormwater management systems which use BMPs that maintain vegetative and porous land cover and include on-site storage mechanisms. These systems will promote infiltration, filtering and slowing of the runoff.

- Maximize on-site storage of stormwater. Provision for storage can reduce peak runoff rates; aid in groundwater recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion and sedimentation; and provide water for other beneficial uses. Where practical, the "blue-green" approach to development should be employed; it inherently provides storage, environmental protection and enhancement of community amenities.

- Stormwater runoff should never be discharged directly into surface or ground waters. Runoff should be routed over a longer distance, through grassed waterways, wetlands, vegetated buffers and other works designed to increase overland "sheet" flow. These systems increase infiltration and evaporation, allow suspended solids to settle, and remove pollutants before they are introduced to Florida's waters.

- Stormwater management systems, especially those emphasizing vegetative practices, should be planned, constructed and stabilized in advance of the facilities that will discharge into them. This principle is frequently ignored thereby causing unnecessary off-site impacts, extra maintenance, re-working of grades, re-vegetation of slopes and grassed waterways, and extra expense to the developer. The stormwater management system, including erosion and sedimentation controls, should be constructed and stabilized at the start of site disturbance and construction activities.

- The stormwater management system must be designed beginning with the outlet or point of outflow from the project. The downstream conveyance system should be evaluated to ensure that it contains sufficient capacity to accept the design discharge without adverse downstream impacts such as flooding, streambank erosion and sedimentation. It may be necessary to stabilize the downstream conveyance system, especially near the stormwater system outlet. Another common problem is a restricted outlet which causes stormwater to back up and exceed the storage capacity of the collection and treatment system resulting in temporary upstream flooding. This may lead to hydraulic failure of the stormwater management system causing resuspension of the pollutants and/or expensive repairs to damaged structures or property. In such circumstances it is advisable to use more than one outlet or to increase the on-site storage volume.

- Whenever possible, construct the components of the stormwater management system on the contour following the topography. This will minimize erosion and stabilization problems caused by excessive velocities; it will also slow the runoff allowing for greater infiltration and filtering.

- Stormwater is a component of the total water resources which should not be casually discarded but used to replenish those resources. Stormwater represents a potential resource out of place, with its location determining whether it is a liability or an asset. Given the water quantity and quality problems facing Florida, it is imperative that we consider stormwater to be an asset. Treated stormwater has a great potential for providing many beneficial uses such as irrigation (farm, lawn, parks, golf courses), recreational lakes, groundwater recharge, industrial cooling and process water, and other nonpotable domestic uses.

- Whenever practical, multiple use temporary storage basins should be an integral component of the stormwater management system. All too often, storage facilities planned as part of the system are conventional, unimaginative ponds which are aesthetically unpleasing. Recreational areas (e.g., ballfields, tennis courts, volleyball courts), greenbelt areas, neighborhood parks and even parking facilities provide excellent settings for the temporary storage of stormwater. Such areas are not usually in use during periods of precipitation and the ponding of stormwater for short durations does not seriously impede their primary functions.

- Storage areas should be designed with sinuous shorelines. Shorelines which are sinuous rather than straight increase the length of the shoreline thereby creating greater development opportunities if a blue-green concept of permanent lakes is being used. The increased shoreline also provides more space for the growth of littoral vegetation thus providing for greater pollutant filtering and for increased and diversified aquatic habitat.

- Vegetated buffer strips should be retained in their natural state or created along the banks of all water bodies. Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a floodplain during periods of high water. They also provide a pervious strip along a shoreline which can accept sheet flow from developed areas and help minimize the adverse impacts of untreated stormwater.

- The stormwater management system must receive regular maintenance. Failure to provide proper maintenance reduces the pollutant removal efficiency of the system and reduces the system's hydraulic capacity. Lack of maintenance, especially to vegetative systems which may require revegetating, can increase the pollutant load of stormwater discharges. The key to effective maintenance is the clear assignment of responsibilites to an established agency (local government) or organization (homeowners association) and a regular schedule of inspections to determine maintenance needs. Even better, stormwater system designers should seek to make their systems as simple, natural and maintenance free as possible.

CHAPTER 17-25
REGULATION OF STORMWATER DISCHARGE

17-25.001 Scope.
17-25.020 Definitions.
17-25.025 Design and Performance Standards.
17-25.027 Legal Operation/Maintenance Entity Requirements.
17-25.030 Exemptions.
17-25.035 Stormwater General Permits.
17-25.040 Construction Permit Requirements for New Stormwater Discharge Facilities.
17-25.042 Permit Requirements for Wetlands Stormwater Discharge Facilities.
17-25.050 Delegation.
17-25.060 Relationship to Other Permitting Requirements.
17-25.070 Transferability of Other Chapters. (Repealed)
17-25.080 General Provisions.
17-25.090 List of Entities to Which Permitting Pursuant to this Chapter has been Delegated; Addresses; Delegation Documents and Rules Adopted by Reference.
17-25.100 Effective Date. (Repealed)

17-25.001 Scope.

(1) The discharge of untreated stormwater may reasonably be expected to be a source of pollution of waters of the state and is, therefore, subject to Department regulation. The Department shall prevent pollution of waters of the state by discharges of stormwater, to ensure that the designated most beneficial uses of waters, as prescribed by Chapter 17-3, Florida Administrative Code, are protected.

(2) A permit under this chapter will be required only for new stormwater discharge facilities as defined herein. This provision shall not affect the Department's authority to require appropriate corrective action, pursuant to Sections 403.121 - 403.161, Florida Statutes, whenever existing facilities cause or contribute to violations of state water quality standards.

(3) Stormwater discharges to groundwaters shall be regulated under the provisions of Section 17-4.245, F.A.C. and other applicable rules of the Department.

(4) The Department intends that, to the greatest extent practicable, the provisions of this chapter be delegated to either local governments or water management districts seeking such delegation.

Specific Authority: 403.061, F.S.
Law Implemented: 403.021, 403.061, 403.101(1), F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 1-26-84. Previously numbered as 17-25.01.

17-25.020 Definitions.

(1) "Artificial Watercourse" means a man-made waterway that was totally dredged or excavated prior to October 1, 1984 and which connects formerly isolated, nonjurisdictional wetlands to other waters. The Department shall bear the burden to show that such artificial watercourse was not totally dredged or excavated or that the connected wetlands were formerly jurisdictional.

(2) "Completion of Construction" means the time at which the stormwater discharge facility is first placed into operation or when the project passes final building inspection or when the project receives a certificate of occupancy, whichever comes first.

(3) "Conservation Plan" means a formal document, prepared or approved by a local Soil and Water Conservation District Board organized pursuant to Chapter 582, Florida Statutes, which outlines a system of management practices to control soil erosion, reduce sediment loss or protect the water quality on a specific parcel of property.

(4) "Construction" means any on-site activity which will result in the creation of a new stormwater discharge facility, including the building, assembling, expansion, modification or alteration of the existing contours of the property, the erection of buildings or other structures, or any part thereof, or land clearing.

(5) "Detention" or "To Detain" means the collection and temporary storage of stormwater in such a manner as to provide for treatment through physical, chemical, or biological processes with subsequent gradual release of the stormwater.

(6) "Engineer" means a Professional Engineer registered in Florida, or other person exempted pursuant to the provisions of Chapter 471, Florida Statutes, who is competent in the fields of hydrology and stormwater pollution control.

(7) "Effective Grain Size" means the diameter of filter sand or other aggregate that corresponds to the 10 percentile finer by dry weight on the grain size distribution curve.

(8) "Filtration or "To Filter" means the selective removal of suspended matter from stormwater by passing the water through at least 2 feet of suitable fine textured granular media such as porous soil, uniformly graded sand and gravel, or other natural or artificial aggregate, which may be used in conjunction with filter fabric and/or underdrain pipe.

(9) "Intermittent Watercourse" means a stream or waterway that flows only at certain times of the year, flows in direct response to rainfall, and is normally an influent stream except when the groundwater table rises above the normal wet season level.

(10) "New Stormwater Discharge Facility" means a stormwater discharge facility which was not in existence on February 1, 1982, or for which a completed stormwater discharge, dredge or fill, or other Department permit or license application had not been received before February 1, 1982, or an existing stormwater discharge facility which is modified, as specified in Section 17-25.040(3), Florida Administrative Code, on or after February 1, 1982. A stormwater discharge facility approved or found to be exempt by the Department before February 1, 1982, or a facility which had been determined by the Department not to be significant pursuant to 17-4.248(5)
before February 1, 1982, or a facility exempted pursuant to Section 17-25.030(2) shall not be considered a new stormwater discharge facility unless modified pursuant to Section 17-25.040(3).

(11) "Regional Stormwater Discharge Facility" means a stormwater discharge facility which is permitted pursuant to Section 17-25.040(6) and is designed and constructed to accept stormwater from multiple parcels within the drainage area served by the regional facility. Drainage area refers to the land or development that is served by and/or contributes stormwater to the regional facility.

(12) "Retention" or "To Retain" means the prevention of, or to prevent the discharge of, a given volume of stormwater runoff into surface waters of the state by complete on-site storage.

(13) "Stormwater" means the flow of water which results from, and which occurs immediately following, a rainfall event.

(14) "Stormwater Discharge Facility" means a stormwater management system which discharges stormwater into surface waters of the State.

(15) "Stormwater Management System" means the designed features of the property which collect, convey, channel, hold, inhibit or divert the movement of stormwater.

(16) "Swale" means a manmade trench which:

(a) has a top width-to-depth ratio of the cross-section equal to or greater than 6:1, or side slopes equal to or greater than 3 feet horizontal to 1 foot vertical; and,

(b) contains contiguous areas of standing or flowing water only following a rainfall event; and,

(c) is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake; and,

(d) is designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce pollutant concentration of any discharge.

(17) "Uniformity Coefficient" means the number representing the degree of homogeneity in the distribution of particle sizes of filter sand or other granular material. The coefficient is calculated by determining the D^{60}/D^{10} ratio where D^{10} and D^{60} refer to the particle diameter corresponding to the 10 and 60 percentile of the material which is finer by dry weight.

(18) "Waters" are as defined in Section 403.031(12), Florida Statutes.

(19) "Wetlands" means, for the purposes of this rule, those waters which are dominated by those plant species listed in Section 17-4.020(18) or Section 17-4.022, F.A.C. and which meet the conditions specified in Section 17-25.042(2), F.A.C.

(20) "Wetlands Stormwater Discharge Facility" means a new stormwater discharge facility which incorporates those wetlands identified in Section 17-25.042(2), F.A.C. into the stormwater management system to provide stormwater treatment.

Specific Authority: 403.061, F.S.
Law Implemented: 403.021, 403.031, 403.061, 403.913, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 3-30-82, 1-26-84, 5-8-85. Previously numbered as 17-25.02.

17-25.020(11) -- 17-25.020(History)

05-14-86

17-25.025 Design and Performance Standards.

The following design and performance standards are established for the purpose of determining compliance with this chapter, however, in some instances they may not result in compliance with water quality standards set forth in Chapters 17-3 and 17-4, F.A.C. No discharge from a stormwater discharge facility shall cause or contribute to a violation of water quality standards in waters of the state. Unless the applicant provides reasonable assurance that the discharge will not cause or contribute to a violation of water quality standards in waters of the state, the Department may require more stringent design and performance standards than are otherwise required by this chapter:

(1) Detention basins shall again provide the capacity for the specified treatment volume of stormwater within 72 hours following a storm event.

(2) Filtration systems shall have pore spaces large enough to provide sufficient flow capacity so that the permeability of the filter is equal to or greater than the surrounding soil. The design shall ensure that the particles within the filter do not move. When sand or other fine textured aggregate other than natural soil are used for filtration, the filter material should be of a quality sufficient to satisfy the following requirements:

(a) Washed (less than 1 percent silt, clay and organic matter) unless filter cloth is used which is suitable to retain the silt, clay and organic matter within the filter;

(b) Uniformity coefficient 1.5 or greater; and

(c) Effective grain size of 0.20 to 0.55 millimeters in diameter. These criteria are not intended to preclude the use of multilayered filters nor the use of materials to increase ion exchange, precipitation or pollutant adsorption capacity of the filter.

(3) Filtration systems shall be designed with a safety factor of at least two unless the engineer affirmatively demonstrates based on plans, test results, calculations or other information that a lower safety factor is appropriate for the specific site conditions. Examples of how to apply this factor include but are not limited to reducing the design percolation rate by half, doubling the length of underdrain or designing for the required drawdown within 36 hours.

(4) Retention basins shall again provide the capacity for the given volume of stormwater within 72 hours following the storm event. The additional storage volume must be provided by a decrease of stored water caused only by percolation through soil, evaporation or evapotranspiration.

(5) Swales shall be designed to percolate 80% of the runoff from a three-year, one-hour design storm within 72 hours after a storm event, assuming average antecedent conditions.

(6) Unless applicable local regulations are more restrictive, for purposes of public safety, permanently wet retention and detention basins shall either be fenced or otherwise restricted from public access or contain side slopes that are no steeper than 4:1 (horizontal:vertical) out to a depth of two feet below the control elevation. All side slopes shall be stabilized by either vegetation or other materials to minimize erosion and subsequent sedimentation of the basins.

(7) Erosion and sediment control best management practices shall be used as necessary during construction to retain sediment on-site. These management practices shall be designed by an engineer or other competent professional experienced in the fields of soil conservation or sediment control according to specific site conditions and shall be shown or noted on the plans of the stormwater management system. The engineer or designer shall furnish the contractor with information pertaining to the construction, operation and maintenance of the erosion and sediment control practices.

(8) Stormwater discharge facilities which receive stormwater from areas which are a potential source of oil and grease contamination in concentrations exceeding applicable water quality standards shall include a baffle, skimmer, grease trap or other mechanism suitable for preventing oil and grease from leaving the stormwater discharge facility in concentrations that would cause or contribute to violations of applicable water quality standards in the receiving waters.

(9) Stormwater discharge facilities which directly discharge to Outstanding Florida Waters shall include an additional level of treatment equal to fifty percent of the treatment criteria specified in Section 17-25.035(1)(b) or Section 17-25.040 or Section 17-25.042, F.A.C.

Specific Authority: 403.061, 403.912, F.S.
Law Implemented: 403.021, 403.061, 403.101(1), F.S.
History: New 1-26-84, Amended 3-28-84, 5-8-85.

17-25.027 Legal Operation/Maintenance Entity Requirements.

(1) The Department considers the following entities to be acceptable for meeting the requirements necessary to ensure that a stormwater discharge facility will be operated and maintained in compliance with the requirements of this chapter and other Department regulations:

(a) local governmental units including counties or municipalities, or Municipal Service Taxing Units.

(b) active water control districts pursuant to Chapter 298 Florida Statutes or drainage districts created by special act, or Community Development Districts pursuant to Chapter 190 Florida Statutes, or Special Assessment Districts pursuant to Chapter 170 Florida Statutes.

(c) state or federal agencies.

(d) duly constituted communication, water, sewer, electrical or other public utilities.

(e) the property owner or developer is normally not acceptable as a responsible entity when the property is intended to be sold to third parties. However, the property owner or developer may be acceptable under one of the following circumstances:

1. Written proof in the appropriate form by either letter or resolution, that a governmental entity or such other acceptable entity as set forth in paragraphs (a)-(c) above, will accept the operation and maintenance of the stormwater management and discharge facility at a time certain in the future.

2. Bonding or other assurances sufficient to operate and perform anticipated maintenance on stormwater facilities.

(f) profit or non-profit corporations including homeowners associations, property owners associations, condominium owners associations or master associations shall be acceptable only under certain conditions that ensure that the corporation has the financial, legal and administrative capability to provide for the long term operation and maintenance of the stormwater discharge facility.

(2) Entity Requirements.

(a) if a Homeowner, Property Owner, Condominium or Master Association is proposed, the owner or developer must submit the Articles of Incorporation, Declaration, Restrictive Covenants, Deed Restrictions or such other organizational or operational documents affirmatively taking responsibility for the operation or maintenance of the stormwater discharge facility.

(b) the Association shall have sufficient powers reflected in its organizational or operational documents to:

1. operate and maintain the stormwater management system and the stormwater discharge facility as exempted or permitted by the Department.

2. establish rules and regulations.

3. assess members.

4. contract for services (if the Association contemplates employing a maintenance company) to provide the services for operation and maintenance.

5. the Association shall exist in perpetuity; however, if the Association is dissolved, the Articles of Incorporation must provide that the stormwater management system and discharge facility shall be maintenanced by an entity as set forth in paragraph (1) of this rule.

(3) Phased Projects.

(a) if an Operation/Maintenance entity is proposed for a project which will be constructed in phases, and subsequent phases will utilize the same stormwater management facilities as the initial phase or phases, the entity shall have the ability to accept responsibility for the operation/maintenance of stormwater discharge facility for future phases of the project.

(b) if the development scheme contemplates independent operation/maintenance entities for different phases, and the stormwater management system is integrated throughout the project, the entities, either separately or collectively shall have the responsibility and authority to operate and maintain the stormwater management system and discharge facility for the entire project. That authority shall include cross easements for stormwater management and the ability to enter and maintain the various facilities, should any sub-entity fail to maintain a portion of the stormwater management system or discharge facility within the project.

(4) The applicant shall be an acceptable entity from the time construction begins until the stormwater discharge facility is dedicated to and accepted by an established legal entity pursuant to (1) above. The applicant shall provide proof of the existence of an entity pursuant to (1) above or of the future acceptance of the facility by an entity described in (1) above prior to initiating construction.

17-25.027(1)(e)2. -- 17-25.027(4)

05-14-86

(5) The provisions of this section shall become effective on October 1, 1985.
Specific Authority: 403.061, 403.087, 403.088, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.182, F.S.
History: New 5-8-85.

17-25.030 Exemptions.

(1) The following types of new stormwater discharge facilities are exempt from the notice and permit requirements of this chapter:

(a) facilities designed to accomodate only one single family dwelling unit, duplex, triplex, or quadruplex, provided the single unit, duplex, triplex or quadruplex is not part of a larger common plan of development or sale;

(b) facilities which are designed to serve single family residential projects, including duplexes, triplexes and quadruplexes, of less than 10 acres total land area and which have less than 2 acres impervious surface provided that the facilities:

1. comply with all regulations or ordinances applicable to stormwater management and adopted by a city or county; and

2. are not part of a larger common plan of development or sale; and

3. discharge into a stormwater discharge facility exempted or permitted by the Department under this chapter which has sufficient capacity and treatment capability as specified in this chapter and is owned, maintained, or operated by a city, county, special district with drainage responsibility, or water management district; however, this exemption does not authorize discharge to a facility without the facility owner's prior written consent; or

4. discharge into a stormwater discharge facility which has sufficient capacity and is part of a master drainage plan adopted by a city or county; however, this exemption does not authorize discharge to a facility without the facility owner's prior written consent.

(c) stormwater discharge facilities whose functioning treatment components consist entirely of swales. However, this exemption is valid only if the swale, as constructed, meets or exceeds the requirements specified in Section 17-25.020(16) and Section 17-25.025(5).

(d) facilities which discharge into a regional stormwater discharge facility which is permitted pursuant to Section 17-25.040 where the appropriate treatment criteria specified in this chapter and applied to the permitted regional facility are met by the discharge; however, this exemption does not authorize discharge to the permitted regional facility without the facility owner's prior written consent.

(e) facilities for agricultural lands, provided those facilities are part of an approved Conservation Plan; however, if the Conservation Plan is not implemented according to its terms, this exemption shall be void; and

(f) facilities for silvicultural lands, provided that the facilities are constructed and operated in accordance with the Silviculture Best Management Practices Manual (1979), published by the State of Florida, Department of Agriculture and Consumer Services, Division of Forestry, which is adopted and made a part of this rule by reference. A copy of this manual may be obtained by writing the Department of Agriculture, Division of Forestry, 3125 Conner Boulevard, Tallahassee, Florida, and may be inspected at all Department of Environmental Regulation offices.

(2) Within the geographical area for which the Department has delegated stormwater permitting to the Southwest Florida Water Management District, the following types of new stormwater discharge facilities are exempt from the permitting requirements of this chapter provided that the owner files notice and an engineer certifies to the District, on forms provided by the District, at least 30 days prior to construction that the discharge facility will meet the criteria specified below, and provided that an entity responsible for operation and maintenance of the proposed facility has been determined. Furthermore, an engineer shall certify on forms provided by the District, within 30 days after completion of construction that the new stormwater discharge facility, as constructed, qualifies for exemption under this section. The District may require that the owner and engineer furnish appropriate design analyses, calculations, drawings, specifications and other information to describe, verify and document that the proposed stormwater discharge facility qualifies for exemption according to this section.

(a) facilities which discharge into a stormwater discharge facility which is permitted pursuant to section 17-25.040 or exempt pursuant to section 17-25.030 where the appropriate treatment criteria specified in this chapter and applied to the permitted or exempt facility are not exceeded by the discharge; however, this exemption does not authorize discharge to permitted or exempt facilities without the facility owners prior written consent; or,

(b) facilities which provide retention, or detention with filtration, of the runoff from the first one inch of rainfall; or, as an option, for projects or project subunits with drainage areas less than 100 acres, facilities which provide retention, or detention with filtration, of the first one half inch of runoff. However, facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment pursuant to Section 17-25.025(9), F.A.C.; or,

(c) modification or reconstruction by a city, county, state agency, special district with drainage responsibility, or water management district of an existing stormwater management system which is not intended to serve new development, and which will not increase pollution loading, or change points of discharge in a manner that would adversely affect the designated uses of waters of the state.

(d) facilities of stormwater management systems that include a combination of management practices including but not limited to retention basins, swales, pervious pavement, landscape or natural retention storage that will provide for the percolation of the runoff from a three-year one-hour design storm.

Specific Authority: 403.061, 403.087, 403.088, 403.504, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.121, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 3-30-82, 1-26-84, 3-28-84, 5-8-85. Previously numbered as 17-25.03.

17-25.030(2) -- 17-25.030(History)

05-14-86

17-25.035 Stormwater General Permits.

(1) Except in the geographical area for which the Department has delegated stormwater permitting to the Southwest Florida Water Management District, the following types of new stormwater discharge facilities may be constructed pursuant to general permit as specified in Section 17-4.710, F.A.C. This general permit shall not expire and shall not be subject to Section 17-4.540(13) unless suspended or revoked in accordance with Section 17-4.530(5).

(a) facilities which discharge into a stormwater discharge facility which is permitted pursuant to Section 17-25.040 or Section 17-25.035(1)(b) or (d), F.A.C. or which was previously approved pursuant to a noticed exemption under Section 17-25.030 where the appropriate treatment criteria specified in this chapter and applied to the permitted or exempt facility are not exceeded by the discharge; however, this does not authorize discharge to the permitted or exempt facility without the facility owner's prior written consent; or,

(b) facilities which provide retention, or detention with filtration, of the runoff from the first one inch of rainfall; or, as an option, for projects or project subunits with drainage areas less than 100 acres, facilities which provide retention, or detention with filtration, of the first one half inch of runoff. However, facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment pursuant to Section 17-25.025(9), F.A.C.; or,

(c) modification or reconstruction by a city, county, state agency, special district with drainage responsibility, or water management district of an existing stormwater management system which is not intended to serve new development, and which will not increase pollution loading, or change points of discharge in a manner that would adversely affect the designated uses of waters of the state; or,

(d) facilities of stormwater management systems that include a combination of management practices including but not limited to retention basins, swales, pervious pavement, landscape or natural retention storage that will provide for the percolation of the runoff from a three-year one-hour design storm.

Specific Authority: 403.814(1), 403.912, F.S.
Law Implemented: 403.061, 403.087, 403.088, 403.121, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, 403.814, F.S.
History: New 5-8-85.

17-25.040 Construction Permit Requirements for New Stormwater Discharge Facilities.

(1) Any person intending to construct a new stormwater discharge facility, except as exempted pursuant to Section 17-25.030, Florida Administrative Code, or as noted in Section 17-25.035, or as permitted in Section 17-25.042, or as noted in Section 17-25.060, Florida Administrative Code, shall apply to the Department for a construction permit, using forms provided by the Department, prior to commencement of construction of the stormwater discharge facility. In a geographical area where delegation has occurred, pursuant to Section 17-25.050, Florida Administrative Code, application shall be made pursuant to the provisions of the rules of the entity receiving the delegation.

(2) Construction of a new stormwater discharge facility shall not be undertaken without a valid construction permit as required pursuant to this section.

(3) Modifications to an existing stormwater management system that will increase the discharge of the stormwater discharge facility beyond its previously designed and constructed capacity, or increase pollution loading, or change points of discharge, except for emergency repairs, are considered new stormwater discharge facilities for purposes of this chapter.

(4) A construction permit may be issued to the applicant, upon such conditions as the Department may direct, only if the applicant affirmatively provides the Department with reasonable assurance based on plans, test results and other information, that the construction, expansion, modification, operation, or activity of the stormwater discharge facility will not discharge, emit, or cause pollution in contravention of Department standards, rules or regulations.

(5) A showing by the applicant that the facility design will provide treatment equivalent to either retention, or detention with filtration, as described in this Chapter, of the runoff from the first one inch of rainfall; or, as an option for projects or project subunits with drainage areas less than 100 acres, the first one half inch of runoff, shall be presumed to provide reasonable assurance pursuant to subsection (4) above, provided that adequate provisions have been made for operation and maintenance of the proposed facility. However, facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment as specified in Section 17-25.025(9).

(6) Regional stormwater discharge facilities shall be permitted upon application and a showing by the applicant that:

(a) the facility will provide treatment equivalent to either retention, or detention with filtration, of the runoff from the first one inch of rainfall; or, as an option, for facilities with a drainage area less than 100 acres, the first one half inch of runoff; and,

(b) facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment as specified in Section 17-25.025(9); and,

(c) the facility is designed to meet the treatment criteria specified in (a) or (b) above for projected future land use conditions and associated stormwater volumes; and,

(d) the owner of the facility notifies the Department on a semi-annual basis, on forms provided by the Department, of all new projects and their associated stormwater volumes that have been allowed to discharge stormwater into the regional facility and certifies that the maximum allowable treatment volume of stormwater has not been exceeded.

(e) adequate provisions have been made for the operation and maintenance of the proposed facility.

(7) In otherwise determining whether reasonable assurance has been provided, the Department shall, where appropriate, consider:

(a) whether best management practices are proposed. such as those described in "A Manual of Reference Management Practices for Urban Activities (July, 1978)", "A Manual of Reference Management Practices for Construction Activities (December, 1977)", "A Manual of Reference Management Practices for Agricultural Activities (November 1978)", "Silviculture Best Management Practices Manual (1979)", "Stormwater Management Manual (October 1981)", or best management practices described in manuals adopted by the Environmental Regulation Commission pursuant to Section 17-25.050, or other appropriate best management practices. The manuals listed above by name are adopted and made a part of this rule by reference. Copies of these documents may be obtained by writing the Department, and may be inspected at all Department offices;

(b) the public interest served by the discharge;

(c) the probable efficacy and costs of alternative controls;

(d) whether the proposed water quality benefits are reasonably related to the costs of the controls; and

(e) whether reasonable provisions have been made for the operation and maintenance of the proposed facility.

Specific Authority: 403.031, 403.061, 403.912, F.S.
Law Implemented: 403.021, 403.031, 403.061, 403.087, 403.088, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 3-30-82, 1-26-84, 3-28-84, 5-8-85. Previously numbered as 17-25.04.

17-25.042 Permit Requirements for Wetlands Stormwater Discharge Facilities.

(1) The wetlands stormwater discharge facility performance standards and other provisions relating to such facilities are an initial but necessary step by the Department in a field in which there exists limited knowledge. In an effort to further refine the state's wetlands stormwater discharge facility policies, monitoring data and other pertinent information relating to the performance standards will be collected and analyzed and periodic reports of the results of this monitoring shall be made available to the public. The Department must attempt to ensure that the wetlands stormwater discharge facility is compatible with the ecological characteristics of the wetlands utilized for stormwater treatment and to ensure that water quality standards will not be violated by discharges from wetlands stormwater discharge facilities. To achieve these goals, specific performance standards are set forth in this chapter. However, recognizing the complexities and concerns of implementing wetlands stormwater treatment performance standards, the Department shall review the monitoring data and other pertinent information on a regular basis. The Department shall present the information to the Commission at a public hearing no later than April 1, 1989. Unless the Commission affirmatively determines that the performance standards remain appropriate, or amends them as it deems necessary, Section 17-25.042(6) shall be repealed effective April 1, 1989.

(2) The wetlands to be used for stormwater management are those:

(a) which are connected to other waters by artificial watercourses; or

(b) which are connected to other waters solely by an intermittent watercourse.

(3) Any person who owns or has written authorization to use a wetland for stormwater treatment shall apply to the Department for a wetlands stormwater discharge facility permit, using forms provided by the Department, and shall receive such permit prior to commencement of construction of the stormwater discharge facility. The application shall be processed by the Department according to the procedures of Chapter 17-4, F.A.C.

(4) A wetlands stormwater discharge facility permit may be issued to the applicant, upon such conditions as the Department may direct, only if the applicant affirmatively provides the Department with reasonable assurance based on plans, test results or other information, that the construction, operation, or activity of the stormwater discharge facility shall not emit, or cause pollution in downstream waters in contravention of Department standards, rules or regulations.

(5) In the review of wetlands stormwater discharge facility permit applications, the Department shall consider the following:

(a) compliance of the wetlands stormwater discharge facility permit with the performance standards specified in Section 17-25.042(6), F.A.C.

(b) if the applicant is unable to show compliance with the performance standards in Section 17-25.042(6), the applicant may qualify for a wetlands stormwater discharge facility permit using alternative design and performance standards approved by the Department provided that the use of the wetlands is compatible with the ecological characteristics of the wetland and the applicant complies with Section 17-25.042(4), F.A.C.

(c) if the applicant proposes to dredge or fill in the wetlands used for stormwater treatment, the Department in its review of the permit application shall evaluate the adverse effects of the dredging or filling on the treatment capability of the wetland.

(6) A showing by the applicant that the wetlands stormwater discharge facility design complies with the performance standards listed below shall create a presumption in favor of the issuance of the permit:

(a) the facility complies with the requirements of Section 17-25.060(2), F.A.C.

(b) the facility is part of a comprehensive stormwater management system that utilizes wetlands in combination with other best management practices to provide treatment of the runoff from the first one inch of rainfall; or, as an option for projects or project subunits with drainage areas less than 100 acres, the first one-half inch of runoff. Those facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment as specified in Section 17-25.025(9), F.A.C.

(c) the utilization of wetlands for stormwater treatment shall not adversely affect the wetland by disrupting the normal range of water level fluctuation of the wetland as it existed prior to construction of the wetlands stormwater discharge facility. Normal range of water level fluctuation will be defined as the maintenance of the fluctuating water surface changes between the normal low water and the normal high water of the wetland system so as to prevent the desiccation or over impoundment of the wetland. The Department shall use water level data, lines on the trees, adventitious roots or other hydrological and biological indicators to determine the normal low and normal high water levels. Upland detention may be necessary to attenuate peak flows and meet the water level fluctuations specified above. When the normal range of water level fluctuations has been artificially altered, the Department shall establish an acceptable range of water level fluctuation based on historical information as to the previous size and nature of the wetlands, if available. If such information is not available, the range of water level fluctuation shall be derived from sound scientific principles or from analysis of other natural wetland systems in the vicinity.

(d) the wetlands stormwater discharge facility must be able to contain the runoff as specified in Section 17-25.042(6)(b), F.A.C. within the wetlands. Where the wetlands stormwater discharge facility alone cannot contain the runoff volume specified in (b) above within the water level ranges specified in (c) above, the other best management practices of the stormwater management system shall not adversely affect the ability of the wetlands stormwater discharge facility from meeting the requirements of this section. The design features of the facility shall maximize residence time of the stormwater within the wetland. The outfall structure shall be designed to bleeddown the volume specified in Section 17-25.042(6)(b) in no less than 120 hours with no more than one-half of the volume to be discharged within the first 60 hours.

(e) stormwater shall be discharged into the wetlands utilized so as to minimize the channelized flow of stormwater by employing methods including, but not limited to, sprinklers, overland flow or spreader swales.

(f) facilities which receive stormwater from areas which are a potential source of oil and grease contamination in concentrations exceeding applicable water quality standards shall include a baffle, skimmer, grease trap or other mechanism to minimize the amounts of oils and greases entering the wetlands utilized for stormwater treatment.

(g) erosion and sediment controls shall be used during construction and operation of the facility to minimize sedimentation of the wetlands utilized for stormwater treatment. The sediment control mechanism shall be built in the uplands and be of sufficient size and design to minimize resuspension and discharge of collected sediments into the wetland and to allow for recurring maintenance removal of sediments without adverse impact to the wetland.

(7) The operation phase of this permit shall not become effective until:

(a) an engineer certifies that the wetlands stormwater discharge facility has been constructed in accordance with the design approved by the Department. Within 30 days after completion of construction of the wetlands stormwater discharge facility, the permittee shall submit the certification and two copies of as-built drawings and notify the Department that the facility is ready for inspection. The certification prepared by an engineer (not necessarily the project design engineer but one who has been retained or employed by the permittee to provide professional engineering services during the construction phase of project completion) shall be made on forms provided by the Department. The engineer shall certify therein that the facility has been constructed substantially in accordance with approved plans and specifications, and that any deviations will not prevent the facility from functioning in compliance with the requirements of this chapter. The engineer shall note and explain substantial deviations from the approved plans and specifications. The certification shall be based upon on-site observation of construction (scheduled and conducted by the engineer or by a project representative under his direct supervision) for the purpose of determining if the work was completed in compliance with approved plans and specifications;

(b) the permittee submits to the Department documentation that adequate provisions have been made for the operation and maintenance of the facility and for meeting any special permit conditions, such conditions may include water quality monitoring.

(8) In order to establish a reliable, scientifically valid data base upon which to evaluate the performance standards and the performance of the wetlands stormwater discharge facility, a monitoring program may be required. Monitoring programs shall provide the Department with comparable data for different types of wetlands and drainage designs. Data to be collected may include, but not be limited to, sedimentation rate, sediment trace metal concentrations, sediment nitrogen and phosphorus concentrations, changes in the frequency, abundance and distribution of vegetation and inflow and outflow water quality for nutrients, turbidity, oils and greases, bacteria and other parameters related to the specific site conditions. Inflow and outflow water quality parameters will be monitored on such storm event occurrences as established by the Department based on a site specific basis. Analytical data must be provided using standard procedures prescribed by a Department approved Quality Assurance Plan and reported in a format provided by the Department. The Department shall eliminate the requirement to continue the monitoring program upon its determination that no further data is necessary to evaluate the performance standards or ensure compliance with the performance standards and applicable water quality standards.

(9) A permit issued pursuant to this section shall be valid for a period of up to five years from the date of issue unless an earlier renewal date is specified by the Department. Both construction and operation of the facility will be covered by the initial permit.

(10) If the facility will continue to operate after the expiration date of the initial permit, the permit must be renewed. A permit may be renewed upon submittal to the Department of a certification that the facility is operating in compliance with the performance criteria of this section and is not causing water quality violations of downstream waters.

17-25.042(7)(a) -- 17-25.042(10)

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The certification shall be treated as an application for permit renewal for purposes of the time provisions specified in Section 120.60, F.S.

(11) The permit may be transferred only pursuant to Florida Administrative Code Rule 17-4.120. Upon transfer, all original permit conditions, schedules and criteria continue to be applicable.

Specific Authority: 403.061, 403.912, 403.918, F.S.
Law Implemented: 403.087, 403.088, 403.918, 403.919, 403.921, 403.924, 403.927, 403.929, F.S.
History: New 5-8-85.

17-25.050 Delegation.

(1) The Department may, after notice in the Florida Administrative Weekly pursuant to the provisions of Chapter 120, Florida Statutes, delegate to either local governments or water management districts seeking such delegation, as provided in Sections 403.182, 403.812, Florida Statutes, and this section, the authority to process notices, issue or deny permits, initiate enforcement actions, and monitor for compliance as provided in Sections 403.182, 403.812, Florida Statutes, and this section. Delegation shall not include the authority for a local government or a water management district to issue or deny permits for its own activities except replacement items or maintenance of existing facilities.

(2) A water management district which has been delegated stormwater regulation pursuant to this section may establish alternative requirements which protect the designated uses of waters of the state provided that the alternative requirements are approved by the Environmental Regulation Commission pursuant to Section 403.804, Florida Statutes and have been incorporated by reference as department stormwater rules in 17-25.090, F.A.C. These alternative requirements incorporated as department rules shall apply in lieu of the provisions of this Chapter in the area of delegation, and applicable surface water management and stormwater permit discharge standards shall be applied in one permit proceeding. Following delegation to a water management district, those activities within the district that meet the exemption criteria of Section 17-25.030(1) shall be exempt from the requirements of Section 17-4.242 regarding Outstanding Florida Waters.

(3) A local government which has been delegated stormwater regulation pursuant to this section may also establish by rule, ordinance or local law, alternative requirements provided the Department determines such alternative requirements are compatible with, or more stringent than, those imposed by this chapter.

Specific Authority: 403.061, 403.062, 403.182, 403.805, 403.812, F.S.
Law Implemented: 403.021, 403.061, 403.062, 403.182, 403.805, 403.812. F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 1-26-84, 5-8-85. Previously numbered as 17-25.05.

17-25.042(10) -- 17-25.050(History)

05-14-86

17-25.060 Relationship to Other Permitting Requirements.

(1) Whenever the construction of a new stormwater discharge facility requires that a dredge or fill permit be secured pursuant to Sections 17-4.280 or 17-4.290 or Chapter 17-12, Florida Administrative Code, or whenever other rules of the Department require that a permit, section 401 federal Clean Water Act certification or other certification be secured, all applicable stormwater requirements under this chapter shall be reviewed as part of those permit applications. A separate permit application under this chapter shall not be required. If the applicant requests a separate stormwater permit, the applicant must notify the Department of any other Department permits, exemptions, or certifications which have or will be requested for the project.

(2) The permit requirements of Chapter 17-4 or other applicable rules, rather than those of this chapter, shall apply to discharges which are a combination of stormwater and industrial or domestic wastewater or which are otherwise contaminated by non-stormwater sources unless:

(a) the stormwater discharge facility is capable of providing treatment of the non-stormwater component sufficient to meet state water quality standards; and

(b) the applicant requests that the permit requirements of this Chapter apply.

Specific Authority: 403.061, 403.062, 403.087, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.101, 403.702, 403.708, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 1-26-84, 5-8-85. Previously numbered as 17-25.06.

17-25.070 Transferability of Other Chapters.

Specific Authority: 403.061, 403.062, 403.087, 403.504, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.101, 403.502, 403.702, 403.708, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Repealed 5-1-82.

17-25.080 General Provisions.

Nothing under this chapter shall preclude:

(1) stormwater effects from being considered in the evaluation of other types of permits where such consideration is relevant to a determination of compliance with applicable Department requirements.

(2) the legal joinder in a permitting proceeding under this chapter of persons who own or control unpermitted stormwater discharge systems which comprise a significant portion of the stormwater discharge facility.

(3) the Department from taking appropriate legal action including but not limited to the requiring of a permit to prevent the impairment of a use for which a water of the state has been designated under Chapter 17-3, Florida Administrative Code.

(4) the Department from entering interagency or interlocal agreements to accomplish the provisions of this chapter.

Specific Authority: 403.061, 403.062, 403.087, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.121, 403.141, 403.161, 403.708, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82. Previously numbered as 17-25.08.

17-25.060(1) -- 17-25.080(History)

05-14-86

17-25.090 List of Entities to Which Permitting Pursuant to this Chapter has been Delegated; Addresses; Delegation Documents and Rules Adopted by Reference.

(1) South Florida Water Management District; Post Office Box V; West Palm Beach, Florida 33402

(a) Surface Water Management Rule; Chapter 40E-4, Florida Administrative Code (March 9, 1983);

(b) General Surface Water Management Rule; Chapter 40E-40, Florida Administrative Code (December 1, 1982);

(c) "Basis of Review for Surface Water Management Permit Applications within the South Florida Water Management District - May 1986."

(d) Nothing in this delegation shall prevent the Department from considering the stormwater impact of dredging or filling regulated pursuant to 17-4.280 or 17-4.290 or Chapter 17-12, Florida Administrative Code, or the District from implementing applicable provisions of Chapters 17-3 and 17-4, Florida Administrative Code. Provided, however, in those cases where the water management district has issued a surface water management permit pursuant to Chapter 373, Part IV, and this delegation, the Department shall confine its review of stormwater quality impacts solely to those generated by dredging and filling regulated pursuant to Rules 17-4.280 and 17-4.290, Florida Administrative Code.

(2) Southwest Florida Water Management District; 2379 Broad Street, Brooksville, Florida 33512.

(a) Regulation of Stormwater Discharge; Chapter 17-25, Florida Administrative Code, except for Section 17-25.042.

(b) When a proposed stormwater discharge facility is associated with activities which require a dredge and fill, industrial waste, or hazardous waste permit from the Department, stormwater permit applications and exemption notices must be submitted to the Department and the Department shall regulate such stormwater discharge facilities within the District.

(3) Suwannee River Water Management District; Route 3, Box 64, Live Oak, Florida 32060.

(a) Surface Water Management and Works of the District Rule; Chapter 40B-4, Florida Administrative Code (August 15, 1985).

(b) The permitting of wetlands stormwater discharge facilities pursuant to Section 17-25.042 is not delegated to the District.

(4) St. Johns River Water Management District, Post Office Box 1429, Palatka, Florida 32078.

(a) Regulation of Stormwater Discharge, Chapter 40C-42, Florida Administrative Code (February 1986).

(b) The permitting of wetlands stormwater discharge facilities pursuant to Section 17-25.042 is not delegated to the District.

Specific Authority: 403.061, 403.812, F.S.
Law Implemented: 403.021, 403.061, 403.812, F.S.
History: Formerly 17-4.248, Amended and Renumbered 2-1-82, Amended 3-30-82, 1-26-84, 3-28-84, 5-8-85, 5-14-86. Previously numbered as 17-25.09.

17-25.090(1) -- 17-25.090(History)

05-14-86

17-4.710 General Permit for New Stormwater Discharge Facilities.

(1) A general permit is hereby granted to any person for the construction and operation of the following types of new stormwater discharge facilities as set forth in Section 17-25.035, F.A.C. provided that notice to the Department pursuant to Rule 17-4.530 is submitted on Form 17-1.215(2) Revised April 1985. This general permit shall not expire and shall not be subject to Section 17-4.540(13) unless suspended or revoked in accordance with Section 17-4.53(5):

(a) facilities which discharge into a stormwater discharge facility which is permitted pursuant to Section 17-25.04, F.A.C. or Section 17-25.035(1)(b) or (d), F.A.C. or which was previously approved pursuant to a noticed exemption under Section 17-25.03 where the appropriate treatment criteria specified in Chapter 17-25 and applied to the permitted or exempt facility are not exceeded by the discharge; however, this exemption does not authorize discharge to the permitted or exempt facility without the facility owner's prior written consent; or,

(b) facilities which provide retention, or detention with filtration, of the runoff from the first one inch of rainfall; or, as an option, for projects or project subunits with drainage areas less than 100 acres, facilities which provide retention, or detention with filtration, of the first one half inch of runoff. However, facilities which directly discharge to Outstanding Florida Waters shall provide additional treatment pursuant to Section 17-25.025(9), F.A.C.; or,

(c) modification or reconstruction by a city, county, state agency, special district with drainage responsibility, or water management district of an existing stormwater management system which is not intended to serve new development, and which will not increase pollution loading, or change points of discharge in a manner that would adversely affect the designated uses of waters of the state; or,

(d) facilities of stormwater management systems that include a combination of management practices including but not limited to retention basins, swales, pervious pavement, landscape or natural retention storage that will provide for the percolation of the runoff from a three-year one-hour design storm.

(2) Except as provided in subsection (1), this general permit is subject to the general conditions of Rule 17-4.540 and the following special conditions:

(a) the stormwater discharge facilities shall be designed and constructed in accordance with the design and performance standards set forth in Section 17-25.025, F.A.C.; and,

(b) adequate provisions have been made for the operation and maintenance of the proposed facility; and,

(c) The design, construction and operation of the stormwater discharge facility shall comply with all other applicable requirements of Chapter 17-25, F.A.C.; and,

(d) the permittee shall submit appropriate design analyses, calculations, drawings, specifications and other information necessary to describe, document and verify that the proposed stormwater discharge facility qualifies for the general permit; and,

(e) the permittee or engineer of record shall file with the Department within 30 days after the facility's completion of construction an as-built certification that the new stormwater discharge facility, as constructed, qualifies for the general permit.

(f) this general permit does not relieve the permittee of the responsibility for obtaining a dredge and fill permit where it is required.

Specific Authority: 403.814(1), 403.912, F.S.

Law Implemented: 403.061, 403.087, 403.088, 403.121, 403.141, 403.161, 403.182, 403.502, 403.702, 403.908, 403.814, F.S.

History: New 5-8-85. Previously numbered as 17-4.71.

17-4.690(2)(f) -- 17-4.710(1)(d)

7-9-87

STORMWATER PERMITTING AND DELEGATION TO THE WATER MANAGEMENT DISTRICTS

(Where do I get my permit?)

TYPE OF ACTIVITY	SFWMD	SWFWMD	SJRWMD	SRWMD	DER
New Stormwater Discharges (17-25.03, 17-25.035, 17-025.04) 1. Retention 2. Detention 3. Wet Detention 4. Other BMP's	X	X	X	X	X
Wetland Stormwater Systems (17-25.042)	X				X
Stormwater Discharge Associated With Dredge/Fill Permits 1. Standard Form	a X				c X
2. Short Form - D/F Not Needed For SW System Construction	a X		a X	a X	
3. Short Form - D/F SW System Construction	a X				c X
4. Incidental D/F Only (17-12.050)	X	X	X	X	
Stormwater Discharge With Industrial Waste, Hazardous Waste, Solid Waste Permit	b X				c X
Existing System Modification or Retrofitting	X				X
Applicable Regulations	Basis of Review 40-E, 40E-40	40D-4 17-25	40C-4 40C-40 40C-42	40B-4	17-25

a) The WMD will permit the stormwater system, DER will review and permit the D/F impacts

b) The WMD will permit the stormwater system, DER will review and permit the other impacts

c) The DER will review the stormwater and other impacts as a consolidated permit with the stormwater system designed to meet the applicable WMD rules

(April, 1987)

4) Erosion and Sediment Control

a. Erosion and Sediment Control Principles
Source: Virginia, VA-2

b. Vegetation for Erosion and Sediment Control
Source: Alabama, AL-1

PART I

EROSION AND SEDIMENT CONTROL PRINCIPLES

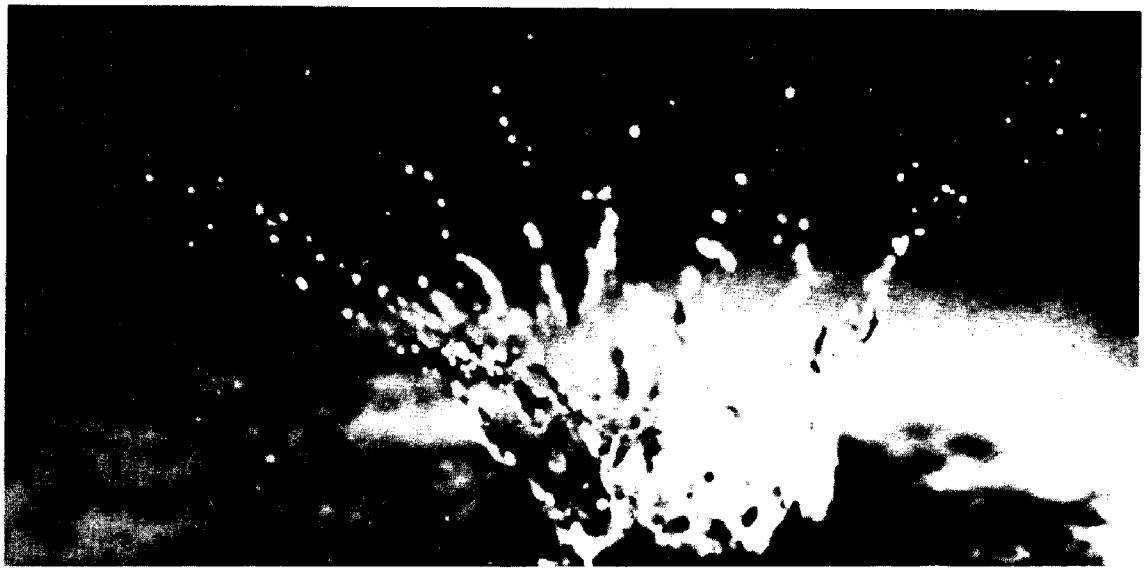
THE EROSION PROCESS

Soil erosion is the process by which the land's surface is worn away by the action of wind, water, ice and gravity. Natural, or geologic erosion has been occurring at a relatively slow rate since the earth was formed, and is a tremendous factor in creating the earth as we know it today. The picturesque mountains of the west, the rolling farmlands of the Piedmont, and the productive estuaries of the Coastal Zone are all products of geologic erosion and sedimentation in Virginia. Except for some cases of shoreline and stream channel erosion, natural erosion occurs at a very slow and uniform rate and remains a vital factor in maintaining environmental balance.

Water-generated erosion is unquestionably the most severe type of erosion, particularly in developing areas; it is, therefore, the problem to which this handbook is primarily addressed. It is helpful to think of the erosive action of water as the effects of the energy developed by rain as it falls, or as the energy derived from its motion as it runs off the land surface. The force of falling raindrops is applied vertically, and force of flowing water is applied horizontally. Although the direction of the forces created is different, they both perform work in detaching and moving soil particles.

Water-generated erosion can be broken down into the following types:

Raindrop erosion is the first effect of a rainstorm on the soil. Raindrop impact dislodges soil particles and splashes them into the air (see picture below). These detached particles are then vulnerable to the next type of erosion.



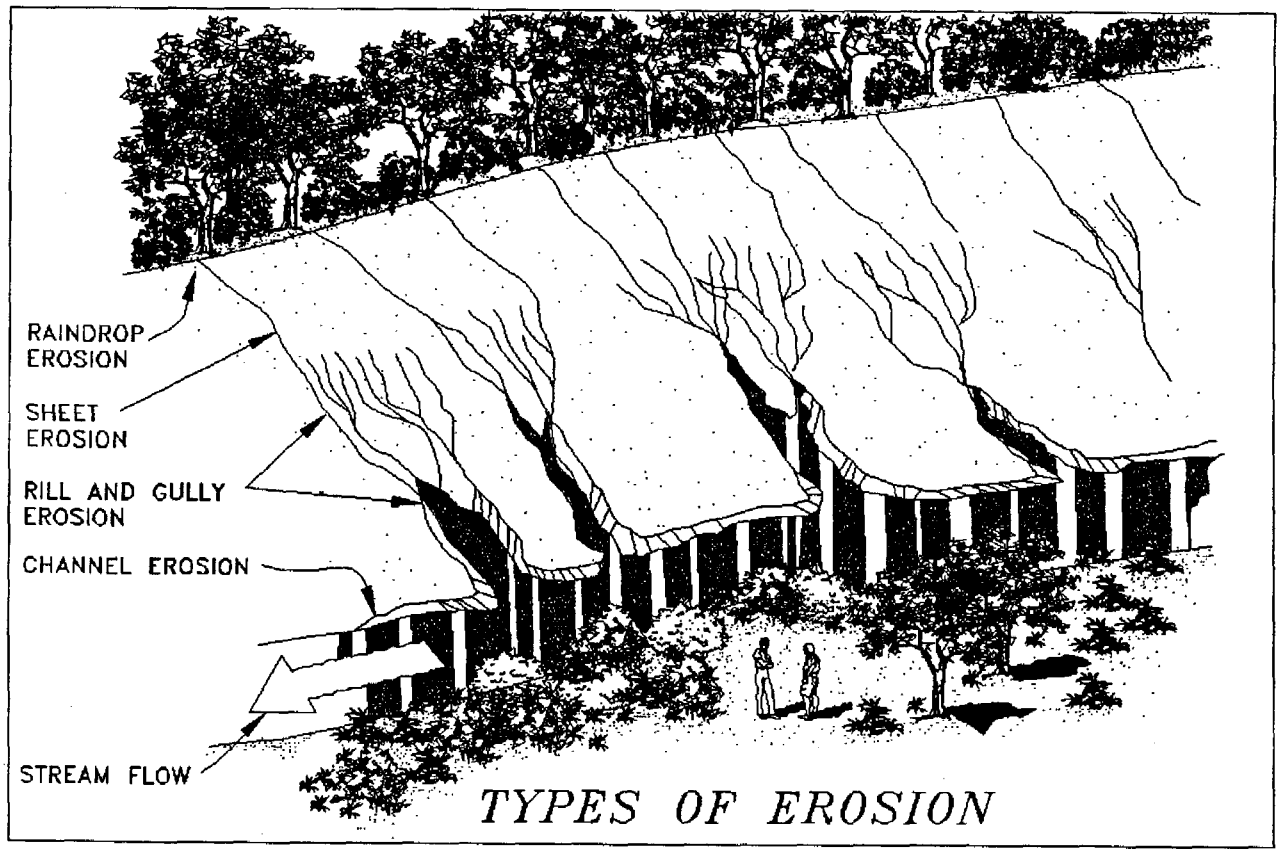
Source: Soil Conservation Society of America

Sheet erosion is the erosion caused by the shallow flow of water as it runs off the land. These very shallow moving sheets of water are seldom the detaching agent, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in the surface irregularities.

Rill erosion is the erosion which develops as the shallow surface flow begins to concentrate in the low spots of the irregular contours of the surface. As the flow changes from the shallow sheet flow to deeper flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to both detach and transport soil materials. This action begins to cut small channels of its own. Rills are small but well-defined channels which are at most only a few inches in depth. They are easily obliterated by harrowing or other surface treatments.

Gully erosion occurs as the flow in rills comes together in larger and larger channels. The major difference between gully and rill erosion is a matter of magnitude. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy equipment and special techniques for stabilization.

Channel erosion occurs as the volume and velocity of flow causes movement of the stream bed and bank materials. Plate 2-1 illustrates the five stages of erosion.



Source: Michigan Soil Erosion and Sedimentation Guidebook Plate 2-1

FACTORS INFLUENCING EROSION

The erosion potential of any area is determined by four principal factors: the characteristics of its soil, its vegetative cover, its topography and its climate. Although each of these factors is discussed separately herein, they are inter-related in determining erosion potential.

Soil characteristics which influence the potential for erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the resistance of the soil to detachment and being carried away by falling or flowing water. The following four factors are important in determining soil erodibility:

1. Soil texture (particle size and gradation)
2. Percentage of organic content
3. Soil structure
4. Soil permeability

Soils containing high percentages of fine sands and silt are normally the most erodible. As the clay and organic matter content of these soils increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays have tendency to resist erosion, once eroded, they are easily transported by water. Soils high in organic matter have a more stable structure which improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Clear, well-drained and well-graded gravel and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

Vegetative cover plays an extremely important role in controlling erosion as it provides the following five benefits:

1. Shields the soil surface from raindrop impact
2. Root systems hold soil particles in place
3. Maintains the soil's capacity to absorb water
4. Slows the velocity of runoff
5. Removes subsurface water between rainfalls through the process of evapo-transpiration

By limiting and staging the removal of existing vegetation and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential such as moderately to highly erodible soils, steep slopes, drainageways, and the banks of streams.

Topography. The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Slope orientation can also be a factor in determining erosion potential. For example, a slope that faces south and contains droughty

soils may have such poor growing conditions that vegetative cover will be difficult to re-establish.

Climate. The frequency, intensity, and duration of rainfall are fundamental factors in determining the amounts of runoff produced in a given area. As both the volume and velocity of runoff increases, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. When precipitation falls as snow, no erosion will take place. However, when the temperature rises, melting snow adds to runoff, and erosion hazards are high. Because the ground is still partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion-resistant. However, soils with high moisture content are subject to uplift by freezing action and are usually very easily eroded upon thawing.

SEDIMENTATION

Normally, runoff builds up rapidly to a peak and then diminishes. Excessive quantities of sediment are derived by erosion, principally during the higher flows. During lower flows, as the velocity of runoff decreases, the transported materials are deposited to be picked up by later peak flows. In this way, sediments are carried downslope, or downstream, intermittently and progressively from their source or point of origin. A study of sedimentation due to highway construction and land development in Virginia, for instance, indicated that 99 percent of the sediment discharge occurred during periods of high flow which took place during only three percent of the period of measurement (77).

SEDIMENT POLLUTION AND DAMAGE

Sediment pollution is soil out of place. It is a product of the activities of man which lead to severe soil loss. When these large quantities of soil enter our waters, then sediment pollution occurs.

Over four billion tons of sediment are estimated to reach the ponds, rivers, and lakes of our country each year, and approximately one billion tons of this sediment is actually carried all the way to the ocean. Approximately 10 percent of this amount is contributed by erosion from land undergoing highway construction or land development (73). Although these latter quantities may appear to be small compared to the total, they could represent more than one-half of the sediment load carried by many streams draining small subwatersheds which are undergoing development (81).

Excessive quantities of sediment cause costly damage to waters and to private and public lands. Obstruction of stream channels and navigable rivers by masses of deposited sediment reduces their hydraulic capacity which, in turn, causes an increase in subsequent flood crests and a consequent increase in the frequency of damaging storm events.

Sediment fills drainage channels, especially along highways and railroads, and plugs culverts and storm drainage systems, thus necessitating frequent and costly maintenance. Municipal

and industrial water supply reservoirs lose storage capacity, the usefulness of recreational impoundments is impaired or destroyed, navigable channels must be continually dredged and the cost of filtering muddy water preparatory to domestic or industrial use becomes excessive - and sometimes exorbitant. The added expense of water purification in the United States, because of sedimentation, amounts to millions of dollars each year.

In an aquatic environment, the general effect of fine-graded sediments such as clays, silts, and fine sands is to reduce drastically both the kinds and the amounts of organisms present. Sediments alter the existing aquatic environment by screening out sunlight and by changing the rate and the amount of heat radiation. Particles of silt settling on stream and lake bottoms form a blanket which creates a hostile environment for the organisms living there and literally smothers many of them and their eggs. The disastrous effect (upon commercially valuable finfish and shellfish populations) of excessive amounts of silt entering estuarine waters was widely publicized in the case of the Chesapeake Bay following flooding of its main tributary, the Susquehanna River, caused by Hurricane "Agnes" in 1972.

Coarser-grained materials also blanket bottom areas to suppress aquatic life found in these areas. Where currents are sufficiently strong to move the bedload, the abrasive action of these materials in motion accelerates channel scour and has an even more severely deleterious effect upon aquatic life. The aesthetic attraction of many steams, lakes, and reservoirs used for swimming, boating, fishing, and other water-related recreational activities has been seriously impaired or destroyed by bank cutting and channel scour - accelerated by a higher flood stages induced by sedimentation.

EROSION AND SEDIMENT HAZARDS ASSOCIATED WITH LAND DEVELOPMENT

The principal effect land development activities have on the natural or geologic erosion process consists of exposing disturbed soils to precipitation and to surface storm runoff. Shaping of land for construction or development purposes alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and storm runoff patterns and eventually the off-site stream and streamflow characteristics. Protective vegetation is reduced or removed, excavations are made, topography is altered and the removed soil material is stockpiled - often without protective cover. In effect, the physical properties of the soil itself are changed. The development process is such that many citizens of a locality may be adversely affected even by development of areas of only limited size. Uncontrolled erosion and sediment from these areas often causes considerable economic damage to individuals and to society, in general. Surface water pollution, channel and reservoir siltation and damage to public facilities, as well as to private property, are some of many examples of problems caused by uncontrolled erosion and sedimentation.

Potential hazards associated with development include:

1. A large increase in areas exposed to storm runoff and soil erosion.

2. Increased volumes of storm runoff, accelerated soil erosion and sediment yield and higher peak flows caused by:

a. Removal of existing protective vegetative cover.
b. Exposure of underlying soil or geologic formations which are less pervious and/or more erodible than original soil surface.
c. Reduced capacity of exposed soils to absorb rainfall due to compaction caused by heavy equipment.
d. Enlarged drainage areas caused by grading operations, diversions, and street constructions.
e. Prolonged exposure of unprotected disturbed areas due to scheduling problems and/or delayed construction.
f. Shortened times of concentration of surface runoff caused by altering steepness, distance and surface roughness and through installation of "improved" storm drainage facilities.
g. Increased impervious surfaces associated with the construction of streets, buildings, sidewalks and paved driveways and parking lots.

3. Alteration of the groundwater regime that may adversely affect drainage systems, slope stability and survival of existing and/or newly established vegetation.

4. Creation of south and west directional exposure of property which may hinder plant growth due to adverse temperature and moisture conditions.

5. Exposure of subsurface materials that are rocky, acid, droughty or otherwise unfavorable to the establishment of vegetation.

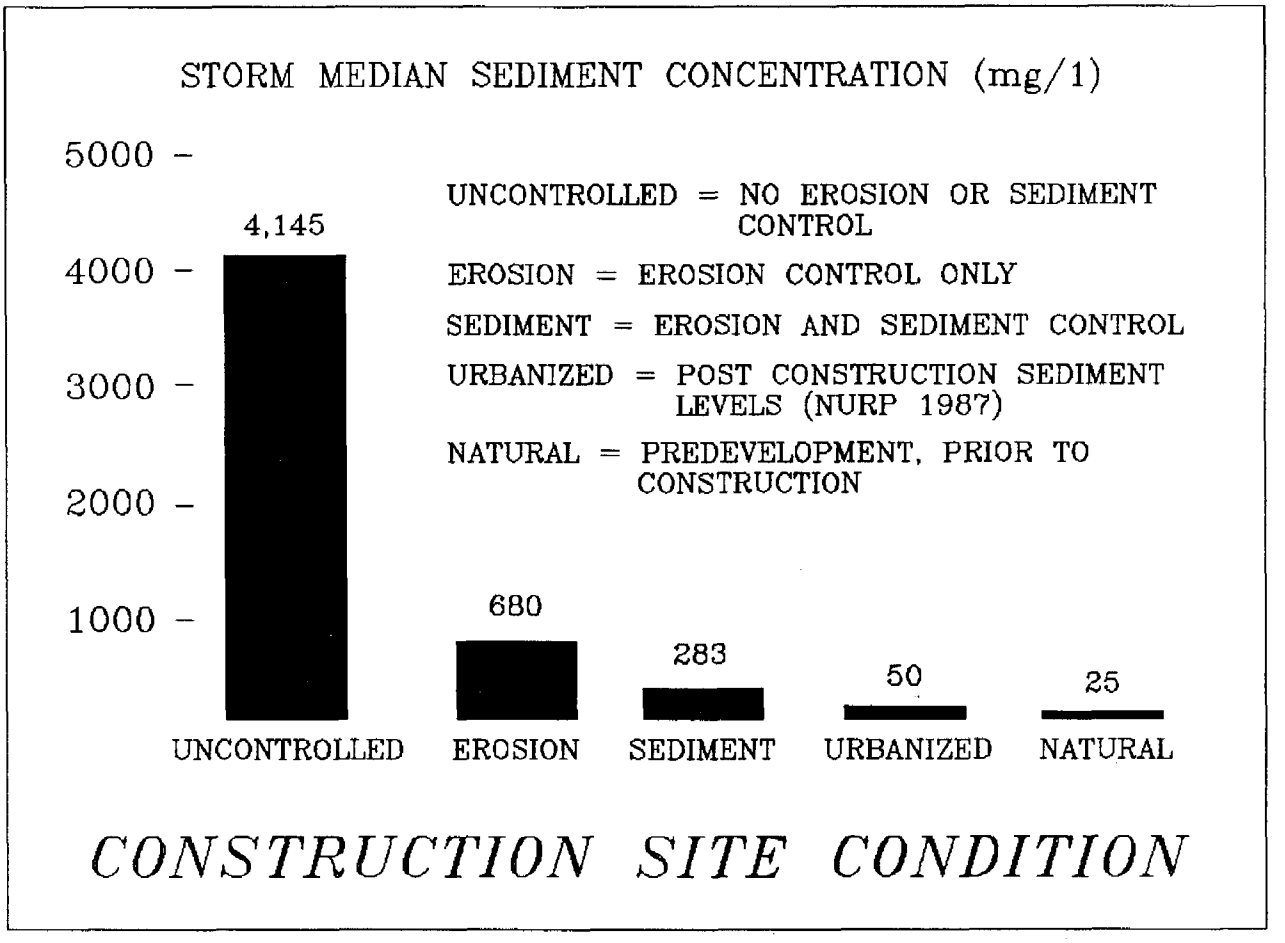
6. Adverse alteration of surface runoff patterns by construction and development.

Increases in sedimentation yield higher levels of nutrients and toxicants. The results of high sediment loading can have a profound effect on the environment. Sediment acts like a magnet to toxicants and trace metals. Additionally, the soil introduces nutrients into streams and groundwater. The net effect is to create a strata known as diagenesis. This activity decreases the oxygen available to support other aquatic life. Even more startling is the apparent ability of sediment to act as long term memory or storage media for toxicants. Studies show that pollutants such as DDT, DDE, PCBs and chlordane whose use has been banned or highly restricted, can still be found at detectable levels in sediment deposited years ago in the bottom of streams and rivers. It has been demonstrated that urbanization and associated sedimentation reduces the diversity of the fish populations in streams as well as the organisms that fish feed on.

The capacity of a stream to maintain its health can be related to the impervious areas within its watershed. Urbanization of a watershed increases the impervious surfaces and increases the pollutant load. One study suggests that once a watershed becomes 12% impervious, the quality of aquatic life has reached a critical threshold.

Responsible development requires that steps be taken to control erosion and sedimentation from construction sites. Plate 2-2 demonstrates the ability of good erosion and sediment controls, versus no controls, in minimizing the detrimental effects of sedimentation.

This chart also demonstrates the fact that once a naturally vegetated area has been developed, sediment levels can be twice the pre-development rate. It is well know that the erosion and sediment threat is greatest during construction; once development is complete (stabilization techniques implemented), there is a dramatic decrease in the pollutant level yield.



Source: Performance of Current Sediment Control Measures at Maryland Construction Sites, Metropolitan Washington Council of Governments

Plate 2-2

In the past, efforts have been made to quantify the damage caused by erosion and sedimentation in terms of dollars spent to dredge navigational channels, loss of reservoir capacity and so on. More recently, efforts have concentrated on the qualitative cost. It is very difficult to place a dollar figure on damage to the environment; however, we cannot escape the fact that human health and well-being is ultimately related to the environment in which we live.

DOLLARS AND SENSE

It is well known that urbanization has the following effects:

* Accelerated Rate of Soil Erosion
* Increase in the Peak Discharge and Total Volume of Stormwater
* Increased Potential for "Flash" Flooding
* Decreased Groundwater Recharge
* Increased Temperature in Natural Receiving Channels
* Increased Pollutant Loading to Receiving Waters

Each of these factors has an associated cost. The VESCL and the VESCR attempt to minimize these costs by regulating land-disturbing activities in the State of Virginia. All of the citizens of the Commonwealth stand to gain when local E&S programs are effective and developers follow responsible management procedures. The net results are dollars saved and a direct benefit to the environment.

COST TO THE DEVELOPER

The VESCL requires that land-disturbing activities have an approved E&S plan prior to commencement of work. The owner must provide the plan or pay someone else (i.e., engineer, architect, planner) to provide this plan. Once a plan is approved, generally a contractor places the controls. However, the owner is ultimately responsible and in fact must certify that the plan will be carried out. Once the project has moved through the bid process, the cost of implementation becomes the primary concern. Proper implementation of the E&S plan can save the developer and the contractor money in excavation costs. If denuded areas are stabilized initially, little or no additional work will be required later. This can speed up completion dates, and overall savings will be realized. This strategy requires that planning take on a more important role in the management of a project. Good management throughout the life of a project will lead to increased savings.

On the other hand, failure to implement an E&S plan or failure to maintain controls during construction of a project can mean additional costs to the developer and the contractor. These additional costs exist at three levels. The primary level is the cost of work being stopped for non-compliance with an approved plan; the secondary level is the cost of repairing damage to adjacent properties; the tertiary level would be the costs associated with missed deadlines, litigation with damaged parties and extra charges from the contractor for additional work. The perception of the public that the developer and the contractor were negligent in performing their responsibilities may also pose a negative cost -if not now, sometime in the future.

At least one engineer has tried to relate these costs to the developer and contractor, based on his own experience and his year of practice. In a seminar on E&S, Mr. Jack Rinker of Rinker-Detwiler and Associates, P.C. presents a scenario called the "Hidden Cost to Down Time from Construction Stops by Government." The following is an abbreviated version of this scenario:

> Assume that a 50-house subdivision is underway. During construction, a rainstorm occurs. This storm can be either moderate or severe. Accordingly, erosion and sedimentation damage from the storm, because E&S measures were never placed, can be either moderate or severe. After the storm, neighbors call the local building official's office to complain. The building official visits the site, observes sedimentation damage and the potential for more, and immediately stops work on the project. This hypothetical situation assumes that the chief administrative officer of the locality has delegated the ability to "stop work" to the building official and that this was deemed an "emergency situation." At this time, all land-disturbing activity on the project is stopped. Three crews are affected by the work stoppage: the grading crew, curb and gutter crew and the utilities contractor. The job superintendent has to divert all of his attention to the immediate erosion problem and calls his office. His office in-turn calls the owner and then the owner calls the engineer and his attorney. The job has come to a virtual standstill because everyone's attention is focused on "putting out the fire." The neighbors are now calling the developer and voicing their disgust. Action must be taken. On the advice of his attorney, the developer makes the decision to have the contractor remove the sediment that has moved onto the neighbors' property. At the request of the owner, the engineer visits the site to assess the damage. The next day, the developer meets with his attorney, the engineer and local government officials to see what must be done to get this job "back on track." The adjacent property owners are still complaining even though work to remove the sediment has begun. The engineer determines that the controls shown on the original E&S plan should have been installed during the first stage of grading to prevent damage to adjacent property. These controls could have prevented the problem in the first place, if they had been installed! Much of the attorney's costly time is spent trying to calm the mood of the neighbors and local officials.

At this point, let us look at the potential damage:

* Moderate Damage: 12 cubic yards of sediment must be removed from one neighbor's property and the lawn must be repaired.

* Severe Damage: 12 cubic yards of sediment must be removed from the neighbor's property; however, the sediment has moved past the property owner's fence and a large section of fence must be removed to gain access to the property with equipment. In the process of getting equipment in and out of the property, six trees and 20 shrubs are damaged. The neighbor is even more angry now!

Possible Costs

Item:	Moderate Damage	Severe Damage
Clean-up crew mobilization	$ 288.00	$ 288.00
Silt removal and hauling	153.00	153.00
Dumping charge at landfill	60.00	60.00
Grading work	133.00	133.00
Fertilizer and seed	111.00	------
Mulch and tack	150.00	------
Sod and fertilizer	------	640.00
Replace 20 shrubs	------	1,680.00
Replace 6 trees	------	1,476.00
Replace 50 feet of fence	------	640.00
Totals:	**$ 895.00**	**$5,070.00**

These items are a secondary cost to the developer. The primary cost still needs to be considered.

Item:	
Developer's infrastructure (cost attributed to the five-day delay of construction): $1,200 per day	$ 6,000.00
Attorney costs: 21 hours @ $150 per hour	3,150.00
Engineer and staff cost: 31 hours @ $75 per hour	2,325.00
Curb and gutter crew start-up cost	1,500.00
Utilities crew start-up cost	2,000.00
Grading crew start-up cost	2,000.00
Total:	**$16,975.00**

During the ten-day period that it took to repair the damage and get the project back on schedule, the developer incurred these expenses:

	Moderate Damage	Severe Damage
	$16,975.00	$16,975.00
	895.00	5,070.00
Totals:	**$17,870.00**	**$22,045.00**

Not reflected in these costs are the tertiary cost such as ten days of additional interest on the construction loan, lost sales of homes and possible litigation costs.

In this case, the cost of the controls shown on the original E&S plan that would have prevented the problem are as follows:

Item:	**Cost**
Silt fence, 350 feet @ $4.50/linear ft.	$ 1,575.00
Diversion dike, 50 feet @ $2.00/linear ft.	100.00
Sediment trap, 1 @ $240.00 each	240.00
Total:	$ 1,915.00

It should be noted that variation in the magnitude of the storm event could make these numbers vary and pose some required clean-up costs - even for a properly controlled site. However, the use of properly installed control measures will still help to mitigate damage caused by less frequent, larger storms.

BASIC PRINCIPLES OF DESIGN AND CONTROL

For an erosion and sediment control program to be effective, it is imperative that provisions for sediment control measures be made in the planning stage. These planned measures, when conscientiously and expeditiously applied during construction, will result in orderly development, which minimizes environmental degradation. From the previous discussion about erosion and sediment processes and the factors affecting erosion, basic technical principles can be formulated to assist the project planner or designer in providing for effective sediment control. These principles should be utilized to the maximum extent possible on all projects.

1. Plan the development to fit the particular topography, soils, drainage patterns and natural vegetation of the site.

   Detailed planning should be employed to assure that roadways, buildings, and other permanent features of the development conform to the natural characteristics of the site. Large graded areas should be located on the most level portion of the site. Areas subject to flooding should be avoided, and floodplains should be kept free

from filling and other development. Area with steep slopes, erodible soils and soils with severe limitations for the intended uses should not be utilized without first overcoming the limitations through sound engineering practices. For instance, long steep slopes can be broken by benching, terracing, or construction diversion structures and thus will not become an erosion problem or transfer a problem down the grade.

Erosion control, development and maintenance costs can be minimized by selecting a site suitable by its nature for a specific proposed activity, rather than by attempting to modify a site to conform to a proposed activity. This kind of planning can be more easily accomplished where there is a general land-use plan based upon a comprehensive inventory of soils, water and other related resources.

2. Minimize the extent of the area exposed at one time and duration of exposure.

When earth changes are required and the natural vegetation is removed, keep the area and the duration of exposure to a minimum. Plan the phases or stages of development so that only the area which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is begun. Immediately after grading is completed, permanent vegetative cover should be established in the area. As cut slopes are made and as fill slopes are brought up to grade, these areas should be revegetated as the work progresses. This is know as staged seeding. Minimizing grading of large or critical areas during the seasons of maximum erosion potential - spring thaw in February and March and the thunderstorm season from May through September reduces the risk of erosion (60).

3. Apply erosion control practices to prevent excessive on-site damage.

This third principle relates to using practices that control erosion on a site to prevent excessive sediment from being produced. Keep soil covered as much as possible with temporary or permanent vegetation or with various mulch materials. Special grading methods such as roughening a slope on the contour or tracking with a cleated dozer may be used. Other practices include diversion structures to divert surface runoff from exposed soils and grade stabilization structures to control surface water.

"Gross" erosion in the form of gullies must be prevented by these water control devices. Lesser types of erosion such as sheet and rill erosion should be prevented but, often, scheduling or the large number of practices required makes this impractical. However, when erosion is not adequately controlled at the source, sediment control for the project as a whole is more difficult and expensive.

4. Apply perimeter control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.

This principle relates to using practices that effectively isolate the development site

from surrounding properties and especially to controlling sediment once it is produced and preventing its transport for the site.

Diversions, dikes, sediment traps, vegetative filters and sediment basins are examples of practices which control sediment. Vegetative and structural sediment control measures can be classified as either temporary or permanent depending on whether or not they will remain in use after development is complete. Generally, sediment can be retained by two methods: a) filtering runoff as it flows through an area, and b) impounding the sediment-laden runoff for a period of time so that the soil particles settle out. Many practices are combinations of these two methods. The best way to control sediment, however, is to prevent erosion as discussed in the third principle.

5. Keep runoff velocities low and retain runoff on the site.

The removal of existing vegetative cover and the resulting increase in impermeable surface area during development will increase both the volume and velocity of runoff. These increases must be taken into account when providing for erosion control. Keeping slope lengths short and gradients low and preserving natural vegetative cover can keep stormwater velocities low and limit erosion hazards. Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways, riprapped channels or similar measures. Consideration should be given to the installation of stormwater retention or detention structures when there is a potential for flooding and damage to downstream facilities resulting from increased runoff from the site. Conveyance systems should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction.

6. Stabilize disturbed areas immediately after final grade has been attained.

Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures should be employed as quickly as possible after the land is disturbed. Temporary vegetation and mulches can be most effective where or when it is not practical to establish permanent vegetation. Such temporary measures should be employed immediately after rough grading is completed if a delay is anticipated in obtaining finished grade. The finished slope of a cut or fill should be stable, and ease of maintenance should be considered in the design. Stabilize roadways, parking areas, and paved areas with a gravel sub-base whenever possible.

7. Implement a thorough maintenance and follow-up program.

This last principle is vital to the success of the other six principles. A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices.

These practices must be maintained just as construction equipment must be maintained and materials checked and inventoried. An example of applying this principle would be to start a routine "end of day check" to make sure that all control practices are working properly. Usually, these seven principles are integrated into a system of vegetative and structural measures along with management techniques and the "Minimum Standards" to develop a plan to prevent erosion and control sediment. In most cases, a combination of limited grading, limited time of exposure, and a judicious selection of erosion control practices and sediment trapping facilities will prove to be the most practical method of controlling erosion and the associated production and transport of sediment.

VEGETATION FOR EROSION AND SEDIMENT CONTROL

Introduction

A dense, vigorous growing vegetative cover protects the soil surface from raindrop impact, a major force in causing erosion and sedimentation. Also, vegetation will shield the soil surface from the scouring effect of overland flow and decreases the erosive capacity of the flowing water by reducing its velocity.

The shielding effect of a plant canopy is augmented by roots and rhizomes that hold the soil, improve its physical condition, and increase the rate of infiltration, further decreasing runoff. Plants also reduce the moisture content of the soil through transpiration, thus increasing its capacity to absorb water.

Suitable vegetative cover offers excellent erosion protection and sedimentation control. Vegetative cover is essential to the design and stabilization of many structural erosion control practices. Vegetative cover is relatively inexpensive to achieve and maintain. Also, it is often the only practical, long-term solution to stabilization and erosion control on many disturbed sites.

Planning from the start for vegetative establishment reduces its cost, minimizes maintenance and repair, and makes structural erosion control measures more effective and less costly to maintain. Landscaping is also less costly where soils have not been eroded, slopes are not too steep, and weeds are not allowed to proliferate. Natural areas (those left undisturbed) can provide low-maintenance landscaping, shade, and screening. Large trees increase property value if they are properly protected during construction.

Besides preventing erosion, healthy vegetative cover provides a stable land surface that absorbs rainfall, cuts down on heat reflectance and dust, and complements architecture. The result is a pleasant environment for employees, tenants and customers, and an attractive site for homes. Property values can be increased dramatically by small investments in erosion control. Even the final landscaping represents only a small fraction of total construction costs and contributes greatly to the marketing potential of a development.

Tree Preservation and Protection

It usually takes 20 to 30 years to grow a tree which provides the benefits of an existing tree. Desirable trees should be protected during construction activities. Many building sites are selected because of the presence of desirable trees but unless sufficient care is taken to protect them this valuable resource may be destroyed. Trees provide the following benefits:

- Stabilize the soil and reduce erosion
- Provide shade and moderate temperature
- Reduce wind velocities
- Provide buffers to reduce noise
- Provide visual screens
- Remove carbon dioxide from the air and release oxygen
- Provide habitat and food for wildlife
- Increase property values
- Improve the aesthetics of the urban environment.

Damage To Trees From Construction

Construction activities expose trees to a variety of stresses resulting in injury ranging from superficial wounds to death. Many damages may occur to trees during construction activities. Understanding the types of damages that may occur to trees is important in planning for protection.

Surface Impacts - Natural and man-related forces exerted on trees can cause significant damage. Wind damage can be a problem especially when trees have been removed from a group of trees. This exposes the survivors to greater wind velocities. Trees develop root anchorage where it is needed the most. Isolated trees develop anchorage rather equally all around with stronger root development on the side of the prevailing wind. The more a tree has been protected from the wind the less anchorage it usually has. The result of excessive thinning of trees may be windthrow. Selective thinning in favor of a single tall tree increases the hazard of lightning strike. Excessive pruning of trees to prevent contact with utility lines or buildings may destroy the

visual appeal of the tree, may provide a source of entry for disease causing fungi, or it may kill the tree.

Tree trunks are often damaged during construction activities. Trees are often scarred by construction equipment. Such superficial wounds provide a source of entry for insects and disease.

Root Zone Impacts - Disturbing the relationship between soil and tree roots can damage or kill a tree. The roots of an existing tree are established in an area where soil, water, oxygen, and nutrients are present. The mass of the root system must be the correct size to balance the intake of water from the soil with the transpiration of water from the leaves.

Raising the grade as little as 6 inches can retard the normal exchange of air and gases. Roots may suffocate due to lack of oxygen or be damaged by toxic gases and chemicals released by soil bacteria. Raising the grade may also elevate the water table. This can cause drowning of the deeper roots.

Lowering the grade is usually not as damaging as elevating the grade. Shallow cuts of 6 to 8 inches will remove most of the topsoil and some feeder roots and expose some to drying and freezing. Deep cuts may sever a large portion of the root system, depriving the tree of water and increasing the chance of windthrow. Lowering the grade may also lower the water table.

Trenching or excavating through a tree's root system can eliminate as much as 40 percent of the tree's roots. Trees which lose as much as 40 percent of their root system usually die within 2 to 5 years. Tunneling may be a better alternative in species that do not have tap roots. Soil compaction caused by heavy equipment, materials storage, and paving within the drip line of tree's may restrict air and water from roots.

Selecting Trees to Be Retained

The proper development of a forested site requires a plan for tree retention before construction begins. See Appendix A-IV-TP-1 for tree suitability for disturbed areas and landscaping. Trees should be identified and located on a map. The following criteria should be used to determine which trees to save:

Life expectancy and present age - Trees with long life spans should be favored. Long-lived species that are old may

succumb to the stresses of construction, so younger trees of desirable species are preferred since they are more resilient and will last longer. However, if the cost of preservation is greater than the cost of replacement with a specie of the same age and size, replacement may be preferred.

Health and disease susceptibility - Check for scarring or disease damage, and rotten or broken trunks or limbs.

Structure - Check for structural defects that indicate weakness or reduce the aesthetic value of a tree: trees growing from old stumps, large trees with overhanging limbs that endanger property, trees with brittle wood, misshapen trunks or crowns, and small crowns at the top of tall trunks. Trees growing in the open often have better form than those growing in the forest. Trees with strong tap or fibrous root systems are preferred to trees with weak rooting habits.

Cleanliness - Trees which seed prolifically or sucker profusely are generally less desirable in urban areas. Trees with fruits that have unpleasant odors should be avoided.

Aesthetics - Trees that are attractive and pleasing to the eye are desirable. Trees that have beauty during several seasons of the year are desirable and add value to the site.

Comfort - Trees provide cooling during the summer and buffer the cold winds of winter. Summer temperatures may be 10 degrees cooler under hardwoods than under conifers. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

Wildlife - Preference may be given to trees that provide food and cover for wildlife.

Relationship to other trees - Trees growing alone generally are more valuable than trees growing in groups but trees in groups are more effective in preventing erosion and excess stormwater runoff.

Adaptability to other trees - Consider the height and spread of trees and how they may interfere with proposed structures and overhead utilities. Roots may interfere with walls, walks, driveways, patios, parking lots, waterlines, and septic tanks.

Trees must be appropriate for the proposed use of the development. Select trees which are pollution-tolerant for areas with heavy traffic and industrial areas, screen and buffer trees for noise or objectionable views and tolerant species for areas exposed to ocean spray.

Site Considerations

Species selection, establishment methods, and maintenance procedures should be based on site characteristics, including soils, slope, aspect, climate, and expected management.

Slope

The steeper the slope, the more essential is a vigorous vegetative cover. Good establishment practices, including seedbed preparation, proper planting, lime, fertilizer, mulching, and anchoring of mulch are critical. The degree of slope may limit the equipment that can be used in seedbed preparation, planting, and maintenance.

Woody plants, shrubs, vines, and trees generally provide better erosion control on steep slope. They may be more costly and slower to establish, but can provide substantial savings in maintenance. Also, they can be more desirable in the over all landscape plan.

Aspect

Aspect affects soil temperature and available moisture. South and west facing slopes tend to be warmer and drier, and often require special treatment. For example, mulch may be essential to retain moisture. Also warm-season species tend to do better on south and west facing slopes since they are usually more drought tolerant.

Climate

The regional climate must be considered in selecting well adapted plant species. Species adaptation and seeding dates in Alabama are based on three broad geographical areas: North, Central, and South. Climatic differences determines the appropriate plant selections based on such factors as cold-hardiness, heat tolerance, and tolerance to a cool growing season.

Management

When selecting plant species for erosion control and stabilization, the post-construction land use and the

expected level of maintenance must be considered. In every case, future site management is an important factor in plant selection.

When a site will receive heavy use such as a sports field, select plant species that are wear resistant and have rapid wear recovery. A wear resistant plant that also recovers rapidly from foot traffic is bermudagrass. Bermudagrass also has a fast establishment rate and is adapted to all geographical areas in Alabama.

Where a neat appearance is desired, use plants that respond to frequent mowing and other types of intensives maintenance. Likely choices for quality turf in north Alabama are bermudagrass or tall fescue, while in central or south Alabama bermudagrass, centipede, or zoysia are good choices.

At sites where low maintenance is desired, low fertility requirements and vegetation persistences are particularly important. Sericea lespedeza and tall fescue are good choices in north Alabama while bahiagrass and centipede do well in central and south Alabama.

Soils

Many soils characteristics, including acidity, moisture retention, drainage, texture, organic matter, fertility, and slope influence the selection of plants and their establishment requirements for example, bahiagrass and centipede are suited to droughty soils since they are more drought tolerant than most other grasses. Chapter 2, "Soils and Geology Considerations," contains a general description of soils in Alabama with respect to characteristics that affect stabilization of disturbed sites.

Site Planning For Tree Protection

Select trees to be saved before beginning construction. No tree should be destroyed or altered until the construction plans are final. Areas such as flood plains and wetlands should be left in their natural condition. Locate roadways to cause the least damage to valuable trees. Follow contours where feasible to minimize cuts and fills. Minimize trenching by locating several utilities in the same trench. Excavations for basements and utilities should be kept away from the drip line of trees.

Storage areas for construction materials and worker parking areas should be noted on the site plan, and located where they will not cause soil compacting over roots.

When retaining existing trees in parking areas, leave enough ground ungraded around the tree to allow for its survival. Tree wells may need to be installed.

Locate erosion and sediment control measures at the limits of clearing and not in wooded areas to prevent deposition of sediment within the drip line of trees being preserved. Sediment basins should be constructed in the natural terrain if possible rather than in locations where extensive grading and tree removal will be required.

Seasonal Considerations

Newly constructed slopes and other barren areas should be seeded or sodded as soon as possible after grading. Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for planting perennial grasses and legumes generally extend from March through May and from late August through October. Outside these dates the probability of failure is higher. If the time of year is not suitable for seeding permanent cover (perennial species) a temporary cover should be planted or the area may be stabilized with gravel or mulch. Temporary seedings of annual species (small grains, ryegrass, millets etc.) often succeed at times of the year that are unsuitable for seeding permanent (perennial) species. Planting dates may differ for temporary species depending on the geographical area of Alabama.

Growing seasons must be considered when selecting species. Grasses and legumes are usually classified as warm- or cool-season in reference to their season of growth. Cool-season species produce most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore, fall is the most dependable time to plant them. Warm-season plants grow most activity during the summer, and go dormant at the first frost in the fall. Spring and early summer are the preferred planting times for warm-season species.

Selection of Vegetation

Plant selection should be considered early in the process of preparing the erosion and sedimentation control plan. A diversity of species can be grown in Alabama due to the variation in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, plant selection should be made with care. Many plants are inappropriate for soil stabilization

because they do not protect the soil effectively, or they can not be established quick and easy. Some plants may be very effective for soil stabilization, but are not aesthetically acceptable on some sites. Some plants may even become troublesome pests.

Initial stabilization of most disturbed sites requires grasses and legumes that grow together without gaps. This is true even where part or all of the site is planted to trees or shrubs. In landscape plantings, disturbed soil between trees and shrubs must also be protected either by mulching or by permanent grass, legumes, or mixtures.

Trees are an excellent type of permanent vegetation to plant on disturbed areas for long term soil and water protection. Trees may be used on all kinds of areas disturbed during construction activities.

Selecting The Right Grasses and/or Legumes

Mixtures vs Single Species Plantings

Single species plantings are desired in some cases, but most of the time a mixture is more desirable. Mixtures can to selected that may provide protective cover more quickly and can be more enduring than a single species. Mixtures need not be elaborate. The addition of a quick-growing annual or short lived perennial provides early protection and facilitates establishment of a slower growing long lived perennial. It is important to evaluate the merits and weakness of each species in selecting the mixtures for the specific site to be treated.

Companion or "Nurse" Crop

The addition of a companion or "nurse" crop (quick-growing annual or weak perennial added to permanent mixtures) is a good practice on difficult sites, late seeding, or in situations where the development of permanent cover is likely to be slow. The companion crop germinates and grows rapidly, holding the soil until the perennial species becomes established. Seeding rate of the companion crop must be limited to avoid crowding, especially under optimum growing conditions.

Plant Species Selection

Detail Information on plant species adapted for soil stabilization use in Alabama is contained in Appendix IV. Using this information makes plant selection more straight forward for most situations. Specific seeding rates and

planting instructions are given in the specifications of the measures.

Annuals

Annual plants grow rapidly, mature, and die in one growing season. They are useful for quick, temporary cover or as a companion crop for slower growing perennials.

Small Grains - Rye (cereal) is usually superior to other small grains (wheat, oats, or barley) for temporary cover. It has more cold hardiness than other annuals and will germinate and grow at lower temperatures. It will provide more fall and early winter growth and matures earlier than other small grains. Rye germinates quickly and is tolerant of poor soils. Including rye in fall seeded perennial mixtures is particularly helpful on difficult soils and erodible slopes or when seeding is late. However, seeding rates of rye should be limited to the suggested rates because thick stand will suppress the growth of perennial seedlings. No more than 60 lb/acre should be planted when rye is used as a companion crop. Rye does grow fairly tall in the spring which may be undesirable. If this is a problem some of the shorter growing varieties of wheat may be used.

Annual ryegrass is **not recommended** for use as a companion crop in perennial mixtures in Alabama. It is highly competitive and, if included in mixtures, crowds out most other species before it matures in late spring or early summer, leaving little or no lasting cover. It will provide dense cover rapidly, so it can be effective as a temporary seeding, but if allowed to mature the seed volunteers and can seriously interfere with subsequent efforts to establish permanent cover.

Millets (Browntop, Foxtail) are warm season annuals, useful for temporary seeding or as a nurse crop. Browntop millet has early rapid growth, growing two to three feet in height. It is adapted to fine and medium textured soils of moderate productivity. Foxtail is a fine stemmed plant growing to a height of four to five feet. The leaves are broad and flat. Foxtail millets do best under fairly abundant moisture conditions. German millet is a type of foxtail millet.

Sudangrass and sorghum-sudangrass hybrids, like the millets, are warm season annuals which are useful for temporary vegetation. They are better adapted to medium to heavy textured soils. The small stemmed, shorter growing varieties are more satisfactory for temporary vegetation than the tall coarse-stemmed varieties.

Annual lespedeza is a warm-season reseeding annual legume growing to a height of six to twelve inches. It is tolerant of low fertility and is adapted to the climate and most soils throughout Alabama. It is not adapted to alkaline soils of the Black Belt or deep sands. It is a good companion crop for spring planted sericea lespedeza, filling in weak or spotty stands the first season without suppressing the sericea. Annual lespedeza can heal damaged areas in the perennial cover for several years after initial establishment. Two species of annual lespedeza are grown in Alabama. "Common" annual lespedeza volunteers in many parts of Alabama and is sold under the variety name Kobe. Korean lespedeza is a slightly larger, coarser and earlier-maturing plant sold under several variety names. Kobe is superior on sandy soils and generally preferable in south Alabama. Korean is better in north Alabama as the seeds mature earlier.

The preferred seeding dates for annual lespedeza are in the late winter to early spring. It can be mixed with fall seeding, in which case some seeds remain dormant over the winter and germinate the following spring.

Cool-Season Perennials

Perennial plants, once established, will live for more than one year. They may die back during a dormant period, but will grow back from their underground tubers or rhizomes in succeeding years. Stands of perennials will persist for a number of years under proper management and environmental conditions. They are the principal components of permanent vegetative cover.

Cool-season perennials produce most of their growth during the spring and fall and are more cold-hardy than most warm-season species. Tall fescue is the only cool-season perennial grass recommended for vegetating disturbed soils in Alabama. A descriptions of tall fescue follows.

Tall fescue, a cool-season grass, is the most widely used species in north Alabama for erosion control. It is well adapted to all of north Alabama and all but the most droughty soils of central Alabama. Also it can be grown on the Black Belt soils of south Alabama. It thrives in full sun to partial shade and is fairly easy to establish. It will provide stabilization the year of establishment. Because tall fescue has a bunch growth habit it is slow to fill in areas with poor stands. Therefore, some maintenance will be required on washed out areas or areas of spotty stands to prevent further damage.

A number of new varieties of tall fescue are becoming available for lawn and other turf use and several offer definite improvements. However, their higher cost over the old standby, Kentucky 31, is seldom justified solely for purposes of stabilization and erosion control. Also, fescue seed infected with a fungal endophyte are preferred since endophyte infected plants are more hardy and stands persist longer.

Tall fescue is a fall planted grass. Liberal fertilization and proper liming are also essential for prompt establishment, but once established it can tolerate minimal maintenance almost indefinitely. White clover is sometimes planted with tall fescue.

Warm-Season Perennials

Warm-season perennials initiate growth later in the spring than cool-season species and experience their greatest growth during the hot summer months. Most species of warm-season perennials do better in the southern one-half of Alabama, but there are species or varieties that will grow in north Alabama. The following grasses have proven the most useful for soil stabilization.

Bahiagrass is a warm-season perennial grass particularly well adapted for growing on sandy soils in the southern half of Alabama. It will tolerate acid and low fertility soils, grow in full sun to light shade, and persist almost indefinitely with little or no maintenance after it is established. However, bahiagrass seedlings are small and lack the vigor some species of warm-season grasses possess, it usually takes two years to establish a good sod. Bahiagrass is established with seed.

Bahiagrass does produce a fairly dense sod suitable for low maintenance areas. It has a high resistance to wear and recovers fairly fast from wear. It produces rhizomes and will fill in small bare spots fairly fast. Bahiagrass will produce seedheads about one to two feet in height throughout the growing season and, where this is not a problem, it is probably the best choice for stabilizing soil in the southern one half of the state.

Pensacola is the better variety of bahiagrass for soil stabilization. It is more tolerant to upland sites and is more cold tolerant than Argentine bahiagrass.

Common Bermudagrass is a long lived perennial that spreads by creeping stolons and rhizomes that will extend outward

several feet in a growing season. It will survive extreme heat and drought. It is not shade tolerant. Bermudagrass is best adapted to well drained fertile soils. It does poorly on extremely droughty sandy soils and will not grow on poorly drained soils. It responds well to fertilizer and will establish a dense sod quickly from seed. Common bermudagrass will grow in all areas of the state.

Bermudagrass requires more maintenance than bahiagrass and, if a regular maintenance fertility program is not used, it will tend to slowly decline. It has a high resistance to wear and a fast recovery from wear which makes it a good choice for heavy use areas.

There are two types of bermudagrass which are important in soil stabilization. Common bermudagrass, which can be established with seed or sprigs, and turf-type bermudagrasses which must be established from vegetative material. Common has longer internodes and larger leaves than the turf-type hybrid bermudagrass. When common bermudagrass will be used for permanent vegetation, only seed that are 98% pure common bermudagrass should be planted. Common bermudagrass seed are often contaminated with giant-type bermudagrass seed. Giant-type bermudagrass is very competitive and fast growing, but is not cold hardy in Alabama. So when common bermudagrass seed contains even a small percent of giant type bermudagrass seed, they will be "choked out" by the giant-type bermudagrass. Since the giant-type bermudagrass is killed by the cold a good sod the year of establishment becomes nothing the second year.

The turf type hybrid bermudagrasses have fine leaves and short internodes which make them desirable for lawn, golf courses and other areas where a quality turf is desired. However, turf type hybrid bermudas are more costly to establish because they must be planted from sprigs, plugs, or solid sodded. Tifway 419 is the most commonly used turf type hybrid bermudagrass.

The agronomic varieties of hybrid bermudas do not lend themselves to soil stabilization of construction areas. They too must be established with vegetative material which makes them costly to establish.

Perennial Legumes

Sericea lespedeza or sericea is a deep rooted, drought resistant perennial legume, adapted to all but the poorly drained and deep sandy soils of the state. It is long lived, tolerant of low fertility soils, pest free, and will fix nitrogen. It can be a valuable component in most low

maintenance mixtures. Sericea is slow to establish and will not contribute much to prevention of erosion the first year; however, once established it persists indefinitely on suitable sites.

Plantings that include sericea require mulch and should include a companion crop such as browntop millet, annual lespedeza, or common bermudagrass. Sericea should be planted as early as possible within the planting date so as to reduce as much weed competition as possible. Also, sericea may be planted in the late fall and winter months because many of the seeds will lie dormant until germination the following spring.

Sericea does not tolerate frequent mowing and may be considered unsightly because the old top growth breaks down slowly.

Crownvetch is a deep rooted, perennial legume adapted only to north exposures in the northern tier of counties in Alabama. It is useful on steep slopes and rocky areas that are likely to be left unmoved. It can be seeded in the spring or fall. Crownvetch requires a specific inoculant.

Selecting the Right Trees

In urban areas trees may be exposed to insufficient sunlight and water; high winds; heat radiation from highways and parking lots; pollutants from cars and industries; root amputation because of sewer, water, gas and electric lines; and topping because of power lines and the covering of roots by pavement. Trees should be selected based on their adaptability and growth habits. The selection of tree species depends on the desired function of the tree, whether it be erosion control, shade, privacy screening, noise screening, appearance, enhancement of wildlife habitat or a combination of these. The following characteristics of a tree should be considered when choosing a tree to plant:

Hardiness

Plant trees that are recommended for the area where they are to be planted (See Appendix A-IV-TP).

Mature Height and Spread

The eventual height of a tree must be considered in relation to planting location to avoid future problems with buildings and utility lines (See Appendix A4-TP)

Growth Rate

Some trees attain mature height at an early age, others take many years. Slow growing trees are usually less brittle and usually live longer.

Root System

Avoid trees which have fibrous roots which may cause damage to water lines, septic tanks or sidewalks and driveways.

Cleanliness

Maintenance problems can be avoided by not selecting trees that drop seedpods, cones, flowers, or twigs in large amounts.

Moisture and Fertility Requirements

If suitable soils with adequate fertility are not available, trees tolerant of poor growing conditions should be planted.

Ornamental Effects

If a tree is unusually attractive in appearance, some other shortcomings may be overlooked.

Evergreen vs. Deciduous

Evergreens retain their leaves throughout the year, and are useful for privacy screens and noise barriers. Deciduous trees drop their leaves in the fall. They are preferable for shade trees.

Pest

Insects and disease problems exist among many trees. Each pest is related to the trees species itself, its vigor and the site on which it is planted. Where control techniques are available, the tree owner's commitment and ability to apply them to a pest problem will determine whether the tree should be planted.

Selecting Shrubs, Vines and Groundcovers

As with trees, several plant characteristics and environmental requirements should be considered when selecting shrubs, vines and groundcovers. The closer to meeting the plants requirements, the greater the chance of achieving a successful landscape.

Hardiness

Plants have varying capacities to tolerate cold or heat. Cold tolerance is of most concern. The state of Alabama spans two major plant hardiness zones, Zone 7 (from the central part of the state northward) and Zone 8 (the southern half of the state). The zones are determined by the range of average annual minimum temperatures. The average range of minimum temperatures for Zone 7 in 0 to 10 degrees F; for Zone 8 it is 10 to 20 degrees F (See Appendix A-IV-SVG).

Landscape plants which are not capable of tolerating temperatures below 10 degrees should not be expected to escape injury during an average winter in Zone 7. However, they should be adequately adapted to Zone 8.

Plant hardiness can be greatly influenced by nearby bodies of water since water buffers change in temperature. Other structures or other plants can moderate extreme temperatures and shelter landscape plants, enabling marginal species to better tolerate winter conditions.

Summer Heat Tolerance

A plant's capacity to survive the stress of high temperature is also a concern. Heat interacts with other environmental factors, especially soil moisture conditions and sunlight to influence the range of adaptability of a plant. Usually associated with high temperatures is rapid depletion of soil moisture, especially in late summer. Direct sunlight increases the severity of heat effects on plants. Since Alabama has periods of high temperatures and short winters, spruce, hemlock, and yew are generally poor performers. Other conifers such as deodar cedars and cryptomeria are not hardy further north into zone 6 but offer good substitutes for hemlocks and spruces in the South.

Moisture Requirements and Soil Drainage

Landscape plants vary widely in the amount of moisture they need to thrive. If a drought tolerant plant receives a lot of rain, it can be more susceptible to invasion by normally weak pathogens, especially where the soil drains slowly. On the other hand, plants which require large amounts of water for best performance are easily drought stressed when water is withheld or if planted in very well-drained soils. Such conditions may actually attract insect pests to stressed plants.

Plants that normally require a lot of water can be irrigated so that the ornamental attributes of the plant are maintained. However, this is a use of water resources that can be avoided if consideration is given to appropriate plant selection.

Soil pH

Soil pH can have a profound influence on landscape plant performance. However, most landscape plants perform adequately within a soil pH range of 5.5 to 6.2. Plants listed in Appendix A4-SVG would grow satisfactorily within this pH range.

Plant Pest Susceptibility

It is unwise to use pest-susceptible plants in areas where those particular pests thrive. For example, most species of euonymus are attacked by euonymus scale and Red Tip is highly susceptible to leaf spot. Other landscape options for plant materials might be selected which do not have the same susceptibilities. Plants listed in Appendix A4-SVG have few if any major pest problems.

Nutritional Requirements

Newly set plants often require little additional fertilizer because of the presence of residual fertilizer in the root ball. At this stage, supplying water is far more important than adding fertilizer. Also, most well-established shrubs require less fertilizer to maintain an attractive plant than is usually required by poorly established shrubs.

Light requirement

Plants which require full sun (at least 8 hours of direct sunlight per day) are weakened in low light situations. Plants that need some shade are often vigorous and unattractive in full sun.

Rate of growth and Mature Size

Obviously, for rapid cover, faster-growing plants are desired. However, mature size and other plant characteristics should be considered. For example, where a screen is needed, a slower-growing evergreen shrub may be desired over a fast-growing deciduous plant. Take all plant characteristics into account when selecting plants for a site. If money is available, both needs can be met by planting fast growing, short-lived plants to provide a quick screen and at the same time planting slower growing plants

and allowing them to mature. When the fast-growing plants become over grown, they can be removed to allow the more desirable plants to take their place.

Establishing Vegetation

Topsoiling

The surface layer of an undisturbed soil is often enriched in organic matter and has physical, chemical, and biological properties that make it a desirable planting and growth medium. These qualities are particularly beneficial to plant establishment. Consequently, **where practical, topsoil should be stripped off prior to construction and stockpiled for use in final vegetation of the site.** Stockpiling topsoil may eliminate costly amendments and repair measures later. Topsoil may not be required for the establishment of less demanding, lower maintenance plants, but it is essential on sites having shallow soils or soils with other severe limitations. It is essential for establishing fine turf and ornamentals.

The need for topsoil should be evaluated, taking into account the amount and quantity of available topsoil and weighing this against the difficulty of preparing a good seedbed on the existing subsoil. Where a limited amount of topsoil is available, it should be reserved for use on the most critical areas.

Soil Amendments

Lime is almost always required on disturbed sites to decrease soil acidly. Lime raises the pH, reduces exchangeable aluminum, and supplies calcium and magnesium for vigorous plant growth. Only the alkaline soils of the Black Belt and north Alabama do not require lime. A soil test should be used to determine the need for liming materials.

Plant nutrients (fertilizer materials) will usually be required even on the best soils. Plant nutrient application rates for a particular species of vegetative cover should be applied according to a soil test report.

Soil amendments should be applied uniformly and well mixed with the top 6 inches of soil during seedbed preparation.

Site Preparation

The soil on a disturbed site must be modified to provide an optimum environment for germination and growth. Addition of

topsoil, soil amendments, and tillage are used to prepare a good seedbed. At planting the soil must be loose enough for water infiltration and root penetration, but firm enough to retain moisture for seedling growth. Tillage generally involves disking, harrowing, chiseling, or some similar method of land preparation. Tillage should be done on the contour where feasible to reduce runoff and erosion. Lime and fertilizer should be incorporated during the tillage.

Planting Methods

Seeding is by far the fastest and most economical method that can be used with most species. However, some grasses do not produce seed and must be planted vegetatively. Seedbed preparation, liming, and fertilization are essentially the same regardless of the method chosen.

Uniform seed distribution is essential. This is best obtained using a cyclone seeder, conventional grain drill, cultipacker seeder, or hydraulic seeder. The grain drill and cultipacker seeder are pulled by a tractor and require a fairly clean, smooth seedbed.

On steep slopes where equipment can not safely work hydroseeding may be the most effective seeding method. A rough surface is particularly important when preparing slopes for hydroseeding. In contrast to other seeding methods, a rugged and even trashy seedbed gives the best results.

Because uniform distribution is difficult to achieve with hand broadcasting, it should be considered only as a last resort. When hand broadcasting of seed is necessary, uneven distribution may be minimized by applying half the seed in one direction and the other half at right angles to the first. Small seed should be mixed with sand for better distraction.

A sod seeder (no-till planter) can plant seed into an existing cover or mulch or be used to restore or repair a weak stand. It can be used on moderately uneven, rough surfaces. It is designed to penetrate the sod, open narrow slits, and deposit seed with a minimum of surface disturbance.

Seeding rates recommended in this handbook have taken into account the "insurance" effect of extra seed. Rates exceeding those given are not recommended because over dense stands are more subject to drought and competitive interference.

Sprigging refers to planting stem fragments consisting of runners (stolons) or lateral, below-ground stems (rhizomes), which are sold by the bushel. Sprigs can be broadcast or planted in furrows using a transplanter. This method works well with bermudagrass. Also sprigs may be broadcast and covered with soil by light disking, or cultipacking. Broadcasting is easier but requires more planting material. Common and forage type hybrid bermudagrass will cover over much more quickly than the lawn type bermudagrass.

Plugging differs from sprigging only in the use of plugs cut from established sod, in place of sprigs. It requires more planting stock, but usually produces a complete cover more quickly than sprigging. It is usually used to introduce a superior grass into an old lawn.

In sodding, the soil surface is completely covered by laying cut sections of turf. It is limited primarily to lawns, steep slopes, and sod waterways in Alabama. Turf-type bermudas, centipede, and zoysia are usually the types of turf used for sodding. Plantings must be wet down immediately after planting, and kept well watered for a week or two thereafter.

Sodding, though quite expensive, is warranted where immediate establishment is required, as in stabilizing drainage ways and steep slopes, or in the establishment of high quality turf. If properly done, it is the most dependable method and the most flexible in seasonal requirements. Sodding can be done almost anytime of the year in Alabama.

Inoculation of legumes

Legumes have a bacteria called rhizobia which invade the root hairs and form gall like "nodules". The host plant supplies carbohydrates to the bacteria, which supply the plant with nitrogen compounds fixed from the atmosphere. A healthy stand of legumes, therefore, does not require nitrogen fertilizer. *Rhizobium* species are host specific in that a given species will inoculate some legumes but not others. Therefore, successful establishment of legumes requires the presence of specific strains of nodule forming, nitrogen fixing bacteria on their roots. In areas where a legume has been growing, sufficient bacteria may be present in the soil to inoculate seeded plants, but in other areas the natural *Rhizobium* population may be too low.

In acid subsoil material, if the specific *Rhizobium* is not already present, it must be supplied by mixing it with the

seed at planting. Cultures for inoculating various legume seed are usually available through seed dealers.

Among the legumes listed for use in this manual, crown vetch is the only one generally requiring inoculation. Lespedeza nodule bacteria are widely distributed in the soils of Alabama unless the site has had all surface soil removed.

Irrigation

Irrigation, though not usually required, can extend seeding dates into the summer and insure seedling establishment. Damage can be caused by both under and over irrigating. If the amount of water applied penetrates only the first few inches of soil, plants may develop shallow root systems that are prone to desiccation during droughts. If supplementary water is used to get seedlings up, it must be continued until plants become completely established.

Mulching

Mulch is essential to the vegetation of most disturbed sites, especially on difficult sites such as southern exposures, channels, and excessively dry soils. The steeper the slope and the poorer the soil, the more valuable mulch becomes. Mulch protects the site from erosion until the vegetation is establish. In addition, mulch aids seed germination and seedling growth by reducing evaporation, preventing soil crusting, and insulating the soil against rapid temperature changes.

Mulch may also protect surfaces that cannot be seeded. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow.

Small grain straw (wheat, oats, barley or rye) is the most widely used and one of the best mulch materials. However, there are other materials that work well but may be only locally available. Mulching materials covered in this manual have their respective advantages and appropriate applications, and a material should not be selected on the basis of cost alone.

Maintenance

Satisfactory stabilization and erosion control requires a complete vegetative cover. Even small breaches in vegetative cover can expand rapidly and, if not repaired, can result is excessive soil loss from an otherwise stable site. A single heavy rain will enlarge rills and bare spots

and, the longer repairs are delayed, the more costly they become. Prompt action will keep soil loss, sedimentation damage, and repair cost down. New plantings should be inspected frequently and maintenance performed as needed. If rills and eroded areas develop, they must be repaired, seeded, and mulched as soon as possible.

Maintenance requirements extend beyond the seeding phase. Damage to vegetation from disease, insects, traffic, etc., can occur at any time. Pest control (weed or insect) may be needed at any time. Weak or damaged spots must be fertilized, seeded and mulched as promptly as possible.

Vegetation established on disturbed soils often requires additional fertilization. Frequency and amount of fertilizer to apply can best be determined through periodic soil testing. A fertilization program is required for the maintenance of turf and sod that is mowed frequently. Maintenance requirements should always be considered when selecting plant species for vegetation.

C. State Laws, Permits, and Model Ordinances

1) Local Program Principles and Processes
   Source: Georgia, GA-1

2) Model Soil Erosion and Sedimentation Control Ordinance
   Source: Georgia, GA-1

CHAPTER 4

LOCAL PROGRAM PRINCIPLES AND PROCESSES

Once again, the Erosion and Sedimentation Act of 1975 states that the governing authority of each county and municipality shall adopt a comprehensive ordinance establishing procedures governing land-disturbing activities conducted within their respective boundaries.

If counties and municipalities have failed to have in effect an ordinance conforming to the provisions of the law, then the State Board of Natural Resources will adopt appropriate rules and regulations governing activities within those areas.

The emphasis of the law is truly on implementation of *local* erosion and sediment control programs. It has been said that, "Unquestionably, local officials have the constitutional authority to make decisions concerning the use and allocation of local land and water resources. Also a sedimentation and pollution control program constitutes a segment of soil and water resources management which ought to be the responsibility of elected officials at the local level." (21)

PRINCIPLES

For any sediment control *program* to become effective, there are certain principles which should be applied for maximum effectiveness.

1. Sediment control should become a stated policy of all concerned, including public and private agencies operating in or having jurisdiction within the boundaries of the unit of government. It is imperative that developers, owners of land to be developed, their designated consultants, planners and engineers become aware of the necessity for sound sediment control programs.
2. A well-planned public information and education program on sediment control is essential for public and private support.
3. Competent technical personnel knowledgeable in local soil and climatic conditions, workable procedures, and inspections are necessary for successful sediment control.
4. To be effective, provision for sediment control must be made in the planning stage. Practical combinations of the basic design principles contained in Chapter 2 should be skillfully planned and applied in a timely manner.
5. Research observations and evaluations should be conducted to provide needed information for improvement of the sediment control program. A comprehensive review and evaluation of the overall sediment and erosion control program should be conducted at least every few years.

PROCESSES

An erosion and sediment control program may be subdivided into four basic processes:

a. ordinance development and implementation
b. plan preparation and review
c. inspection and enforcement
d. information, education and training

ORDINANCE DEVELOPMENT AND IMPLEMENTATION

Local officials have a working knowledge of local conditions and problems. It is they who can best implement ordinances which take local needs into account.

In the past, the cost of correcting expensive sediment damages has often been the responsibility of local units of government. Therefore, it is advisable that local governments have direct control over the enforcement of laws pertaining to erosion.

Although the direct responsibility for drafting ordinances falls on local officials, citizen participation should be encouraged to insure that the final product will reflect their needs and wishes.

A model ordinance has been developed by the State Soil and Water Conservation Commission for use by officials in municipalities and counties. The model is intended primarily to provide guidelines for control of *urban* soil erosion and sediment pollution. It is designed to meet state requirements for establishing programs as required in Act 599. A copy of the model is contained in Appendix D of this manual.

Following the body of the model ordinance is a brief explanation of the contents. This explanation is intended to clarify certain sections or phrases contained in the model. Opinions expressed therein are not necessarily requirements to be fulfilled. Local authorities may wish to develop individual ordinances from the wealth of comprehensive material available for this. Or they may utilize another of the models available. Regardless of the method used, the contents of the model ordinance should be tailored to fulfill specific needs of the local governing authority. A review of the final draft by the county or city attorney should be mandatory.

The adoption of an ordinance should be considered as only the first step toward a sound soil erosion and sedimentation control program. It is essential that sufficient lead time be provided for education of the public and technical training of persons directly in-

volved in its full implementation.

PLAN PREPARATION AND REVIEW PROCESS

All parties involved in the plan development and review process must realize without exception that there is more *than one approach* to minimizing erosion and sedimentation damages. Flexibility without compromising the primary objective must be encouraged to arrive at a common solution to erosion and sediment control problems on any given site. All available resources should be explored. Local officials should plan to provide assistance to the developer and his consulting planners and engineers prior to plan submission before plan processing can be effective. Assistance from federal and state agencies having expertise in the field of soil and water conservation should be provided to the developer and his consultant. Developers may benefit by entering into an agreement for assistance through their Soil and Water Conservation District. Technical expertise can then be provided by federal and state agencies.

The erosion and sediment control plan should be submitted as early in the planning stage as possible. The plan itself should embrace all aspects of the requirements of the basic design principles as specified in Chapter 2 of this manual. In addition, practical combinations of vegetative and structural conservation practices should be designed in accordance with the minimum requirements of the Standards and Specifications contained in Chapter 6.

It is recommended that the plan review process be broken down into the preliminary planning phase and the final design phase to reduce costly engineering fees. Such fees are normally considerably higher than preliminary planning fees. Costs for changes to engineering drawings and specifications can be prohibitive. An early, or first phase, submission of erosion and sediment control plans will promote general agreement and cooperation and provide for changes with minimum delay to the development process.

The responsibility for plan reviews has been delegated by Act 599 to the Soil and Water Conservation Districts. This does not relieve the county or municipality, however, from a responsibility to assure that plans conform to other local regulations and ordinances.

PLAN PROCESSING

Following is a recommended procedure for preparation and processing of an erosion and sediment control plan:

1. The owner, developer, or the authorized agent for either the owner or the developer, prepares the erosion and sediment control plan. The plan is prepared in accordance with the minimum requirements and recommendations contained in the Manual for Erosion and Sediment Control. (The manual should be incorporated by reference in the local erosion and sediment control ordinance.) Plans should be prepared only after consultation with the local governing authority, the Soil and Water Conservation District, and other agencies or individuals having expertise in the field of soil and water conservation.

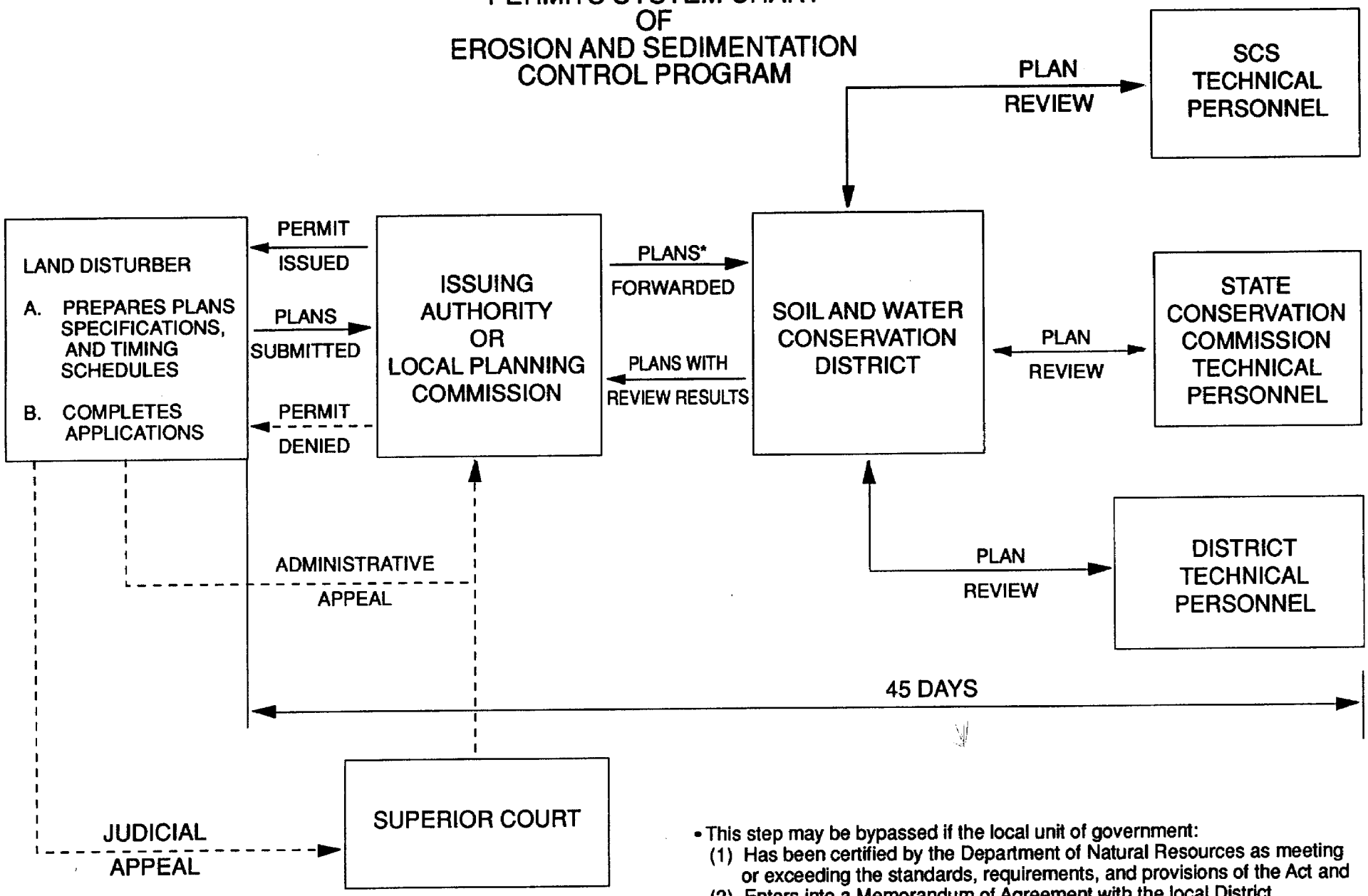
2. The owner, developer, or the authorized agent for the owner or developer, submits the plans to the local permit-issuing authority after completing an application for a permit. (Local officials should determine the number of copies of plans and applications to be submitted by the owner, etc. It is suggested that a minimum of three copies of the plan be submitted.) If an application form has not been developed by the local unit of government, a letter of transmittal containing the following information should accompany the plans.
   a. The name, address and phone number of the applicant.
   b. The name, address and phone number of the land owner of record.
   c. The name, address and phone number of the person responsible for carrying out the plan.
   d. The name, address and phone number of the person preparing the plan.
   e. The location of the activity including land lot and tax map page numbers.
   f. Any other information as determined by the local unit of government.

   The local unit of government may require that a preliminary erosion and sediment control plan be submitted along with a preliminary site plan. The preliminary erosion control plan should not be cluttered with detailed erosion and sediment control measures but should include the following information:
   a. soil boundaries of all major soil series
   b. approximate limits of grading
   c. tentative measures for sediment and erosion control.
   d. phasing of development to minimize area and duration of exposure of soils to erosive elements.

   It is suggested that the governing authority of the county or municipality delegate the authority for receiving applications and processing permits to the county engineer, director of public works or other qualified individuals knowledgeable in the processing of site development plans. If in the ordinance the responsibilities of the governing authority are delegated to the constitutional or statutory local planning and zoning commission, then it is suggested that the plans and applications be processed by the director of the planning and zoning commission.

Figure 4-1

PERMITS SYSTEM CHART OF EROSION AND SEDIMENTATION CONTROL PROGRAM



• This step may be bypassed if the local unit of government:
(1) Has been certified by the Department of Natural Resources as meeting or exceeding the standards, requirements, and provisions of the Act and
(2) Enters into a Memorandum of Agreement with the local District.

3. Two copies of the erosion and sediment control plan shall be forwarded as soon as possible to the local Soil and Water Conservation District, or its delegated authority, for review. In determining the adequacy of the plan, the district official (supervisors) will be guided by the requirements and recommendations contained in the local manual. District supervisors may request the assistance from the erosion and sediment control specialist with the State Soil and Water Conservation Commission, specialists from the district or technical personnel of the Soil Conservation Service. The district supervisor, after consultation with his district board, will forward the plans and recommendations to the permit-issuing authority of the municipality or county. These recommendations should include measures necessary to meet requirements and recommendations outlined in the manual. A copy of the recommendations of the district's technical advisor may be forwarded to the permit issuing authority.

4. The permit-issuing authority of the local unit of government, after consultation with the governing board and after a thorough review of the plan for compliance with other resolutions or ordinances rules and regulations, should then issue or deny a permit. If a plan is not approved, the modifications necessary to permit approval of the plan should be specified in writing. Time is of essence in erosion and sediment control plan processing. Act 599 states that permits shall be issued or denied as soon as practicable after the application is filed with the issuing authority—but in any event not later than 45 days of receipt of the plan and completed application.

Plan Revisions

An approved plan may be revised if inspections reveal that the erosion and sediment control plan is inadequate in accomplishing the objectives of the law. If so, modifications to correct the deficiencies must have the concurrence of the plan-reviewing authority.

Revision may also be required when the person responsible for carrying out the approved plan finds that, because of changed conditions or other reasons, the approved plan cannot be effectively carried out. Again, the plan reviewing authority must give concurrence on proposed plan changes.

Checklist of Plan Preparation and Review

The following checklist has been developed to assist both the plan preparer and the plan reviewer in determining the adequacy of the plan.

1. Does the proposed plan contain information reflecting actual existing site conditions?
2. Will the roadways, buildings and other permanent features conform to the natural topography of the site?
3. Will the limitations of soils and steep slopes be overcome by sound engineering practices?
4. Will clearing be limited to only those areas of the site to be developed?
5. Will natural vegetation be retained and provisions made for protection of existing vegetation and for supplemental planting?
6. Will major land clearing and grading operations be scheduled during seasons of low potential sediment runoff?
7. Will the time of exposure of land clearing and grading be kept to a minimum?
8. Will permanent structures, temporary or permanent vegetation or mulch be scheduled for installation as quickly as possible after the land is disturbed?
9. Will all storm water management facilities, temporary or permanent, be designed to safely convey water to a stable outlet?
10. Will sediment basins, sediment barriers, and related devices be planned to filter or trap sediment on the site? Can these structures be easily maintained?
11. Will proposed vegetation be suitable for the intended use?
12. Do potential pollution hazards, including off-site sediment, noise and dust exist?
13. Are proposed permanent facilities subjected to flood or sediment damages?
14. Do subsurface conditions exist which could lead to pollution of ground water or aquifer recharge areas?
15. Is the construction schedule adequate?
16. Will erosion and sediment control measures be in place before extensive grading and clearing begins?
17. Have areas been designated for storage of salvaged topsoil?
18. Can *all* soil and sediment control measures be adequately maintained?

INSPECTION AND ENFORCEMENT PROCESS

With regard to the inspection and enforcement process, it should be noted that it is not the purpose of this manual to support or promulgate specific courses of action by local authorities in these areas. Except as provided by Act 599, the local authorities are expected to exercise autonomy in determining the extent of any enforcement and inspection processes. The information provided here, as elsewhere in the manual, is only in keeping with the responsibility of a publication such as this to offer, for informational purposes, the alternatives available and in no way represents official opinion

or recommendation.

These responsibilities begin after the issuance of a permit for a land-disturbing activity. A crucial element in any sediment and erosion control program is adequate field inspection for evaluating compliance to the approved erosion and sediment control plan. These inspections *might* be effectively incorporated in other existing local inspection programs.

Although Act 599 specifies that the actual responsibility for inspection is that of the governing authority, on-site inspection may be assigned to a building inspector or another person employed by the local unit of government. The inspector, whether a soils engineer, civil engineer, soil conservationist, or technician, should have some knowledge in the field of soil and water conservation.

To assure that the enforcing agency and the permit applicant are in agreement about the control procedures to be followed, a pre-construction conference would be desirable. This conference should be held prior to beginning the land disturbing activity. All facets of the proposed work should be discussed at this meeting and anticipated problems reviewed. The need for installing temporary sediment control measures prior to actual clearing and grading operations should be emphasized. The individual responsible for carrying out the plan should also be informed of local inspection policies and schedules.

The institution of both scheduled and random inspections would be appropriate. The former would be a routine inspection related directly to construction operations and carried out on a rigid schedule. Random or impromptu site inspections would assure continuing compliance and the proper maintenance of erosion and sediment control measures.

The implementation of a record system would insure coordination of the inspection process with other departments and local agencies. The record system should contain a detailed filing system for all land-disturbing activities. This file should contain a record including the date of each inspection, the date land-disturbing activities commenced, and pertinent comments concerning compliance or noncompliance with the erosion and sediment control plan. In cases of noncompliance, the report should contain statements of the conservation measures needed for compliance and the recommended time in which such measures should be installed. Inspection reports should be immediately forwarded to the local governing authority.

In the event that inspections indicate a violation exists, some type of system for notifying the violator would probably be necessary. An effective system often utilized by authorities involves a written "Notice to Comply." Such a notice would describe the violation and give a detailed description of conservation measures necessary to assure compliance with the approved erosion and sediment control plan. If proper action is not taken within a reasonable time, the local governing authority could then prepare a letter of intent to utilize a performance bond, cash bond, escrow monies or other legal arrangement insuring installation of the approved measure.

The county engineer, building inspector, etc., would represent the issuing authority in handling complaints about missing or ineffective erosion control measures. When it is determined that ineffective erosion control measures are being followed but those measures comply with the approved erosion control plan, the city engineer, building inspector, etc., should notify the local Soil and Water Conservation District.

Checklist of Site Inspection

The process of inspecting construction operations requires knowledge of the basic principles and control measures in Chapter 2. A thorough understanding of the erosion and sediment control plan is absolutely essential. The following checklist is supplied to assist the inspector in fulfilling his responsibilities.

1. Are all erosion and sediment control measures in place, adequate and properly constructed?
2. Have clearing operations been confined within the limits as shown on the plan?
3. Is vegetation outside of the clearing area protected? Supplemented?
4. Is sediment being transported from the site onto public rights-of-way by vehicular traffic?
5. Are erosion problems present in the vicinity of temporary or permanent storm water management facilities?
6. Are sediment basins, sediment barriers and related devices effective in retaining sediment on the site?
7. Is appropriate vegetation being established as needed on the specified area?
8. Is work progressing in accordance with the proposed schedule?
9. Is the contractor following the plan and construction sequence?
10. Have temporary stream channel crossings been installed and maintained?
11. Are embankment slopes and permanent structures installed in areas subject to flood or sediment damage?
12. Has topsoil been salvaged and stored in the area designated by the plans?
13. Do severe fire hazards exist which would result in brush or grass fires?
14. Are all erosion and sediment control measures properly maintained?
15. Is excessive sediment leaving the site for any reason?

Enforcement, Penalties and Incentives

For each proposed land-disturbing activity, a decision should be made on precautions insuring that conservation measures are installed. These precautions may include a cash bond, cash escrow, letter of

credit, or any combination thereof. The purpose is to insure that the planned conservation measures are installed at the applicant's expense if he fails to do it within the specified time. If a cash incentive is used, it should be required prior to commencing the land disturbing activity.

In the event that the requirements of the erosion and sediment control plans are not being fulfilled, one alternative the local units of government may consider is withholding future permits such as additional grading, building, etc., involving the particular land-disturbing site.

Local authorities may consider assessing fees for erosion and sediment control plan processing. The cost of inspection services could be recouped, if desired, by levying permit fees.

INFORMATION, EDUCATION AND TRAINING PROCESS

One of the most important processes in *any* erosion and sediment control program is an effective information and education effort. A local program *must* have the acceptance and the support of those persons most affected—the developers, engineers, planners, and architects, as well as the general public. Without their support, effective sediment and erosion control *will not* take place. It is very important that the "conservation pays" ethic be adopted by these groups.

Each municipality and county must formulate plans for an information/education program. Consideration should be given to:

1. Informing the developer and others affected by the requirements of the local program and of the assistance which will be made available to them.
2. Training seminars, conferences and educational material for the developer, his consultants, contractors and other support personnel of the developers.
3. Training seminars for the local government personnel authorized to perform the functions of inspections and enforcement and administrative duties within the local erosion and sediment control program.

An initial training program for new employees, or personnel such as building inspectors who will have an added duty of inspection for erosion control, is mandatory. Annual refresher courses or training programs should be planned.

Assistance in planning and conducting local training programs may be obtained through the Soil and Water Conservation Districts.

APPENDIX D

Model Soil Erosion And Sedimentation Control Ordinance

NOW, THEREFORE, BE IT ORDAINED, by the

_____of_____

SECTION I TITLE

This ordinance will be known as "_____ Soil Erosion and Sedimentation Control Ordinance."

SECTION II DEFINITIONS

The following definitions shall apply in the interpretation and enforcement of this ordinance, unless otherwise specifically stated:

1. Buffer: An area along the course of any State waters to be maintained in an undisturbed and natural condition.
2. Conservation Commission: The State Soil & Water Conservation Commission.
3. Cut: A portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface. Also know as excavation.
4. Department: The Department of Natural Resources.
5. Director: The Director of the Environmental Protection Division.
6. District: The (Local SWCD Name) Soil and Water Conservation District.
7. Division: The Environmental Protection Division.
8. Drainage Structure: Any roadway drainage structure as defined below, and any piping or ditching for stormwater management purposes.
9. Erosion: The process by which land surface is worn away by the action of wind, water, ice or gravity.
10. Erosion and Sediment Control Plan: A plan for the control of soil erosion and sediment resulting from land-disturbing activity. Also known as the "plan".
11. Existing Grade: The vertical location of the existing ground surface prior to cutting or filling.
12. Filling: The placement of any soil or other solid materials either organic or inorganic on a natural ground surface or excavation.
13. Finished Grade: The final elevation and contour of the ground after cutting or filling and conforming to the proposed design.
14. Grading: Altering ground surfaces to specified elevations,dimensions, and/or slopes; this includes stripping, cutting, filling, stockpiling and shaping or any combination thereof and shall include the land in its cut or filled condition.
15. Issuing Authority: The governing authority of county or municipality which has been certified by the Director of the Environmental Protection Division of the Department of Natural Resources as an issuing authority, pursuant to the Erosion and Sedimentation Act of 1975, as amended .
16. Land-Disturbing Activity: Any activity which may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands within the state, including, but not limited to, clearing, dredging, grading, excavating, transporting, and filling of land but not including agricultural practices as described in Section III, Paragraph 5.
17. Metropolitan River Protection Act (MRPA): A state law referenced as O.C.G.A. 12-5-440 et seq., which addresses environmental and developmental matters in certain metropolitan river corridors and their drainage basins.
18. Natural Ground Surface: The ground surface in its original state before any grading, excavation or filling.
19. Nephelometric Turbidity Units (NTU): Numerical units of measure based upon photometric analytical techniques for measuring the light scattered by finely divided particles of a substance in suspension. This technique is used to estimate the extent of turbidity in water in which colloidally dispersed particles are present.
20. One Hundred Year Flood Plain: Land in the flood plain subject to a one percent or greater statistical occurrence probability of flooding in any given year.
21. Permit: The authorization necessary to conduct a land-disturbing activity under the provisions of this ordinance.
22. Person: Any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, state agency, municipality or other political subdivision of this State, any interstate body or any other legal entity.
23. Project: The entire proposed development project regardless of the size of the area of land to be disturbed.
24. Roadway Drainage Structure: Bridges, culverts and ditches associated with roadway construction, which allow stream flows to move freely under a stream crossing or to convey storm-water run-off from a roadway to a stream.
25. Sediment: Solid material, both organic and inorganic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, ice, or gravity as a product of erosion.
26. Sedimentation: The action or process of forming or depositing sediment.
27. Stabilization: The process of establishing an en-

during soil cover of vegetation and/or mulch or other ground cover and/or in combination with installing temporary or permanent structures for the purpose of reducing to a minimum the erosion process and the resultant transport of sediment by wind, water, ice or gravity.

28. State Waters: Any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs, wells, and other bodies of surface or subsurface water, natural and artificial, lying within or forming a part of the boundaries of the State which are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.
29. Structural Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by utilizing the mechanical properties of matter for the purpose of either changing the surface of the land or storing, regulating or disposing of runoff to prevent excessive sediment loss. Examples of structural erosion and sediment control practices are riprap, sediment basins, dikes, level spreaders, waterways or outlets, diversions, grade stabilization structures, sediment traps, land grading, etc.
30. Trout Streams: All streams or portions of streams within the watershed as designated by the Game and Fish Division of the Georgia Department of Natural Resources under the provisions of the Georgia Water Quality Control Act, O.C .G .A. 12-5-20, et seq. Streams designated as primary trout waters are defined as water supporting a self-sustaining population of rainbow, brown or brook trout. Streams designated as secondary trout waters are those in which there is no evidence of natural trout reproduction, but are capable of supporting trout throughout the year.
31. Vegetative Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by covering the soil with:
    i. Permanent seeding, sprigging or planting, producing long-term vegetative cover; or
    ii. Temporary seeding, producing short-term vegetative cover; or
    iii. Sodding, covering areas with a turf of perennial sod-forming grass.
32. Watercourse: Any natural or artificial watercourse, stream, river, creek, channel, ditch, canal, conduit, culvert, drain, waterway, gully, ravine, or wash in which water flows either continuously or intermittently and which has a definite channel, bed and banks, and including any area adjacent thereto subject to inundation by reason of overflow or floodwater.

SECTION III EXEMPTIONS

This ordinance shall apply to any land-disturbing activity undertaken by any person on any land except for the following:

1. Surface mining, as the same is defined in O.C.G.A. 12-4-72;
2. Granite quarrying and land clearing for such quarrying;
3. Such minor land-disturbing activities as home gardens and individual home landscaping, repairs, maintenance work, and other related activities which result in minor soil erosion;
4. (A) The construction of single-family residences when such are constructed by or under contract with the owner for his own occupancy; or
   (B) The construction of single-family residences not a part of a larger project and not exempted under subparagraph (A) of this paragraph; provided, however, that construction of any such residence not otherwise exempt must conform to the minimum standards as set forth in Section IV and that such standards may be enforced by the issuing authority;
5. Agricultural practices involving the establishment, cultivation, or harvesting of products of the field or orchard; the preparation and planting of pasture land; forestry land management practices, including harvesting; farm ponds; dairy operations; livestock and poultry management practices; and the construction of farm buildings:
6. Any project carried out under the technical supervision of the Soil Conservation Service of the United States Department of Agriculture;
7. Any project involving one and one-tenth acres or less; provided, however, that this exemption shall not apply to any land-disturbing activity within 200 feet of the bank of any State Waters, and for purposes of this paragraph, "State Waters" excludes channels and drainageways which have water in them only during and immediately after rainfall events and intermittent streams which do not have water in them year-round; provided, however, that any person responsible for a project which involves one and one-tenth acres or less, which involves land-disturbing activity, and which is within 200 feet of any such excluded channel or drainageway, must prevent sediment from moving beyond the boundaries of the property on which such project is located and provided, further, that nothing contained herein shall prevent the issuing authority form regulating any such project which is not specifically exempted by sub-paragraph (B) of paragraph (4) or by paragraphs (1), (2), (3), (5), (6), (8), (9), or (10) of this section;

8. Construction or maintenance projects, or both, undertaken or financed in whole or in part, or both, by the Department of Transportation, the Georgia Highway Authority, or the Georgia Tollway Authority; or any road construction or maintenance project, or both, undertaken by any county or municipality; or construction and maintenance, or either, by any water or sewerage authority established by the General Assembly of this state; provided, however, that:
   (A) If such projects are constructed within 200 feet of the banks of any channels or drainageways which have water in them only during and immediately after rainfall events, or intermittent streams which do not have water in them year-round, then such projects shall conform to the specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects;
   (B) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is less than three square miles, then such projects shall conform to the specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects.
   (C) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is equal to or more than three square miles, then such projects shall conform to the minimum standards set forth in Section IV and;
   (D) If such projects are constructed within 100 feet (horizontal) of the banks of any state waters classified as "trout streams" pursuant to the "Georgia Water Quality Control Act", regardless of the size of the watershed area, then such projects shall conform to the minimum standards as set forth in Section IV.
9. Any land-disturbing activities conducted by any airport authority, provided that any such land-disturbing activity shall conform to the minimum standards set forth in Section IV or;
10. Any land-disturbing activities conducted by any electric membership corporation or municipal electrical system or any public utility under the regulatory jurisdiction of the Public Service Commission, provided that any such land-disturbing activity shall conform to the minimum requirements set forth in Section IV.

SECTION IV MINIMUM REQUIREMENTS FOR EROSION AND SEDIMENTATION CONTROL

A. GENERAL PROVISIONS

Excessive soil erosion and resulting sedimentation can take place during land-disturbing activities. Therefore, plans for those land-disturbing activities which are not excluded by this ordinance shall contain provisions for application of soil erosion and sediment control measures. The provisions shall be incorporated into the erosion and sediment control plans. Soil erosion and sediment control measures shall conform to the requirements of this ordinance. The application of measures shall apply to all features of the site, including street and utility installations, drainage facilities and other temporary and permanent improvements. Measures shall be installed to prevent or control erosion and sediment pollution during all stages of any land-disturbing activity.

B. REQUIREMENTS

The permittee shall follow sound conservation and engineering practices to prevent and minimize erosion and resulting sedimentation consistent with the following requirements:

1. Stripping of vegetation, regrading and other development activities shall be conducted in a manner so as to minimize erosion.
2. Cut-fill operations must be kept to a minimum.
3. Development plans must conform to topography and soil type so as to create the lowest practical erosion potential.
4. Whenever feasible, natural vegetation shall be retained, protected and supplemented.
5. The disturbed area and the duration of exposure to erosive elements shall be kept to a practicable minimum.
6. Disturbed soil shall be stabilized as quickly as practicable.
7. Temporary vegetation or mulching shall be employed to protect exposed critical areas during development.
8. Permanent vegetation and structural erosion control measures shall be installed as soon as practicable.
9. To the extent necessary, sediment in run-off water must be trapped by the use of debris basins, sediment basins, silt traps, or similar measures until the disturbed area is stabilized
10. Adequate provisions must be provided to minimize damage from surface water to the cut face of excavations or the sloping surface of fills.
11. Cuts and fills may not endanger adjoining property.
12. Fills may not encroach upon natural watercourses or constructed channels in a manner so as to adversely affect other property owners.

13. Grading equipment must cross flowing streams by means of bridges or culverts except when such methods are not feasible and provided, in any such case, that such crossings are kept to a minimum.
14. Land-disturbing activity plans for erosion and sedimentation control shall include provisions for control or treatment of any source of sediments and adequate sedimentation control facilities to retain sediments on site or preclude sedimentation of adjacent streams beyond the levels specified in paragraph (18) of this section;
15. Land-disturbing activities shall not be conducted within the 100-year flood plain unless compliance with any applicable local flood plain management ordinance is demonstrated or such construction is in compliance with the Federal Emergency Management Agency regulations or flood storage compensation for flood waters is provided;
16. An undisturbed natural vegetative buffer of 25 feet measured from the stream banks shall normally be retained adjacent to any state waters except where otherwise required by the "Metropolitan River Protection Act," O.C.G.A. 12-5-440, et seq., or by the department pursuant to O.C.G.A. 12-2-8, or when the economic use and the contour of the land require a different buffer subject to the division's approval, or where a drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented;
17. Land-disturbing activities shall not be conducted within 100 feet (horizontal) of the banks of any "trout streams" pursuant to the "Georgia Water Quality Control Act", O.C.G.A. 12-5-20, et seq., unless a variance for such activity is granted by the director except where a roadway drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented; and
18. Discharges of stormwater runoff from disturbed areas shall be controlled to the extent that turbidity of the stormwater runoff shall not exceed 50 nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the stormwater runoff discharge at the time of such discharge except where a roadway drainage structure must be constructed. The turbidity of the receiving stream downstream of the construction site shall not exceed 60 nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the construction site. Downstream turbidity measurements shall be taken at points where the entering discharge is fully mixed with the receiving stream flow. Should the division determine that other turbidity limits may be applicable, the issuing authority may accept same.

SECTION V APPLICATION/ PERMIT PROCESS

A. GENERAL
The landowner, developer and designated planners and engineer shall review the general development plans and detailed plans of the issuing authority that affect the tract to be developed and the area surrounding it. They shall review the zoning ordinance, subdivision ordinance, this ordinance, and other ordinances which regulate the development of land within the boundaries of the issuing authority.

B. APPLICATION REQUIREMENTS
1. No person shall conduct any land-disturbing activity within the confines of the City or County Name without first obtaining a permit from the Issuing Authority of City or County Name to perform such activity.
2. The application of a permit shall be submitted to the Issuing Authority and must include the applicant's erosion and sedimentation control plan with supporting data, as necessary and plans shall include, as a minimum, the data specified in Section V, C of the ordinance. Soil erosion and sedimentation control plans shall conform to the provisions of Section IV of this ordinance. Applications for a permit will not be accepted unless accompanied by ____ copies of the applicants soil erosion and sedimentation control plans.
3. A fee, in the amount of _____, shall be charged for each application.
4. Immediately upon receipt of any application and plan for a permit, the Issuing Authority shall refer the application and plan to the local Soil and Water Conservation District for its review and approval or disapproval concerning the adequacy of the erosion and sediment control plan. The results of the District review shall be forwarded to the Issuing Authority. No permit will be issued unless the plan has been approved by the District, and any variances required by Section IV B (16 & 17) and bonding, if required as per Section V B (5), have been obtained. Such review will not be required if the Issuing Authority and the District have entered into an agreement which allows the Issuing Authority to conduct such review and approval of the plan without referring the application and plan to the District.

5. When reviewing any application for a land-disturbing activity permit, the Issuing Authority shall consider the past record of the permit applicant in complying with previous land-disturbing activity permits and this ordinance. If the applicant has had two or more violations of previous permits or this ordinance within three years prior to the date of the filing of the application under consideration, the Issuing Authority may require the applicant to post a bond up to, but not exceeding, $3,000 per acre of the proposed land-disturbing activity prior to issuing the permit. If the applicant does not comply with this ordinance or with the conditions of the permit after issuance, the Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

C. PLAN REQUIREMENTS

1. Plans must be prepared to meet the minimum requirements as obtained in Section IV of this ordinance. Conformance with the minimum requirements may be attained through the use of design criteria in the Manual for Erosion and Sediment Control in Georgia, revised in 1992, published by the State Soil and Water Conservation Commission as a guide; or through the use of alternate design criteria which conform to sound conservation and engineering practice. The Manual for Erosion and Sediment Control in Georgia is hereby incorporated by reference into this ordinance.

   The Plan for the land-disturbing activity shall consider the interrelationship of the soil types, geological and hydrological characteristics, topography, watershed, vegetation, proposed permanent structures including roadways, constructed waterways, sediment control and storm water management facilities, local ordinances and State laws.

2. Data Required For Site Plan:
   (A) Narrative or notes, and other information: Notes or narrative should be located on the site plan in general notes or in erosion and sediment control notes.
   (B) Description of existing land use at project site and description of proposed project.
   (C) Name, address, and phone number of developer/owner.
   (D) Name and phone number of 24-hour local contact who is responsible for erosion and sediment controls.
   (E) Size of project, or phase under construction, in acres.
   (F) Activity schedule - show anticipated starting and completion dates for project. Include the statement in bold letters, that "the installation of erosion control measures and practices shall occur prior to or concurrent with land-disturbing activities."
   (G) Stormwater and sediment management systems-storage capacity, hydrologic study, and calculations, including off-site drainage area.
   (H) Vegetative plan for all temporary and permanent vegetative practices, including species, planting dates, and seeding, fertilizer, lime, and mulching rates. Vegetative plan should show options for year-round seeding.
   (I) Detail drawings for all structural practices. Specifications may follow guidelines set forth in the Manual for Erosion and Sediment Control in Georgia.
   (J) Maintenance statement "Erosion control measures will be maintained at all times. Additional erosion and sediment control measures will be installed if deemed necessary by on-site inspection."

3. Maps, drawings, and supportive computations shall bear the signature/seal of a registered or certified professional in engineering, architecture, landscape architecture, and surveying, or erosion and sedimentation control.
   (A) Graphic scale and north point or arrow indicating magnetic north.
   (B) Vicinity maps showing location of project and existing streets.
   (C) Boundary line survey.
   (D) Delineation of disturbed areas within project boundary.
   (E) Existing and planned contours, with contour lines drawn with an interval of not more than five (5) feet. (The procedure or method used in arriving at the contour intervals shall be indicated.)
   (F) Adjacent areas and feature areas such as streams, lakes, residential areas, etc. which might be affected should be indicated on the plan.
   (G) Proposed structures or additions to existing structures and paved areas.
   (H) Delineate 100-year flood plain. (Reference data used in determination.)
   (I) Delineate the 25-foot undisturbed vegetative buffer adjacent to state waters.
   (J) Delineate the 100-foot management zone along designated trout streams where applicable.
   (K) Location of erosion and sediment control practices, preferably using uniform coding symbols from the Manual for Erosion and Sediment Control in Georgia, Chapter 6.

4. Maintenance of all soil erosion and sedimentation control practices, whether temporary or permanent, shall be at all times the responsibility of the owner.

D. *PERMITS*

1. Permits shall be issued or denied as soon as practicable but in any event not later than forty-five (45) days after receipt by the issuing authority of a completed application, providing variances and bonding are obtained, where necessary.
2. No permit shall be issued by the Issuing Authority unless the erosion and sedimentation control plan has been approved by the District and the Issuing Authority has affirmatively determined that the plan is in compliance with this ordinance, any variances required by Sec. IV B (16 & 17) are obtained, bonding requirements, if necessary, as per Sec. V B 5 are met and all ordinances and rules and regulations in effect within the City or County name are met. If the permit is denied, the reason for denial shall be furnished the applicant.
3. If the tract is to be developed in phases, then a separate permit shall be required for each phase.
4. The permit, may be suspended, revoked, or modified by the Issuing Authority, as to all or any portion of the land affected by the plan, upon finding that the holder or his successor in the title is not in compliance with the approved erosion and sediment control plan or that the holder or his successor in title is in violation of this ordinance. A holder of a permit shall notify any successor in title to him as to all or any portion of the land affected by the approved plan of the conditions contained in the permit.

SECTION VI INSPECTION AND ENFORCEMENT

A. The _____ will periodically inspect the sites of land-disturbing activities for which permits have been issued to determine if the activities are being conducted in accordance with the plan and if the measures required in the plan are effective in controlling erosion and sedimentation.

If, through inspection, it is deemed that a person engaged in land-disturbing activities as defined herein has failed to comply with the approved plan, with permit conditions, or with the provisions of this ordinance, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply within the time specified, he shall be deemed in violation of this ordinance.

B. The _____ shall have the power to conduct such investigations as it may reasonably deem necessary to carry out duties as prescribed in this ordinance, and for this purpose to enter at reasonable times upon any property, public or private, for the purpose of investigation and inspecting the sites of land-disturbing activities.

C. No person shall refuse entry or access to any authorized representative or agent of the Issuing Authority, the Conservation Commission, the District, or Division who requests entry for the purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties.

SECTION VII PENALTIES AND INCENTIVES

A. FAILURE TO OBTAIN A PERMIT FOR LAND-DISTURBING ACTIVITY

If any person commences any land-disturbing activity requiring a land-disturbing permit as prescribed in this ordinance without first obtaining said permit, the person shall be subject to revocation of his business license, work permit or other authorization for the conduct of a business and associated work activities within the jurisdictional boundaries of the Issuing Authority.

B. STOP-WORK ORDERS

Upon notice from the Issuing Authority or its agent, work on any project that is being done contrary to the provisions of this ordinance or in a dangerous or unsafe manner, shall be immediately stopped. Such notice shall be in writing and shall be given to the owner of the property, his authorized agent or the person or persons in charge of the activity on the property, and shall state the conditions under which work may be resumed. Where an emergency exists, no written notice shall be required.

C. BOND FORFEITURE

If, through inspection, it is determined that a person engaged in land-disturbing activities has failed to comply with approved plan, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance with the plan and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply within the time specified, he shall be deemed in violation of this ordinance and, in addition to other penalties, shall be deemed to have forfeited his performance bond, if required to post one under the provisions of Section V B 5. The Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

D. CIVIL PENALTIES

Any person violating any provisions of this ordinance, permitting conditions, or stop-work order shall be liable for a civil penalty of not less than $500 per day, by a sentence of imprisonment not exceeding 60 days in jail or both fine and jail or work alternative. Each day the violation continues shall constitute a separate offense.

SECTION VIII ADMINISTRATIVE APPEAL, JUDICIAL REVIEW

A. *ADMINISTRATIVE REMEDIES*

The suspension, revocation, modification or grant with condition of a permit by the Issuing Authority upon finding that the holder is not in compliance with the approved erosion and sediment control plan; or that the holder is in violation of permit conditions; or that the holder is in violation of any ordinance; shall entitle the person submitting the plan or holding the permit to a hearing before the _____ within _____ days after receipt by the Issuing Authority of written notice of appeal.

B. *JUDICIAL REVIEW*

Any person, aggrieved by a decision or order of the Issuing Authority, after exhausting his administrative remedies, shall have the right to appeal de novo to the Superior Court of_____.

SECTION IX EFFECTIVITY, VALIDITY AND LIABILITY

A. *EFFECTIVITY*

This ordinance shall become effective on the_____day of _____, 19_____

B. *VALIDITY*

If any section, paragraph, clause, phrase, or provision of this ordinance shall be adjudged invalid or held unconstitutional, such decisions shall not affect the remaining portions of this ordinance.

C. LIABILITY

Neither the approval of a plan under the provisions of this ordinance, nor the compliance with the provisions of this ordinance shall relieve any person from the responsibility for damage to any person or property otherwise imposed by law nor impose any liability upon the (Municipality/County) or (District) for damage to any person or property.

Attest:

_____
Signature

_____
Signature

D. Implementation Measures

D. Implementation Measures

1) Construction Procedures

a. Construction Sequence
Source: Mississippi, MS-1

b. Construction Sequence Schedule
Source: North Carolina, NC-1

Construction Sequence

1. Obtain plan approval and other applicable permits.

2. Flag the work limits and mark the oak tree and buffer zone area for protection.

3. Hold preconstruction conference at least one week prior to starting construction. Weekly reviews of erosion, sediment, and stormwater control plan will be conducted.

4. Install sediment basins as the first construction activity.

5. Install storm drain with block and gravel inlet protection at construction entrance/exit.

6. Install temporary gravel construction entrance/exit.

7. Construct temporary diversions above proposed building sites. Install level spreader and vegetate disturbed areas.

8. Complete site clearing except for the old gully waterway in the northwest portion of the site. This area will be cleared during last construction phase for the installation of the riprap waterway liner.

9. Clear waste disposal area in northeast corner of property, only as needed.

10. Rough grade site, stockpile topsoil, construct waterways, install culverts and outlet protection, and install sediment fence as needed. Maintain diversions along top of fill slope daily. NOTE: A temporary diversion will be constructed across the middle of the graded area to reduce slope length and the bare areas mulched should grading be discontinued for more than 3 weeks.

11. Finish the slopes around buildings as soon as rough grading is complete. Leave the surface slightly roughened and vegetate and mulch immediately.

12. Complete final grading for roads and parking and stabilize with gravel. Construct retention basin, build smart box. Smart box and retention basin will be by-passed until parking lot is paved to prevent damage from excessive sedimentation.

13. Complete final grading for buildings.

14. Complete final grading of grounds, topsoil critical areas, and permanently vegetate, landscape, and mulch.

15. Install riprap outlet waterway and extend riprap to pipe outlet under entrance road.

16. All erosion and sediment control practices will be inspected weekly and after rainfall events. Needed repairs will be made immediately.

17. After site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas, install detention structures.

18. Estimated time before final stabilization--9 months.

Maintenance Plan

Short Term

1. All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every week. Any needed repairs will be made immediately to maintain all practices as designed.

2. Sediment will be removed from the sediment basin and block and gravel inlet protection device when storage capacity has been approximately 50 percent filled. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.

3. Sediment will be removed from behind the sediment fence when it becomes a maximum of about 0.5 feet deep at the fence. The sediment fence will be replaced as necessary to maintain a barrier.

4. All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

5. As needed, new or additional workers will be informed of the plan details in the operation and maintenance of plan features.

Long Term

1. All vegetated areas will be maintained in adequate condition to provide proper ground cover, thereby reducing erosion potential.

2. Areas where vegetation is lost will be fertilized, seeded, and maintained as necessary to restore proper ground cover.

3. Pollution treatment areas such as the retention basin will have excess sediment and debris removed as necessary. Sealed vegetative surfaces may require coring, grooving, slicing, forking, or spiking to restore surface infiltration. Thatch build-up will also be addressed.

4. Structural measures will be examined at least annually and maintenance performed as needed.

Note: This page is intentionally blank.

6.01 CONSTRUCTION SEQUENCE SCHEDULE

Definition

A specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion and sedimentation control measures.

Purpose

To reduce on-site erosion and off-site sedimentation by performing land-disturbing activities and installing erosion and sedimentation control practices in accordance with a planned schedule.

Conditions Where Practice Applies

All land-development projects that will disturb more than one contiguous acre.

Planning Considerations

The removal of existing surface ground cover leaves a site vulnerable to accelerated erosion. Good planning will reduce land clearing, provide necessary controls, and restore protective cover in an efficient and effective manner. Appropriate sequencing of construction activities can be a cost-effective way to help accomplish this goal.

Scheduling considerations are summarized in Table 6.01a. The generalized construction activities shown in the table do not usually occur in a specified linear sequence, and schedules will vary due to weather and other unpredictable factors. However, the proposed construction sequence should be indicated clearly in the erosion and sedimentation control plan.

Construction access is normally the first land-disturbing activity. Exercise care not to damage valuable trees or disturb designated buffer zones.

Next, install **principal sediment basins** and traps before any major site grading takes place. Erect additional sediment traps and sediment fences as grading takes place to keep sediment contained on-site at appropriate locations.

Locate **key runoff-control measures** in conjunction with sediment traps to divert water from planned undisturbed areas out of the traps and sediment-laden water into the traps. Install diversions above areas to be disturbed prior to grading. Place necessary perimeter dikes with stable outlets before opening major areas for development. Install additional needed runoff-control measures as grading takes place.

Install the **main runoff conveyance system** with inlet and outlet protection devices early, and use it to convey storm runoff through the development site without creating gullies and washes. Install inlet protection for storm drains as soon as the drain is functional to trap sediment on-site in shallow pools and to allow flood flows to safely enter the storm drainage system. Install outlet protection at the same time as the conveyance system to prevent damage to the receiving stream.

Normally, install stream stabilization, including necessary stream crossings, independently and ahead of other construction activities. It is usually best to schedule this work as soon as weather conditions permit. Site clearing and pro-

Table 6.01a
Considerations for Construction Scheduling

Construction Activity[1]	Schedule Consideration
Construction access. Construction entrance, construction routes, equipment parking areas.	First land-disturbing activity—Stabilize bare areas immediately with gravel and temporary vegetation as construction takes place.
Sediment traps and barriers. Basin traps, sediment fences, and outlet protection.	Install principal basins after construction site is accessed. Install additional traps and barriers as needed during grading.
Runoff control. Diversions, perimeter dikes, water bars, and outlet protection.	Install key practices after principal sediment traps and before land grading. Install additional runoff-control measures during grading.
Runoff conveyance system. Stabilize streambanks, storm drains, channels, inlet and outlet protection, slope drains.	Where necessary, stabilize streambanks as early as possible. Install principal runoff conveyance system with runoff-control measures. Install remainder of system after grading.
Land clearing and grading. Site preparation--cutting, filling and grading, sediment traps, barriers, diversions, drains, surface roughening.	Begin major clearing and grading **after** principal sediment and key runoff-control measures are installed. Clear borrow and disposal areas only as needed. Install additional control measures as grading progresses. Mark trees and buffer areas for preservation.
Surface stabilization. Temporary and permanent seeding, mulching, sodding, riprap.	Apply temporary or permanent stabilization measures immediately on all disturbed areas where work is delayed or complete.
Building construction. Buildings, utilities, paving.	Install necessary erosion and sedimentation control practices as work takes place.
Landscaping and final stabilization. Topsoiling, trees and shrubs, permanent seeding, mulching, sodding, riprap.	Last construction phase—Stabilize all open areas, including borrow and spoil areas. Remove and stabilize all temporary control measures.

[1]Maintenance, (1) maintenance inspections should be performed weekly, and (2) after periods of rainfall, maintenance repairs should be made immediately.

ject construction increases storm runoff, often making streambank stabilization work more difficult and costly.

Begin **land clearing and grading** as soon as key erosion and sediment control measures are in place. Once a scheduled development area is cleared, grading should follow immediately so that protective ground cover can be reestablished quickly. Do not leave any area bare and exposed for extended periods. Leave adjoining areas planned for development, or to be used for borrow and disposal, undisturbed as long as possible to serve as natural buffer zones.

Runoff control is essential during the grading operation. Temporary diversions, slope drains, and inlet and outlet protection installed in a timely manner can be very effective in controlling erosion during this critical period of development.

Immediately after land clearing and grading, apply **surface stabilization** on graded areas, channels, dikes and other disturbed areas. Stabilize any disturbed area where active construction will not take place for 30 working days by tem-

porary seeding and/or mulching or by other suitable means. Install permanent stabilization measures immediately after final grading, in accordance with the vegetative plan. Temporary seeding and/or mulching may be necessary during extreme weather conditions with permanent measures delayed for a more suitable time.

Coordinate **building construction** with other development activities so that all work can take place in an orderly manner and on schedule. Experience shows that careful project scheduling improves efficiency, reduces cost, and lowers the potential for erosion and sedimentation problems.

Landscaping and final stabilization is the last major construction phase, but the topsoil stockpiling, tree preservation, undisturbed buffer area, and well-planned road locations established earlier in the project may determine the ease or difficulty of this activity. All disturbed areas should have permanent stabilization practices applied. Unstable sediment should be removed from sediment basins and traps. All temporary structures should be removed after the area above has been properly stabilized. Borrow and disposal areas should be permanently vegetated or otherwise stabilized.

In planning construction work, it may be helpful to outline all land-disturbing activities necessary to complete the proposed project. Then list all practices needed to control erosion and sedimentation on the site. These two lists can then be combined in logical order to provide a practical and effective construction sequence schedule.

A construction sequence schedule is shown as part of the sample erosion plan (*Chapter 7, Sample Erosion and Sedimentation Control Plan*).

Design Criteria

As a minimum, the construction sequence schedule should show the following:

- The erosion and sedimentation control practices to be installed,
- Principal development activities,
- What measures should be in place before other activities are begun,
- Compatibility with the general construction schedule of the contract.

Construction Specifications

Many timely construction techniques can reduce the erosion potential of a site, such as (1) shaping earthen fills daily to prevent overflows and (2) constructing temporary diversions ahead of anticipated storms. These types of activities cannot be put on the construction sequence schedule but should be used whenever possible.

Following a planned construction sequence schedule to control erosion should help keep field personnel aware of the possibilities of erosion prevention through construction management.

Maintenance

Follow the construction sequence throughout project development. When changes in construction activities are needed, amend the sequence schedule in advance to maintain management control.

Orderly modification assures coordination of construction and erosion control practices to minimize erosion and sedimentation problems. When major changes are necessary, send a copy of the modified schedule to the local sediment control agency.

References

Chapter 4, Preparing the Erosion and Sedimentation Control Plan
Chapter 7, Sample Erosion and Sedimentation Control Plan

2) Practice Categories - Standards for Structural Practices

a. Section A - Water Handling
Source: Maryland, MD-1

b. Section B - Grade Stabilization Structures
Source: Maryland, MD-1

c. Section C - Sediment Trapping Devices
Source: Maryland, MD-1

d. Section D - Dewatering Practices
Source: Maryland, MD-1

e. Section E - Filtering Practices
Source: Maryland, MD-1

f. Section F - Land Grading and Structural Stabilization
Source: Maryland, MD-1

g. Section H - Miscellaneous Practices
Source: Maryland, MD-1

Section A - WATER HANDLING

1.0 STANDARDS AND SPECIFICATIONS

FOR

EARTH DIKES

Definition

A temporary berm or ridge of soil, compacted, stabilized and located in such a manner as to direct water to a desired location.

Purpose

The purpose of the earth dike is to direct runoff to a sediment trapping device which reduces the potential for erosion and sedimentation. Earth dikes can also be used for diverting clean water away from disturbed areas.

Conditions Where Practice Applies

Earth dikes are often constructed across disturbed areas and around construction sites such as parking lots and subdivisions. The dikes shall remain in place until the disturbed areas are permanently stabilized.

Earth Dikes are constructed:

1. To divert sediment laden runoff from a disturbed area to a sediment trapping device.

2. Across disturbed areas to shorten overland flow distances.

3. To direct sediment laden water along the base of slopes to a trapping device.

4. To divert clear water from an undisturbed area to a stabilized outlet. Runoff shall be discharged at non-erosive rates.

Table 1 Design Criteria

	Dike A	Dike B
Drainage Area	(See Table 2)	(See Table 2)
Slope (of dike)	(See Table 2)	(See Table 2)
Dike Height (a)	18 in.	30 in.
Dike Width (b)	24 in.	36 in.
Flow Width (c)	4 ft.	6 ft.
Flow Depth in Channel (d)	12 in.	24 in.
Side Slopes	2 : 1 or flatter	2 : 1 or flatter

Note: **1. For slopes or drainage areas other than specified on Table 2, an engineering design is required. If the slope of the earth dike or the drainage area contributing to the dike falls between values on Table 2, round up to the next higher slope or drainage area.**

2. Stabilization of the earth dike shall be completed within seven days of installation.

Construction Specifications

1. All temporary earth dikes shall have uninterrupted positive grade to an outlet. Earth dikes having longitudinal slopes flatter than 1% should have spot elevations along the flow line.

2. Diverted runoff from disturbed areas shall be directed to a sediment trapping devices.

3. Diverted runoff from undisturbed areas shall outlet directly onto an undisturbed, stabilized area at a non-erosive velocity ($\leq$ 4 fps for grass).

4. All trees, brush, stumps, and obstructions shall be removed and disposed of so as not to interfere with the proper functioning of the earth dike berm and flow channel.

5. The dike shall be excavated or shaped to line, grade and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

6. Fill shall be compacted by earth moving equipment.

7. All earth removed and not needed for construction shall be placed so that it will not interfere with the functioning of the earth dike berm and flow channel.

8. Inspection and maintenance must be provided periodically and after each rain event.

Stabilization

Stabilization of the earth dike shall be completed within 7 days of installation in accordance with the standards and specifications for Vegetative Practices (Section G). The earth dike flow channel shall be stabilized in accordance with Table 2, and the following criteria:

Flow Channel Stabilization

1. Seed and cover with straw mulch.

2. Seed and cover with Erosion Control Matting or line with sod.

3. 4" - 7" stone or recycled concrete equivalent pressed into the soil in a minimum 7" layer.

The earth dike type (A or B) and lining (1, 2, or 3) shall be shown on the plans using the standard symbol and A-1, or B-3, etc. Earth dike type and lining may vary along its length.

In highly erodible soils, as defined by the local approval agency, refer to the next higher slope grade for the type of stabilization needed.

Engineering Design Criteria

Engineering design may preempt the use of Table 2. The basis for the engineering design shall be the 2-year frequency storm using SCS criteria, assuming the worst soil cover conditions to prevail in the contributing drainage area over the life of the earth dike. Manning's Equation shall be used to determine earth dike flow channel velocities associated with the developed discharges. The Manning's Roughness coefficients to be used in the equation are 0.025 for seed and mulch, 0.03 for soil stabilization matting or sod, and for 4"- 7" stone use 0.045 for flow depths up to 1 foot (Dike A) and 0.038 for flow depths between 1 and 2 feet (Dike B). The allowable flow channel velocities shall be $<$ 4 fps for Seed and Mulch, $<$ 6 fps for Stabilization Matting or sod, and $<$ 8 fps for 4"- 7" stone.

Outlet

1. Earth dikes must have an outlet that functions without causing erosion.

2. Runoff from disturbed areas shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin until the drainage area above the earth dike is adequately stabilized.

3. The on-site location may need to be adjusted to meet field conditions.

4. Clear water diversions around disturbed areas shall be discharged into an undisturbed, stabilized area or watercourse at a non erosive velocity.

Removal

Following completion of all construction and stabilization at a site with established vegetation, all temporary earth dikes shall be removed and the areas occupied by the dikes shall be graded and stabilized with vegetation.

Directions for Using Table 2

1. Determine the location on the Erosion and Sediment Control plan where using the earth dike to divert runoff is feasible. Determine the longitudinal slopes of the proposed temporary earth dike location.

2. Determine the maximum drainage area to various design points along the proposed earth dike alignment.

3. Enter Table 2 with the slope and drainage corresponding to the previously determined design points along the earth dike. Using Table 2 choose an earth dike type (A or B) and lining (1, 2, or 3) for the earth dike alignment between the design points.

4. Review the slopes along the earth dike alignment between the design points to insure that the slope/drainage area relationship does not exceed the chosen lining.

Table 2: Earth Dike Selection

	Drainage Area (acres)									
Slope % **	1	2	3	4	5	6	7	8	9	10
1	SEED	AND	4							
2	MULCH	4		SEED	AND	SOIL	STABILIZATION			
3				MATTING				6	6	6
4	4*						6			
5					6	6				
6				6		4" – 7"		STONE	PRESSED	
7			6			7" (Min)		INTO	GROUND	
8										
9										
10		6								

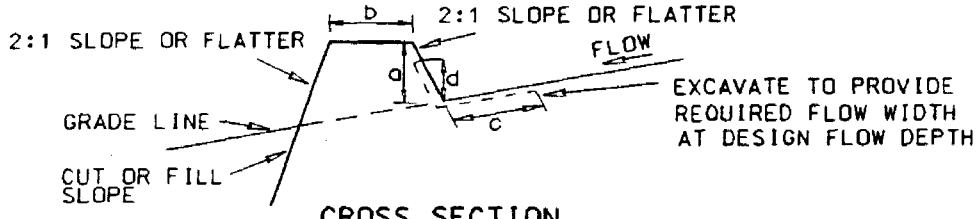
"A" Dike

"B" Dike

*Velocity of discharge in feet/second

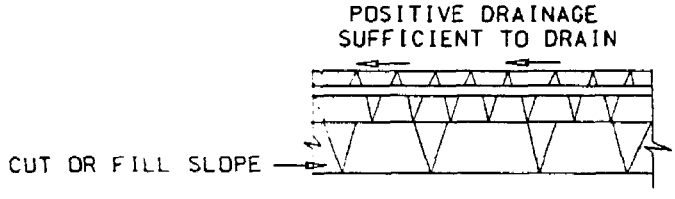
** For slopes steeper than 10% refer to Section B - Grade Stabilization Structures

DETAIL 1 - EARTH DIKE



CROSS SECTION

	DIKE A	DIKE B
a-DIKE HEIGHT	18"	30"
b-DIKE WIDTH	24"	36"
c-FLOW WIDTH	4'	6'
d-FLOW DEPTH	12"	24"



PLAN VIEW

STANDARD SYMBOL
A-2 B-3

FLOW CHANNEL STABILIZATION
GRADE 0.5% MIN. 10% MAX.

1. Seed and cover with straw mulch.
2. Seed and cover with Erosion Control Matting or line with sod.
3. 4" - 7" stone or recycled concrete equivalent pressed into the soil 7" minimum

Construction Specifications

1. All temporary earth dikes shall have uninterrupted positive grade to an outlet. Spot elevations may be necessary for grades less than 1%.

2. Runoff diverted from a disturbed area shall be conveyed to a sediment trapping device.

3. Runoff diverted from an undisturbed area shall outlet directly into an undisturbed, stabilized area at a non-erosive velocity.

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

5. The dike shall be excavated or shaped to line, grade and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

6. Fill shall be compacted by earth moving equipment.

7. All earth removed and not needed for construction shall be placed so that it will not interfere with the functioning of the dike.

8. Inspection and maintenance must be provided periodically and after each rain event.

2.0 STANDARDS AND SPECIFICATIONS

FOR

TEMPORARY SWALES

Definition

A temporary, excavated drainage way constructed and located to convey runoff to a desired location.

Purpose

The purpose of a temporary swale is to prevent runoff from entering disturbed areas by intercepting and diverting it to a stabilized outlet or to intercept sediment laden water and divert it to a sediment trapping device.

Conditions Where Practice Applies

Temporary Swales are constructed:

1. To divert sediment laden runoff from a disturbed area to a sediment trapping device.

2. Across disturbed areas to shorten overland flow distances.

3. To direct sediment laden water along the base of slopes to a trapping device.

4. To divert clear water from an undisturbed area to a stabilized outlet. Runoff shall be discharged at non-erosive rates.

Table 3 Temporary Swale Design Criteria

	Swale A	Swale B
Drainage Area	(see Table 4)	(see Table 5)
Slope of swale	(see Table 4)	(see Table 5)
Bottom Width of Flow Channel	4'min.	6'min.
Depth of Flow Channel	1'min.	1'min.
Side Slopes	2:1 or flatter	2:1 or flatter

Note: **1. For slopes or drainage areas other than specified on Table 4 or 5, an engineering design is required. If the slope of the swale or the drainage area contributing to the swale falls between values on Table 4 or 5, round up to the next higher slope or drainage area.**

2. Stabilization of the swale shall be completed within seven days of installation.

Construction Specifications

1. All temporary swales shall have uninterrupted positive grade to an outlet. Swales having longitudinal slopes flatter than 1% should have spot elevations along the flow line.

2. Runoff diverted from a disturbed area shall be conveyed to a sediment trapping device.

3. Runoff diverted from an undisturbed area shall outlet directly into an undisturbed stabilized area at a non-erosive velocity ($\leq$ 4 fps for grass).

4. All trees, brush, stumps, obstructions, and other objectional material shall be removed and disposed of so as not to interfere with the proper functioning of the swale flow channel.

5. The swale shall be excavated or shaped to line, grade and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

6. Fill, if necessary, shall be compacted by earth moving equipment.

7. All earth removed and not needed on construction shall be placed so that it will not interfere with the functioning of the swale flow channel.

8. Inspection and maintenance must be provided periodically and after each rain event.

Stabilization

Stabilization of the temporary swale shall be completed within 7 days of installation in accordance with the standards and specifications for Vegetative Practices (Section G). The temporary swale flow channel shall be stabilized in accordance with Table 4 or 5, and the following criteria:

Flow Channel Stabilization

1. Seed and cover with straw mulch.

2. Seed and cover with Erosion Control Matting or line with sod.

3. 4"- 7" stone or recycled concrete equivalent pressed into the soil in a minimum 7" layer.

The temporary swale type (A or B) and lining (1, 2, or 3) shall be shown on the plans using the standard symbol and A-1, or B-3, etc. Temporary Swale type and lining may vary along its length.

In highly erodible soils, as defined by the local approval agency, refer to the next higher slope grade for the type of stabilization needed.

Engineering Design Criteria

Engineering design may preempt the use of Table 4 or 5. The basis for the engineering design shall be the 2-year frequency storm using SCS criteria, assuming the worst soil cover conditions to prevail in the contributing drainage area over the life of the temporary swale. Manning's Equation shall be used to determine temporary swale flow channel velocities associated with the developed discharges. The Manning's Roughness coefficients to be used in the equation are 0.025 for seed and mulch, 0.03 for soil stabilization matting or sod, and for 4"- 7" stone use 0.045 for flow depths up to 1 foot. The allowable flow channel velocities shall be < 4 fps for Seed and Mulch, < 6 fps for Stabilization Matting or sod, and < 8 fps for 4"- 7" stone. For site conditions exceeding those where Temporary Swale criteria apply, refer to 28.0 Lined Waterway or Outlet.

Outlet

1. Temporary swales must have an outlet that functions without causing erosion.

2. Runoff from disturbed areas shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin until the drainage area above the swale is adequately stabilized.

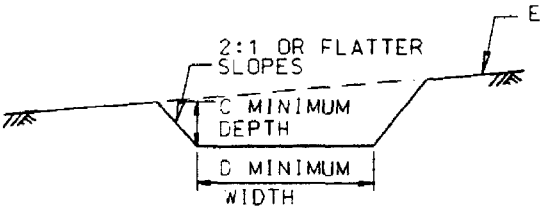
3. The location may need to be adjusted to meet field conditions.

4. Clear water diversions around disturbed areas shall be discharged onto an undisturbed, stabilized area or watercourse at a non erosive velocity.

Removal

Following completion of all construction and stabilization at a site with established vegetation, all temporary earth swales shall be removed and the areas occupied by the swales shall be graded and stabilized with vegetation.

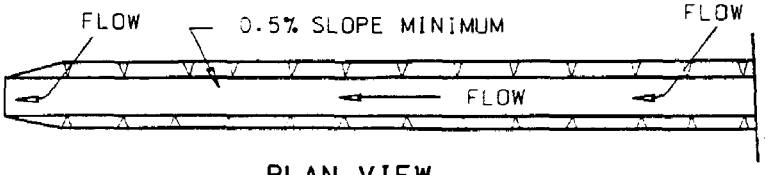
DETAIL 2 – TEMPORARY SWALE



CROSS SECTION

	SWALE A	SWALE B
C	1' MIN.	1' MIN.
D	4' MIN.	6' MIN.

OUTLET AS REQUIRED



PLAN VIEW

DRAINAGE AREA = 10 ac (MAX)
SLOPE = 10% (MAX)

STANDARD SYMBOL
A - 2 / B - 3

FLOW CHANNEL STABILIZATION
GRADE 0.5% MIN. 10% MAX.

1. Seed and cover with straw mulch.
2. Seed and cover with Erosion Control Matting or line with sod.
3. 4"-7" stone or recycled concrete equivalent pressed into soil in a minimum 7" layer.

Construction Specifications

1. All temporary swales shall have uninterrupted positive grade to an outlet. Spot elevations may be necessary for grades less than 1%.

2. Runoff diverted from a disturbed area shall be conveyed to a sediment trapping device.

3. Runoff diverted from an undisturbed area shall outlet directly into an undisturbed stabilized area at a non-erosive velocity.

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

5. The swale shall be excavated or shaped to line, grade and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.

6. Fill, if necessary, shall be compacted by earth moving equipment.

7. All earth removed and not needed for construction shall be placed so that it will not interfere with the functioning of the swale.

8. Inspection and maintenance must be provided periodically and after each rain event.

Table 4 Temporary Swale Selection

4' Flat Bottom

Slope %	Drainage Area (acres)									
	1	2	3	4	5	6	7	8	9	10
1	SEED	AND				4				
2	MULCH		4	4	4					
3		4		SEED	AND	SOIL	STABILIZATION		6	6
4					MATTING			6		
5	4*						6			
6						6				
7					6		4" – 7" STONE		PRESSED	
8				6			7" (Min.) INTO		GROUND	
9										
10			6							

*Velocity of flow in feet/second

Table 5 Temporary Swale Selection

6' Flat Bottom

Slope %	Drainage Area (acres)									
	1	2	3	4	5	6	7	8	9	10
1	SEED	AND				4				
2	MULCH		4	4	4					
3		4		SEED	AND	SOIL	STABILIZATION		6	6
4					MATTING			6		
5	4*						6			
6						6				
7					6		4" -7" STONE PRESSED			
8							7" (Min.) INTO GROUND			
9										
10				6						

*Velocity of flow in feet/second

3.0 STANDARDS AND SPECIFICATIONS

FOR

DIKE/SWALE

Definition

A temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area.

Purpose

The purpose of a perimeter dike/swale is to prevent storm runoff from entering a disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

Conditions Where Practice Applies

A perimeter dike/swale is constructed to divert flows around disturbed areas, or along tops of slopes to prevent flows from eroding the slope, or along the base of slopes to direct sediment laden flows to a trapping device. The perimeter dike/swale shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

An engineering design is not required for perimeter dike/swale. The following criteria shall be used:

Drainage area - Less than 2 acres (for drainage areas larger than 2 acres see Earth Dike or Temporary Swale).

Height - 12 inches minimum from bottom of swale to top of dike evenly divided between dike height and swale depth. Bottom width of dike - 3 feet minimum. Width of swale - 3 feet minimum (see standard drawing).

Grade - Dependent upon topography, but shall have positive drainage (sufficient grade to drain) to an adequate outlet. **Maximum allowable grade not to exceed 10 percent.**

Stabilization - The disturbed area of the dike and swale shall be stabilized within 7 days of installation, in accordance with the following:

PD/S Type	Drainage Area	Stabilization
PD/S - 1	1 acre or less	Seed and Mulch
PD/S - 2	1-2 acres	Seed and cover with erosion control matting or line with sod

Construction Specifications

1. All perimeter dike/swales shall have an uninterrupted positive grade to an outlet. Spot elevations may be necessary for grades less than 1%.

2. Runoff diverted from a disturbed area shall be conveyed to a sediment trapping device.

3. Runoff diverted from an undisturbed area shall outlet into an undisturbed stabilized area at a non-erosive velocity ($\leq$ 4 fps for grass).

4. The swale shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified in the standard.

5. Fill shall be compacted by earth moving equipment.

6. Stabilization of the area disturbed by the dike and swale shall be completed within 7 days and in accordance with the stabilization specifications on the plans (Ref: 20.0 Vegetative Stabilization).

7. Inspection and required maintenance shall be provided after each rain event.

Note: The maximum drainage area for this practice is 2 acres.

Outlet

1. A perimeter dike/swale shall have an outlet that functions without causing erosion.

2. Runoff diverted from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area.

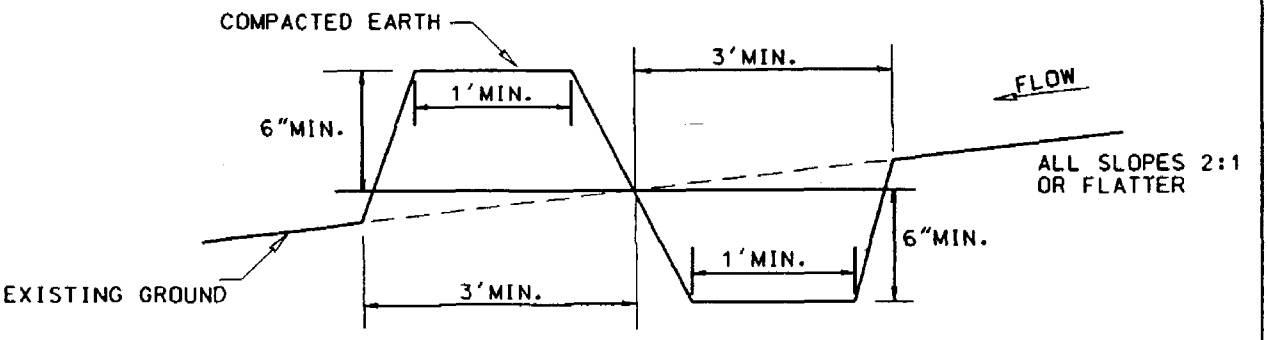
3. Runoff diverted from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin.

4. The location of a dike/swale may need to be adjusted in the field in order to provide positive drainage to a trapping device and to utilize the most suitable outlet.

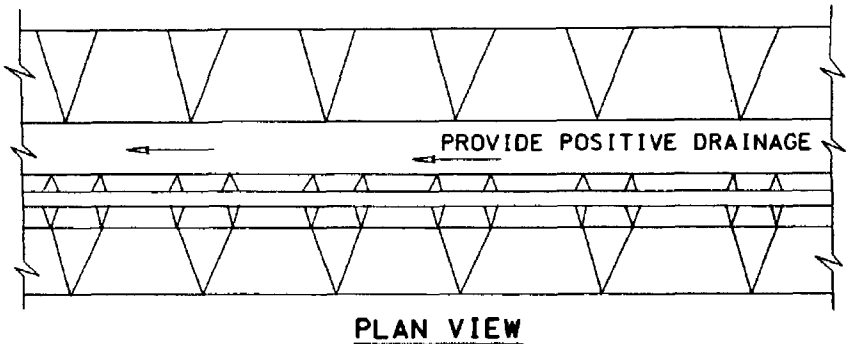
Removal

Following completion of all construction and stabilization at a site with established vegetation, all temporary dike/swales shall be removed and the areas occupied by the dike/swales shall be graded and stabilized as specified on the plans.

DETAIL 3 - PERIMETER DIKE /SWALE



CROSS SECTION

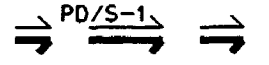


PLAN VIEW

STABILIZATION

PD/S-1 SEED AND MULCH (DRAINING ≤ 1 ACRE)
PD/S-2 SEED AND COVER WITH SOIL
STABILIZATION MATTING OR
LINE WITH SOD (DRAINING BETWEEN 1 AND 2 ACRES)

STANDARD SYMBOL



Construction Specifications

1. All perimeter dike/swales shall have an uninterrupted positive grade to an outlet. Spot elevations may be necessary for grades less than 1%.

2. Runoff diverted from a disturbed area shall be conveyed to a sediment trapping device.

3. Runoff diverted from an undisturbed area shall outlet into an undisturbed stabilized area at a non-erosive velocity.

4. The swale shall be excavated or shaped to line, grade, and cross-section as required to meet the criteria specified in the standard.

5. Fill shall be compacted by earth moving equipment.

6. Stabilization with seed and mulch or as specified of the area disturbed by the dike and swale shall be completed within 7 days upon removal.

7. Inspection and required maintenance shall be provided after each rain event.

Note: The maximum drainage area for this practice is 2 acres.

4.0 STANDARDS AND SPECIFICATIONS

FOR

TEMPORARY STORM DRAIN DIVERSION

Definition

Temporary storm drain diversions redirect a storm drain system or outfall channel to discharge into a sediment trap or basin.

Purpose

To prevent sediment laden water conveyed by the storm drain system from reaching a watercourse or off-site property.

Conditions Where Practice Applies

One of the following practices or procedures shall be used to temporarily divert storm drain systems. A special exception may be given, at the discretion of the local plan approval agency, where site conditions make this procedure impossible.

Design Criteria

1. Construction of a sediment trap or basin below a permanent storm drain outfall: the storm drain system outfalls into a temporary basin or trap constructed below the permanent outfall channel.

2. In-line diversion of storm drain at an inlet or manhole: this diversion requires installing a pipe stub in the side of a manhole or inlet and temporarily blocking the permanent outfall pipe from that structure. A temporary outfall ditch or pipe may be used to convey storm flow from the stub to a sediment trap or basin. This method may be used just above a permanent outfall or prior to connecting into an existing storm drain system.

3. Delay completion of the permanent storm drain outfall and temporarily divert storm flow into a sediment basin or trap: an earth dike, swale or designed diversion, can be used depending on the drainage area, to direct flow into a sediment basin or trap.

4. Installation of a stormwater management basin early in the construction sequence: install temporary measures to allow use as a sediment basin. Because these structures are designed to receive storm drain outfalls, diversion should not be necessary.

5. Inlet protection is not required if storm drain diversions have been installed and are functioning properly.

Removal and Restoration

When the areas contributing sediment to the storm drain system have been stabilized, restore the system to its planned use.

The following removal and restoration procedure is recommended and must be included in the sequence of operations for the sediment control plan:

1. Flush the storm drain system prior to removal of the trap or basin to remove any accumulated sediment.

2. Establish a permanent stabilized outfall channel as noted on the plans.

3. For sites where an inlet was modified, plug the temporary pipe stub and open the permanent outfall pipe.

4. Remove the sediment control devices, such as traps, basins, dikes, swales, etc..

5. Restore the area to grades shown on the plan and stabilize with vegetative measures.

6. For basins that will be converted to stormwater management, remove the accumulated sediment, open the low flow orifice, and seed all disturbed areas in the basin to permanent vegetation.

Section B - GRADE STABILIZATION STRUCTURES

5.0 STANDARDS AND SPECIFICATIONS

FOR

PIPE SLOPE DRAIN

Description of Practice

A pipe slope drain is a pipe that is installed to convey surface runoff down the face of unstabilized slopes. It is used to minimize erosion on the slope face. **Use of flexible piping is preferred.**

Conditions Where Practice Applies

Pipe slope drains are used in conjunction with earth dikes. The dikes direct surface runoff to the slope drain, which conveys concentrated flow down the face of a slope. When used to convey water down an unstabilized fill slope on a road construction project the drainage area to the pipe slope drain will be limited to 2 acres. When used as an inflow protection device the drainage area will be 5 acres.

Table 6 Design Criteria for Pipe Slope Drain

Size	Diameter (inches)	Pipe/Tubing Maximum Drainage Area (Acres)
PSD-12	12	0.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5
PSD-(2) (24)[1]	24	5.0

Inlet

At the inlet of the pipe slope drain, the height of the earth dike shall be at least two times the pipe diameter and measured from the invert of the pipe . A standard flared entrance section shall be installed and secured at the inlet to the pipe slope drain with a watertight connection. To prevent erosion, geotextile fabric shall be placed under the inlet and shall extend 5' in front of the inlet and be keyed in 6" on all sides.

Outlet

When the drainage area is disturbed, the pipe slope drain shall outlet into a sediment trap or basin, or a stable conveyance that leads to a trap or basin. The point of discharge shall be as far away from the trap or basin outlet structure as possible. When the drainage area is stabilized, the pipe slope drain shall outlet onto a stabilized area at a non-erosive velocity. The point of discharge may be protected by rock outlet protection.

[1] Due to the height limitations on earth dikes, the maximum pipe diameter for pipe slope drain is 24". For drainage areas over 3 1/2 acres two 24" pipes shall be used. A minimum spacing of 2D (4 feet) is required between pipes.

Construction Specifications

1. The Pipe Slope Drain (PSD) shall have a slope of 3 percent or steeper.

2. The top of the earth dike over the inlet pipe shall be at least 2 times the pipe diameter measured at the invert of the pipe.

3. Flexible tubing is preferred. However, corrugated metal pipe or equivalent PVC pipe can be used. All connections shall be watertight.

4. A flared end section shall be attached to the inlet end of pipe with a watertight connection. Geotextile Class E[2] or better shall be placed under the inlet of the pipe slope drain and shall extend out 5' from the inlet. The geotextile fabric shall be keyed in on all sides.

5. The Pipe Slope Drain shall be securely anchored to the slope. Spacing for anchors shall be as provided by manufacturer's specification. In no case shall less than two (2) anchors be provided, equally spaced along the length of pipe. These details should be provided by pipe suppliers.

6. The soil around and under the pipe and end section shall be hand tamped in 4 inch lifts to the top of the earth dike.

7. Whenever possible where a PSD drains an unstabilized area, it shall outlet into a sediment trap or basin. If this is not possible then the slope drain will discharge into a stable conveyance that leads to a sediment trap or basin. When discharging into a trap or basin the PSD shall discharge at the same elevation as the wet pool elevation. The discharge from the PSD must be as far away from the sediment control outlet as possible.

8. When the drainage area is stabilized, the PSD shall discharge onto a stabilized area at a non-erosive velocity. 4"- 7" stone underlain with Geotextile Class C[3] shall be employed as necessary.

9. Inspection and any required maintenance shall be performed periodically and after each rain event.

10. The inlet must be kept open at all times.

[2,3] Refer to Table 27.

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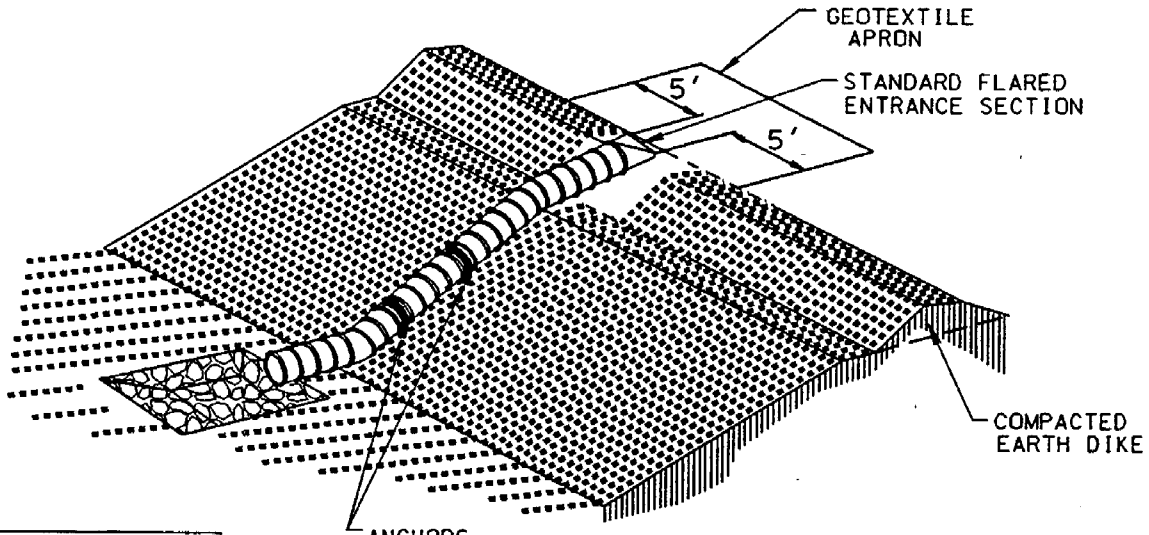
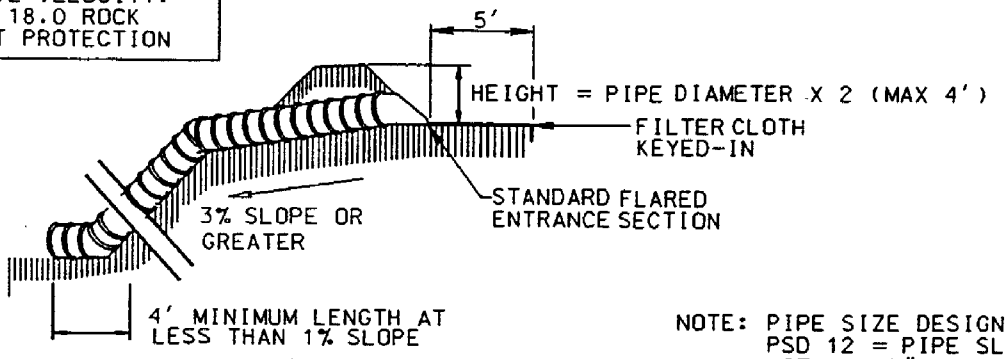
DETAIL 4 – PIPE SLOPE DRAIN



DISCHARGE INTO A STABILIZED WATER-COURSE. SEDIMENT TRAPPING DEVICE, OR INTO A STABILIZED AREA AT A NON-EROSIVE VELOCITY. REF: 18.0 ROCK OUTLET PROTECTION

STANDARD SYMBOL

PSD – 12



NOTE: PIPE SIZE DESIGNATION IS: PSD 12 = PIPE SLOPE DRAIN WITH A 12" DIAMETER PIPE.

Table 6 Design Criteria for Pipe Slope Drain

Size	Pipe/Tubing Diameter (D) in	Maximum Drainage Area (Acres)
PSD-12	12	0.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5
PSD-24 (2)	24	5.0

PIPE SLOPE DRAIN

Construction Specifications - Pipe Slope Drain

1. The Pipe Slope Drain (PSD) shall have a slope of 3 percent or steeper.

2. The top of the earth dike over the inlet pipe shall be at least 2 times the pipe diameter measured at the invert of the pipe.

3. Flexible tubing is preferred. However, corrugated metal pipe or equivalent PVC pipe can be used. All connections shall be watertight.

4. A flared end section shall be attached to the inlet end of pipe with a watertight connection. Filter cloth shall be placed under the inlet of the pipe slope drain and shall extend out 5' from the inlet. The filter cloth shall be "keyed in" on all sides.

5. The Pipe Slope Drain shall be securely anchored to the slope by staking at the grommets provided. Spacing for anchors shall be as provided by manufacturer's specification. In no case shall less than two (2) anchors be provided, equally spaced along the length of pipe. These details should be provided by pipe suppliers.

6. The soil around and under the pipe and end section shall be hand tamped in 4 inch lifts to the top of the earth dike.

7. All pipe connections shall be watertight.

8. Whenever possible where a PSD drains an unstabilized area, it shall outlet into a sediment trap or basin. If this is not possible then the slope drain will discharge into a stable conveyence that leads to a sediment trap or basin. When discharging into a trap or basin the PSD shall discharge at the same elevation as the wet pool elevation. The discharge from the PSD must be as far away from the sediment control outlet as possible.

9. When the drainage area is stabilized, the PSD shall discharge onto a stabilized area at a non-erosive velocity.

10. Inspection and any required maintenance shall be performed periodically and after each rain event.

11. The inlet must be kept open at all times.

6.0 STANDARDS AND SPECIFICATIONS

FOR

RIP-RAP INFLOW PROTECTION

Definition

A temporary or permanent, lined drainageway installed to convey concentrated runoff into sediment traps and basins or down steep slopes as applicable. Rip-rap Inflow Protection consists of the installation of rock or recycled concrete equivalent in a flow channel for stabilization.

Purpose

The purpose of Rip-rap Inflow Protection is to provide stable conveyance of concentrated runoff down steep slopes, (i.e. into temporary sediment traps and basins) thereby preventing erosion of the flow channel.

Conditions Where Practice Applies

Rip-rap Inflow Protection is required where the slope of a drainage way contributing to a sediment trap or basin exceeds 10:1 but is less than 4:1. Runoff may be directed to the inflow device by means of dikes or swales.

Design Criteria

Rip-rap Inflow protection shall be 4"- 12" rip-rap (min.), underlain with Geotextile Class C[4] and placed from the ditch overfall elevation to the bottom of the trap or basin when the inflow slope is between 4:1 and 10:1. Slopes flatter than 10:1 shall be stabilized in accordance with Temporary Swale or Earth Dike criteria as applicable. For slopes steeper than 4:1, see Gabion Inflow Protection.

Construction Specifications

1. Rip-rap Inflow Protection shall be 1' in depth, have a trapezoidal cross section with 2:1 or flatter side slopes and a 3' minimum bottom width. The channel shall be lined with 4" - 12" rip-rap or SHA Class I[5] to a depth of 18".
2. Filter cloth shall be installed under all rip-rap. Filter cloth shall be Geotextile Class C.
3. Entrance and exit sections shall be installed as shown on the detail section.
4. Rip-rap used for the lining may be recycled for permanent outlet protection if the basin is to be converted to a stormwater management facility.
5. Gabion Inflow Protection may be substituted for Rip-rap Inflow Protection.
6. Rip-rap should blend into existing ground.
7. Rip-rap Inflow Protection shall be used where the slope is between 4:1 and 10:1. For slopes flatter than 10:1 use Earth Dike or Temporary Swale.

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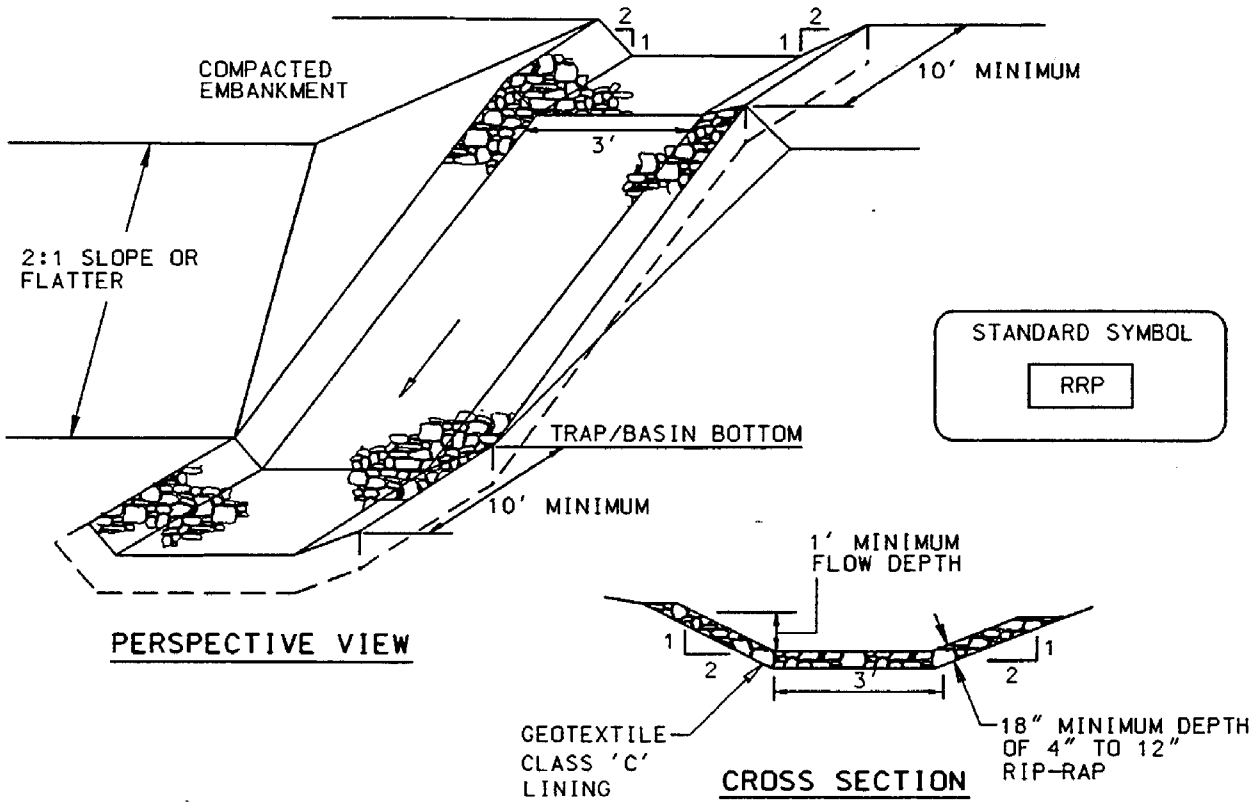
[4] Refer to Table 27

[5] See Table 28

DETAIL 5 – RIP-RAP INFLOW PROTECTION



Construction Specifications

1. Rip-rap lined inflow channels shall be 1' in depth, have a trapezoidal cross section with 2:1 or flatter side slopes and 3' (min.) bottom width. The channel shall be lined with 4" to 12" rip- rap to a depth of 18".

2. Filter cloth shall be installed under all rip-rap. Filter cloth shall be Geotextile Class C.

3. Entrance and exit sections shall be installed as shown on the detail section.

4. Rip-rap used for the lining may be recycled for permanent outlet protection if the basin is to be converted to a stormwater management facility.

5. Gabion Inflow Protection may be used in lieu of Rip-rap Inflow Protection.

6. Rip-rap should blend into existing ground.

7. Rip-rap Inflow Protection shall be used where the slope is between 4:1 and 10:1, for slopes flatter than 10:1 use Earth Dike or Temporary Swale lining criteria.

7.0 STANDARDS AND SPECIFICATIONS

FOR

GABION INFLOW PROTECTION

Definition

A temporary or permanent, lined drainageway installed to convey concentrated runoff into sediment traps and basins or down steep slopes as applicable. Gabion Inflow Protection consists of the installation of wire baskets (Gabions) filled with rock or recycled concrete equivalent in a flow channel for stabilization.

Purpose

The purpose of Gabion Inflow Protection is to provide stable conveyance of concentrated runoff down steep slopes, (i.e. into temporary sediment traps and basins) thereby preventing erosion of the flow channel.

Conditions Where Practice Applies

Gabion Inflow Protection is required where the slope of a drainage way contributing to a sediment trap or basin, or other steep area as applicable, exceeds 4:1 (25%). Surface runoff may be directed to the inflow device by means of dikes or swales.

Design Criteria

Gabion Inflow Protection shall be 4"- 7" stone[6] (min.) placed within manufactured wire baskets, underlain with Geotextile Class C[7] and placed from the ditch overfall elevation to the bottom of the trap or basin when the inflow slope is between 2:1 and 4:1. Slopes flatter than 10:1 shall be stabilized in accordance with Temporary Swale or Earth Dike criteria as applicable. For slopes between 4:1 and 10:1, see Rip-rap Inflow Protection.

Construction Specifications

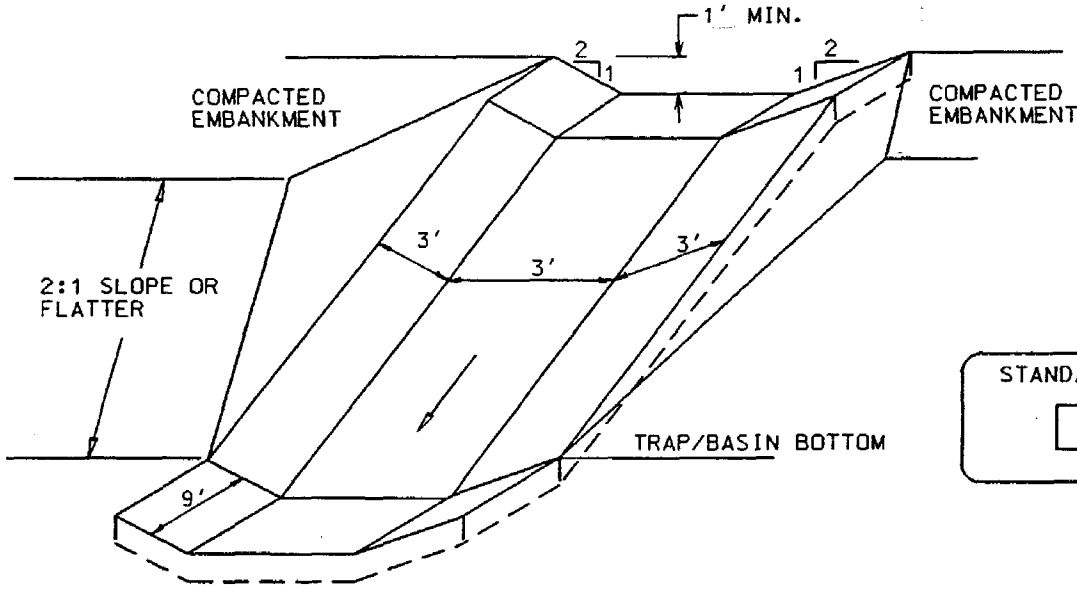
1. Gabion Inflow Protection shall be constructed by arranging 9'x 3'x 9" gabion baskets forming a trapezoidal cross section 1' deep with 2:1 side slopes and 3' bottom width.
2. Geotextile Class C shall be installed under all gabion baskets.
3. The stone used to fill the gabion baskets shall be 4" - 7".
4. Gabion shall be installed in accordance with manufacturer's recommendations.
5. Gabion Inflow Protection shall be used where concentrated flow is present on slopes steeper than 4:1.

---

[6] See Table 28

[7] Refer to Table 27

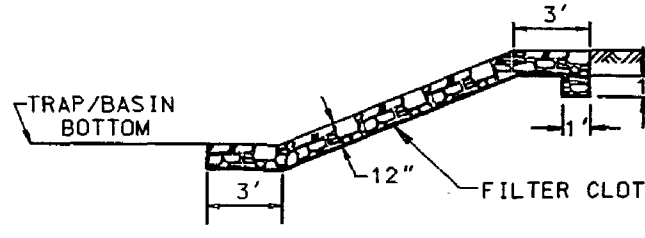
DETAIL 6 – GABION INFLOW PROTECTION



STANDARD SYMBOL

GM

PERSPECTIVE VIEW



PROFILE ALONG CENTERLINE

Construction Specifications

1. Gabion inflow protection shall be constructed of 9' x 3' x 9" gabion baskets forming a trapezoidal cross section 1' deep, with 2:1 side slopes, and a 3' bottom width.
2. Geotextile Class C shall be installed under all gabion baskets.
3. The stone used to fill the gabion baskets shall be 4" - 7".
4. Gabions shall be installed in accordance with manufacturers recommendations.
5. Gabion Inflow Protection shall be used where concentrated flow is present on slopes steeper than 4:1.

8.0 STANDARDS AND SPECIFICATIONS

FOR

STONE CHECK DAMS

Description of Practice

Stone Check Dams are stone weirs placed in series in swales or ditches.

Purpose

Stone Check Dams are constructed to reduce runoff velocities to non-erosive rates and to prevent channel erosion in drainage courses.

Design Criteria

1. Stone check dams shall be located so as to provide maximum velocity reduction. This may be achieved by considering the volume of runoff, the drainage area and the slope. The check dams should be placed in reasonably straight ditch sections to minimize the potential for erosion in the channel bend. All stone check dams should be keyed into the sides and bottom of the channel. **This practice is not to be used as a sediment trapping device.** Sediment laden runoff must pass through a sediment trapping device prior to being discharged from the site.

2. The distance between the Stone Check Dams will vary with the longitudinal ditch slope. Stone Check Dams shall be constructed using 4"- 7" stone[8] or recycled concrete equivalent and shall be placed to form a weir. The outlet crest or the top of the stone weir shall be approximately 6" lower than the outer edges. The inside or upstream side of the weir shall be lined with a 1' thick layer of washed (3/4" to 1 1/2") crushed aggregate. Geotextile Class E[9] or better under the bottom and sides of the dam prior to placement of stone is optional.

3. The height of the stone outlet weir should not exceed one-half the depth of the ditch or swale. Additionally, the maximum height of the weir must not exceed 2.0 feet to prevent scour of the toe of the dam. If the check dam exceeds this, these provisions do not apply and an engineering analysis should be conducted. The stone check dam should be wide enough to reach from bank to bank of the ditch or swale with the weir section length in the center of the dam.

4. The number of check dams will depend on the length and slope of the ditch or swale.

---

[8] Refer to Table 28

[9] Refer to Table 27

5. The required spacing is determined as:

$$x = \frac{y}{S}$$

where:

x = Check dam spacing (ft)
y = Check dam height (ft)
S = Natural channel slope (ft/ft)

Figure 1 may be used to determine the check dam spacing. The spacing requirements do not change significantly with varying ditch cross sections, but are most sensitive to the channel slope and height of the check dam.

Construction Specifications

1. Swales and ditches shall be prepared in accordance with the construction specifications described in Section A-2, Standards and Specifications for Temporary Swale.
2. The check dam shall be constructed of 4" to 7" stone. The stone shall be placed so that it completely covers the width of the channel and keyed into the channel banks.
3. The top of the check dam shall be constructed so that the center is approximately 6 inches lower than the outer edges, forming a weir that water can flow across.
4. The maximum height of the check dam at the center shall not exceed 2'.
5. The upstream side of the check dam shall be lined with approximately 1' of 3/4" - 1½" aggregate.
6. Accumulated sediment shall be removed when it has built up to 1/2 of the original height of the weir crest.

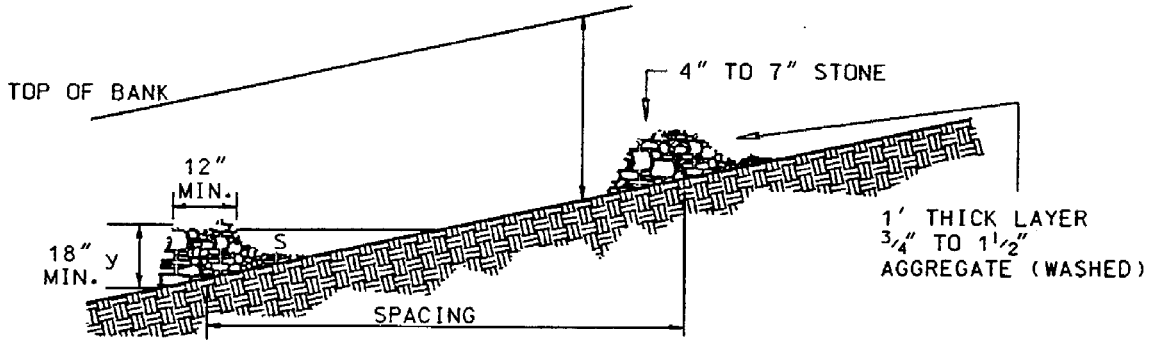
Sediment Removal

While this practice is not intended to be used for sediment trapping, some sediment will accumulate behind the check dam. Check dams should be checked periodically and after each significant rainfall. Accumulated sediment should be removed when it has reached 1/2 of the original height of the weir crest.

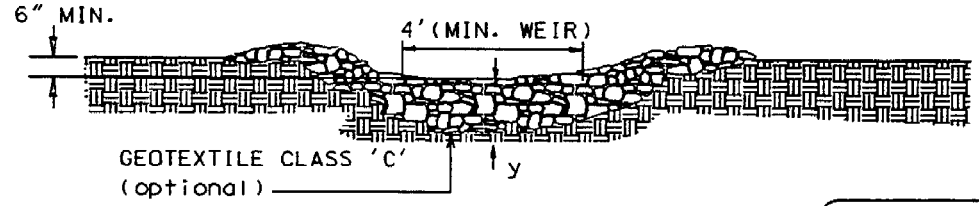
Check Dam Removal

In temporary swales and channels, check dams should be removed and the ditch filled in when it is no longer needed. In permanent channel structures, check dams may be removed when a permanent lining can be installed. In the case of grass lined ditches, check dams may be removed when the grass has matured sufficiently to protect the swale or channel. The area beneath the check dams should be seeded and mulched immediately after they are removed.

DETAIL 7 - STONE CHECK DAM



DITCH PROFILE



CROSS SECTION

STANDARD SYMBOL

CD

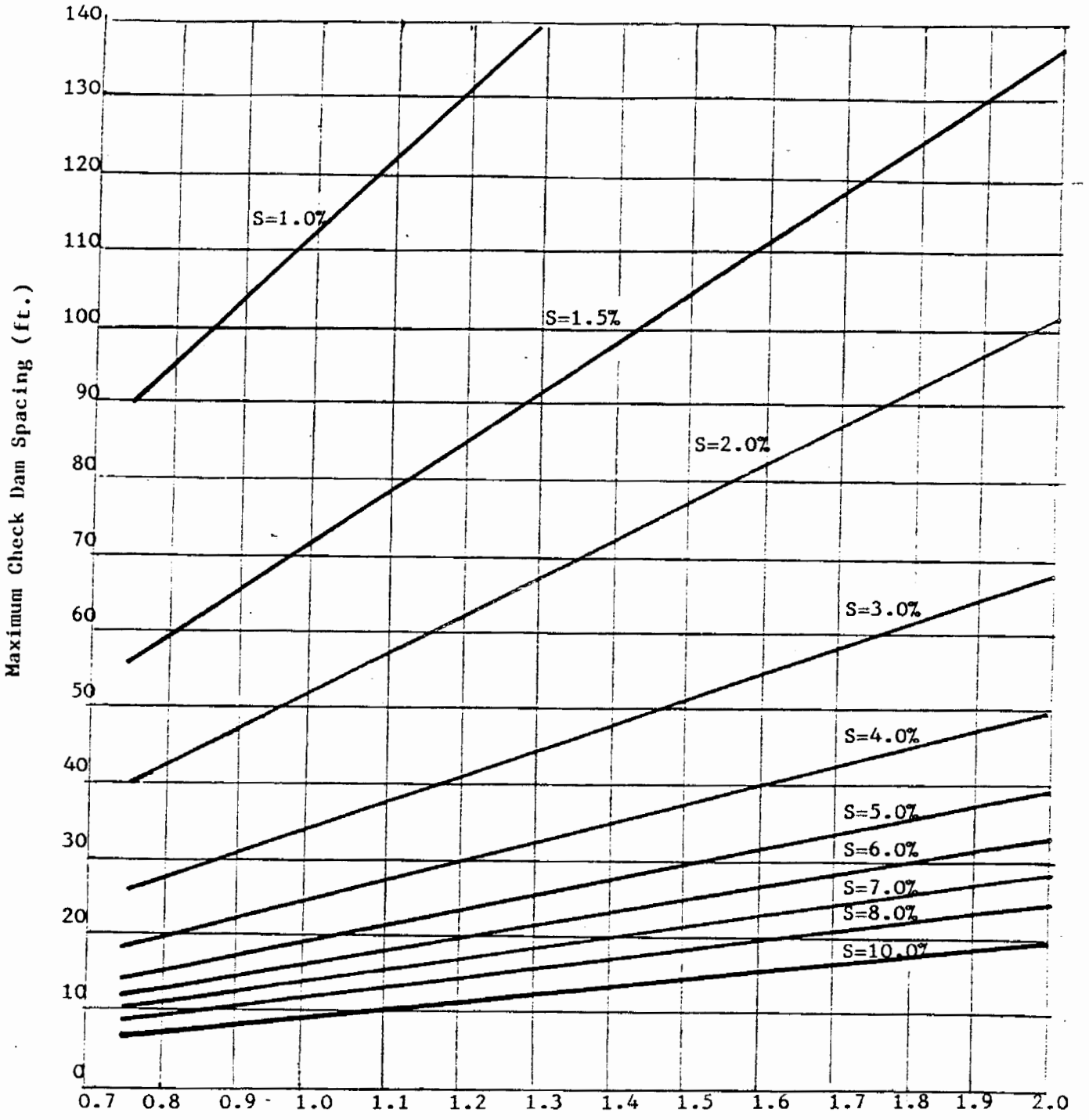
STANDARD STONE CHECK DAM DESIGN

SLOPE	SPACING
2% or less	80'
2.1% to 4%	40'
4.1% to 7%	25'
7.1% to 10%	15'
over 10%	use lined waterway design

Construction Specifications

1. Swales and ditches shall be prepared in accordance with the construction specifications described in Section A-2. Standards and Specifications for Temporary Swale.
2. The check dam shall be constructed of 4"-7" stone. The stone shall be placed so that it completely covers the width of the channel and is keyed into the channel banks.
3. The top of the check dam shall be constructed so the the center is approximately 6" lower than the outer edges, forming a weir that water can flow across.
4. The maximum height of the check dam at the center shall not exceed 2'.
5. The upstream side of the check dam shall be lined with approximately 1' of 3/4" to 1 1/2" aggregate.
6. Accumulated sediment shall be removed when it has built up to 1/2 of the original height of the weir crest.

FIGURE 1



Design of Stone Check Dam Spacing

(n=0.030, Ve = 2.0 fps)

Section C - SEDIMENT TRAPPING DEVICES

9.0 STANDARDS AND SPECIFICATIONS

FOR

SEDIMENT TRAPS

Definition

A temporary sediment control device formed by excavation and/or an embankment with an approved outlet used to intercept sediment laden runoff and to retain the sediment.

Purpose

The purpose of a sediment trap is to intercept sediment laden runoff and trap the sediment in order to protect drainageways, properties, and rights-of-way downstream of the sediment trap from sedimentation.

Conditions Where Practice Applies

A sediment trap is installed at points of discharge from a disturbed area.

Wet and Dry Storage

The storage requirement for sediment traps I, II and IV and sediment basins is 3600 cubic feet per acre of contributory drainage area. The sediment traps and basins storage volume of 3600 cubic feet minimum per acre shall be divided equally into "dry" or dewatered storage and "wet" or retention storage. The basins and traps will be dewatered to the wet pool elevation corresponding to 1800 cubic feet of storage per acre of drainage. Sediment trap III consists of only "wet" storage and the volume required is 5400 cubic feet per acre of drainage area.

Design Criteria

1. The maximum drainage area for each type sediment trap shall be as follows:

Practice #	Practice Type	Max. Drainage Area
ST-I	Pipe Outlet	5.0 ac.
ST-II	Stone Outlet	5.0 ac.
ST-III	Rip-rap Outlet	10.0 ac.
ST-IV	Stone Outlet/Rip-rap Outlet	10.0 ac.

2. The volume of a natural sediment trap may be approximated by the equation:

   Volume (ft^3) = 0.4 x surface area (ft^2) x maximum depth (ft).

3. Sediment traps shall be located so that they can be installed prior to grading or filling. Traps must not be located any closer than 20 feet from an existing building foundation. Care must be taken when placing sediment traps in structural fill areas (i.e. proposed roadways and building foundations). When these traps are removed the wet soil around the traps must also be removed to facilitate compaction. Trap bottoms shall be generally level. Plan view must indicate bottom dimensions. Showing contours/grading of traps may be required on plans to ensure constructability.

Locate traps to:

a. Obtain maximum storage benefit from the terrain with a 2:1 length to width ratio desired.
b. Facilitate cleanout.
c. Facilitate disposal of the trapped sediment.

4. Sediment shall be removed and the trap restored to the original dimensions when the sediment has accumulated to one half of the wet storage depth of the trap. Sediment removed from the trap shall be deposited in a protected area and in such a manner that it will not erode.

5. **All embankments for sediment traps shall not exceed 4' in height as measured at the low point of the original ground along the centerline of the embankment.** Embankments shall have a minimum 4' wide top and side slopes of 2:1 or flatter. The embankment shall be compacted by traversing with equipment while it is being constructed. Once constructed the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

The elevation of the top of any dike directing water to any sediment trap will equal or exceed the maximum elevation of the embankment along the entire length of the trap.

6. All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimized. Sediment traps shall have 2:1 or flatter side slopes.

7. The outlet shall be designed, according to the standards set forth herein, constructed and maintained in such a manner that sediment does not leave the trap and that erosion at or below the outlet does not occur. Sediment traps must outlet onto stabilized (preferably undisturbed) ground, into a watercourse, stabilized channel, or into a storm drain system.

8. Following completion of all construction and stabilization at a site, all temporary sediment traps shall be removed and the areas occupied by the traps shall be graded and stabilized. Slope Silt Fence or other sediment control devices may be required during trap removal.

If any of the design criteria presented here cannot be met, see Standard and Specifications for Sediment Basin.

Trap details needed on Soil Erosion and Sediment Control Plans

There is no standard symbol for a sediment trap. Each trap shall be delineated on the plans in such a manner that it will not be confused with any other features. Each plan shall include all the information necessary to properly construct and maintain the trap. If tablular form is used to present the numbered information below, then each trap on the plan shall have a number and the numbers shall be consecutive. Please use caution in siting sediment traps, plot contours if necessary to ensure constructability. The following information, at a minimum, shall be shown for each trap on the plans:

1. Trap number.
2. Type of trap (ST-I, ST-II, etc.).
3. Drainage area (5 acres max. for ST-I and ST-II, 10 acres max. for ST-III and ST-IV).
4. Storage required (total).
5. Storage provided (total).
6. Weir length or pipe size, outfall length (for ST-IV) and channel depth (for ST-III).
7. Storage depth below outlet and cleanout elevation.
8. Embankment height and elevation (if applicable).
9. Typical detail of each trap used.
10. Trap bottom, wet storage limit and crest elevations.

9.1 Pipe Outlet Sediment Trap ST-I

This practice consists of a trap formed by an embankment or excavation. The outlet for the trap is through a perforated riser and a barrel pipe through the embankment. The barrel pipe and riser shall be made of corrugated metal or PVC pipe. All pipes shall be circular and watertight. The top of the embankment shall be at least 1 foot above the crest of the riser.

The riser shall be perforated above the wet pool elevation. Perforations shall be slits 1/2" wide by 6 inches in length or 1 inch diameter holes spaced six (6) inches both vertically and horizontally.

No perforations will be allowed within six (6) inches of the top of the horizontal barrel. All pipe connections shall be watertight. The riser shall be wrapped with 1/2" hardware cloth (wire) then wrapped with Geotextile Class E[10] and secured with strapping or connecting bands at the top and bottom of the cloth. The hardware cloth and geotextile shall cover an area at least six (6) inches above the highest perforation and six (6) inches below the lowest perforation. The top of the riser pipe shall have a trash rack/anti-vortex device that meets the requirements of Detail 16 and shall not be covered with geotextile fabric.

The riser shall have a base with sufficient weight to prevent flotation of the riser. Two approved bases are:

1. A concrete base twice the diameter of the riser, 12" thick with the riser embedded 9" into the concrete base (see Detail 15).

2. A 1/4" inch minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2' of stone, gravel, or recycled concrete placed on it to prevent flotation. In either case, each side of the square base measurement shall be the riser diameter plus 24 inches.

Note: Pipe outlet sediment traps shall be limited to five (5) acres maximum drainage area.

Table 7 Pipe Outlet Diameter Selection

Minimum Sizes Barrel Diam. (Inches)	Minimum Sizes Riser Diam. (Inches)	Minimum Sizes Trash Rack Diam. (Inches)	Maximum Drainage Area (Acres)
12"	15"	21"	1
15"	18"	27"	2
18"	21"	30"	3
21"	24"	36"	4
21"	27"	42"	5

[10] Refer to Table 27.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. The total trap volume shall be 3600 cubic feet/acre of contributory drainage area (See Table 9). The top of the embankment must be $\geq$ 1'above the crest of the riser.

4. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half of the wet storage depth of the trap (900 cf/ac). The sediment shall be deposited in a suitable area and in such a manner that it will not erode.

5. The structure shall be inspected periodically and after each rain and repairs made as needed.

6. Construction operations shall be carried out in such a manner that erosion and water pollution are abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

7. The structure shall be removed and area stabilized when the drainage area has been permanently stabilized.

8. All cut and fill slopes shall be 2:1 or flatter.

9. All pipe connections shall be watertight.

10. Above the wet storage elevation, the riser shall be perforated with 1/2" wide by 6" long slits or 1" diameter holes spaced 6" vertically and horizontally. No perforations will be allowed within 6" of the horizontal barrel.

11. The riser shall be wrapped with 1/2" hardware cloth (wire) then wrapped with Geotextile Class E[11]. The geotextile fabric shall extend 6" above the highest slit and six 6" below the lowest slit. Where ends of geotextile fabric come together, they shall be overlapped, folded and fastened to prevent bypass. Geotextile fabric shall be replaced as necessary to prevent clogging.

[11] Refer to Table 27.

12. Straps or connecting bands shall be used to hold the geotextile fabric and wire fabric in place and shall be placed at the top and bottom of the cloth.

13. Fill material around the pipe spillway shall be hand compacted in 4" layers. A minimum of 2' of hand-compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.

14. The riser shall be anchored with either a concrete base or steel plate base to prevent flotation. Concrete bases shall be at least twice the riser diameter and 12" thick with the riser embedded 9". Steel bases shall be at least twice the riser diameter, 1/4" minimum thickness plate, attached to the bottom of the riser with a continuous weld to form a watertight connection, and covered with 2' of stone, gravel, or tamped earth.

15. Anti seep collars shall be designed in accordance with Table 16 and Details 13 and 14.

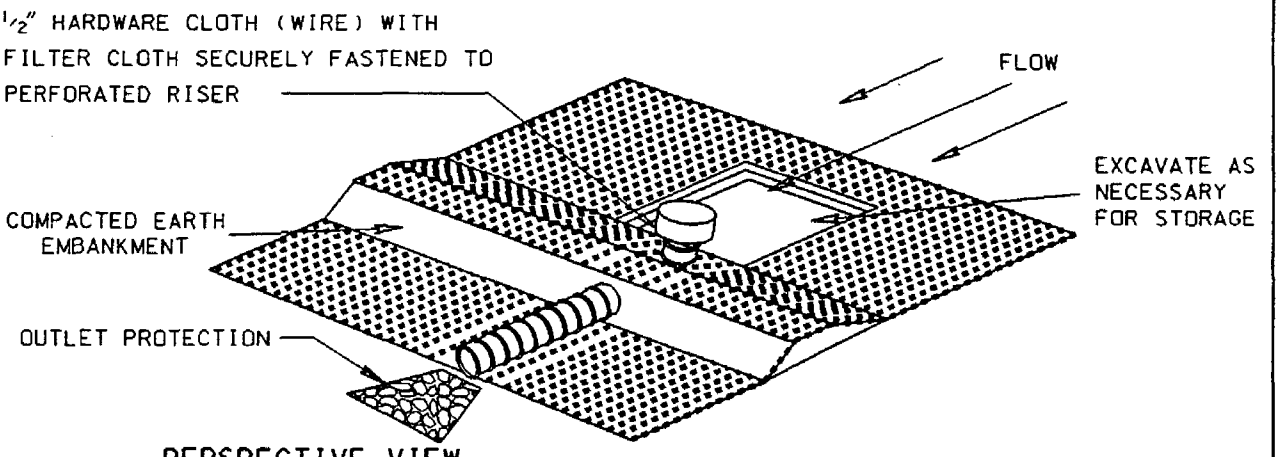
16. Concentric trash rack and anti-vortex device design details are on Detail 16.

17. Refer to Section D for dewatering requirements of sediment traps.

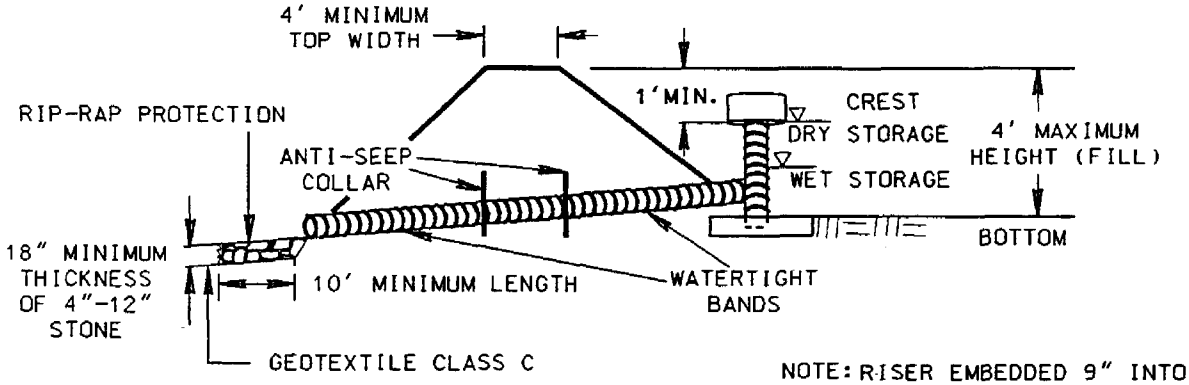
18. Outlet - An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel. Protection against scour at the discharge end of the pipe spillway shall be provided in accordance with the Standards and Specifications for Rock Outlet Protection or a practice from Section B - Grade Stabilization Structures.

19. Where discharge occurs at the property line, local ordinances and drainage easement requirements shall be met.

DETAIL 8 – PIPE OUTLET SEDIMENT TRAP – ST I



PERSPECTIVE VIEW



EMBANKMENT SECTION
THROUGH RISER

NOTE: RISER EMBEDDED 9" INTO CONCRETE OR ¼" STEEL PLATE ATTACHED TO RISER WITH A CONTINUOUS WELD ON BOTTOM AND 2' OF STONE PLACED ON STEEL PLATE TWICE THE RISER DIAMETER (MIN.)

Construction Specifications

1. The area under the embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. The total trap volume as measured from the bottom to riser crest elevation shall be 3600 cubic feet per acre of drainage area (see Table 9). The top of embankment must be $\geq 1'$ above the riser crest elevation.

4. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half of the wet storage depth of the trap (900cf/ac). The sediment shall be deposited in a suitable area and in such a manner that it will not erode.

5. The structure shall be inspected periodically and after each rain and repairs made as necessary.

PIPE OUTLET SEDIMENT TRAP - ST I

6. Construction operations shall be carried out in such a manner that erosion and water pollution are abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

7. The structure shall be removed and area stabilized when the drainage area has been properly stabilized.

8. All cut and fill slopes shall be 2:1 or flatter.

9. All pipe connections shall be watertight.

10. Above the wet storage elevation, the riser shall be perforated with ½" wide by 6" long slits or 1" diameter holes spaced 6" vertically and horizontally. No perforations will be allowed within 6" of the horizontal barrel.

11. The riser shall be wrapped with ½" hardware cloth (wire) then wrapped with Geotextile Class E. The filter cloth shall extend 6" above the highest slit and 6" below the lowest slit. Where ends of filter cloth come together, they shall be overlapped, folded and fastened to prevent bypass. Filter cloth shall be replaced as necessary to prevent clogging.

12. Straps or connecting bands shall be used to hold the filter cloth and wire fabric in place. They shall be placed at the top and bottom of the cloth.

13. Fill material around the pipe spillway shall be hand compacted in 4" layers. A minimum of 2' of hand-compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.

14. The riser shall be anchored with either a concrete base or steel plate base to prevent flotation. Concrete bases shall be at least twice the riser diameter and 12" deep with the riser embedded 9". Steel plate bases shall be at least twice the riser diameter, ¼" minimum thickness and attached to the bottom of the riser by a continuous weld to form a watertight connection. Then place 2' of stone, gravel or tamped earth on the plate.

15. Anti seep collars shall be constructed in accordance with plans (ref. table 16 and Details 13 and 14).

16. Concentric trash rack and anti-vortex device design details are on Detail 16.

17. Refer to Section D for dewatering requirements of sediment traps.

18. Outlet - An outlet shall be provided, which includes a means of conveying the discharge in an erosion free manner to an existing stable channel.

19. Where discharge occurs at the property line, local ordinances and drainage easement requirements shall be met.

9.2 Stone Outlet Sediment Trap ST-II

This practice consists of a trap formed by an embankment or excavation. The outlet of this trap is over a stone section placed on level ground. The minimum length weir (feet) of the outlet shall be equal to four (4) times the drainage area (acres).

The outlet crest (top of stone in weir section) shall be level, at least 1' foot below the top of the embankment and no more than 3' above ground beneath the outlet. 4" to 7" stone[12] or recycled concrete equivalent over Geotextile Class C[13] shall be used in the outlet. A 1' thick layer of 3/4" to 1 1/2" washed aggregate[14] shall be placed on the upstream face of the outlet. Geotextile Class C placed on the upstream face of the outlet may be substituted for the small stone.

Note: Stone outlet sediment traps shall be limited to a 5 acre maximum drainage area.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. All cut and fill slopes shall be 2:1 or flatter.

4. The stone used in the outlet shall be 4" - 7" stone with a 1' thick layer of 3/4" to 1 1/2" washed aggregate placed on the upstream face of the outlet. Stone facing shall be maintained as necessary to prevent clogging. Geotextile Class C may be substituted for the stone facing by placing it on the inside face of the outlet.

5. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half of the wet storage depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

6. The structure shall be inspected periodically and after each rain and repairs made as needed.

7. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

[12,14] Refer to Table 28

[13] Refer to Table 27

8. The structure shall be removed and the area stabilized when the drainage area has been properly stabilized.

9. Refer to Section D for specifications concerning trap dewatering.

10. Minimum trap depth shall be measured from the weir elevation.

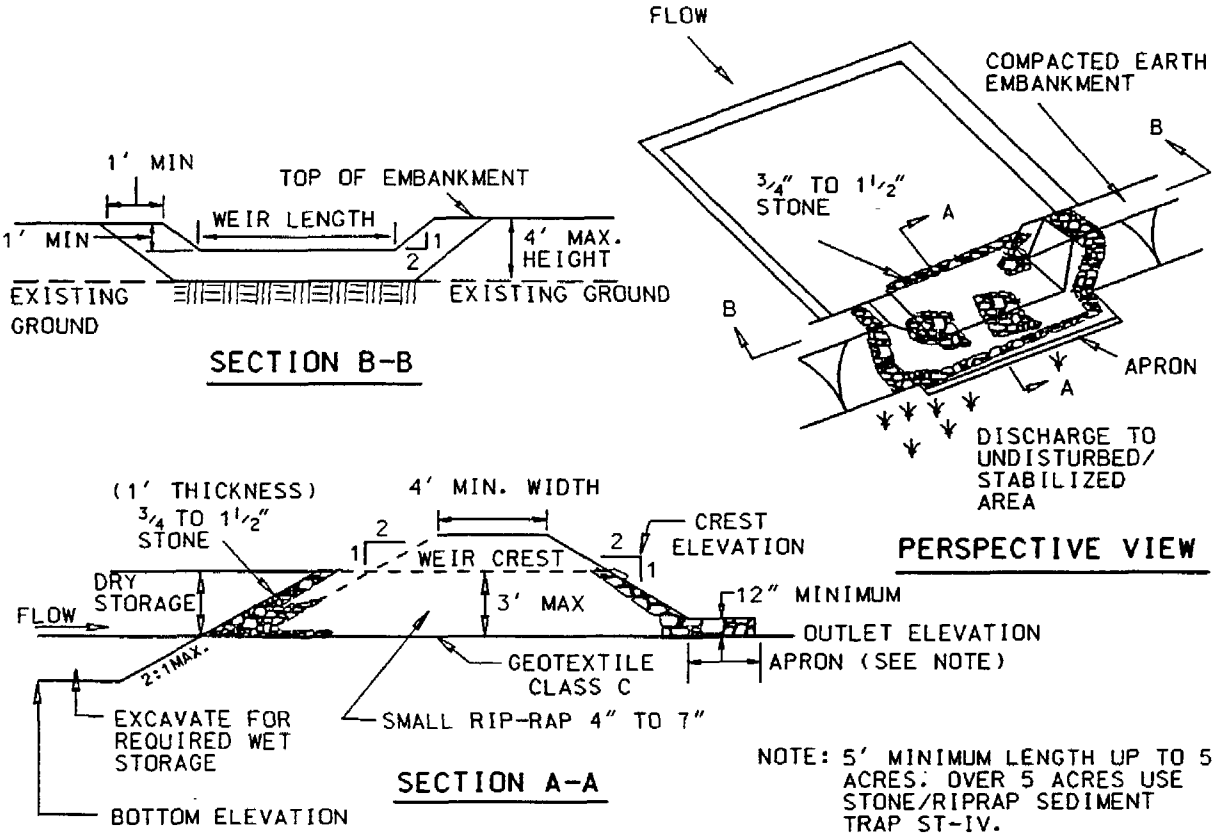
11. The elevation of the top of any dike directing water into the trap must equal or exceed the elevation of the trap embankment.

12. Geotextile Class C shall be placed over the bottom and sides of the outlet channel prior to the placement of stone. Sections of geotextile fabric must overlap at least 1' with the section nearest the entrance placed on top. The geotextile fabric shall be embedded at least 6" into existing ground at the entrance of the outlet channel.

13. Outlet - An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel.

14. For storage requirements see Table 9.

DETAIL 9 - STONE OUTLET SEDIMENT TRAP - ST II



Construction Specifications

1. Area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. All cut and fill slopes shall be 2:1 or flatter.

4. The stone used in the outlet shall be small rip-rap 4" to 7" in size with a 1' thick layer of 3/4" to 1 1/2" washed aggregate placed on the upstream face of the outlet. Stone facing shall be as necessary to prevent clogging. Geotextile Class C may be substituted for the stone facing by placing it on the inside face of the stone outlet.

5. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to one half of the wet storage depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

STONE OUTLET SEDIMENT TRAP - ST II

6. The structure shall be inspected periodically and after each rain and repairs made as needed.

7. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentration inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

8. The structure shall be dewatered by approved methods, removed and the area stabilized when the drainage area has been properly stabilized.

9. Refer to Section D for specifications concerning trap dewatering.

10. Minimum trap depth shall be measured from the weir elevation.

11. The elevation of the top of any dike directing water into the trap must equal or exceed the elevation of the trap embankment.

12. Geotextile Class C shall be placed over the bottom and sides of the outlet channel prior to the placement of stone. Sections of filter cloth must overlap at least 1' with the section nearest the entrance placed on top. The filter cloth shall be embedded at least 6" into existing ground at the entrance of the outlet channel.

13. Outlet - An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel.

9.3 Rip-rap Outlet Sediment Trap ST-III

This practice consists of a trap formed by an excavation and embankment. The outlet for this trap shall be through a partially excavated channel lined with rip-rap or recycled concrete equivalent. The outlet channel shall discharge onto a stabilized area or to a stable watercourse. **The rip-rap outlet sediment trap may be used for drainage areas of up to a maximum of 10 acres.**

Dry storage is not required in the Rip-rap Outlet Sediment Trap, only excavation for wet storage. The storage required is 5400 cubic feet per acre of drainage area for Rip-rap Outlet Sediment Traps.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

3. All cut and fill slopes shall be 2:1 or flatter.

4. Elevation of the top of any dike directing water into trap must equal or exceed the height of trap embankment.

5. Storage area provided shall be figured by computing the volume measured from top of excavation (For storage requirements see Table 10).

6. Geotextile Class C[15] shall be placed over the bottom and sides of the outlet channel prior to placement of stone. Sections of fabric must overlap at least 1' with section nearest the entrance placed on top. Fabric shall be embedded at least 6" into existing ground at entrance of outlet channel.

7. The outlet channel shall be constructed using 4"- 12" stone, placed 18" thick.

8. Outlet - An outlet shall include a means of conveying the discharge in an erosion free manner to a stable channel. Protection against scour at the discharge point shall be provided as necessary.

9. Outlet channel must have positive drainage from the trap.

10. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 of the wet storage depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

11. The structure shall be inspected periodically after each rain and repaired as needed.

[15] Refer to Table 27.

12. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

13. The structure shall be dewatered by approved methods, removed and the area stabilized when the drainage area has been properly stabilized.

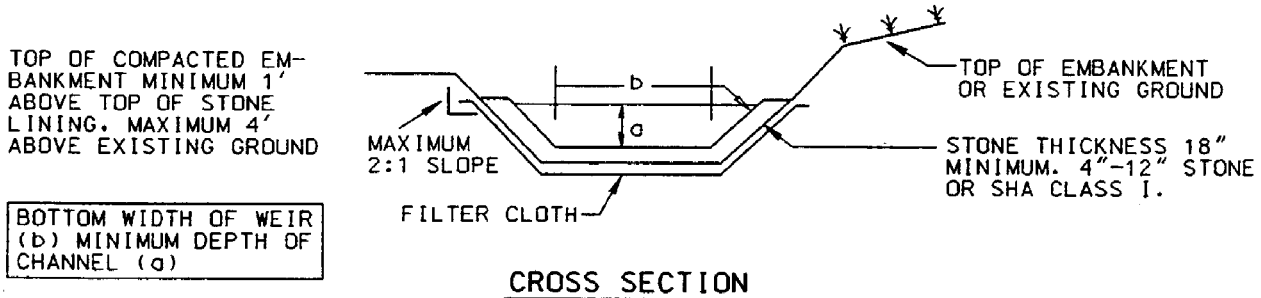
14. For storage requirements see Table 10.

Table 8 Riprap Outlet Sediment Trap

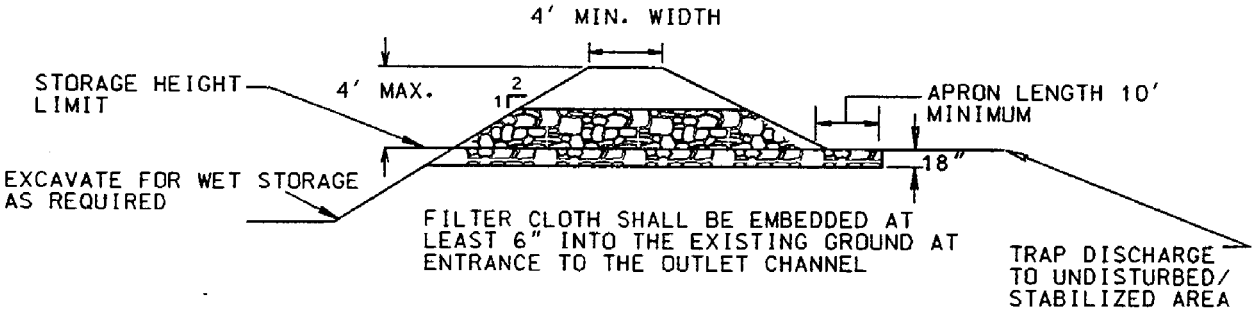
ST-III and IV (for Stone Lined Channel)

Contributing Drainage Area (Acres)	Depth of Channel (a) (Feet)	Width of Weir (b) (Feet)
1	1.5	4.0
2	1.5	5.0
3	1.5	6.0
4	1.5	10.0
5	1.5	12.0
6	1.5	14.0
7	1.5	16.0
8	2.0	10.0
9	2.0	10.0
10	2.0	12.0

DETAIL 10 - RIP-RAP OUTLET SEDIMENT TRAP - ST III



CROSS SECTION



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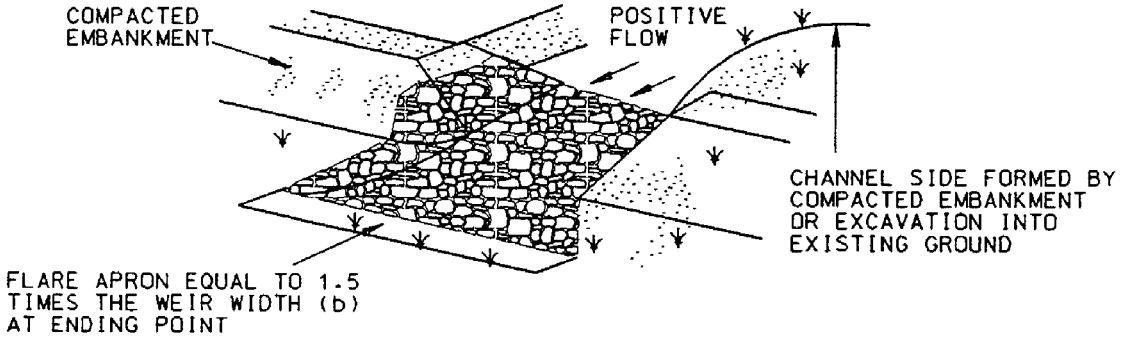

PERSPECTIVE VIEW

NOTE: MAXIMUM DRAINAGE AREA= 10 ac.

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RIP-RAP OUTLET SEDIMENT TRAP - ST III

Constuction Specifications

1. The area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Maximum height of embankment shall be 4', measured at centerline of embankment.

3. All cut and fill slopes shall be 2:1 or flatter.

4. Elevation of the top of any dike directing water into trap must equal or exceed the height of trap embankment.

5. Storage area provided shall be figured by computing the volume measured from top of excavation. (For storage requirements see Table 10).

6. Filter cloth shall be placed over the bottom and sides of the outlet channel prior to placement of stone. Section of fabric must overlap at least 1' with section nearest the entrance placed on top. Fabric shall be embedded at least 6" into existing ground at entrance of outlet channel.

7. Stone used in the outlet channel shall be 4" - 7" placed 18" thick.

8. Outlet - An outlet shall be provided, which includes a means of conveying the discharge in an erosion free manner to an existing stable channel. Protection against scour at the discharge end shall be provided as necessary.

9. Outlet channel must have positive drainage from the trap.

10. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to $^1/_4$ of the wet storage depth of the trap (1350 cf/ac). Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

11. The structure shall be inspected periodically after each rain and repaired as needed.

12. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

13. The structure shall be dewatered by approved methods, removed and the area stabilized when the drainage area has been properly stabilized.

9.4 Stone/Rip-rap Outlet Sediment Trap ST-IV

This practice consists of a trap formed by an excavation and embankment. The outlet for this trap shall be through a partially excavated channel lined with rip-rap and containing a stone or recycled concrete equivalent outlet structure. The outlet shall discharge onto a stabilized area or to a stable watercourse. The stone outlet/rip-rap outlet sediment trap may be used for drainage areas up to a maximum of 10 acres. The outlet of this trap is over a stone section placed in the rip-rap channel. The minimum length weir (feet) of the stone section shall be equal to four (4) times the drainage area (acres). The Detail for ST-II shall be used on the plans for constructing ST-IV with the rip-rap apron length shown.

The outlet crest (top of stone in weir section) shall be level, at least 1' foot below top of embankment and no more than 3' above ground beneath the outlet. 4"- 7" stone shall be used in the weir and 4" - 12" or Class I rip-rap shall be used to construct the outlet. A 1' thick layer of 3/4" - 1 1/2" washed aggregate shall be placed on the upstream face of the outlet. Geotextile Class E or C[16] placed on the upstream face of the outlet may be substituted for the 3/4" - 1 1/2" stone.

Construction Specifications

1. The area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Maximum height of embankment shall be four (4) feet, measured at centerline of embankment.

3. All cut and fill slopes shall be 2:1 or flatter.

4. Elevation of the top of any dike directing water into trap must equal or exceed the height of trap embankment.

5. Storage area provided shall be figured by computing the volume measured from top of weir. (For storage requirements see Table 9).

6. Geotextile Class C shall be placed over the bottom and sides of the outlet channel prior to placement of stone. Sections of fabric must overlap at least 1' with section nearest the entrance placed on top. Fabric shall be embedded at least 6" into existing ground at entrance of outlet channel.

7. 4"- 7" stone shall be used to construct the weir and 4" to 12" or Class I rip-rap shall be used to construct the outlet channel.

8. Outlet - An outlet shall include a means of conveying the discharge in an erosion free manner to an existing stable channel. Protection against scour at the discharge point shall be provided as necessary.

[16] Refer to Table 27.

9. Outlet channel must have positive drainage away from the trap.

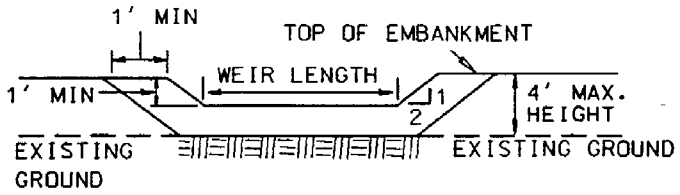
10. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to 1/2 of the wet storage depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

11. The structure shall be inspected periodically after each rain and repaired as needed.

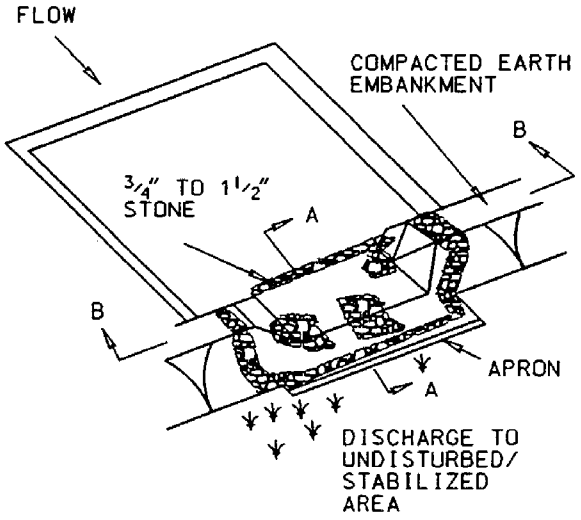
12. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

13. The structure shall be removed and the area stabilized when the drainage area has been properly stabilized.

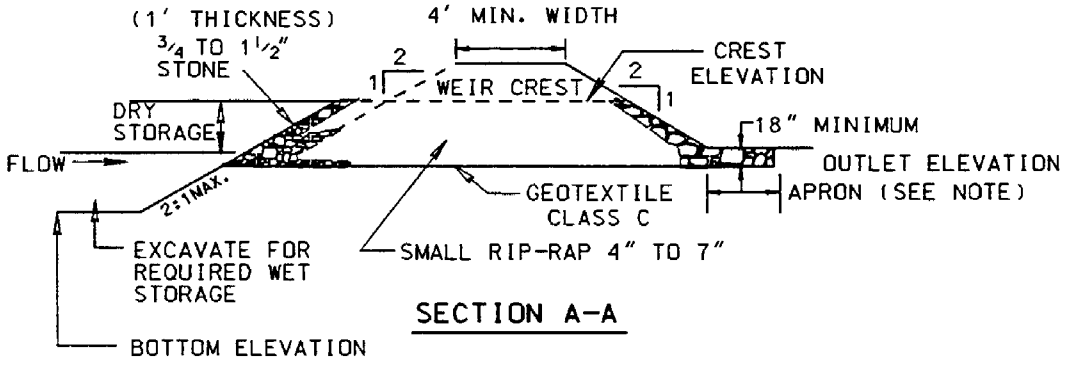
DETAIL 10A – STONE / RIP-RAP OUTLET SEDIMENT TRAP – ST IV



SECTION B-B



PERSPECTIVE VIEW



SECTION A-A

NOTE: 5' MIN LENGTH UP TO 5 ACRES. OVER 5 ACRES USE 10' MIN

STONE / RIP-RAP OUTLET SEDIMENT TRAP - ST IV

Constuction Specifications

1. The area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

2. The fill material for the embankment shall be free of roots or other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Maximum height of embankment shall be 4', measured at centerline of embankment.

3. All cut and fill slopes shall be 2:1 or flatter.

4. Elevation of the top of any dike directing water into trap must equal or exceed the height of trap embankment.

5. Storage area provided shall be figured by computing the volume measured from top of excavation. (For storage requirements see Table 9).

6. Geotextile Class C shall be placed over the bottom and sides of the outlet channelprior to placement of stone. Section of fabric must overlap at least 1' with section nearest the entrance placed on top. Fabric shall be embedded at least 6" into existing ground at entrance of outlet channel.

7. 4" - 7" stone shall be used to construct the weir and 4" - 12" or Class I rip-rap shall be used to construct the outlet channel.

8. Outlet - An outlet shall include a means of conveying the discharge in an erosion free manner to an existing stable channel. Protection against scour at the discharge point shall be provided as necessary.

9. Outlet channel must have positive drainage from the trap.

10. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to $^1/_2$ of the wet storage depth of the trap (900 cf/ac). Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

11. The structure shall be inspected periodically after each rain and repaired as needed.

12. Construction of traps shall be carried out in such a manner that sediment pollution is abated. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. Points of concentrated inflow shall be protected in accordance with Grade Stabilization Structure criteria. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon trap completion and monitored and maintained erosion free during the life of the trap.

13. The structure shall be dewatered by approved methods, removed and the area stabilized when the drainage area has been properly stabilized.

Table 9 Sediment Trap Design Criteria
ST-I, ST-II, ST-IV

DRAINAGE AREA (AC.)	TRAP TYPE*	TOTAL VOLUME (CF)	WET VOLUME (CF)	DRY VOLUME (CF)	MINIMUM DEPTH (FT)	MINIMUM LENGTH (FT)	MINIMUM WIDTH (FT)
1	I/II	3600	1800	1800	2.5	46	23
2	I/II	7200	3600	3600	2.5	68	34
3	I/II	10800	5400	5400	2.5	86	42
4	I/II	14400	7200	7200	3.0	90	43
5	I/II	18000	9000	9000	3.0	101	50
6	IV	21600	10800	10800	4.0	90	46
7	IV	25200	12600	12600	4.0	100	50
8	IV	28800	14400	14400	4.0	105	55
9	IV	32400	16200	16200	4.0	110	60
10	IV	36000	18000	18000	4.0	123	60

*I - PIPE OUTLET (POST), II - STONE OUTLET (SOST), IV - STONE/RIPRAP OUTLET (SROST)

1. The length to width ratio should be 2:1.

2. Minimum length and width dimensions apply to the bottom of the traps.

3. The side slopes will be 2:1 or flatter.

4. If the stone outlet is used in conjunction with rip-rap channel protection then the storage requirement will be 3600 cubic feet per acre. If the stone outlet and rip-rap apron are used, the length of the apron will be a minimum of 10'.

Table 10 Sediment Trap Design Criteria ST-III

DRAINAGE AREA (AC.)	TRAP TYPE*	TOTAL VOLUME (CF)	WET VOLUME (CF)	MINIMUM DEPTH (FT)	MINIMUM LENGTH (FT)	MINIMUM WIDTH (FT)
1	III	5400	5400	2.5	58	29
2	III	10800	10800	2.5	85	42
3	III	16200	16200	2.5	107	53
4	III	21600	21600	3	111	55
5	III	27000	27000	3	125	62
6	III	32400	32400	4	115	57
7	III	37800	37800	4	125	62
8	III	43200	43200	4	135	67
9	III	48600	48600	4	143	72
10	III	54000	54000	4	152	76

* III - RIP-RAP OUTLET (ROST)

1. The length to width ratio should be 2:1.
2. Minimum length and width dimensions apply to the bottom of the traps.
3. The side slopes shall be 2:1 or flatter.
4. See Table 8 for minimum apron length for rip-rap outlet sediment traps.

10.0 STANDARD AND SPECIFICATIONS

FOR

SEDIMENT BASINS

Definition

A temporary barrier or dam constructed across a drainage way or at other suitable locations to intercept sediment laden runoff. This barrier may be combined with excavation to achieve the required storage.

Purpose

Sediment basins protect downstream properties and drainageways by trapping sediment and controlling the release of stormwater runoff.

Wet and Dry Storage

The minimum storage volume requirement for sediment basins is 3600 cubic feet per acre of contributory drainage area. The basin storage volume of 3600 cubic feet per acre shall be divided equally into "dry" or dewatered storage and "wet" or retention storage. Basins shall be dewatered to the wet pool elevation corresponding to 1800 cubic feet of storage per acre of drainage area.

Conditions Where Practice Applies

A sediment basin is required to control runoff and sediment from large areas where sediment traps are not appropriate. Stormwater management ponds may be used as sediment basins provided that they meet the requirements of this section and that the construction sequence addresses converting the sediment basin to the permanent stormwater management pond.

Conditions of Use

This standard applies to the installation of temporary sediment basins on sites where: (a) failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities; (b) the drainage area does not exceed 100 acres; (c) the maximum embankment height does not exceed 15 feet measured from the natural ground to the embankment top along the centerline of embankment; and (d) the basin is to be removed within 36 months after the beginning of construction of the basin. Where these criteria cannot be met, the structure shall be designed to conform with the Natural Resources Article, Title 8, Subtitle 8, Annotated Code of Maryland or Maryland SCS Standards and Specifications No. 378 for Ponds. The total volume of permanent sediment basins shall equal or exceed the capacity requirements for temporary basins contained herein.

Design Criteria

Design and construction shall comply with state and local laws, ordinances, rules and regulations.

1. Location The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, sediment basins should be located so that storm drains may outfall or be diverted into the basin.

2. Volume of the Basin The volume of the sediment basin, as measured from the bottom of the basin to the elevation of the principal spillway crest shall be at least 3600 cubic feet per acre of total drainage area (134 cubic yards). This 3600 cubic feet of storage is approximately equal to 1 inch of runoff per acre of drainage area. The sediment basin storage volume of 3600 cubic feet minimum per acre shall be divided equally into "dry" or dewatered storage and "wet" or retention storage. See Basin Draw-Down for dewatering criteria.

Sediment basins shall be cleaned out when the basin is filled with sediment to 900 cf/acre of total drainage area. Cleanout shall be performed to restore the original design volume to the basin. The elevation corresponding to the maximum allowable sediment level shall be determined and shall be stated in the design data as a distance below the top of the riser. The distance between the top of the riser and the cleanout elevation shall be clearly shown on the riser, above the pool elevation.

3. Surface Area Basins shall be designed so that the ratio of acres of surface area to cubic feet/second of discharge (from a 10 year storm) is greater than or equal to 0.0035. The surface area shall be measured at the design high water elevation.

4. Shape of the Basin It is recommended that the designer of a sediment basin strive to incorporate the following features:

a. Length to width ratio greater than 2:1, where length is the distance between the inlet and outlet.

b. A wedge shape with the inlet located at the narrow end.
c. In situations where the above conditions cannot be met, baffles designed to maximize detention time may be required.
d. The dimensions necessary to obtain the required basin volume and surface area shall be clearly shown on the plans to facilitate plan review, construction and inspection.

5. Inflow Protection Whenever the inflow to the basin is not stabilized refer to the inflow protection specifications. Inflow protection provides safe conveyance of concentrated runoff into temporary sediment basins to prevent erosion. Inflow protection shall meet or exceed the practices found in Section B of these Standards and Specifications. Points of runoff entry should be located as far away from the riser as possible, to maximize travel time in conjunction with dikes, swales or other water control devices as warranted by site conditions.

6. Embankment The embankment plans shall include elevations at the top of earth fill at constructed and settled height.

7. Side Slopes The combined upstream and downstream side slopes of the settled embankment shall not be less than five horizontal to one vertical (5:1) with neither slope steeper than 2:1. Slopes must be designed to be stable in all cases.

8. Top Width For dam embankments up to ten (10) feet, the top will be level and a minimum of eight (8) feet in width. For embankments between ten (10) feet and fifteen (15) feet, the top width will be ten (10) feet.

9. Spillway Design Runoff shall be computed by the method outlined in Chapter 2, Estimating Runoff, "Engineering Field Manual for Conservation Practices" available in the Soil Conservation Service offices, or by TR-55, Urban Hydrology. Runoff computations shall be based upon the worst soil-cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. The combined capacities of the principal and emergency spillways shall be sufficient to pass the "routed" peak rate of runoff from a 10-year frequency storm.

10. Principal Spillway A spillway shall be provided which consists of a vertical pipe or box type riser joined (watertight connection) to a pipe (barrel) which shall extend through the embankment and outlet beyond the downstream toe of the fill . The storage volume required shall be measured from the riser crest elevation to the bottom of the basin. The minimum size of the barrel shall be what is required to pass 10% of the 10 year storm or 8 inches in diameter whichever is larger.

a. Crest elevation The crest elevation of the riser shall be a minimum of one foot below the elevation of the control section of the emergency spillway.

b. Watertight Riser and Barrel Assembly The riser and all pipe connections shall be completely watertight except for the inlet opening at the top or dewatering openings and shall not have any other holes, leaks, rips or perforations.

c. Basin Draw-down The water in the basin from the riser crest to the permanent pool shall be drawn down over a 10 hour period through an internal orifice in a draw-down device. A draw-down device shall be included in the sediment basin plans submitted for approval and shall be installed during construction of the basin. Design of a draw-down device shall be required if an orifice size other than those provided in Table 11 is to be used. Design of perforations in the horizontal or vertical dewatering device is required. Draw-down shall be done in such a manner as to remove the clean water without removing sediment that has settled out or floating debris. This shall be done by constructing a perforated horizontal or vertical draw-down device with an internal orifice to control discharge. If perforating the riser is desired as a draw-down device, the minimum detention time shall be 10 hours, however, the riser must be wrapped with 1/2" hardware cloth and Geotextile Class E or C[17]. Other methods may be used as long as detailed drawings are provided on the approved sediment control plans.

[17] Refer to Table 27.

NOTE: If the basin is to be converted to a stormwater management pond the riser should not be perforated. If PVC pipe is used for the principle spillway then the concrete pipe chart will be used for hydraulic design. Use manufacturer's specification for loading.

d. Anti-vortex Device and Trash Rack An anti-vortex device and trash rack shall be securely installed on top of the riser and shall be the concentric type meeting these specifications for corrugated metal pipe risers and shall meet MD 378 for all others.

e. Base The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Steel base plates of at least 1/4" thickness shall be twice the diameter of the riser and shall have at least 2' of compacted earth, stone or gravel placed over it to prevent flotation. Concrete riser bases shall be twice the diameter of the riser, a minimum of 18" thick, contain steel reinforcement as shown in Detail 15, and shall have the riser embedded 9" minimum. Risers over 10 feet in height require that anti-floatation calculations be performed and shall be based on the following:

1. The riser shall be analyzed for floatation assuming all orifices and pipes are plugged.

2. The factor of safety against floatation shall be 1.2 or greater.

f. Anti-seep Collars Anti-seep collars shall be installed around all conduits through earth fills of impoundment structures according to the following criteria:

1. Collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.

2. Collar spacing shall be between 5 and 14 times the vertical projection of each collar.

3. Collars should be placed within the saturation zone. In cases where spacing limit will not allow this, at least one collar shall be placed in the saturation zone.

4. **All anti-seep collars and their connections shall be watertight.**

5. Anti-seep collars shall be placed a minimum of two feet from pipe joints.

6. Anti-seep collars must have 2' minimum projection.

g. Outlet - An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel. **Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references concerning the easements will be shown on the erosion and sediment control plan.** Protection against scour at the discharge end of the pipe spillway shall be provided. See Section 18.0 Standard and Specifications for Rock Outlet Protection.

11. Emergency Spillways The entire flow area of the emergency spillway shall be constructed in undisturbed ground (not fill). The emergency spillway cross-section shall be trapezoidal with a minimum bottom width of eight feet. This spillway channel shall have a straight, level control section of at least 25 feet in length. The exit channel section shall have sufficient slope such that the discharge capacity of the spillway is not hindered in any way and allows the discharge to be released at a non-erosive velocity.

a. Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the 10-year 24-hour duration storm, less any reduction due to flow in the principal spillway. Emergency spillway dimensions may be determined by using the method in Detail 12 and Table 14.

b. Velocities - The velocity of flow in the exit channel shall not exceed 5 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.

c. Freeboard - Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. Freeboard shall be at least one foot.

12. Sediment Disposal The sediment basin plans shall indicate the method(s) of disposing of the sediment removed from the basin. The sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the basin or adjacent to a stream or floodplain. **Disposal sites must be considered in an approved sediment control plan.** The sediment basin plans shall show the method of disposal of the sediment basin after the drainage area is stabilized, and shall include the stabilization of the sediment basin site. **Sediment shall not be allowed to flush into a stream or drainage way.** For dewatering methods see Section D.

Construction Specifications

1. Site Preparation: Perimeter sediment control devices must be installed prior to clearing and grubbing. Areas where the embankment is to be placed shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots or other objectionable material. The pool area shall not be cleared until completion of the dam embankment unless the pool area is to be used for borrow. In order to facilitate clean-out and restoration, the pool area (measured at the top of the pipe spillway) shall be cleared of all brush, trees, and other objectionable materials.

2. Cut-off Trench: A cut-off trench shall be excavated along the centerline of earth fill embankments. The minimum depth shall be four feet. The cut-off trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be two feet, but wide enough to permit operation of excavation and compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be dewatered during the backfilling-compaction operations. For dewatering see Section D.

3. Embankment: The fill material shall be taken from approved areas shown on the plans. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Relatively pervious materials such as sand or gravel (Unified Soil Classes GW, GP, SW & SP) or organic materials (Unified Soil Classes OL and OH) shall not be placed in the embankment. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Fill material shall be placed in six-inch to eight-inch thick continuous lifts over the entire length of the fill. Compaction shall be obtained by routing and hauling the construction equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. **The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement.**

4. Principal Spillway: Steel risers shall be securely attached to the barrel or barrel stub by welding the full circumference making a watertight structural connection. Concrete risers shall be poured with the principal spillway in place or precast with voids around the principal spillway filled with concrete or shrink proof grout for watertight connection. The barrel stub must be attached to the riser at the same percent (angle) of grade as the outlet conduit. The connection between the riser and the riser base shall be watertight. All connections between barrel sections must be achieved by approved watertight band assemblies. The barrel and riser shall be placed on a firm, smooth foundation of impervious soil as the embankment is constructed. **Breaching the embankment to install the barrel is unacceptable.** Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collars. The fill material around the pipe spillway shall be placed in four inch lifts and hand compacted under and around the pipe to at least the same density as the adjacent embankment. A depth of 1.5 times the pipe diameter (min.) shall be backfilled over the principal spillway and hand compacted before crossing it with construction equipment.

5. Emergency Spillway: **The emergency spillway shall be installed in undisturbed ground.** The achievement of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of $\pm$ 0.2 feet.

6. Vegetative Treatment: Stabilize the embankment in accordance with the appropriate vegetative Standard and Specifications immediately following construction. In no case shall the embankment remain unstabilized for more than seven (7) days. Once constructed, the top and outside face of the embankment shall be stabilized with seed and mulch. The remainder of the interior slopes should be stabilized (one time) with seed and mulch upon basin completion and monitored and maintained erosion free during the life of the basin.

7. Safety: Local requirements concerning fencing and signs shall be met, warning the public of hazards of soft sediment and floodwater.

8. Maintenance: Repair all damage caused by soil erosion and construction equipment at or before the end of each working day. Sediment shall be removed from the basin when it reaches the specified distance below the top of the riser as shown on the riser. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain. Disposal areas must be stabilized.

9. Final Disposal: When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the approved sediment control plan. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. If the site is scheduled for future construction, then the basin material and trapped sediments must be removed and safely disposed of and the basin shall be backfilled with a structural fill. When the basin area is to remain open space, the pond may be pumped dry (using methods in Section D - Dewatering), graded, and back filled.

10. Conversion to Stormwater Management Structure: After permanent stabilization of all disturbed contributory drainage areas, temporary sediment basins, if initially built and certified to meet permanent standards, may be converted to permanent stormwater management structures. To convert the basin from temporary to permanent use, the outlet structure must be modified in accordance with approved stormwater management design plans. Additional grading may also be necessary to provide the required storage volume in the basin. **Conversion can only take place after all disturbed areas have been permanently stabilized to the satisfaction of the inspection authority and storm drains have been flushed.**

INFORMATION TO BE SUBMITTED

Sediment basin designs and construction plans submitted for review to the Soil Conservation District or other agencies shall include the following:

1. Sediment controls necessary for the installation of the basin.

2. Specific location of the basin.

3. Plan view of the basin and emergency spillway showing existing and proposed contours.

4. Cross section of dam, including elevations at the top of earth fill at constructed and settled height, principal spillway and emergency spillway; profile of emergency spillway.

5. Details of pipe connections, riser to pipe connections, riser base, anti-seep collars, trash rack, cleanout elevation, and anti-vortex device.

6. Runoff calculations for the 10-year frequency storm assuming worst soil conditions.

7. Storage Computation

   a. Total volume required including volumes of "wet" and "dry" storage.

   b. Total volume provided including volumes of "wet" and "dry" storage.

   c. Level of sediment at which cleanout shall be required, stated as a distance from the riser crest to the sediment surface.

8. Calculations showing design of pipe and emergency spillways.

9. Maintenance equipment access points.

10. Dewatering method (sump pit, etc.).

11. Bottom dimensions of basins.

12. Drainage Area Map clearly showing the maximum contributory drainage area to reach the basin.

13. Other information as required by the approval agency.

Bibliography

Hoan, CT., Tapp, J.S. "Design of Sedimentation Basins," NCHRP Synthesis of Highway Practices (1980) Ware, A.D.,

Institute of Mining and Minerals Research, The Deposits Sedimentation Pond Design Manual, Lexington 1979, University of Kentucky.

Barfield, Billy J. and Clar, Michael L., Development of New Design Criteria for Sediment Traps and Basins. 1985.

Figure 2 Temporary Sediment Basin Design Data Sheet

Computed by:_____ Date: _____ Checked by: _____ Date: _____

Project name:_____ Basin #: _____

Location:_____

_____

Total area draining to basin: _____ acres (ac)

Basin Volume Design

Note: 1. Also see Surface Area Design #30, this form.

2. To convert ft^3 to yd^3, divide ft^3 by 27. To convert ft^2 to yd^2, divide ft^2 by 9.

1. Min. required vol. = 3600 ft^3/ac x _____ ac. drainage = _____ ft^3
2. Actual Volume of basin =_____ft^3
3. Excavate _____ft^3 (_____yd^3) to obtain required capacity.
4. Vol. at dewatering elev. = 1800 ft^3/ac x _____ ac. = _____ ft^3
5. Vol. of basin at cleanout = 900 ft^3/ac x _____ ac. = _____ ft^3
6. Elevation corresponding to min. required volume of basin (riser crest elevation) _____ ft.
7. Permanent pool elevation _____ ft.
8. Distance from riser crest elevation to permanent pool elevation _____ ft.
9. Basin cleanout elevation _____ ft.
10. Distance from riser crest elevation to cleanout elevation_____ ft.

Spillway Design

11. Q_{10} = _____cfs (peak discharge from 10-yr, 24-hr storm event, attach computations)

Principal Spillway (Qps) (See Detail 11)

12. Design Principal Spillway (Barrel) discharge, Design Q_{ps} = _____ cfs (min. 10% of 10 year peak or 8" Diameter Pipe)
13. H = _____ ft.; Barrel length = _____ ft.
14. Barrel Diam. _____ in. Note: Q_{ps} must equal or exceed Design Q_{ps}

    Q_{ps} = Q (from Table 13 or 14) _____ x (length correction factor) _____ = _____ cfs.
15. Riser Diameter _____ in.; Riser Height _____ ft.; Riser Head (h) = _____ ft.
16. Trash Rack Diam. _____ in.; Trash Rack Height = _____ in.

NOTE: A table showing design data shall be included on the plan for each basin.

Emergency Spillway (Qes)

17. Emergency spillway cap., $Q_{es} = Q_{10} - Q_{ps}$ =_____ -_____ =_____cfs
18. Width _____ ft; Hp _____ft
19. Entrance channel slope _____%.
20. Exit channel slope _____%

Anti-Seep Collar Design (If Required)

21. y = _____ ft.; z =_____:1; pipe slope = _____ %; Ls = _____ ft
22. Use _____ collars, _____ ft. - _____ in. square; projection = _____ ft.

Design Elevations

23. Riser Crest =_____ ft.
24. Design High Water =_____ft.
25. Emergency Spillway Crest =_____ ft.
26. Min. settled top of dam =_____ ft.
27. Permanent pool =_____ ft.
28. Bottom of Basin =_____ ft.
29. Draw-down orifice invert =_____ ft.

Surface Area Design

30. Min.basin surface area; SA $\geq$ 0.0035 x Q_{10} = 0.0035 x _____ cfs $\leq$ _____ac.

Draw-down Device

31. Draw-down device orifice diameter = _____ in. (From Table 11)
32. A_t = Total area of perforations $\geq 4A_o$

    A_t= (# of perforation/foot)(perforation area ft^2)(perforated section length ft.)

    A_t= _____ft^2

A_o = Internal orifice area (from Table 11 or computed)

Table 11 Draw-down Device
Orifice Area and Diameter

Drainage Area (acres)	Maximum Orifice Diameter (d_o)	Maximum Orifice Area (A_o)
5-10	4"	0.087 ft^2
10-20	6"	0.20 ft^2
20-40	8"	0.34 ft^2
40-60	10"	0.55 ft^2
60-80	12"	0.79 ft^2
80-100	14"	1.07 ft^2

Draw-down Device Equations

$$Q_{d\text{-}d}\ (\text{cfs}) = \frac{(1800\ \text{cf/acre})(\text{number of acres})}{(10\ \text{hours})(3600\ \text{seconds/hour})}$$

$$A_o = \frac{Q_{d\text{-}d}}{C\sqrt{2gh_{d\text{-}d}}} \qquad d_o = \sqrt{\frac{4\,A_o}{\pi}}$$

$h_{d\text{-}d}$ = 2/3 (Riser Crest Elevation - Wet Storage Elevation)
C = Constant = 0.6
A_o = Internal Orifice Area (ft.^{2})
π = Constant = 3.142
d_o = Maximum Orifice Diameter
g = Gravitational Constant = 32.166 ft/s^2

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET
INSTRUCTIONS FOR USE OF FORM

1. The minimum required volume of storage is 3600 cubic feet per acre (ft^3/ac) of drainage area. Compute the volume of basin storage using the *entire* drainage area. Do not estimate storage based only on disturbed area.

2. The volume of a naturally shaped basin (no excavation) may be approximated by the formula Volume = 0.4 Ad, where Volume is in ft^3, A is the surface area of the basin in square feet (ft^2), and d is the maximum depth of the basin in feet (ft.). Volume may be computed from contour information or other suitable methods.

3. If the volume of the basin is not adequate for the required storage, excavate to obtain the required volume.

4. The volume of the basin for a permanent pool is 1800 ft^3/ac from each acre of drainage area. The basin is dewatered to this permanent pool elevation and volume through the draw-down device.

5. The volume of the basin for cleanout of settled sediment is 900 ft^3/ac for each acre of drainage area. As the basin fills with sediment to this volume, the sediment shall be removed to restore the original design volume.

6. Determine the design elevation for the minimum required storage volume of the basin. The design elevation is set at the riser crest to provide the required 3600 ft^3/ac of drainage area.

7. Determine the design elevation of the permanent pool level. The basin shall be dewatered to this elevation using a draw-down device or perforations in the riser. The design elevation of the permanent pool corresponds to 1800 ft^3/ac of volume. The size of the internal orifice governs the discharges between the riser crest and permanent pool elevations, with the draw-down time being 10 hours (minimum).

8. Subtract the permanent pool elevation from the riser crest elevation.

9. Determine the elevation of basin cleanout, storage corresponding to 900 ft^3/ac.

10. Subtract the cleanout elevation from the riser crest elevation. The distance (ft.) between the riser crest elevation and cleanout elevation shall be clearly shown on the riser.

11. The peak discharge rate is computed for a 10-year, 24-hour storm event using approved SCS methods (Q_{10}) assuming worst soil cover conditions.

12. The minimum principal spillway discharge capacity (Q_{ps}) under H(ft) head shall be the discharge through an 8" pipe or 10 percent of Q_{10}, whichever is greater.

NOTE: If there is no emergency spillway then $Q_{ps} = Q_{10}$.

13. "H" is the distance in feet between the centerline of the outlet pipe and the emergency spillway crest. Determine the length of the barrel.

14. Determine the barrel diameter for Q_{ps} using the Pipe Spillway Design Charts.

15. Determine the riser diameter, length, and "h" to release the principal spillway discharge using the solid lines on Table 15. The riser crest should be set (minimum) 1 foot below the emergency spillway (See Detail 11).

16. Determine the trash rack and anti-vortex device size using Detail 16.

17. Compute the capacity required for the emergency spillway capacity (Q_{es}) by subtracting the actual flow carried by the principal spillway from Q_{10}.

18. Using Table 14 and Detail 12, determine values of Hp and bottom width for the emergency spillway.

19. Determine the entrance channel slope.

20. Determine the exit channel slope.

21. Determine the anti-seep collar design. (See Table 16 and Detail 13).

22. Determine the number of anti-seep collars to use.

23. Determine the design elevation of the riser crest.

24. Design high water is the elevation of the emergency spillway crest plus the value of Hp.

25. Determine the design elevation of the emergency spillway.

26. The minimum settled top of dam elevation requires 1.0 ft. of freeboard above design high water. The minimum constructed top of dam elevation shall include a 10% increase in height to allow for settlement.

27. Determine the elevation where 1/2 of the total storage volume is attained. This elevation, known as the permanent pool elevation, is also the invert elevation of the basin draw-down device.

28. Fill in the basin bottom elevation.

29. Fill in the draw-down orifice invert. For a horizontal draw-down device this elevation should be the same as the permanent pool elevation.

30. Compute the minimum basin surface area using the equation given on the Sediment Basin Design Data Sheet and Q_{10}.

31. Choose a basin draw-down orifice size from the Table 11 or design one using the parameters given.

32. Using orifice area from Table 11, or calculations, and a maximum perforation diameter of 1" (0.0055 ft^2 area), determine the length of pipe required to provide sufficient perforations so that the area of perforations (total) is greater than or equal to four times the internal orifice area.

Table 12 Corrugated d Pipe Inlet Flow Chart

70 Feet of Corrugated Metal Pipe Conduit $K_m = K_e + K_b = 1.00$

(Full Flow Assumed, n=0.025, Diameter of Pipe in Inches, H in Feet)

H	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"
1'	0.33	0.70	1.25	1.98	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137
2'	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194
3'	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159	196	237
4'	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274
5'	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306
6'	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225	277	336
7'	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362
8'	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388
9'	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411
10'	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433
11'	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454
12'	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318	392	475
13'	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494
14'	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513
15'	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531

L (ft) — Correction Factors for Other Pipe Lengths

20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09
40	1.28	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94	.94	.95
120	.78	.79	.79	.80	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.92
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.89
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.86

Table 13 Reinforced Concrete Pipe Inlet Flow Chart

70 Feet of Reinforced Concrete Pipe Conduit $K_m = K_e + K_b = 1.00$

(Full Flow Assumed, n=0.013, Diameter of Pipe in Inches, H in Feet)

HD	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1'	3.08	5.17	7.83	11.1	14.9	24.2	35.8	49.7	65.8	84.2	105	128	153	180	210	242	276	312
2'	4.35	7.31	11.1	15.7	21.0	34.2	50.6	70.3	93.1	119	148	181	216	255	297	342	390	441
3'	5.33	8.95	13.6	19.2	25.8	41.9	62.0	86.1	114	146	182	221	265	312	363	419	478	541
4'	6.15	10.3	15.7	22.1	29.8	48.4	71.6	99.4	132	168	210	255	306	360	420	483	552	624
5'	6.88	11.6	17.5	24.7	33.3	54.1	80.1	111	147	188	234	286	342	403	469	540	617	698
6'	7.54	12.7	19.2	27.1	36.4	59.3	87.7	122	161	206	257	313	374	441	514	592	676	765
7'	8.14	13.7	20.7	29.3	39.4	64.0	94.8	131	174	223	277	338	404	477	555	640	730	826
8'	8.70	14.6	22.2	31.3	42.1	68.5	101	141	186	238	297	361	432	510	594	684	780	883
9'	9.23	15.5	23.5	33.2	44.6	72.6	107	149	197	253	315	383	459	541	630	725	827	936
10'	9.73	16.3	24.8	35.0	47.0	76.5	113	157	208	266	332	404	483	570	664	764	872	987
11'	10.2	17.1	26.0	36.7	49.3	80.3	119	165	218	279	348	424	507	598	696	802	9151	1035
12'	10.7	17.9	27.1	38.3	51.5	83.9	124	172	228	292	363	442	530	624	727	837	9555	1081
13'	11.1	18.6	28.2	39.9	53.6	87.3	129	179	237	304	378	461	551	650	757	872	9948	1125
14'	11.5	19.3	29.3	41.4	55.7	90.6	134	186	246	315	392	478	572	674	785	904	1032	1168
15'	11.9	20.0	30.3	42.9	57.6	93.8	139	192	255	326	406	495	592	698	813	9364	1068	1209

L (ft) — Correction Factors for Other Pipe Lengths

20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1.09	1.08	1.07	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	1.05	1.05	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.001	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	.93	.94	.94	.95	.95	.96	.97	.97	.98	.98	.98	.98	.98	.99	.99	.99	.99	.99
100	.90	.91	.92	.93	.93	.95	.95	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99
120	.84	.86	.87	.89	.90	.91	.93	.94	.94	.95	.96	.96	.96	.97	.97	.97	.97	.98
140	.80	.82	.83	.85	.86	.88	.90	.91	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97
160	.76	.78	.80	.82	.83	.86	.88	.89	.90	.91	.92	.93	.94	.94	.95	.95	.95	.96

Table 14

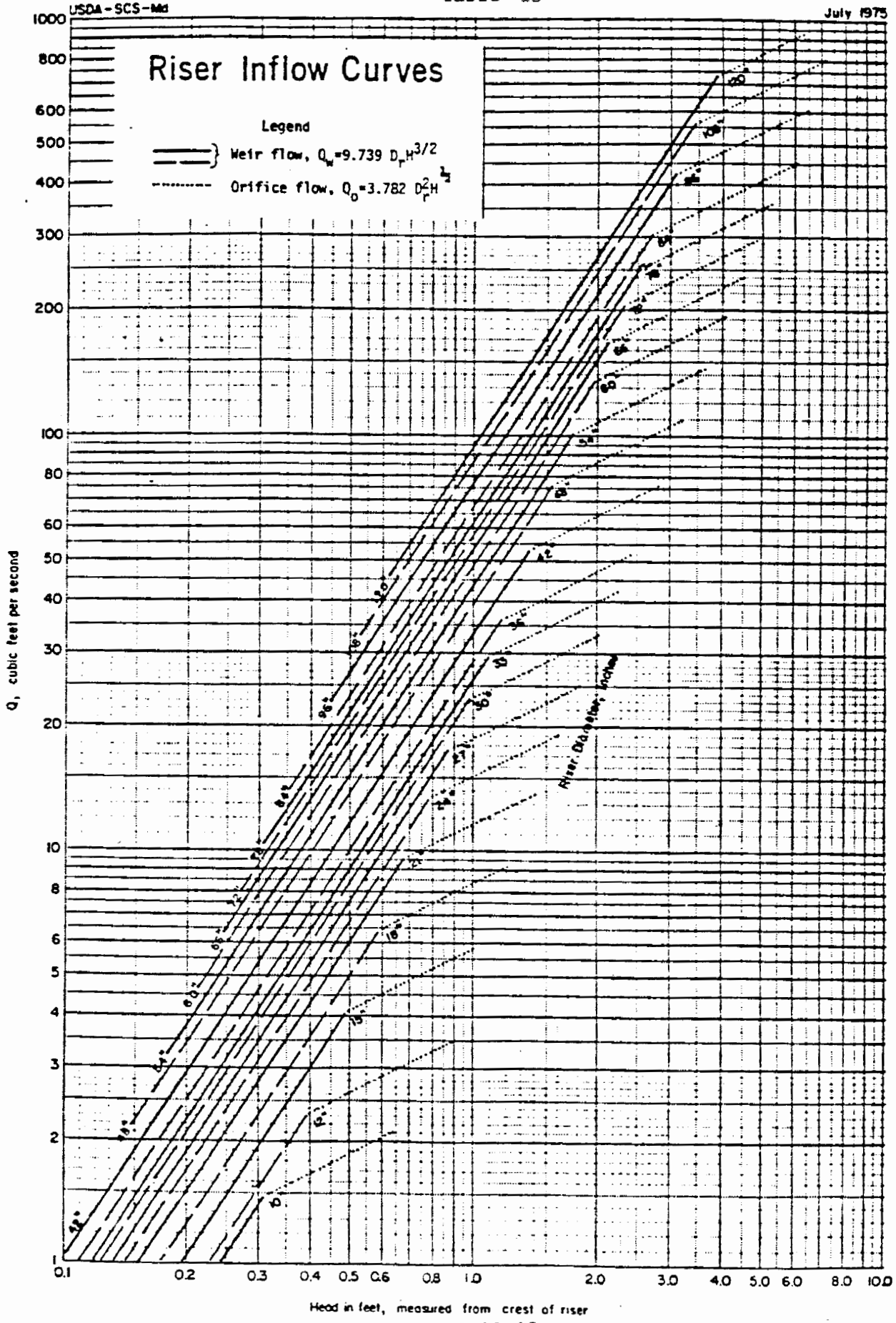
DESIGN DATA FOR EARTH SPILLWAYS

STAGE (Ho) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
0.8	Q	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
1.0	Q	20	24	29	33	38	42	47	51	56	61	63	68	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
1.2	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
1.3	Q	32	38	46	53	58	65	73	80	86	91	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
1.4	Q	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
1.5	Q	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	178
	V	4.8	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
1.6	Q	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	187	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
1.8	Q	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
2.1	Q	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3

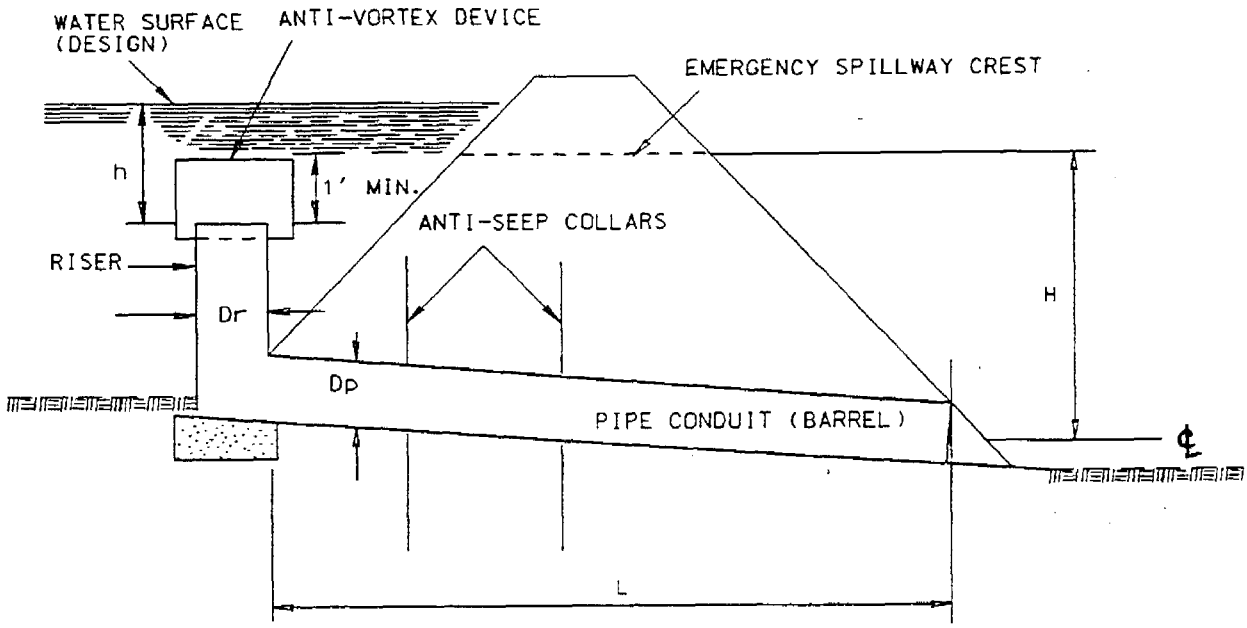
DATA TO RIGHT OF HEAVY VERTICAL LINES SHOULD BE USED WITH CAUTION, AS THE RESULTING SECTIONS WILL BE EITHER POORLY PROPORTIONED, OR HAVE VELOCITIES IN EXCESS OF 6 FEET PER SECOND.

Source: USDA-SCS

Table 15


USDA-SCS-Md
July 1975
Riser Inflow Curves
Legend
Weir flow, $Q_w = 9.739\ D_r H^{3/2}$
Orifice flow, $Q_o = 3.782\ D_r^2 H^{1/2}$
Q, cubic feet per second
Head in feet, measured from crest of riser
Riser Diameter, inches
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.8
1.0
2.0
3.0
4.0
5.0
6.0
8.0
10.0

DETAIL 11 - PIPE SPILLWAY DESIGN



H= Head on pipe spillway (pipe flow), feet (centerline of outlet to emergency spillway crest or to design high water if no emergency spillway).
h= Head over riser crest, in feet.
L= Length of pipe in feet.
Dp= Diameter of pipe conduit (barrel).
Dr= Diameter of riser.

CHART USE INSTRUCTIONS

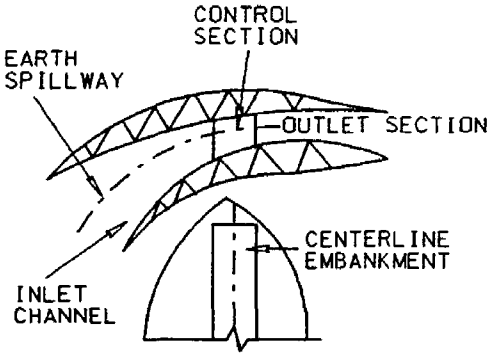
1. Enter chart, Table 13 or Table 14 with H and required discharge.
2. Find the diameter of the pipe conduit that provides equal or greater discharge.
3. Enter chart, Table 12, with actual pipe discharge.
4. Read across chart to select the smallest riser that provides discharge within the weir flow portion of the rating curve.
5. Read down the chart to find the corresponding h required.

EXAMPLE

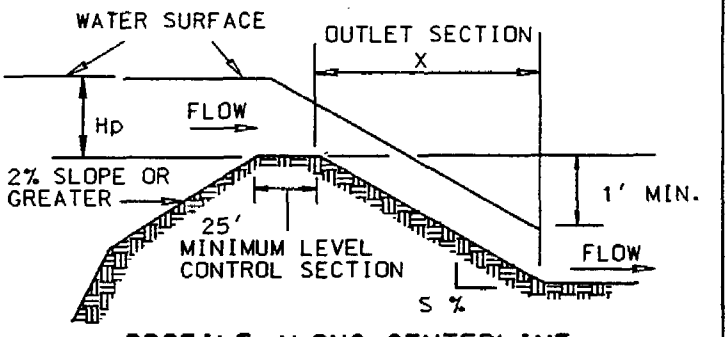
Given: Q (required) = 5.8 cfs
L= 60'
H= 9' to centerline of pipe= Free outlet

Find: Pipe size, actual Q and size of riser.
Q of 12" pipe= 6.0 cfs. x (correction factor) 1.07= 6.4 cfs.
from the Pipe Flow Chart.
From Riser Inflow Curves, smallest riser= 18" (@ H= 0.6)

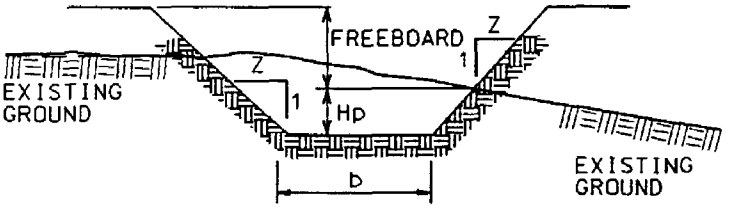
DETAIL 12 - EMERGENCY SPILLWAY



PLAN VIEW OF EMERGENCY SPILLWAY



PROFILE ALONG CENTERLINE OF EMERGENCY SPILLWAY



CROSS SECTION OF EMERGENCY SPILLWAY AT CONTROL SECTION

LEGEND

n= manning's Coefficient of Roughness.
Hp= Difference in elevation between the crest of the emergency spillway and the control section and water surface of the reservoir, in feet.
b= Bottom width of emergency spillway at the control section, in feet. (8' Minimum)
Q= Total discharge, in cfs.
V= Velocity, in feet per second, that will exist in the channel below the control section, at design Q, if constructed to slope (S) that is shown. (Vmax = 5 fps.)
S= Flattest slope (S), in %, allowable for the channel below the control section.
X= Minimum length of the channel below the control section, in feet.
Z= Side slope ratio.

Minimum Z = 2

NOTES

1. For a given Hp a decrease in the exit slope from S as given in the table decreases the spillway discharge but increasing the exit slope from S does not increase the discharge. If an exit slope (Se) steeper than S is used, then the velocity (Ve) in the exit channel will increase according to the following relationship:

$$Ve = V \left(\frac{Se}{S}\right)^{0.3}$$

2. Data to the right of the heavy vertical lines on Table 14 should be used with caution, as the resulting sections will be either poorly proportioned or have velocities in excess of 5 ft./sec.

Designing Anti-Seep Collars (Refer to Detail 13)

1. Determine the length of pipe within the saturation zone of the embankment (L_s) either graphically or by using the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end and that the slope of the pipe (S_o) is constant.

$$L_s = \frac{Y(Z+4)}{(1-4\ S_o)}$$

2. Determine the vertical projection (P_1) required to increase L_s by 15% either graphically as shown on C-10-22 or by using the equation:

$$P_1 = 0.075\ L_s$$

3. Choose the actual vertical projection (2' minimum) of each anti-seep collar (P) by rounding up P_1 or rounding down P_1 and using multiple collars.

4. Determine the number of anti-seep collars (N) required of the chosen vertical projection (P) using equation:

$$\frac{P_1}{P} = N$$

5. Either round up N or repeat steps 3 and 4 to determine optimum P/N relationship.

6. Provide construction specifications relative to the materials to be used and method for anchoring the anti-seep collar(s) to the pipe in a water tight manner.

7. Anti-seep collar spacing shall be between 5 and 14 times the vertical projection of each collar.

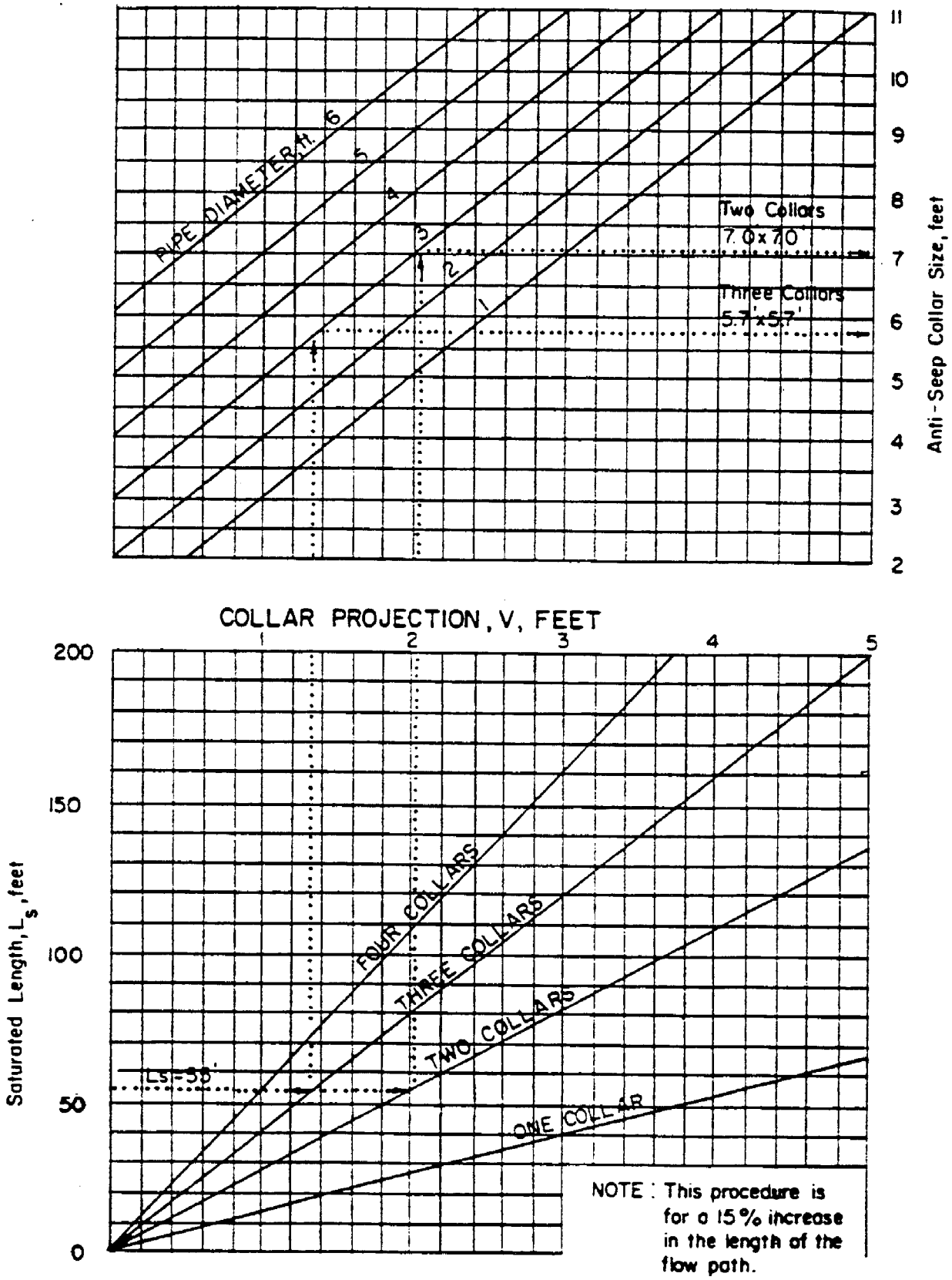
8. Anti-seep collar dimensions shall extend a minimum of 2 feet in all directions around the pipe.

9. Anti-seep collars shall be placed a minimum of two feet from pipe joints.

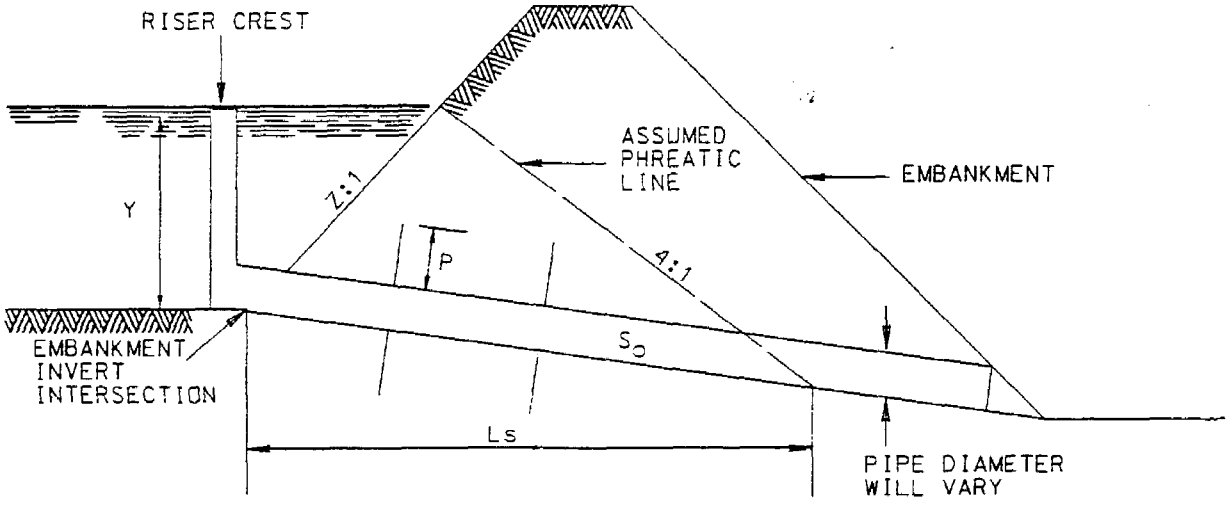
10. Anti-seep collars should be placed within the saturation zone. In cases where the spacing limit will not allow this, at least one collar shall be placed in the saturation zone.

Table 16

ANTI-SEEP COLLAR DESIGN



DETAIL 13 - ANTI-SEEP COLLAR DESIGN



ANTI-SEEP COLLAR DESIGN

where: p= vertical projection of anti-seep collar(ft).

Ls = length of pipe in the saturated zone (ft.)

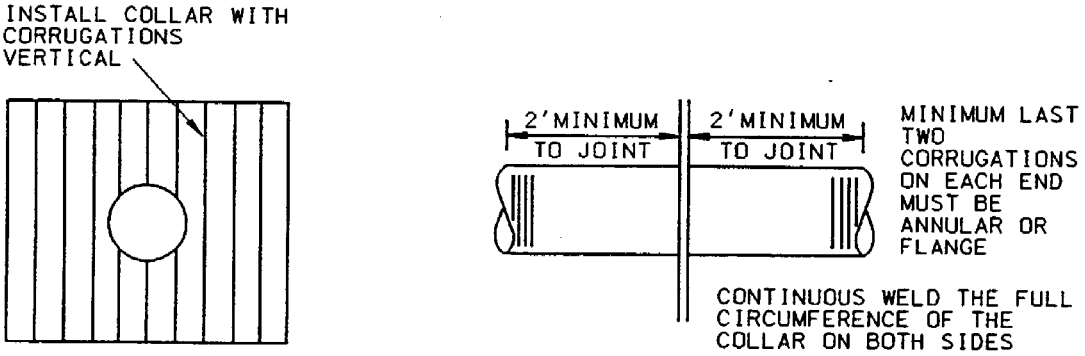
y= distance in feet from upstream invert of pipe to highest normal water level expected to occur during the life of the structure. usually the top of the riser.

z= slope of upstream embankment as a ratio of z ft. horizontal to one ft. vertical.

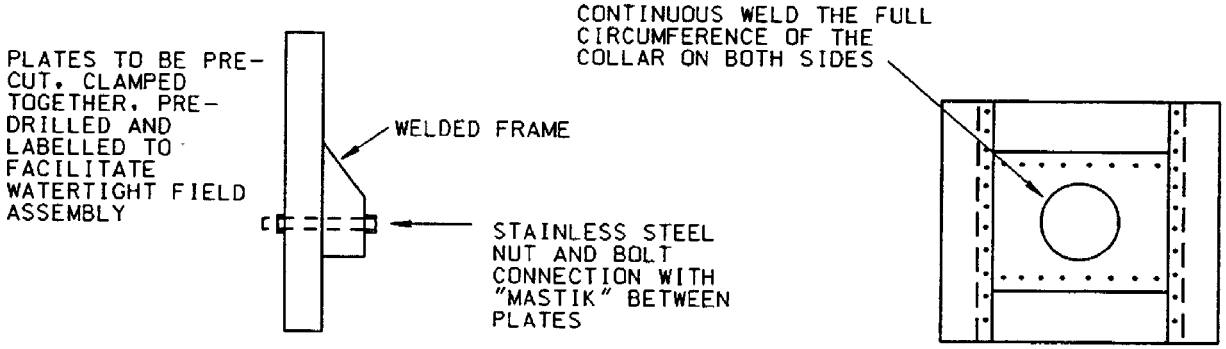
s_o= slope of pipe in feet per foot.

This procedure is based on the phreatic line as shown in the drawing above:

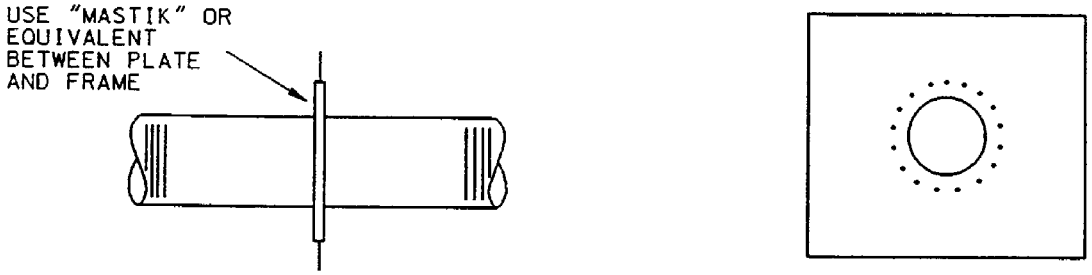
DETAIL 14 – TYPICAL ANTI-SEEP COLLARS



COLLAR WELDED IN PLACE ON BARREL SECTION

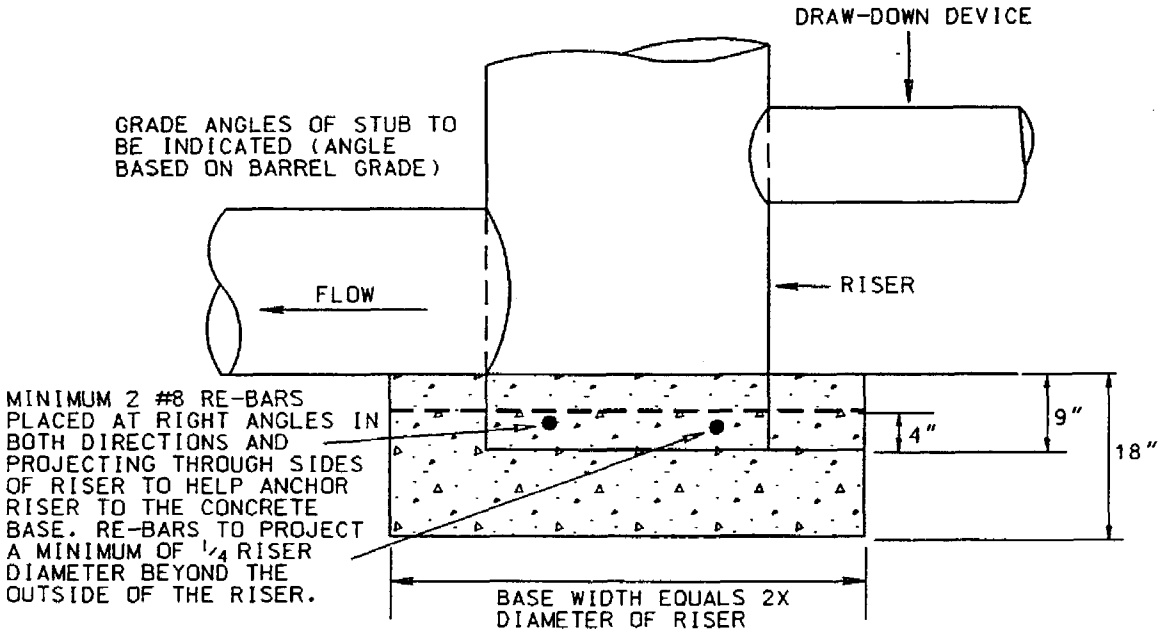


ANTI-SEEP COLLAR DESIGN



COLLAR FOR FLANGE JOINT PIPE

DETAIL 15 - RISER BASE DETAIL



NOTE: ANCHORING BARS SHOULD PROJECT 1/4 DIAMETER BEYOND OUTSIDE OF THE RISER.

Construction Specifications

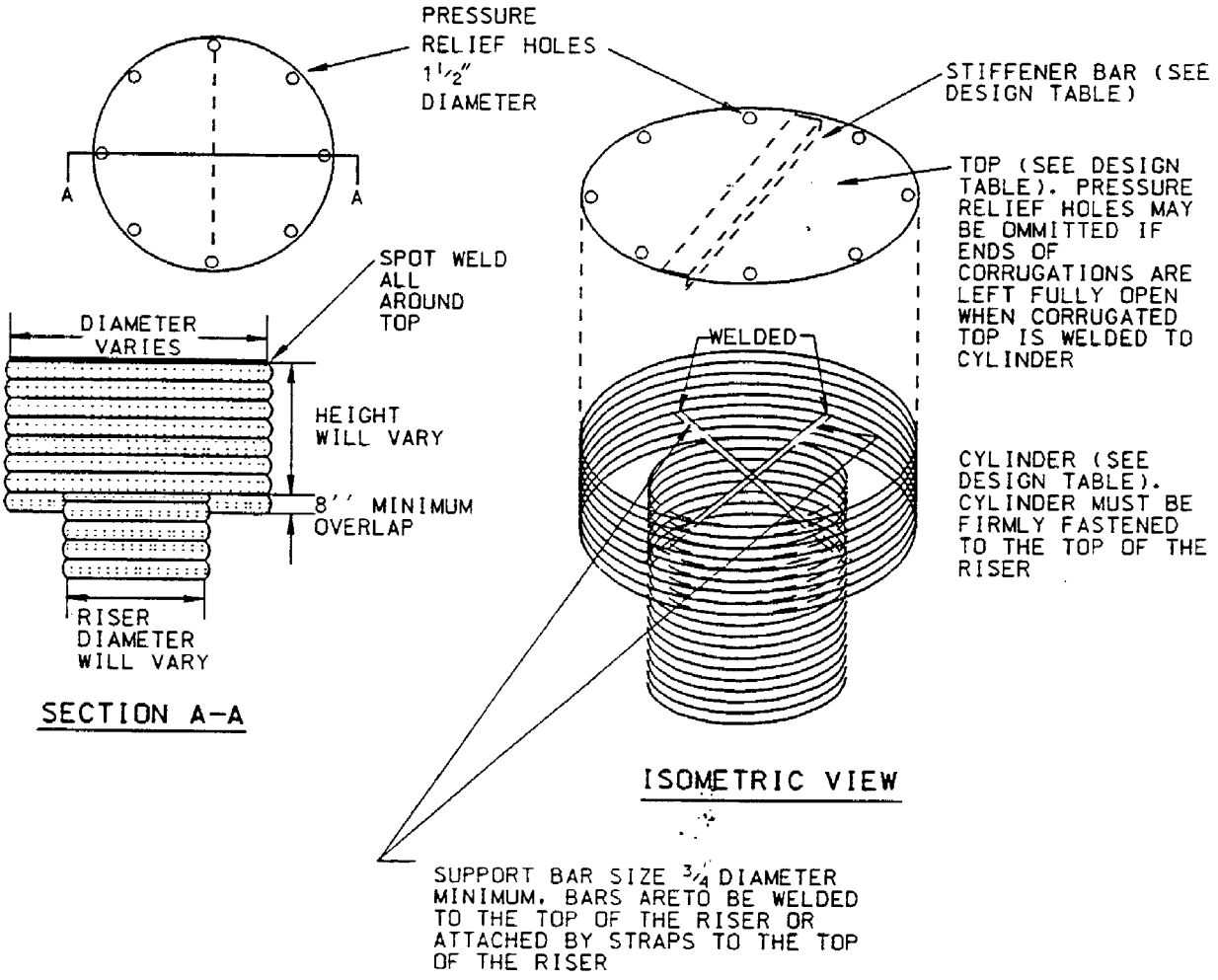
The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two approved bases for risers 10" or less in height are:

1. A concrete base 18" thick with the riser embedded 9" in the base.

2. A 1/4" minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2' of stone, gravel, or compacted earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter.

Note: For risers greater than ten feet high computations shall be made to design a base which will prevent floatation. The minimum factor of safety shall be 1.20 (downward forces = 1.20 x upward forces).

DETAIL 16 – CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE



DETAIL 16 CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE (continued)

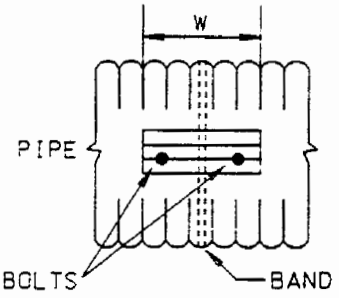
Riser Diam., in.	Trash Rack Cylinder Diam. in.	Thick., gage	H. in.	Minimum Size Support Bar	Minimum Top Thickness	Stiffener
12	18	16	6	#6 Rebar	16 ga.	--
15	21	16	7	"	"	--
18	27	16	8	"	"	--
21	30	16	11	"	"	--
24	36	16	13	"	14 ga.	--
27	42	16	15	"	14 ga.	--
36	54	14	17	#8 Rebar	12 ga.	--
42	60	14	19	"	"	--
48	72	12	21	1-1/4" pipe or 1-1/4 x 1-1/4 x 1/4 angle	10 ga.	--
54	78	12	25	"	"	--
60	90	12	29	1-1/2" pipe or 1-1/2 x 1-1/2 x 1/4 angle	8 ga.	--
66	96	10	33	2" pipe or 2x2x3/16 angle	8 ga., w/stiffener	2x2x1/4 angle
72	102	10	36	"	"	2-1/2x2-1/2x1/4 angle
78	114	10	39	2-1/2" pipe or 2x2x1/4 angle	"	"
84	120	10	42	2-1/2" pipe or 2-1/2x2-1/2x1/4 angle	"	2-1/2 x2-1/2x 5/16 angle

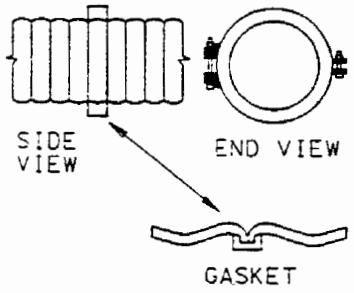
Note: The above trash rack and anti-vortex device information is only for corrugated metal pipe. Concrete risers must meet the requirements of MD 378.

DETAIL 17 TYPES OF COUPLERS FOR CORRUGATED STEEL PIPE

(ALL CONNECTOR BANDS REQUIRE NEOPRENE GASKETS)

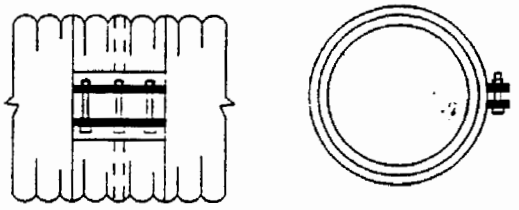
SIDE VIEW ANNULAR COUPLING BAND



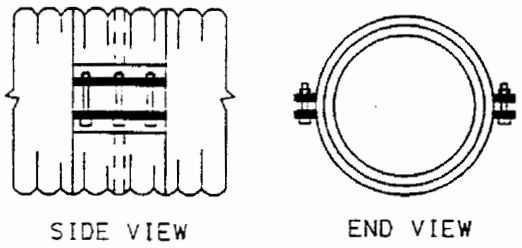


BAR AND STRAP CONNECTOR CHANNEL COUPLING BAND FOR FLANGED END CORRUGATED STEEL PIPE

STANDARD LAP-TYPE COUPLING BANDS FOR ANNULAR OR HELICAL CORRUGATED STEEL PIPE

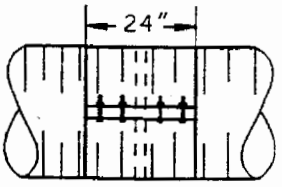


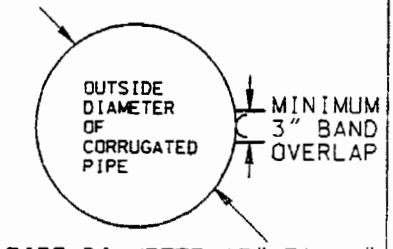
ONE PIECE LAP-TYPE COUPLING FOR ANNULAR OR HELICAL PIPE 12" TO 24" IN DIAMETER



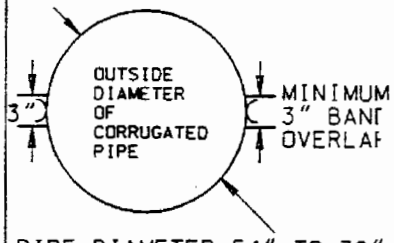
TWO PIECE LAP-TYPE COUPLING FOR ANNULAR OR HELICAL PIPE 12" TO 24" IN DIAMETER

ROD AND LUG TYPE COUPLING BAND 9 CORRUGATIONS 24" WIDE



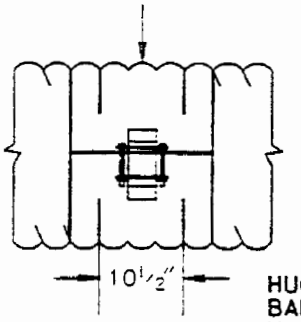


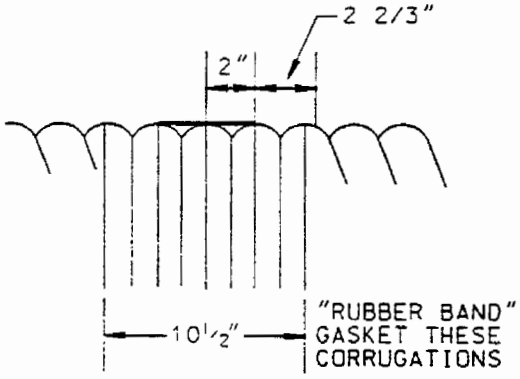
PIPE DIAMETER 15" TO 48"



PIPE DIAMETER 54" TO 72"

BAR AND STRIP CONNECTOR





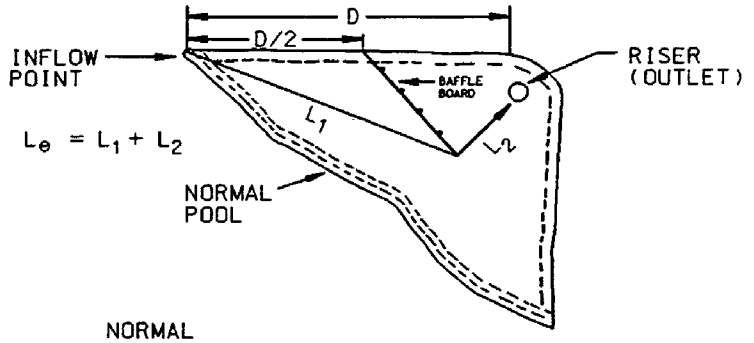
HUGGER TYPE COUPLING BAND FOR REFORMED END H.C.S.P. OR ANNULAR C.S.P.

CONTINUOUS CORRUGATION ANNULAR BAND

UNDER NO CIRCUMSTANCES. WILL THE DIMPLE (UNIVERSAL) CONNECTOR BAND BE ACCEPTABLE FOR USE IN ANY SEDIMENT CONTROL OR STORMWATER MANAGEMENT STRUCTURE

DETAIL 18 – SEDIMENT BASIN BAFFLES

PLAN VIEWS



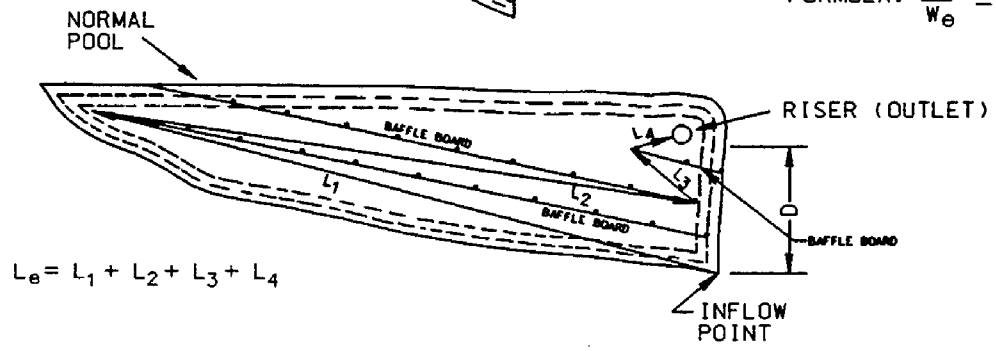
D = DISTANCE BETWEEN INFLOW AND OUTFLOW

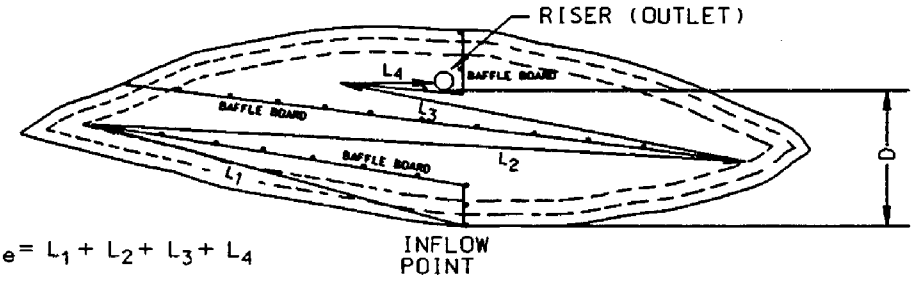
A = AREA OF NORMAL POOL

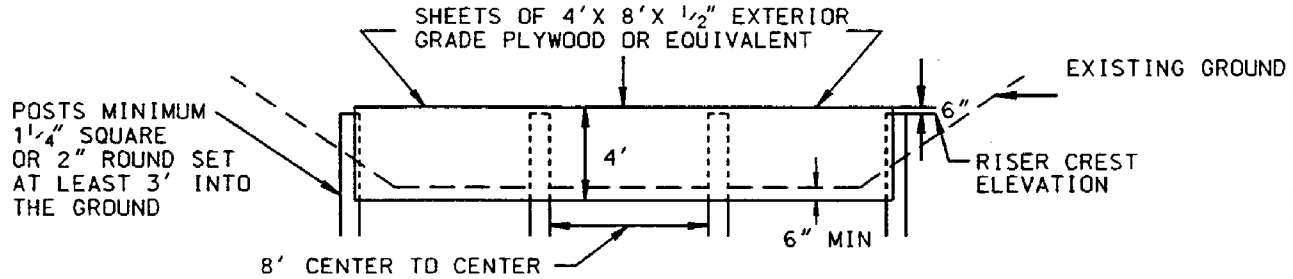
W_e = EFFECTIVE WIDTH = A/D

L_e = TOTAL DISTANCE FROM THE INFLOW POINT AROUND THE BAFFLES TO THE RISER

FORMULA: $\frac{L_e}{W_e} \geq 2$







BAFFLE DETAIL

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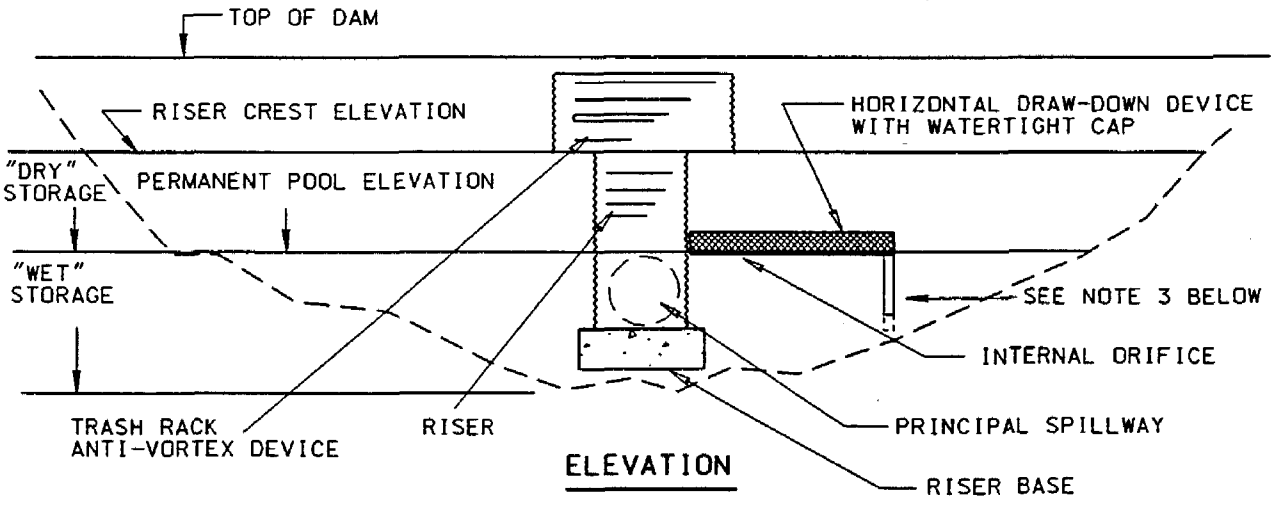
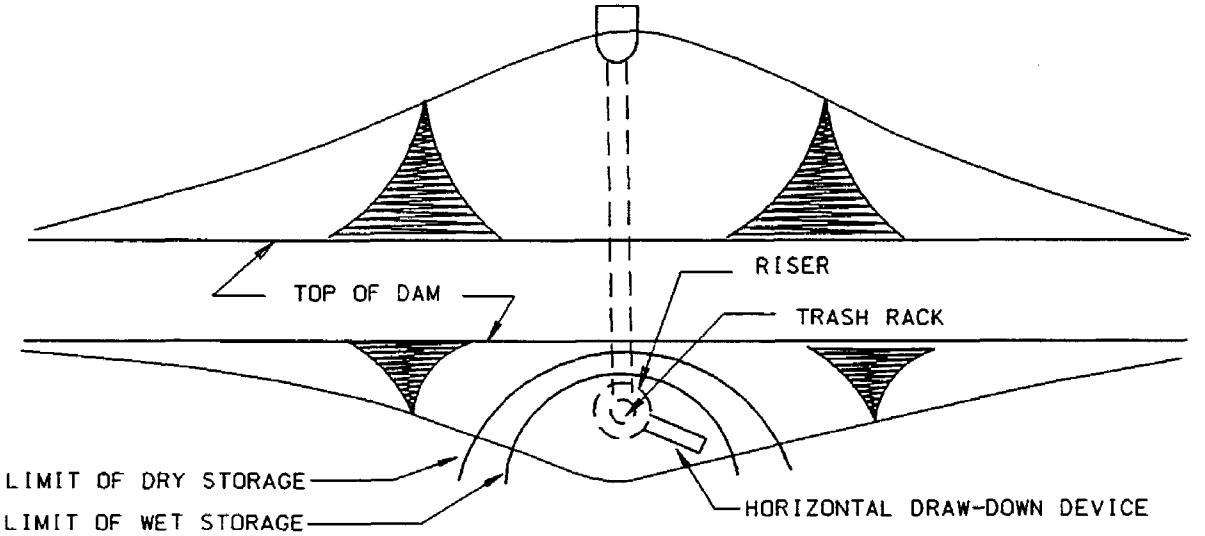
1994

BASIN DRAWDOWN SCHEMATIC
HORIZONTAL DRAW-DOWN DEVICE



ELEVATION



PLAN VIEW

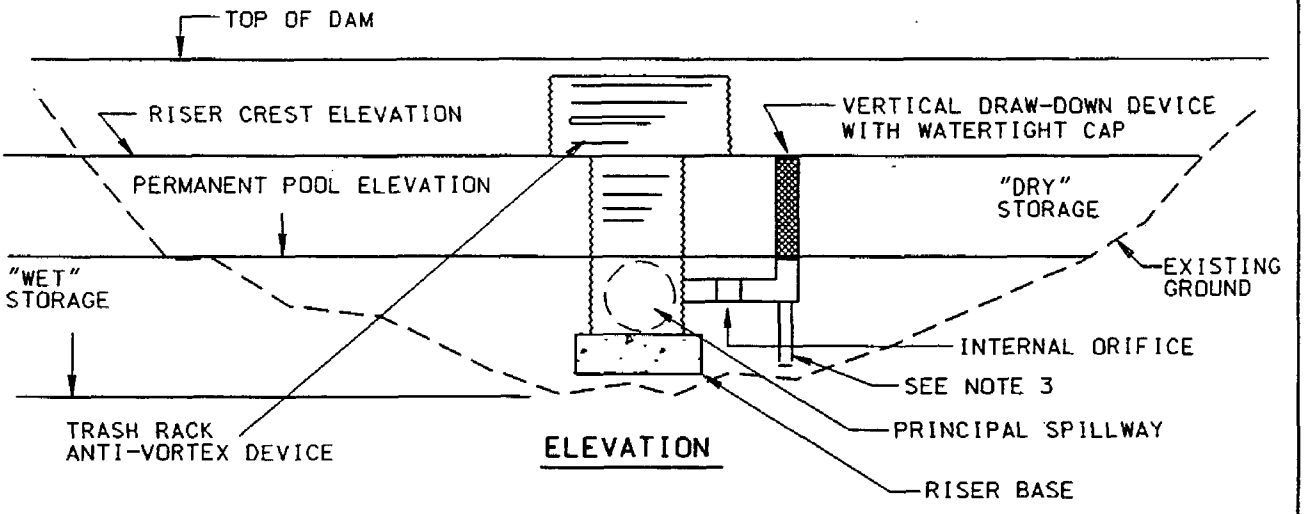
Construction Specifications

1. The total area of the perforations must be greater than 2 times the area of the internal orifice.

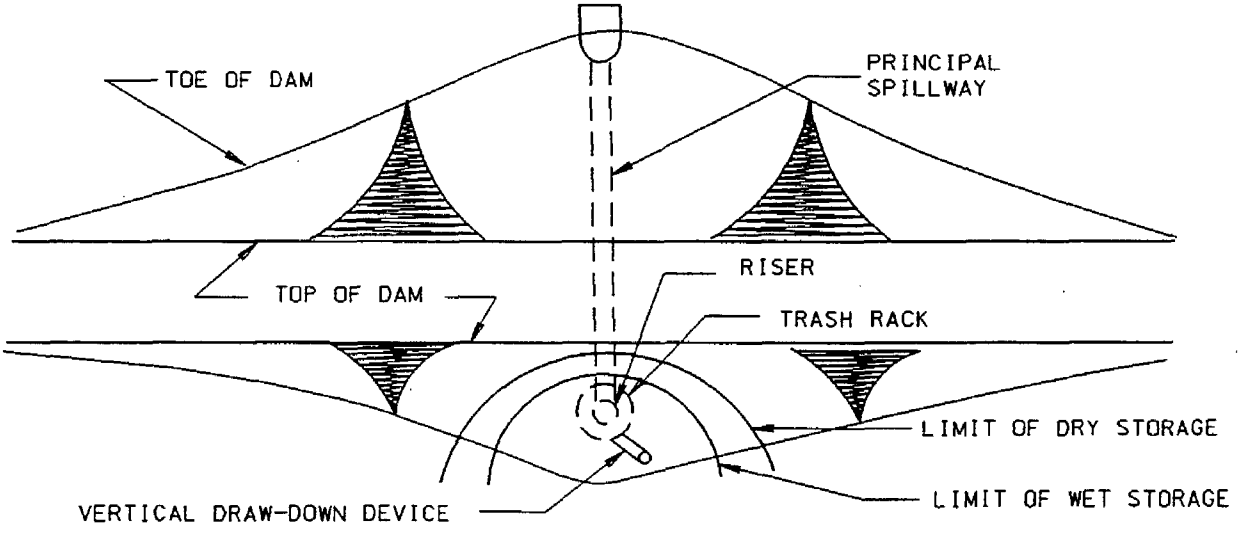
2. The perforated portion of the draw-down device shall be wrapped with ½" hardware cloth and geotextile fabric. The geotextile fabric shall meet the specifications for Geotextile Class E.

3. Provide support of draw-down device to prevent sagging and floatation. An acceptable preventative measure is to stake both sides of draw-down device with 1" steel angle, or 1' by 4" square or 2" round wooden posts set 3' minimum into the ground then joining them to the device by wrapping with 12 gauge minimum wire.

BASIN DRAWDOWN SCHEMATIC
VERTICAL DRAW-DOWN DEVICE



ELEVATION



PLAN VIEW

Construction Specifications

1. Perforations in the draw-down device may not extend into the wet storage.

2. The total area of the perforations must be greater than 2 times the area of the internal orifice.

3. The perforated portion of the draw-down device shall be wrapped with ½" hardware cloth and geotextile fabric. The geotextile fabric shall meet the specifications for Geotextile Class E.

4. Provide support of draw-down device to prevent sagging and floatation. An acceptable preventative measure is to stake both sides of draw-down device with 1" steel angle, or 1' by 4" square or 2" round wooden posts set 3' minimum into the ground then joining them to the device by wrapping with 12 guage minimum wire.

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11.0 STANDARDS AND SPECIFICATIONS

FOR

STONE OUTLET STRUCTURES

Definition

A temporary stone dike installed in conjunction with and as a part of an earth dike.

Purpose

The purpose of the Stone Outlet Structure is to filter sediment laden runoff, provide a protected outlet for an earth dike, provide for diffusion of concentrated flow, and allow the area behind the dike to dewater.

Conditions Where Practice Applies

Stone outlet structures apply to any point of discharge where there is need to dispose of runoff at a protected outlet or to diffuse concentrated flow for the duration of the period of construction. **The drainage area to this practice shall be 1/2 acre or less.**

Outlet

The stone outlet structure shall be located so as to discharge onto an already stabilized area or into a stable watercourse. Stabilization shall consist of complete vegetative cover, paving, etc., sufficiently established to be erosion resistant.

Construction Specifications

1. 2" to 3" stone[18] or recycled concrete equivalent is preferred but clean gravel may be used if stone is not available.

2. The crest of the stone dike shall be at least 6" lower than the lowest elevation of the top of the earth dike and shall be level.

3. The stone outlet structure shall be embedded into the soil a minimum of 4".

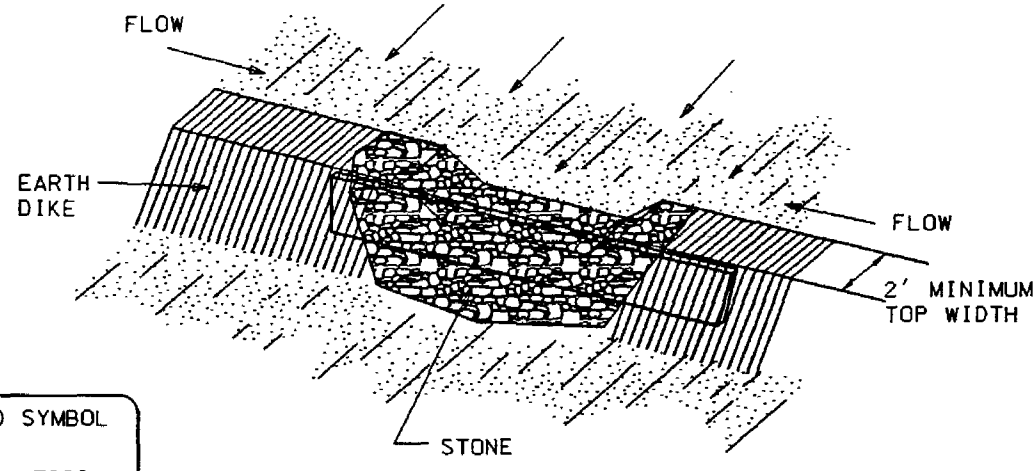
4. The minimum length of the crest of the stone outlet structure shall be 6'.

5. The baffle board shall extend 1' into the dike and 4" into the ground and be staked in place.

6. The drainage area to this structure shall be less than 1/2 acre.

[18] Refer to Table 28

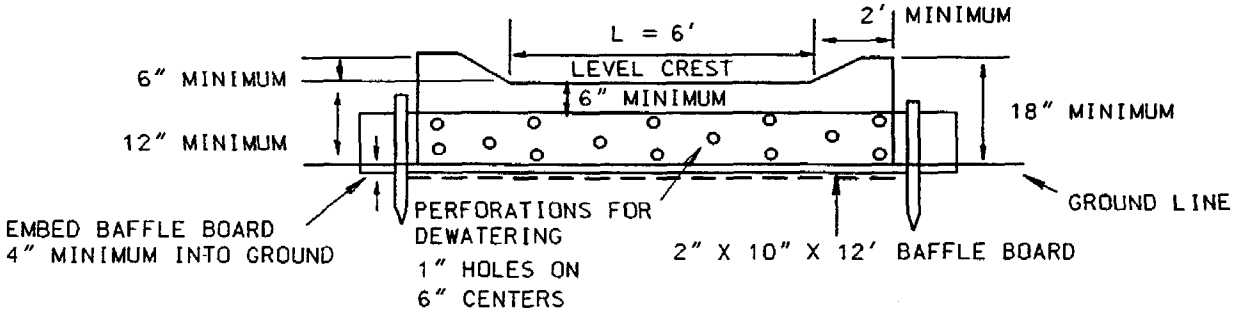
DETAIL 19 – STONE OUTLET STRUCTURE



STANDARD SYMBOL

TSOS

PERSPECTIVE VIEW



CROSS SECTION

Construction Specifications

1. Crushed stone shall be used. Gravel may be used if crushed stone is not available. The stone shall be 2"-3" in size.

2. The crest of the stone dike shall be at least 6" lower than the lowest elevation of the top of the earth dike and shall be level.

3. The stone outlet structure shall be embedded into the soil a minimum of 4".

4. The minimum length of the crest of the stone outlet structure shall be 6'.

5. The stone outlet structure shall be inspected after each rain. Stone shall be replaced when the structure ceases to function and ponding results.

6. The baffle board shall be extended one foot into the dike, staked and embedded 4" into the existing ground.

7. The drainage area to this structure shall be less than $^1/_2$ acre.

Section D - DEWATERING PRACTICES

DEWATERING STRATEGY

Dewatering refers to the act of removing and discharging water from excavated areas on construction sites or from sediment traps or basins on construction sites. Standards and specifications for dewatering practices follow.

These standards apply to removal and discharge of water from any excavated area or sediment trap or basin at any construction site. Given the unique conditions at any particular construction site, any or all of the practices may apply. Regardless of the applicability of the practices listed herein, operators are required to use acceptable procedures for maintenance and dewatering. In all cases, every effort shall be made to eliminate sediment pollution associated with dewatering.

Designers shall specify the preferred procedures for dewatering on plans. In particular, designers should identify procedures for dewatering sediment traps and basins prior to elimination of the last sediment control facility on the site or prior to conversion of sediment control facilities to stormwater management facilities. Recommended procedures shall be consistent with these standards. Atypical site conditions may require innovative dewatering designs. Dewatering measures not referenced in this standard may be used with the consent of the approval authority.

Dewatering of Excavated Areas

A. Designers shall specify on plans, and in sequences of construction included on plans, practices for dewatering of excavated areas. Plan reviewers shall check to see that procedures for dewatering are included on plans.

B. In all cases, water removed from excavated areas shall be discharged such that it shall pass through a sediment control device prior to entering receiving waters. Sediment control devices include sediment traps and basins, in addition to the practices in this section.

Approved Practices for Dewatering of Excavated Areas

1. Pumping of water to an existing sediment basin or trap in which the entire volume of water from the area to be dewatered can be contained without discharge to receiving waters.

2. Pumping of water to an existing sediment basin or trap such that the entire volume of water from the area to be dewatered can be managed without exceeding the design outflow from the sediment control structure.

3. Removable Pumping Station - Standards and specifications for Removable Pumping Station are on Detail 20A.

4. Use of a Sump Pit - Standards and specifications for a sump pit are on Detail 20B.

5. Sediment Tank - Standards and specifications for a sump pit are on Detail 21.

Dewatering of Sediment Traps and Basins

Designers shall specify on plans, and in sequences of construction included on plans, the practices for dewatering of traps and basins. Plan reviewers shall check to see that procedures for dewatering to be used are included on plans. In all cases, water removed from traps and basins shall be discharged so that it passes through a sediment control device prior to entering receiving waters.

Approved Practices for Dewatering of Traps and Basins

1. Removable pumping station

2. Use of a Sump Pit.

3. Use of a floating suction hose to pump the cleaner water from the top of the pond. As the cleaner water is pumped the suction hose will lower and eventually encounter sediment laden water. When this happens the pumping operation will cease. Provisions shall be made to filter water prior to discharge to receiving waters. When floating suction hoses are used, personnel shall be assigned to monitor pumping operations to ensure that sediment pollution is abated. **Pumping sediment laden water into the waters of the State without filtration is strictly forbidden.**

4. Vegetative buffers - The maintenance of areas of existing vegetation adjacent to wetlands, streams, and other areas of significant natural resource value in connection with sediment control practices noted in this manual can ensure that such areas are not adversely affected by grading and construction or by stormwater runoff once construction is completed. The maintenance of such areas adjacent to streams is particularly important because they lessen the impact of sedimentation on fish and spawning to keep streams at water temperatures favorable to fish and other aquatic species, and provide food such as leaves and twigs for aquatic organisms, particularly in headwater streams.

The width needed for such areas in order to provide adequate protection is dependent on the type of area to be protected, the type of vegetation in the buffer, the slope present, the ability of the soils in the buffer to absorb water, the size distribution of the incoming sediment, and the rate of runoff. However, research studies have shown that the maintenance of a buffer of 100 feet in width in areas with low to moderate slopes should generally provide adequate protection.

12.0 DEWATERING SPECIFICATIONS

FOR

REMOVABLE PUMPING STATION

Definition

A temporary structure which is used to remove water from excavated areas, sediment traps and basins.

Purpose

The Removable Pumping Station is an easily maintained device that filters sediment laden water at a pump intake, prior to discharging to a suitable area.

Conditions Where Practice Applies

Removable Pumping Stations are constructed when water collects and must be pumped away during excavation, cofferdam dewatering, maintenance or removal of sediment traps and basins or for other uses as applicable. These are preferred over Sump Pits on projects where a long duration of pumping is expected.

Design Criteria

The number of Removable Pumping Stations and their locations shall be determined by the designer and included on the plans. Contractors may relocate sump pits to optimize use but discharge location changes must be coordinated with inspectors. A design is not required but construction must conform to the general criteria outlined on Detail 20A.

A perforated, vertical standpipe wrapped with wire mesh and geotextile is placed inside a larger pipe. The outside pipe is then enveloped by a cone of washed stone. Water is then pumped from the center of the inside pipe to a suitable discharge area.

Water pumped from the standpipe should discharge into a sediment trap, sediment basin or stabilized area.

Construction Specifications

1. The inner pipe shall be constructed by perforating a 12" to 36" diameter pipe with a watertight cap on the bottom end and wrapping it with 1/2" hardware cloth and Geotextile Class E[19]. The perforations shall be 1/2" X 6" slits or 1" diameter holes 6" on center.

2. The outer pipe shall be at least 4" larger in diameter than the inside pipe. Both the inner and outer pipes should extend 12" to 18" above the riser crest elevation, or anticipated high water elevation.

[19] Refer to Table 27

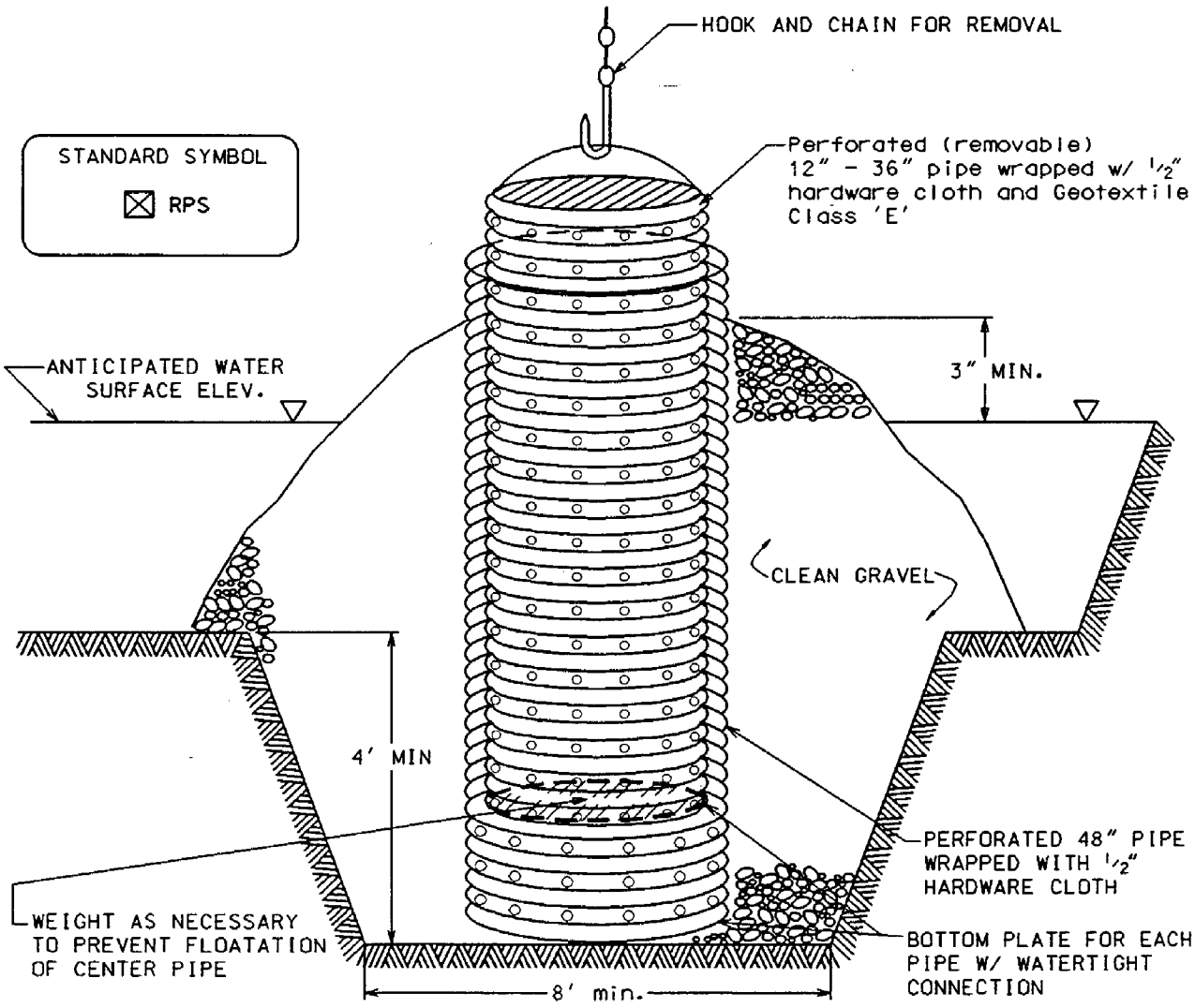
3. Filter material ranging from clean gravel (minimal fines) to #57 stone[20] (1 1/2" maximum diameter) should be backfilled around the outer pipe.

4. The suction hose from the pump shall be placed inside the inner pipe to begin dewatering. The discharge hose shall be placed in a stabilized area downslope of unstabilized areas to prevent erosion. Meadow or wooded areas are preferred discharge locations but storm drains and paved areas are acceptable.

5. Maintenance - The inner pipe can easily be removed to facilitate changing the geotextile when it clogs. Maintenance must be performed when the pump runs dry and backed up water remains.

[20] Refer to Table 28

DETAIL 20A - REMOVABLE PUMPING STATION



ELEVATION (CUT AWAY)

Construction Specifications

1. The outer pipe should be 48" dia. or shall, in any case, be at least 4" greater in diameter than the center pipe. The outer pipe shall be wrapped with ½" hardware cloth to prevent backfill material from entering the perforations.

2. After installing the outer pipe, backfill around outer pipe with 2" aggregate or clean gravel.

3. The inside stand pipe (center pipe) should be constructed by perforating a corrugated or PVC pipe between 12" and 36" in diameter. The perforations shall be ½" X 6" slits or 1" diameter holes 6" on center. The center pipe shall be wrapped with ½" hardware cloth first, then wrapped again with Geotextile Class E.

4. The center pipe should extend 12" to 18" above the anticipated water surface elevation or riser crest elevation when dewatering a basin.

13.0 STANDARDS AND SPECIFICATIONS

FOR

SUMP PIT

Description of Practice

A temporary pit from which pumping is conducted to remove excess water while minimizing sedimentation.

Purpose

The sump pit filters water being pumped to reduce sedimentation to receiving streams.

Conditions Where Practice Applies

Sump Pits are constructed when water collects and must be pumped away during excavating, cofferdam dewatering, maintenance or removal of sediment traps and basins or other uses as applicable.

Design Criteria

The number of sump pits and their locations shall be determined by the designer and included on the plans. Contractors may relocate sump pits to optimize use but discharge location changes must be coordinated with inspectors. A design is not required but construction must conform to the general criteria outlined on Detail 20B.

A perforated vertical standpipe is wrapped with 1/2" hardware cloth and Geotextile Class E[21], then placed in the center of an excavated pit which is then backfilled with filter material consisting of anything from clean gravel (minimal fines) to #57 stone (1 1/2" maximum diameter). Water is then pumped from the center of the standpipe to a suitable discharge area such as into a sediment trap, sediment basin or stabilized area.

Construction Specifications

1. Pit dimensions are variable, with the minimum diameter being twice the diameter of the standpipe.

2. The standpipe should be constructed by perforating a 12" to 36" diameter pipe then wrapping it with 1/2" hardware cloth and Geotextile Class E. The perforations shall be 1/2" X 6" slits or 1" diameter holes 6" on center.

3. A base of filter material consisting of anything from clean gravel (minimal fines) to #57 stone (1 1/2" maximum diameter) should be placed in the pit to a depth of 12". After installing the standpipe, the pit surrounding the standpipe should then be backfilled with the same filter material.

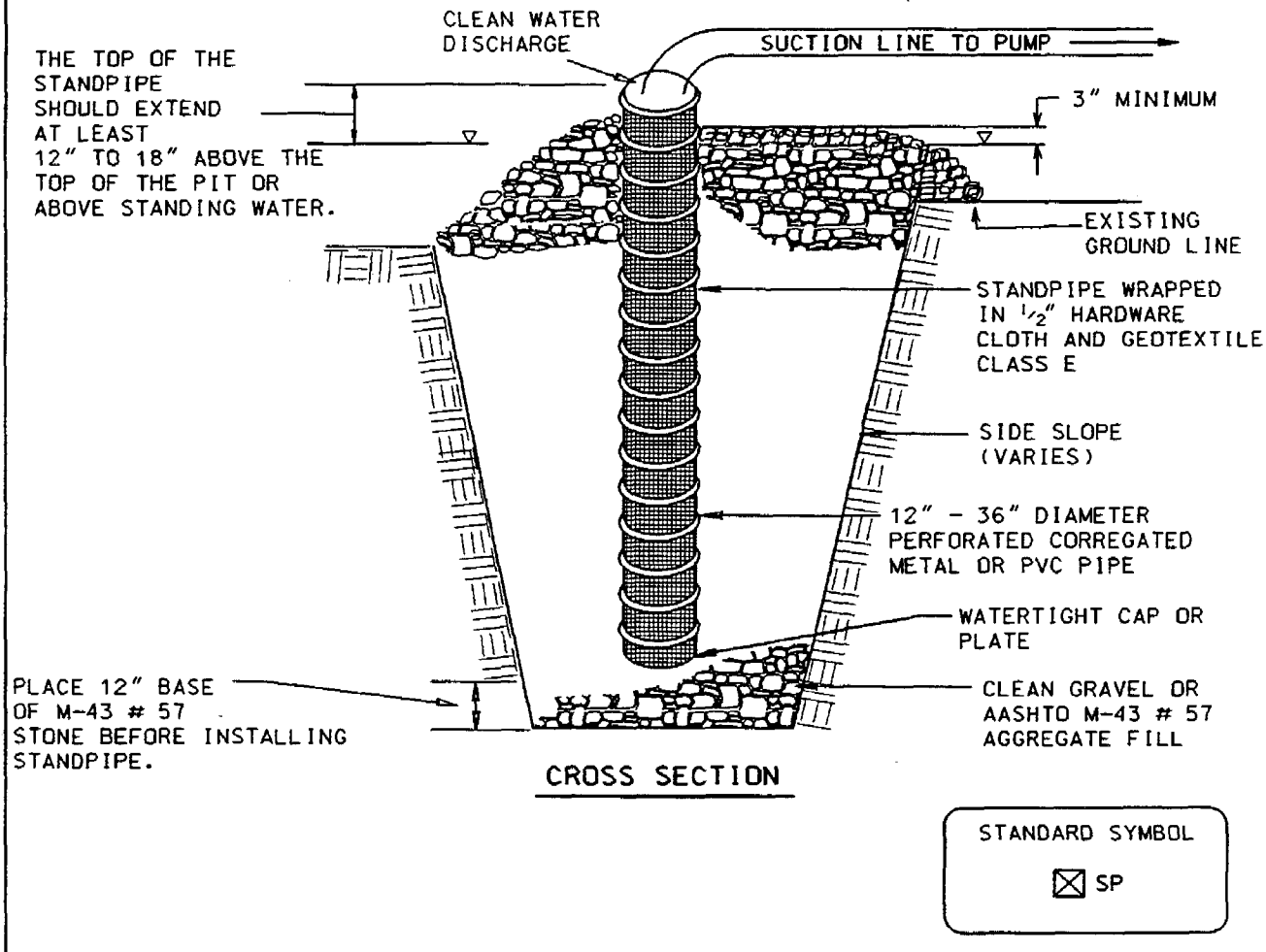
4. The standpipe shall extend 12" to 18" above the lip of the pit or riser crest elevation (basin dewatering) and filter material should extend 3" minimum above the anticipated standing water level.

Maintenance

To maintain, sump pits must be removed and reconstructed when pump runs dry.

[21] Refer to Table 27

DETAIL 20B - SUMP PIT



CROSS SECTION

STANDARD SYMBOL

⊠ SP

Construction Specifications

1. Pit dimensions are variable. with the minimum diameter being 2 times the standpipe diameter.

2. The standpipe should be constructed by perforating a 12" to 24" diameter corrugated or PVC pipe. Then wrapping with ½" hardware cloth and Geotextile Class E. The perforations shall be ½" x 6" slits or 1" diameter holes.

3. A base of filter material consisting of clean gravel or #57 stone should be placed in the pit to a depth of 12". After installing the standpipe. the pit surrounding the standpipe should then be backfilled with the same filter material.

4. The standpipe should extend 12" to 18" above the lip of the pit or the riser crest elevation (basin dewatering only) and the filter material should extend 3" minimum above the anticipated standing water elevation.

14.0 STANDARDS AND SPECIFICATIONS

FOR

SEDIMENT TANK

Definition

A sediment tank is a compartmented tank container through which sediment laden water is pumped to trap and retain the sediment.

Purpose

To trap and retain sediment prior to pumping the water to drainageways, adjoining properties, and rights-of-way below the sediment tank site.

Conditions Where Practice Applies

A sediment tank is to be used on sites where excavations are deep, and space is limited, such as urban construction, where direct discharge of sediment laden water to stream and storm drainage systems is to be avoided.

Design Criteria

1. Location The sediment tank shall be located for ease of clean-out and disposal of the trapped sediment and to minimize interference with construction activities and pedestrian traffic.

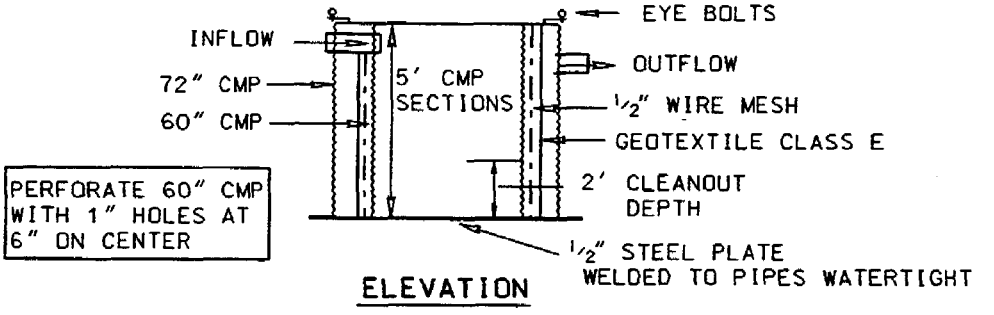
2. Tank Size The following formula should be used in determining the storage volume of the sediment tank: 1 cubic foot of storage for each gallon per minute of pump discharge capacity.

An example of a typical sediment tank is shown below. Other container designs can be used if the storage volume is adequate and approval is obtained from the local approving agency.

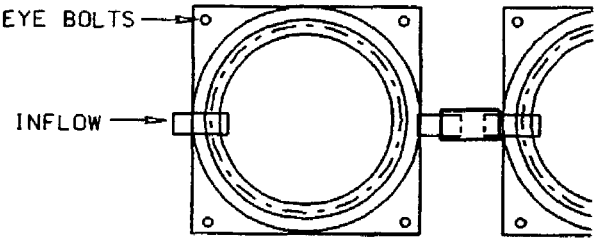
Tanks may be connected in series. Geotextile fabric mesh sizes may vary from tank to tank with the downstream-most layer meeting Geotextile Class C[22] or better.

[22] Refer to Table 27

DETAIL 21 – PORTABLE SEDIMENT TANK



ELEVATION



PLAN VIEW

STANDARD SYMBOL

⊠ PST

Construction Specifications

1. The following formula should be used in determining the storage volume of the sediment tank: 1 cubic foot of storage for each gallon per minute of pump discharge capacity.

2. An example of a typical sediment tank is shown above. Other container designs can be used if the storage volume is adequate and approval is obtained from the local approving agency.

3. Tanks may be connected in series.

Section E - FILTERING PRACTICES

15.0 STANDARDS AND SPECIFICATIONS

FOR

SILT FENCE

Definition

Temporary barriers of woven geotextile fabric used to intercept, reduce velocity and filter surface runoff from disturbed areas.

Purpose

Silt fences filter sediment from runoff so that deposition of transported sediment can occur. Silt fences can be used to intercept sheet flow only. They cannot be used as velocity checks in ditches or swales, or placed where they will intercept concentrated flow.

Conditions Where Practice Applies

Silt fence is limited to intercepting sheet flow runoff from limited distances according to slope. Silt fence provides filtering and velocity dissipation to promote gravity settling of sediments.

Design Criteria

1. Silt fence should be used with caution in areas of rocky soils that may prevent trenching.

2. Silt fence should be placed on or parallel to contours.

3. The length of silt fences must conform to the following:

Table 17 Silt Fence Design Constraints

Slope Steepness	(Maximum) Slope Length	(Maximum) Silt Fence Length
Flatter than 50:1 (2%)	unlimited	unlimited
50:1 to 10:1 (2 - 10%)	125 feet	1,000 feet
10:1 to 5:1 (10 - 20%)	100 feet	750 feet
5:1 to 3:1 (20 - 33%)	60 feet	500 feet
3:1 to 2:1 (33 - 50%)	40 feet	250 feet
> 2:1 (> 50%)	20 feet	125 feet

4. In areas of less than 2% slope and sandy soils (USDA general classification system, soil class A) maximum slope length and silt fence length will be unlimited. In these areas a silt fence may be the only perimeter control required.

5. Downslope from the silt fence should be undisturbed ground.

Construction Specifications

1. Fence posts shall be a minimum of 36 inches long driven 16" minimum into ground. Wood posts shall be 1 1/2" X 1 1/2" (minimum) square cut, or 1 3/4" (minimum) diameter round and shall be of sound quality hardwood. Steel posts will be standard T or U section weighing not less than 1.00 pound per linear foot.

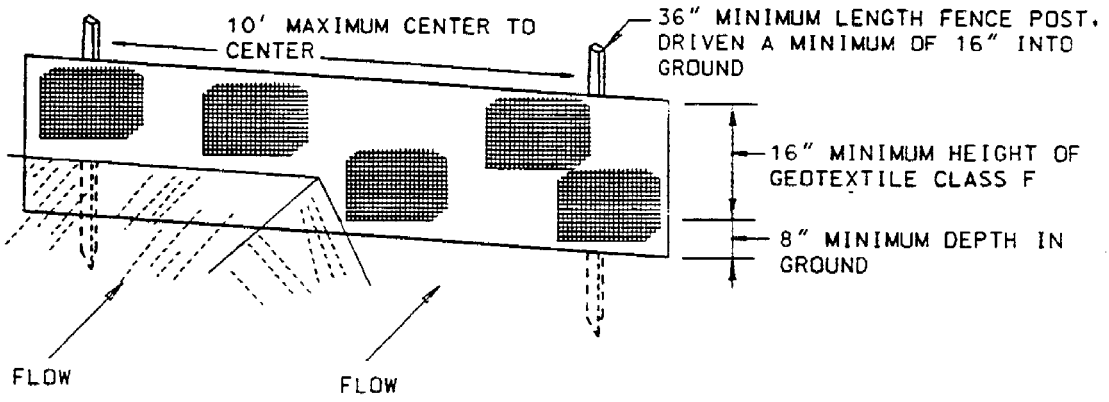
2. Geotextile shall be fastened securely to each fence post with wire ties or staples at top and mid-section and shall meet the following requirements for Geotextile Class F:

Tensile Strength	50 lbs/in (min.)	Test: MSMT 509
Tensile Modulus	20 lbs/in (min.)	Test: MSMT 509
Flow Rate.	3 gal/ft^2/minute (max.)	Test: MSMT 322
Filtering Efficiency	75% (min.)	Test: MSMT 322

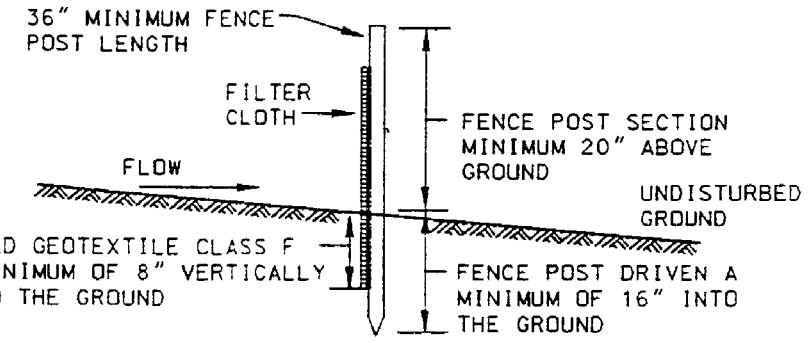
3.Where ends of geotextile fabric come together, they shall be overlapped, folded and stapled to prevent sediment bypass.

4.Silt Fence shall be inspected after each rainfall event and maintained when bulges occur or when sediment accumulation reached 50% of the fabric height.

DETAIL 22 – SILT FENCE

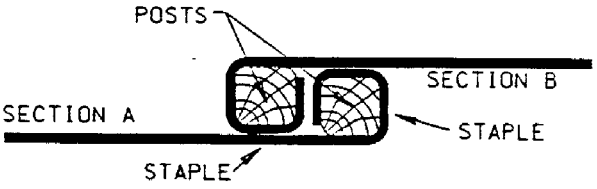


PERSPECTIVE VIEW

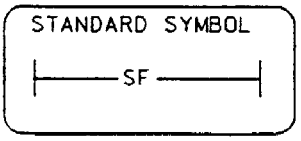


CROSS SECTION

TOP VIEW



JOINING TWO ADJACENT SILT FENCE SECTIONS



Construction Specifications

1. Fence posts shall be a minimum of 36" long driven 16" minimum into the ground. Wood posts shall be $1\frac{1}{2}$" x $1\frac{1}{2}$" square (minimum) cut, or $1\frac{3}{4}$" diameter (minimum) round and shall be of sound quality hardwood. Steel posts will be standard T or U section weighting not less than 1.00 pond per linear foot.

2. Geotextile shall be fastened securely to each fence post with wire ties or staples at top and mid-section and shall meet the following requirements for Geotextile Class F:

Tensile Strength	50 lbs/in (min.)	Test: MSMT 509
Tensile Modulus	20 lbs/in (min.)	Test: MSMT 509
Flow Rate	0.3 gal ft^2/ minute (max.)	Test: MSMT 322
Filtering Efficiency	75% (min.)	Test: MSMT 322

3. Where ends of geotextile fabric come together, they shall be overlapped, folded and stapled to prevent sediment bypass.

4. Silt Fence shall be inspected after each rainfall event and maintained when bulges occur or when sediment accumulation reached 50% of the fabric height.

SILT FENCE

Silt Fence Design Criteria

Slope Steepness	(Maximum) Slope Length	(Maximum) Silt Fence Length
Flatter than 50:1	unlimited	unlimited
50:1 to 10:1	125 feet	1,000 feet
10:1 to 5:1	100 feet	750 feet
5:1 to 3:1	60 feet	500 feet
3:1 to 2:1	40 feet	250 feet
2:1 and steeper	20 feet	125 feet

Note: In areas of less than 2% slope and sandy soils (USDA general classification system, soil Class A) maximum slope length and silt fence length will be unlimited. In these areas a silt fence may be the only perimeter control required.

16.0 STANDARDS AND SPECIFICATIONS

FOR

STORM DRAIN INLET PROTECTION

Definition

A filter constructed around a storm drain inlet.

Purpose

Storm Drain Inlet Protection is used to filter sediment laden runoff before it enters the storm drain system.

Conditions Where Practices Applies

Storm drain inlet protection is a secondary sediment control device and is not to be used in place of a sediment trapping device unless approved by the appropriate approval authority.

Design Criteria

Storm drain inlet protection shall be used when the drainage area to an inlet is disturbed and the following conditions prevail:

1. It is not possible to temporarily divert the storm drain outfall into a sediment-trapping device;

2. Watertight blocking of inlets is not advisable; and

3. Drainage area is less than 1/4 acre for curb or standard inlet protections and 1 acre for elevated or yard inlets. For yard inlets, the total for inlets in series must be 1 acre or less and the contributing drainage area must have slopes flatter than 5%.

Maintenance

Maintenance requirements for storm drain inlet protection are intense, due to the susceptibility to clogging. When the structure does not drain completely within 48 hours after a storm event, it is clogged. When this occurs, accumulated sediment must be removed and the geotextile fabric and stone must be cleaned or replaced.

Construction Specifications

A. Standard Inlet Protection (Elevated or Yard Inlet)

1. Excavate completely around the inlet to a depth of 18" below the notch elevation.

2. Drive 2" X 4" construction grade lumber posts 1' into the ground at each corner of the inlet. Place nail strips between the posts on the ends of the inlet. Assemble the top portion of the 2" X 4" frame using the overlap joint shown on Detail 23A. The top of the frame (weir) must be 6" below adjacent roadways where flooding and safety issues may arise.

3. Stretch 1/2" X 1/2" wire mesh tightly around the frame and fasten securely. The ends must meet and overlap at a post.

4. Stretch the Geotextile Class E[23] tightly over the wire mesh with the geotextile extending from the top of the frame to 18" below the inlet notch elevation. Fasten the geotextile firmly to the frame. The ends of the geotextile must meet at a post, be overlapped and folded, then fastened down.

5. Backfill around the inlet in compacted 6" layers until the layer of earth is level with the notch elevation on the ends and top elevation on the sides.

6. If the inlet is not in a sump, construct a compacted earth dike across the ditch line directly below it. The top of the earth dike should be at least 6" higher than the top of the frame.

7. The structure must be inspected periodically and after each rain and the geotextile replaced when it becomes clogged.

B. At Grade Inlet

1. Lift grate and wrap with Geotextile Class E to completely cover all openings, then set grate back in place.

2. Place 3/4 to 1 1/2"[24] stone, 4 - 6" thick on the grate to secure the fabric and provide additional filtration.

C. Curb Inlet Protection (COG or COS Inlets)

1. Attach a continuous piece of 1/2" X 1/2" wire mesh (30" minimum width by throat length, plus 4') to the 2" x 4" weir (measuring throat length plus 2') as shown on the standard drawing.

2. Place a continuous piece of approved Geotextile Class E of the same dimensions as the wire mesh over the wire mesh and securely attach it to the 2" x 4" weir.

3. Securely nail the 2" X 4" weir to a 9" long vertical spacer to be located between the weir and the inlet face (max. 4' apart).

4. Place the assembly against the inlet throat and nail (minimum 2' lengths of 2" x 4" to the top of the weir at spacer locations). These 2" x 4" anchors shall extend across the inlet top and be held in place by sandbags or alternate weight.

5. The assembly shall be placed so that the end spacers are 1' beyond both ends of the throat opening.

[23] Refer to Table 27

[24] Refer to Table 28

6. Form the 1/2" x 1/2" wire mesh and the geotextile fabric to the concrete gutter and against the face of the curb on both sides of the inlet. Place clean 3/4" to 1 1/2" stone over the wire mesh and geotextile in such a manner as to prevent water from entering the inlet under or around the geotextile.

7. This type of protection must be inspected frequently and the geotextile fabric and stone replaced when clogged with sediment.

8. Assure that storm flow does not bypass the inlet by installing a temporary earth or asphalt dike to direct the flow to the inlet.

D. Median Inlet Protection (MIP)

1. Construct standard Slope Silt Fence having 5' post spacing 1' - 6" away from the existing inlet only on the sides of the inlet receiving sheet flow and in the location of the "wings".

2. In the location of concentrated flow, construct a stone check dam using 4" - 7" stone for the base faced on the upstream side with 3/4" - 1 ½" aggregate, 1' thick. The the stone check dam shall be 16" high with the weir 10" above the invert of the ditch or valley gutter and shall be the same width as the ditch or gutter bottom or 2' (min.). Where the end of the "wings" meet the ground shall be at or above the weir elevation.

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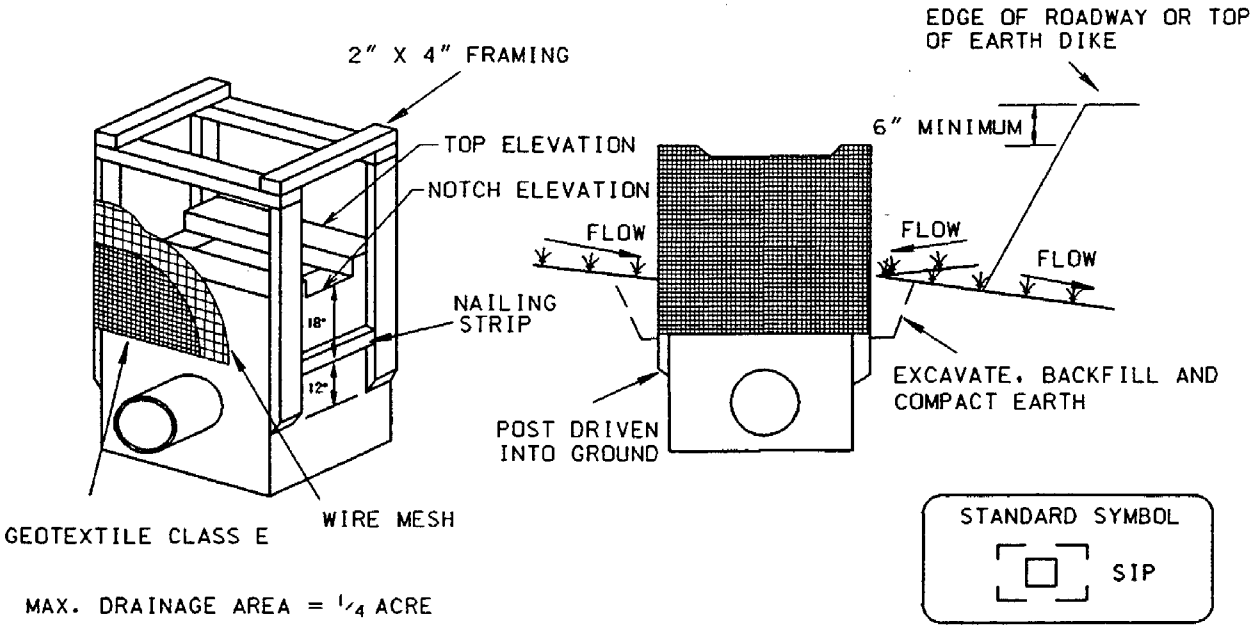
DETAIL 23A – STANDARD INLET PROTECTION



MAX. DRAINAGE AREA = $^{1}/_{4}$ ACRE

Construction Specifications

1. Excavate completely around the inlet to a depth of 18" below the notch elevation.

2. Drive the 2" x 4" construction grade lumber posts 1' into the ground at each corner of the inlet. Place nail strips between the posts on the ends of the inlet. Assemble the top portion of the 2" x 4" frame using the overlap joint shown on Detail 23A. The top of the frame (weir) must be 6" below adjacent roadways where flooding and safety issues may arise.

3. Stretch the 1/2" x 1/2" wire mesh tightly around the frame and fasten securely. The ends must meet and overlap at a post.

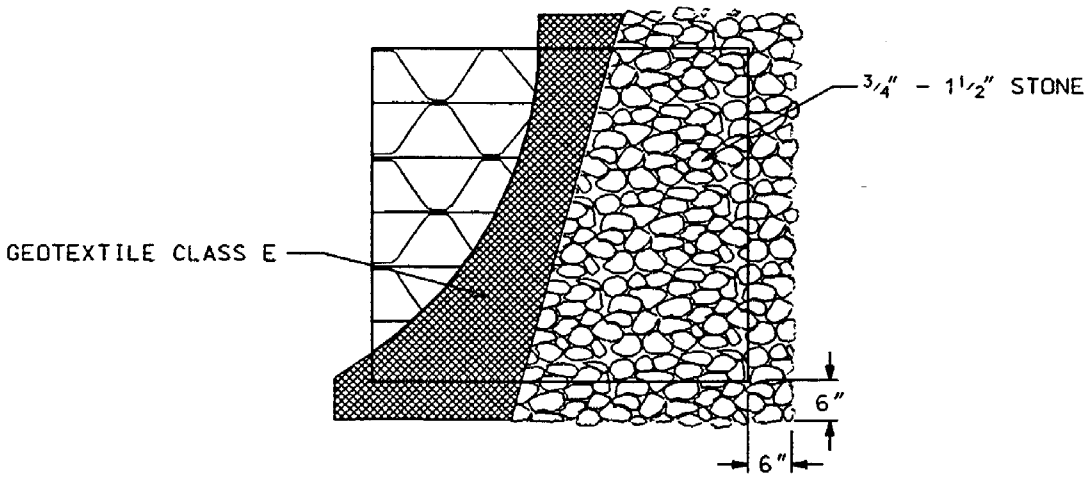
4. Stretch the Geotextile Class E tightly over the wire mesh with the geotixtile extending from the top of the frame to 18" below the inlet notch elevation. Fasten the geotextile firmly to the frame. The ends of the geotextile must meet at a post, be overlapped and folded, then fastened down.

5. Backfill around the inlet in compacted 6" layers until the layer of earth is level with the notch elevation on the ends and top elevation on the sides.

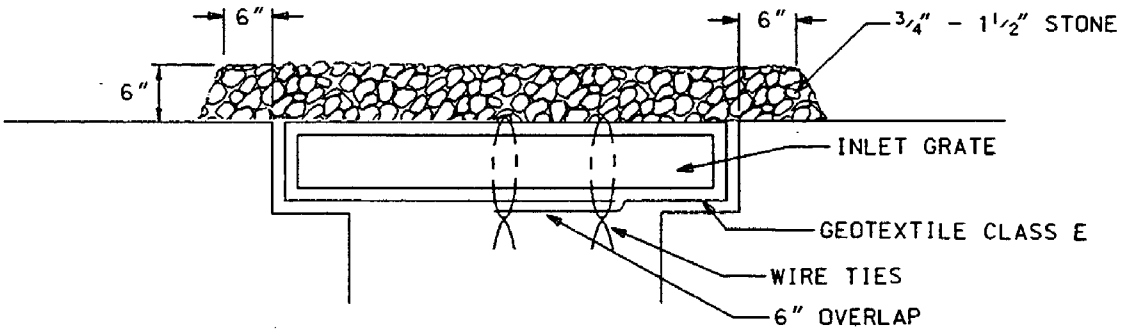
6. If the inlet is not in a sump, construct a compacted earth dike across the ditch line directly below it. The top of the earth dike should be at least 6" higher than the top of the frame.

7. The structure must be inspected periodically and after each rain and the geotextile replaced when it becomes clogged.

DETAIL 23B - AT GRADE INLET PROTECTION



PLAN/CUT AWAY VIEW



CROSS SECTION

STANDARD SYMBOL

AGIP

MAX. DRAINAGE AREA = 1/4 ACRE

Construction Specifications

1. Lift grate and wrap with Geotextile Class E to completely cover all openings, then set grate back in place.

2. Place 3/4" to 1 1/2" stone, 4"-6" thick on the grate to secure the fabric and provide additional filtration.

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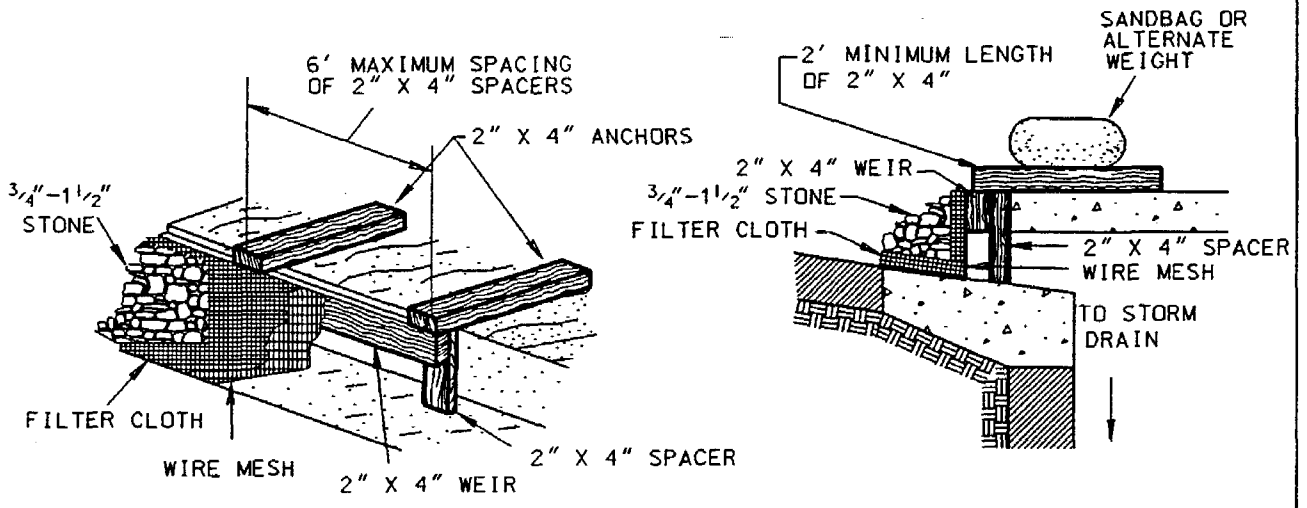
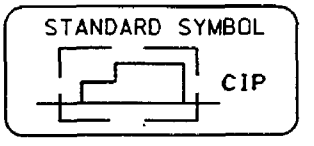
DETAIL 23C – CURB INLET PROTECTION (COG OR COS INLETS)



MAX. DRAINAGE AREA = 1/4 ACRE



Construction Specifications

1. Attach a continuous piece of wire mesh (30" minimum width by throat length plus 4') to the 2" x 4" weir (measuring throat length plus 2') as shown on the standard drawing.

2. Place a continuous piece of Geotextile Class E the same dimensions as the wire mesh over the wire mesh and securely attach it to the 2" x 4" weir.

3. Securely nail the 2" X 4" weir to a 9" long vertical spacer to be located between the weir and the inlet face (max. 4' apart).

4. Place the assembly against the inlet throat and nail (minimum 2' lengths of 2" x 4" to the top of the weir at spacer locations). These 2" x 4" anchors shall extend across the inlet top and be held in place by sandbags or alternate weight.

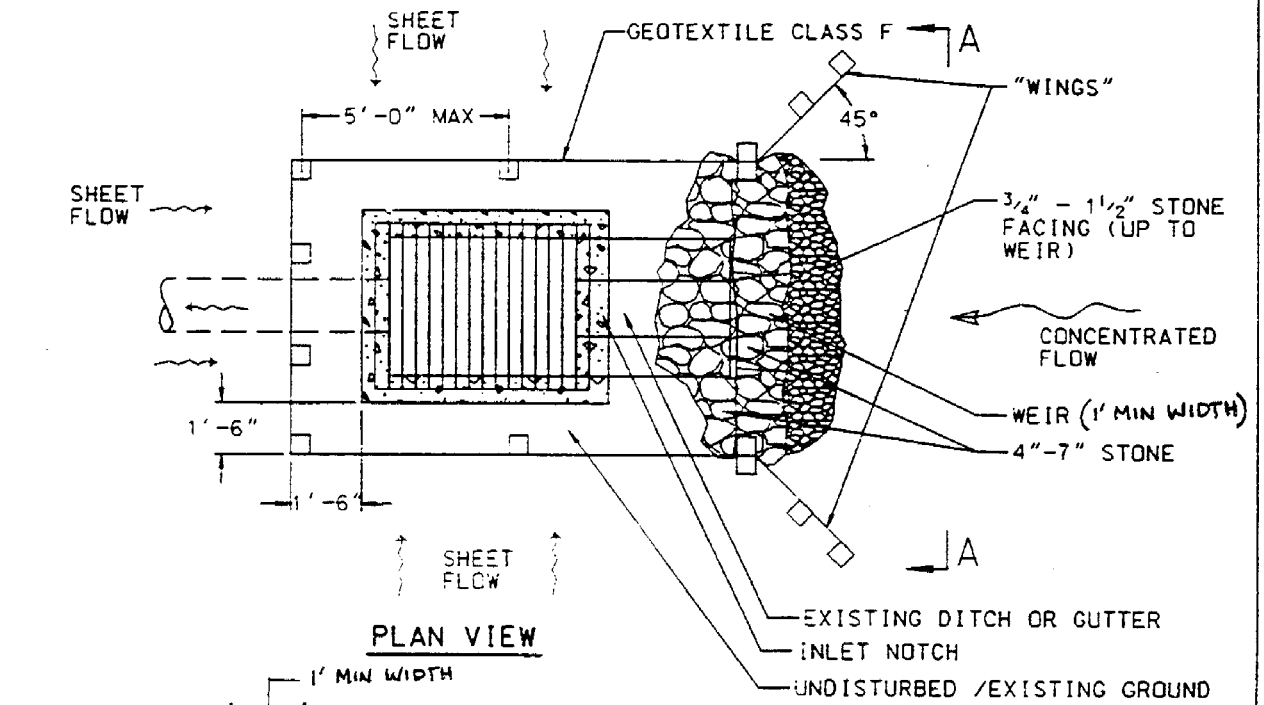
5. The assembly shall be placed so that the end spacers are a minimum 1' beyond both ends of the throat opening.

6. Form the 1/2" x 1/2" wire mesh and the geotextile fabric to the concrete gutter and against the face of the curb on both sides of the inlet. Place clean 3/4" x 1 1/2" stone over the wire mesh and geotextile in such a manner to prevent water from entering the inlet under or around the geotextile.

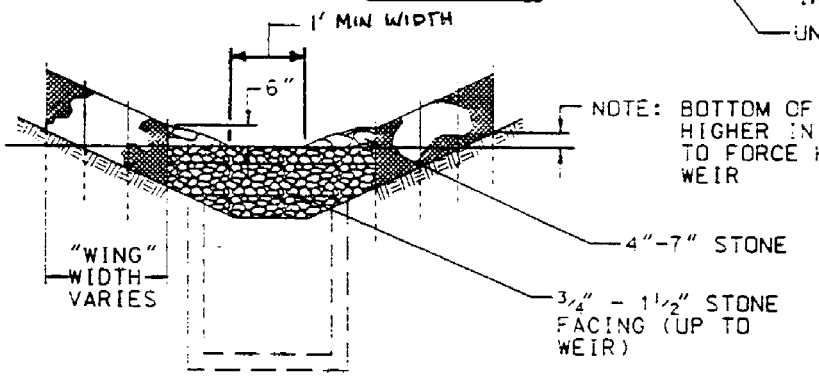
7. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.

8. Assure that storm flow does not bypass the inlet by installing a temporary earth or asphalt dike to direct the flow to the inlet.

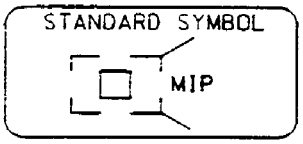
DETAIL 23D – MEDIAN INLET PROTECTION



PLAN VIEW



SECTION A-A



Construction Specifications

1. Fence posts shall be 36" (min.) long, driven 16" into the ground and spaced 5' (max.) apart. Wood posts shall be 1½" x 1½" (min.) square cut or 1¾" (min.) diameter round and shall be of sound quality hardwood. Steel posts shall be standard T or U section weighing not less than 1.0 #/linear foot.

2. Geotextile Class F shall be fastened securely to each post with wire ties or staples at top and mid-section.

3. Where ends of geotextile fabric come together they shall be overlapped, folded and stapled.

4. Median Inlet Protection shall be inspected after each rain and maintained when bulges occur in the fabric or when the stone gets clogged.

5. Stone used to construct the weir shall be 4" – 7" with a 1' thick layer of ¾" – 1½" stone on the upstream face.

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Section F - LAND GRADING AND STRUCTURAL STABILIZATION

17.0 STANDARDS AND SPECIFICATIONS

FOR

STABILIZED CONSTRUCTION ENTRANCE

Definition

A stabilized layer of aggregate that is underlain with Geotextile Class C[25]. Stabilized entrances are located at any point where traffic enters or leaves a construction site.

Purpose

Stabilized construction entrances reduce tracking of sediment onto streets or public rights-of-way and provide a stable area for entrance or exit from the construction site.

Conditions Where Practice Applies

1. Stabilized construction entrances shall be located at points of construction ingress and egress.

2. For single family residences, the entrance should be located at the permanent driveway.

3. Stabilized construction entrances should not be used on existing pavement.

Design Criteria

1. Length - minimum of 50' (30' for single residence lot).

2. Width - 10' minimum, should be flared at the existing road to provide a turning radius.

3. Geotextile Class C shall be placed over the existing ground prior to placing stone. The plan approval authority may not require geotextile fabric for single family residences.

4. Stone - crushed aggregate (2" to 3")[26], or recycled concrete equivalent shall be placed at least 6" deep over the length and width of the entrance.

5. Surface Water - all surface water flowing to or diverted toward construction entrances shall be piped under the entrance to maintain positive drainage. Pipe installed under the construction entrance shall be protected with a mountable berm. The pipe shall be sized according to the drainage, with the min. diameter being 6". A pipe will not be necessary when the SCE is located at a high spot.

6. Location - A stabilized construction entrance shall be located at every point where construction traffic enters or leaves a construction site. Vehicles leaving the site must travel over the entire length of the stabilized construction entrance.

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[25] Refer to Table 27.

[26] Refer to Table 28

Maintenance

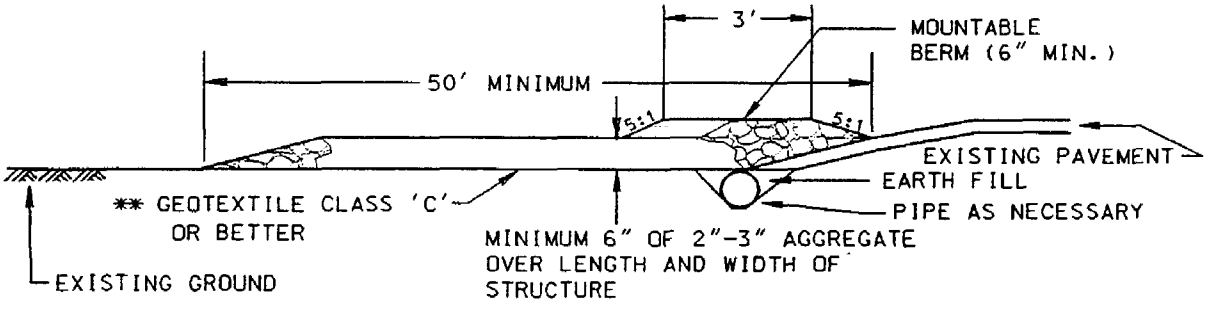
The entrance shall be maintained in a condition which will minimize tracking of sediment onto public rights-of-way. This may require adding stone or other repairs as conditions demand. All sediment spilled, dropped, or tracked onto public rights-of-way must be removed immediately by vacuum sweeping, scraping, or sweeping.

When necessary, wheels shall be cleaned or washed 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. Daily inspection and maintenance is required.

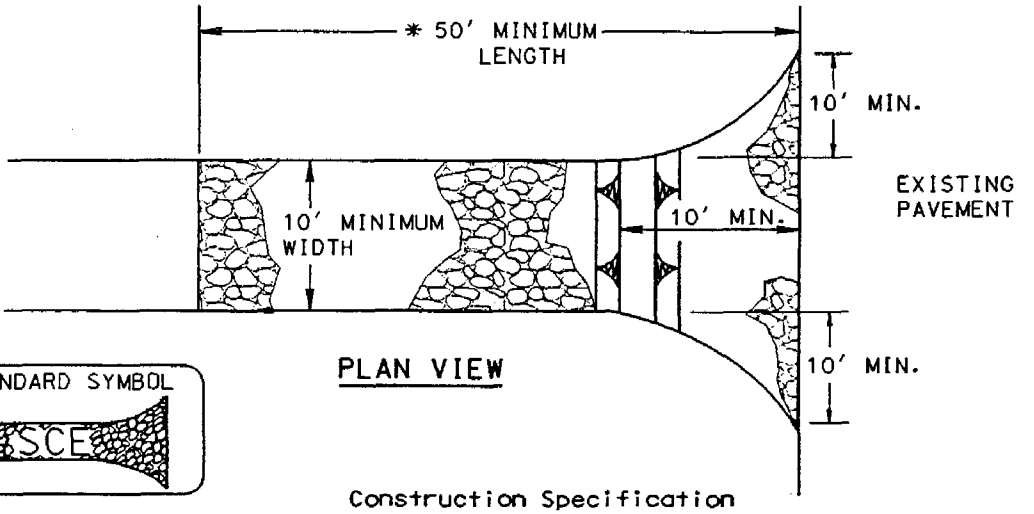
Removal

After construction is complete and the site is stabilized, the stabilized construction entrance will be removed and the area stabilized unless it will be used as an underlayment for a driveway.

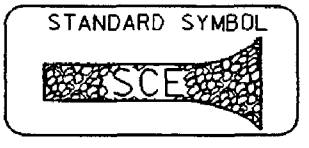
DETAIL 24 – STABILIZED CONSTRUCTION ENTRANCE



PROFILE



PLAN VIEW



Construction Specification

1. Length – minimum of 50' (*30' for single residence lot).

2. Width – 10' minimum, should be flared at the existing road to provide a turning radius.

3. Geotextile fabric (filter cloth) shall be placed over the existing ground prior to placing stone. **The plan approval authority may not require single family residences to use geotextile.

4. Stone – crushed aggregate (2" to 3") or reclaimed or recycled concrete equivalent shall be placed at least 6" deep over the length and width of the entrance.

5. Surface Water – all surface water flowing to or diverted toward construction entrances shall be piped through the entrance, maintaining positive drainage. Pipe installed through the stabilized construction entrance shall be protected with a mountable berm with 5:1 slopes and a minimum of 6" of stone over the pipe. Pipe has to be sized according to the drainage. When the SCE is located at a high spot and has no drainage to convey a pipe will not be necessary. Pipe should be sized according to the amount of runoff to be conveyed. A 6" minimum will be required.

6. Location – A stabilized construction entrance shall be located at every point where construction traffic enters or leaves a construction site. Vehicles leaving the site must travel over the entire length of the stabilized construction entrance.

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18.0 STANDARDS AND SPECIFICATIONS

FOR

ROCK OUTLET PROTECTION

Definition

Rock placed at the outfall of channels or culverts.

Purpose

To reduce the velocity of flow in the receiving channel to non-erosive rates.

Conditions Where Practice Applies

This practice applies where discharge velocities and energies at the outlets of culverts are sufficient to erode the next downstream reach. This applies to outlets of all types such as sediment basins, stormwater management ponds, and road culverts.

Design Criteria

The design method presented here applies to sizing rock rip-rap and gabions to protect a downstream area. It does not apply to rock lining of channels or streams. The design of rock outlet protection depends entirely on the location. Pipe outlets at the top of cuts or on slopes steeper than ten percent cannot be protected by rock aprons or rip-rap sections due to reconcentration of flows and high velocities encountered after the flow leaves the apron.

Be aware that many counties and state agencies have regulations and design procedures established for dimensions, type and size of materials, and locations where outlet protection is required.

1. Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have Minimum Tailwater Condition.

2. Apron Size

The apron length and width shall be determined from the curves according to the tailwater condition:

Minimum Tailwater	Use Table 19
Maximum Tailwater	Use Table 20

If the pipe discharges directly into a well-defined channel,the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less. The upstream end of the apron adjacent to the pipe shall have a width two times the diameter of the outlet pipe or conform to pipe end section if used.

3. Bottom Grade

The outlet protection apron shall be constructed with no slope along its length. There shall be no obstruction at the end of the apron. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground.

4. Alignment

The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

5. Materials

The outlet protection may be done using rock rip-rap, or gabions. Rip-rap shall be composed of a well-graded mixture of stone sized so that fifty (50) percent of the pieces, by weight, shall be larger than the size determined by using the charts. The minimum d_{50} size to be used shall be nine (9) inches. A well-graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone in such a mixture shall be 2.0 times the size selected on the chart located in the following paragraph.

6. Thickness

For SHA rip-rap specifications the following values are used:

Table 18

Rip-rap Sizes and Thicknesses (SHA Specifications)

	D_{50}	D_{100}	Thickness
Class I	9.5"	15"	19"
Class II	16"	24"	32"
Class III	23"	34"	46"

7. Stone Quality

Stone for rip-rap shall consist of field stone or rough and hewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5. Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic foot and does not have any exposed steel or reinforcing bars.

8. Filter

A filter is a layer of material placed between the rip-rap and the underlaying soil surface to prevent soil movement into and through the rip-rap to prevent piping, reduce uplift pressure, and collect water. Rip-rap shall have a filter placed under it in all cases. A filter can be of two general forms: a gravel layer or a Geotextile Class C[27].

9. Gabions

Gabion baskets may be used as rock outlet protection, provided they are made of hexagonal triple twist mesh with heavily galvanized steel wire. The maximum lined dimension of the mesh opening shall not exceed 4 1/2 inches. The area of the mesh opening shall not exceed ten (10) square inches. Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according to the manufacturer's specifications. The area on which the gabion is to be installed shall be graded as shown on the drawings. Foundation conditions shall be the same as for placing rock rip-rap. Geotextile Class C shall be placed under all gabions. Gabions must be keyed in to prevent undermining of the main gabion structure. Refer to Table 28 for Gabion stone sizes.

Maintenance

Once a rip-rap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows to see if scour beneath the rip-rap has occurred or if any stones have been dislodged. Repairs should be made immediately.

Design Procedure

1. Investigate the downstream channel to assure that non-erosive velocities can be maintained.

2. Determine the tailwater condition at the outlet to establish which curve to use.

3. Enter the appropriate chart with the depth of flow and discharge velocity to determine the rip-rap size and apron length required. References to pipe diameters in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity must be used.

4. Calculate apron width at the downstream end if a flared section is to be employed.

Examples

Example 1: Pipe Flow (Full) with Discharge to Unconfined Section :

Q = 280 cfs, diameter = 66", tailwater is 2' above pipe invert (min. tailwater condition).

Read d_{50} = 1.2 feet, and apron length = 38 feet.

Apron width = diameter + L a = 5.5 + 38 = 43.5 feet.

[27] Refer to Table 27

Example 2: Box Flow (Partial) with High Tailwater:

A box culvert is flowing under partial flow conditions:

A concrete box 5.5 feet x 10 feet is flowing 5.0 deep; Q = 600 cfs, and tailwater (surface) is 5' above invert (maximum tailwater condition);

V = Q/A = 600/(5 x 10) = 12 fps

At the intersection of the curve, d = 60 inches, V = 12 fps, read d_{50} = 0.4 feet.
Since d_{50} 9 inches, use d_{50} = 9 inches.

Then reading to the d = 60 inch curve, read apron length = 40 feet.

Apron width, W = conduit width + 0.04 L a = 10 + (0.4)(40) = 26 feet.

Example 3: Open Channel Flow with Discharge to Unconfined Section:

A trapezoidal concrete channel 5 feet wide with 2:1 side slopes is flowing 2 feet deep;

Q = 180 cfs (velocity = 10 fps); and the tailwater (surface) downstream is 0.8 foot (minimum tail water condition).

At the intersection of the curve, d = 24 inches, V = 10 fps, read d_{50} = 0.7 feet.
Since d_{50} 9 inches, use d_{50} = 9 inches.

Then reading to the d = 24 inch curve, read apron length = 22 feet.
Apron width, W = bottom of width of channel + L a = 5 + 22 = 27 feet.

Example 4: Pipe Flow (Partial) with Discharge to a Confined Section:

A 48 inch pipe is discharging with a depth of 3 feet;

Q = 100 cfs and the discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 foot bottom, 2:1 side slopes, n =.04, and a grade of 0.6 %.

Calculation of the downstream channel (Manning's Equation) indicates a normal depth of 3.1 feet and a normal velocity of 3.0 fps. Since the receiving channel is confined, the maximum tailwater condition controls.

At the intersection of the curve, d = 36 inches, and V = 10 fps, read d50 = 0.3 feet.

Since d_{50} 9 inches, use d_{50} = 9 inches.

Then reading to the d = 36 inch curve, read apron length = 30 feet.

Since the maximum flow depth in this reach is 3.1 feet, then the minimum depth of the rip-rap must be 4.1 feet.

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile Class C[28] or better shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile fabric over the damaged part or by completely replacing the geotextile fabric. All overlaps whether for repairs or for joining two pieces of geotextile fabric shall be a minimum of one foot.

4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogenous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile fabric. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

[28] Refer to Table 27

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION (Tw <0.5 diam.)

Median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.

Velocities shown are for pipes flowing full.

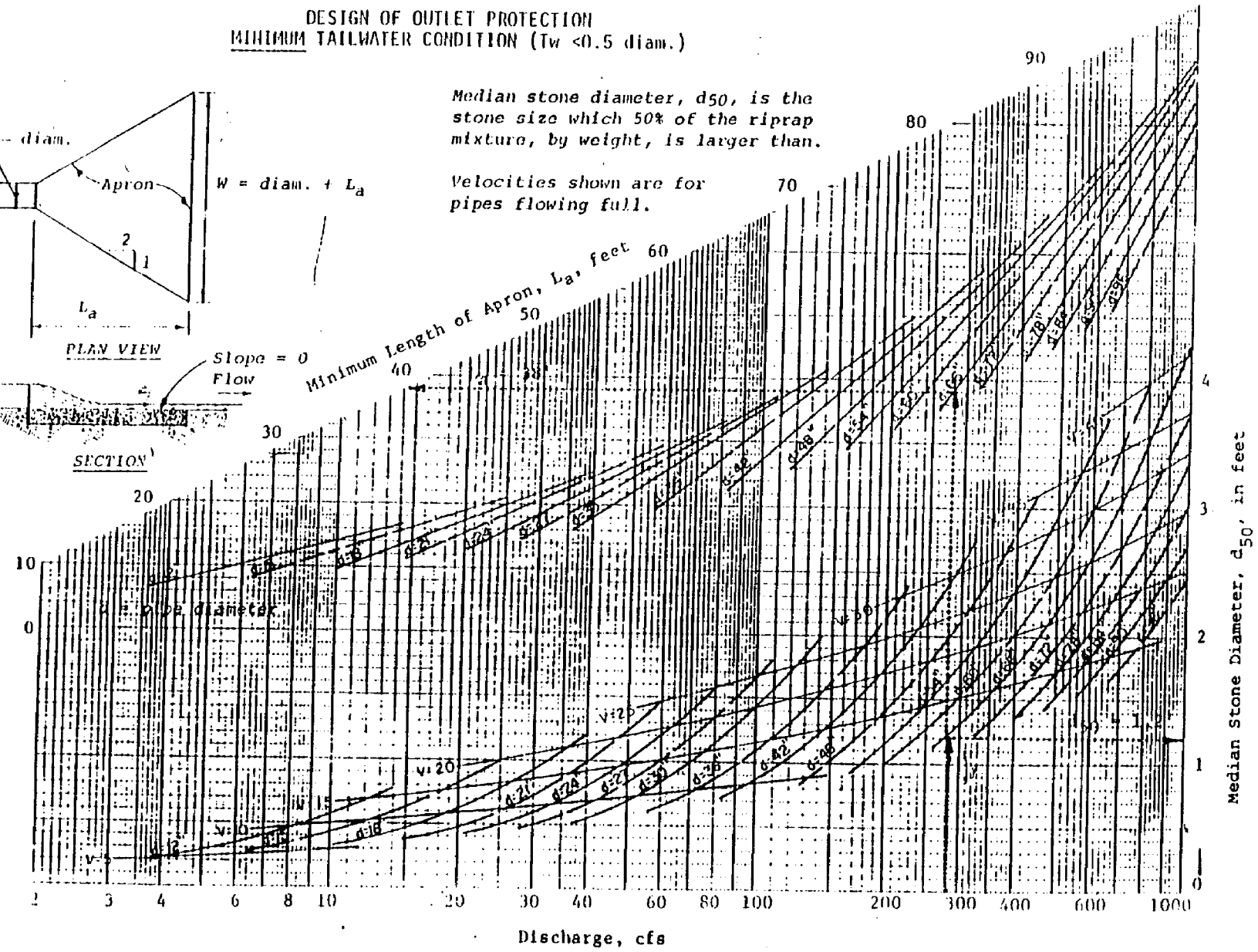
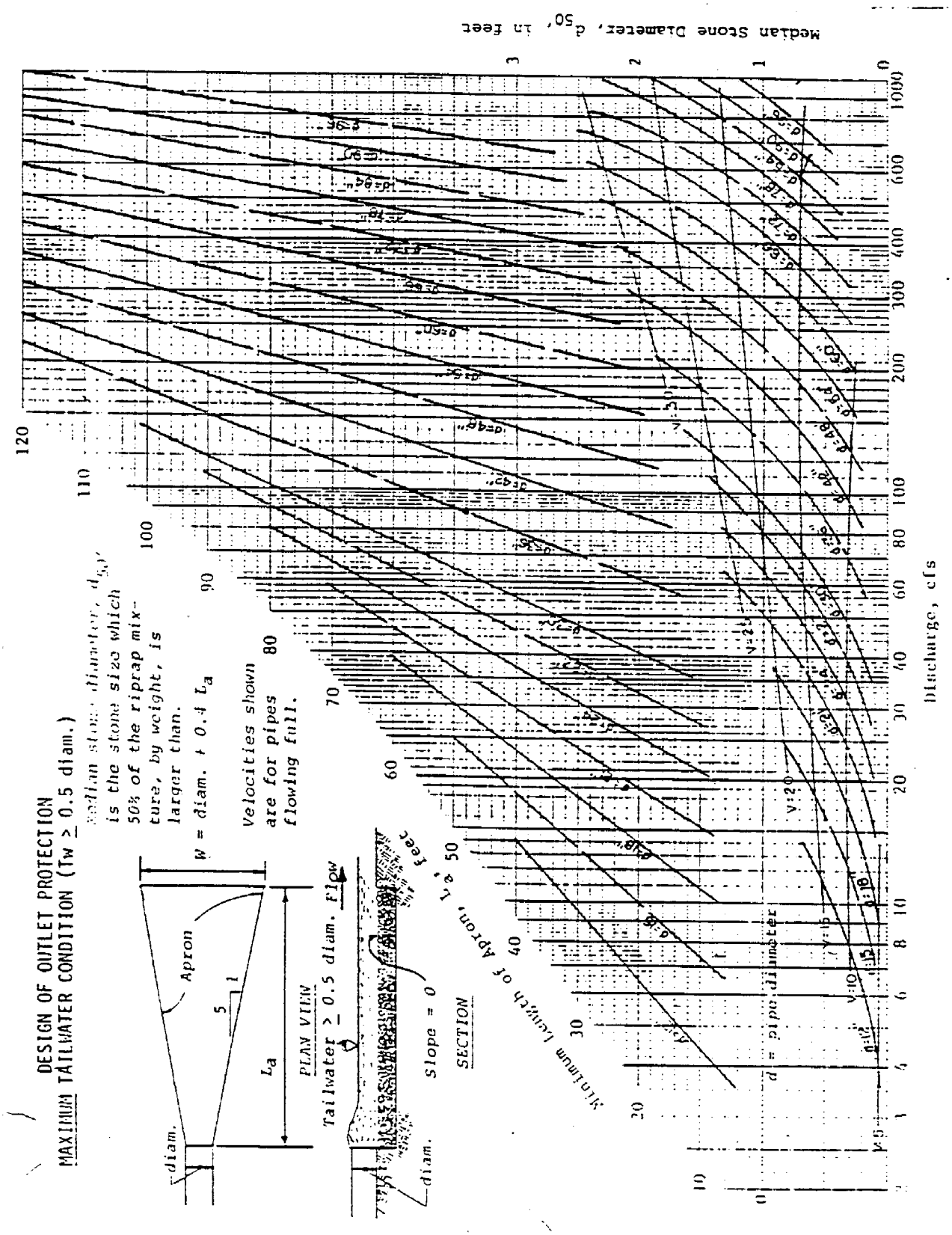
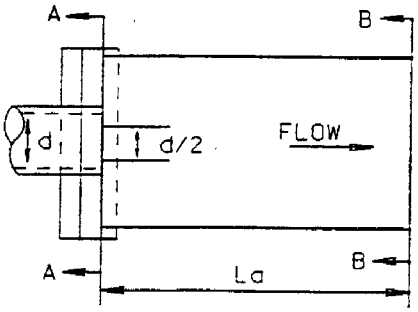


Table 20

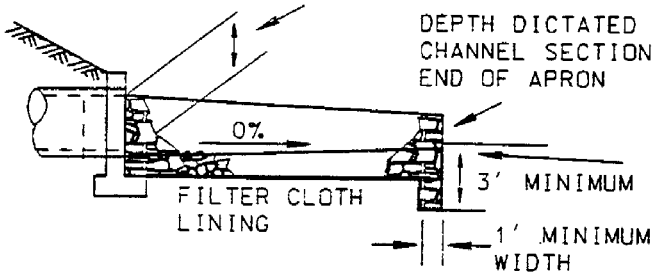

DESIGN OF OUTLET PROTECTION
MAXIMUM TAILWATER CONDITION (Tw ≥ 0.5 diam.)
Median stone diameter, d50, is the stone size which 50% of the riprap mixture, by weight, is larger than.
W = diam. + 0.4 La
Velocities shown are for pipes flowing full.
Apron
5
1
La
diam.
PLAN VIEW
Tailwater ≥ 0.5 diam.
Flow
Slope = 0
SECTION
Minimum Length of Apron, La, feet
Median Stone Diameter, d50, in feet
Discharge, cfs
d = pipe diameter
V=10
V=20
V=21

DETAIL 25 – ROCK OUTLET PROTECTION I



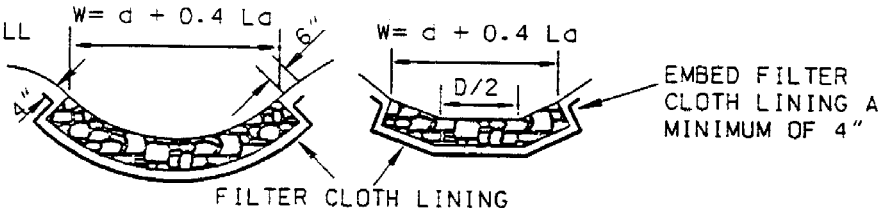
DISCHARGE TO SEMI CONFINED SECTION (MAXIMUM TAILWATER CONDITION)

MINIMUM DEPTH = DISCHARGE OR TAILWATER DEPTH. WHICHEVER IS GREATER



NOTE: FILTER CLOTH MUST EXTEND A MINIMUM OF 6" BEYOND APRON AND SIDES

CHANNEL CROSS SECTION WILL VARY FROM A-A TO B-B



SECTION B-B SECTION A-A

ROCK OUTLET PROTECTION I

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

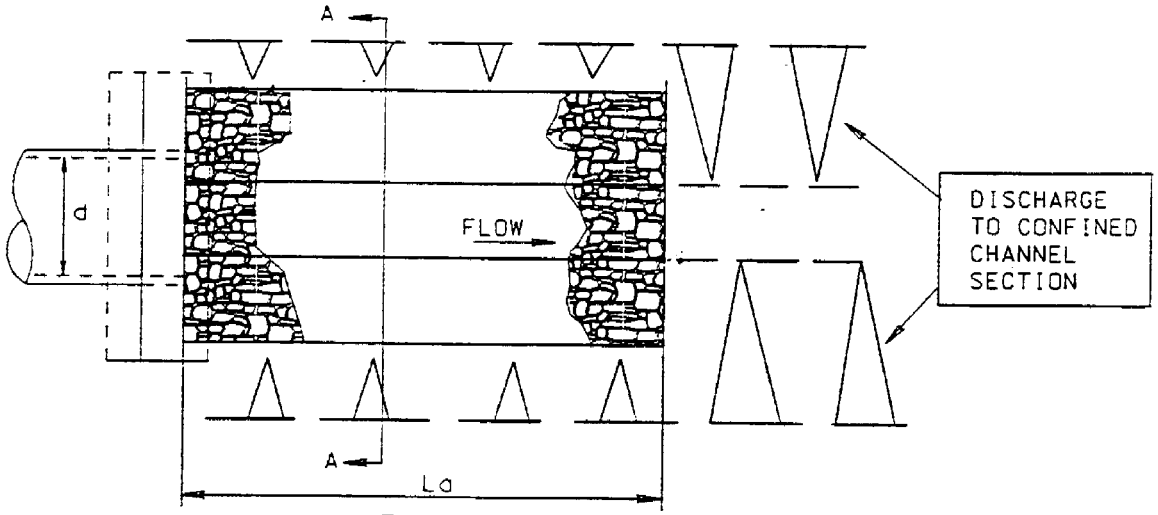
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

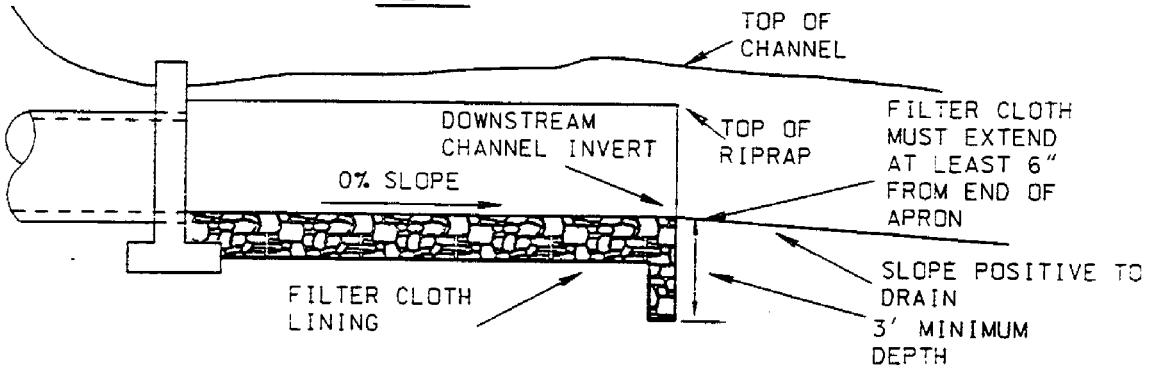
4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

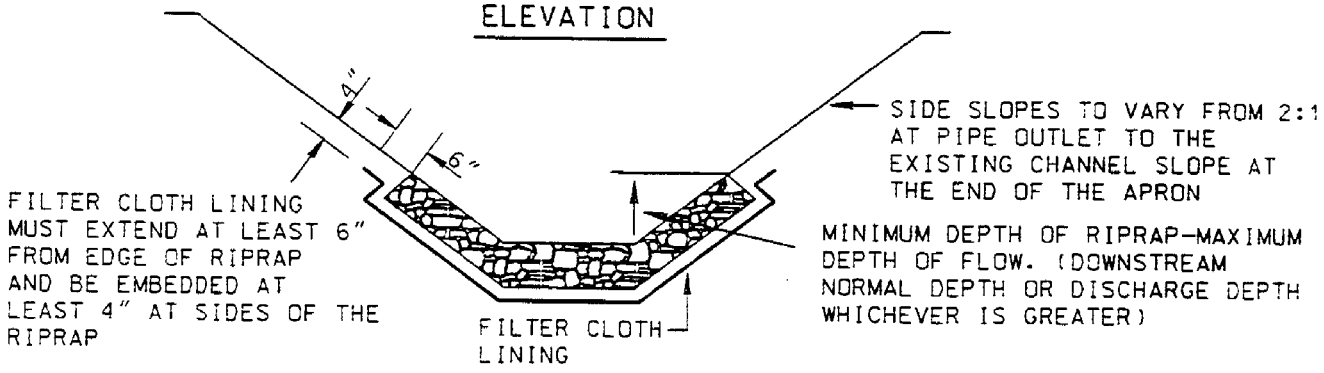
DETAIL 26 - ROCK OUTLET PROTECTION II



PLAN



ELEVATION



SECTION A-A

ROCK OUTLET PROTECTION II

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

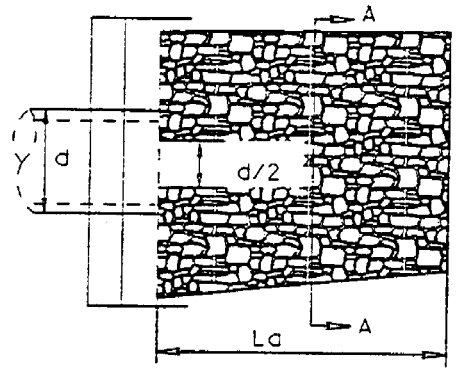
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

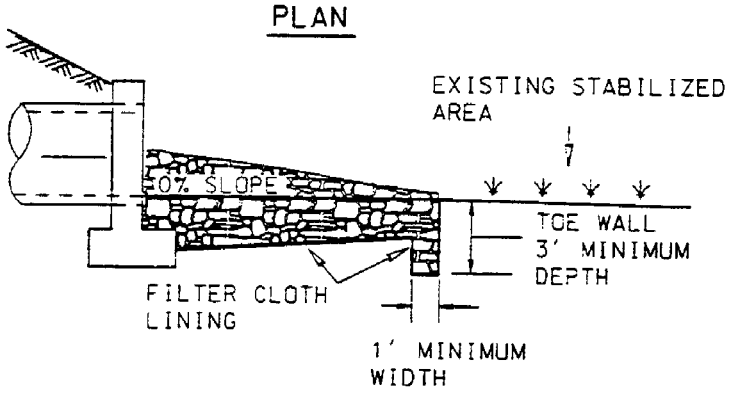
4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

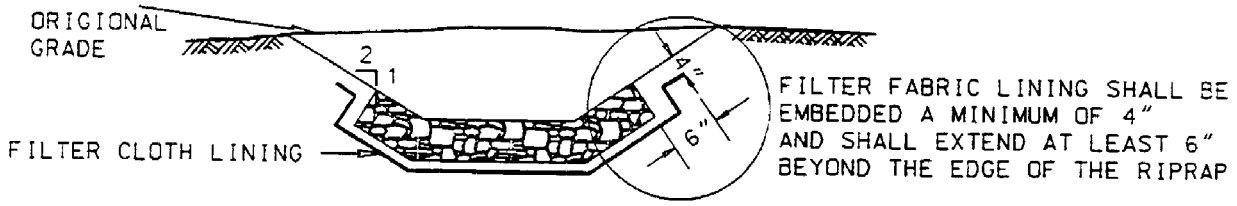
DETAIL 27 – ROCK OUTLET PROTECTION III



PLAN



ELEVATION



SECTION A–A

ROCK OUTLET PROTECTION III

Construction Specifications

1. The subgrade for the filter, rip-rap, or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. The rock or gravel shall conform to the specified grading limits when installed respectively in the rip-rap or filter.

3. Geotextile shall be protected from punching, cutting, or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of geotextile over the damaged part or by completely replacing the geotextile. All overlaps whether for repairs or for joining two pieces of geotextile shall be a minimum of one foot.

4. Stone for the rip-rap or gabion outlets may be placed by equipment. They shall be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for rip-rap or gabion outlets shall be delivered and placed in a manner that will ensure that it is reasonably homogeneous with the smaller stones and spalls filling the voids between the larger stones. Rip-rap shall be placed in a manner to prevent damage to the filter blanket or geotextile. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

5. The stone shall be placed so that it blends in with the existing ground. If the stone is placed too high then the flow will be forced out of the channel and scour adjacent to the stone will occur.

19.0 STANDARDS AND SPECIFICATIONS

FOR

LAND GRADING

Definition

Reshaping of the existing land surface in accordance with a plan as determined by engineering survey and layout.

Purpose

The purpose of a land grading specification is to provide for erosion control and vegetative establishment on those areas where the existing land surface is to be reshaped by grading according to plan.

Design Criteria

The grading plan should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surroundings to avoid extreme grade modifications. Information submitted must provide sufficient topographic surveys and soil investigations to determine limitations that must be imposed on the grading operation related to slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal and vegetative treatment, etc.

Many counties have regulations and design procedures already established for land grading and cut and fill slopes. Where these requirements exist, they shall be followed. The plan must show existing and proposed contours of the area(s) to be graded. The plan shall also include practices for erosion control, slope stabilization, safe disposal of runoff water and drainage, such as waterways, lined ditches, reverse slope benches (include grade and cross section), grade stabilization structures, retaining walls, and surface and subsurface drains. The plan shall also include phasing of these practices. The following shall be incorporated into the plan:

1. Provisions shall be made to safely conduct surface runoff to storm drains, protected outlets or to stable water courses to insure that surface runoff will not damage slopes or other graded areas.

2. Cut and fill slopes that are to be stabilized with grasses shall not be steeper than 2:1. (Where the slope is to be mowed the slope should be no steeper than 3:1; 4:1 is preferred because of safety factors related to mowing steep slopes.) Slopes exceeding 2:1 shall require special design and stabilization considerations that shall be adequately shown on the plans.

3. Reverse benches shall be provided whenever the vertical interval (height) of any 2:1 slope exceeds 20 feet; for 3:1 slope it shall be increased to 30 feet and for 4:1 to 40 feet. Benches shall be located to divide the slope face as equally as possible and shall convey the water to a stable outlet. Soils, seeps, rock outcrops , etc., shall also be taken into consideration when designing benches.

   a. Benches shall be a minimum of six-feet wide to provide for ease of maintenance.

   b. Benches shall be designed with a reverse slope of 6:1 or flatter to the toe of the upper slope and with a minimum of one foot in depth. Bench gradient to the outlet shall be between 2 percent and 3 percent, unless accompanied by appropriate design and computations.

c. The flow length within a bench shall not exceed 800' unless accompanied by appropriate design and computations. For flow channel stabilization see temporary swale.

4. Surface water shall be diverted from the face of all cut and/or fill slopes by the use of earth dikes, ditches and swales or conveyed downslope by the use of a designed structure, except where:

a. The face of the slope is or shall be stabilized and the face of all graded slopes shall be protected from surface runoff until they are stabilized.

b. The face of the slope shall not be subject to any concentrated flows of surface water such as from natural drainageways, graded swales, downspouts, etc.

c. The face of the slope will be protected by special erosion control materials, to include, but not limited to: approved vegetative stabilization practices (see section G), rip-rap or other approved stabilization methods.

5. Cut slopes occurring in ripable rock shall be serrated as shown on the following diagram. These serrations shall be made with conventional equipment as the excavation is made. Each step or serration shall be constructed on the contour and will have steps cut at nominal two-foot intervals with nominal three-foot horizontal shelves. These steps will vary depending on the slope ratio or the cut slope. The nominal slope line is 1:1. These steps will weather and act to hold moisture, lime, fertilizer and seed thus producing a much quicker and longer lived vegetative cover and better slope stabilization. Overland flow shall be diverted from the top of all serrated cut slopes and carried to a suitable outlet.

6. Subsurface drainage shall be provided where necessary to intercept seepage that would otherwise adversely affect slope stability or create excessively wet site conditions.

7. Slopes shall not be created so close to property lines as to endanger adjoining properties without adequately protecting such properties against sedimentation, erosion, slippage, settlement, subsidence or other related damages.

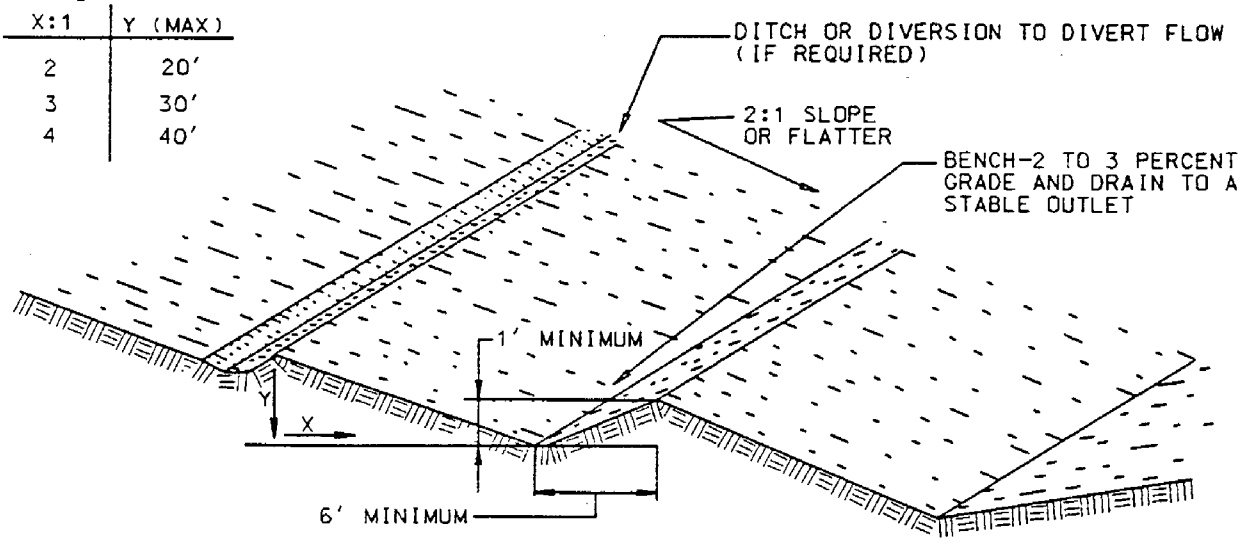
8. Fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris, and other objectionable material. It should be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers or over eight (8) inches in diameter where compacted by rollers or other equipment.Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

9. Stockpiles, borrow areas and spoil shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

10. All disturbed areas shall be stabilized structurally or vegetatively in compliance with 20.0 Standards and Specifications for Vegetative Stabilization.

DETAIL 28 – BENCHED SLOPES

SLOPE X:1	Y (MAX)
2	20'
3	30'
4	40'



Construction Specifications

1. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

2. All fill shall be placed and compacted in layers not to exceed 8" in thickness.

3. Except for approved landfills or nonstructural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

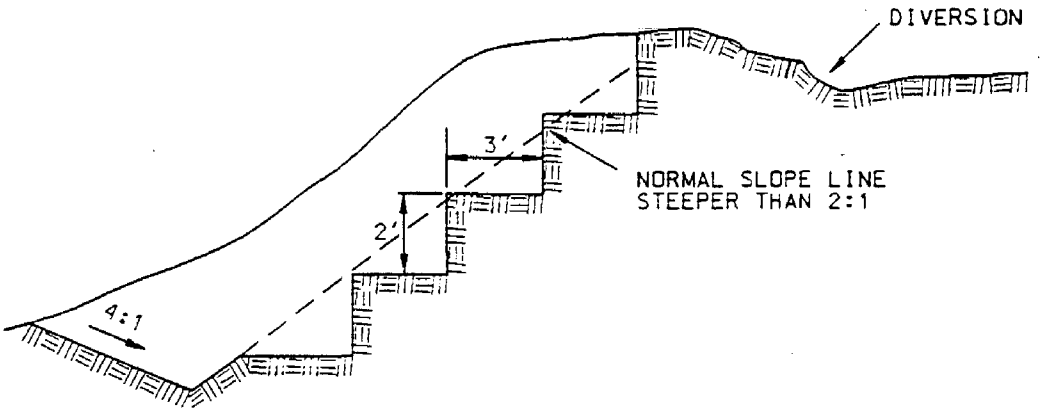
4. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills. Fill shall not be placed on a frozen foundation.

5. All benches shall be kept free of sediment during all phases of development.

6. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specification for Subsurface Drain or other approved methods.

7. All graded areas shall be permanently stabilized immediately following finished grading.

DETAIL 29 - SERRATED SLOPES



TYPICAL SECTION

Construction Specifications

1. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

2. All fill shall be placed and compacted in layers not to exceed 8" in thickness.

3. Except for approved landfills or nonstructural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

4. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills. Fill shall not be placed on a frozen foundation.

5. All benches shall be kept free of sediment during all phases of development.

6. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specification for Subsurface Drain or other approved methods.

7. All graded areas shall be permanently stabilized immediately following finished grading.

Section H - MISCELLANEOUS PRACTICES

Table 27 Geotextile Fabrics

CLASS	APPARENT OPENING SIZE MM. MAX.	GRAB TENSILE STRENGTH LB. MIN.	BURST STRENGTH PSI. MIN.
A	0.30	250	500
B	0.60	200	320
C	0.30	200	320
D	0.60	90	145
E	0.30	90	145
F (SILT FENCE)	0.40-0.80*	90	190

* US Std Sieve CW-02215

The properties shall be determined in accordance with the following procedures:

-Apparent opening size MSMT 323

-Grab tensile strength ASTM D 1682: 4x8" specimen, 1x2" clamps, 12"/min. strain rate in both principal directions of geotextile fabric.

-Burst strength ASTM D 3786

The fabric shall be inert to commonly encountered chemicals and hydrocarbons, and will be rot and mildew resistant. It shall be manufactured from fibers consisting of long chain synthetic polymers, and composed of a minimum of 85% by weight of polyolephins, polyesters, or polyamides. The geotextile fabric shall resist deterioration from ultraviolet exposure.

In addition, Classes A through E shall have a 0.01 cm./sec. minimum permeability when tested in accordance with MSMT 507, and an apparent minimum elongation of 20 percent (20%) when tested in accordance with the grab tensile strength requirements listed above.

Silt Fence

Class F geotextile fabrics for silt fence shall have a 50 lb./in. minimum tensile strength and a 20 lb./in. minimum tensile modules when tested in accordance with MSMT 509. The material shall also have a 0.3 gal./ft.^{2}/min. flow rate and seventy-five percent (75%) minimum filtering efficiency when tested in accordance with MSMT 322.

Geotextile fabrics used in the construction of silt fence shall resist deterioration from ultraviolet exposure. The fabric shall contain sufficient amounts of ultraviolet ray inhibitors and stabilizers to provide a minimum of 12 months of expected usable construction life at a temperature range of 0 to 120 degrees F.

Table 28 Stone Size

	SIZE RANGE	D_{50}	D_{100}	AASHTO	WEIGHT
NUMBER 57*	3/8" - 1 1/2"	1/2"	1 1/2"	M-43	N/A
NUMBER 1	2" - 3"	2 1/2"	3"	M-43	N/A
RIP-RAP**	4" - 7"	5 1/2"	7"	N/A	N/A
CLASS I	N/A	9.5"	15"	N/A	150lb max
CLASS II	N/A	16"	24"	N/A	700lb max
CLASS III	N/A	23"	34"	N/A	2000lb max

* This classification is to be used on the inside face of stone outlets and check dams.

** This classification is to be used when ever small rip-rap is required. The State Highway Administration designation for this stone is Stone For Gabions (§905.01.04).

Stone For Gabion Baskets

BASKET THICKNESS		SIZE OF INDIVIDUAL STONES	
INCHES	MM	INCHES	MM
6	150	3 - 5	75 - 125
9	225	4 - 7	100 - 175
12	300	4 - 7	100 - 175
18	460	4 - 7	100 - 175
36	910	4 - 12	100 - 300

NOTE: Recycled concrete equivalent may be substituted for all stone classifications. Recycled concrete equivalent shall be concrete broken into the sizes meeting the appropriate classification, shall contain no steel reinforcement, and shall have a density of 150 pounds per cubic foot.

25.0 STRAW BALE DIKE

Definition

Straw bale dikes are temporary barriers of straw or similar material used to intercept and direct surface runoff.

Purpose

The straw bale dike filters sediment from runoff so that deposition of transported sediment can occur. The straw bale dike is used to intercept or direct sediment laden runoff to a sediment trap so that deposition of transported sediment can occur.

1. The use of straw bale dikes is not recommended as a primary sediment control device. Straw bale dikes clog and deteriorate rapidly and require frequent maintenance.

2. Straw bale dikes can be used to intercept sheet flow only. They cannot be used as velocity checks in swales, or placed where they will intercept concentrated flow.

3. Straw bale dikes can be used only on projects that will be completed within three months.

4. Straw bale dikes should not be used on slopes exceeding 5:1.

5. The length of straw bale dikes must conform to the following limitations:

Table 29 Straw Bale Design Criteria

Slope	Slope Steepness	Slope Length	Dike Length
0% to 2%	Flatter than 50:1	300 feet	500 feet
2% to 10%	50 :1 to 10 :1	125 feet	500 feet
10% to 20%	10 :1 to 5 :1	100 feet	500 feet

Construction Specifications

1. Bales shall be placed in a row on the contour with the ends of each bale tightly abutting the adjacent bales.

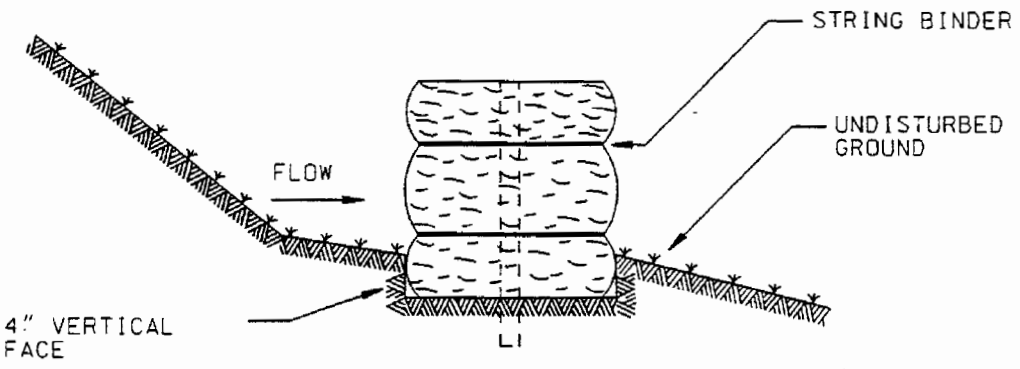
2. Each bale shall be entrenched 4" min. in the soil and placed so the bindings are horizontal.

3. Bales shall be securely anchored in place by either two stakes or re-bars driven through the bale 12 to 18" into the ground. The first stake in each bale shall be driven toward the previously laid bale at an angle to force the bales together. Stakes shall be driven flush with the top of the bale.

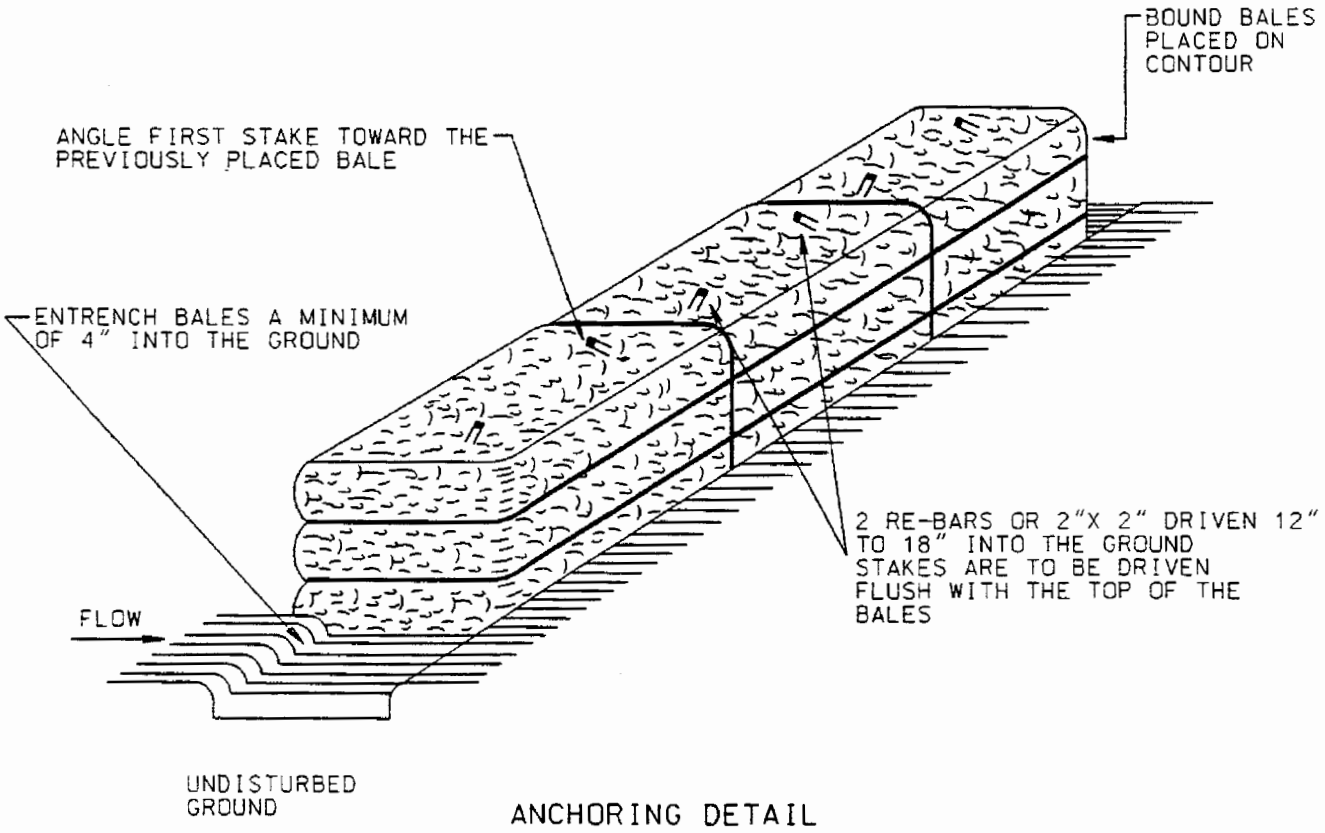
4. Straw bale dikes shall be inspected frequently and after each rain event and maintenance performed as necessary.

5. All bales shall be removed when the site has been stabilized. The trench where the bales were located shall be graded flush and stabilized.

DETAIL 32 STRAW BALE DIKE



BEDDING DETAIL



ANCHORING DETAIL

STRAW BALE DIKE

CONSTRUCTION SPECIFICATIONS

1. Bales shall be placed at the toe of a slope, on the contour, and in a row with the ends of each bale tightly abutting the adjacent bales.

2. Each bale shall be entrenched in the soil a minimum of 4 inches and placed so the bindings are horizontal.

3. Bales shall be securely anchored in place by either two stakes or re-bars driven through the bale 12 to 18 inches into the ground. The first stake in each bale shall be driven toward the previously laid bale at an angle to force the bales together. Stakes shall be driven flush with the top of the bale.

4. Straw bale dikes shall be inspected frequently and after each rain event and maintenance performed as necessary.

5. All bales shall be removed when the site has been stabilized. The trench where the bales were located shall be graded flush and stabilized.

26.0 SUPER SILT FENCE

Definition

A temporary barrier of Geotextile Class F over chain link fence used to intercept sediment laden runoff from small drainage areas.

Purpose

To reduce runoff velocity and allow the deposition of transported sediment to occur. Limits imposed by ultraviolet light stability of the fabric will dictate the maximum period that the silt fence may be used.

1. Super silt fence provides a barrier that can collect and hold debris and soil, preventing the material from entering critical areas, streams, streets, etc.

2. Super silt fence can be used where the installation of a dike would destroy sensitive areas, woods, wetlands, etc.

3. Super silt fence should be placed as close to the contour as possible. No section of silt fence should exceed a grade of 5% for a distance of more than 50 feet.

Table 30 Design Criteria

Length of the flow contributing to Super Silt Fence shall conform to the following limitations:

Slope	Slope Steepness	Slope Length (maximum)	Silt Fence Length (maximum)
0 - 10%	0 - 10:1	Unlimited	Unlimited
10 - 20%	10:1 - 5:1	200 feet	1,500 feet
20 - 33%	5:1 - 3:1	100 feet	1,000 feet
33 - 50%	3:1 - 2:1	100 feet	500 feet
50% +	2:1 +	50 feet	250 feet

Where ends of the geotextile fabric come together, the ends shall be overlapped, folded, and stapled to prevent sediment bypass.

Construction Specifications

1. Fencing shall be 42 inches in height and constructed in accordance with the latest Maryland State Highway (SHA) Details for Chain Link Fencing. The SHA specification for a 6 foot fence shall be used, substituting 42 inch fabric and 6 foot length posts.

2. Chain link fence shall be fastened securely to the fence posts with wire ties or staples. The lower tension wire, brace and truss rods, drive anchors and post caps are not required except on the ends of the fence.

3. Filter Cloth shall be fastened securely to the chain link fence with ties spaced every 24" at the top and mid section.

4. Filter colth shall be embedded a minimum of 8" into the ground.

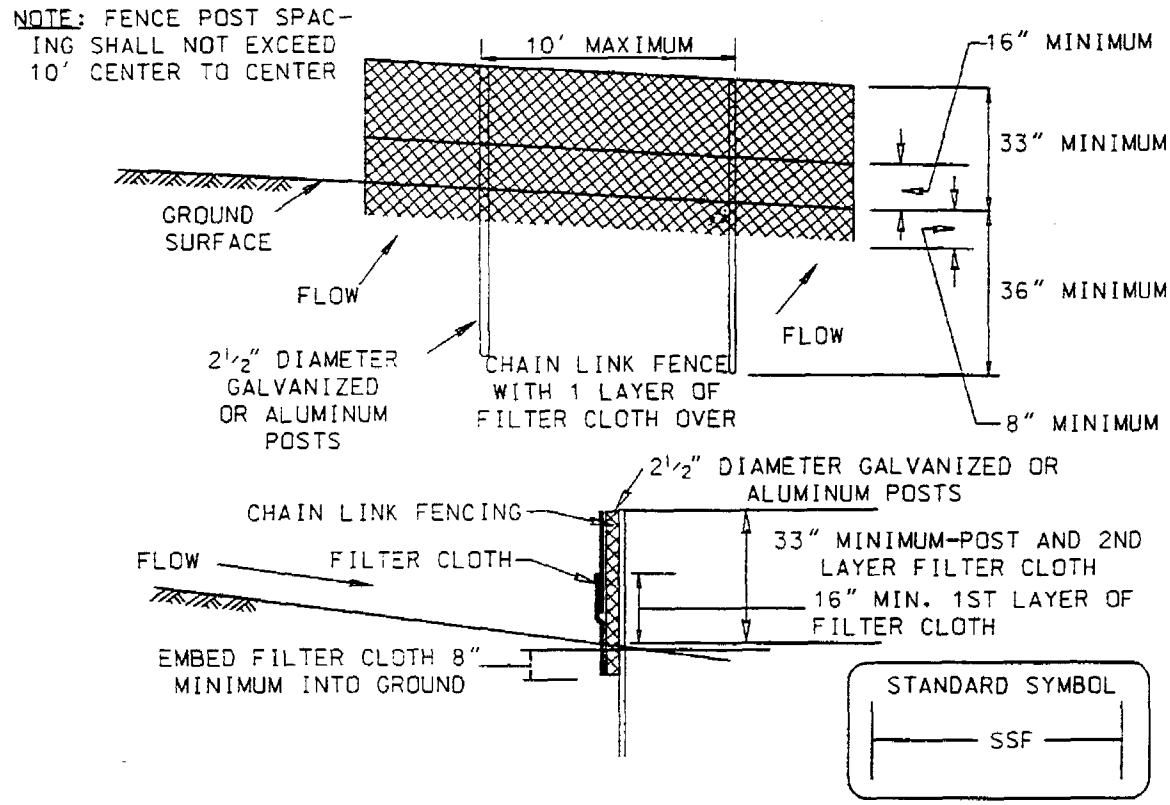
5. When two sections of geotextile fabric adjoin each other, they shall be overlapped by 6" and folded.

6. Maintenance shall be performed as needed and silt buildups removed when "bulges" develop in the silt fence, or when silt reaches 50% of the fence height.

7. Filter cloth shall meet the following requirements for Geotextile Class F:

Tension Strength	50 lb/in (min.)	Test: MSMT 509
Tensile Modulus	20 lb/in (min.)	Test: MSMT 509
Flow Rate	0.3 gal/ft^2/minute (max.)	Test: MSMT 322
Filtering Efficiency	75% (min.)	Test: MSMT 322

DETAIL 33 - SUPER SILT FENCE



Construction Specifications

Fencing shall be 42 inches in height and constructed in accordance with the latest Maryland State Highway Details for Chain Link Fencing. The specification for a 6 foot fence shall be used, substituting 42 inch fabric and 6 foot length posts.

1. The poles do not need to set in concrete.

2. Chain link fence shall be fastened securely to the fence posts with wire ties or staples.

3. Filter cloth shall be fastened securely to the chain link fence with ties spaced every 24" at the top and mid section.

4. Filter cloth shall be embedded a minimum of 8" into the ground.

5. When two sections of filter cloth adjoin each other, they shall be overlapped by 6" and folded.

6. Maintenance shall be performed as needed and silt buildups removed when "bulges" develop in the silt fence.

SUPER SILT FENCE

Design Criteria

Slope	Slope Steepness	Slope Length (maximum)	Silt Fence Length (maximum)
0 - 10%	0 - 10:1	Unlimited	Unlimited
10 - 20%	10:1 - 5:1	200 feet	1,500 feet
20 - 33%	5:1 - 3:1	100 feet	1,000 feet
33 - 50%	3:1 - 2:1	100 feet	500 feet
50% +	2:1 +	50 feet	250 feet

27.0 SUBSURFACE DRAIN

Definition

A conduit, such as tile, pipe, or tubing, installed beneath the ground surface which intercepts, collects, and/or conveys drainage water.

Purpose

A subsurface drain may serve one or more of the following purposes:

1. Improve the environment for vegetative growth by regulating the water table and groundwater flow.

2. Intercept and prevent water movement into a wet area.

3. Relieve artisan pressures.

4. Remove surface runoff.

5. Provide internal drainage of slopes to improve their stability and reduce erosion.

6. Provide internal drainage behind bulkheads, retaining walls, etc.

7. Replace existing subsurface drains that are interrupted or destroyed by construction operations.

8. Provide subsurface drainage for dry stormwater management structures.

9. Improve dewatering of sediment in sediment basins. (See Standard and Specifications for Sediment Basins.)

Conditions Where Practice Applies

Subsurface drains are used in areas having a high water table or where subsurface drainage is required. The soil shall have enough depth and permeability to permit installation of an effective system. This standard does not apply to storm drainage systems or foundation drains. An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity of water to be discharged without causing damage above or below the point of discharge and shall comply with state and local laws.

Design Criteria

The design and installation shall be based on adequate surveys and on site soils investigations.

1. Required Capacity of Drains

The required capacity shall be determined by one or more of the following:

a. Where subsurface drainage is to be uniform over an area through a systematic pattern of drains, a drainage coefficient of 1" to be removed in 24 hours shall be used. (See Drain Charts in the Appendix)

b. Where subsurface drainage is to be by a random interceptor system, a minimum inflow rate of 0.5 cfs per 1,000 feet of line shall be used to determine the required capacity. If actual field tests and measurements of flow amounts are available, they may be used for determining capacity. For interceptor subsurface drains on sloping land, increase the inflow rate as follows:

Land Slopes	Increase Inflow Rate By
2 - 5 percent	10 percent
5 - 12 percent	20 percent
Over 12 percent	30 percent

c. Additional design capacity must be provided if surface water is allowed to enter the system.

2. Size of Subsurface Drain

The size of subsurface drains shall be determined from the Drain Charts. All subsurface drains shall have a nominal diameter which equals or exceeds four 4".

3. Depth and Spacing

The minimum depth of cover of subsurface drains shall be 24" where possible. The minimum depth of cover may be reduced to 15" where it is not possible to attain the 24" depth and where the drain is not subject to equipment loading or frost action. Roots from some types of vegetation can plug drains as the drains get closer to the surface.

The spacing of drain laterals will be dependent on the permeability of the soil, the depth of installation of the drain and degree of drainage required. Generally, drains installed 36" deep and spaced 50'center-to-center will be adequate. For more specific information see the "Maryland Drainage Guide".

4. Minimum Velocity and Grade

The minimum grade for subsurface drains shall be 0.10 percent. Where surface water enters the system a velocity of not less than 2' per second shall be used to establish the minimum grades. Provisions shall be made for preventing debris or sediment from entering the system by means of filters or collection and periodic removal of sediment from installed traps.

5. Materials for Subsurface Drains

Acceptable subsurface drain materials include perforated, continuous closed joint conduits of polyethylene plastic, concrete, corrugated metal, asbestos-cement, bituminized fiber, and polyvinyl chloride.

The conduit shall meet strength and durability requirements of the site.

6. Loading

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

7.Envelopes and Envelope Materials

Envelopes shall be used around subsurface drains for proper bedding and to provide better flow into the conduit. Not less than 3" of envelope material shall be used for sand-gravel envelopes. Where necessary to improve the characteristics of flow of groundwater into the conduit, more envelope material may be required.

Where county regulations do not allow sand-gravel envelopes, but require a special type and size of envelope material, they shall be followed.

Envelope material shall be placed to the height of the uppermost seepage strata. Behind bulkheads and retaining walls, it shall go to within twelve inches of the top of the structure. This standard does not cover the design of filter materials where needed.

Materials used for envelopes shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelope materials shall consist of either geotextile fabric or sand-gravel material, which shall pass a 1 1/2" sieve, 90 to 100 percent shall pass a 3/4" sieve, and not more than 10 percent shall pass a No. 60 sieve.

Geotextile fabric[43] envelopes can be either woven or nonwoven monofilament yarns and shall have a sieve opening ranging from 40-80. The envelope shall be placed in such a manner that once the conduit is installed, it shall completely encase the conduit.

The conduit shall be placed and bedded in a sand-gravel envelope. A minimum of 3" of envelope materials shall be placed on the bottom of a conventional trench. The conduit shall be placed on this and the trench completely filled with envelope material to a minimum depth of 3" above the conduit.

Soft or yielding soils under the drain shall be stabilized where required and lines protected from settlement by adding gravel or other suitable material to the trench, by placing the conduit on plank or other rigid support, or by using long sections of perforated or watertight pipe with adequate strength to insure satisfactory subsurface drain performance.

8.Use of Heavy Duty Corrugated Plastic Drainage Tubing

Heavy duty corrugated drainage tubing shall be specified where rocky or gravelly soils are expected to be encountered during installation operations. The quality of tubing will also be specified when cover over this tubing is expected to exceed 24" for 4", 5", 6", or 8" tubing. Larger size tubing designs will be handled on an individual job basis.

[43] Class F, see Table 27.

9.Auxiliary Structure and Subsurface Drain Protection

The outlet shall be protected against erosion and undermining of the conduit, against damaging periods of submergence, and against entry of rodents or other animals into the subsurface drain. An animal guard shall be installed on the outlet end of the pipe. A continuous 10' section of corrugated metal, cast iron, or steel pipe without perforations shall be used at the outlet end of the line and shall outlet 1.0 foot above the normal elevation of low flow in the outlet ditch or above mean high tide in tidal areas. No envelope material shall be used around the 10' section of pipe. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend to a point above the toe of the ditch side slope. If not possible, the side slope shall be protected from erosion.

Conduits under roadways and embankments shall be watertight and designed to withstand the expected loads.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Surface waterways shall be used where feasible.

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

Construction Specifications

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

2. All subsurface drains shall be laid to a uniform line and covered with envelope material. The pipe or tubing shall be laid with the perforations down and oriented symmetrically about the vertical center line. Connections will be made with manufactured functions comparable in strength with the specified pipe or tubing unless otherwise specified. The method of placement and bedding shall be as specified on the drawing.

3. Envelope material shall consist of geotextile fabric or a sand/gravel (which shall pass the 1 1/2" sieve, 90 to 100 percent shall pass 3/4" sieve, and not more than 10 percent shall pass the No. 60 sieve).

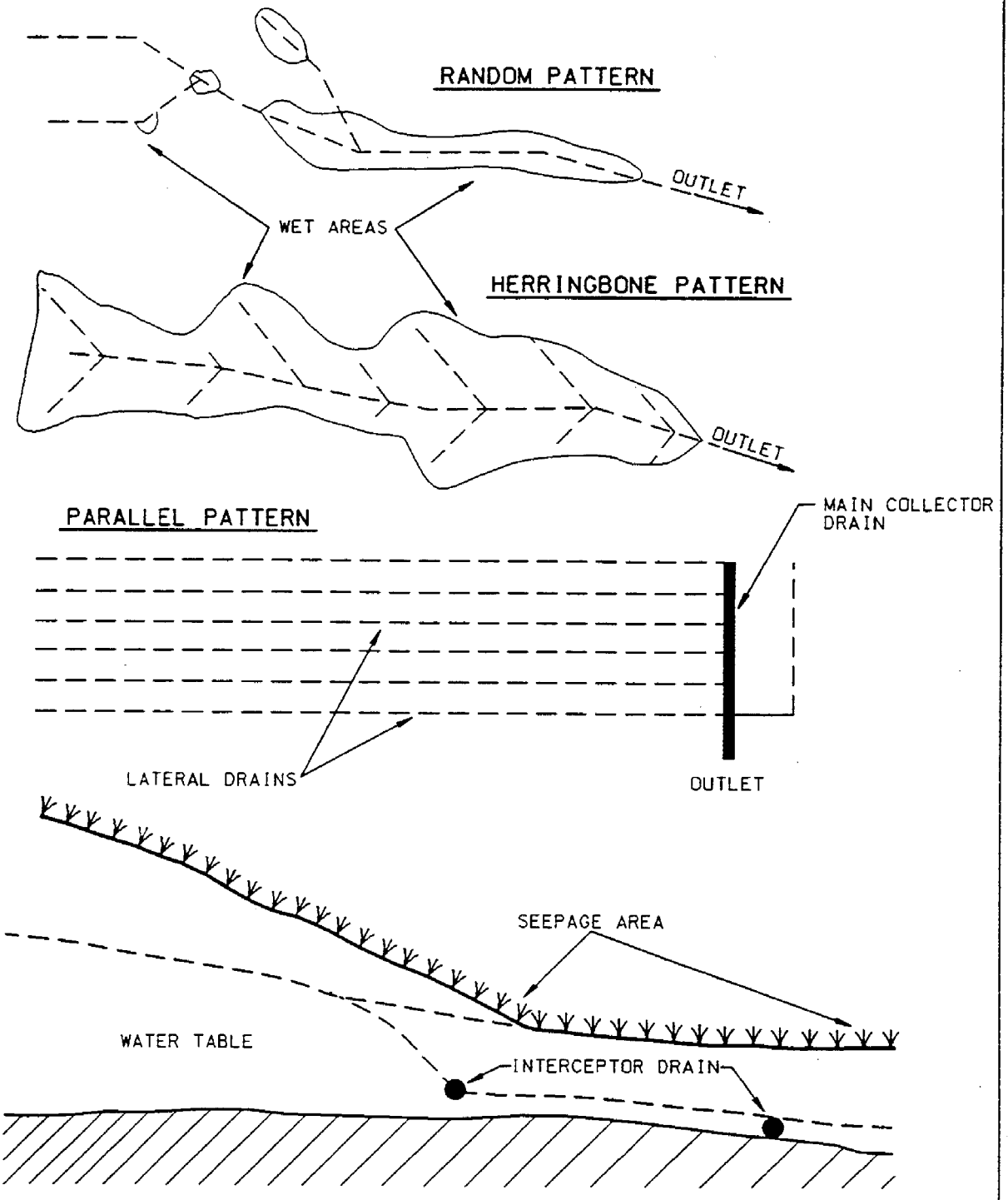
4. The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material unless connected to a structure.

5. A continuous 10' section of corrugated metal, cast iron, or steel pipe without perforations shall be used at the outlet end of the line. No envelope material shall be used around the 10' section of pipe. An animal guard shall be installed on the outlet end of the pipe.

6. Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur.

7. Where surface water is entering the system, the pipe outlet section of the system shall contain a swing type trash and animal guard.

FIGURE 6 – SUBSURFACE DRAIN



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1994

28.0 LINED WATERWAY OR OUTLET

Definition

A waterway or outlet with a lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to the designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

Purpose

To provide for the disposal of concentrated runoff without damage from erosion or flooding where grassed waterways would be inadequate due to high velocities.

Scope

This standard applies to waterways or outlets with linings of cast-in-place concrete, flagstone mortared in place, rock rip-rap, gabions, or similar permanent linings. It does not apply to irrigation ditch and canal linings, grassed waterways with stone centers, or small lined sections to carry prolonged low flows, or to reinforced concrete channels. The maximum capacity of the waterway flowing at design depth shall not exceed 100 cubic feet per second.

Conditions Where Practice applies

This practice applies where the following or similar conditions exist:

1. Concentrated runoff is such that a lining is required to control erosion.

2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.

3. The location is such that damage from use by people or animals precludes use of vegetated waterways or outlets.

4. Soils are highly erosive or other soil and climate conditions preclude using vegetation.

5. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

Design criteria

1. Capacity

   a. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour storm. Velocity shall be computed using Manning's equation with a coefficient of roughness "n" as follows:

Lined Material	"n"
Concrete (Type):	
Trowel Finish	0.015
Float Finish	0.019
Gunite	0.019
Flagstone	0.022
Rip-rap	Determine from Table 34
Gabion	0.030

b. Rip-rap and filter (bedding) shall be designed in accordance with criteria set forth in the National Cooperative Highway Research Program Report 108, available from the University Microfilm International, 300 N. Ree Road, Ann Arbor, Michigan 48016, Publication No. PB-00839; or Publication No. FHWA-IP-89-016, dated March 1989, available from Federal Highway Admin,, 4009 7th Street, S.W., Washington, Service's Engineering Field Manual, Chapter 16.

2. Velocity

a. Maximum design velocity shall be as shown below. Except for short transition sections, flow with a channel gradient within the range of 0.7 to 1.3 of this flow's critical slope must be avoided unless the channel is straight. Velocities exceeding critical will be restricted to straight reaches.

Design Flow Depth (ft.)	Maximum Velocity (ft./sec.)
0.0 - 0.5	25
0.5 - 1.0	15
Greater than 1.0	10

b. Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical, or to a velocity the downstream soil and vegetative conditions will allow.

3. Cross Section

The cross section shall be triangular, parabolic, or trapezoidal. Monolithic concrete or gabions may be rectangular.

4. Freeboard

The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required where good vegetation can be grown and is maintained.

5. Side Slope

Steepest permissible side slopes, horizontal to vertical, will be as follows:

a. Non-Reinforced Concrete

i. Hand-placed, formed concrete
Height of lining, 1.5 ft. or less .....Vertical

ii. Hand-placed screened concrete or mortared in place flagstone
Height of lining, less than 2 ft.....1 to 1
Height of lining, more than 2 ft.....2 to 1

b. Slip form concrete:

i. Height of lining, less than 3 ft.....1 to 1

c. Rock rip-rap.....2 to 1

i. Gabions.....Per specifications for gabions

6. Lining Thickness

a. Concrete.....4 in. (In most problem areas, minimum thickness shall be 5 in. with welded wire fabric reinforcing.)

b. Rock rip-rap.....1.5 x maximum stone size plus thickness of filter or bedding

c. Flagstone.....4 in. including mortar bed

7. Related Structures - Side inlets, drop structures, and energy dissipators shall meet the hydraulic and structural requirements of the site.

8. Filters or Bedding - Filters or bedding to prevent piping, reduce uplift pressure, and collect water will be used as required and will be designed in accordance with sound engineering principles. Weep holes and drains will be provided as needed.

9. Concrete

a. Concrete used for lining shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product will be required. A mix that can be certified as suitable to produce a minimum strength of at least 3,000 pounds per square inch will be required. Cement used shall be Portland Cement, Type I, II, IV, or V. Aggregate used shall have a maximum diameter of one and one half inches.

b. Weep holes should be provided in concrete footings and retaining walls to allow free drainage of water. Pipe used for weep holes shall be non-corrosive.

10. Mortar - Mortar used for mortared in-place flagstone shall consist of a mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

11. Contraction Joints - Contraction joints in concrete linings, where required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

12. Rock Rip-rap or Flagstone - Stone used for rip-rap or gabions shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

13. Cutoff - Cutoff walls shall be used at the beginning and ending of concrete lining, and for rock rip-rap lining, shall be keyed into the channel bottom at both ends of the lining.

14. Gabion Baskets - Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the site into a rectangular basket of similar size. Gabion baskets shall be installed according to the manufacturers specifications.

15. Geotextile fabric

Geotextile Class C[44] shall be placed beneath all rip-rap and gabions. The geotextile fabric shall consist of either woven or non-woven monofilament fiber and shall conform to ASTM D 1777, ASTM D 1682, having a thickness of 20-60 mils, and a grab strength of 90-120 lbs.

Construction Specifications

1. The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.

2. The cross-section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

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

4. Concrete linings shall be placed to the thickness shown on the plans and finished in a workmanlike manner. Adequate precautions shall be taken to protect freshly-placed concrete from freezing or extremely high temperatures, to insure proper curing.

5. Filter, bedding, and rock rip-rap shall be placed to line and grade and in the manner specified.

6. Construction operations shall be done in such a manner that erosion, air, and water pollution will be minimized and held within legal limits. The completed job shall present a workmanlike appearance. All disturbed areas shall be vegetated or otherwise protected against soil erosion.

Maintenance

1. Pavement or lining should be maintained as built to prevent undermining and deterioration. Trees should be removed next to pavements, as roots can cause uplift damage.

2. Vegetation next to pavement should be maintained in good condition to prevent scouring if the pavement is overtopped. See Standard and Specifications for Critical Area Stabilization for vegetative details.

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[44] Refer to Table 27

29.0 TEMPORARY ACCESS WATERWAY CROSSINGS

Definition

A temporary access waterway crossing is a structure placed across a waterway to provide access for construction purposes for a period of less than one year. Temporary access crossings shall not be utilized to maintain traffic for the general public.

Purpose

The purpose of the temporary access waterway crossing is to provide safe, pollution free access across a waterway for construction equipment by establishing minimum standards and specifications for the design, construction, maintenance, and removal of the structure. Temporary access waterway crossings are necessary to prevent construction equipment from damaging the waterway, blocking fish migration, and tracking sediment and other pollutants into the waterway. These standards and specifications may represent a channel constriction thus the **temporary** nature of waterway access crossings must be stressed. They should be planned to be in service for the shortest practical period of time and removed as soon as their function is completed.

Conditions Where Practice Applies

Any temporary access crossing shall conform to the technical requirements of these Standards and Specifications as well as any specific requirements imposed by the Water Resources Administration's Waterway Permits Division (301) 974-2265 Annapolis, Maryland. The following standards and specifications for temporary access waterway crossings are applicable in non-tidal waterways. These Standards and Specifications provide designs based on waterway geometry rather than the drainage area contributing to the point of crossing. The principal consideration for development of these Standards and Specifications is concern for soil erosion and sediment control. Structural integrity and safety must also be considered when designing temporary access waterway crossings to withstand expected loads. The three types of standard temporary access waterway crossings are bridges, culverts, and fords.

General Requirements

1. In-stream excavation

In-Stream excavation shall be limited to only that necessary to allow installation and removal of the standard methods as presented below in the individual practices section and shall not take place within the restricted time periods.

2. Elimination of Fish Migration Barriers

Of the three basic methods presented below in the individual practices section, bridges pose the least potential for creating barriers to aquatic migration. The construction of any specific crossing method, shall not cause a significant water level difference between the upstream and downstream water surface elevations.

Stream closure dates for fish spawning or migration within waterways are as follows:

Use I and IP	March 1 - June 15
Use II	June 1 - September 30 and December 16 - March 14
Use III and IIIP	October 1 - April 30
Use IV	March 1 - May 31
SAV (All flowing streams)	April 15 - October 15

Therefore, the stream channel must not be disturbed during these periods. For more information about the closures based on stream uses contact MDE Water Quality Certification Division at (410) 631-3509 and for more information about closures based on submerged aquatic vegetation (SAV) contact the Department of Natural Resources at (410) 974-3841.

3. Crossing Alignment

The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

4. Road Approaches

The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50' from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50' minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2' above the existing floodplain elevation. To the extent possible, the work on the approaches primarily within the floodplain shall be limited to grading to keep the road close to the existing grades.

5. Surface Water Diverting Structure

A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with the Standards and Specifications for the individual design standard of choice. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

6. Road Width

All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.

7. Time of Operation

All temporary crossings shall be removed within 14 calendar days after the structure is no longer needed. Unless prior written approval is obtained from the Water Resources Administration, all structures shall be removed within one year from the date of the installation. Removal of the structure shall not take place during the spawning periods for the stream as stated above.

8. Materials:

a. Aggregate - There shall be no earth or soil materials used for construction within the waterway channel. State Highway Administration coarse aggregate designation No. 5, (3/4" to 4") also referenced as AASHTO designation No. 1, shall be the minimum acceptable aggregate size for temporary crossings. Larger aggregates will be allowed.

b. Geotextile fabric - Geotextile fabric is a fabric consisting of either woven or nonwoven plastic, polypropylene, or nylon used to distribute the load, retain fines, allow increased drainage of the aggregate, and reduce mixing of the aggregate with the subgrade soil. Approved geotextile fabrics shall be used, as required by the specific method.

Temporary Access Waterway Crossing Methods

1. Considerations for Choosing a Specific Method

The following criteria for soil erosion and sediment control shall be considered when selecting a specific temporary access waterway crossing standard method:

a. Site aesthetics: Select a standard design method that will least disrupt the existing terrain of the stream reach. Consider the effort that will be required to restore the area after the temporary crossing is removed.

b. Site location: Locate the temporary crossing where there will be the least disturbance to the soils of the existing waterway banks. When possible, locate the crossing at a point receiving minimal surface runoff.

c. Physical site constraints: The physical constraints of a site may preclude the selection of some of the standard methods.

d. Time of year: The time of year may preclude the selection of one or more of the standard methods due to fish spawning or migration restrictions.

e. Vehicular loads and traffic patterns: Vehicular loads, traffic patterns, and frequency of crossings should be considered in choosing a specific method.

f. Maintenance of crossing: The standard methods will require various amounts of maintenance. The bridge method should require the least maintenance, whereas the ford method will probably require more intensive maintenance.

g. Removal of the structure: Ease of removal and subsequent damage to the waterway should be primary factors in considering the choice of a standard method.

Temporary Ford

A temporary access ford is a shallow structure placed in the bottom of the waterway over which the water flows while still allowing traffic to cross the waterway.

Considerations

Temporary fords maybe used when bridge or culvert crossings are not possible and the streambed is armored with naturally occurring bedrock, or can be protected with an aggregate layer in conforming with these specifications.

Construction Specifications

1. Restrictions - Use or removal of a temporary access will not be permitted between - Class III, October 1 through April 30 and Class IV, March 1 through May 31. For other streams, use or removal of a temporary ford will be prohibited from March 1 through June 15 of each year because fish are spawning during this period.

2. The approaches to the structure shall consist of stone pads.

The entire ford approach (where banks were cut) shall be covered with geotextile fabric and protected with aggregate to a depth of 4 inches.

3. Fords shall be prohibited when the stream banks are 4 feet or more in height above the invert of the stream and a bridge or culvert crossing cannot be constructed.

4. The approach roads at the cut banks shall be no steeper than 5:1. Spoil material from the banks shall be stored out of the flood plain and stabilized.

5. One layer of geotextile fabric shall be placed on the streambed, streambanks, and road approaches prior to placing the bedding material on the stream channel or approaches. The geotextile fabric shall extend a minimum of 6 inches and a maximum one foot beyond bedding material.

6. The bedding material shall be coarse aggregate or gabion mattresses filled with coarse aggregate.

7. All fords shall be constructed to minimize the blockage of stream flow and shall allow free flow over the ford. The placing of any material in the waterway bed will cause some upstream ponding. The depth of this ponding will be equivalent to the depth of the material placed within the stream and therefore should be kept to a minimum height. However, in no case will the bedding material be placed deeper than 12 inches or one half (1/2) the height of the existing banks, whichever is smaller.

8. Stabilization - All areas disturbed during ford installation shall be stabilized within 14-calendar days of that disturbance in accordance with the Standards for "Critical Area Stabilization With Permanent Seeding."

Ford Removal and Clean-Up Requirements

Removal and Final Clean-Up

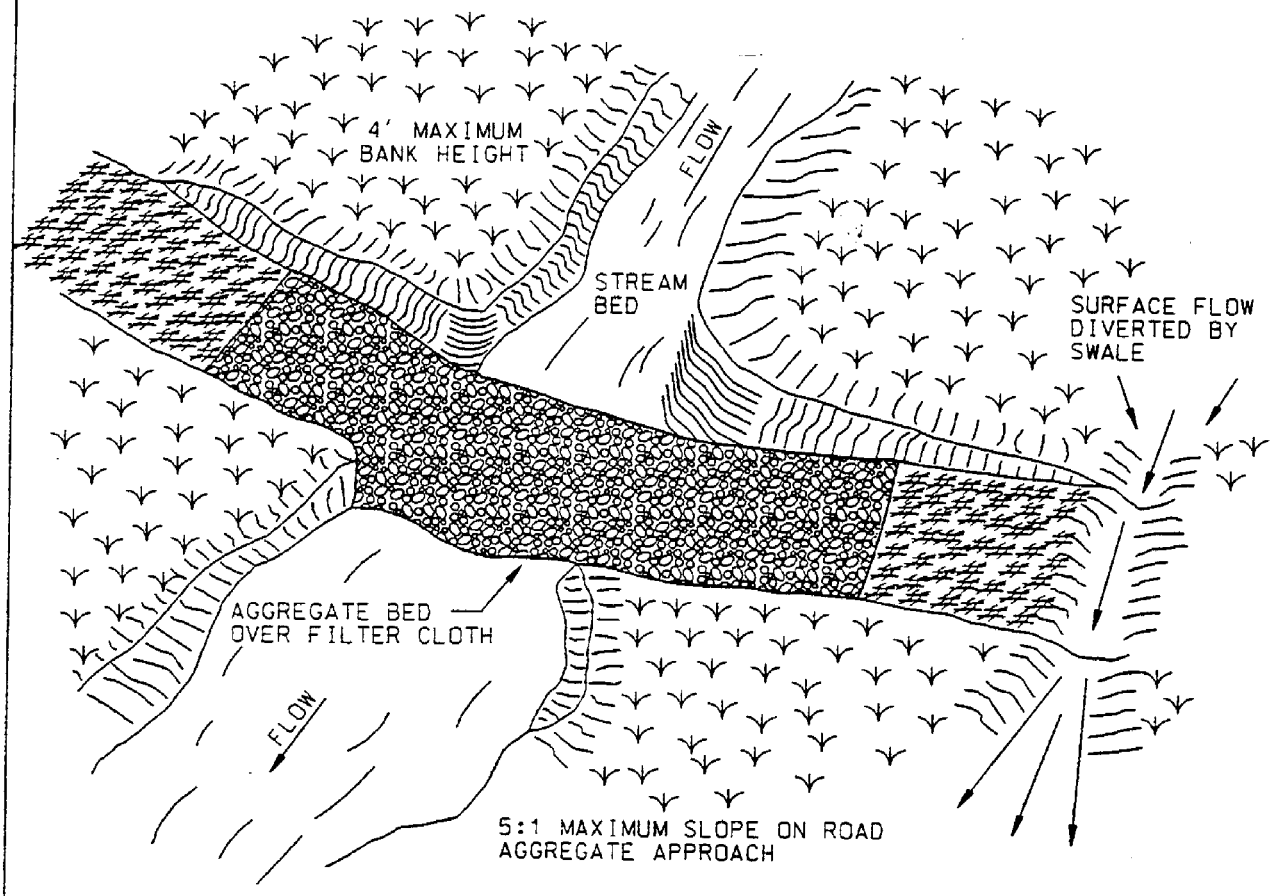
When the temporary structure has served its purpose. Care should be taken so that any aggregate left does not create an impoundment or restrict fish passage. Final clean-up shall consist of removal of excess temporary ford materials from the waterway. All materials shall be stored outside the waterway floodplain.

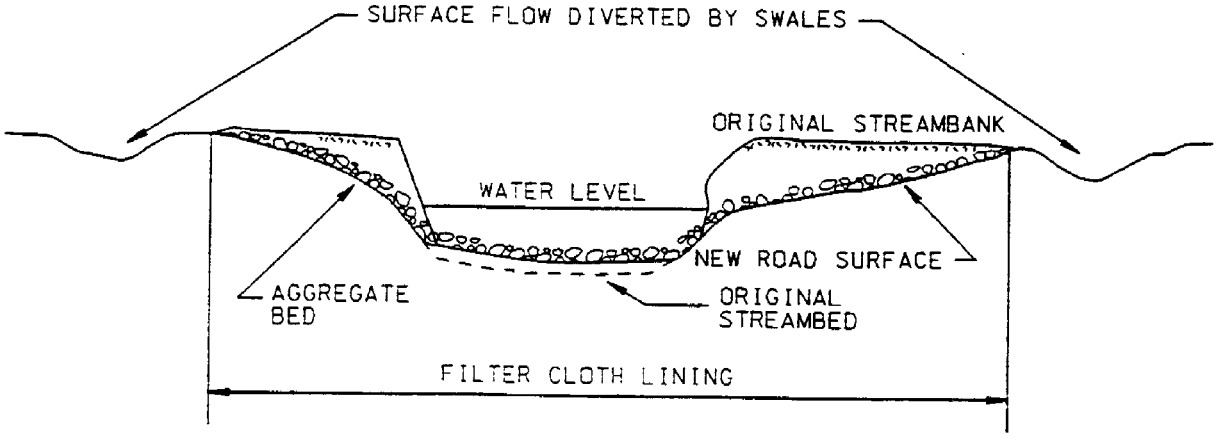
1. Method - Clean up shall be accomplished without construction equipment working in the stream channel.

2. Approach Disposition - The approach slopes of the cut banks shall not be backfilled.

3. Final Stabilization - All areas disturbed during ford removal shall be stabilized within 14-calendar days of that disturbance in accordance with the Standard for "Critical Area Stabilization With Permanent Seeding."

DETAIL 34 TEMPORARY ACCESS FORD





TEMPORARY ACCESS FORD

Construction Specifications

1. Restrictions - Use or removal of a temporary access will not be permitted between October 1 and April 30 for all Class III and Class IV Trout Waters. For other streams, use or removal of a temporary ford will be prohibited from March 1 through June 15 of each year because fish are spawning during this period.

2. The approaches to the structure shall consist of stone pads. The entire ford approach (where banks were cut) shall be covered with filter cloth and protected with aggregate to a depth of 4 inches.

3. Fords shall be prohibited when the stream banks are 4 feet or more in height above the invert of the stream and a bridge or culvert crossing can easily be constructed.

4. The approach roads at the cut banks shall be no steeper than 5:1. Spoil material from the banks shall be stored out of the flood plain and stabilized.

5. One layer of filter cloth shall be placed on the streambed, streambanks, and road approaches prior to placing the bedding material on the stream channel or approaches. The filter cloth shall extend a minimum of 6 inches and a maximum one foot beyond bedding material.

6. The bedding material shall be coarse aggregate or gabion mattresses filled with coarse aggregate.

7. Aggregate used in ford construction shall be SHA Class I.

8. All fords shall be constructed to minimize the blockage of stream flow and shall allow free flow over the ford. The placing of any material in the waterway bed will cause some upstream ponding. The depth of this ponding will be equivalent to the depth of the material placed within the stream and therefore should be kept to a minimum height. However, in no case will the bedding material be placed deeper than 12" or 1/2 the height of the existing banks, whichever is smaller.

9. Stabilization - All areas disturbed during ford installation shall be stabilized within 14-calendar days of that disturbance in accordance with the Standards for Stabilization With Permanent Seeding."

INDIVIDUAL PRACTICES

Temporary Access Bridge

A temporary access bridge is a structure made of wood, metal, or other materials which provides access across a stream or waterway.

Considerations

1. Preferred Method - This is the preferred method for temporary access waterway crossings. Normally, bridge construction causes the least disturbance to the waterway bed and banks when compared to the other access waterway crossings. Disturbance to the stream banks shall be kept to a minimum.

2. Most bridges can be quickly removed and reused.

3. Temporary access bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings.

Construction Specifications

1. Restriction - Construction, use, or removal of a temporary access bridge will not normally have any time of year restrictions since construction, use, or removal should not affect the stream or its banks, unless the bridge is built with a pier(s) in the water.

2. Bridge Placement - A temporary bridge structure shall be constructed at or above the bank elevation to prevent the entrapment of floating materials and debris.

3. Abutments - Abutments shall be placed parallel to, and on, stable banks.

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

5. Stringers - Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

6. Deck Material - Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

7. Run Planks (optional) - Run planking shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

8. Curbs or fenders - Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

9. Bridge Anchors - Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

10. Stabilization - All areas disturbed during installation shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Areas Stabilization With Permanent Seeding."

Bridge Maintenance Requirements

1. Inspection - Periodic inspection shall be performed by the user to ensure that the bridge, streambed, and stream banks are maintained and not damaged.

2. Maintenance - Maintenance shall be performed, as needed to ensure that the structure complies with the standard and specifications. This shall include removal and disposal of any trapped sediment or debris. Sediment shall be disposed of outside of the flood plain and stabilized.

Bridge Removal and Clean-Up Requirements

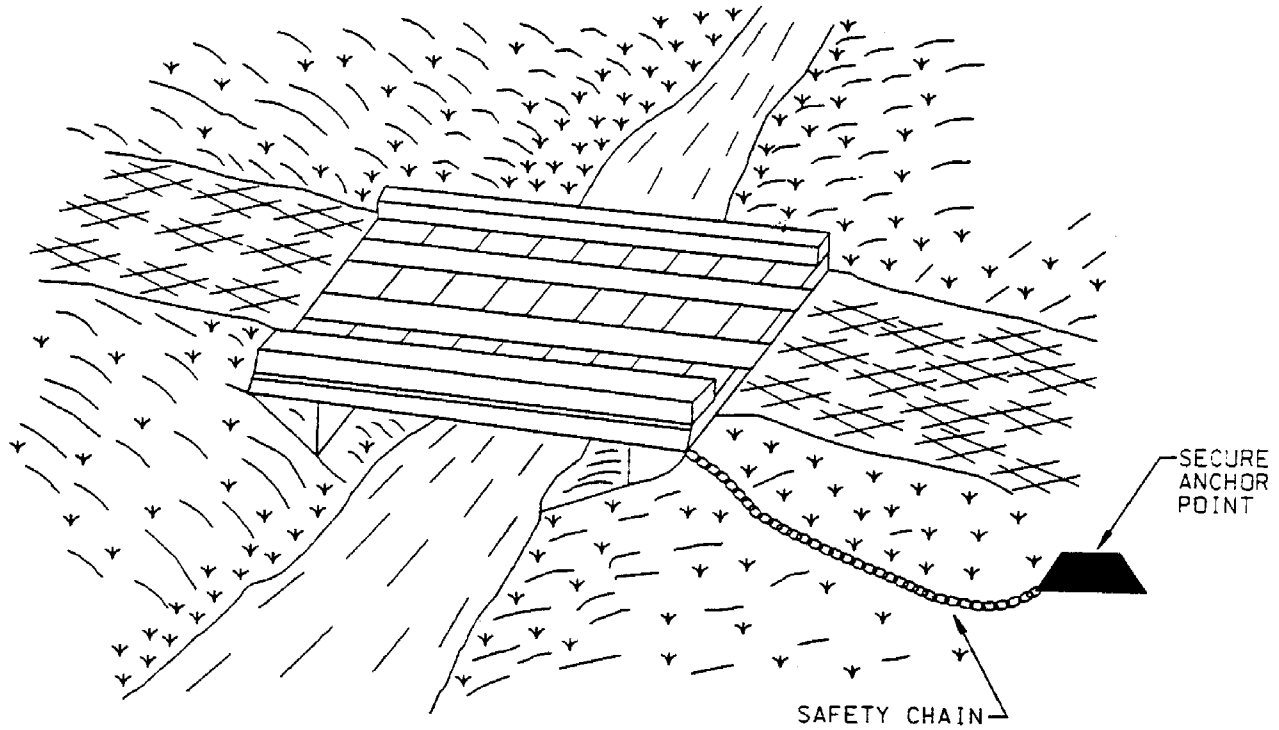
1. Removal - When the temporary bridge is no longer needed, all structures including abutments and other bridging materials shall be removed within 14 calendar days. In all cases, the bridge materials shall be removed within one year of installation.

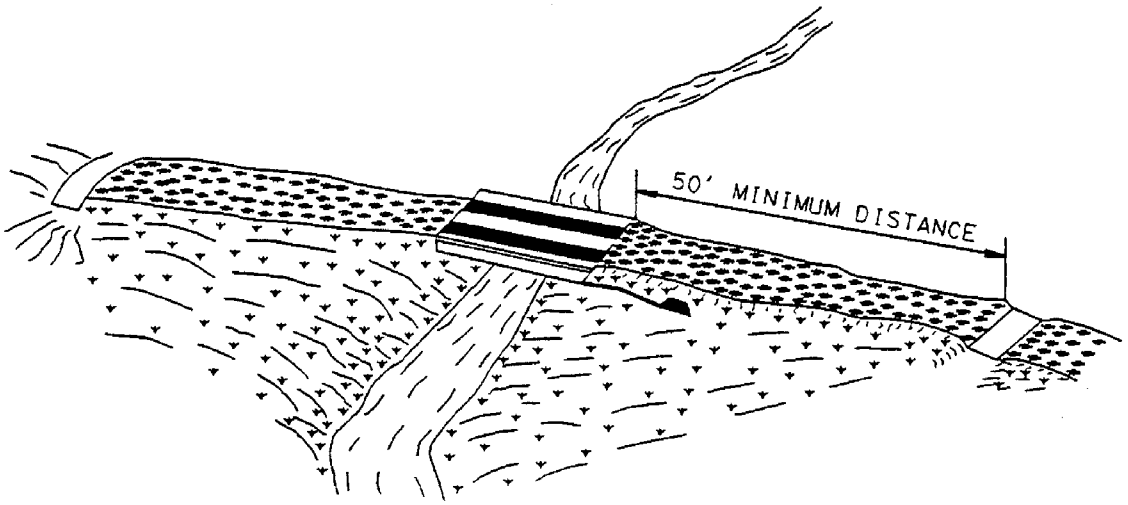
2. Final Clean-Up - Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside the waterway floodplain.

3. Method - Removal of the bridge and clean up of the area shall be accomplished without construction equipment working in the waterway channel.

4. Final Stabilization - All areas disturbed during removal shall be stabilized within 14 calendar days of that disturbance in accordance with the Standards for "Critical Area Stabilization With Permanent Seeding."

DETAIL 35 TEMPORARY ACCESS BRIDGE





TEMPORARY ACCESS BRIDGE

Construction Specifications

1. Restriction - Construction, use, or removal of a temporary access bridge will not normally have any time of year restrictions since construction, use, or removal should not affect the stream or its banks, unless the bridge is built with a pier(s) in the water.

2. Bridge Placement - A temporary bridge structure shall be constructed at or above the bank elevation to prevent the entrapment of floating materials and debris.

3. Abutments - Abutments shall be placed parallel to, and on, stable banks.

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

5. Stringers - Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

6. Deck Material - Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

7. Run Planks (optional) - Run planking shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

8. Curbs or fenders - Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

TEMPORARY ACCESS BRIDGE

9. Bridge Anchors - Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

10. Stabilization - All areas disturbed during installation shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Areas Stabilization With Permanent Seeding."

Temporary Access Culvert

A temporary access culvert is a structure consisting of a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossing.

Considerations

1. Temporary culverts are used where (1) the channel is too wide for normal bridge construction, (2) anticipated loading may prove unsafe for single span bridges, or (3) aecess is not needed from bank to bank.

2. This temporary waterway crossing method is normally preferred over a ford type of crossing, since disturbance to the waterway is only during construction and removal of the culvert.

3. Temporary culverts can be salvaged and reused.

Construction Specifications

1. Restrictions - No Construction or removal of a temporary access culvert will be permitted between - Class III, October 1 through April 30 and Class IV, March 1 through May 31. For other streams, use or removal of a temporary ford will be prohibited from March 1 through June 15 of each year because fish are spawning during this period.

2. Culvert Strength - All culverts shall be strong enough to support their cross sectional area under maximum expected loads.

3. Culvert Size - The size of the culvert pipe shall be the largest pipe diameter that will fit into the existing channel without major excavation of the waterway channel or without major approach fills. If a channel width exceeds 3 feet, additional pipes may be used until the cross sectional area of the pipes is greater than 60 percent of the cross sectional area of the existing channel. The minimum size culvert that may be used is a 12" diameter pipe. In all cases, the pipe(s) shall be large enough to convey normal stream flows.

4. Culvert Length - The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe to the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.

5. Geotextile fabric - Geotextile fabric shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The geotextile fabric shall cover the streambed and extend a minimum six inches and a maximum one foot beyond the end of the culvert and bedding material. Geotextile fabric reduces settlement and improves crossing stability.

6. Culvert Placement - The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration (free passage of fish).

7. Culvert Protection - The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used they shall be separated by at least 12" of compacted aggregate fill.

8. Stabilization - All areas disturbed during culvert installation shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Area Stabilization With Permanent Seeding."

Culvert Maintenance Requirements

1. Inspection - Periodic inspection shall be performed to ensure that the culverts, streambed, and streambanks are not damaged, and that sediment is not entering the stream or blocking fish passage or migration.

2. Maintenance - Maintenance shall be performed, as needed in a timely manner to ensure that structures are in compliance with this standard and specifications. This shall include removal and disposal of any trapped sediment or debris. Sediment shall be disposed of and stabilized outside the waterway floodplain.

Culvert Removal and Clean-Up Requirements

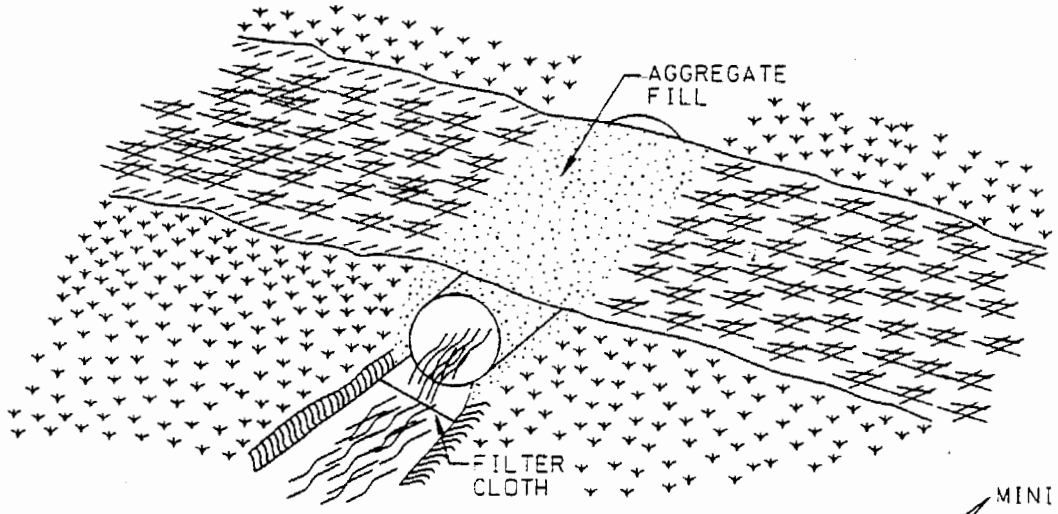
1. Removal - When the crossing has served its purpose, all structures including culverts, bedding and geotextile fabric materials shall be removed within 14 calendar days. In all cases, the culvert materials shall be removed within one year of installation. No structure shall be removed during the spawning season as stated in the general temporary access criteria.

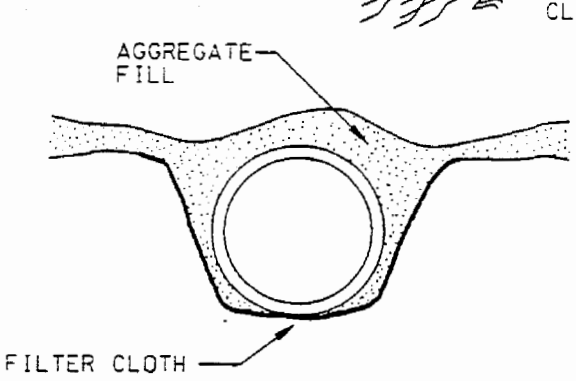
2. Final Clean-up - Final clean-up shall consist of removal of the temporary structure from the waterway, removal of all construction materials, restoration of original stream channel cross section, and protection of the stream banks from erosion. Removed material shall be stored outside of the waterway floodplain.

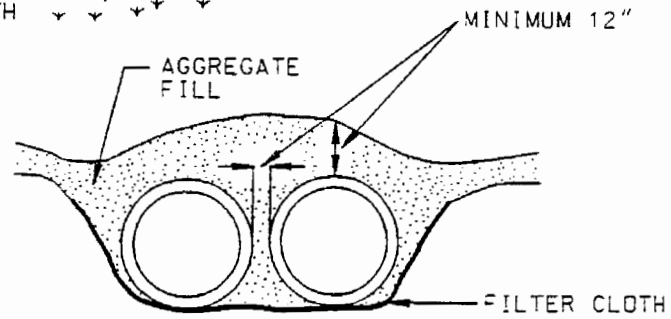
3. Method - Removal of the structure and clean up of the area shall be accomplished without construction equipment working in the waterway channel.

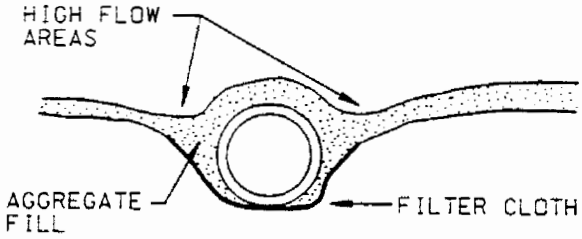
4. Final Stabilization - All areas disturbed during culvert removal shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Area Stabilization With Permanent Seeding."

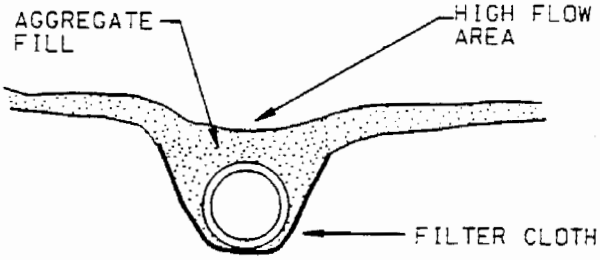
DETAIL 36 TEMPORARY ACCESS CULVERT

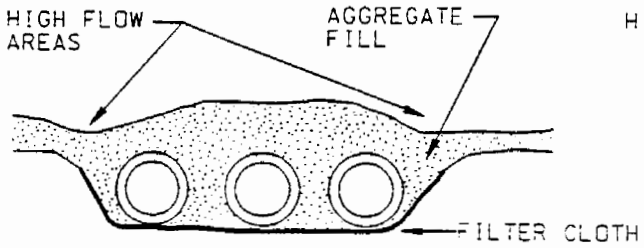




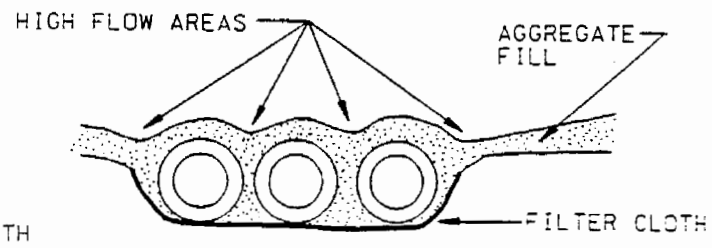








MULTIPLE PIPES



MULTIPLE PIPES

TEMPORARY ACCESS CULVERT

Construction Specifications

1. Restrictions - No Construction or removal of a temporary access culvert will be permitted between October 1 through April 30 for Class III and Class IV Trout Waters or between March 1 through June 15 for non-trout waterways.

2. Culvert Strength - All culverts shall be strong enough to support their cross sectional area under maximum expected loads.

3. Culvert Size - The size of the culvert pipe shall be the largest pipe diameter that will fit into the existing channel without major excavation of the waterway channel or without major approach fills. If a channel width exceeds 3 feet, additional pipes may be used until the cross sectional area of the pipes is greater than 60 percent of the cross sectional area of the existing channel. The minimum size culvert that may be used is a 12" diameter pipe. In all cases, the pipe(s) shall be large enough to convey normal stream flows.

4. Culvert Length - The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe to the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.

5. Filter Cloth - Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum six inches and a maximum one foot beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability.

6. Culvert Placement - The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration (free passage of fish).

7. Culvert Protection - The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used they shall be separated by at least 12" of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in Section I.H.1. above.

8. Stabilization - All areas disturbed during culvert installation shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Area Stabilization With Permanent Seeding."

30.0 DUST CONTROL

Definition

Controlling dust blowing and movement on construction sites and roads.

Purpose

To prevent blowing and movement of dust from exposed soil surfaces, reduce on and off-site damage, health hazards, and improve traffic safety.

Conditions Where Practice Applies

This practice is applicable to areas subject to dust blowing and movement where on and off-site damage is likely without treatment.

Specifications

Temporary Methods

1. Mulches - See standards for vegetative stabilization with mulches only. Mulch should be crimped or tacked to prevent blowing.

2. Vegetative Cover - See standards for temporary vegetative cover.

3. Tillage - To roughen surface and bring clods to the surface. This is an emergency measure which should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12" apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

4. Irrigation - This is generally done as an emergency treatment. Site is sprinkled with water until the surface is moist. Repeat as needed. At no time should the site be irrigated to the point that runoff begins to flow.

5. Barriers - Solid board fences, silt fences, snow fences, burlap fences, straw bales, and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 10 times their height are effective in controlling soil blowing.

6. Calcium Chloride - Apply at rates that will keep surface moist. May need retreatment.

Permanent Methods

1. Permanent Vegetation - See standards for permanent vegetative cover, and permanent stabilization with sod. Existing trees or large shrubs may afford valuable protection if left in place.

2. Topsoiling - Covering with less erosive soil materials. See standards for topsoiling.

3. Stone - Cover surface with crushed stone or coarse gravel.

References

1. Agriculture Handbook 346. Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss.

2. Agriculture Information Bulletin 354. How to Control Wind Erosion, USDA-ARS.

3) Practice Categories - Standard for Vegetative Practices

a. Vegetative Standards
Source: Georgia, GA-1

b. Vegetative - Standards
Source: Alabama: AL-1

Coastal Dune Stabilization (With Vegetation)

Cs

DEFINITION

Planting vegetation on dunes that are denuded, artificially constructed, or re-nourished.

PURPOSE

To stabilize soil on dunes allowing them to become more resistant to wind and waves, and to allow development of dunes in areas where they have been damaged or destroyed.

CONDITIONS

On bare or sparsely vegetated dunes or areas where dune development is desired.

PLANNING CONSIDERATIONS

1. Coastal beaches are subject to regulation from a variety of Federal, State, and local agencies. Permits must be requested and granted by all appropriate jurisdictions before work is performed.

2. Coastal areas are affected by many dynamic systems. Detailed studies are often required to determine the possible effects that may result from dune modifications. Environmental assessments are generally required including public review and comment.

3. Protection of dunes from human and vehicular traffic is essential if vegetation is to succeed. Crosswalks or crossover structures should be planned to provide beach access.

4. Plant species that are native to coastal areas should be used whenever possible.

5. An irrigation system will be required during the first growing season in order to obtain good survival.

6. Vegetation: Commercially available plants include the following:

   a. Marshhay cordgrass (Spartina patens) "Flageo" variety or native collections.
   Marshhay cordgrass is a perennial grass that occurs on dunes throughout the South Atlantic and Gulf region and in Puerto Rico. It is the dominant plant on dunes composed of broken shale and coquina rock along the northern Florida coast. The grass is especially tolerant of salt.

   Stems are slender and grow two to three feet tall. Leaves are rolled inward and resemble rushes. Seed heads are composed of two to several compressed spikes attached at about 90 degrees to the culm. Plants spread by means of a network of slender rhizomes.

   Plantings of vegetative material in early spring are most successful. Bare root or potted planting stock is recommended for large plantings. Stems rooted at the base can be planted at a depth of four to five inches deep. Plants that have developed rhizomes are preferred for planting stock.

   b. Bitter panicum (Panicum amarum)

   Bitter panicum is a perennial grass found on dunes throughout the South Atlantic and Gulf regions. It is most common in South Florida and Texas.

   Plants grow to an average height of three to four feet tall. Leaves are smooth and bluish green color. Seed heads are narrow, compressed, and generally are sparsely seeded. Plants spread from a very aggressive, scattered system of rhizomes, but stands are rather open.

   Bitter panicum produces few viable seed but is easier to transplant than sea oats. They can be propagated from a stem with part of the rhizome attached or from rhizomes that are eight to twelve inches long. Plant rhizomes about four inches deep in early spring.

   Plants may be propagated by removing all of the stem from robust plants and placing them in the dune at an angle of about 45 degrees. Several nodes should be buried. Spacing should be no more than six feet apart .

c. Coastal Panicgrass (Panicum amarum v. amaralum)

Coastal panicgrass is a somewhat dense, upright perennial bunchgrass found on coastal dunes throughout the South Atlantic and Gulf area. It is the dominant plant at many locations in, West Florida, Alabama, and Texas.

The stems are coarse, straight, stiff, and up to four feet tall. Partially compressed seed heads produce moderate amounts of viable seed each fall. The crowns enlarge slowly from short, almost vertical tillers.

Plant seed one to three inches deep and mulch the area. Seedling survival depends on adequate moisture after germination. Clumps of coastal panicgrass can be dug, divided and planted during rainy seasons or when irrigation is available.

Sand Fence Use In Building Dunes

Sand fence may be used to build sand dunes when sand is available. Costs are usually higher but dune development is faster when compared to vegetation alone and generally less expensive than building dunes with machinery.

To form a barrier dune, construct sand fences a minimum of 100 feet from the mean high tide line. Two or more parallel fences spaced from 30 to 40 feet apart are needed. Locate fences as near as possible to a 90 degree angle with toe prevailing winds, but as near parallel to the water line as possible.

Where winds are generally parallel with the water line, a single line of fence may be constructed at least 140 feet from the mean high tide. Construct short sections of fence (approximately 30 feet long) parallel to the prevailing wind and approximately perpendicular to the original fence. Place these fences opposite the water side and space these fences about 40 feet apart.

As sand collects over the fence, additional fence can be constructed over the original fence until the desired height is obtained.

Old dunes may be widened by constructing sand fence about 15 feet to the seaward side of the base of the old dune.

Vegetation must be established following development of dune, or allowed to develop from existing stands as dunes develop.

SPECIFICATIONS

Sand Fence Specifications

Use standard commercial 4-foot high snow fence that consists of wooden slats wired together with spaces between the slats. Distance between slats is approximately equal to the slat width, or generally 1 1/4 inches. Slats will be made from grade A or better spruce. Slats will be woven between five two-wire cables of copper-bearing, galvanized wire. Slats will be dipped in a red oxide, weather resistant stain. The fence must be sound, free of decay, broken wire or missing or broken slats.

Fence will be supported by black locust, red cedar, or white cedar posts. Other wood of equal life or strength may be used. Posts will be a minimum of 7' with a minimum diameter of three inches. Posts will be spaced no farther than 10 feet apart.

Four wire ties will be used to fasten fence to posts. Weave fence between posts so that every other post will be attached on the ocean side of posts. Tie wires will be no smaller than 12-gauge galvanized wire.

Posts will be set in holes at least three feet deep.

Three or four rows of fence should be used if sufficient land area and sand is available.

MAINTENANCE

Maintaining Dunes

A strong, uniform dune line must be maintained to provide maximum protection from wind and water. Blow-outs, wash pits, or other natural or man-made damage must be repaired quickly in order to prevent weakening the entire system. Blow-outs in a dune system can be repaired by placing sand fence between existing dunes. One or more fences may be required. It is essential to tie the ends of the fence into the existing dune to keep the wind from slipping around the ends. Maintain fences, and erect additional fences if needed, until the eroding area is replenished to the desired height and permanently stabilized.

Foot and vehicular traffic must be controlled or prohibited on dunes in order to maintain vegetation and prevent excessive sand movement. Elevated walks, semi-permanent paved paths, and portable roll-up walkways are satisfactory. Walkways should be curved to reduce wind movement. Both inland and secondary dunes must be protected from traffic.

Vegetative Maintenance

Plantings are maintained with applications of fertilizer applied to keep desired density of plants. Annual application of about 50 pounds of nitrogen per acre should be applied. Where vegetation has been destroyed, replanting should be considered.

Disturbed Area Stabilization (With Mulching Only)

Ds1

DEFINITION

Applying plant residues or other suitable materials not produced on the site to the soil surface.

PURPOSE

To reduce runoff and erosion; conserve moisture, prevent surface compaction or crusting; to control undesirable vegetation; to modify soil temperature; to increase biological activity in the soil.

SPECIFICATIONS

A. For temporary protection of critical areas without seeding.

This standard applies to grades or cleared areas which may be subjected to erosion for 6 months or less, where seedings may not have a suitable growing season to produce an erosion retardant cover, *but which can be stabilized with a mulch cover.*

Site Preparation

1. Grade, as needed and feasible, to permit the use of equipment for applying and anchoring mulch.
2. Install needed erosion control measures as required such as dikes, diversions, berms, terraces and sediment barriers.
3. As needed and feasible, loosen compact soil to a minimum depth of 3 inches.

Mulching Materials

1. Dry straw or hay — spread at a rate of 2 1/2 tons per acre.
2. Wood waste, chips, sawdust or bark— spread 2 to 3 inches deep (about 6 to 9 tons per acre).
3. Erosion control matting or netting, such as excelsior, jute, textile and plastic matting and netting — applied in accordance with manufacturers recommendations.
4. Cutback asphalt, slow curing — applied at 1200 gallons per acre (or 1/4 gallon per sq. yd.)
5. Polyethylene film — secured over banks or stockpiled soil material for temporary protection.

Applying and Anchoring Mulch

1. Apply straw or hay mulch uniformly by hand or mechanically. Anchor as appropriate and feasible. It may be pressed into the soil with a disk harrow with the disk set straight or with a special "packer disk." The disk may be smooth or serrated and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the disk should be dull enough not to cut the mulch but to press it into the soil leaving much of it in an erect position.
   Straw hay mulch spread with special blower-type equipment may be anchored with emulsified asphalt (Grade AE-5 or SS-1). The asphalt emulsion must be sprayed onto the mulch as it is ejected from the machine. Use 100 gallons of water per ton of mulch.
2. Spread wood waste uniformly on slopes that are 3:1 and flatter. No anchoring is needed.
3. Commercial matting and netting. Follow manufacturer's specification included with the material.
4. Apply asphalt so area has uniform appearance. (Note: Use in areas of pedestrian traffic could cause problems of "tracking in" or damage to shoes, clothing, etc.)

B. To conserve moisture and control weeds in nurseries, ornamental beds, around shrubs, and on bare areas on lawns.

Mulching materials

Use one of the materials given below and apply at thickness indicated.

Material	Depth
1. Grain straw or grass hay	6" to 10"
2. Pine needles	4" to 6"
3. Wood waste (sawdust, bark, chips)	4" to 8"
4. Shredded residues (crops, leaves, etc.)	4" to 8"

5. Completely cover area with black polyethylene film and hold in place by placing soil on the outer edge.

When using organic mulches, apply 20-30 pounds of nitrogen in addition to the normal amount needed for plant growth to offset the tie up of N by decomposition of mulch.

Disturbed Area Stabilization (With Temporary Seedings)

Ds2

DEFINITION

Establishing temporary vegetative cover with fast growing seedings on disturbed or denuded areas.

PURPOSE

— To reduce erosion, sediment and runoff damages to downstream resources.
— To improve wildlife habitat.
— To improve aesthetics.
— To improve safety and public road rights-of-way.
— To improve tilth and add organic matter for permanent plantings.

CONDITIONS

This practice is applicable on areas subject to erosion for up to twelve months or until establishment of finished grade or permanent vegetative cover. Temporary vegetative measures should be coordinated with permanent measures to assure economical and effective stabilization.

SPECIFICATIONS

A. Grading and Shaping

1. Excessive water run-off must be controlled by planned and installed erosion control practices such as closed drains, ditches, dikes, diversions, sediment basins and others.
2. No shaping or grading is required if slopes can be stabilized by hand-seeded vegetation or if hydraulic seeding equipment is to be used.

B. Seedbed Preparation

1. When a hydraulic seeder is used, seedbed preparation is not required.
2. When using conventional or hand-seeding, seedbed preparation is not required if the soil material is loose and not sealed by rainfall.
3. When soil has been sealed by rainfall or consists of smooth undisturbed cut slopes, the soil shall be pitted, trenched or otherwise scarified to provide a place for seed to lodge and germinate.

C. Lime and Fertilizer

1. Agricultural lime is not required.
2. On reasonably fertile soils or soil material, fertilizer is not required.
3. On soils of very low fertility, use 500 to 700 pounds of 10-10-10 fertilizer or the equivalent per acre (12-16 lbs./1,000 sq. ft.). If the site will permit, apply before land preparation and disk, rip or chisel to incorporate.

D. Seeding

1. Select a grass or grass-legume mixture suitable to the area and season of the year.
2. Apply seed uniformly by hand, cyclone seeder, drill, cultipacker-seeder, or hydraulic seeder (slurry including seed and fertilizer). Drill or cultipacker seeders should normally place seed one-half to one inch deep.

E. Mulching

Temporary vegetation can, in most cases, be established without the use of mulch. Mulch without seeding should be considered for short term protection. See Ds1 - Disturbed Area Stabilization, (With Mulching Only).

F. Irrigation

If water is applied, it must be at a rate not causing runoff and erosion. Thoroughly wet the soil to a depth that will insure germination of the seed. Subsequent applications should be made when needed.

Table 6-24.1

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas — Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
BARLEY (Hordeum vulgare)			M-L 4/ P C		
alone	3 bu. (144 lbs.)	3.3 lb			14,000 seed per pound. Winterhardy. Use on productive soils.
in mixtures	1/2 bu. (24 lbs.)	0.6 lb.			
LESPEDEZA, ANNUAL (Lespedeza striata)			M-L P C		
alone	40 lbs.	0.9 lb.			200,000 seed per pound. May volunteer for several years. Use inoculant EL.
in mixtures	10 lbs.	0.2 lb.			
LOVEGRASS, WEEPING (Eragrostis curvula)			M-L P C		1,500,000 seed per pound. May last for several years. Mix with Sericea lespedeza.
alone	4 lbs.	0.1 lb.			
in mixtures	2 lbs.	0.05 lb.			
MILLET, BROWNTOP (Panicum fasciculatum)			M-L P C		137,000 seed per pound. Quick dense cover. Will provide too much competition in mixtures if seeded at high rates.
alone	40 lbs.	0.9 lb.			
in mixtures	10 lbs.	0.2 lb.			

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas — Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
MILLET, PEARL (Pennesetum glaucum)			M-L P C		88,000 seed per pound. Quick dense cover. May reach 5 feet in height. Not recommended for mixtures.
alone	50 lbs.	1.1 lb			
OATS (Avena sativa)			M-L P C		13,000 seed per pound. Use on productive soils. Not as winterhardy as rye or barley.
alone	4 bu. (128 lbs.)	2.9 lb.			
in mixtures	1 bu. (32 lbs.)	0.7 lb.			
RYE (Secale cereale)			M-L P C		18,000 seed per pound. Quick cover. Drought tolerant and winterhardy.
alone	3 bu. (168 lbs.)	3.9 lb.			
in mixtures	1/2 bu. (28 lbs.)	0.6 lb.			
RYEGRASS, ANNUAL (Lolium temulentum)			M-L P C		227,000 seed per pound. Dense cover. Very competitive and is not to be used in mixtures.
alone	40 lbs.	0.9 lb.			
SUDANGRASS (Sorghum sudanese)			M-L P C		55,000 seed per pound. Good on droughty sites. Not recommended for mixtures.
alone	60 lbs.	1.4 lb			

Table 6-24.1 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
TRITICALE (X-Triticosecale)			C	..... ——— ——— ———	
alone	3 bu. (144 lbs.)	3.3 lb.			Use on lower part of Southern Coastal Plain and In Atlantic Coastal Flatwoods only.
in mixtures	1/2 bu. (24 lbs.)	0.6 lb.			
				J F M A M J J A S O N D	
WHEAT (Triticum aestivum)			M-L P C	..... ——— ——— ———	
alone	3 bu. (180 lbs.)	4.1 lb.			15,000 seed per pound. Winterhardy.
in mixtures	1/2 bu. (30 lbs.)	0.7 lb.			

1/ Temporary cover crops are very competitive and will crowd out perennials if seeded too heavily.
2/ Reduce seeding rates by 50% when drilled.
3/ PLS is an abbreviation for Pure Live Seed.
4/ M-L represents the Mountain; Blue Ridge; and Ridges and Valleys MLRAs
P represents the Southern Piedmont MLRA
C represents Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs

Disturbed Area Stabilization (With Permanent Vegetation)

Ds3

DEFINITION

Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).

PURPOSE

To stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources.

CONDITIONS

On highly erodible or critically eroding areas. These areas usually cannot be stabilized by ordinary conservation treatment and management and if left untreated can cause severe erosion or sediment damage. Examples of applicable areas are dams, dikes, levees, cuts, fills, and denuded or gullied areas where vegetation is difficult to establish by usual planting methods.

PLANNING CONSIDERATIONS

1. Use conventional planting methods where possible.
2. Companion crops aid in getting permanent cover established, especially when mixed plantings are done during marginal planting periods.
3. No-till planting is effective when planting is done following a summer or winter annual cover crop. Sericea lespedeza planted no-till into stands of rye is an excellent procedure.
4. Block sod is effective in controlling erosion adjacent to concrete flumes and other structures.
5. Consider using irrigation, especially when late plantings are done.
6. Use low maintenance plants in most cases to ensure long-lasting erosion control.
7. Mowing should not be performed during the quail nesting season, (September to April).
8. Wildlife plantings should be included in critical area plantings.

Commercially available plants include the following:	Remarks
Type of Plant	
A. Mast Bearing Trees: Beech, Black Cherry, Blackgum, Chestnut, Chinkapin, Hackberry, Hickory, Honey Locust, Native Oak, Persimmon, Pine, Sawtooth Oak and Sweetgum.	All trees that produce nuts or fruits are favored by many game species, except hickory which provides nuts used mainly by squirrels and bear.
B. Shrubs and Small Trees: Autumn Olive, Bayberry, Bicolor Lespedeza, Crabapple, Dogwood, Huckleberry or Native Blueberry, Mountain Laurel, Native Holly, Red Cedar, Red Mulberry, Russion Olive, Privet, Sumac, Wax Myrtle, Wild Plum and Blackberry.	Plant in patches without tall trees to develop stable shrub communities. All produce fruits used by many kinds of wildlife, except for lespedeza which produces seeds used by quail and songbirds.
C. Grasses, Legumes, Vines and Temporary Cover: Bahiagrass, Bermudagrass, Grape, Grass-Legume mixtures, Partridge Pea, Annual Lespedeza, Honeysuckle, Orchardgrass (for mountains) and temporary cover (such as Browntop Millet).	For openings. Provides herbaceous cover in clearings for a game bird, brood-rearing habitat. Appropriate legumes such as vetches, clovers, and lespedezas may be mixed with grass, but they may die out after a few years.

SPECIFICATIONS

Grading and Shaping

A. Grading and shaping is not normally required where hydraulic seeding and fertilizing equipment is to be used. Vertical banks shall be sloped to enable plant establishments.
B. When conventional seeding and fertilizing is to be done, grade and shape where feasible and practical, so that equipment can be used safely and efficiently during seedbed preparation, seeding, mulching and maintenance of the vegetation.
C. Concentrations of water that will cause excessive soil erosion will be diverted to a safe outlet. Diversions and other treatment practices must conform with the appropriate standards and specifications.

Seedbed Preparation

A. Seedbed preparation is not required where hydraulic seeding and fertilizing equipment is to be used.
B . When conventional seeding is to be used, seedbed preparation will be done as follows:
    1. Broadcast plantings.
        a. Tillage at a minimum, shall adequately loosen the soil to a depth of 4 to 6 inches; alleviate compaction; incorporate lime and fertilizer; smooth and firm the soil; allow for the proper placement of seed, sprigs, or plants; and allow for the anchoring of straw or hay mulch if a disk is to be used.
        b. Tillage may be done with any suitable equipment.
        c. Tillage may be done on the contour where feasible.
        d. On slopes too steep for the safe operation of tillage equipment, the soil surface will be pitted or trenched across the slope with appropriate hand tools to provide a place 6 to 8 inches apart in which seed may lodge and germinate.
    2. Individual plants.
        a. Where individual plants are to be set, the soil will be well prepared by excavating holes, opening furrows, or dibble planting.
        b. For nursery stock plants, holes shall be large enough to accommodate roots without crowding.
        c. Where pine seedlings are to be planted, subsoil under the row 36 inches deep on

the contour 4 to 6 months prior to planting. Subsoiling should be done when the soil is dry, preferably in August or September.

Lime and Fertilizer—Rates and Analysis

A. Where permanent vegetation is to be established, agricultural lime shall be applied as indicated by soil test or at the rate of 1 to 2 tons per acre. Agricultural lime shall be within the specifications of the Georgia Department of Agriculture.

Lime spread by conventional equipment will be "ground limestone." Ground limestone is calcitic or dolomitic limestone ground so that 90 percent of the material will pass through a 10-mesh sieve, not less than 50 percent will pass through a 50-mesh sieve and not less than 25 percent will pass through a 100-mesh sieve.

Agricultural lime spread by hydraulic seeding equipment will be "finely ground limestone." Finely ground limestone is calcitic or dolomitic limestone ground so that 98 percent of the material will pass through a 20-mesh sieve and not less than 70 percent will pass through a 100-mesh sieve.

It is desirable to use dolomitic limestone in the Sand Hills, Southern Coastal Plain and Atlantic Coast Flatwoods MLRAs.

B. No agricultural lime is required where only temporary seeding is to be done or where only trees are planted.

C. Initial fertilization requirements for each species or combination of species are listed in Table 6-25.1

Lime Fertilizer—Application

A. When hydraulic seeding equipment is used:
   1. The initial fertilizer will be mixed with seed, inoculant (if needed) and wood cellulose or wood pulp fiber mulch and applied in a slurry. The slurry mixture will be agitated during application to keep the ingredients thoroughly mixed. The mixture will be spread uniformly over the area within one hour after being placed in the hydroseeder.
   2. Finely ground limestone will be mixed with water and applied immediately after mulching is completed or in combination with the top dressing.

B. When conventional planting is to be done, lime and fertilizer will be applied uniformly in one of the following ways:
   1. Apply before land preparation so that it will be mixed with the soil during seedbed preparation; or,
   2. Mix with the soil used to fill the holes, distribute in furrows; or
   3. Broadcast after steep surfaces are scarified, pitted or trenched.
   4. A fertilizer pellet will be placed at root depth beside each pine tree seedling.

Plant Selection

A. Refer to Tables 6-24.1, 6-25.2, 6-25.3 and 6-25.4 for approved species.

B. Species not listed shall be approved by the State Resource Conservationist of the Soil Conservation Service before they are used.

C. Plants shall be selected on the basis of species characteristics; site and soil conditions; planned use and maintenance of the area; time of year of planting; method of planting; and the needs and desires of the land user.

D. Plant selections may include companion crops to provide quick cover. Care shall be taken in selecting companion crop species and seeding rates to limit competition so that the desired permanent vegetation may become established as soon as possible.

E. The term "pure live seed" is used to express the quality of seed, even if it is not shown on the label. Pure live seed, PLS, is expressed as a percentage of the seeds that are pure and will germinate. PLS is determined by multiplying the percent of pure seed times the percent of germination and dividing by 100.

EXAMPLE:

Common bermuda seed
70% germination
80% purity

$$PLS = \frac{70\% \text{ germination} \times 80\% \text{ purity}}{100}$$

$$PLS = \frac{56}{100} = 0.56 = 56\%$$

The percent of PLS helps you determine the amount of seed you need. If the seeding rate is 10 pounds PLS and the bulk seed is 56 percent PLS, the bulk seeding rate is:

$$\frac{10 \text{ lbs. PLS/acre}}{56\% \text{ PLS}} = 17.9 \text{ lbs/acre}$$

You would need to plant 17 .9 lbs/acre to provide 10 lbs/acre of pure live seed.

Inoculants

A. All legume seed shall be inoculated with appropriate nitrogen-fixing bacteria.
B. The inoculant shall be a pure culture prepared specifically for the seed species and used within the dates on the container.
C. A mixing medium recommended by the manufacturer shall be used to bond the inoculant to the seed.
D. For conventional seeding, two times the amount of inoculant recommended by the manufacturer shall be used.
E. For hydraulic seeding, four times the amount of inoculant recommended by the manufacturer shall be used.
F. All inoculated seed shall be protected from the sun and high temperatures and shall be planted the same day inoculated. No inoculated seed shall remain in the hydroseeder longer than one hour.

Planting

A. Hydraulic seeding - Mix the seed, inoculant, fertilizer, and wood cellulose or wood pulp fiber mulch with water and apply in a slurry uniformly over the area to be treated. Apply within one hour after the mixture is made.
B. Conventional seeding - Seeding will be done on a freshly prepared and firmed seedbed. For broadcast planting, use a cultipacker-seeder, drill, rotary seeder, other mechanical seeder, or hand seeding to distribute the seed uniformly over the area to be treated. Cover the seed lightly with a cultipacker or other suitable equipment.
C. No-till seeding is permissible into annual cover crops when planting is done following maturity of the cover crop or if the temporary cover stand is sparse enough to allow adequate growth of the permanent species. No-till seeding must be done with appropriate no-till seeding equipment. The seed must be uniformly distributed and planted at the proper depth.
D. Individual plants - Shrubs, vines and sprigs may be planted with appropriate planters or hand tools. Pine trees will be planted manually in the subsoil furrow. Each plant will be set in a manner that will avoid crowding the roots.

   Nursery stock plants shall be planted at the same depth or slightly deeper than they grew at the nursery. The tips of vines and sprigs must be at or slightly above the ground surface.

   Where individual holes are dug, place fertilizer in the bottom of the hole, add two inches of soil and set the plant.

Mulching

Use mulch on all slopes steeper than 3 percent; when seedings are made so late in the fall and winter that germination cannot be expected until spring; in the bottom of spillways; and on roadbanks.

Temporary vegetation seeded alone may be established on good sites without the use of mulch.

Mulching material will consist of:

A. Use dry straw or dry hay of good quality and free of weed seeds. Dry straw will be applied at the rate of 2 tons per acre. Dry hay will be used at a rate of 2 1/2 tons per acre; or,
B. For hydraulic seeding, use wood cellulose mulch or wood pulp fiber at the rate of 500 pounds per acre and dry straw or dry hay at the rate listed in A, above; or,
C. For hydraulic seeding on slopes 3/4:1 or steeper, 1,000 pounds of wood cellulose or wood pulp fiber which includes a tackifier may be substituted for the treatment in B, above; or,
D. Use three tons per acre of Sericea lespedeza hay containing mature seed; or,
E. Apply pine straw or pine bark at a thickness of 3 inches. Other suitable materials in sufficient quantity may be used where ornamentals or other ground covers are planted; or,
F. Soil retention blankets, erosion control netting, other manufactured materials, or block sod may be required in addition to mulch on unstable soils and concentrated flow areas.

Wood cellulose and wood pulp fibers shall not contain germination or growth inhibiting factors. They will have the property to be evenly dispersed when agitated in water. The fibers shall have a contrasting color to the soil to allow visual metering and aid in uniform application during seeding.

Applying Mulch

A. Straw or hay mulch will be spread uniformly within 24 hours after seeding and/or planting. The mulch may be spread by blower-type spreading equipment, other spreading equipment or by hand. About 75 percent of the soil surface will be covered.
B. Wood cellulose or wood fiber mulch will be applied with hydraulic seeding equipment.

Anchoring Mulch

A. Anchor straw or hay mulch immediately after application by one of the following methods:
   1. By emulsified asphalt, (a) sprayed uniformly onto the mulch as it is ejected from the blower

onto the mulch as it is ejected from the blower machine, or (b) sprayed on the mulch immediately following mulch application when straw or hay is spread by methods other than special blower equipment.

The combination of asphalt emulsion and water shall consist of a homogeneous mixture satisfactory for spraying. The mixture shall consist of 100 gallons of grade SS-1h or CSS-1h emulsified asphalt and 100 gallons of water per ton of mulch.

Care shall be taken at all times to protect the public, adjacent property, pavements, curbs, sidewalks, and all other structures from asphalt discoloration.

2. Press the mulch into the soil immediately after the mulch is spread. A special "packer disk" or disk harrow with the disks set straight may be used. The disks may be smooth or serrated and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the disks shall be dull enough to press the mulch into the ground without cutting it, leaving much of it in an erect position.
3. Apply synthetic tackifiers or binders applied immediately after the mulch is spread. Synthetic tackifiers will be mixed and applied according to manufacturer's specifications.
4. Fall and winter plantings may include 1/2 bushel of rye or wheat to stabilize the mulch.
5. Plastic mesh or netting with no larger than one inch by one inch mesh may be needed to anchor straw or hay mulch on unstable soils and concentrated flow areas.

B. Where wood cellulose or wood pulp fiber mulch is applied alone, a tackifier will be used.

Irrigation

Irrigation will be applied at a rate that will not cause runoff.

Topdressing

Topdressing will be applied on all temporary grass species and permanent grasses planted alone or in mixtures with other species. Recommended rates of application are listed in Table 6-25.1.

Second Year and Maintenance Fertilization

Second year fertilizer rates and maintenance fertilizer rates are listed in Table 6-25.1.

Lime and Maintenance Application

Apply one ton of agricultural lime every 4 to 6 years or as indicated by soil tests.

Use and Management

Mow Sericea lespedeza only after frost to ensure that the seeds are mature. Mow between November and March.

Bermudagrass, Bahiagrass and Tall fescue may be mowed as desired. Maintain at least 6 inches of top growth under any use and management. Moderate use of top growth is beneficial after establishment.

Exclude livestock until the plants are well established.

Table 6-25.1

FERTILIZER REQUIREMENTS

TYPE OF SPECIES	YEAR	ANALYSIS OR EQUIVALENT N-P-K	RATE	N TOP DRESSING RATE
1. Cool season grasses	First	6-12-12	1500 lbs./ac.	50-100 lbs./ac. 1/ 2/
	Second	6-12-12	1000 lbs./ac.	—
	Maintenance	10-10-10	400 lbs./ac.	30
2. Cool season grasses and legumes	First	6-12-12	1500 lbs./ac.	0-50 lbs./ac. 1/
	Second	0-10-10	1000 lbs./ac.	—
	Maintenance	0-10-10	400 lbs./ac.	—
3. Ground covers	First	10-10-10	1300 lbs./ac. 3/	—
	Second	10-10-10	1300 lbs./ac. 3/	—
	Maintenance	10-10-10	1100 lbs./ac.	—
4. Pine seedlings	First	20-10-5	one 21-gram pellet per seedling placed in the closing hole	—
5. Shrub Lespedeza	First	0-10-10	700 lbs./ac.	—
	Maintenance	0-10-10	700 lbs./ac. 4/	
6. Temporary cover crops seeded alone	First	10-10-10	500 lbs./ac.	30 lbs./ac. 5/
7. Warm season grasses	First	6-12-12	1500 lbs./ac.	50-100 lbs./ac. 2/ 6/
	Second	6-12-12	800 lbs./ac.	50-100 lbs./ac. 2/
	Maintenance	10-10-10	400 lbs./ac.	30 lbs./ac.
8. Warm season grasses and legumes	First	6-12-12	1500 lbs./ac.	50 lbs./ac. 6/
	Second	0-10-10	1000 lbs./ac.	
	Maintenance	0-10-10	400 lbs./ac.	

1/ Apply in spring following seeding.
2/ Apply in split applications when high rates are used.
3/ Apply in 3 split applications.
4/ Apply when plants are pruned.
5/ Apply to grass species only.
6/ Apply when plants grow to a height of 2 to 4 inches.

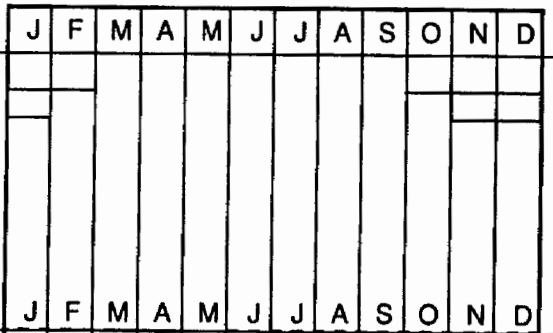
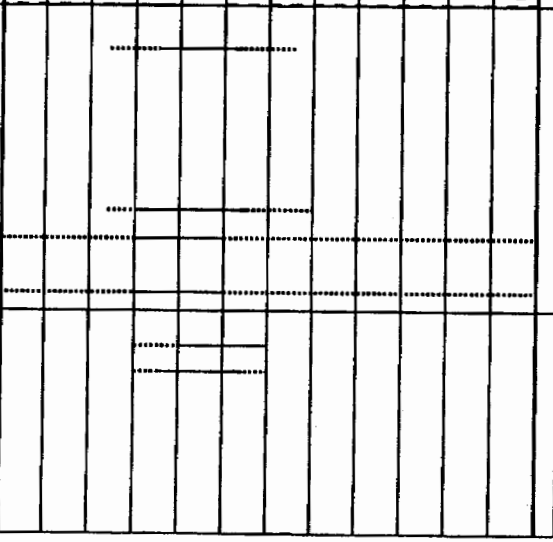
Table 6-25.2

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
BAHIA, PENSACOLA (Paspalum notatum)			P 3/ C		166,000 seed per pound. Low growing. Sod forming. Slow to establish. Plant with a companion crop. Will spread into bermuda pastures and lawns. Mix with Sericea lespedeza or weeping lovegrass.
alone or with temporary cover	60 lbs.	1.4 lb.			
with other perennials	30 lbs.	0.7 lb.			
BAHIA, WILMINGTON (Paspalum notatum)			M-L P		Same as above.
alone or with temporary cover	60 lbs.	1.4 lb.			
with other perennials	30 lbs.	0.7 lb.			
BERMUDA, COMMON (Cynodon dactylon) Hulled seed			P C		1,787,000 seed per pound. Quick cover. Low growing and sod forming. Full sun. Good for athletic fields.
alone	10 lbs.	0.2 lb.			
with other perennials	6 lbs.	0.1 lb.			

Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)	Remarks
BERMUDA, COMMON (Cynodon dactylon) Unhulled seed			P C		
with temporary cover	10 lbs.	0.2 lb.			Plant with winter annuals.
with other perennials	6 lbs.	0.1 lb.			Plant with Tall fescue.
BERMUDA SPRIGS (Cynodon dactylon)	40 cu. ft. or sod plugs 3' x 3'	0.9 cu. ft.	M-L		A cubic foot contains approximately 650 sprigs. A bushel contains 1.25 cubic feet or approximately 800 sprigs.
Coastal, Common, Midland, or Tift 44					
Coastal, Common, or Tift 44			P C		Same as above
Tift 78			C		Southern Coastal Plain only.
CENTIPEDE (Eremochloa ophiuroides)	Block sod only		P C		Drought tolerant. Full sun or partial shade. Effective adjacent to concrete and in concentrated flow areas. Irrigation is needed until fully established. Do not plant near pastures. Winterhardy as far north as Athens and Atlanta.

J F M A M J J A S O N D

Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas — Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
CROWNVETECH (Coronilla varia)					100,000 seed per pound. Dense growth. Drought tolerant and fire resistant. Attractive rose, pink, and white blossoms spring to late fall. Mix with 30 pounds of Tall fescue or 15 pounds of rye. Inoculate seed with M inoculant. Use from North Atlanta and Northward
with winter annuals or cool season grasses	15 lbs.	0.3 lb.	M-L P	J F M A M J J A S O N D	
FESCUE, TALL (Festuca arundinacea)					227,000 seed per pound. Use alone only on better sites. Not for droughty soils. Mix with perennial lespedezas or Crownvetch. Apply topdressing in spring following fall plantings. Not for heavy use areas or athletic fields.
alone	50 lbs.	1.1 lb.	M-L P	J F M A M J J A S O N D	
with other perennials	30 lbs.	0.7 lb.			
KUDZU (Pueraria thumbergiana)					Rapid and vigorous growth. Excellent in gully erosion control. Will climb. Good livestock forage.
plants or crowns	3' - 7' apart		ALL	J F M A M J J A S O N D	

Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

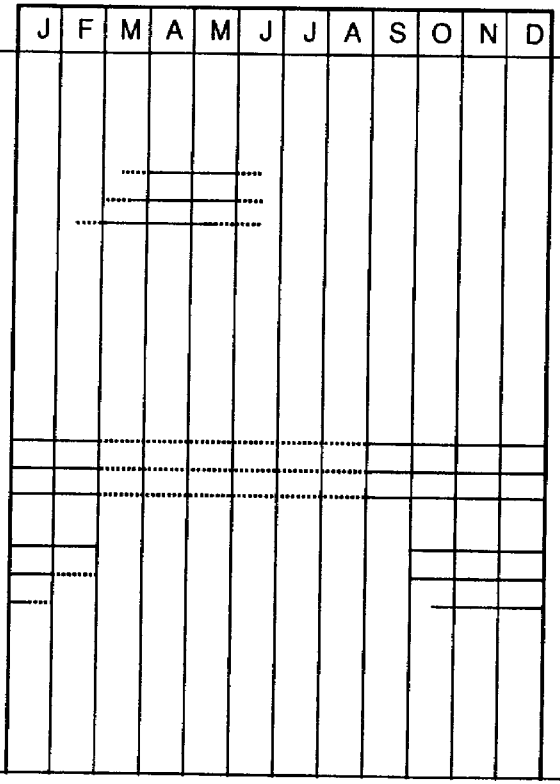
Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)	Remarks
LESPEDEZA, SERICEA (Lespedeza cuneata)					
scarified	60 lbs.	1.4 lb.	M-L P C		350,000 seed per pound. Widely adapted. Low maintenance. Mix with Weeping lovegrass, Common bermuda, bahia, or tall fescue. Takes 2 to 3 years to become fully established. Excellent on roadbanks. Inoculate seed with EL inoculant.
unscarified	75 lbs.	1.7 lb.	M-L P C		Mix with Tall fescue or winter annuals.
seed-bearing hay	3 tons	138 lb.	M-L P C		Cut when seed is mature, but before it shatters. Add Tall fescue or winter annuals.

Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)	Remarks
LESPEDEZA Ambro virgata (Lespedeza virgata DC) or Appalow (Lespedeza cuneata [Dumont] G. Don)					300,000 seed per pound. Height of growth is 18 to 24 inches. Advantageous in urban areas. Spreading-type growth. New growth has bronze coloration. Mix with weeping lovegrass, common bermuda, bahia, tall fescue or winter annuals. Do not mix with Sericea lespedeza. Slow to develop solid stands. Inoculate seed with EL inoculant.
scarified	60 lbs.	1.4 lb.	M-L P C		
unscarified	75 lbs.	1.7 lb.	M-L P C		
LESPEDEZA, SHRUB (Lespedeza bicolor)) (Lespedeza thumbergii) plants	3' X 3'		M-L P C		Provide wildlife food and cover.
LOVEGRASS, WEEPING (Eragrostis curvula)					1,500,000 seed per pound. Quick cover. Drought tolerant. Grows well with Sericea lespedeza on roadbanks.
alone	4 lbs.	0.1 lb.	M-L P C		
with other perennials	2 lbs.	0.05 lb.			

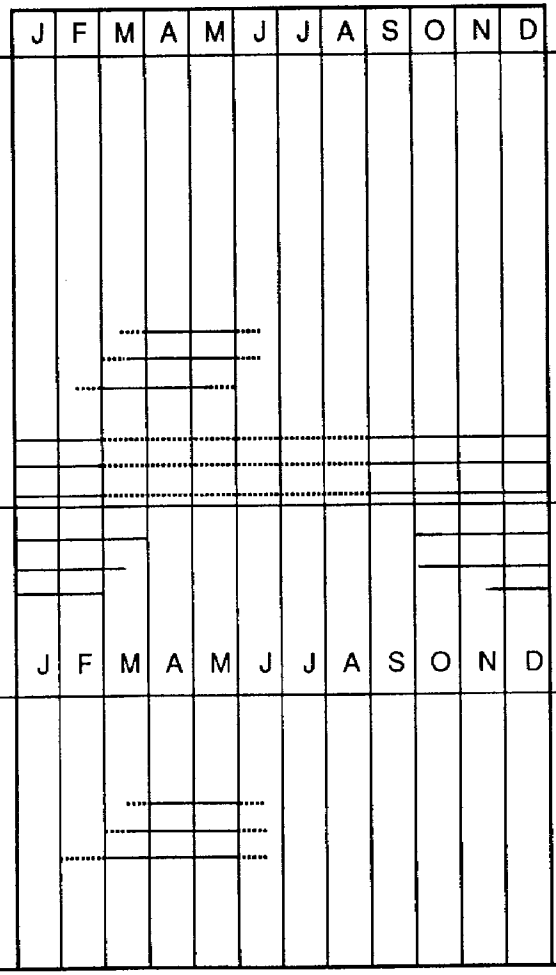


Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)	Remarks
MAIDENCANE (Panicum hemitomon) sprigs	2' x 3' spacing		ALL	J F M A M J J A S O N D	For very wet sites. May clog channels. Dig sprigs from local sources. Use along river banks and shorelines.
PANICGRASS, ATLANTIC COASTAL (Panicum amarum var. amarulum))	20 lbs.	0.5 lb.	P C	J F M A M J J A S O N D	Grows well on coastal sand dunes, borrow areas, and gravel pits. Provides winter cover for wildlife. Mix with Sericea lespedeza except on sand dunes.
REED CANARY GRASS (Phalaris arundinacea) alone	50 lbs.	1.1 lb.	M-L P	J F M A M J J A S O N D	Grows similar to Tall fescue.
with other perennials	30 lbs.	0.7 lb.			
SUNFLOWER, 'AZTEC' MAXIMILLIAN (Helianthus maximiliani)	10 lbs.	0.2 lb.	M-L P C	J F M A M J J A S O N D	227,000 seed per pound. Mix with Weeping lovegrass or other low-growing grasses or legumes.
SWITCHGRASS (Panicum virgatum)	40 lbs.	0.9 lb	M-L P C	J F M A M J J A S O N D	Streambanks

1/ Reduce seeding rates by 50% when drilled.
2/ PLS is an abbreviation for Pure Live Seed. Refer to Section V.E. of these specifications.
3/ M-L represents to Mountain; Blue Ridge; and Ridges and Valleys MLRAs.
P represents the Southern Piedmont MLRA.
C represents the Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs.

Table 6-25.3

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Ground covers include a wide range of low-growing plants planted together in considerable numbers to cover large areas of the landscape. Ground covers grow slower than grasses. Weeds are likely to compete, especially the first year. Maintenance is needed to insure survival. These ground covers will not be used unless proper maintenance is planned. Maintain mulch at three-inch thickness until plants provide adequate cover.

Fall planting is encouraged because the need for constant watering is reduced and plants have time to establish new roots before hot weather.

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Albelia	Abelia grandiflora	3-4 ft.	5 ft.	Also a prostrate form 2 feet high. Sun, semi-shade. Semi-evergreen.
Carolina Yellow Jessamine	Gelsemium sempervirens	low	3 ft.	Vine. Yellow, trumpet-like flowers. Hardy, one of best vines. Evergreen. Native to Georgia.
Carpet Blue	Ajuga reptans	2-4 in.	3 ft.	Needs good drainage, partial shade. Blue or white flowers. Evergreen.
Bearberry Cotoneaster	Cotoneaster dammeri	2-4 ft.	5 ft.	White flowers, red fruit. Sun. Evergreen.
Ground Cover Cotoneaster	Cotoneaster salicifoluis 'Repens'	1-2 ft.	5 ft.	White flowers, red fruit. Sun. Evergreen.
Rock Cotoneaster	Cotoneaster horizontalis	1-2 ft.	5 ft.	Semi-evergreen. Sun.
Virginia Creeper	Parthenocissue quinquefolia	low	3 ft.	Red in fall. Vine. Deciduous. Native to Georgia.
Daylily	Hemerocallis spp.	2-3 ft.	2 ft.	Many flower colors. Full sun. Very hardy.
Elaegnus	Elaegnus pungens	8-10 ft.	6 ft.	Fast grower. Sun, semi-shade.
English Ivy	Hedera helix	low	3 ft.	Shade only. Climbs.

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Wintercreeper Euonymus	Euonymus fortunii 'Coloratus'	18 in.	4 ft.	Orange fruit in fall, will climb. Evergreen. Sun or semi-shade. Good on banks.
Everblooming Honeysuckle	Lonecera heckrottii	low	3 ft.	Coral-red flowers in summer. Semi-evergreen. Climbs.
Compacta Holly	Ilex crenata 'Compacta'	3-4 ft.	5 ft.	Sun, semi-shade.
Chinese Holly	Ilex cornuta 'Rotunda'	3-4 ft.	5 ft.	Very durable. Sun, semi-shade.
Dwarf Burford Holly	Ilex burfordii 'Nana'	5-8 ft.	8 ft.	
Dwarf Yaupon Holly	Ilex vomitoria 'Nana'	3-4 ft.	5 ft.	Very durable. sun, semi-shade.
Repandens Holly	Ilex crenata 'Repandens'	2-3 ft.	5 ft.	Sun, semi-shade.
Andorra Juniper	Juniperus horizontalis 'Plumosa'	2-3 ft.	5 ft.	Excellent for slopes. Sun.
Andorra Compacta	Juniperus horizontalis 'Plumosa compacta'	1-2 ft.	5 ft.	More compact than andora.
Blue Chip Juniper	Juniperus horizontalis 'Blue Chip'	8-10 in.	4 ft.	
Blue Rug Juniper	Juniperus horizontalis 'Wiltonii'	4-6 in.	3 ft.	Very low. Sun.
Parsons Juniper	Juniperus davurica 'Expansa' (Squamata Parsoni)	18-24 in.	5 ft.	One of the best, good winter cover.
Pfitzer Juniper	Juniperus chinensis 'Pfitzerana'	6-8 ft.	6 ft.	Needs room.

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Prince of Wales Juniper	Juniperus horizontalis 'Prince of Wales'	8-10 in.	4 ft.	Feathery appearance.
Sargent Juniper	Juniperus chinensis 'Sargentii'	1-2 ft.	5 ft.	Full sun. Needs good drainage. Good winter color.
Shore Juniper	Juniperus conferta	2-3 ft.	5 ft.	Emerald Sea or Blue Pacific cultivars are good.
Liriope	Liriope muscari	8-10 in.	3 ft.	
Creeping Liriope	Liriope spicata	10-12 in.	1 ft.	Spreads by runners.
Big Leaf Periwinkle	Vinca major	12-15 in.	4 ft.	Lilac flowers in spring. Semi-shade.
Common Periwinkle	Vinca minor	5-6 int.	4 ft.	Lavender-blue flowers in spring. Semi-shade
Cherokee Rose	Rosa laevigata	2 ft.	5 ft.	Rampant grower. Not for restricted spaces. State flower.
Memoria Rose	Rosa weuchuriana	2 ft.	5 ft.	Rampant grower.
St. Johnswort	Hypericum calycenum	8-12 in.	3 ft.	Semi-shade.
Anthony Waterer Spirea	Spirea bumalda	3-4 ft.	5 ft.	Sun.
Thunberg Spirea	Spirea thinbergii	3-4 ft.	5 ft.	Sun.
Chinese Wisteria	Wisteria sinensis	10 ft. tree or trailing	6 ft.	Rapid growth.

Table 6-25.4

TREES FOR EROSION CONTROL

SITE	SOIL MATERIAL	COMMON SOILS	PLANTING TREE SPECIES 1/	SPACING	PLANTING DATES 3/
Borrow areas, graded areas, and spoil material	Sandy	Lakeland, Troup	Loblolly pine (Pinus taeda) Longleaf pine (Pinus palustris) Slash pine (Pinus elliottii)	2/	M-L,P 12/1-3/15 C 12/1-3/1
	Loamy	Orangeburg, Tifton	Loblolly pine Slash pine	2/	M-L,P 12/1-3/15 C 12/1-3/1
	Clay	Cecil, Faceville	Loblolly pine Slash pine Virginia pine (Pinus virginiana)	2/	M-L,P 12/1-3/15 C 12/1-3/1
Streambanks			Willows 4/ (Salix species)	2 ft x 2 ft	ALL 2/15-3/15

1/ Other trees and shrubs listed on Table 6-25.3 may be interplanted with the pines for improved wildlife benefits.

2/ Type of Planting	Tree Spacing	No. of Trees Per Acre
Trees alone	4 ft. x 4 ft.	2722
Trees in combination with grasses and/ or other plants	6 ft. x 6 ft.	1210

3/ M-L represents the Mountains; Blue Ridge; and Ridges and Valleys MLRAs
P represents the Southern Piedmont MLRA
C represents the Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs

4/ Fertilization of companion crop is ample for this species.

Dust Control on Disturbed Areas

Du

DEFINITION

Controlling surface and air movement of dust on construction sites, roads, and demolition sites.

PURPOSE

To prevent surface and air movement of dust from exposed soil surfaces and reduce the presence of airborne substances which may be harmful or injurious to human health, welfare, or safety, or to animals or plant life.

CONDITIONS

This practice is applicable to areas subject to surface and air movement of dust where on and off-site damage may occur without treatment.

METHOD AND MATERIALS

A. TEMPORARY METHODS

Mulches. See standard *Ds1 - Disturbed Area Stabilization (With Mulches Only).* Synthetic resins may be used instead of asphalt to bind mulch material. Resins such as Curasol or Terratack should be used according to manufacturer's recommendations.

Vegetative Cover. See standard *Ds2- Disturbed Area Stabilization (With Temporary Seeding).*

Spray-on Adhesives. These are used on mineral soils (not effective on muck soils). Keep traffic off these areas.

Tillage. This practice is designed to roughen and bring clods to the surface. It is an emergency measure which should be used before wind erosion starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

Irrigation. This is generally done as an emergency treatment. Site is sprinkled with water until the surface is wet. Repeat as needed.

Barriers. Solid board fences, snowfences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling wind erosion.

Calcium Chloride. Apply at rate that will keep surface moist. May need retreatment.

B. PERMANENT METHODS

Permanent Vegetation. See standard *Ds3 - Disturbed Area Stabilization (With Permanent Vegetation).* Existing trees and large shrubs may afford valuable protection if left in place.

Topsoiling. This entails covering the surface with less erosive soil material. See standard *Tp - Topsoiling.*

Stone. Cover surface with crushed stone or coarse gravel.

Table 6-26.1

Adhesive	Water Dilution	Type of Nozzle	Application Rate (Gallons/Ac.)
Anionic Asphalt emulsion	7:1	Coarse Spray	1,200
Latex emulsion	12½:1	Fine Spray	235
Resin-in-water emulsion	4:1	Fine Spray	300

BUFFER ZONE (BZ)

Definition

A strip of undisturbed, original vegetation or established vegetation surrounding the land-disturbing site, or bordering streams, lakes, and wetlands.

Purpose

To provide a buffer zone to reduce storm runoff velocities, filter sediment in runoff water, act as a screen for "vision pollution", reduce construction noise, and improve aesthetics on the land disturbed.

Conditions Where Practice Applies

On construction sites, construction routes, and other disturbed areas where natural vegetation is available and can be preserved for a buffer zone.

Planning Considerations

1. Construction activities that disturb soil can be unsightly, sources of excessive noise, and a significant source of dust and sediment.

2. When planning long term construction projects or when planning future projects buffer zones may be established with thickly planted, fast growing, trees. These trees may be part of the overall landscape of the project.

3. The natural vegetation in buffer zones may be supplemented by planting fast growing, trees and shrubs on long term construction projects.

4. When planning the landscape consider the corporation of all or parts of the natural vegetation or planted trees in the buffer zones.

Specifications

1. Preserve a strip of natural vegetation along permanent and intermittent streams and lakes for bank stabilization and sediment trapping. Minimum width of a buffer zone of natural vegetation for shore line or stream bank protection should be at least 35 feet. However; depending on the size of stream or lake, soil type, existing vegetation, and bank height the width may be increased up to 100 feet. Also, with narrow

buffer zones additional supporting practices will usually be needed.

2. Preserve a strip of natural vegetation between residences, businesses, roads or other areas needing screening from the construction site. Natural vegetation can be supplemented with trees and/or shrubs to improve the screening or effectiveness of the buffer zone. The width should be adequate to permit the buffer zone to serve as an effective screen or its intend purpose. See practice IV-PV, Permanent Vegetation, IV-SVG, Shrub, Vine and Groundcover Planting, or IV-TP, Tree Planting for planting details when is supplementing the natural vegetation. Table BZ-1 list some fast growing trees and large shrubs for use in establishing or supplementing buffer zones or vegetative screens.

3. Establish a strip of fast growing trees between residences, businesses, roads, churches or other areas needing screening from the construction site. Large shrubs may be added to make the buffer zone more effective. The established buffer zone should be a part of the overall landscape plan. Also, planting the buffer zone as soon as possible before construction begins will improve its effectiveness. If sufficient time is lacking for trees to grow, larger plant materials and irrigation can be used. See practices IV-TP, Tree Planting, IV-PV, Permanent Vegetation, and IV-IS, Irrigation Systems for details in establishment. Table BZ-1 list some fast growing trees and large shrubs for use in establishing buffer zones or vegetative screens.

References

1. Chapter III Sediment Barrier/Fence (SF)

2. Chapter IV Irrigation (IR)

3. Chapter IV Permanent Vegetation (PV)

4. Chapter IV Tree Planting on Disturbed Areas (TP)

5. Chapter IV Shrub, Vine and Groundcover Planting (SVG)

6. Chapter IV Tree Preservation and Protection (TPP)

Table BZ-1
Fast Growing Trees and Large Shrubs
for Screens and Buffer Zones

Common Name	Mature Height	Remarks
Green Ash	60-80 ft.	Does best in moist sites and well suited for alkaline soils.
Loblolly Pine	50-85 ft.	Adaptable to more sites and soils than most pine
Yellow Poplar	70-100 ft.	Does best in moist sites but has some insect and disease problems.
Bradford pear	30-60 ft.	Pest resistant, has flowers and good fall color.
Slash Pine	60-100	Best adapted to coastal areas and wet, sandy soils. Limited to south ALabama.
Wax Myrtle	8-15 ft.	Evergreen shrub adapted to coastal plain soils.
Shrub Lespedeza	8-12 ft.	Best adapted to coastal plain soils. Wildlife plant.
Willow	30-50 ft.	Must have a moist site. Good for buffer zones along streams.

DUST CONTROL (DU)

Definition

The control of dust during land disturbing activities.

Purpose

To prevent surface and air movement of dust from disturbed soil surfaces that may cause off site damage, health hazards, and traffic safety problems.

Conditions Where Practice Applies

On construction routes and other disturbed areas subject to surface dust movement and dust blowing where off site damage may occur if dust is not controlled.

Planning Considerations

1. Construction activities that disturb soil can be a significant source of air pollution. Large quantities of dust can be generated, especially in "heavy" construction activities such as land grading for road construction and commercial, industrial or subdivision development.

2. The scheduling of construction operations so that the least amount of area is disturbed at one time is important in planning for dust control.

3. The greatest dust problems occur during dry periods. Therefore, do not expose large areas of bare soil, especially during drought conditions. Also, leave undisturbed buffer areas between graded areas wherever possible.

4. Installing temporary or permanent surface stabilization measures immediately after completing land grading will dust problems.

Specifications

1. Vegetative Cover - For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control. Establish vegetative cover according to practice IV-TV, Temporary Vegetation (Seeding) or practice IV-PV, Permanent Vegetation.

2. Mulches - Mulch offers a fast, effective means of controlling dust when properly applied. Synthetic

resins may be used instead of asphalt to bind straw mulch. Use the resins according to manufacturer's recommendations. See practice IV-MU, Mulching.

3. Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. May need to retreat.

4. Spray-on adhesives may be used on mineral soils for dust control. Traffic must be kept off treated areas. Examples of spray-on adhesives for use in dust control are listed in Table DU-1.

Table DU-1
Spray-on Adhesives for Dust Control on Mineral Soil

Material	Water Dilution	Type of Nozzle	Apply Gal/Ac
Anionic asphalt emulsion	7:1	Coarse Spray	1,200
Latex emulsion	12.5:1	Fine Spray	235
Resin in water	4:1	Fine Spray	300

5. Sprinkling or Irrigation - Sprinkling is especially effective for dust control on haul roads and other traffic routes. Sprinkle the site until the surface is wet. Repeat as needed. Also bare areas may be kept wet with irrigation to control dust as an emergency treatment.

6. Stone used to stabilize construction roads can also be effective for dust control.

7. Tillage will roughen the site and bring clods and moist soil to the surface. This is a temporary emergency measure that can be used on large open disturbed areas as soon as soil blowing starts. Begin plowing on the windward edge of the site.

8. Barriers - A board fence, wind fence, sediment fence, hay bales, or similar barriers can control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals about 15 times the barrier height. Where dust is a known problem, preserve windbreak vegetation.

References

1. Chapter III-Sediment Barrier/Fence
2. Chapter III-Surface Roughening
3. Chapter IV-Irrigation
4. Chapter IV-Mulching
5. Chapter IV-Permanent Vegetation
6. Chapter IV-Temporary Vegetation

IRRIGATION (IR)

Definition

The application of water by means of sprinklers, spray devices, emitters or other water application devices in order to develop and/or sustain plant growth.

Purpose

To insure that plants survive and that vegetative cover and/or root development takes place if drought conditions occur after initial planting/establishment.

Conditions Where Practice Applies

On disturbed areas where permanent sod and plant material is planted and on temporary and permanent seeded sites where rapid germination, root development and vegetative growth is essential. Also in areas where prompt use and aesthetics are important, such as, public parks, commercial lawns, golf courses and athletic fields.

Planning Considerations

1. Either permanent or temporary irrigation can be installed. Permanent irrigation is most suited to areas where continued aesthetic value requires a lush, green appearance. These type sites include commercial lawns and landscape areas, golf courses, public parks, and other public areas.

2. Temporary irrigation may be installed on sites where it is important from an erosion standpoint to rapidly develop growth from seed or protect planted vegetation (sod and plants) if drought conditions threaten the survival and/or establishment of such vegetation.

3. A water source must be identified for carrying out any irrigation practice. This source is often a public water supply in the case of new construction. Remote sites may require pumping from surface water or installation of wells near the site. As a planning guide, 27,154 gallons is required to apply 1 inch per acre. Daily requirements of from .05 to .3 inches/acre may be required depending on the type plant, site, stage of growth, and time of year.

4. Proper operation of the irrigation system should be considered during the initial planning phase. For vegetative establishment on newly seeded areas or for establishment of sodded areas or trees, an irrigation system should be planned so that it can be operated frequently to continually maintain favorable soil moisture. As time passes and plant growth occurs, the operating frequency should be decreased or the interval between irrigations should be lengthened to encourage deep rooting of plants. The specific time interval will depend to some extent on the time of year, stage of growth and plants grown. The key is to initially maintain near optimum soil moisture conditions so that plants do not suffer from lack of water, and at the same time, encourage development of a deep root system so that soil erosion possibilities are reduced.

5. Irrigation components should be selected and installed in accordance with recommended irrigation design practices. Systems should be designed to uniformly apply water to the soil's surface in the case of sprinklers and provide equal quantities of water to equal size plants in the case of micro (drip) irrigation. Sprinkler irrigation should be used to establish vegetative cover over large areas.

Specifications

1. Sprinkler systems should be selected such that the application uniformity is at least 70% and sprinklers should be placed such that head to head coverage is achieved, i.e., water from one sprinkler should be thrown to the adjacent sprinkler and visa versa. Sprinklers should be operated at sufficient pressure (as recommended by the manufacturer) to adequately break up and distribute the water over the area.

2. Sprinklers should be selected so that the average application rate (inches per hour) to the soil does not exceed the intake rate of soil. In some cases, especially on new construction sites, this may not be possible and short cycles of frequent irrigation may be necessary to take advantage of rapid intake characteristics of soils during initial wetting.

3. In cases where temporary irrigation must be used at remote sites, irrigation systems should be managed to encourage reliance on natural rainfall in the shortest possible time. This means that after irrigation is used frequently for initial establishment, the irrigation intervals should be lengthened to encourage deep rooting and removal of the temporary irrigation equipment.

4. Appropriate local, state and federal laws/regulations should be abided by related to installation of backflow prevention equipment on irrigation systems.

References

Irrigation, 5th Edition, The Irrigation Association, 1983.

MULCHING (MU)

Definition

Application of a protective layer of straw, other plant residues, stone, or synthetic materials to the soil surface.

Purpose

To protect the soil surface from the forces of raindrop impact and overland flow. Mulch fosters the growth of vegetation, reduces evaporation, insulates the soil, and suppresses weed growth. Mulch is frequently used to accent landscape plantings.

Conditions Where Practice Applies

Mulch temporary or permanent seedings immediately after planting. Mulch around plantings of trees, shrubs, or ground covers to stabilize the soil between plants. Areas that cannot be seeded because of the season should be mulched to provide temporary protection of the soil surface. Use an organic mulch in this case that can be incorporated into the soil during seedbed preparation.

Planning Considerations

1. A surface mulch is the most effective, practical means of controlling runoff and erosion on disturbed land prior to vegetation establishment. Mulch reduces soil moisture loss by evaporation, prevents crusting and sealing of the soil surface, moderates soil temperatures, provides a suitable microclimate for seed germination, and may increase the infiltration rate of the soil.

2. Organic mulches such as straw, wood chips, and shredded bark have been found to be the most effective mulch materials. Materials containing weed and grass seeds which may compete with establishing vegetation should not be used. Also, decomposition of some wood products can tie up significant amounts of soil nitrogen, making it necessary to modify fertilization rates or add fertilizer with the mulch.

3. A variety of erosion control blankets have been developed in recent years for use as mulch, particularly in critical areas such as waterways and channels. Various types of netting materials are also available to anchor organic mulches.

4. Chemical soil stabilizers or soil binders, when used alone, are less effective than other types of mulches. These products are primarily useful for tacking wood fiber or straw mulches.

5. The choice of materials for mulching should be based on soil conditions, season, type of vegetation, and size of the area. A properly applied and tacked mulch is always beneficial. It is especially important when conditions of germination are not optimum, such as midsummer and early winter, and on difficult sites such as cut slopes and drought soils.

6. Organic Mulches

   A. Straw is the most commonly used material in conjunction with seeding. Wheat straw is the mostly commonly used straw, and can be spread by hand or with a mulch blower. If the site is susceptible to blowing wind, the straw should be tacked down to prevent loss.

   B. Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips do not require tacking. Because they decompose slowly they must be treated with 12 pounds of nitrogen per ton to prevent nutrient deficiency in plants. They can be an inexpensive mulch if the chips are obtained from trees cleared on the site.

   C. Wood fiber refers to short cellulose fibers applied a as a slurry in hydroseeding operations. Wood fiber hydroseeder slurries may be used to tack straw mulch on steep slopes, critical areas, and where harsh climatic conditions exist. Wood fiber mulch does not provide sufficient erosion protection to be used alone.

   D. Peanut hulls, cotton burs, and pine straw are organic materials that make excellent mulches but may only be available locally or seasonally. Creative use of these materials can reduce costs.

7. Erosion Control Blankets and Netting

   A. Jute mesh or the various types of netting is very effective in holding mulch in place on waterways and slopes before grasses become established.

B. Erosion control blankets promote seedling growth in the same way as organic mulches. They are very useful in establishing grass in channels and waterways. A wide variety of synthetic and organic materials are available such as wood excelsior, small grain straw, coconut fiber, or mixtures of these materials. When installing erosion control blankets, it is critical to obtain a firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion will occur underneath.

Specifications

1. Select a mulch material based on the site and practice requirements, availability of material, and availability of labor and equipment. Table MU-1 lists commonly used mulches.

2. Before mulching, complete the required grading, install sediment control practices, and prepare the seedbed. Also, plant and cover seed before mulching except when seed is applied as part of a hydroseeder slurry containing wood fiber mulch.

3. Uniformly spread organic mulches by hand or with a mulch blower at a rate which provides about 75% ground cover. When spreading straw mulch by hand, divide the area to be mulched into sections of approximately 1000 sq. ft. and place 70-90 pounds of straw (1 1/2 to 2 bales) in each section to facilitate uniform distribution. This will be 1 1/2 to 2 tons of straw per acre. In hydroseeding operations a green dye may be added to the slurry, to assure a uniform application.

4. Anchoring Straw Mulch

   A. When straw mulch is subject to be blown away by wind, it must be anchored immediately after spreading. It can be anchored with a mulch anchoring tool or a regular farm disk, which weight has been added to and the disk set to run straight. The disk should not be sharp enough to cut the straw.

   B. Liquid mulch binders can also be used to tack mulch subject being blown away by wind. Applications of liquid mulch binders and tackifiers should be heaviest at the edges of areas and at crests of ridges and banks, to resist wind. Binders should be applied uniformly to the

rest of the area. Binders may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil. Applying straw and binder together is the most effective method. Liquid binders include asphalt and an array of commercially available synthetic binders.

C. Emulsified asphalt is the most commonly used mulch binder. Any type thin enough to be blown from spray equipment is satisfactory. Asphalt is classified according to the time it takes to cure. Rapid setting (RS or CRS designation) is formulated for curing in less than 24 hours, even during periods of high humidity; It is bests used in spring and fall. Medium setting (MS or CMS) is formulated for curing within 24 to 48 hours, and slow setting (SS or CSS) is formulated for use during hot, dry weather, requiring 48 hours or more curing time.

D. Apply asphalt at 10 gallons per 1000 sq. ft.(500 gallons per acre). Heavier applications will cause straw to "perch" over rills.

E. Straw mulch may also be anchored with lightweight plastic, cotton, jute, wire or paper netting which are stapled over the mulch. The manufacturer's recommendations on stapling netting should be followed.

5. Installation of Erosion Control Blankets

A. All smoothing, seedbed preparation, and vegetation operations must be completed prior to placing the erosion control blanket. Any rocks, clods, sticks, or other debris which would prevent the blanket form making close contact with the soil should be removed. The erosion control blanket should be placed immediately after planting seed.

B. Unroll the erosion control blanket from the top down, parallel to the direction of flow, in flumes and ditches and perpendicular to the direction of flow on slopes. Allow the blankets to lay loosely on the soil but without wrinkles-do not stretch.

C. To secure the blanket, bury the upslope end in a slot or trench no less than 6 inches deep, cover with soil, and tamp firmly. Staple the blanket every 12 inches across the top end and every 3 feet around the edges and bottom. Where erosion

control blankets are laid side by side, the adjacent edges should be overlapped with the uphill blanket on top and stapled together. Each blanket should also be stapled down the center, every 3 feet. Do not stretch the erosion control blanket when applying staples.

Table MU-1
Mulching Materials and Application Rates

Material	Rate Per Acre	Notes
Straw	1 1/2-2 tons	Spread by hand or machine; tack down when subject to blowing.
Wood chips	5-6 tons	Treat with 12 lbs nitrogen/t.
Bark blower.	35 cu yds	Can apply with mulch Do not use asphalt taack.
Pine straw	1-2 tons	Spread by hand or machine; will not blow like straw.
Peanut hulls	10-20 tons	Will wash off slopes. Treat with 12 lbs nitrogen/ton.

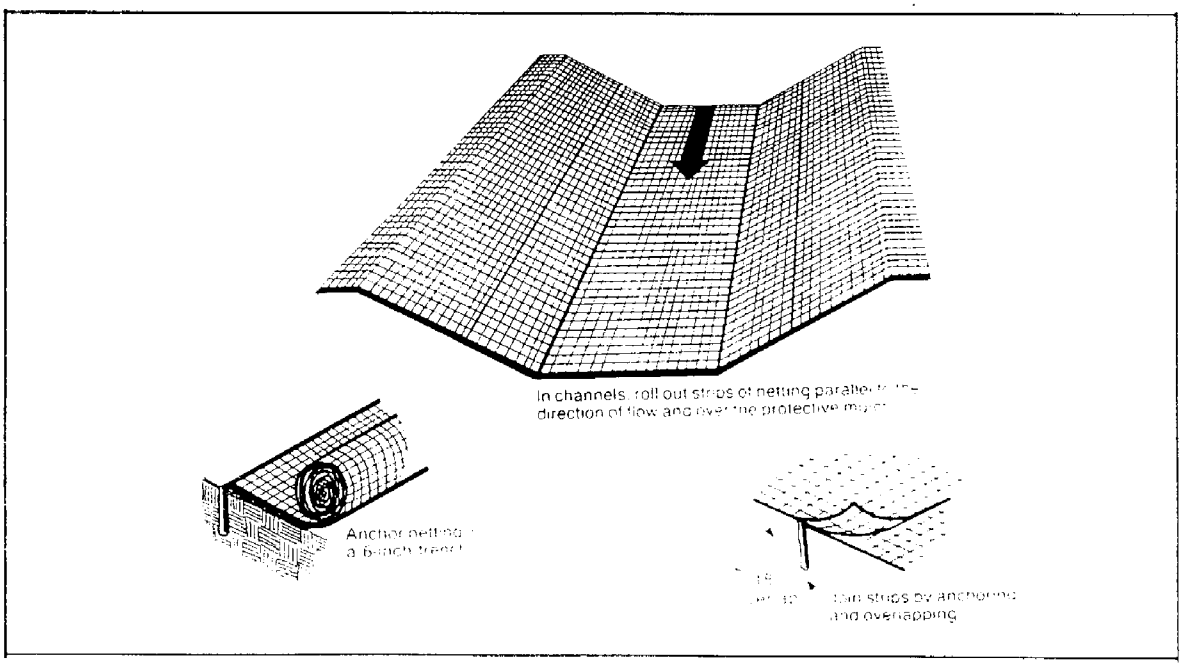


Figure MU-1 Installation of erosion control blankets and netting

Maintenance

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation, or failure. Where erosion is observed, apply additional mulch. If washout occurs, repair the slope grade. reseed , and reinstall mulch. Continue inspectons until vegeration if firmly established.

PERMANENT SEEDING - (PS)

Definition

Controlling runoff and erosion on disturbed areas by establishing perennial vegetative cover with seed.

Purpose

To reduce erosion and decrease sediment yield from disturbed areas, and to permanently stabilize such areas in a manner that is economical, adapts to site conditions, and allows selection of the most appropriate plant materials.

Conditions Where Practice Applies

Disturbed areas where permanent, long-lived vegetative cover is needed or the most effective method of stabilizing the soil. Permanent seeding may also be used on rough-graded areas that will not be brought to final grade for a year or more.

Planning Considerations

1. The most common and economical means of stabilizing disturbed soils is by seeding grasses and legumes. The advantages of seeding over other means of establishing plants include the smaller initial cost, lower labor input, and greater flexibility of method. Disadvantages of seeding include potential for erosion during the establishment stage, seasonal limitations on suitable seeding dates, and weather related problems such as droughts etc.

2. The probability of successful plant establishment can be maximized through good planning. The selection of plants for permanent vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

3. The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

4. Endophyte infected tall fescue appears to establish quicker and have better survival under adverse conditions than endophyte free tall fescue.

5. The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6 inches might not be compacted. A loose, rough seedbed with irregularities that hold seeds and fertilizer is essential for hydroseeding. Cut slopes should be roughened (Practice III-SR, Surface Roughening).

6. Good mulching practices are critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, jute, excelsior, or synthetic matting may be required to protect the slope.

Specifications

1. Grading and shaping - Minor grading and shaping may be needed to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

2. Plant Selection - Plant selection for permanent vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the intended use of the vegetated area. Climate factors can vary widely in Alabama. To simplify plant selection, a table of the adapted plants, including characteristics, for permanent seeding in each of the physiographic regions of Alabama, is provided (A-IV-PS). Also see *Chapter IV, Vegetation Establishment for Erosion and Sediment Control*, pages 7 to 13.

   Plant selection may include companion plants to provide quick cover on difficult sites, late seedings, or in situations where the desired permanent cover may be slow to establishment. Annuals are usually used for companion plants. The plants used for temporary vegetation may be used for companion plants provided the seeding rate is reduced by one half. See *Chapter IV, Vegetation Establishment for Erosion and Sediment Control*, pages 8 and 9 and practice IV-TV, Temporary Vegetation. Ryegrass or other highly competive plants should not be used as a companion plant.

Table PS-1
Perennial Grasses, Legumes and Mixtures; Seeding Rates; and Planting Dates for Disturbed Areas

Species	Seeding Rates/Ac	Seeding Dates & Adapted Area North	Central	South
Bahiagrass, Pensacola	40 lbs	---	Mar 1-July 1	Feb 1-Nov 1*
Bermudagrass, Common	10 lbs	Apr 1-July 1	Mar 15-July 15	Mar 1-July 15
Bahiagrass, Pensacola Common Bermudagrass	30 lbs 5 lbs	---	Mar 1-July1	Mar 1-July 15
Bermudagrass, Hybrid (Lawn Types)	Solid Sod	Anytime	Anytime	Anytime
Bermudagrass, Hybrid (Lawn Types)	Sprigs 1/sq ft	Mar 1-Aug 1	Mar 1-Aug 1	Feb 15-Sep 1
Fescue, Tall	40-50 lbs	Sep 1-Nov 1	Sep 1-Nov 1	---
Sericea	40-60 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15
Sericea & Common Bermudagrass	40-60 lbs 10 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15

* Fall planting of bahia should contain 45 pounds of smallgrain to provide cover during winter months.

Note: Legume seed should be treated with the inoculant specific for the species of legume.

3. Seedbed Requirements - Establishment of vegetation should not be attempted on sites that are unsuitable due to inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. A good growth medium should have these criteria:

- Enough fine-grained (silt and clay) soil material to maintain adequate moisture and nutrient supply.
- Sufficient pore space to permit root penetration.

- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

- A favorable pH range for plant growth, usually 6.0 - 6.5.

- Freedom from large roots, branches, stones, or large clods. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.

If any of the above criteria are not met - i.e., if the existing soil is too coarse, dense, shallow or acidic to foster vegetation - special amendments or topsoil should be used to improve soil conditions. The soil conditioners described below may be beneficial or, preferably, topsoil may be applied in accordance with practice III-TS, Topsoil.

4. Soil Conditioners - In order to improve the structure or drainage characteristics of a soil, the following materials may be added. These amendments should only be necessary where soils have limitations that make them poor for plant growth or for turf establishment.

   A. Peat - Appropriate types are sphagnum moss peat, reed-sedge peat, or peat humus, all from fresh-water sources. Peat should be shredded and conditioned in storage piles for at least 6 months after excavation.

   B. Sand - Clean and free of toxic materials.

   C. Vermiculite - Horticultural grade and free of toxic substances.

   D. Rotted manure - Stable or cattle manure not containing undue amounts of straw or other bedding materials.

   E. Thoroughly rotted sawdust - Free of stones and debris. All 6 lbs of nitrogen to each cubic yard.

5. Soil Amendments

   A. Liming Materials

Lime (Agricultural limestone) should have a neutralizing value of not less than 90 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve and 50 percent will pass through a 60 mesh sieve.

Selma chalk should have a neutralizing value of not less than 80 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve.

B. Plant Nutrients - Commercial grade fertilizers that comply with current Alabama Fertilizer Laws should be used to supply nutrients required to establish vegetation.

C. Rates of Soil Amendments - Lime and fertilizer needs should be determined by soil tests. Soil testing is performed by the Auburn University Soil Testing Laboratory. The local county Cooperative Extension Service can provide information on obtaining soil tests. Commercial laboratories that make recommendations based on soil analysis may be used.

When soil tests are not available, use the following rates for application of soil amendments.

Lime (Agricultural limestone or equivalent):
- Light-textured, sandy soils: 2 tons/acre
- Heavy-textured, clayey soils: 3 tons/acre (Do not apply lime to alkaline soils)

Fertilizer:
- Grasses alone: 800 to 1200 lbs/acre of 10-10-10 or the equivalent.
- Grass-legume mixtures: 800 to 1200 lbs/acre of 5-10-10 or the equivalent.
- Legumes alone: 800 to 1200 lbs/acre of 0-10-10 or the equivalent.

D. Application of Soil Amendments - Apply lime and fertilizer evenly and incorporate into the top 6 inches of soil by disking, chiseling or other suitable means during seedbed preparation. Operate machinery on the contour.

6. Seedbed Preparation - Install necessary mechanical erosion and sedimentation control practices before

seedbed preparation, and complete grading according to the approved plan.

Complete the seedbed preparation, which began with incorporation of soil amendments with tillage as a minimum, that will adequately loosen the soil to a depth of at least 6 inches. Break up large clods, alleviate compaction, and smooth and firm the soil into a uniform surface. Fill in or level depressions that can collect water.

7. Planting Methods

A. Seeding - Use certified seed for permanent seeding whenever possible. Certified seed is inspected by the Alabama Crop Improvement Association. It meets Alabama standards and will be tagged with a "Certified Seed" tag. All seed sold in Alabama is required by law to be tagged. Seed tags contain important information on seed purity, germination, and presence of weed seeds. Seed must meet State standards for content of noxious weeds. Do not accept seed containing "prohibited" noxious weed seed.

Seeding dates are given in Table PS-1 and Appendix A-IV-PV. Seeding properly carried out within the optimum dates have a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activates.

Inoculate legume seed with the *Rhizobium* bacteria appropriate to the species of legume (Chapter IV page 19-20).

Plant seed uniformly with a cyclone seeder, drill, cultipacker seeder, or by hand on a fresh, firm, friable seedbed. If the seedbed has been sealed by rainfall, it should be disked so the seed will be sown in freshly prepared seedbed.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern; then

apply the second half in the same way, but moving at right angles to the first pass.

Cover broadcast seed by raking or chain dragging; then firm the surface with a roller or cultipacker to provide good seed contact. Small grains should be planted no more than 1 inch deep and grasses and legume seed no more than 1/2 inch deep.

B. Hydroseeding - Surface roughening is particularly important when hydroseeding, as roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seeded preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

Mix seed, inoculant if required, and a seed carrier with water and apply as a slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or cane fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at four times the recommended rate when adding inoculant to a hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should be not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor. Fertilizer may be applied with a hydroseeder as a separate operation after seedlings are established.

Lime is not normally applied with a hydraulic seeder because it is abrasive but if necessary it can be added to the seed slurry and applied at seeding or it may be applied with the fertilizer mixture. Also lime can be blown onto steeper slopes in dry form.

C. Sprigging - Hybrid bermudagrass cannot be grown from seed and must be planted vegetatively. Vegetative methods of establishing common and hybrid bermudagrass, centipedegrass, and zoysia include sodding, plugging and sprigging (Practice IV-SD, Sodding). Sprigs are fragments of horizontal stems which include at least one node

(joint). They are normally sold by the bushel and can either be broadcast or planted in furrows using a tractor-drawn transplanter.

Furrows should be 4-6 inches deep and 2 feet apart. Place sprigs about 2 feet apart in the row with one end at or above ground level.

Broadcast sprigs at the specified rate (Table PV-1). Press into the top 1/2 to 2 inches of soil with a cultipacker or with a disk set nearly straight so that the sprigs are not brought back to the surface. A mulch tacking machine may be used to press sprigs into the soil.

8. Mulching - The use of a mulch will help ensure establishment of vegetation under normal conditions and is essential to seeding success under harsh site conditions (Practice IV-MU, Mulching). Harsh site conditions include:

   - Seeding in late fall (wood fiber mulches are not adequate for this use),
   - Slopes steeper than 3:1,
   - Adverse soils (shallow, rocky, or high in clay or sand), and
   - Areas receiving concentrated flow.

9. Irrigation - Moisture is essential for seed germination and vegetation establishment. Supplemental irrigation can be very helpful in assuring adequate stands in dry seasons or to speed development of full cover. It is a requirement for establishment of vegetation from sprigs and should be used elsewhere when feasible. However; irrigation is rarely critical for low-maintenance vegetation planted at the appropriate time of the year.

   Water application rates must be carefully controlled to prevent runoff. Inadequate or excessive amounts of water can be more harmful than no supplemental water (Practice IV-IR, Irrigation).

10. Maintenance - Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect vegetated areas for failure and make necessary repairs and vegetate as soon as possible.

If stand has inadequate cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider seeding temporary cover if the time of year is not appropriate for establishment of permanent vegetation. See Practice IV-TV, Temporary Vegetation - Seeding.

If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

Fertilization - On the typical disturbed site, full establishment usually requires application of fertilizer in the second growing season. Turf grasses require annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixtures.

Protect establishing vegetation from traffic that will be harmful. Use either temporary fences or barriers to protect areas that may be damaged by excessive traffic.

References

1. Chapter III-SR Surface Roughening
2. Chapter III-TS Topsoil
3. Chapter IV-IR Irrigation
4. Chapter IV-MU Mulching
5. Chapter IV-TV Temporary Vegetation - Seeding

SODDING (SD)

Definition

Permanently stabilizing areas by laying a continuous cover of grass sod.

Purpose

To prevent erosion and damage from sediment and runoff by stabilizing the soil surface with permanent vegetation; to provide immediate vegetative cover of critical areas; to stabilize disturbed areas with a suitable plant material that cannot be established by seed; and to stabilize drainage ways and channels and other areas of concentrated flow where flow velocities will not exceed that specified for a vegetated waterway.

Conditions Where Practice Applies

Disturbed areas which require immediate and permanent vegetative cover, or where sodding is preferred to other means of grass establishment such as waterways or sod flumes carrying intermittent flow at acceptable velocities, areas around drop inlets, residential or commercial lawns and golf courses where prompt use and aesthetics are important, and steep critical areas needing immediately cover.

Planning Considerations

1. Advantages of properly installed sod include immediate erosion control, nearly year-round establishment capability, less chance of failure than with seeding, and rapid stabilization of surfaces for traffic areas, channel linings, or critical areas.

2. Initially it is more costly to install sod than to plant seed; however, the higher cost may be justified for specific situations where sod performs better than seed.

3. Sodding for soil stabilization eliminates the seeding and mulching operations, but site preparation is required. Sodding is a more reliable method of producing adequate cover and erosion control than seeding.

4. Sod can be laid during the times of the year when seeded grasses may fail, provided there is adequate water available for irrigation in the early

establishment period. Irrigation is essential, at all times of the year, to install sod.

5. In waterways and sod flumes that carry concentrated flow, properly pegged sod provides immediate protection and is preferable to seeding.

6. Sod placed around drop inlets can protect them from sediment and help maintain the necessary grade around the inlet.

7. The site should be prepared and ready for laying of sod when it is delivered. Leaving sod stacked or rolled can cause severe damage and loss of plant material.

Specifications

1. Selection of appropriate types of sod - The type of sod selected should be adapted to both the site and the intended purpose. In Alabama these are limited to bermuda, zoysia, centipede, St. Augustine, tall fescue, and bahiagrass. Tall fescue and bahiagrass is not readily available but can be obtained from some growers. Species selection is primarily determined by region, availability, and intended use (table SD-1).

Table SD-1
Types of Sod Available in Alabama

Warm Season Grasses:	**Varieties**	**Adaptable Region**
Bermudagrass	Tifway, Tifgreen Tiflawn, common	North Central South
Bahiagrass	Pensacola	Central South
Centipede	No improve varieties	Central South
St. Augustine	Bitterblue, Raleigh, common	South
Zoysia	Emerald, Meyer,	Central South
Cool Season Grasses:		
Tall Fescue	Kentucky 31	North

2. Sod Quality - Sod should be machine cut at a uniform depth of 1/2 to 2 inches (excluding shoot growth and thatch). The sections of sod should be strong enough to support their on weight and retain their size and shape when lifted by one end. Sod should be placed within 36 hours of harvest.

3. Site preparation - Test soil to determine the exact requirements for lime and fertilizer. Soil test may be conducted by Auburn University Soil Testing Laboratory or other laboratories that make recommendations based on soil analysis. When soil test recommendations are unavailable, the following soil amendments may be sufficient:

   Agricultural limestone at a rate of 2 tons per acre (100 lbs per 1000 sq. ft.)

   Fertilizer at a rate of 1000 lbs per acre (25 lbs per 1000 sq. ft.) of 10-10-10.

   Equivalent nutrients may be applied with other fertilizer formulations. The soil amendments should be spread evenly over the treatment area and incorporated into the top 6 inches of soil by disking, chiseling or other effective, means. If topsoil is applied, follow specifications given in practice III-TS, Topsoil

   Prior to laying sod, clear the soil surface of trash, debris, roots, branches, stones, and clods larger than 2 inches in diameter. Fill or level low spots in order to avoid standing water. Rake or harrow the site to achieve a smooth and level final grade.

   Complete soil preparation by rolling or cultipacking to firm the soil. Avoid using heavy equipment on the area, particularly when the soil is wet, as this may cause excessive compaction and make it difficult for the sod to take root.

4. Sod installation - A step-by-step procedure for installing sod is illustrated in Figure SD-1 and described below.

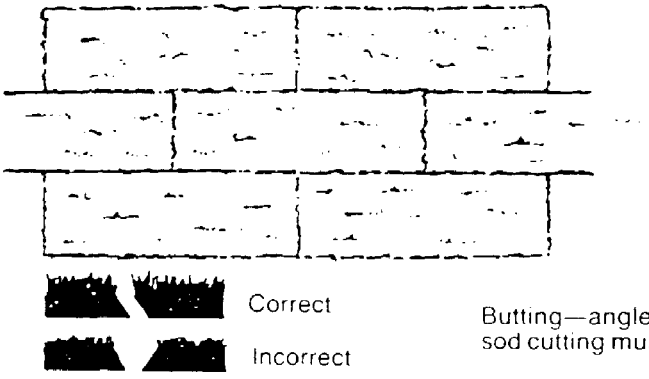
   A. Moistening the sod after it is unrolled helps maintain its viability. Store it in the shade during installation.

   B. Rake the soil surface to break the crust just before laying sod. During the summer, lightly irrigate the soil, immediately before laying the

sod to cool the soil and reduce root burning and dieback.

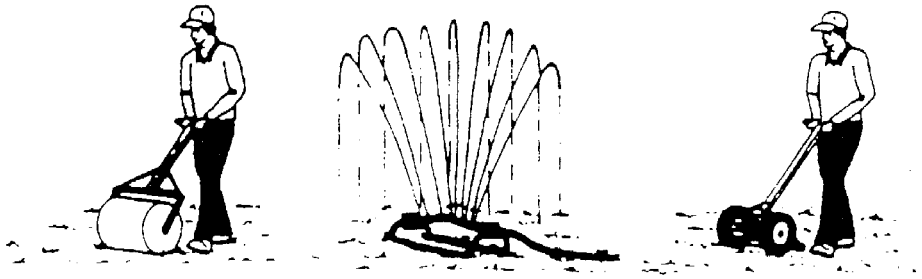
C. Do not lay sod on gravel, frozen soils, or soils that have been recently sterilize or treated with herbicides.

D. Lay the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger strips in a brick-like pattern. Be sure that the sod is not stretched or overlapped and that all joints are butted tightly to prevent voids. Use a knife or sharp spade to trim and fit irregularly shaped areas.



Lay sod in a staggered pattern with strips butted tightly against each other. A sharpened mason's trowel can be used to tuck down the ends and trim pieces.

Butting—angled ends caused by the automatic sod cutting must be matched correctly.



Roll sod immediately to achieve firm contact with the soil.

Water to a depth of 4" as soon as the sod is laid, and continue watering as needed

Mow when the sod is established (2-3 wks). Set the mower high (2-3").

Figure SD-1 Proper installation of grass sod

E. Install strips of sod with their longest dimension perpendicular to the slope. On slopes 3:1 or greater, or wherever erosion may be a problem, secure sod with pegs or staples.

F. As sodding of clearly defined areas is completed, roll sod to provide firm contact between roots and soil.

G. After rolling, irrigate until the soil is wet at least 6 inches below the sod.

H. Keep sodded areas moist to a depth of 4 inches until the grass takes root. This can be determined by gently tugging on the sod. Resistance indicates that rooting has occurred.

I. Mowing should not be attempted until the sod is firmly rooted, usually 2 to 3 weeks.

5. Sodded waterways - Sod provides a resilient channel lining, providing immediate protection from concentrated flow and eliminating the need for installing mats or mulch. The following points apply to the use of sod in waterways:

A. Prepare the soil as described in Practice III-WW, Waterway or Storm Water Conveyance Channels. The sod type must be able to withstand the velocity of flow specified in the channel design.

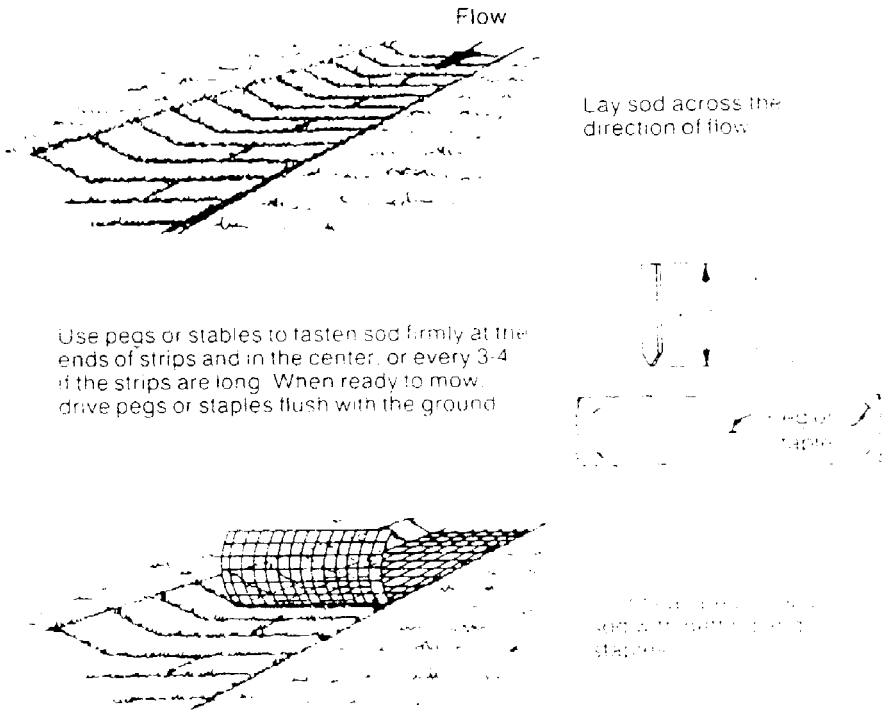


Figure SD-2 Installation of sod in waterways

B. Lay sod strips perpendicular to the direction of flow, with the lateral joints staggered in a brick-like pattern. Edges should butt tightly together (figure SD-2).

C. After rolling or tamping to create a firm contact, peg or staple individual sod strips to resist washout during establishment. Jute or other netting material may be pegged over the sod for extra protection on critical areas.

Maintenance

1. After the first week, water as necessary to maintain adequate moisture in the root zone and prevent dormancy of the sod.

2. Do not remove more than one-third of the shoot in any mowing. Grass height should be maintained between 2 and 3 inches unless otherwise specified.

3. After the first growing season, established sod requires fertilization, and may also require lime. Follow soil test recommendations when possible, or use the rates in table SD-2.

Table SD-2
Characteristics of Grasses Used as Sod in Alabama

Grass	Adaptation					Maintenance	
	Shade	Heat	Cold	Drought	Wear	Mowing Height	Mowing Frequency
Bermudagrass	no	good	poor	excel.	excel.	1 in.	high
Bahiagrass	fair	good	poor	excel.	good	2-3 in.	high
Centipede	fair	good	poor	good	poor	11/2 in.	low
Tall fescue	good	fair	good	good	good	3 in.	high
St. Augustine	good	good	poor	poor	poor	2-3 in.	med.
Zoysia	fair	good	fair	excel.	good	1 in.	high

Reference

1. Chapter III-Topsoil
2. Chapter III-Waterway or Storm Water Conveyance Channel
3. Chapter IV-Irrigation

SHRUB, VINE AND GROUNDCOVER PLANTING (SVG)

Definition

Stabilizing disturbed areas by establishing a vegetative cover of shrubs, vines or groundcovers.

Purposes

To aid in stabilizing soil on areas where the shrubs, vines and groundcovers are the vegetation desired to provide food and shelter for wildlife, to provide windbreaks or screens and to improve aesthetics of the area.

Conditions Where Practice Applies

Shrubs, vines and groundcovers may be used on slopes where mowing is not feasible; as ornamentals for landscaping purposes; or in shaded areas where grass establishment is difficult.

Planning Considerations

1. Shrubs, vines and groundcovers provide alternatives to grasses and legumes as low-maintenance, long-term erosion control. However, they are normally planted only for special, high-value applications, or for aesthetic reasons, because there is additional cost and labor associated with their use.

2. Very few of these plants can be dependably planted from seed, and none are capable of providing the rapid cover possible with grasses. Consequently, short-term stabilization efforts must involve using a dependable mulch along with special cultural practices to ensure establishment.

3. There are many different species of shrubs, vines and groundcovers from which to choose. It is essential to select plant material suited to both the intended use and site. Specific characteristics and requirements of recommended species are given in Appendix A-IV-SVG as an aid to their selection. The diversity of available plant material makes it impractical to give planting specifications for even the most common species. Instead, only general planting guidelines are provided.

4. Shrubs vary in form from small trees to sprawling, woody vines and groundcovers. They differ from most trees in that multiple stems arise from a common base. Shrubs can be used to:

   - Increase the aesthetic value of plantings,
   - Provide visual screening and protective barriers,
   - Enhance windbreaks,
   - Provide food and cover for wildlife,
   - Accelerate the transition to a diverse landscape,
   - Provide post-construction landscaping.

5. Vines and groundcovers - As used by landscapers, "groundcover" refers to low-growing, herbaceous or woody plants that spread vegetatively to produce a dense, continuous cover. They are used in landscape plantings or as an alternative to turf. Typically only a few ornamental grasses are included in this category. Many ground covers, such as English ivy, are vines that spread along the ground but also climb on buildings, fences, or other vegetation.

   Groundcovers can differ in growth rate, and shade tolerance. They may be evergreen or deciduous. Some are suitable only as part of a high-maintenance landscape; others can be used to stabilize large areas with little maintenance.

   In addition to stabilizing disturbed soil, vines and groundcovers perform the following functions:

   - They maintain cover in shaded areas where turf will not thrive.
   - They provide attractive cover that does not need mowing
   - They restrict pedestrian traffic.

Specifications

1. Planting Shrubs

   A. When - Late winter (before leaves emerge) is the best time for planting deciduous shrubs and early fall is the best for evergreens. Shrubs grown and

marketed in containers can be planted anytime during the year except when the ground is frozen.

B. Planting Methods, Individual Shrubs - Provide as large an area as possible for initial root development. The hole should be dug to a depth that allows the root ball to extend one inch above the soil surface, and should be as big around as three to five times the diameter of the root ball.

C. Planting Method, Shrubs in Prepared Beds - Bed preparation differs somewhat from planting in individual holes. Bed areas are usually tilled or spaded, typically to a depth of 8 to 12 inches. Contrary to the individual planting, soil amendments, such as peat or compost at a rate of 1 part amendment to 3 parts native soil, are beneficial to shrubs because they provide a uniform root environment across the bed area. This type of soil amendment also enables plants to respond positively to water and fertilizers when they are applied. The hole for the shrub planted in a bed area can be a few inches wider in diameter than the root ball.

D. Container Plants - Remove container plants from their containers, cutting the container if necessary. If the plant is root-bound (roots circling the outside of the root ball), score the roots from top to bottom about four times, cutting about 1/4 inch deep with a knife, or gently massage the root ball until roots point outward.

Place the shrub into the hole. Using only the native backfill, add soil back to the hole until it is 1/2 to 2/3 full. Water in the backfill soil around the root ball. Add soil to ground level and thoroughly water again. A small dike may be formed around the edge of the planting hole to hold water around the root ball if in sandy soils or on slopes. In a tight clay soil trapping additional water in the root zone can be detrimental.

E. Bare Root Plants - For bare root plants, soak roots in water. When planting, spread the roots in the hole and gradually add soil. Firm the soil, being careful to avoid breaking roots. Fill the hole with water, and allow it to drain. Then fill the hole with soil, and water again thoroughly.

F. Burlapped Plants - For burlapped plants, cut any wire or string around the plants' stems. Do not remove the burlap. Fold the burlap back so it will be buried by soil. Burlap which is allowed to remain exposed after planting can act as a wick, causing the root ball to dry out. From this point, follow the same procedure for filling the hole as that described for container plants.

G. Mulch - Once plants are installed, add mulch. Mulch is beneficial to plants at most stages of development but is particularly important for new plantings. Mulch conserves soil moisture, prevents soil crusting, and suppresses weeds. As a result, more water is made available for use by the landscape plant, which helps reduce stress conditions in the first year planting. See practice IV-MU, Mulching.

H. Water - Water is most important for growth in a new planting. For the first few months, water plants frequently in the area over and beyond the root ball if rainfall does not supply one inch of water per week. This will provide the water to areas where it is taken up by plants until the roots begin to establish in the surrounding soil. Be conscious of plants that have been in the ground for less than one year, and water them thoroughly during extended dry periods.

2. Planting vines and Groundcovers

A. When - Ground covers are best planted in early fall or early spring.

B. Site Preparation - Good soil is important in establishing ground covers because their dense growth requires large amounts of nutrients and water. Well-drained soils high in organic matter work best.

Add lime and fertilizer according to soil test. In absence of a soil test incorporate into the top six inches of soil 50 pounds of ground agricultural limestone and 25 pounds of 8-8-8 fertilizer per 1000 square feet. Also, incorporate organic matter in the form of peat, compost, aged sawdust, or well-rotted manure.

On steep slopes, till the soil in contour rows, or dig single holes for each plant. Blend the needed lime, fertilizer, and organic material with the soil removed from each hole or furrow. Mix fertilizer thoroughly with the soil before planting, and use it sparingly to avoid burning roots. To eliminate harmful competition from weeds, an appropriate preemergent herbicide may be useful in weeding is not practical.

C. Planting - Most groundcovers are planted from container-grown nursery stock. Planting density determines how quickly full cover is achieved; a one foot spacing is often used for rapid cover. Large plants such as junipers can be spaced on three foot centers.

Transplanting to the prepared seedbed can be done using a small trowel or a spade. Make a hole large enough to accommodate the roots and soil. Backfill and firm the soil around the plant, water immediately, and keep well watered until established. Water slowly and over longer periods to allow for infiltration end reduce runoff.

D. Mulching - Competition from volunteer plants inhibits development and maintenance of the groundcover. A thick durable mulch such as shredded bark (not chips) or pine straw should prevent erosion and reduce weed competiion.

On steep slopes or highly erodible soils, install erosion control netting or matting prior to planting, and duck plants into the soil through slits in the net. Plant in a staggered pattern.

Maintenance

Shrubs, vines and groundcovers need about an inch of water a week for the first two years after planting. When rain does not supply this need, shrubs should be watered deeply not more than once a week. Once established, fertilizing every three years is generally sufficient. A soil test is the best way to determine what nutrient elements are needed. Fertilizer formulations of 12-4-8 or 15-0-15 can be used in the absence of a soil test. Apply two pounds of fertilizer per 1000 square feet of area. Maintain a layer of mulch around the base of each plant.

References

1. Chapter III-Topsoil (TS)
2. Chapter IV-Irrigation (IR)
3. Chapter IV-Mulching (MU)
4. Chapter IV-Tree Planting on Disturbed Areas (TP)
5. Chapter IV-Tree Preservation and Protection (TPP)
6. Appendix A-IV-SVG-1
7. Appendix A-IV-SVG-2

TEMPORARY VEGETATION - SEEDING (TV)

Definition

Planting rapid growing annual grasses, small grains, or legumes to provide initial, temporary cover for erosion control on disturbed areas.

Purpose

To temporarily stabilize bare areas that will not be brought to final grade for a period of more than 30 working days.

Temporary seedling controls runoff and erosion until permanent vegetation or other erosion control measures can be established. In addition, it provides residue for soil protection and seedbed preparation and reduces problems of mud and dust production from bare soil surfaces during construction.

Conditions Where Practice Applies

On any cleared, bare, or sparsely vegetated soil surface where vegetative cover is needed for less than one year. Application of this practice include diversions, dams, temporary sediment basins, temporary roads banks, and soil stockpiles.

Planning Considerations

1. Temporary vegetative cover can provide short term protection before establishing perennial vegetation. It can control rills and excessive erosion on earthen sediment control structures such as diversions, dams and sediment basins.

2. Temporary vegetation will reduce the amount of maintenance associated with sediment basins. The frequency of sediment basin cleanups will be reduced if watershed areas outside the active construction zone are stabilized.

3. Certain plants species used for temporary vegetation will produce large quantities of residue which can provide mulch for establishment of the permanent vegetation.

4. Proper seedbed preparation and selection of appropriate species are important with this practice. Failure to follow establishment guidelines and recommendations

carefully may result in an inadequate or short-lived stand of vegetation that will not control erosion.

5. Temporary vegetation is used to provide cover for no more than one year. Permanent vegetation should be established at the proper planting time for permanent vegetative cover.

Specifications

1. Grading and shaping - Minor grading and shaping may be needed to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

2. Plant Selection - Plant selection for temporary vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the needed use of the vegetative cover. Plant species commonly used for temporary cover are contained in Table TV-1.

Table TV-1
Commonly Used Plants for Temporary Cover

Species	Seeding Rate/Ac	Seeding Dates		
		North	Central	South
Millet, Browntop or German	40 lbs	May 1-Aug 1	Apr 1-Aug 15	Apr 1-Aug 15
Rye	3 bu	Sep 1-Nov 15	Sep 15-Nov 15	Sep 15-Nov 15
Ryegrass	30 lbs	Aug 1-Sep 15	Sep 1-Oct 15	Sep 1 -Oct 15
Sorghum-Sudan Hybrids	40 lbs	May 1-Aug 1	Apr 15-Aug 1	Apr 1-Aug 15
Sudangrass	40 lbs	May 1-Aug 1	Apr 15-Aug 1	Apr 1-Aug 15
Wheat	3 bu	Sep 1-Nov 1	Sep 15-Nov 15	Sep 15-Nov 15

3. Soil Amendments

A. Apply lime according to soil test recommendations. If the pH of the soil in not known, use 2 tons of agricultural limestone or equivalent per acre on coarse textured soils and 3 tons per acre on fine

textured soils. Do not apply lime to alkaline soils or to areas which have been limed during the preceding 2 years.

B. Fertilizer application rates should be based on soil test results. When soil test are not possible, apply 500 to 700 pounds of 10-10-10 grade fertilizer.

4. Seedbed Preparation - Complete grading before preparing seedbeds and install all necessary erosion control practices, such as sediment basins. If soils become compacted during grading, loosen them to a depth of 6 to 8 inches using a ripper or chisel plow. Good seedbed preparation is essential to successful plant establishment. A good seedbed is well pulverized, loose, and smooth. Incorporate lime and fertilizer into the top 6 inches of soil during seedbed preparation. If rainfall has caused the surface to become sealed or crusted, loosen it just prior to seeding by disking, raking, harrowing, or other suitable methods. When hydroseeding methods are used, the surface should be left with a more irregular surface of clods.

5. Planting - Evenly apply seed using a cyclone seeder (broadcast), drill, cultipacker seeder, or hydroseeder. Use seeding rates given in Table TV-1. Broadcast seeding and hydroseeding are appropriate for steep slopes where equipment cannot operate safely.

   Small grains should be planted no more than 1 inch deep, and grasses and legumes no more than 1/2 inch deep. Broadcast seed must be covered by raking or chain dragging, and then lightly firmed with a roller or cultipacker, Hydroseeding mixtures should include a wood fiber mulch which is dyed an appropriate color to facilitate uniform application of the seed.

6. Mulching - The use of an appropriate mulch will help ensure establishment of vegetative cover under normal conditions and is essential to seeding success under harsh site conditions (practice IV-MU, Mulching). Harsh site conditions include:

   - seeding in late fall for winter cover (wood fiber mulches are not considered adequate for this use),

   - slopes steeper than 3:1,

- adverse soils (shallow, rocky, or high in clay or sand, and

- areas receiving concentrated flow.

If the area to be mulched is subject to concentrated water flow, as in channels, anchor mulch with netting (practice IV-MU, Mulching)

7. Irrigation - Use irrigation when available and needed to insure establishment. Apply irrigation at a rate that will not cause runoff. See practice IV-IR, Irrigation.

8. Maintenance - Reseed and mulch areas where seedlings emergence is poor or where erosion occurs as soon as possible. Do not mow. Protect from traffic as much as possible.

References

1. Chapter III-SR Surface Roughening

2. Chapter III-TS Topsoil

3. Chapter IV-IR Irrigation

4. Chapter IV-MU Mulching

5. Chapter IV-PV Permanent Vegetation

TREE PLANTING ON DISTURBED AREAS (TP)

Definition

Stabilizing disturbed areas by planting trees.

Purposes

To aid in stabilizing soil on areas where trees are the desired vegetation, to provide food and shelter for wildlife, where wildlife habitat is desired, and to improve the aesthetics of the area.

Conditions Where Practice Applies

On areas where trees are desired for soil conservation, wildlife, or landscaping purposes.

Planning Considerations

1. Trees planted in combination with grasses or legumes should be planted as soon as possible after establishing the grass or legume because of the competition for moisture, nutrients and sunlight.

2. Trees should be adapted to the soil and climate.

3. Trees that have undesirable characteristics should be avoided.

Specifications

Planting Bare-rooted Tree Seedlings

When - Bare-root seedlings should be planted from Dec. 1 to March 15. Planting should be done when the soil is neither too dry not too wet. Planting should be avoided during freezing weather and when the ground is frozen.

Planting methods - Tree seedlings may be planted by hand or machine. Any tool or piece of equipment that gives satisfactory results may be used. Dibble bars, mattocks, augers, post-hole diggers and shovels may be used to plant trees by hand. Wildland tree planting machines should be used on rough areas or areas with clayey or compacted soils.

Old field tree planters should be limited to old field areas with light soils that are not compacted. On sloping land planting should be done on the contour where possible.

Planting rate - To control erosion pines should be planted at a rate of 600 to 700 trees per acre and hardwoods should be planted at a rate of 300 to 500 trees per acre. Severely eroding areas should be planted at the rate of 600 to 900 trees per acre for both pine and hardwood species. Trees planted to enchance wildlife or to improve aesthetics may be planted as scattered individuals or in groups. Trees planted in groups are less susceptible to windthrow.

Depth of planting - Trees should be planted deeper than they grew in the nursery. Plant small stock 1 inch deeper and medium to large stock 1/2 inch deeper. On most soils, longleaf pine seedlings should be planted 1/4 inch deeper than they grew in the nursery.

Condition of roots - Roots should be planted straight down and not twisted, balled, nor U-shaped. Roots that are too long to be planted properly should be pruned.

Firmness - Soil should be packed firmly around the planted seedlings. No air pockets should be left in either machine furrows or holes made by planting tools.

Care of seedlings - The roots of seedlings must be kept moist and cool at all times. After lifting, seedlings should not be exposed to sun, wind, heating, drying or freezing before they are planted. Baled seedlings may be kept up to 3 weeks if they are properly stacked, watered, and kept in a cool place. When planting is delayed longer than 3 weeks, the roots of seedlings should be covered with moist soil (heeled-in) or the seedlings should be put in cold storage.

During planting, the roots of seedlings must be kept moist and only one seedling should be planted at a time. At the end of each day, loose seedlings should be either repacked in wet moss or heeled-in.

Planting Balled and Burlapped and Container-Grown Trees

When - Late winter (before leaves emerge) is the best time for planting deciduous trees and early fall is the best for evergreens. Trees may be planted anytime during the year except when the ground is frozen. Watering is essential during dry periods.

Tree preparation - The proper digging of a tree includes the conservation of as much of the root system as possible, particularly the fine roots. Soil adhering to the roots should be damp when the tree is dug, and kept moist until planting. The soil ball should be 12 inches in diameter for each inch of diameter of the trunk. The tree should be carefully excavated and the soil ball wrapped in burlap and tied with rope. Use of a mechanical tree spade is also acceptable. Containerized trees should be planted when they are young with a trunk diameter of less than 2 inches.

Any trees that are to be transported for a long distance should have the branches bound in with a soft rope to prevent damage.

Site preparation - The planting hole should be dug deep and wide enough to allow proper placement of the root ball. The final level of the root ball's top should be level with the ground surface (See Figure TP-1).

As the hole is dug the topsoil should be kept separate from the subsoil. If possible the subsoil should be replaced with topsoil. If topsoil is unavailable the subsoil can be improved by mixing in 1/3 volume of peat moss or well-rotted manure.

Heavy or poorly drained soils are not good growth media for trees. When it is necessary to transplant trees into such soils, extra care should be taken.

Planting the tree - Depth of planting must be close to the original depth. The tree may be set just a few inches higher than in its former location, especially if soil is poorly drained. Do not set the tree lower than before. Soil to be placed around the root ball should be moist but not wet.

Set the tree in the hole and if the tree is balled and burlapped remove the rope which holds the burlap. Loosen the burlap and remove completely if practical. Do not break the soil of the root ball. Fill the hole with soil half-way and add water to settle the soil and eliminate air pockets. When the water has drained off, fill the hole the remainder of the way. Use extra soil to form a shallow basin around the tree. This will help retain water.

Newly planted trees may need artificial support to prevent excessive swaying.

Stakes and guy wires may be used (See Figure TP-1). Guying should be loose enough to allow some movement of the tree. Following planting much with organic matter (wood chips, bark, pine needles, peanut hulls etc.) to a depth of no more than 3 inches. Mulch should not be placed against the trunk of the tree.

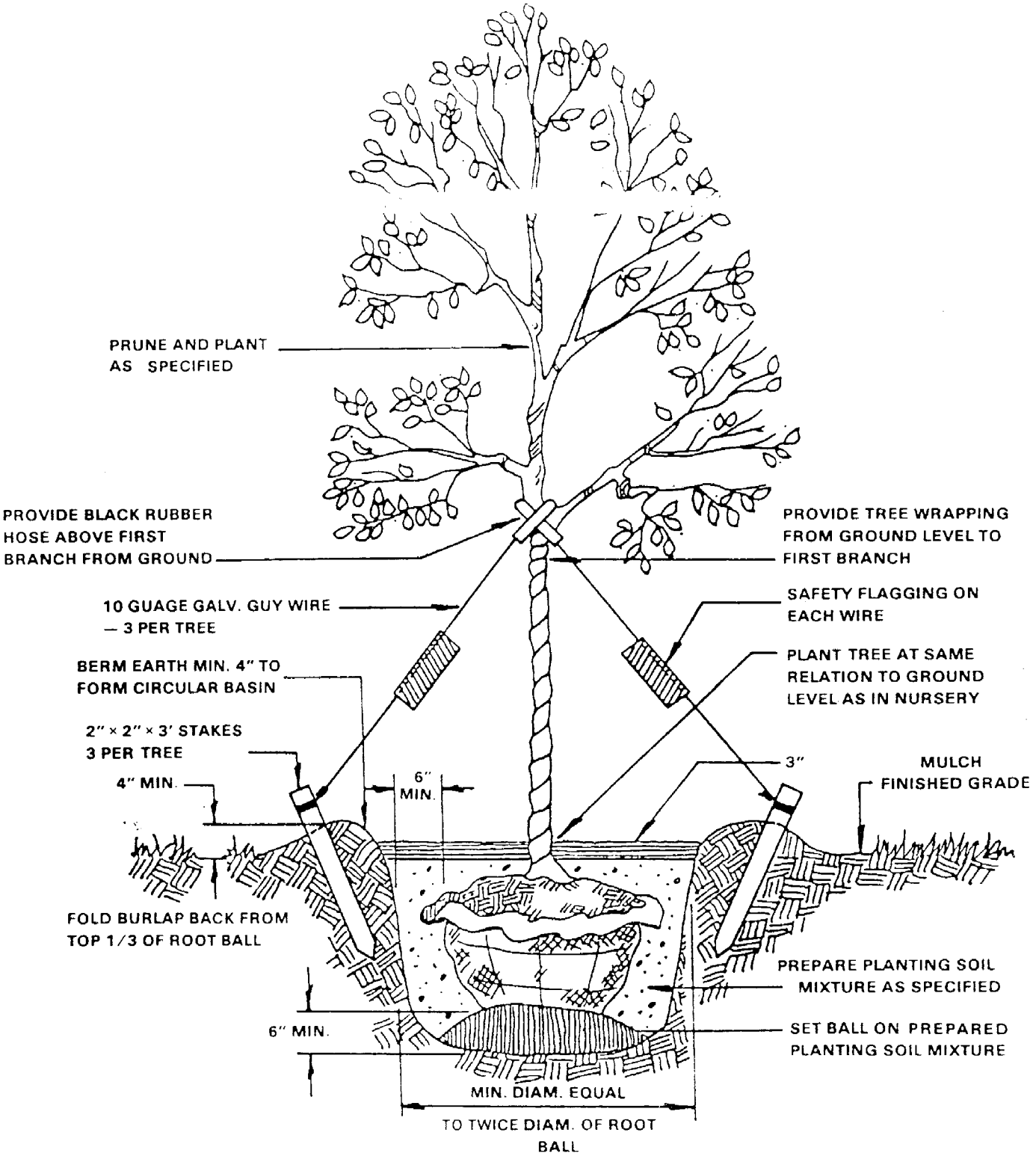


Figure TP-1. Tree Planting Diagram

Maintenance of Tree Plantings

Tree maintenance helps to obtain higher survival and accelerated tree growth. It may not be feasible to provide maintenance to large areas planted to trees to control erosion. However, individual trees or groups of trees planted to enchance wildlife or to improve aesthetics will greatly benefit from a tree maintenance program.

Trees need an inch of water a week for the first two years after planting. When rain does not supply this need, trees should be watered deeply not more than once a week. Transplanted trees should be fertilized one year or so after planting. A soil test is the best way to determine what elements are needed. Fertilizer formulations of 10-8-6 or 10-6-4 can be used in the absence of a soil test. About 2 pounds of fertilizer should be used for each inch of tree diameter measured at 4.5 feet above the ground.

Fertilizer must come in contact with the roots to benefit the tree. The easiest way to apply fertilizer is to simply broadcast it over the root system. As the tree grows, the roots will grow well beyond drip line. This should be taken into account when applying fertilizer by the broadcast method. Another way to apply fertilizer is to make holes in the tree's root area with a bar or auger. Holes should be 18 inches deep, spaced about 2 feet apart, and located around the drip line of the tree. Distribute the fertilizer evenly into these holes and close the holes with the heel of the shoe or by filling with topsoil or peat moss. Trees should be fertilized in late fall or early spring before leaves emerge.

TREE PRESERVATION AND PROTECTION (TPP)

Definition

Protection of desirable trees from mechanical and other injury during land disturbing and construction activity.

Purposes

To insure the survival of desirable trees where they will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade and other environmental benefits while the land is being converted from forest to urban-type uses.

Conditions Where Practice Applies

Forested areas subject to land disturbing activities.

Planning Considerations

1. Trees to save should be identified prior to any construction activity.

2. It takes newly planted trees 20 to 30 years to provide many of the desired benefits of trees.

Specifications

During the preconstruction conference with the contractor, tree preservation and protection measures should be reviewed.

Groups of trees to be retained should be located on a plan map as well as individual trees to be retained. Limits of clearing should be located outside the drip line of groups or individual trees to be saved. The clearing should never be closer than 5 feet to the trunk of a tree. Trees to be retained should be marked with a highly visible paint or surveyor's ribbon in a band circling the tree at a height visible to equipment operators.

Construction equipment, vehicular traffic, stockpiles of construction materials, topsoil etc, shall not be permitted within the tree drip line of any tree to be retained. Trees being removed shall not be pushed into trees to be retained. Equipment operators shall not clean any of their equipment by slamming it against trees to be retained.

Burning of debris should not be done within 100 feet of the drip line of any trees to be retained. Fires shall be limited in size to prevent damage to any nearby trees.

Toxic material shall not be stored any closer than 100 feet to the drip line of any trees to be retained. Toxic materials shall be disposed of according to state laws.

Tree Armoring

Trees should be protected by fencing or armoring where necessary (See Figure TPP-1). The following types of fencing or armoring may be used:

Board Fence - A board fence may be constructed with 4-inch square posts set securely in the ground and protruding at least 4 feet above the ground. A minimum of two horizontal boards should be placed between the posts. The fence should be placed at the limits of the clearing around the drip line of the tree. If it is not practical to erect a fence at the drip line, construct a triangular fence near the trunk. The limits of clearing will still be the drip line as the root zone within the drip line will still require protection.

Cord Fence - Posts at least 2 inches square or 2 inches in diameter set securely in the ground and protruding at least 4 feet above the ground shall be placed at the limits of clearing with two rows of cord 1/4 inch or thicker at least two feet apart running between posts with strips of surveyor's tape tied securely to the string at intervals of 3 feet or less.

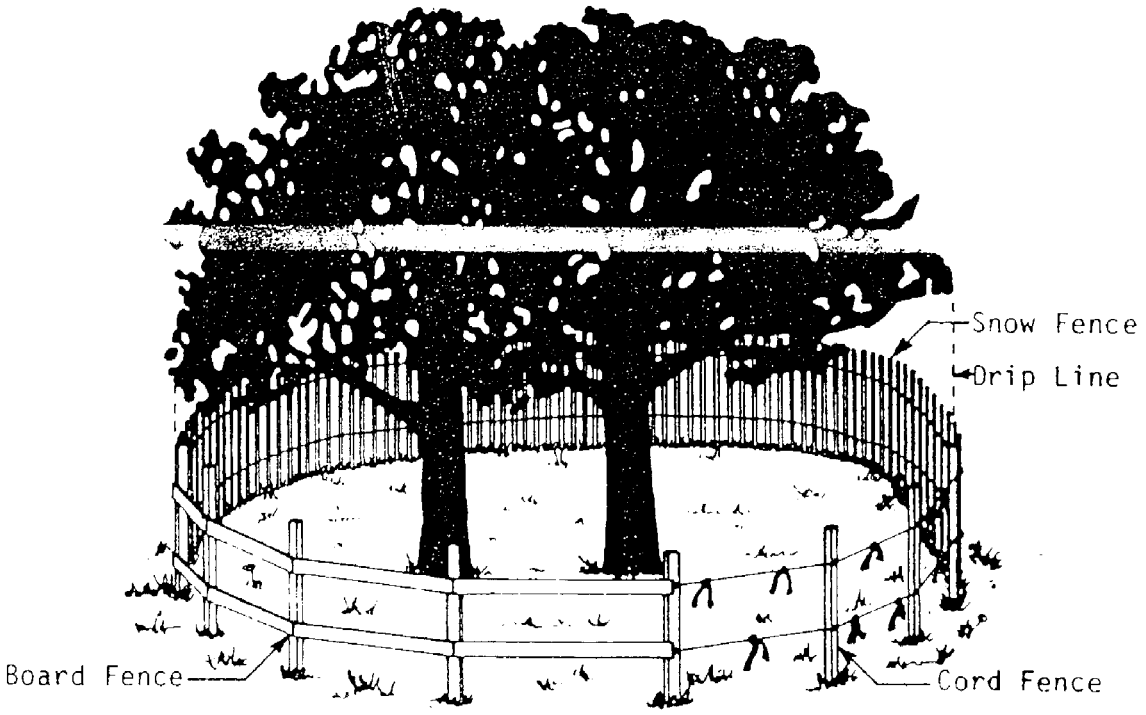
Earth Berms - Temporary earth berms may be constructed. The base of the berm on the tree side should be located along the limits of clearing. Earth berms may not be used for this purpose if their presence will conflict with drainage patterns.

Additional Trees - Additional trees may be left standing as protection between the trees to be retained and the limits of clearing. However, in order for this alternative to be used, trees in the buffer must be no more than 6 feet apart to prevent passage of equipment and material through the buffer.

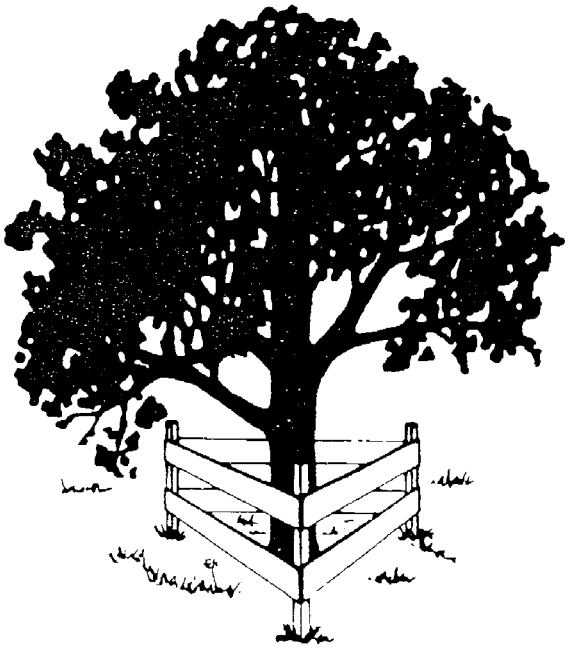
These additional trees shall be reexamined prior to the completion of construction and either given sufficient treatment to insure survival or be removed.

Trunk Armoring - As a last resort, a tree may be armored with burlap wrapping and 2-inch studs wired vertically no more than 2 inches apart to a height of 5 feet. The armoring should encircle the tree trunk. Nothing should never be nailed to a tree. The root zone within the drip line will still require protection.

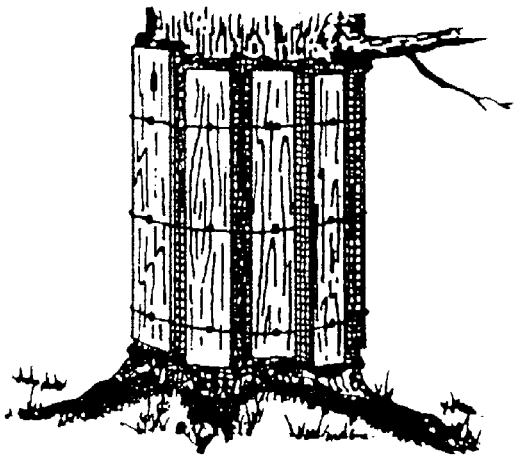
Fencing and armoring devices should be in place before any construction work is done and should be kept in good condition for the duration of construction activities. Fencing and armoring should not be removed until the completion of the construction project.



Correct Methods of Tree Fencing



Triangular Board Fence



Correct Trunk Armoring

Figure TPP-1. Fencing and Armoring

Raising the Grade

When the ground level must be raised around an existing tree or group of trees several methods may be used to insure survival

A well may be created around a group of trees or an individual tree slightly beyond the drip line to retain the natural soil in the area of the feeder roots.

Figure TPP-2. Tree Well

In the case of an individual tree, when the above alternative is not practical or desirable, the following method is recommended to insure survival of the tree. Remove vegetation and organic matter from beneath the tree or trees for a distance of 3 feet beyond the drip line and loosen the surface soil to a depth of approximately 3 inches without damaging the roots.

Apply fertilizer in the root area of the tree to be retained. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees under 6 inches dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6 inches dbh.

A dry well shall be constructed so as to allow for tree trunk diameter growth (See Figure TPP-3). A space of at least 1 foot between the tree trunk and the well wall is adequate for old, slow growing trees. Clearance for younger trees shall be at least 2 feet. The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 1 inch per foot of wall height.

The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks. Openings should be left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

Drain lines composed of 4-inch high quality drain tiles shall begin at the lowest point inside the well and extend outward from the tree trunk in a wheel and spoke pattern with the trunk as the hub. Radial drain lines shall slope away from the well at a rate of 1/8 inch per foot. The circumference line of tiles should be located beneath the drip line of the trees. Vertical tiles or pipes shall be placed over the intersections of the two tile systems if a fill of more than 2 feet is contemplated. Vertical tiles shall be held in place with stone fill. Tile joints shall be tight. A few radical tiles shall extend beyond each intersection and shall slope sharply downward to insure good drainage. Tar paper or its approved equivalent shall be placed over the tile and/or pipe joints to prevent clogging and large stone shall be placed around and over drain tiles and/or pipes for protection.

A layer of 2 to 6 inches of stone shall be placed over the entire area under the tree from the well outward at least as far as the drip line. For fills up to 2 feet deep. a layer

of stone 8 to 12 inches thick should be adequate.

A thick layer of this stone not to exceed 30 inches will be needed for deeper fills. A layer of 3/4-inch to 1-inch stone covered by straw, fiberglass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material. Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

Crushed stone shall be placed inside the dry well over the openings of the radial tiles to prevent clogging. The area between the trunk and the well wall shall either be covered by an iron grate or filled with a 50-50 mixture of crushed charcoal and sand to prevent anyone from falling into the dry well.

Where water drainage through the soil is not a problem, coarse gravel in the fill may be substituted for the tile. This material has sufficient porosity to ensure air drainage. Instead of the vertical tiles or pipes in the system, stones, crushed rock and gravel may be added so that the upper level of these porous materials slants toward the surface in the vicinity below the drip line.

Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.

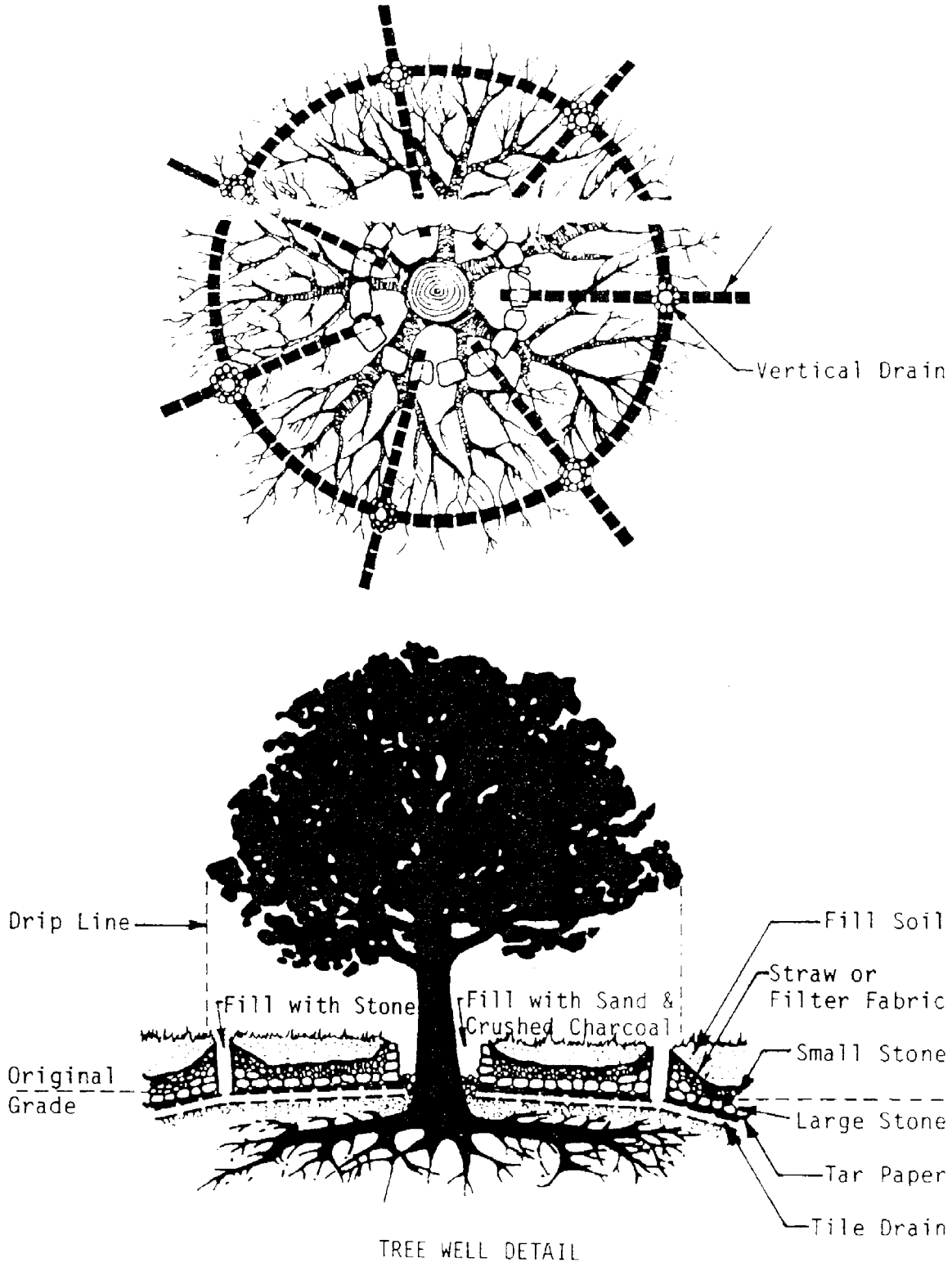


Figure TPP-3. Tree Well Detail

Lowering the Grade: Trees shall be protected from the harmful grade cuts by the construction of a tree wall (See Figure TPP-4). Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly and covered with moist peat moss, burlap or other suitable material to keep them from drying out.

The wall shall be constructed of large stones, brick, building tile, concrete block or cinder block. The wall should be backfilled with topsoil, peat moss, or other organic matter to retain moisture and aid in root development. Apply fertilizer and water thoroughly. The tree should be pruned to reduce the leaf surface in proportion to the amount of root loss. Drainage should be provided through the wall so water will not accumulate behind the wall. Lowering the grade on one side of the tree or group of trees can be accomplished by constructing only half of this system.

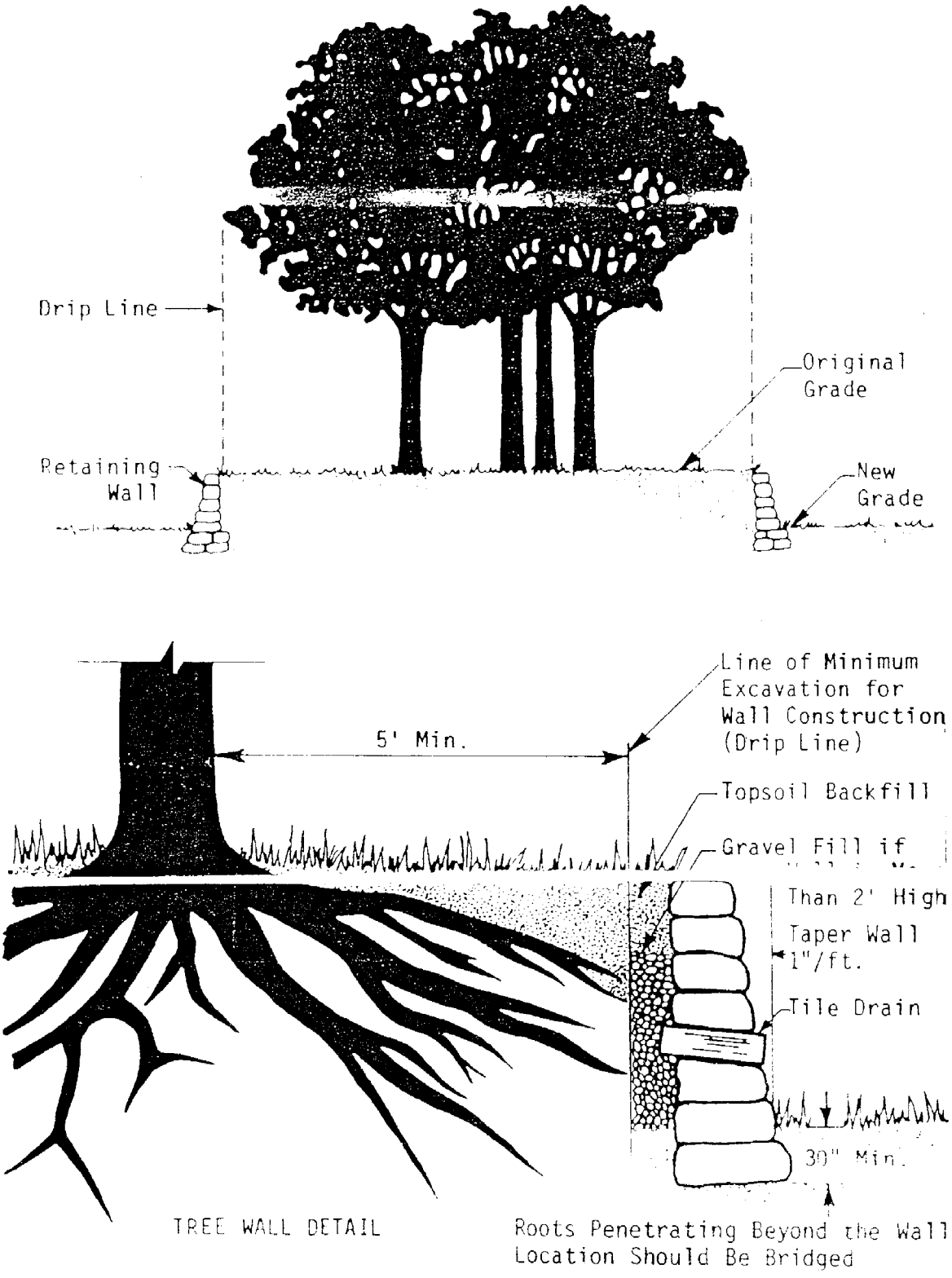
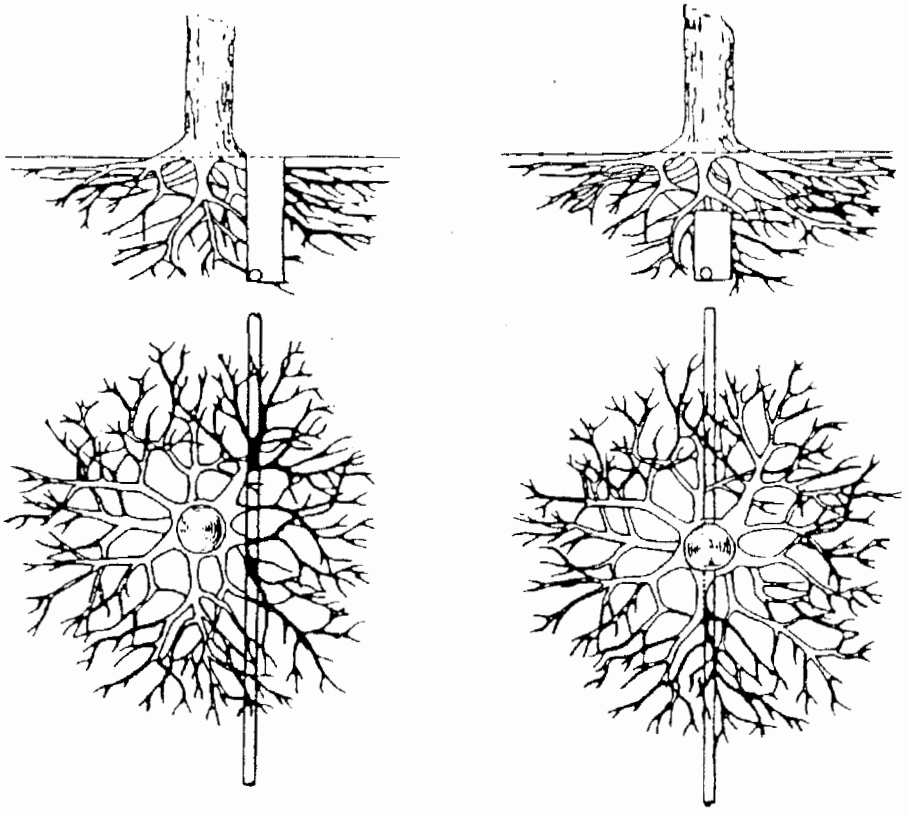


Figure TPP-4. Tree Wall Detail

Trenching and Tunnelling: Trenching should be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged or killed by trenching activities. When possible trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunneling under large roots and areas of heavy root concentration. Tunneling under a specie that does not have a large tap root may be preferable to trenching beside it as it has less impact on root systems.



Destruction of Feeder Roots Will Probably Kill the Tree

Tunneling Under the Tree Will Preserve Important Feeder Roots

TRENCHING vs TUNNELING

Figure TPP-5. Trenching vs Tunneling

Roots should not be left exposed to the air but should be covered with soil as soon as possible or protected and kept moist with burlap or peat moss until the trench or tunnel can be filled. The ends of damaged and cut roots shall be cut off smoothly and moist peat moss, burlap or topsoil should be placed over the exposed area.

Trenches and tunnels shall be filled as soon as possible. Care should be taken to ensure that air spaces are not left in the soil. Peat moss or other organic matter shall be added to the fill material as an aid to inducing and developing root growth. The tree should be fertilized and mulched to stimulate new root growth and enhance general tree vigor. If a large part of the root system has been damaged the crown leaf surface area should be reduced in proportion to the root damage. This may be accomplished by pruning 20 to 30 percent of the crown foliage. If the roots are damaged during the winter the crown should be pruned before the next growing season. If roots are cut during the growing season, pruning should be done immediately.

Treating Damaged Trees: When trees are damaged during construction activities certain maintenance practices can be applied to protect the health of the tree. Soil aeration may be needed if the soil has been compacted. The soil around trees can be aerated by punching holes 1 foot deep and 18 inches apart under the crown of trees with an iron pipe. Damaged roots should be cut off cleanly and moist peat moss, burlap or topsoil should be placed over the exposed area. Bark damage should be treated by removing loose bark. Tree limbs damaged during construction or removed for any other reason shall be cut off above the collar at the branch junction.

Trees that have been stressed or damaged should be fertilized to aid their recovery. Trees should be fertilized in the spring or fall. Fall applications are preferred. Fertilizer should be applied to the soil over the feeder roots. In no case should it be applied closer than 3 feet to the trunk. Root systems of trees extend some distance beyond the drip line. The area to be fertilized should be increased by 1/4 the area of the crown. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees under 6 inches dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6 inches dbh.

A ground cover or organic mulch layer should be maintained around trees to prevent erosion, protect roots and to conserve water.

4) Practice Categories - Design Information/Fact Sheets

a. Urban Conservation Fact Sheets
Source: Kansas, KS-1

b. Standard Drawings
Source: Illinois, IL-3

VI. Urban Conservation Fact Sheets

Controlling Urban Site Erosion

Diversions

Draining Wet Areas

Establishing Lawns - Cool Season

Establishing Lawns - Warm Season

Retaining Walls

Riprap

Rock Chutes

Seeding and Mulching

Silt Fences

Sodding

Soil Erosion - Water

Soils

Straw Bale Sediment Trap

Underground Drain Pipes

Waterways and Lined Channels

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Controlling Urban Site Erosion

Description

Erosion and sedimentation go hand-in-hand. Both are costly enemies to developers and to the community. Erosion removes topsoil and creates gullies, greatly increasing the cost of establishing grass.

Sediment that leaves a construction site fills road ditches, clogs culverts and storm sewers and pollutes lakes and streams. It is much more expensive to remove sediment from these areas than to prevent sediment from leaving a construction site. The following information provides practical methods for controlling erosion and trapping sediment on construction sites. Select the methods that are appropriate for your site. Then incorporate those methods into an erosion and sediment control plan.

Application

The longer an area is allowed to remain bare of vegetation, the more severe and cumulative the effects of erosion and sedimentation become. Therefore it is desirable to keep the period between grading and vegetative establishment as short as possible. The following vegetative and non-vegetative methods are used to protect soil from erosion.

Vegetative Soil Cover

Vegetative methods are the least expensive means of erosion control. Establishing grass or other vegetation protects soil from the impact of falling raindrops and helps hold the soil in place. Temporary and permanent vegetative covers may be used.

Temporary seedings provide quick cover to control erosion before the final grading and landscaping of a lot. It also is used when permanent seeding is not desired or when it is not the right time of the year to establish the desired permanent vegetation. Wheat and rye are common, temporary cover crops. They are seeded at a rate of 150 pounds per acre, or about four pounds per 1,000 square feet.

Establishing permanent vegetation may include seeding grass or other species, putting down sod or planting trees and shrubs. Success requires careful species selection, proper seedbed preparation and follow-up care.

Non-Vegetative Soil Cover

Non-vegetative soil cover methods include using various mulches and a wide variety of manufactured soil erosion-control blankets. The primary purpose of mulch is to protect the soil from the impact of falling raindrops, and to provide an environment conducive to plant growth. Mulch helps plants grow by retaining moisture and by shading soil from the sun.

Mulch also is used when an area is seeded with vegetation. In those cases, the seed is spread first. Then mulch is applied. Straw is the most commonly used mulch because it is widely available and is relatively inexpensive. Hay, wood chips, wood shavings, shredded bark, jute fiber, and shredded newsprint also have proven successful as mulches.

Straw mulch should be applied uniformly over an area at a rate of about two tons per acre, or two bales per 1,000 square feet. On large areas, the straw can be distributed with a mechanical mulch blower.

Some degree of "tacking" usually is required to attach the mulch to the surface to prevent straw from blowing away or washing down the hill. Tacking is done by spraying the surface with a commercially-available tacking agent or by disking lightly with a straight disk, an implement pulled behind a tractor with disk-shaped blades aligned parallel to the direction of travel.

Erosion control blankets are used where steep hills or storm water runoff make it difficult to keep conventional straw mulch in place. These blankets consist of a natural or synthetic fiber material that is sandwiched between a permanent or degradable netting. Strips of the blanket material are unrolled down the hill and anchored into the soil on the uphill side. In all cases, success with erosion control blankets requires strict adherence to the manufacturer's installation instructions.

Runoff Control

Erosion from construction sites results from uncontrolled water that detaches soil particles and carries them away. These problems can be alleviated by controlling the flow of water by using diversions, waterways, and underground

(over)

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

drains. Information sheets that outline those procedures are available from your local Soil Conservation Service office.

Sediment Control

The two most common methods for preventing sediment from leaving a construction site are sediment filters and sediment basins. Keep in mind, however, that it always is better to prevent erosion from occurring than to catch the sediment it causes.

Sediment filters, commonly called silt fences, are used around the perimeters of construction sites and around inlets to storm sewers to remove sediment from the surface water leaving the construction sites. One of the most effective products available consists of a reinforced mesh fabric attached to wooden stakes. The stakes are driven into the ground to form a fence-like barrier. The lower edge of the mesh fabric is placed in a trench so that it is at least six inches below the ground. Soil is packed around the bottom of the fence to keep water from running under the fabric. These filters take up little space, and are effective when properly installed.

Sediment basins, either earthen or straw bale, are also used to prevent sediment form leaving construction sites. The effectiveness of using straw bales requires proper installation. Like silt fences, straw bales must be set in trenches and anchored with stakes to keep surface water from running around or under the barriers.

Grass filter strips sometimes are grown around the perimeters of construction sites where space and time for establishment permit them. The size of the grass filter strips should be proportional to the drainage areas. While not as effective as silt fences, grass filter strips filter sediment from low-velocity storm water flow, especially when used in conjunction with other erosion-reducing measures. The grass strips work only with evenly-dispersed flows of water. They will not work in ditches or areas where water flows rapidly.

Where To Get Help

Keeping soil on construction sites is vastly cheaper than cleaning up the sediment caused by soil erosion. When sediment is allowed to run off construction sites, the community bears the burden and expense of cleaning up the choked storm sewers, ditches, lakes and streams. The methods covered here have proven to be cost effective in the communities where they have been used.

For more information about erosion control methods and sediment pollution control methods for construction sites, contact your local Soil Conservation Service office.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Diversions

Description

Diversions are structures built across hills to intercept runoff water and carry it to stable outlets. Redirecting the runoff protects downhill areas from soil erosion and excessive wet conditions. Diversions may be constructed using soil, railroad ties or other materials.

A. Earthen Diversions

An earthen diversion consists of a channel and ridge (see picture below) constructed across the slope. The width of the base of the ridge should be a minimum of 6 feet. A height of 18 inches and side slopes of 4:1 (4 feet horizontally for every foot vertically) are recommended for the ridge. The slope or grade of the diversion channel should be non-erosive. When the diversion is to be grassed a grade of 2% or less (2 feet of drop for every 100 linear feet) is recommended. If the diversion is unvegetated, a grade of 1/2% or less (6 inches drop for every 100 linear feet) is recommended. When building an earthen diversion, consider the following tips.

* Provide a stable outlet - such as grass, concrete or other non-erosive surfaces - for diversion of water.

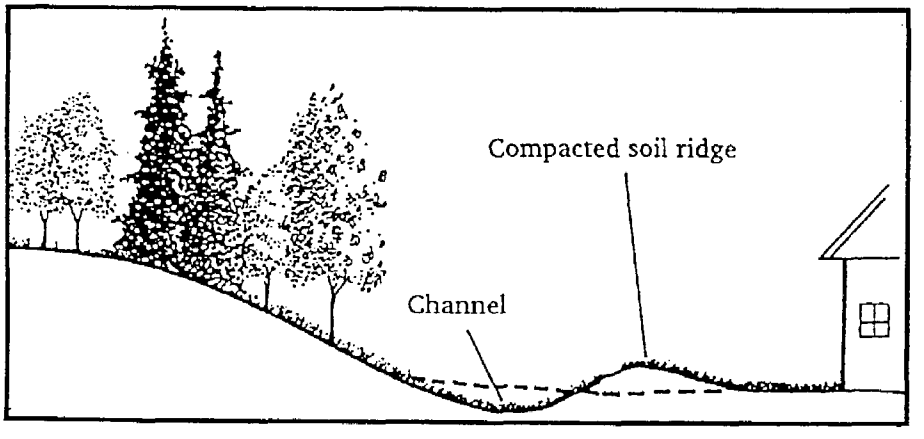
* Take aesthetics into consideration before construction.

* During the construction compact the soil well.

* If necessary, stockpile the topsoil and spread it over graded area to make it easier to re-establish vegetation.

* Before the soil ridge is pushed up, it is recommended that the soil that will be under the ridge be roughed up, and moistened, if needed. Grass should also be removed. Grass should not be used in the ridge of the diversion as this may cause uneven settlement. These measures will create a bond between the existing soil and soil ridge to prevent it from sliding.

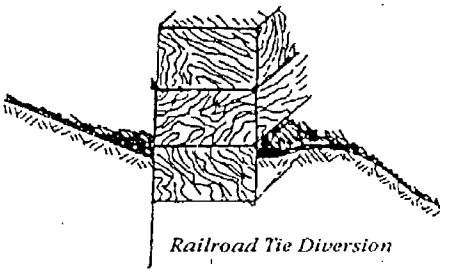
* If the diversion is to be seeded, lime and fertilize according to a soil test, then seed and mulch the area. Contact your local Extension office for soil test information.



Earthen Diversion.
(The dashed line represents the original ground surface.)

B. Railroad Tie Diversions

* Provide a stable outlet - such as grass, concrete or other non-erosive surfaces - for diversion of water.



Railroad Tie Diversion

* One railroad tie should be set at least halfway into the ground. Additional height is attained by adding railroad ties to the top.

* Additional rows of railroad ties should be spiked or bolted together so that they are not moved by flowing water.

* Seams or joints between railroad ties should be sealed to keep out water.

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Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

Maintenance

Sediment should be cleaned out of diversion channels to keep the diversion working.

Vegetative linings common to all diversions require mowing, spraying and other practices to maintain the desired plant cover and to control woody vegetation that may choke or obstruct channels. In addition, maintaining the correct plant cover in the channel will help prevent channel erosion and "piping" erosion from developing along woody plant roots.

Diversions should be inspected periodically, usually after each heavy storm. Sediment should be removed promptly. Breaks in the ridge, ditches and scoured areas should be repaired immediately.

Where To Get Help

For more information about diversions for urban areas, contact your local Soil Conservation Service office.

United States
Department of
Agriculture

Soil
Conservation
Service

Salina,
Kansas

Fact Sheet

Draining Wet Areas

Description

The expression "drainage problems" is used collectively to categorize conditions such as floods, springs and seeps, puddles and wet basements. These problems usually are caused by heavy rains. However, they may be associated with soil permeability and its ability to effectively convey water through the subsurface or on the surface of the soil. Drainage problems should be considered to be both soil related and water related.

It is easy to determine that a drainage problem exists. Flooding, a soggy area in a lawn and a wet basement are all examples of drainage problems; the causes of a surface moisture condition, a subsurface moisture condition or both. To correct a poor drainage situation, both the characteristics of the problem and the source of the problem must be known.

Surface drainage problems are easily identified by water that stays on the surface of the land in depressions or does not run off in a timely manner.

Leaking water, sewer lines and overloaded septic leach fields have been identified as sources of subsurface drainage problems in urban areas.

Application

Refer to the fact sheets for the following practices for specific information.

- Subsurface
- Underground Drain Pipes
- Foundation Drain (see Fact Sheet "Underground Drain Pipes")
- Surface
- Waterways and Lined Channels
- Diversions
- Drop Inlet (see Fact Sheet "Underground Drain Pipes")

Maintenance

Maintenance of drainage systems should include periodic inspection of all components. Examples are maintaining the sod in water channels and making sure that drain pipes are open and not damaged. Damages to components should be repaired in a timely manner and all drainageways should be kept free of sediment and debris.

Where To Get Help

For more information about urban drainage, contact your local Soil Conservation Service office.

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Establishing Lawns

Cool Season

Description

Your success with establishing and keeping grass on disturbed areas will largely depend on the care you take during the establishment process. Most failures result from seeding at the wrong times, from not preparing an adequate seedbed and from planting the seed improperly. This guide outlines necessary steps in establishing and maintaining your lawn of cool season grasses. Cool season grasses commonly used for lawns are fescue (K-31 tall fescue for high traffic or large open areas. Turf type fescues used for formalized lawn areas.), bluegrass, and perennial ryegrass.

Application

Begin by planning. Inventory trees and evaluate shady areas. Have your soil analyzed. Grass mixtures that do well in shade, have low fertility requirements and withstand droughty conditions can be bought at most garden centers. You can get a soil analysis for a nominal fee by contacting your local county Extension office.

Remember, your success in this undertaking requires planting seed at the correct times. Plant cool season grass lawns between August 15 and September 15. A target date to shoot for is Labor Day. These grasses can be planted in early spring to May 1, but you will have to water frequently to maintain your stand.

On areas where a grass cover is needed sooner than can be established by seeding, you should consider sodding the area. Refer to the fact sheet entitled "sodding" for additional information.

After selecting your seed mixture, determining lime and fertilizer needs and picking a planting date, you are ready to establish your lawn. In the absence of a soil test, refer to the chart below for lime and fertilizer recommendations.

Apply the lime and fertilizer to the soil surface and work it into the ground at least three inches with a power tiller or disk. If power equipment is unavailable, rake the area as deeply as possible. Then smooth and roll the area to form a firm, fine seedbed. Broadcast lawn seed uniformly at the recommended rate (see seeding table). If you broadcast the seed with a cyclone spreader, apply seed at a one-half rate and cover the lawn two times using a crossing pattern (see illustration). This will help assure uniform coverage of the area to be seeded. After the seed is broadcast, lightly rake the soil with a flexible tine rake. Do not cover the seed too deeply. Most grass seeds only require one-fourth-inch coverage to germinate and grow. It's a good sign if, during raking, you see seed still on the surface.

Next, lightly mulch. Spread clean straw or prairie hay at a rate of two bales per 1,000 square feet. Immediately after seeding and mulching, soak with water and keep the surface wet by watering several times a day. Do not water so much as to cause erosion. After grass emerges, watering should be less frequent and deeper to encourage root development deeper into the soil. Continue watering as needed during drought. Soaking lawns four to six inches deep once a week usually maintains a healthy stand of grass.

Maintenance

The last step is maintenance, your key to a healthy, long-lasting lawn. Do not mow closer than three

(over)

Nutrient and Mulching Recommendations *

Soil Treatment	Rate per 1,000 Square Feet
Limestone (if needed)**	
Ground (agricultural grade)	50 lbs.
Hydrated	35 lbs.
Fertilizer	
10-10-10	15-20 lbs.
12-12-12	12-17 lbs.
Straw or Hay	2 bales

* Apply lime and fertilizer according to a soil test where available.

** For soils with a known high ph, lime is not needed.

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

inches during hot summer months, and maintain a two-inch minimum during the spring and fall. No more than one-third of the leaf should be clipped to maintain a leaf surface capable of properly utilizing sunlight for good growth.

The starter fertilizer you used when planting in the fall will be adequate for about four to eight weeks. When seedlings show signs of losing vigor, apply a lawn fertilizer mix at half the regular rate. After the lawn is fully established, early fall (September) fertilization usually will be the most beneficial to the entire plant. Labor Day is also a good target date for fertilizing.

Weed, insect, and disease control in established lawns is a common practice in lawn maintenance. Consult your local garden center or Extension Service office for recommendations.

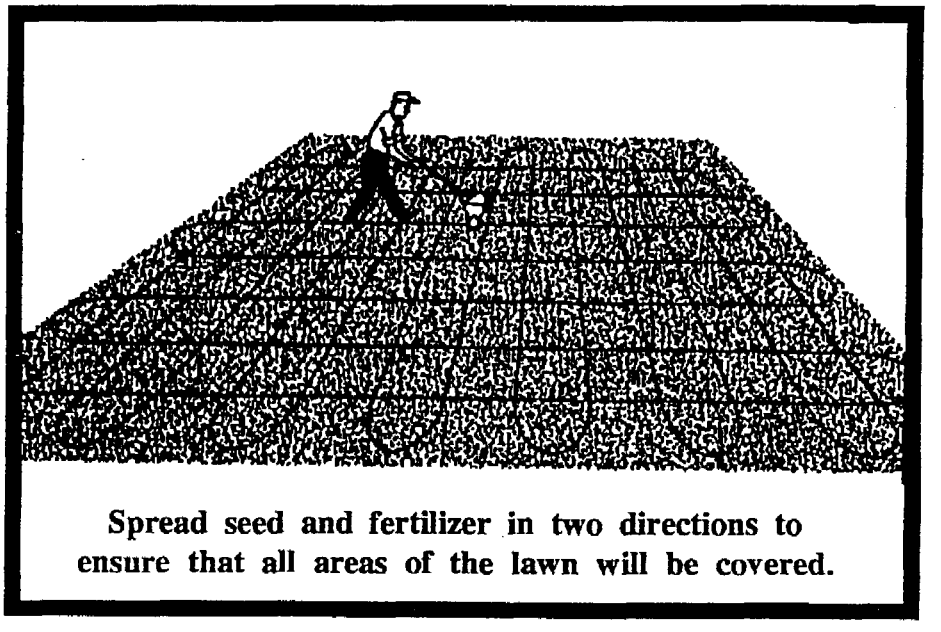
Lawn Publications

The following publications will help you plan the proper care for your new lawn. Ask for them at your County Extension Service Office.

Buffalograss Lawns	MF-658
Fall Lawn Fertilizing Program	MF-628
Fertilizing Your Lawn	MF-544
Overseeding Your Lawn	MF-534
Keys to a Good Lawn	MF-652
Mowing Your Lawn	MF-438
Planting Your Lawn	MF-608
Selecting A Grass For Your Lawn	MF-353
Watering Your Lawn	MF-440
Lawn Weed Control	MF-630
Tall Fescue Lawns	MF-664
Zoysia Lawns	MF-683

Where To Get Help

For more information about establishing lawns, contact your local Soil conservation Service office or your local Extension Service office.



Spread seed and fertilizer in two directions to ensure that all areas of the lawn will be covered.

Grass Variety	Seeding Rate per 1000 sq. ft.	Drought Tolerance	Shade Tolerance	Level of Maintenance Required
Fescue	6-8 lbs.	Good	High	Moderate
Bluegrass	2-3 lbs.	Fair	Moderate	Moderate-High
Ryegrass	5-6 lbs.	Poor	High	High
Mixture: Bluegrass, Ryegrass, Fine Fescues	6-8 lbs.	Fair	High	Moderate

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Establishing Lawns

Warm Season

Description

Your success with establishing and keeping grass on disturbed areas will largely depend on the care you take during the establishment process. Most failures result from seeding at the wrong times, from not preparing an adequate seedbed and from planting the seed improperly. This guide outlines necessary steps in establishing and maintaining your lawn of warm season grasses. Warm season grasses commonly used for lawns are buffalograss, bermudagrass and zoysia.

Application

Begin by planning. Inventory trees and evaluate shady areas. Have your soil analyzed. You can get a soil analysis for a nominal fee by contacting your local county Extension office.

Remember, your success in this undertaking requires planting seed at the correct times. Plant warm season grass lawns between December 1 and May 15. The optimum seeding dates are between March 15 and May 1.

On areas where a grass cover is needed sooner than can be established by seeding, you should consider sodding the area. Refer to the fact sheet entitled "sodding" for additional information.

After selecting your seed mixture, determining lime and fertilizer needs and picking a planting date, you are ready to establish your lawn. In the absence of a soil test, refer to the chart below for lime and fertilizer recommendations.

Apply the lime and fertilizer to the soil surface and work it into the ground at least three inches with a power tiller or disk. If power equipment is unavailable, rake the area as deeply as possible. Then smooth and roll the area to form a firm, fine seedbed.

Broadcast lawn seed uniformly at the recommended rate (see seeding table). If you broadcast the seed with a cyclone spreader, apply seed at a one-half rate and cover the lawn two times using a crossing pattern (see illustration). This will help assure uniform coverage of the area to be seeded. After the seed is broadcast, lightly rake the soil with a flexible tine rake. Do not cover the seed too deeply. Most grass seeds only require one-fourth-inch coverage to germinate and grow. It's a good sign if, during raking, you see seed still on the surface. Next, lightly mulch. Spread clean straw or prairie hay at a rate of two bales per 1,000 square feet. Immediately after seeding and mulching, soak with water and keep the surface wet by watering several times a day. Do not water so much as to cause erosion. After grass emerges, watering should be less frequent and deeper to encourage root development deeper into the soil. Continue watering as needed during drought. Soaking lawns four to six inches deep once a week usually maintains a healthy stand of grass.

Maintenance

The last step is maintenance, your key to a healthy, long-lasting lawn. Do not mow closer than three inches during hot summer months, and maintain a two-inch minimum during the spring and fall. No more than one-third of the leaf should be clipped to maintain a leaf surface capable of properly utilizing sunlight for good growth.

Weed, insect, and disease control in established lawns is a common practice in lawn maintenance. Consult your local garden center or Extension Service office for recommendations.

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Nutrient and Mulching Recommendations *

Soil Treatment	Rate per 1,000 Square Feet
Limestone (if needed)**	
Ground (agricultural grade)	50 lbs.
Hydrated	35 lbs.
Fertilizer	
10-10-10	15-20 lbs.
12-12-12	12-17 lbs.
Straw or Hay	2 bales

* Apply lime and fertilizer according to a soil test where available.

** For soils with a known high pH, lime is not needed.

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

Lawn Publications

The following publications will help you plan the proper care for your new lawn. Ask for them at your County Extension Office.

Buffalograss Lawns	MF-658
Fall Lawn Fertilizing Program	MF-628
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Lawn Weed Control	MF-630
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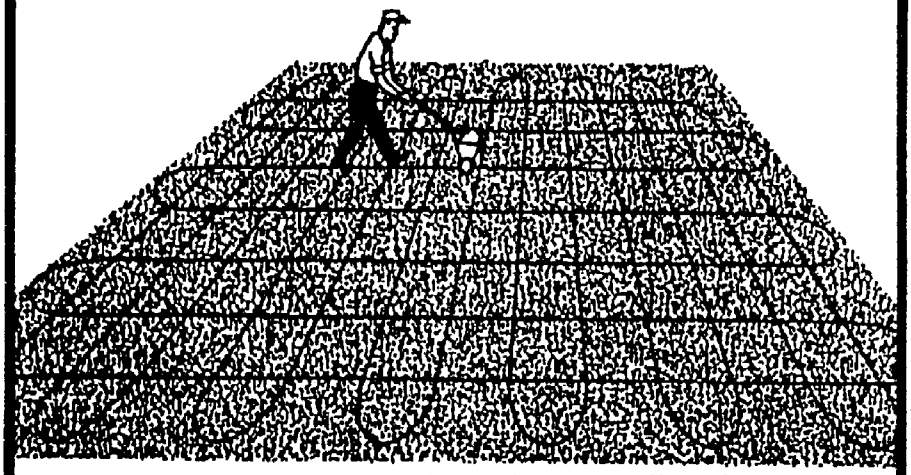
Zoysia Lawns	MF-683



Spread seed and fertilizer in two directions to ensure that all areas of the lawn will be covered.

Where To Get Help

For more information about establishing lawns, contact your local Soil Conservation Service office or your local Extension Service office.

Grass Variety	Seeding Rate per 1000 sq. ft.	Drought Tolerance	Shade Tolerance	Level of Maintenance Required
Buffalograss	1-2 lbs.	Excellent	Low	Low
Bermudagrass**	2-3 lbs. or 1/ 1 bu. of stolons if sprigging	Excellent	Low	Moderate
Zoysia**	2-3 sq. yd. of sod if sprigging	Good	Moderate	Low-Moderate

* Zoysia loses drought tolerance when it becomes thatchy.

**Check on adaptation and areas in Kansas where these grasses should be planted.

1/ See Kansas State University Horticulture Fact Sheet for more information.

United States
Department of
Agriculture

Soil
Conservation
Service

Salina,
Kansas

Fact Sheet

Retaining Walls

Description

Retaining walls are vertical walls that stabilize slopes created by construction of stream bank erosion. They are used where shaping the area to a stable slope is not practical.

Application

Retaining walls must have enough strength and stability to resist being fractured or displaced by the soil it is designed to hold in place. The pressure against the wall increases in relation to the height of the wall, and as extra loads, such as tractors or buildings, are placed on the soil above the wall. Large retaining walls require detailed and complex engineering analysis.

The site conditions most critical to retaining walls are the soil's stability and drainage. Soils prone to landslides and heaving can adversely affect retaining walls. In fact, they can make a site unfavorable altogether by causing the retaining wall to tilt or collapse. Surface water flowing over the top of a retaining wall also may affect the structure if the soil at the foot of the wall is not protected against erosion.

Here are some tips to consider when building retaining walls:

* Excessively high walls are expensive to build because of high soil pressure. This often can be avoided by building multiple walls. For instance, two five-foot retaining walls could be built instead of one 10-foot wall.

* Place weep holes in the retaining wall to help drain away excessive water and to prevent water table build up. Use gravel wrapped with filter fabric to keep soil from flushing out through the weep holes.

* Backfill with coarse material, such as sand and gravel. It won't swell when wet, doesn't need

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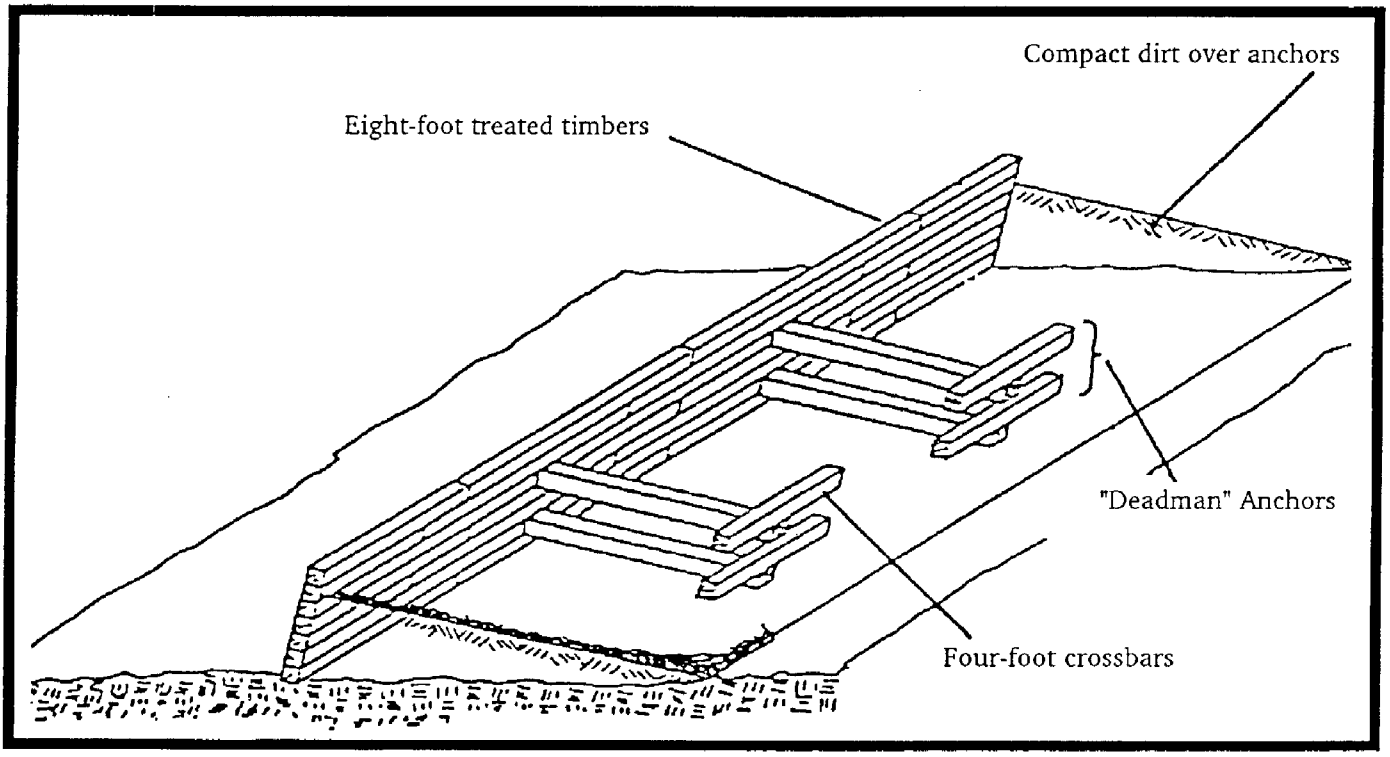


Railroad Tie Retaining Wall

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

to be compacted to fill the voids and provides excellent internal drainage.

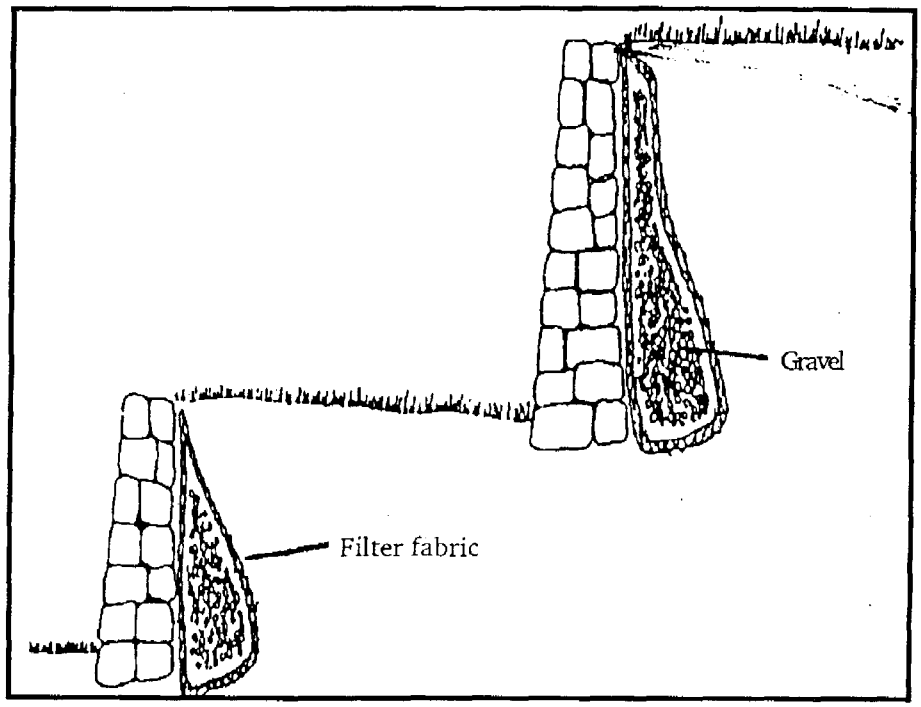
* Don't plant trees above the wall or within 50 feet of the wall, because pressure from their expanding root systems may damage the wall.

* Make sure soil used to fill around the retaining wall is well compacted.

* Retaining walls may be constructed using many different materials. Rock and mortar, brick and mortar, reinforced concrete, railroad ties and heavy timber, steel bins and gabions (rock-filled wire cages) are among the most common.

* Stabilize the retaining wall by using an anchor or "deadman". Another technique is to make the wall massive enough that it cannot be displaced by the soil.

* All retaining walls will settle to some extent. But, to avoid an unstable-looking structure, retaining walls should be tilted slightly uphill to allow for settlement.



Stone Retaining Wall

Maintenance

Regardless of the type of retaining wall used, good maintenance is necessary. Typical maintenance begins with periodic examinations of the wall and careful monitoring of any defects. Any needed repairs should be done immediately.

Where To Get Help

For more information about retaining walls, contact your local Soil Conservation Service office.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Riprap

Description

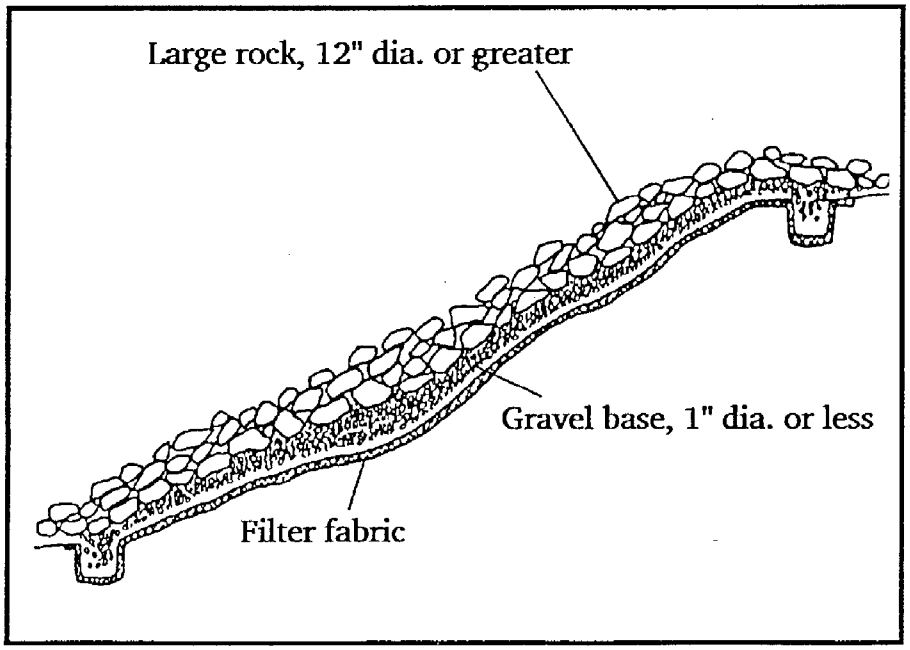
Riprap is loose rock used to protect the soil surface. It can be used in severe situations to stabilize banks and prevent erosion when vegetation cannot. Riprap is an expensive alternative because of the cost of quarrying, transporting and placing the rock.

Streambank Protection - Riprap is an effective way to stabilize eroding streambanks. A stable toe at the bottom of the riprap hill must be established for the success of this measure. This requires that the riprap start at the bottom of the trench several feet below the creek bottom, or on bedrock if it is encountered. The weight of the rock should rest on the bank rather than on lower courses of rock. This can be accomplished by sloping the bank no steeper than 1.5 horizontal to 1 vertical.

Slope Stability - Steep slopes, whether natural or man-made, can be unstable and slide because of soil structure or subsurface seepage. A saturated layer of soil beneath the surface can act as a lubricated plane on which the upper layers of soil can slide. Riprap, when properly applied to these areas, can add needed weight to the surface as well as let the subsurface water flow safely away. This riprap application needs to be designed with a stable toe with special attention given to the underlying bedding system. If the slope is not subject to heavy overland flows, the rock can be smaller. If the slope is steeper than 2 horizontal to 1 vertical, other alternatives, such as a retaining wall should be considered.

Pipe Outlets - Downstream scouring is inevitable where large pipes and culverts discharge great volumes of water unless some measure of protection is taken to dissipate the energy. A grouted riprap splash pad or a riprap-lined plunge pool of water to absorb the energy are comparatively inexpensive solutions.

Rock Chutes - Refer to fact sheet entitled, Rock Chutes.



Riprap-Lined Hillside

Application

Consider the following construction tips when using riprap. Rock for riprap must be dense and durable so it will not break easily. The thickness of the riprap layer and rock size is determined by specific site conditions. Generally, the riprap layer should be 50 percent thicker than the largest rock used. Depending on the runoff flow, the size of the rock can range from a couple of inches to more than a foot in diameter. To assure the success of the riprap project, the design should be completed by someone fully trained and experienced in this line of work. In general, riprap is installed as follows:

The initial excavation for the job must be deep enough to include the thickness of the riprap layer, the bedding and the anticipated water depth. The final bottom grade of the excavation must be free of topsoil, roots, frozen material and other debris which could cause instability.

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Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

To be effective, riprap must protect the underlying soil from water flowing swiftly over the surface, and at the same time allow excess water within the soil to freely drain without displacing the soil particles. Riprap is usually placed on the soil in two layers. The first is a six-inch uniform layer of well-graded sand-gravel (one-inch or less) filter or a nylon filter fabric. If a nylon filter fabric is used, a layer of one-inch or smaller gravel can be used to prevent tearing when the second layer of rock is placed on the fabric. The second layer is a one-foot or greater layer of large stone. When the large stone is placed on the filter fabric, care should be taken to avoid puncturing the fabric.

Where riprap is subject to exceptionally fast-flowing water, a slurry of Portland cement and sand, called grout, can be poured over the rock surface. This further binds the rock fragments together. Grouting the rock also discourages vandalism, and prevents the intrusion of vegetative growth.

Maintenance

Riprap structures should be inspected periodically to make sure rock has not been displaced. If rock displacement is severe, and occurs quite often, grouting or larger rock may be warranted. Cracked, grouted riprap should be repaired as needed. Unwanted vegetation can be sprayed, but it often is advantageous to allow vegetation to gradually take over and obliterate the rock.

Where To Get Help

For more information about the use of riprap in urban areas, contact your local Soil Conservation Service office.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Rock Chutes

Description

Rock chutes are channels lined with rock to protect them from eroding. The channels are used to carry water down a slope without creating a gully. The rock protects the soil by slowing down the water which normally would erode even sod-covered soil.

Application

Rock chutes have been used successfully on grades as steep as 3:1 (three feet horizontally for each vertical foot).

Failures can result from improper rock size, poor quality rock, unstable chute outlets, undermining, improper placement, settlement, undersized capacity, channel linings that are too thin, poor alignment and lack of maintenance.

Recommended rock size is based on the anticipated velocity of the water the channel is to carry. Bigger rock is used for faster velocities. Smaller rock is used for slower velocities. Making the channel wider will decrease the velocity.

Rock used for rock chutes must be dense and durable so it will not break easily.

Various rock sizes should be distributed randomly. Smaller rocks fill the voids between the larger rocks, causing the rocks to interlock. Rock of only one size is not suitable.

It is important that the end of the rock chute be stable and on a gentle slope. This keeps water leaving the chute from eroding the soil at the end of the chute. The velocity of the water at the end of the chute should not be fast enough to erode vegetated soil. The rock lining should extend several feet beyond the sloping section being protected. The rock chute should also contain a section at the inlet which should be nearly level.

The channel through the steep section of the rock chutes should be as straight as possible. When water flows at a high velocity, curves must be designed carefully to prevent water from jumping out.

The rock chutes should be 50 percent thicker than the largest rock used. For example, if the largest rock used is 12" thick then the rock chute should be 18" thick. The rock should be placed on sand or gravel and on a fabric liner if the area contains fine soils. There are a number of alternatives to rock chutes. They should be used when they would be more economical than rock. Other useable materials include concrete, concrete blocks, steel, aluminum, treated wood and gabions (rock-filled wire baskets).

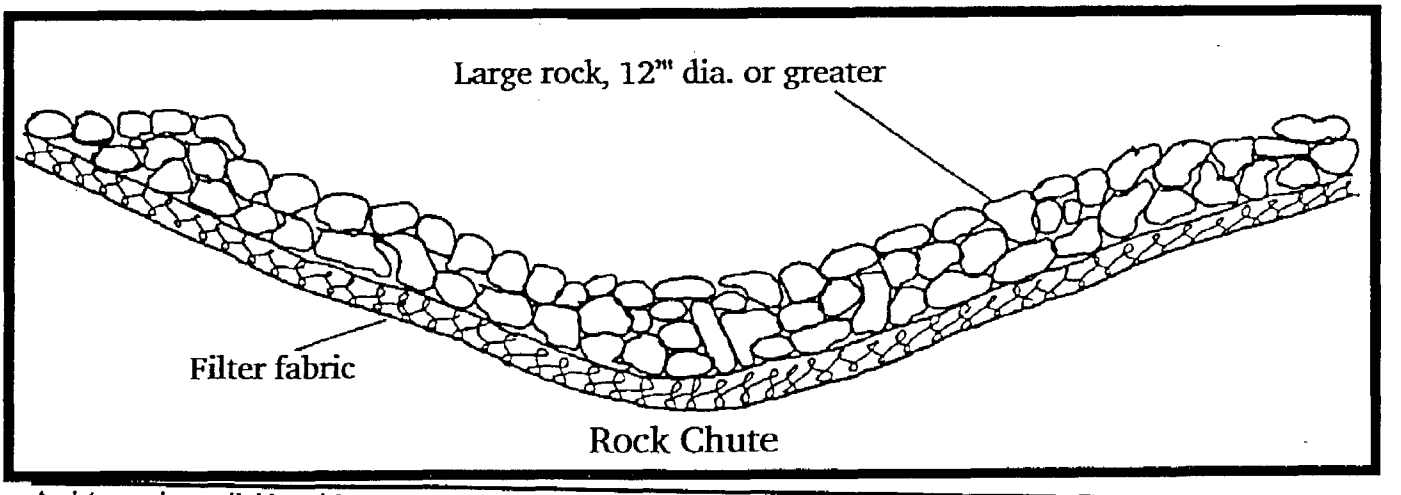
Rock has one advantage over other materials. It can shift to adjust to slight movement, whereas a more rigid material might crack.

Maintenance

Rock chutes should be inspected periodically, usually after each heavy storm. They especially should be inspected after the first storm because displacement is most likely then. Blockages should be removed promptly and necessary repairs made such as replacing any rocks which have been washed out.

Where To Get Help

For more information about rock chutes, contact your local Soil Conservation Service office.



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United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Seeding and Mulching

Description

Seeding and mulching techniques are used to establish grass wherever soil is exposed around buildings, new construction areas, subdivision developments and any other area that has been cleared of its protective vegetation.

Seeding and mulching stabilizes the soil and reduces the damages and inconveniences caused from sediment movement. This sheet provides information to help establish temporary and/or permanent vegetation on highly erodible sites, such as steep hills. For information about seeding lawns, refer to the fact sheet entitled "Establishing Lawns".

Application

Before seeding an exposed area, all other necessary water-control measures, such as diversions and drains, should be installed. This will prevent damage caused by surface water until the grass or other vegetation is established.

When the runoff-control measures have been completed, the area should be smoothed, either by grading the area or by filling in all gullies and depressions. Remember that slopes with a grade of more than 3:1 are difficult to maintain and to keep vegetated.

If topsoil has been removed from the area, it may be necessary to have more hauled to the site. The area should have at least four inches of topsoil, which should be free of stones, roots and other debris that hinder seedbed preparation and maintenance after the grass is established. However, it is important that you do not adversely alter the drainage pattern of your lot when you add topsoil.

If topsoil needs to be added, first break up the subsoil to alleviate compaction. All mechanical operations should be performed on the contour, or as near the contour as possible to reduce erosion caused by water running down paths created by the machinery. Lime and fertilizer - applied in accordance with soil test results - should be mixed thoroughly with the topsoil. In the absence of a soil test, follow the recommendations of the chart.

After selecting your seed mixture, determining lime and fertilizer needs and choosing a planting date, you are ready to seed. Apply the lime and fertilizer to the soil surface and work it into the ground at least three inches with a power tiller or disk. If power equipment is unavailable, rake the area as deeply as possible. Then smooth and roll the area to form a firm, fine seedbed.

Broadcast seed uniformly at the recommended rate (see the table). If you broadcast the seed with cyclone spreader, apply seed at

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Nutrient and Mulching Recommendations *

Soil Treatment	Rate per 1,000 Square Feet
Limestone	
Ground (agricultural grade)	50 lbs.
Hydrated	35 lbs.
Fertilizer	
10-10-10	15-20 lbs.
12-12-12	12-17 lbs.
Straw or Hay	2 bales

* Apply lime and fertilizer according to a soil test where available.

Time of year	Kind of Cover	Seed Depth	Min. Rate of Seeding
Mar. 15 to May 15	Spring Oats	1"-2"	4 bu./acre
	or barley		4 bu./acre
	Annual Ryegrass	1/4"-1/2"	10-20 lbs./acre
May 15 to July 15	Grain Sorghums (drilled)	1"-2"	30 lbs./acre
	Forage Sorghums (drilled)	1"-2"	30 lbs./acre
	Sudangrass (drilled)	1"-2"	30 lbs./acre
July 15 to August 15	No Planting - consider using mulches described under mulching.		

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

a one-half rate and cover the area twice using a crossing pattern. This will help assure uniform coverage of the area to be seeded. After the seed is broadcast, lightly rake the soil with a flexible tine rake. Do not cover the seed too deeply. Most grass seeds only require one-fourth-inch coverage to germinate and grow. It's a good sign if, during raking, you see seed still on the surface.

Next, lightly mulch. Spread clean straw or hay at a rate of two bales per 1,000 square feet immediately after spreading the seed. The mulch will protect the seed and new seedlings from erosion and retain moisture until plants are well established. On steep slopes, anchor the mulch to the soil with netting, or use a commercially-available fiber mat containing mulch.

Maintenance

Inspect all seeded areas after heavy rains, and seed and mulch damaged areas as soon as possible. If 60 percent or more of an area is damaged, the entire area should be re-established by using the same fertilizer and seeding recommendations as before.

Weeds should be controlled during establishment of grass by mowing them or by using approved

Where To Get Help

For more information about seeding and mulching, contact your local Soil Conservation Service office, or the local Extension Service office.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Silt Fences

Description

Silt fences are temporary sediment control measures installed on the contour to intercept and detain sediment from small unprotected areas. Silt fences are constructed by attaching a heavy-duty synthetic filter fabric to supporting posts. When properly installed and maintained, silt fences are effective sediment barriers. They should be used only below unprotected areas where it is impractical to prevent erosion.

Application

Silt fences may be used where: (1) the drainage area is less than 2 acres; (2) the maximum slope length above the silt fence is 150 feet; and (3) water reaches the silt fence as sheet flow without significant concentrations. Silt fences should not be used in channels, waterways or other concentrated flow paths.

Silt fences should be installed across the slope, and constructed so runoff cannot bypass the ends. If the silt fence is longer than 600 feet, the silt fence should be constructed in separate, independent units, with each unit having a length less than 600 feet.

Silt fences may be constructed with supporting fences, such as snow fences or wire mesh fences. The supporting fences should be strong enough to withstand the load from pond water and trapped sediment. The support posts should be spaced at 10 feet or less, and should be placed or driven at

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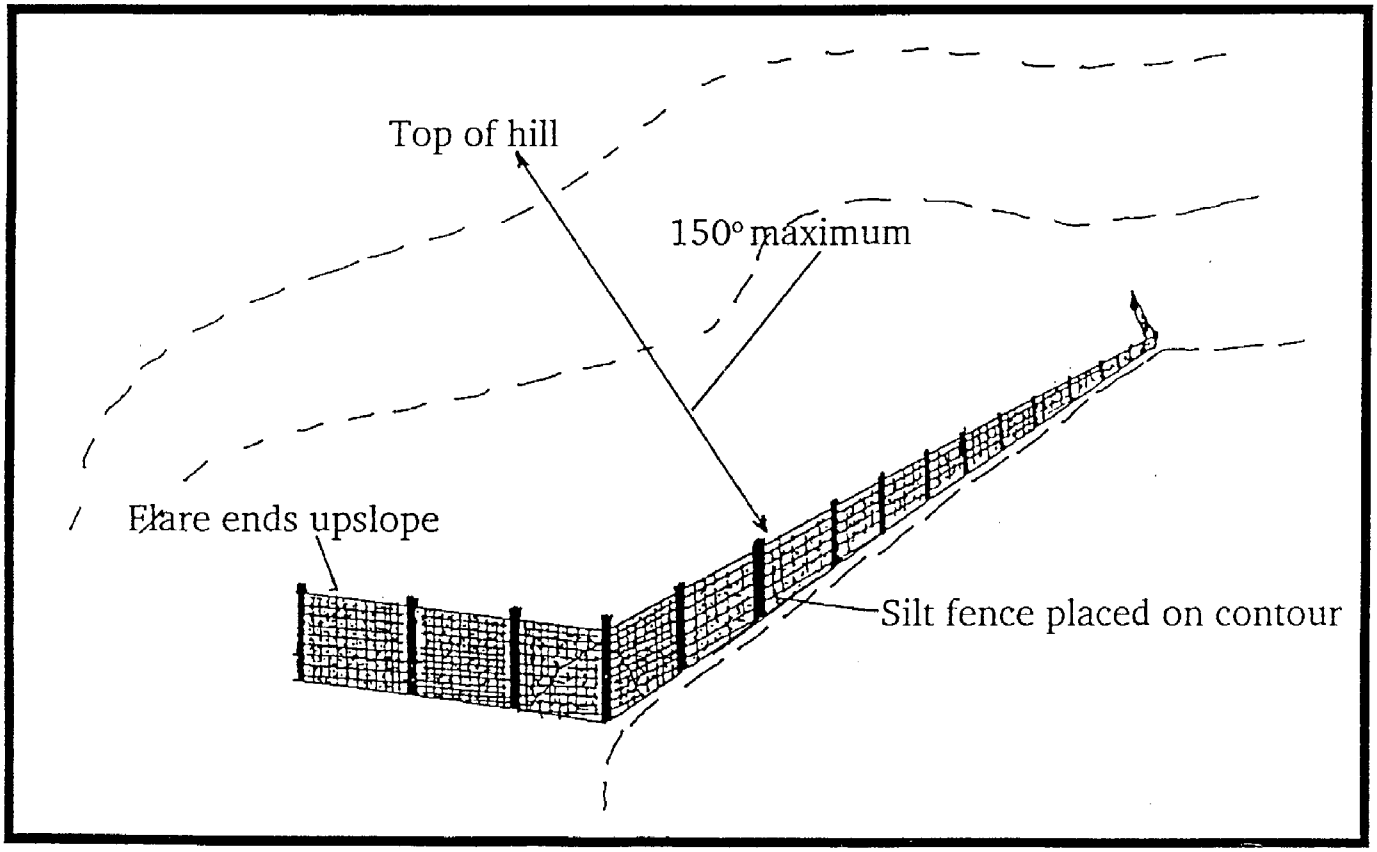
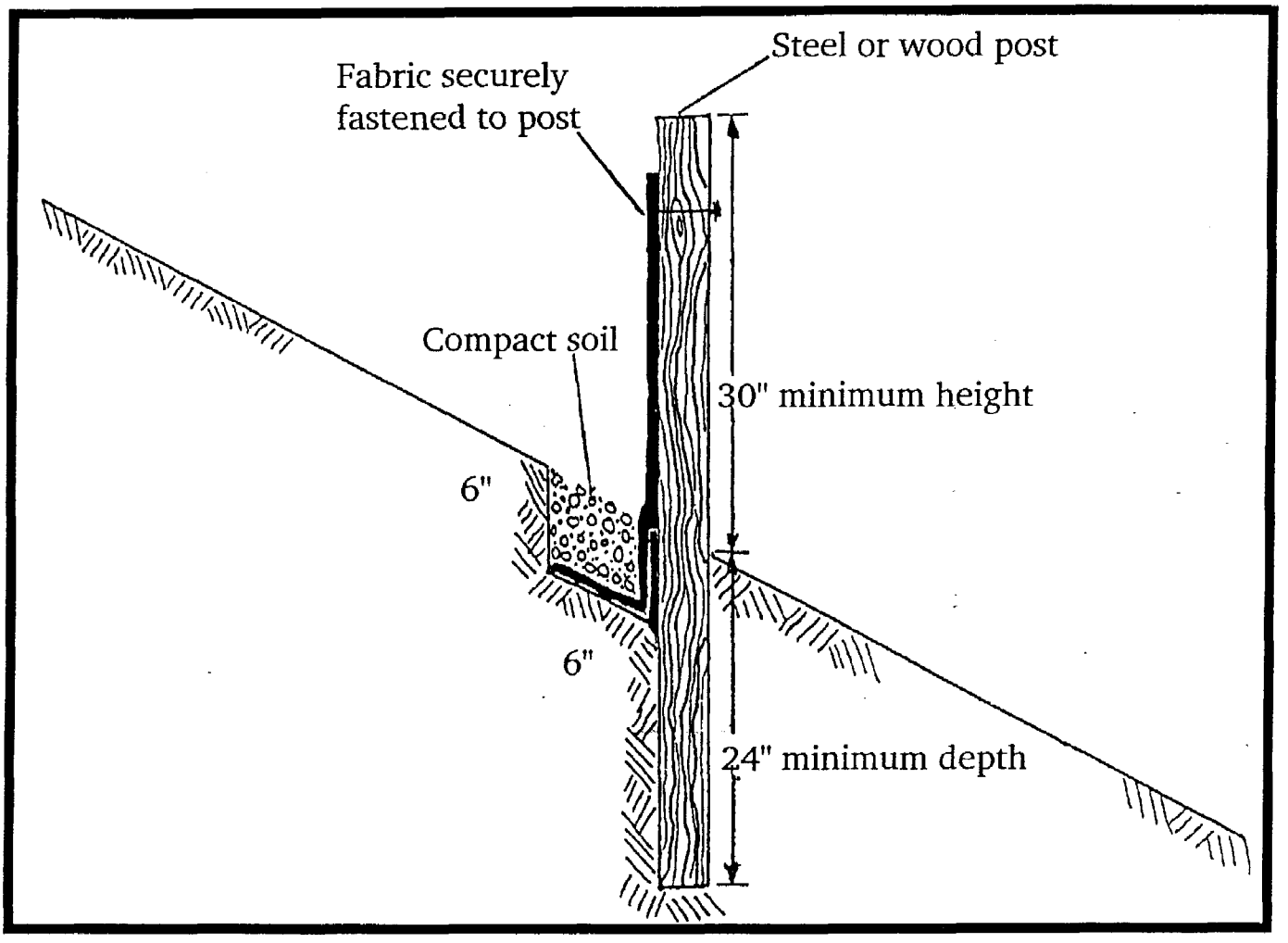


Silt Fence

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

Anchoring Detail of Silt Fence



least 2 feet into the ground. Posts should be 4-inch diameter wood posts or standard steel posts.

When a silt fence is installed without a supporting fence, the posts should be spaced at 4 feet or less. Posts should be spaced or driven at least 2 feet into the ground. Posts should be 2-inch square or heavier wood posts or standard steel posts.

A trench for anchoring the fabric is dug along the upslope side of the posts. The trench should be about 6 inches wide and 6 inches deep. The fabric is laid in the trench, which is then backfilled and compacted. This prevents water and sediment from passing underneath the silt fence.

The filter fabric should be furnished in a continuous roll cut to the length of the silt fence to avoid splices. When splices are necessary, the fabric should be spliced at a support post with a minimum of 6-inch overlap, folded over, and securely fastened.

The synthetic filter fabric should be a pervious sheet of polypropylene, nylon, polyester or ethylene yarn uniform in texture and appearance and free from defects, flaws or tears that would affect its physical properties. When installing fabric for silt fences, follow manufacturer's recommendations.

Maintenance

Silt fences require maintenance to preserve their effectiveness. All silt fences should be inspected immediately after each heavy rainstorm and at least daily during prolonged rainfall. Any required repairs should be made immediately. When sediment deposits reach approximately one-half the height of the silt fence, the sediment should be removed or a second silt fence should be installed.

Where To Get Help

For more information about establishing silt fences, contact your local Soil Conservation Service office or your local Extension Service office.

United States
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Soil
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Salina,
Kansas

Fact Sheet

Sodding

Description

Sod is established grass cut with a thin layer of soil attached and rolled out on the site - much like laying a carpet. Sodding gives instant cover and erosion control, but costs more than seeding, plugging or sprigging.

Sodding is used "where a very high quality turf is desired or grass cover is needed sooner than can be established by seeding. Sodding stabilizes the soil and reduces the damages and inconveniences caused from sediment movement.

This sheet provides information on establishing vegetation by sodding.

Application

The first step is selecting the type of sod desired.

Six considerations when choosing your sod are as follows:

1. Cultivated sod is preferred over native or pasture sod. Pasture sod generally contains mixtures which result in irregular spots.
2. Sod should be free of weeds and undesirable coarse weedy grasses.
3. Sod should be of uniform thickness.
4. Sod should have a compact root mat to assure mechanical strength and to assure early and firm anchoring to the soil surface.
5. For critical slopes, a sod of tall fescue and bluegrass is to be preferred over straight bluegrass sod, especially if the site is droughty or shaded.
6. Only fresh sod should be used.

To provide the best possible soil condition for sodding, fill areas must be compacted enough to resist uneven settling. Cut areas or heavily compacted areas must be loosened, if needed, to permit grass root penetration. The entire surface to be sodded should be free from large clods, stones, or other debris.

Where determining lime and fertilizer needs, a soil analysis should be used when available. In the absence of a soil test, refer to the chart below for lime and fertilizer recommendations. Lime and fertilizer should be uniformly applied and incorporated into the ground at least three inches with a power tiller or disk. If power equipment is unavailable, rake the area as deeply as possible.

Sod may be placed nearly anytime of the year when moisture requirements are met, except when the ground is frozen or during summer heat. Immediately before placing sod, the soil surface shall be loosened to a depth of one inch and thoroughly dampened if not already moist.

The following items should be considered when placing the sod:

1. Sod strips should be laid on the contour, never up and down the slope, starting at the bottom of the slope and working up.
2. Place sod strips with snug, even joints.
3. Roll or tamp sod immediately following placement to ensure solid contact of root-mat and soil surface.

Maintenance

The last step is maintenance. Water when necessary during the first growing season to ensure survival of the sod. Apply fertilizer as needed to maintain density, color,

Where To Get Help

For more information about establishing lawns, contact your local Soil Conservation Service office or your local Extension Service office.

Nutrient and Mulching Recommendations *

Soil Treatment	Rate per 1,000 Square Feet
Limestone (if needed)**	
Ground (agricultural grade)	50 lbs.
Hydrated	35 lbs.
Fertilizer	
10-10-10	15-20 lbs.
12-12-12	12-17 lbs.
Straw or Hay	2 bales

* Apply lime and fertilizer according to a soil test where available.
** For soils with a known high pH, lime is not needed.

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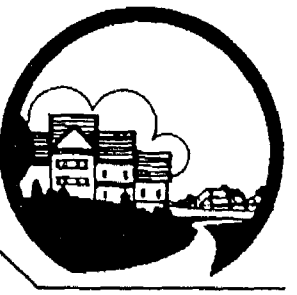
Fact Sheet



Soil Erosion - Water

Description

Poorly planned urban development can result in serious soil erosion and sedimentation, a common type of pollution that degrades our environment. Fortunately, soil erosion can be prevented, and it costs much less to prevent soil erosion than to repair the damage it causes.

Soil is both a major pollutant and a carrier of other pollutants. In 1984, R. P. Beasley, J.M. Gregory and T. R. McCarty wrote in "Erosion and Sediment Pollution Control" that 109 million tons of soil move past St. Louis in the Mississippi River each year. To haul the same amount of sediment, 1,244 dump trucks - each carrying 10 tons - would have to carry one load per hour, working around-the-clock for the entire year.

Sediment pollution of streams and reservoirs reduces their capacity and increases the expense municipalities and industries pay to treat the water. Millions of dollars are spent each year dredging channels and harbors and removing sediment from road ditches and culverts. Soil erosion on the land and sediment suspended in water destroy fish and wildlife habitat. Agricultural and industrial chemicals are carried off the land along with suspended soil particles. Together, they pollute our waters.

The Erosion Process

The impact of a raindrop on bare soil is like a small explosion on the surface that sends soil particles in all directions. As the rainfall continues, and the soil becomes saturated, a uniform layer of water moves along the surface. The explosive activity of the raindrops keeps the water agitated, allowing soil particles to remain in suspension as the sheet of water flows down the hill. This type of erosion removes a thin, uniform layer of soil. It is called sheet erosion.

Erosion from concentrated runoff occurs when soil surface depressions or obstructions act as channels for the running water. The rate of soil removal increases in these areas, creating small channels, known as rills. This form of erosion is referred to as rill erosion.

Gully erosion develops in areas where runoff is so great that the soil cannot bear the scouring action. The runoff forms deep, large crevices. Likely places for gullies to develop may be valley floors, pipe discharge sites or where rills join to form one channel. Rill and gully erosion are highly-visible, dramatic processes that cause large amounts of soil loss. Streambanks also are subject to water-induced erosion. Streambanks erode from the scouring activity of water passing through their channels. The most severe streambank erosion occurs along the outside curves of a stream.

Streambank erosion is a process in which a streambank changes from a natural slope to a nearly vertical slope to an undercut slope. Eventually, the undercut slope collapses into the streambed, and the process begins again.

Piping erosion is a process by which soil is removed by subsurface water movement. This is associated with fine-textured soils, and most often develops in flat upland areas adjacent to steep slopes.

Piping erosion can be initiated by subsurface water movement along tree roots, rodent burrows, buried utility lines, pipes, rocks and various forms of fill material. Since water seeks the path of least resistance, it passes through voids and along impervious surfaces. As the water moves along the voids, it removes the finer soil particles, creating more voids and enlarging existing ones. Eventually, the cavities become so large and weak that they collapse, leaving holes or depressions on the surface.

A depression in a flat area's surface usually is the first sign of piping. A small hole on the side of a hill with sediment deposits just below it is another indication of piping erosion.

Solutions

Many measures are available to prevent and control soil erosion and sedimentation on both developed and developing sites. These measures fall into three categories based on their intended use. The categories are sediment control, runoff control and soil stabilization. Sediment-control measures protect off-site areas from sediment damage. Such off-site areas might include streets, parking lots, culverts and ditches, as well as lakes and streams. Control measures range from silt fences and grass filter strips to sediment basins and dust abatement techniques.

(over)

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

Runoff-control measures are used to prevent or control gully erosion, channel erosion and streambank erosion. Diversions, waterways, spillways, surface outlets and underground drainage and outlet systems move water from one place to another with minimal erosion.

Soil-stabilization measures protect soil from forces that detach soil particles. Vegetative and non-vegetative soil covers and diversions are included in this category. Careful planning is the key to controlling soil erosion and sedimentation while developing land.

Where To Get Help

Soil surveys provide detailed information on the suitability of soils for various purposes. They will help you make wise planning decisions. The published soil survey of a county or other area includes descriptions of soils, interpretations for soil use and maps showing the location and extent of each kind of soil. Copies of your county's soil survey are available from the Soil Conservation Service.

For more information about preventing or controlling soil erosion in urban areas, contact your local Soil Conservation Service office.

United States
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Salina,
Kansas

Fact Sheet

Soils

Description

The success of a construction project often is related directly to the proper interpretation of the soil. Rapid population growth and increasing mobility have placed more people in situations where soil conditions directly affect them. This is especially true in rural-urban fringe areas where people move to enjoy country living. A lack of knowledge and understanding for the soil has resulted in many costly mistakes.

Soil Properties

All land users should consider the importance of soils, whether they are working with an existing residential or commercial area or developing land for a particular purpose. Knowledge of soil types and their features can help the land user solve current problems and avoid future problems. There are many soil features to consider and this may determine whether a soil is suitable for a particular use. The soil property-land use table on the back shows how land uses are affected by a particular soil property.

Texture: Soil particles vary in size. From coarse to fine, they are classified as sand, silt or clay. The percentage of each in any given soil determines its texture. Soil texture partly controls other soil properties. These include permeability, rate of runoff, available water capacity and soil drainage.

Permeability: How easily water, air or roots can travel through soil is a measure of its permeability. Permeability is influenced by soil texture, structure, compaction and the presence or absence of cementing agents.

Depth to High Water Table: Soil below groundwater is saturated. The groundwater or water table may be high year round or just during heavy rains. How high the water table rises, and how long it stays there, will affect what can be done on the soil. High water tables near a home or building can create wet basements, cause septic systems to fail and restrict landscape plant selection.

Slope: The percent slope of land is the measurement of the vertical rise or fall of the surface in 100 feet.

Depth to Bedrock: The depth from the soil surface to bedrock influences the soil's potential uses.

Stones and Rock Fragments: The size of surface rock fragments and the percentage of ground they cover are important to land use planning.

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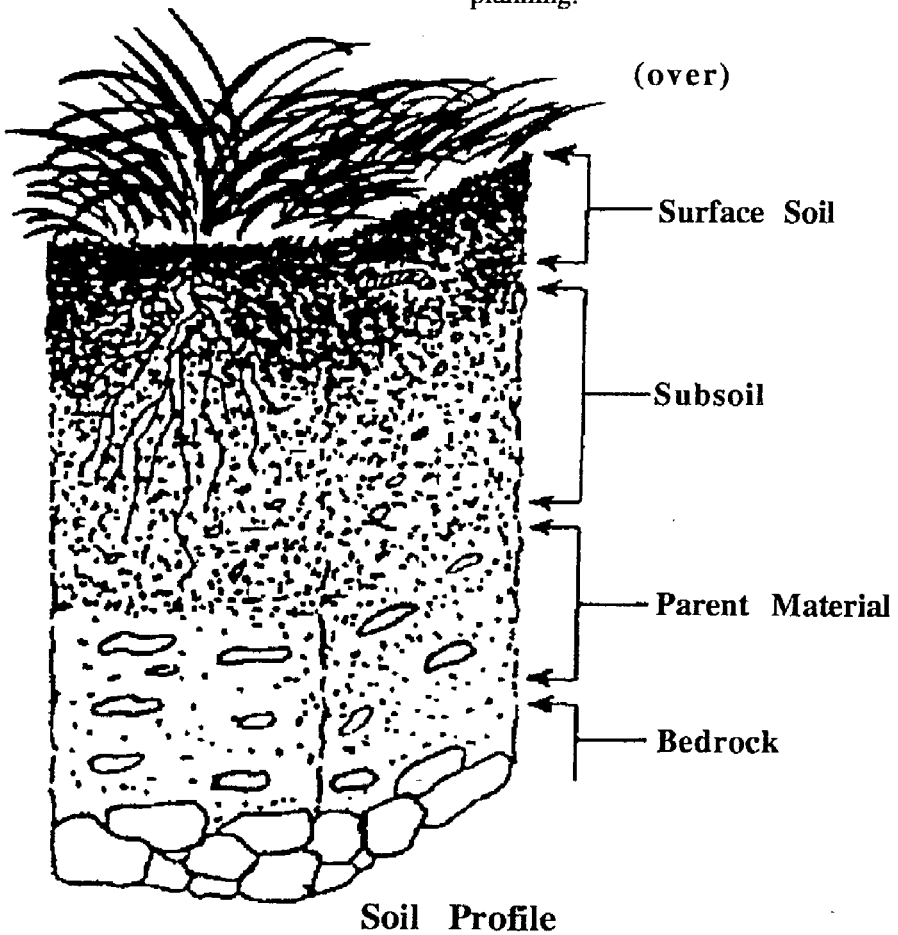


Soil Profile

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

Flooding and Ponding: Periodic floodwater, from either overflowing streams or runoff from nearby slopes, make such sites risky for construction

Shrink-Swell Potential: This refers to the relative change in soil volume expected when the soil moisture changes. The soil shrinks when it drys, and swells when it gets wet. Shrinking or swelling of soils may damage building foundations, roads and other structures.

Potential Frost Action: This is the likelihood of upward or lateral movement of soil (frost heave) by the formation of ice layers within the soil and the subsequent loss of strength upon thawing.

Soil Survey

Most land users cannot determine the potentials and limitations of the soils of a specific area without assistance. A valuable reference to help land use planners, developers or landowners match the soil with its potential uses is a soil survey.

A soil survey is an inventory of the soil in a county or other area of interest. It indicates what soils are in the area, how much of each soil there is and where the individual soils are located.

Soil surveys provide physical and chemical information about soils, along with a discussion of their suitability, limitations and management for specific uses. Soil scientists observe soil color; texture; abundance and size of roots and pores; acidity; the steepness, length and shape of slopes; position on the landscape; depth of the seasonal high water table; and kinds of native plants and other features that help characterize and identify soils.

After soil scientists have located and identified different soils in an area, they produce soil maps by drawing boundaries on aerial photographs. The dominant soils of an area are identified on the maps. Aerial photographs show trees, fields, buildings, streams and roads, all of which help in locating soil boundaries.

Where To Get Help

For more information about soils, or to get a copy of a soil survey for your county, contact your local Soil Conservation Service office.

Soil Property	Selected Land Use					
	Septic Tank Absorption Fields	Sanitary Landfill (Trench)	Sanitary Landfill (Area)	Buildings	Local Roads and Streets	Lawns and Landscaping
Wetness	*	*	*	*	*	*
Permeability	*	*	*			
Depth to Rock or Clay Pan	*	*	*	*	*	*
Slope	*	*	*	*	*	*
Surface Texture						*
Subsurface Texture		*		*	*	
Small Stones						*
Large Stones	*	*		*	*	*
Flooding	*	*	*	*	*	*
Shrink-Swell Potential				*	*	

*Indicates that a particular land use could be affected by a specific soil property.

For more detailed soils information, review a published soil survey for your county.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Straw Bale Sediment Trap

Description

A straw bale sediment trap is a temporary measure consisting of two or more entrenched and anchored straw bales. This measure is used to intercept and detain small amounts of sediment-laden runoff generated from exposed soil area.

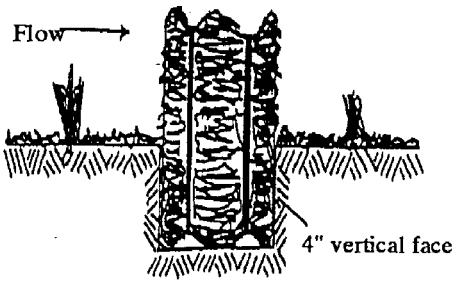
Application

To be effective this measure should be used where the drainage area is less than 2 acres. This measure should be used only for sheet flow condition. This measure is not meant to be used where water is concentrated in a gully or channel.

Straw bales should be composed of clean straw. They should be entrenched into the ground to a depth of 4 inches, and anchored with two stakes. The stakes may be a 2-inch by 2-inch wooden post, metal fence posts, or re-bar. Stakes should be clearly marked and identified to prevent injuries

Careful installation of this practice is very important. Each bale should be tightly butted against the previous bale. The stakes should be angled toward the previously laid bale to minimize the gaps between the bales. Wedge loose straw between the bales. Soil should be compacted against the upstream side of the bale. Straw bale sediment traps most often fail from water undermining the bales, or from gaps between the bales.

Straw bale barriers should be placed across the slope with the ends flared uphill. The maximum slope length above a straw bale barrier should be no more than 150 feet.



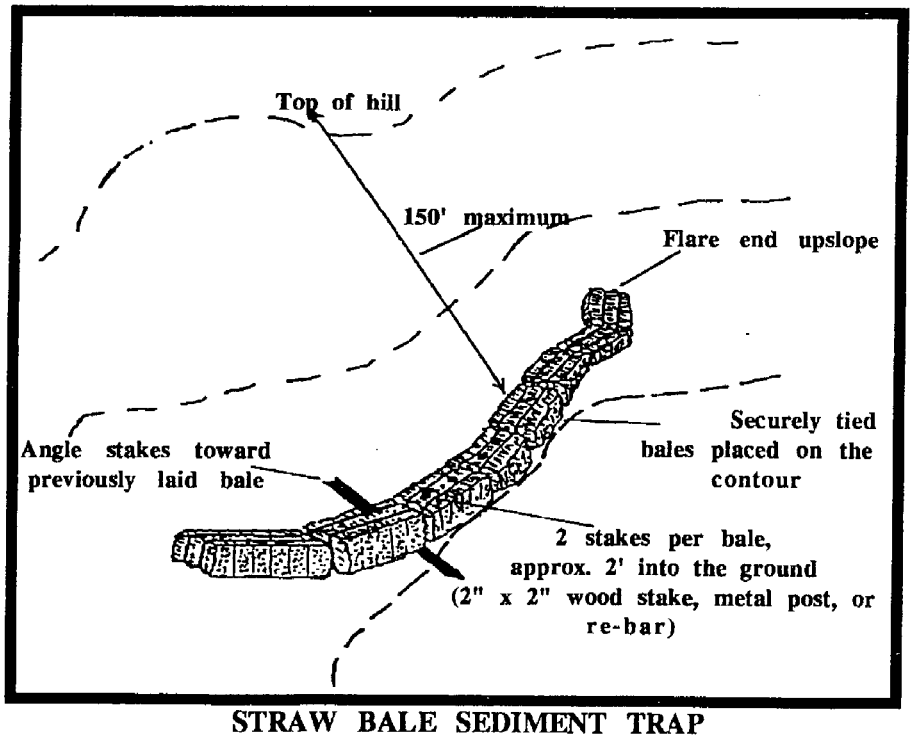
EMBEDDING DETAIL OF STRAW BALE SEDIMENT TRAP

Maintenance

Barriers should be inspected periodically, usually after each heavy rainstorm. When the sediment has accumulated behind the barrier to a depth equal to half the height of the bale, the sediment should be removed. Deteriorated, destroyed, or rotted bales should be replaced immediately. Bales should be removed when they have served their usefulness so as not to block or impede storm flow or drainage.

Where To Get Help

For more information about straw bale sediment traps, contact your local Soil Conservation Service office or your local Extension Service office.



STRAW BALE SEDIMENT TRAP

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Underground Drainpipes

Description

Drainage systems featuring underground pipes are designed to intercept water and carry it to more desirable locations without causing soil erosion. Underground drainpipes can correct both surface and subsurface drainage problems. Surface drainage systems carry away surface water. Subsurface drainage systems intercept water below the surface.

Application

Underground drainpipes can be used to intercept subsurface moisture, to lower a water table, or to intercept seepage that contributes to wet surface conditions. In bottom land or flat land areas with isolated water-logged pockets, subsurface drainage systems are used to improve infiltration. Better infiltration means the surface will dry faster.

Underground drainpipes also are widely used to:

* Remove surface runoff caught by diversions, terraces and waterways.
* Carry away water exiting from gutter downspouts so that water falling from the downspouts does not erode the ground beneath the downspout.
* Remove standing water near buildings, airport runways and recreational areas.
* Catch and carry away subsurface moisture around foundations, a common cause of wet basements.
* Dry puddles and isolated and wet areas.
* Control pests by eliminating stagnant water that acts as a breeding ground.
* Carry away water that enters the pipes through grates placed in streets, driveways and parking lots.

Following are some things to consider when installing underground drainpipes as part of surface and subsurface drainage systems:

A. Surface Drainage Systems

Most surface drainage systems consist of a drop inlet connected to an underground pipe which carries away the surface water. The drop inlet may consist of a grate or a perforated riser.

* Grates of risers are needed at the inlet to the pipes to keep debris out of the system. Domed grates are preferred.
* Solid pipes should be used underground to act as a carrier of the surface water.
* Welded steel or corrugated metal grates will be necessary if vehicles will be driven over them.
* Soil used to fill around the pipes should be well compacted to prevent seepage along the outside of the pipe. Such seepage is referred to as piping erosion.
* Anti-seep collars (plates attached to the pipes) should be used to discourage piping erosion.
* The water inlet should be large enough to handle the volume of water likely to reach the inlet during a storm.
* The outlet end of the pipe

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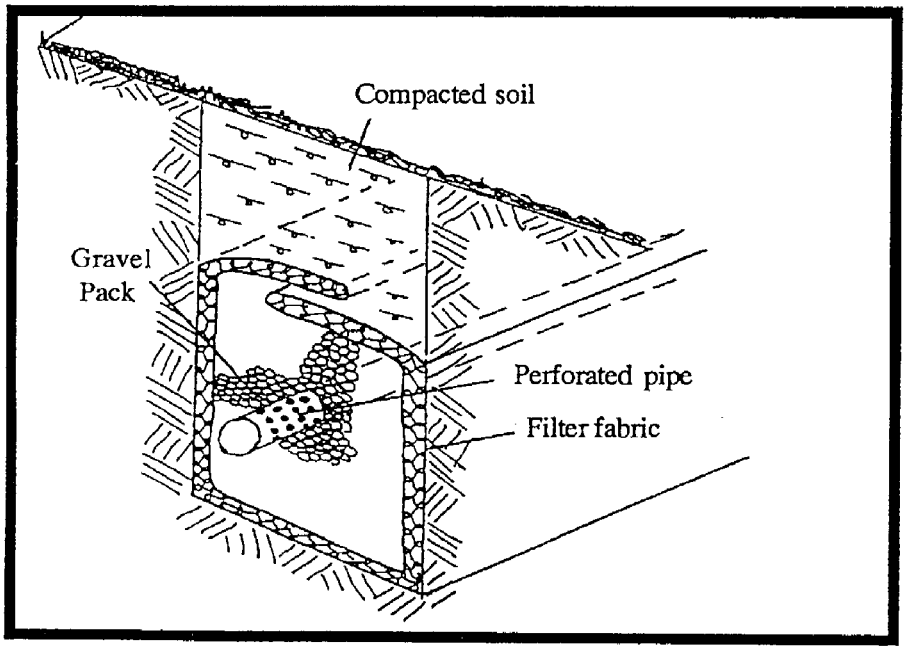
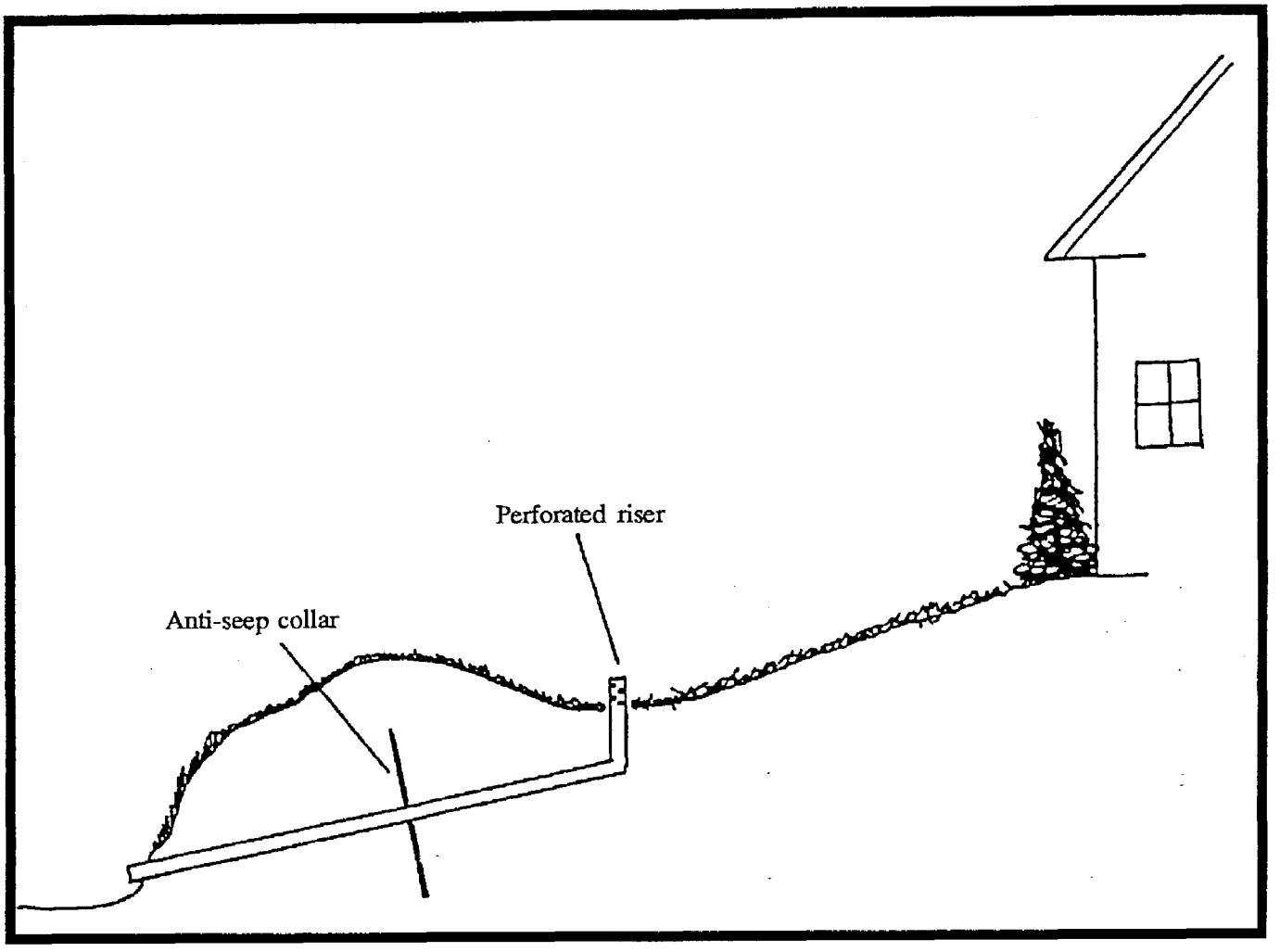


UNDERGROUND DRAINPIPE DETAIL

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.



SURFACE DRAINAGE SYSTEM

should be on a gentle slope. To help prevent erosion it is best that the water outlet empties onto a small rock apron.

* Install a guard at the pipe's outlet to prevent rodents from entering the pipe.

B. Subsurface Drainage Systems

Most subsurface drainage systems consist of perforated pipes placed underground to intercept and carry off excess subsurface water. This could include open areas as well as foundation drains.

* Pipes should be installed in a uniformly-graded trench that drains to a stable outlet.

* Pipes placed around houses need to be carefully backfilled with one-inch diameter gravel or rock that does not contain lime dust.

* Use perforated pipe to allow underground water to enter the pipe, but use a section of solid pipe at the outlet of an underground drainpipe to help prevent soil erosion near the outlet.

* If needed, wrap pipe and gravel in filter fabric to prevent fine soil particles from entering and clogging the drainpipe.

* Care needs to be taken so that the pipe is not crushed when backfilling with rock and soil.

* Perforated pipe should not be used on grades in excess of 10 percent (1' drop for every 10' horizontally).

* Install animal guards at pipe outlets to keep rodents from entering the pipe.

* The trench should have a low area in its floor that will cradle the pipe.

Maintenance

Maintenance of surface and subsurface drainage systems utilizing underground pipes is a must. Be sure to keep both outlets and inlets clear of trash, and inspect the systems after storms. Promptly remove debris, which can gather at the inlets. Be sure sediment or trash does not plug the outlets and cause water to back up in the lines.

Where To Get Help

For more information about underground drainpipes, contact your local Soil Conservation Service office.

United States Department of Agriculture

Soil Conservation Service

Salina, Kansas

Fact Sheet

Waterways and Lined Channels

Description

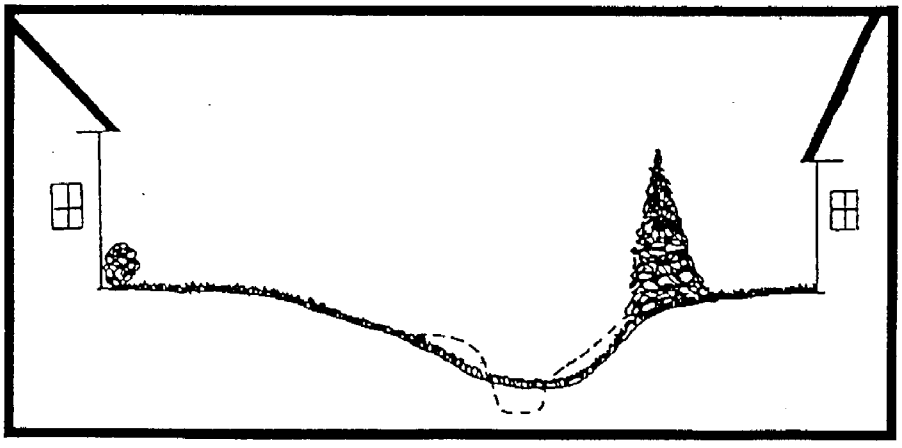
A waterway is a natural or constructed path that transports water through a yard or lot without causing soil erosion. Waterways are used to dispose of excess surface water from areas subjected to fast-flowing water. Gullies form in these areas if they are not protected from the moving water.

Most often, vegetation in a waterway is all that is needed to control the runoff. But if the flowing water causes erosion, linings of cast-in-place concrete, riprap, gabions (rock-filled wire baskets) or similar permanent linings should be used.

Application

If lined channels are necessary, it is important to install the lining in accordance with the manufacturer's guidelines. The following tips will help you get good results from grassed waterways.

* Use fiber mats or temporary check dams to protect the waterway from soil erosion until the grass is established. In some cases, it may be necessary to block the water out of the waterway until the grass is established.
* Make sure the bottom of the waterway is smooth with no drop offs, especially at the bottom end of the waterway.
* Save topsoil and spread it over the finished waterway. It is easier to establish grass in good soil.
* Before seeding, lime and fertilize the waterway according to the results of a soil test, available from the Extension Service or others.
* Use a type of grass that is suitable for the soil and moisture conditions at the site. Refer to the fact sheets on seeding and mulching or sodding for information on establishing grass in the waterway.
* Remove brush and debris from the waterway. Don't bury it. Decomposition of buried material causes settlement.



GRASSED WATERWAY
(The dashed line represents the original ground surface.)

Maintenance

A high fertility program, including heavy nitrogen fertilization, helps grass compete with weeds and legumes, and maintain a thick, vigorous stand.

Control weeds and brush by cutting them or by using herbicides. Contact your local Extension office or others for herbicide recommendations.

To prevent the grass from being smothered from accumulated growth, keep the grass cut to a moderate height. Mow frequently enough so that the grass clippings do not smother the grass.

Gullies can be caused by construction irregularities, by sediment deposits, by using the waterway as a pathway or play area and by unstable outlets that drop off at the lower end of the waterway. Control unstable outlets by grading and seeding them.

Gullies must be filled and reseeded or covered with sod. Material used to fill gullies must be well compacted. Overfilling slightly will allow for settling and will divert water somewhat until the new grass is established. Sediment deposits should be removed before they damage the grass.

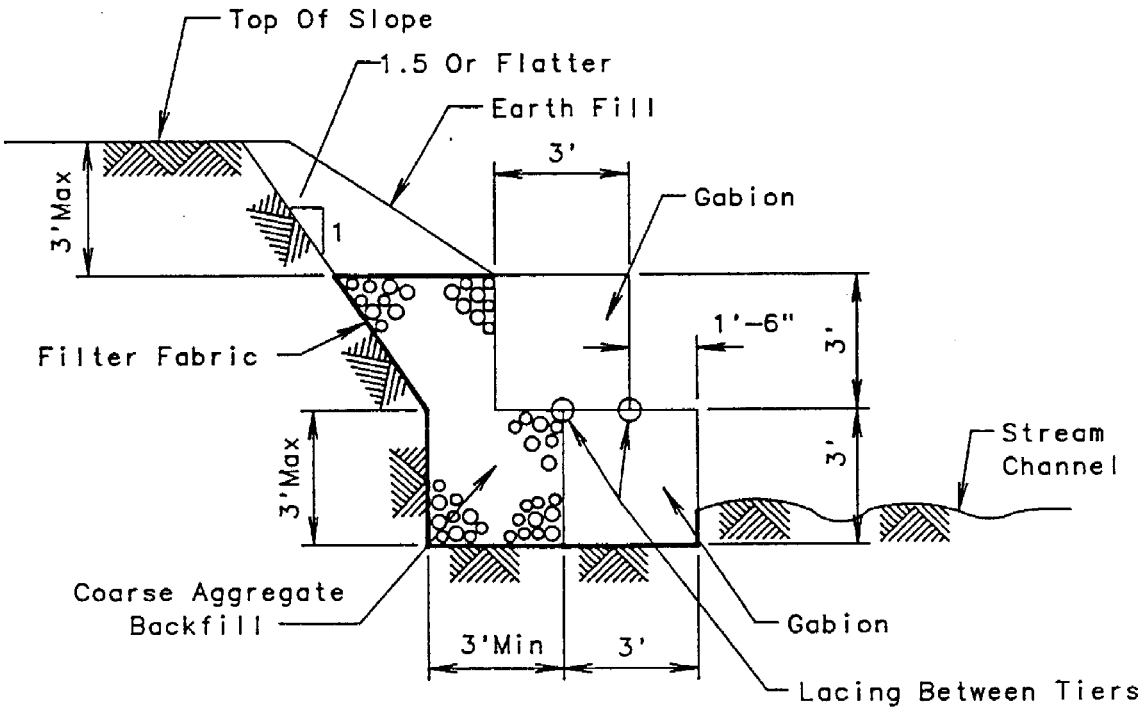
Where To Go For Help

For more information about constructing and maintaining waterways and lined channels, contact your local Soil Conservation Service office.

Assistance is available without regard to race, creed, color, sex, age, handicap, marital status or national origin.

STRUCTURAL STREAMBANK STABILIZATION - GABIONS

2 BASKETS HIGH W/O MAT



SECTION

NOTES:

1. The filter fabric shall meet the requirements in material specification 592 GEOTEXTILE Table 1 or 2, Class I, II or III.
2. The coarse aggregate backfill shall meet the IDOT requirement for the following gradations CA-1, CA-3 or RR-1.
3. The Gabions shall be installed according to construction specification 64 WIRE MESH GABIONS
4. Baskets which are stacked in tiers shall have vertical seams staggered for each row and tier.
5. The coarse aggreate backfill shall be placed level with the top of the lower basket before the upper basket is installed.

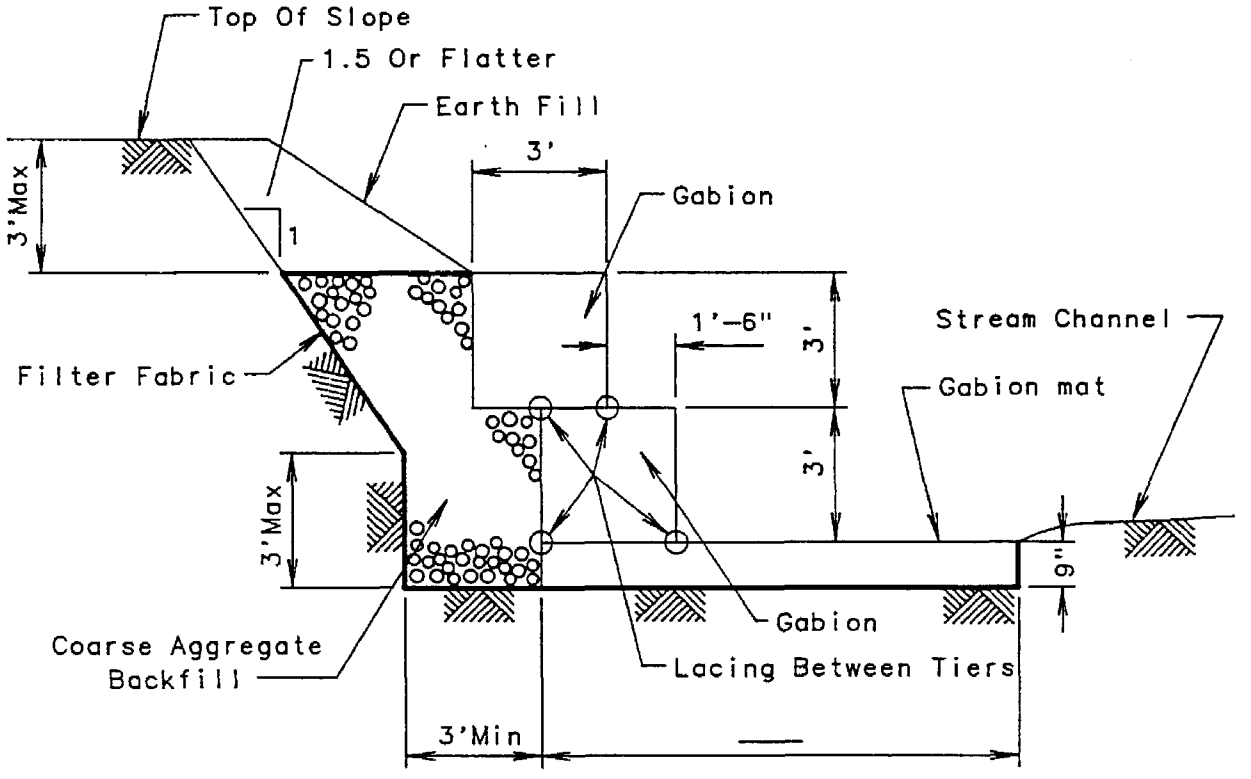
REFERENCE			
Project			
Designed	Date		
Checked	Date		
Approved	Date		

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ILLINOIS

STANDARD DWG. NO.
IL-641
SHEET 1 OF 1
DATE 5-16-94

STRUCTURAL STREAMBANK STABILIZATION - GABIONS

2 BASKETS HIGH WITH MAT



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Designed	Date		
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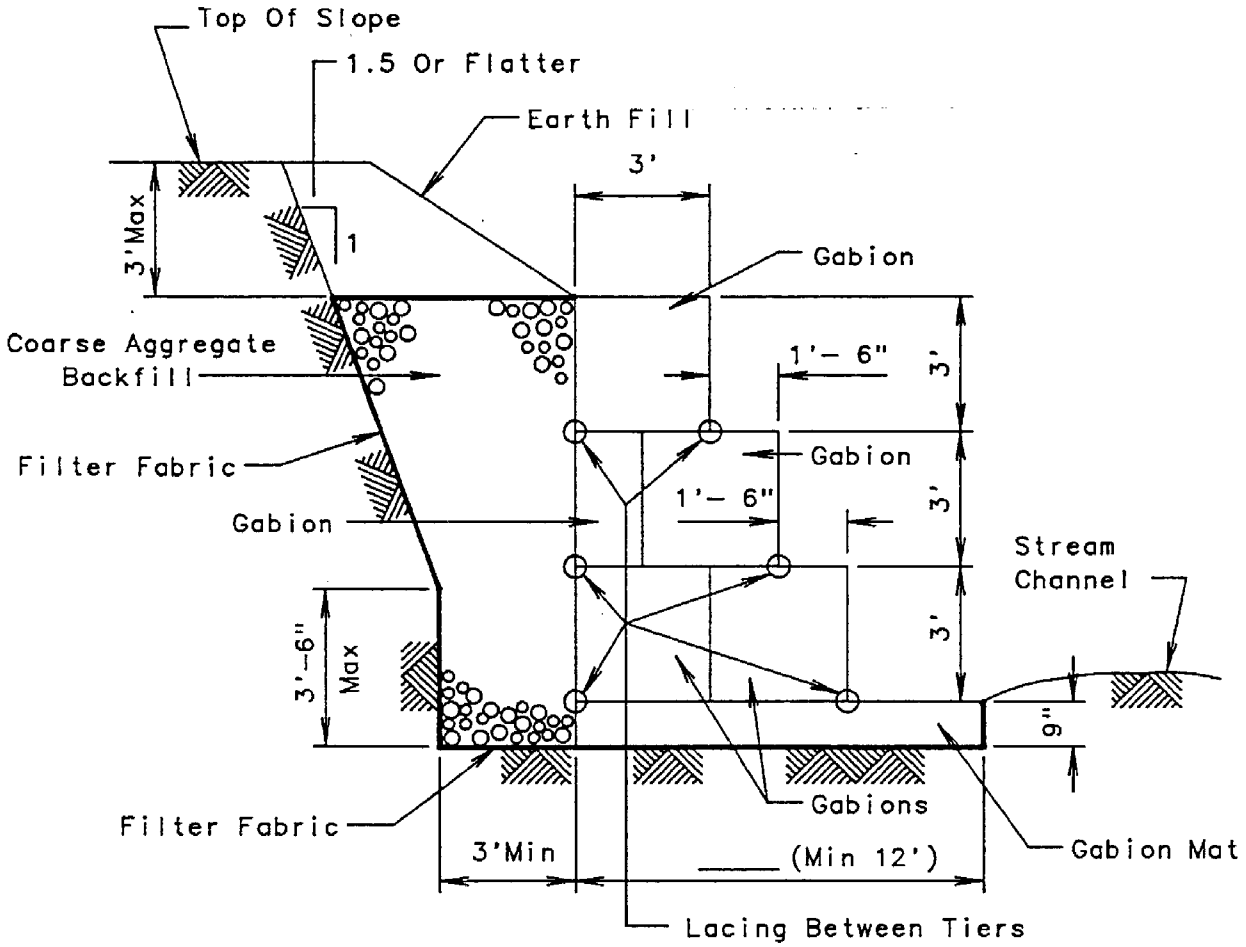
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ILLINOIS

STANDARD DWG. NO.
IL-642
SHEET 1 OF 1
DATE 5-16-94

STRUCTURAL STREAMBANK STABILIZATION - GABIONS

3 BASKETS HIGH WITH MAT



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REFERENCE			
Project			
Designed	Date		
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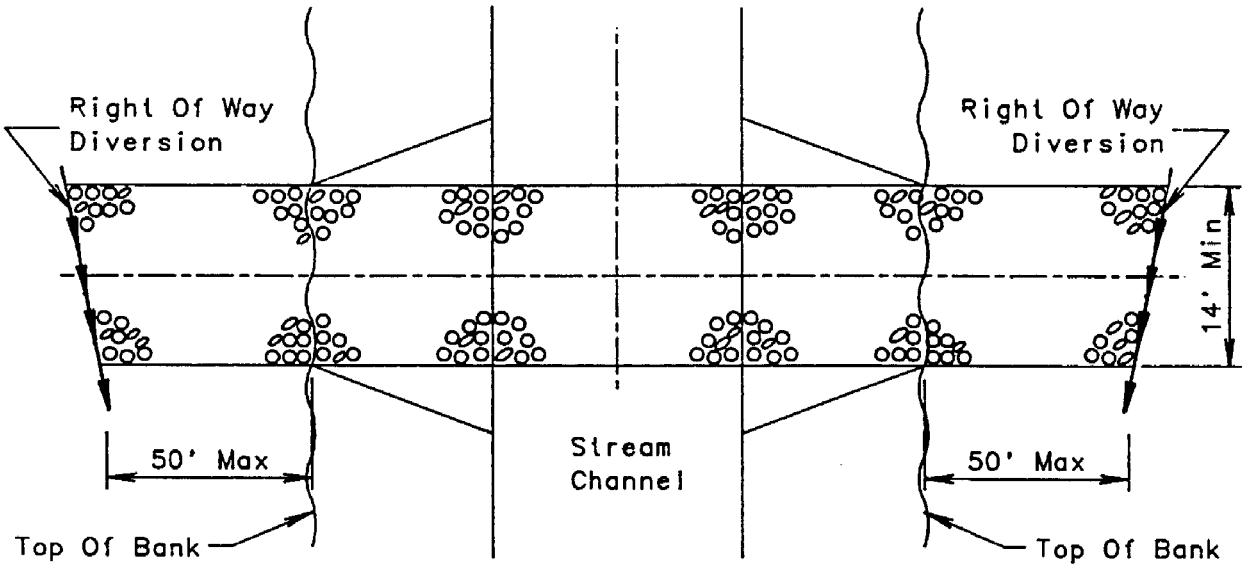
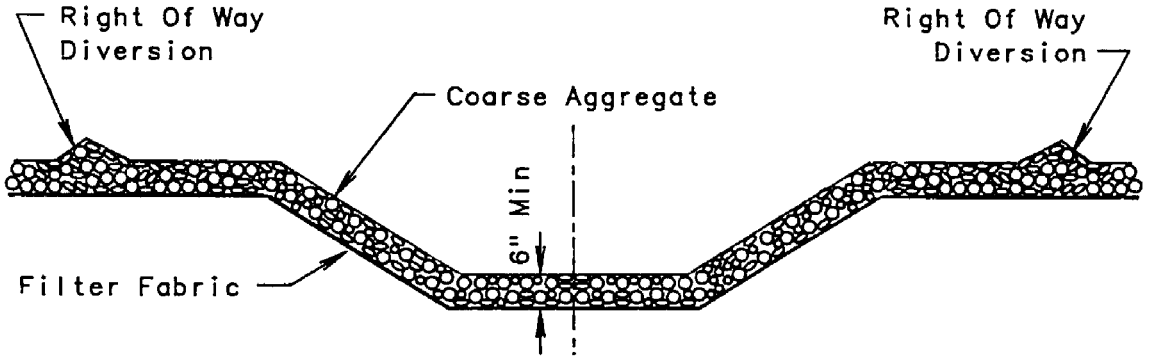
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ILLINOIS

STANDARD DWG. NO.
IL-644
SHEET 1 OF 1
DATE 5-16-94

TEMPORARY STREAM CROSSING PLAN



PLAN VIEW



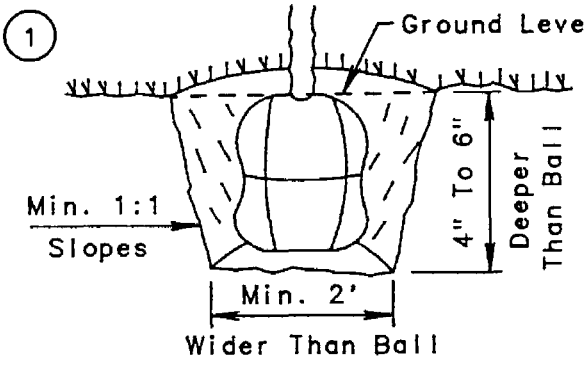
SECTION

NOTES:

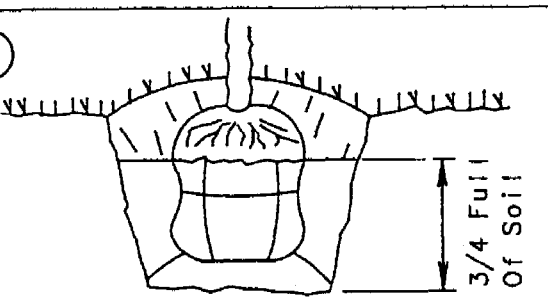
1. Filter fabric shall meet the requirements of material specification 592 GEOTEXTILE, Table 1 or 2, Class I, II or IV and shall be placed over the cleared area prior to the placing of rock.
2. Rock or reclaimed concrete shall meet one of the following IDOT coarse aggreate gradation, CA-1, CA-2, CA-3 or CA-4 and be placed according to construction specification 25 ROCKFILL using placement Method I.
3. The stream crossing shall be made as perpendicular to the centerline of the stream as possible.
4. The crossing shall be removed immediately when no longer needed and the stream channel restored to its original cross section.

REFERENCE			STANDARD DWG. NO.
Project		U.S. DEPARTMENT OF AGRICULTURE	IL-675
Designed	Date	SOIL CONSERVATION SERVICE	SHEET 1 OF 1
Checked	Date	ILLINOIS	DATE 4-1-94
Approved	Date		

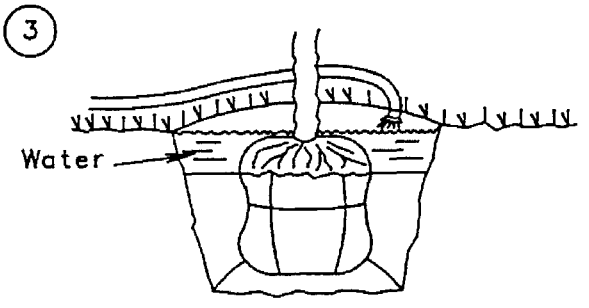
PLANTING PROCEDURE FOR BALLED AND BURLAPPED OR CONTAINER GROWN TREES AND SHRUBS



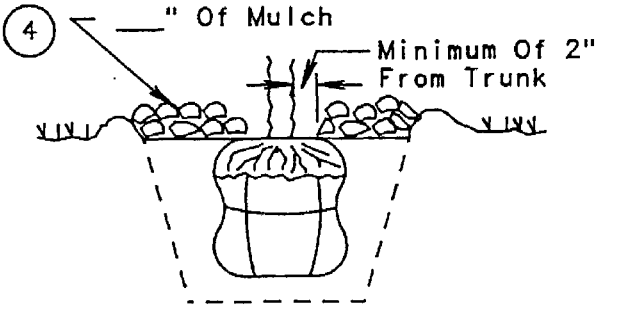
Add enough tamped soil in the bottom of the hole to set the ball at or slightly higher than the original planting depth.



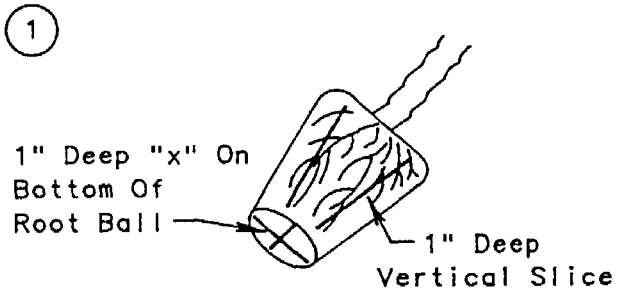
Fill the hole 3/4 full of tamped soil then remove all exposed burlap and twine using a sharp utility knife.



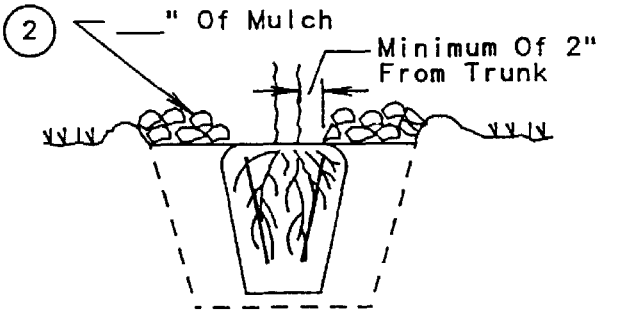
Fill the remaining 1/4 of the hole with water to remove air pockets and settle the soil. Finish filling the hole with soil after all the water has drained.



Unless soil is poorly drained, mound soil around edges of hole 4" to 6" high. Add a minimum of 4" of approved mulching material. Keep mulch about 2" from tree trunk.



Cut the circling roots of container grown trees with a sharp utility knife. Make 4 vertical slices on the sides and an "x" on the bottom. All slices should be 1-inch in depth.



Plant container-grown trees using same steps as for B & B trees except that the plastic container should be completely removed.

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SOIL CONSERVATION SERVICE
ILLINOIS

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IL-685
SHEET 1 OF 1
DATE 8-22-94

TREES AND SHRUB PLANTING SITE PLAN

SITE MAP

Show Location And Name Of Streets, Buildings, Landmarks, Trees, And Shrubs To Be Planted.

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TREES AND SHRUB PLANTING SITE PLAN

Site No.	Acres	Species	Map Sym.	Distance Between Rows (Ft.)	Spacing Of Plants In Rows (Ft.)	Number Of Plants Per Acre	Total No. Of Plants Needed

SITE PREPARATION

MULCHING REQUIREMENT

MAINTENANCE

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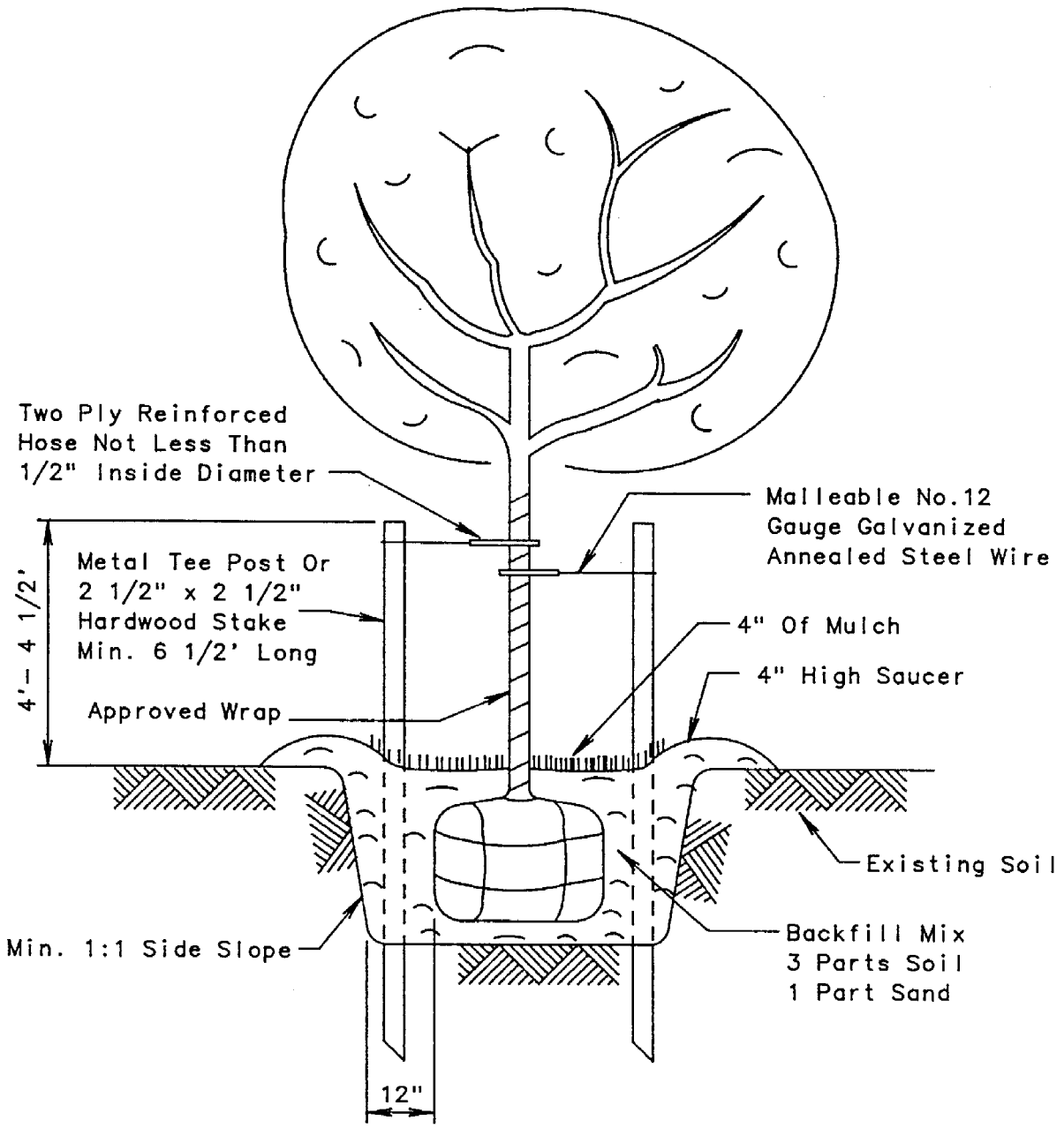
TWO GUY METHOD-TREES UNDER 8'



No Scale

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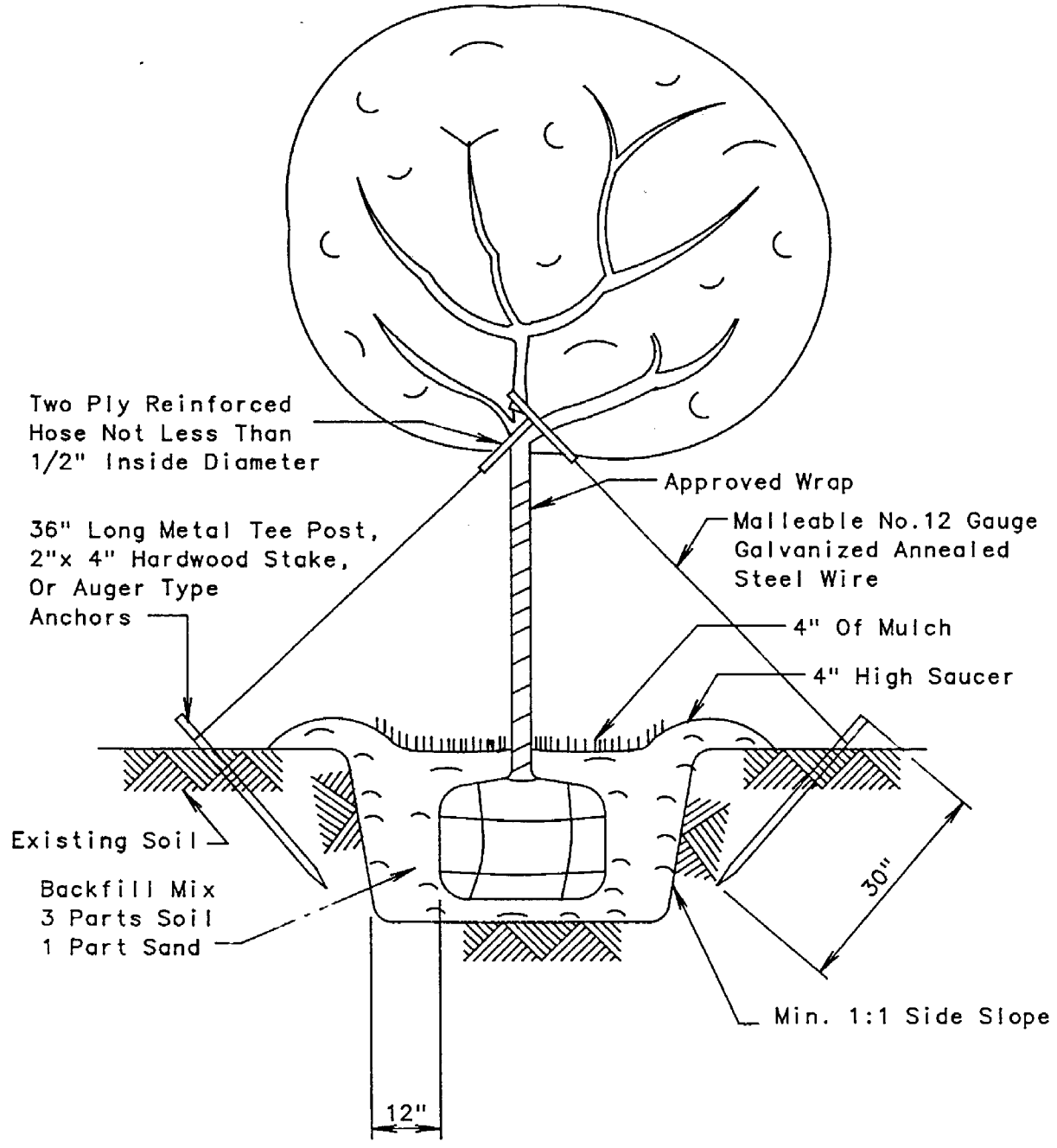
THREE GUY METHOD-TREES OVER 8'



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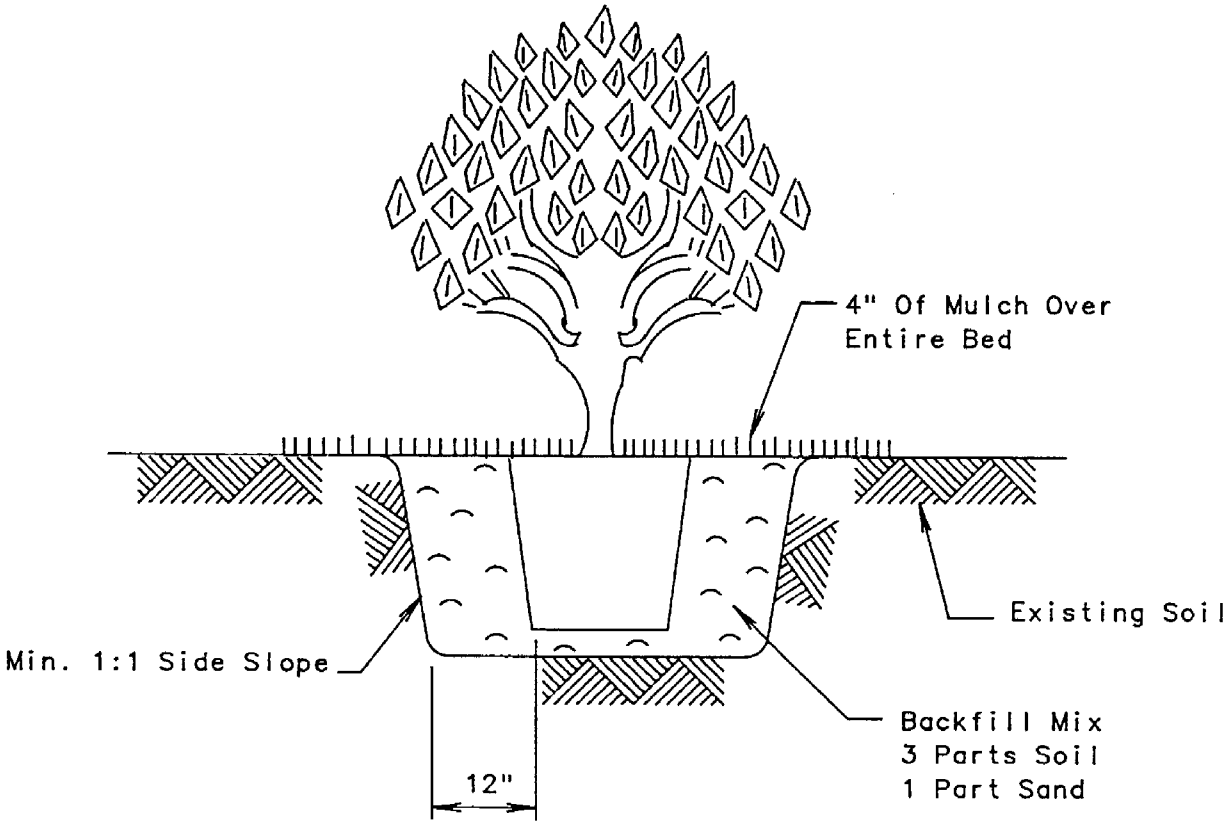
PLANTING PROCEDURE FOR SHURBS



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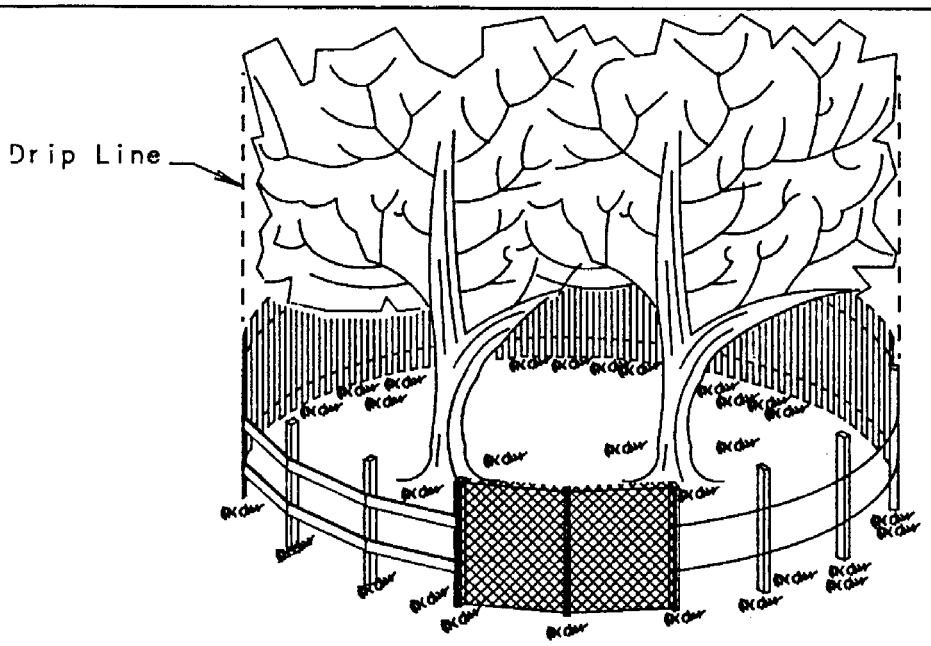
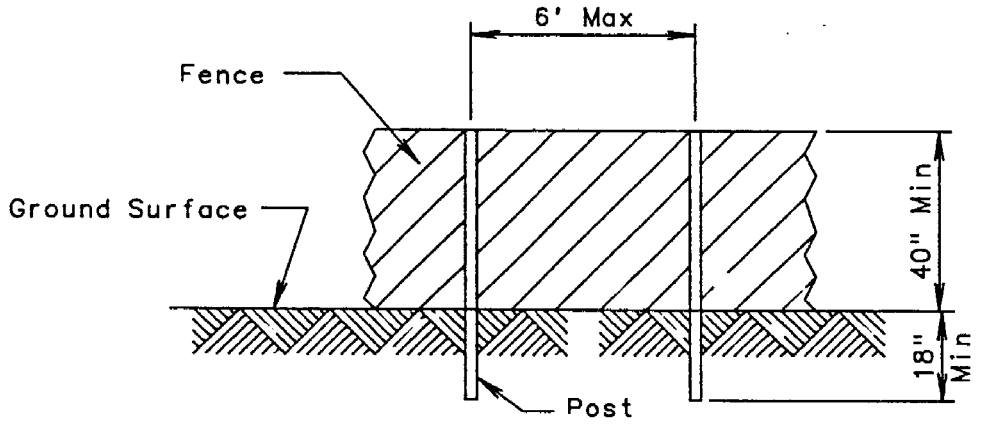
TREE PROTECTION - FENCING



SIDE VIEW



POST AND FENCE DETAIL

NOTES:

1. The fence shall be located outside the drip line of the tree to be saved and in no case closer than 5 feet to the trunk of any tree.
2. Fence posts shall be either standard steel posts or wood posts with a minumum cross sectional area of 3.0 sq.in.
3. The fence may be either 40" high snow fence, 40" plastic web fencing or any other material as approved by the engineer/inspector.

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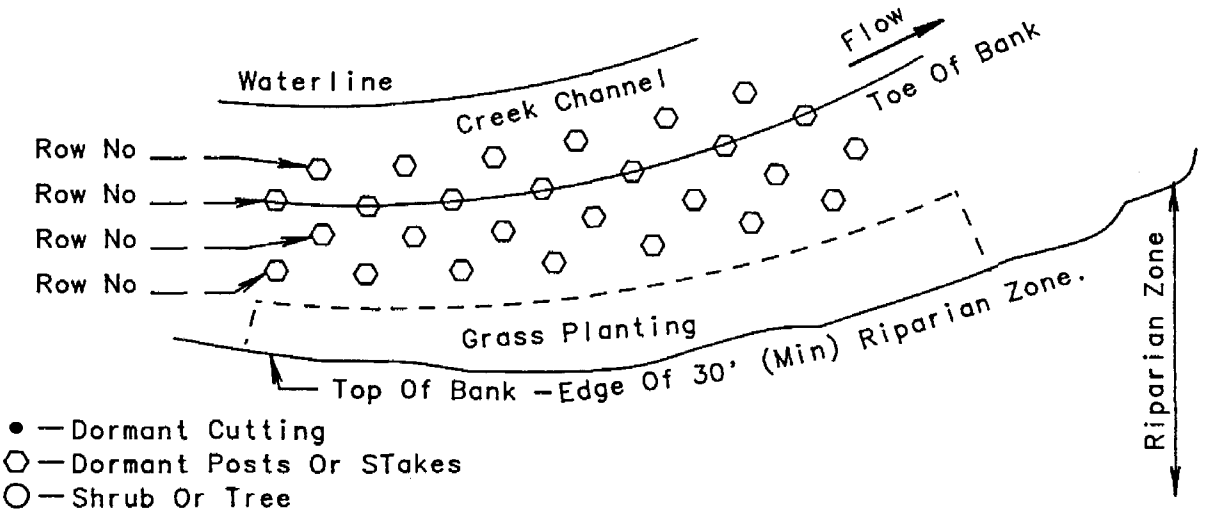
VEGETATIVE STREAMBANK STABILIZATION

SAMPLE SITE PLAN



SITE PLAN

GRASSES					
Reach No.	Length	Area (Sq.Ft.)	Species To Be Seeded	Lbs. Of PLS Per 1000 Sq. Ft.	Total Lbs.

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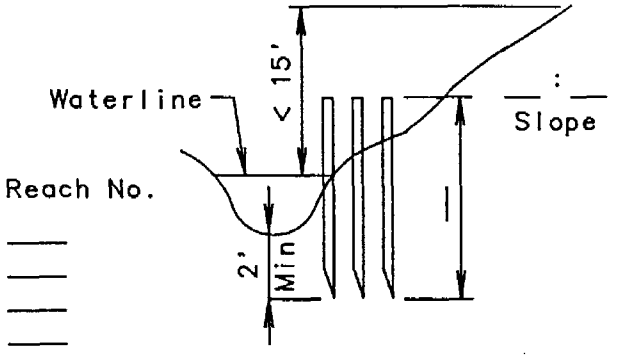
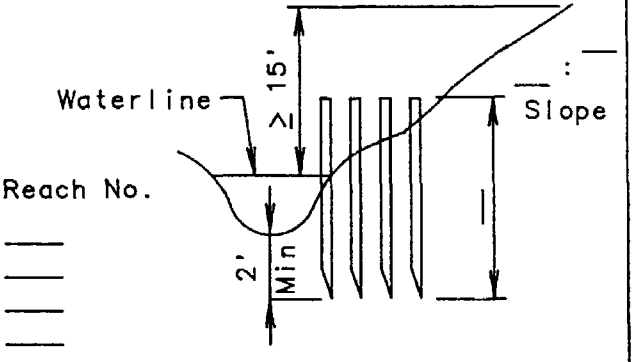
VEGETATIVE STREAMBANK STABILIZATION

SITE PLAN



BANK HEIGHT < 15'



BANK HEIGHT ≥ 15'

WOODY PLANTS

Reach No.	Length (Feet)	Row No.	Species To Plant	Between Row Spacing (Ft.)	In Row Spacing (Ft.)	Number Plants Per Row	Total Plants

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VEGETATIVE STREAMBANK STABILIZATION

SITE PLAN

RIPARIAN ZONE TREE AND SHRUB PLANTING						
Reach No.	Length (Feet)	Row No.	Species To Plant	Between Row Spacing (Ft.)	In-Row Spacing (Ft.)	Total Plants

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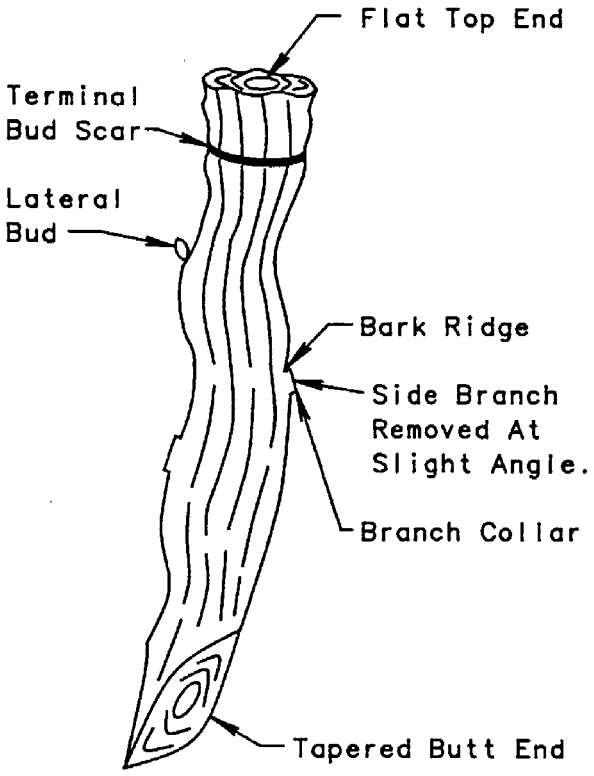
VEGETATIVE STREAMBANK STABILIZATION - DETAILS



Material Type (Circle One)

Cutting Stake Post

Minimum Length = _____ Ft. _____ Inches
Minimum Diameter At Top = _____ Inches

Figure 1

PLANTING MATERIAL PREPARATION

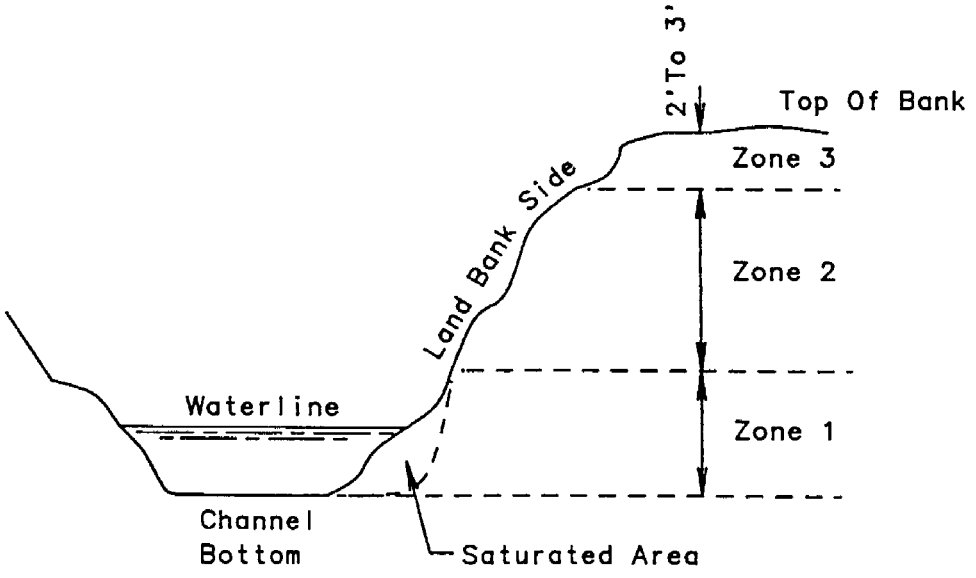


Figure 2

PLANT ZONES

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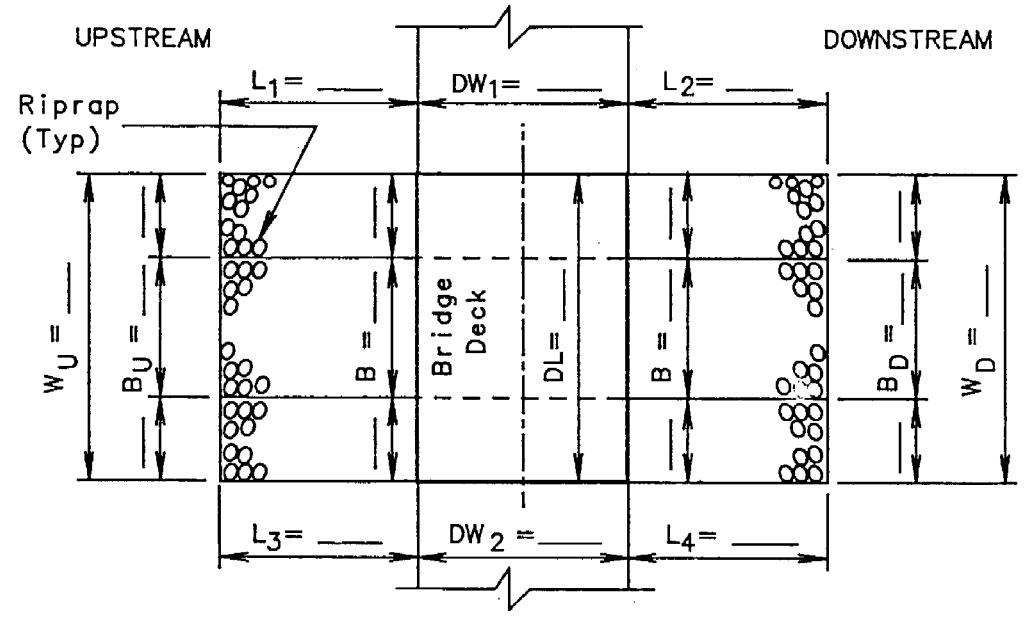
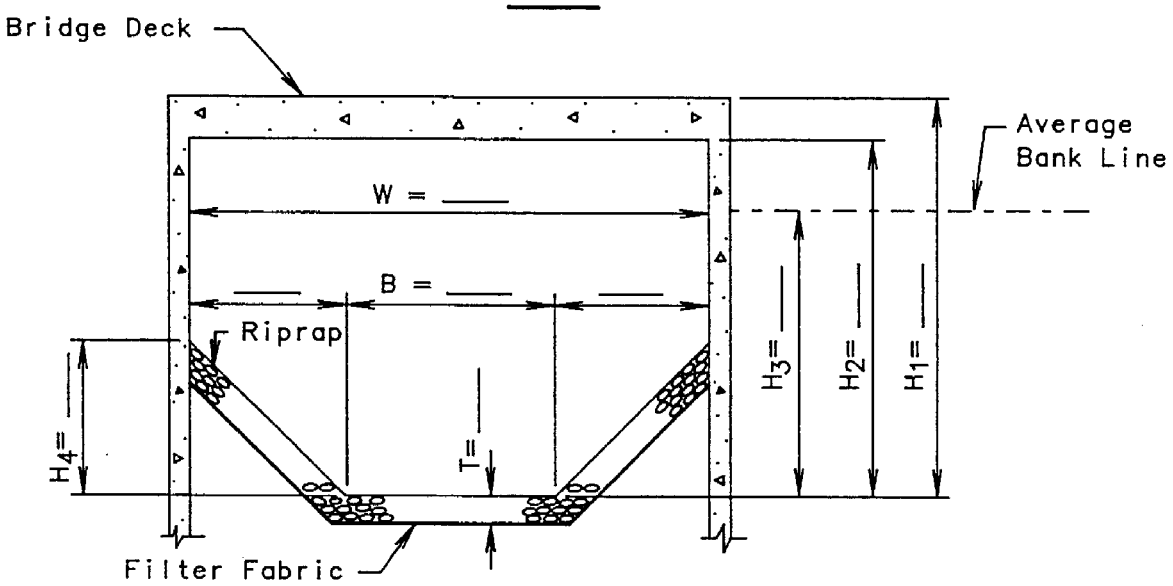
BRIDGE SCOUR PROTECTION



PLAN



SECTION ON CENTERLINE

NOTES:

1. The filter fabric shall meet the requirements for the following specification 592 GEOTEXTILE table I, II OR III.
2. The rock riprap shall meet IDOT requirement for the followng gradation: RR ____ Quality ____.
3. The riprap shall be placed according to construction specification 61 LOOSE ROCK RIPRAP. The rock may be equipment placed.

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Approved	Date		

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E. Glossary

31.0 GLOSSARY

AASHTO - American Association of State Highway & Transportation Officials (Formerly AASHO.)

ACCEPTABLE OUTLET - That point where storm water runoff can be released into a watercourse or drainage way of adequate capacity without causing scour or erosion.

ACID SOIL - A soil giving an acid reaction throughout most or all of the portion occupied by roots. (Precisely, below a pH of 7.0; practically, below a pH of 6.6.)

ALLUVIAL FAN - A sloping, fan shaped mass of sediment deposited by a stream where it emerges from an upland onto a plain.

ALLUVIUM - A general term for all detrital material deposited or in transit by streams, including gravel, sand silt, clay and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

ANGLE OF REPOSE - The stable angle between the horizontal and the maximum slope that a soil assumes through natural processes which will not slough.

ANTI-SEEP COLLAR - An impermeable diaphragm usually of sheet metal or concrete constructed at intervals within the zone of saturation along the conduit of a principal spillway to increase the seepage length along the conduit and thereby prevent piping or seepage along the conduit.

ANTI-VORTEX DEVICE - A device designed and placed on the top of a riser or at the entrance of a pipe to prevent the formation of a vortex in the water at the entrance.

APRON - A floor or lining to protect a surface from erosion, for example, the pavement below chutes, spillways, or at the toes of dams.

ASPECT - The direction a slope faces - a physiographic feature of steep slopes which influences plant growth and adaptation.

ATTERBERG LIMITS - Atterberg limits are soil properties measured for soil materials passing the No. 40 sieve.

> Liquid Limit (LL) - the liquid limit is the water content corresponding to the arbitrary limit between the liquid & plastic states of consistency of a soil.
>
> Plastic Limit (PL) - The plastic limit is the water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of a soil.
>
> Plasticity Index (PI) - The plasticity index is the numerical difference between the liquid limit and plastic limit.

BAFFLES - Vanes, guides, grids, grating or similar devices placed in a conduit to deflect or regulate flow and effect a more uniform distribution of velocities.

BARREL - The usually mild sloping closed conduit used to convey water under or through a dam; part of a principal spillway.

BASE FLOW - The stream discharge from ground water accretion.

BEDLOAD - The sediment that moves by sliding, rolling or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at velocities less than the surrounding flow.

BERM - A shelf that breaks the continuity of a slope.

BIODEGRADABLE - Capable of being broken down (degraded) by common soil organisms.

BLIND DRAIN - A type of drain consisting of an excavated trench refilled with pervious material, such as coarse sand, gravel or crushed stone, through whose voids water percolates and flows to an outlet. Often referred to as a French drain because of its initial development and widespread use in France.

BRACKISH (WATER) - Slightly to moderately salty water.

BULKHEAD - A wall made from wood, steel, concrete, etc. for protection of shoreline from waves or currents.

CALCIUM SULFATE - Gypsum. A hydrated form used to treat high sodium soils.
$CaSO_4$

CHANNEL - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

CHANNEL IMPROVEMENT - The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its water carrying capacity.

CHANNEL STABILIZATION - Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, structural linings, vegetation and other measures.

CHANNEL STORAGE - Water temporarily stored in channels while enroute to an outlet.

CHECK DAM - A small dam construction in a gully or other small watercourse to decrease the stream flow velocity (by reducing the channel gradient), minimize channel scour, and promote deposition of sediment.

CHUTE - A high velocity, open channel for conveying water to a lower level without erosion.

CLAY (SOILS) - 1. A mineral soil separate consisting of particles less than 0.002 millimeter in equivalent diameter. 2. A soil texture class. 3. (Engineering) A fine grained soil (more than 50 percent passing the No. 200 sieve) that has a high plasticity index in relation to the liquid limit. (Unified Soil Classification System)

COMPACTION - To unite firmly. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength and reducing permeability.

CONDUIT - Any channel intended for the conveyance of water, whether open or closed.

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

COOL (SLOPE, EXPOSURE) - A slope facing north or east, or a slope shaded during the hot part of the day.

CORDGRASS - Grasses of genus Spartina which are so named because of seed heads which have the appearance of coarse cord. These grasses are important soil binders along saltwater shorelines and marshes.

CORE TRENCH - A trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

CRADLE (ENGINEERING) - A structure usually of concrete shaped to fit around the bottom and sides of a conduit to support the conduit, increase its strength and in dams, to fill all voids between the underside of the conduit and the soil.

CREST - 1. the top of a dam, dike, spillway or weir, frequently restricted to the overflow portion. 2. The summit of a wave or peak of a flood.

CRITICAL AREA OR SITE - Sediment producing, highly erodible or severely eroded areas.

CRITICAL DEPTH (HYDRAULICS) - Depth of flow in a channel of specified dimensions at which specific energy is a minimum for a given discharge.

CROWN (OF SLOPE) - Top of slope; apex.

CRUSHED STONE - Aggregate consisting of angular particles produced by mechanically crushing rock.

CULM - The stem of grasses, sedges and rushes which is jointed and usually hollow in grasses and usually solid in sedges and rushes.

CULTIPACKER SEEDER - A farm tool equipped with a seedbox which drops the seed between cultipacker rollers to place the seed to firm soil where they will be pressed into soil by the second corrugated roller.

CUT - Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

CUT-AND-FILL - Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

CUTOFF - A wall or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

CUTTINGS - A small shoot cut from a plant to start a new plant.

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

DAM - A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention of soil, sediment or other debris.

DEBRIS - Broken remains of plants, objects and rocks that form trash or remains.

DECIDUOUS - Plants that shed their leaves annually as opposed to evergreen.

DEPOSITION - The accumulation of material dropped because of a slackening movement of the transporting agent, water or wind.

DESICCATION - Drying out as of root systems of plants before they are planted.

DESILTING AREA - An area of grass, shrubs or other vegetation used for inducing deposition of silt and other debris from slowing water, located above a pond, field or other area needing protection from sediment accumulation. (See filter strip.)

DETENTION DAM - A dam constructed for the purpose of temporary storage of stream flow or surface runoff which releases the stored water at controlled rates.

DIKE (ENGINEERING) - An embankment to confine or control water, for example, one built along the banks of a river to prevent overflow or lowlands; a levee.

DISTURBED AREA - An area in which the natural vegetative soil cover has been removed or altered and, therefore, is susceptible to erosion.

DIVERSION - A channel with a supporting ridge on the lower side constructed across the slope to divert water from areas where it is in excess to sites where it can be used or disposed of safely. Diversions differ from terraces in that they are individually designed.

DOLOMITIC (LIMESTONE) - Liming materials that contain more than 6 percent magnesium (mg); high magnesium lime.

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

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

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

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

DRAUGHTY (SOIL OR SLOPE) - Lacking moisture during part of the growing season during a typical year.

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

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

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

DRY STORAGE - The 1800 cubic feet of storage in a trap or basin that is dewatered after rain events.

EMERGENCY SPILLWAY - A dam spillway designed and constructed to discharge flow in excess of the principal spillway design discharge.

ENERGY DISSIPATOR - A designed device such as an apron of rip-rap or a concrete structure placed at the end of a water transmitting apparatus such as pipe, paved ditch or paved chute for the purpose of reducing the velocity, energy and turbulence of the discharged water.

ENTRANCE HEAD - The head required to cause flow into a conduit or other structure, including both entrance loss and velocity head.

EROSION - 1. The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. 2. Detachment and movement of soil or rock fragments by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

Accelerated erosion - Erosion much more rapid than normal, natural or geological erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophes that expose base surfaces, for example, fires.

Gully erosion - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 or 2 feet to as much as 75 to 100 feet.

Rill erosion - An erosion process in which numerous small channels only several inches deep are formed. See rill.

Sheet erosion - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not subsequently removed by surface runoff.

EROSIVE VELOCITIES - Velocities of water that are high enough to wear away the land surface. Exposed soil will generally erode faster than stabilized soils. Erosive velocities will vary according to the soil type, slope, structural or vegetative stabilization used to protect the soil.

ESTHETIC (AESTHETIC) - Pleasing in appearance; showing good taste.

EVERGREEN - Plants which have leaves or needles yearlong as opposed to those that lose their leaves during part of the year.

EXCELSIOR BLANKET - An erosion retardant material made from excelsior strands held together with net-like stands of plastic or other material.

EXPOSURE (SLOPE) -

North - Slopes facing in any compass direction clockwise between N45W and S45E.

South - Those slopes which face in any compass direction clockwise between S45E and N45W.

FILTER STRIP - A strip of permanent vegetation above ponds, diversions and other structures to retard flow of runoff water, causing deposition of transported material, thereby reducing sediment flow.

FINES (SOIL) - Generally refers to the silt and clay size particles in soil.

FREEBOARD (HYDRAULICS) - The distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditions.

GABION - A flexible woven-wire basket composed of two to six rectangular cells filled with small stones. Gabions may be assembled into many types of structures such as revetments, retaining walls, channel liners, drop structures and groins.

GABION MATTRESS - A thin gabion, usually six or nine inches thick, used to line channels for erosion control.

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

GRAFTING - A method of propagating plants by joining wood from one plant to another plant to get more desirable growth on the second plant.

GRASSED WATERWAY - A natural or constructed waterway, usually broad and shallow covered with erosion resistant grasses, to convey surface water down the slope.

GRAVEL - 1. Aggregate consisting of mixed sizes of 1/4 inch to 3 inch particles which normally occur in or near old streambeds and have been worn smooth by the action of water. 2. A soil having particle sizes, according to the Unified Soil Classification System, ranging from the No. 4 sieve size angular in shape as produced by mechanical crushing.

GRAVEL FILTER - Washed and graded sand and gravel aggregate placed around a drain or well screen to prevent the movement of fine materials from the aquifer into the drain or well.

GROIN - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shoreline.

GROUND COVER - Plants which are low-growing and provide a thick growth which protects the soil as well as providing some beautification of the area occupied.

GULLY - A channel or miniature valley cut by concentrated runoff through which water commonly flows only during and immediately after heavy rains or during the melting of snow. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lessor depth and would be smoothed by ordinary farm tillage.

HEAD (HYDRAULICS) - 1. The height of water above any plane of reference. 2. The energy, either kinetic or potential, possessed by each unit weight of a liquid expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various terms such as pressure head, velocity head, and head loss.

HERBACEOUS PERENNIAL (PLANTS) - A plant whose stems die back to the ground each year.

HERBICIDE - Chemical formulation used to control weeds or brush.

HULLED (SEED) - Hulless seed, such as sericea lespedeza. Seed are usually processed after threshing to take off outer hull to facilitate scarification and quicken germination.

HYDRAULIC GRADE LINE - In a closed conduit a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the hydraulic grade line is the free water surface.

HYDRAULIC GRADIENT - The slope of the hydraulic grade line. The slope of the free surface of water flowing in an open channel.

HYDRAULIC JUMP - The sudden turbulent rise in water level from a flow stage below critical depth to flow stage above critical depth, during which the velocity passes from super critical to subcritical.

HYDROGRAPH - A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

HYDROSEEDER - A machine designed to apply seed, fertilizer, lime and short fiber wood or paper mulch to the soil surface.

HYDRO-SEEDING - Seeding with a hydroseeder.

INFLOW PROTECTION - A water handling device used to protect the transition area between any water conveyance (dike, swale, or swale dike) and a sediment trapping device.

INTERCEPTOR DRAIN - A surface or subsurface drain, or a combination of both, designed and installed to intercept flowing water.

LIME - Basic calcareous materials used to raise pH of acid soils for benefit of plants being grown. May be either ground limestone or hydrated lime.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and currents.

MANNING'S FORMULA (HYDRAULICS) - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Where V is the mean velocity of flow in feet per second; R is the hydraulic radius; S is the slope of the energy gradient or for assumed uniform flow the slope of the channel, in feet per foot; and n is the roughness coefficient or retardance factor of the channel lining.

MULCH - Covering on surface of soil to protect and enhance certain characteristics, such as water retention qualities.

MULCH ANCHORING TOOL - A tool that looks like a dull disk designed to press straw and similar mulches into the soil to prevent loss due to wind, water or gravity.

NETTING (MULCH) - Paper or cotton material used to hold mulch material on the soil surface.

NITROGEN - FIXING (BACTERIA) - Bacteria having the ability to fix atmospheric nitrogen, making it available for use by plants. Inoculation of legume seeds is one way to insure a source of these bacteria for specified legumes.

NON-EROSIVE VELOCITY - Controlling the velocity of water to prevent detachment and movement of soil or rock. Erosive velocity will vary according to the soil type, slope, structural or vegetative stabilization used to protect the soil.

NORMAL DEPTH - Depth of flow in an open conduit during uniform flow for the given conditions. (See uniform flow.)

NOXIOUS WEEDS - Harmful; undesirable; hard to control.

a. Restricted - May be sold in the trade but are limited to very small amounts as undesirable contaminates.

b. Prohibited - Prohibited from sale.

OUTFALL - The point where water flows from a conduit, stream or drain.

OUTLET - The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

OUTLET CHANNEL - A waterway constructed or altered primarily to carry water form man-made structures such as terraces, subsurface drains, diversions and impoundments.

OVERFALL - Abrupt change in stream channel elevation; the part of a dam or weir notch over which the water flows.

PAPER FIBER - A short fiber mulch material usually applied by hydroseeder along with fertilizer and seed.

PARENT MATERIAL - The unconsolidated rock material from which the soil profile develops.

PENDULOUS - More or less hanging or inclined downward.

PERMANENT SEEDING - Results in establishing perennial vegetation which may remain on the area for many years.

PERMISSIBLE VELOCITY (HYDRAULICS) - The highest average velocity at which water may be carried safely in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. A safe, non-eroding or allowable velocity.

pH - A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7.0 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

PHREATIC LINE - The upper surface of the zone of saturation in an embankment is the phreatic (zero pressure) surface; in cross-section, this is called the phreatic line.

PIPING - Removal of soil material through subsurface flow channels or "pipes" developed by seepage water.

PLUGS - Pieces of turf or sod, usually cut with a round tube, which can be used to propagate the turf or sod by vegetative means.

PROJECTION - In sediment basins or other dams the perpendicular distance that the anti-seep collar extends from the outside surface of the pipe or pipe cradle.

RECYCLED CONCRETE EQUIVALENT - May be substituted for stone or rip-rap as called for in these specifications except where stone must be "washed". Concrete used in place of stone shall be broken into the stone sizes required for the application, shall be angular, resist crumbling and shall contain no steel reinforcement.

RETENTION - The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

REVETMENT - Facing of stone or other material, either permanent or temporary, placed along the edge of a stream or shoreline to stabilize the bank and to protect it from the erosion action of water.

RHIZOME - Any prostrate, more or less elongated stem growing partly or completely beneath the surface of the ground; usually rooting at the nodes and becoming upcurved at the apex.

RIGHT-OF-WAY - Right of passage, as over another's property. A route that is lawful to use. A strip of land acquired for transport or utility construction.

RILL - A small channel cut by concentrated runoff but through which water commonly flows only during and immediately after rains or during the melting of snow. A rill is usually only a few inches deep (but no more than a foot) and, hence, no obstacle to tillage operations.

RIP-RAP - Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves); also applies to brush or pole mattresses, or brush and stone, or similar materials used for soil erosion control.

ROUGHNESS COEFFICIENT (HYDRAULICS) - A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

RUNOFF (HYDRAULICS) - That portion of the precipitation on a drainage area that is discharged from the area in the stream channels. Types include surface runoff, ground water runoff or seepage.

SALINE SOIL - A non-alkali soil containing sufficient soluble salts to impair plant growth.

SAND - 1. (Agronomy) A soil particle between 0.05 and 2.0 millimeters in diameter. 2. A soil textural class. 3. (Engineering) According to the Unified Soil Classification System, a soil particle larger than the No. 200 sieve (0.074mm) and passing the No. 4 sieve (approximately 1/4 inch).

SCD - Soil Conservation District.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENTATION - Deposition of detached soil particles.

SEDIMENT DISCHARGE (SEDIMENT LOAD) - The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

SEEPAGE - 1. Water escaping through or emerging from the ground. 2. The process by which water percolates through the soil.

SEEPAGE LENGTH - In sediment basins or ponds, the length along the pipe and around the anti-seep collars that is within the seepage zone through an embankment. (See "phreatic line".)

SHA - Maryland State Highway Administration.

SHEET FLOW - Water, usually storm runoff, flowing in a thin layer over the ground surface.

SIDE SLOPES (ENGINEERING) - The slope of the sides of a canal, dam or embankment. It is customary to name the horizontal distance first, as 1.5 to 1, or frequently, 1 1/2 : 1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.

SILT - 1. (Agronomy) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter. 2. A soil textural class. 3. (Engineering) According to the Unified Soil Classification System a fine grained soil (more than 50 percent passing the No. 200 sieve) that has a low plasticity index in relation to the liquid limit.

SLURRY - A thickened, aqueous mixture of such things as seed, fertilizer, short fiber mulch or soil.

SMALL GRAIN MULCH MATERIAL - Straw material from oats, barley, wheat, or rye.

SOD - A piece of earth containing grass plants with their matted roots. Turf.

SOIL - 1. (Agronomy) the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. 2. (Engineering) Earth and rock particles resulting from the physical and chemical disintegration of rocks, which may or may not contain organic matter. It includes fine material (silts and clays), sand and gravel.

SOIL TEST - Chemical analysis of soil to determine needs for fertilizers or amendments for species of plant being grown.

SPECIFIC ENERGY - The average energy per unit weight of water at a channel section as expressed with respect to the channel bottom.

SPILLWAY - An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled to regulate the discharge of excess water.

SPREADER (HYDRAULICS) - A device for distributing water uniformly in or from a channel.

STABILIZATION - Providing adequate measures, vegetative and/or structural that will prevent erosion from occurring.

STABILIZED AREA - An area sufficiently covered by erosion resistant material such as a good cover of grass, or paving by asphalt, concrete, or stone, in order that erosion of the underlying soil does not occur.

STABILIZED GRADE - The slope of a channel at which neither erosion nor deposition occurs.

STABLE (STREAM OR CHANNEL) - The condition of a stream, channel or other water course in which no erosion or deposition occurs; adequately protected from erosion.

STAGE (HYDRAULICS) - The variable water surface or the water surface elevation above any chosen datum.

STATIC HEAD - Head resulting from elevation differences, for example, the difference in elevation in headwater and tailwater in a hydroelectric plant.

STILLING BASIN - An open structure or excavation at the foot of an outfall, conduit, chute, drop, or spillway to reduce the energy of the descending stream of water.

STOLON - A trailing or reclining above ground stem capable of rooting and/or sending up new shoots from the nodes.

STRUCTURAL - Relating to something constructed or built by man.

STRUCTURAL (SOIL) - The combination or arrangement of primary soil particles into secondary particles, units or peds. (Dune sand is structureless)

SUBCRITICAL FLOW - Flow at velocities less than critical velocity.

SUBGRADE - The soil prepared and compacted to support a structure or a pavement system.

TAILWATER (HYDRAULICS) - Water, in a river or channel, immediately downstream from a structure.

TEMPORARY SEEDING - A seeding which is made to provide temporary cover for the soil while waiting for further construction or other activity to take place.

TERRACE - An embankment or combination of an embankment and channel constructed across a slope at a suitable spacing to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Normally used only on cropland.

TEXTURE (SOIL) - The relative proportions of various soil separates in a soil material.

THATCH - A tightly intermingled layer of living and dead stems, leaves and roots of grasses.

TIDAL BANKS - Vertical or sloping banks adjoining oceans, rivers, bays, estuaries, etc. which are affected by fluctuations of daily tides.

TIME OF CONCENTRATION - Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to the outlet.

TOE (OF SLOPE) - Where the slope stops or levels out. Bottom of the slope.

TOE WALL - Downstream wall of a structure, usually to prevent flowing water from eroding under the structure.

TOPSOIL - Fertile or desirable soil material used to top dress roadbanks, subsoils, parent material, etc.

TRAP EFFICIENCY - The capability of a reservoir to trap sediment. The ratio of sediment trapped to the sediment delivered, usually expressed in percent.

TRASH RACK - Grill, grate or other device at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversize debris from entering the structure.

UNHULLED (SEED) - Seed still encased with a hull. Example: Sericea lespedeza before it is rendered hulless by mechanically removing the hull.

UNIFIED SOIL CLASSIFICATION SYSTEM (ENGINEERING) - A classification system based on the identification of soils according to their particle size, gradation, plasticity index and liquid limit.

UNIFORM FLOW - A state of steady flow when the mean velocity and cross-sectional area are equal at all sections of a reach.

UNIVERSAL SOIL LOSS EQUATION - An equation used for the design of water erosion control system: A=RKLSCP where A is average annual soil loss in tons per acre per year; R is rainfall factor; K is soil erodibility factor; L is length of slope; S is percent of slope; C is cropping and management factor; and P is conservation practice factor.

UPLIFT (HYDRAULICS) - The upward force of water on the base or underside of a structure.

VARIETY - A variant within a species which reproduces true by seed or vegetative propagation.

VELOCITY HEAD (HYDRAULICS) - Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity (32.16 feet per second per second).

WATER SURFACE PROFILE (HYDRAULICS) - The longitudinal profile assumed by the surface of a stream flowing in an open channel; the hydraulic grade line.

WEEP-HOLES (ENGINEERING) - Openings left in retaining walls, aprons, linings or foundations to permit drainage and reduce pressure.

WET STORAGE - The wet storage area is the 1800 cubic feet in the permanent pool of water in a sediment trap or basin.

WETTED PERIMETER (HYDRAULICS) - The length of the line of intersection of the plane or the hydraulic cross-section with the wetted surface of the channel.

WING WALL - Side wall extensions of a structure used to prevent sloughing of banks or channels and to direct and confine overfall.

WOOD FIBER - A short fiber mulch material, usually applied with a hydro-seeder in an aqueous mixture.