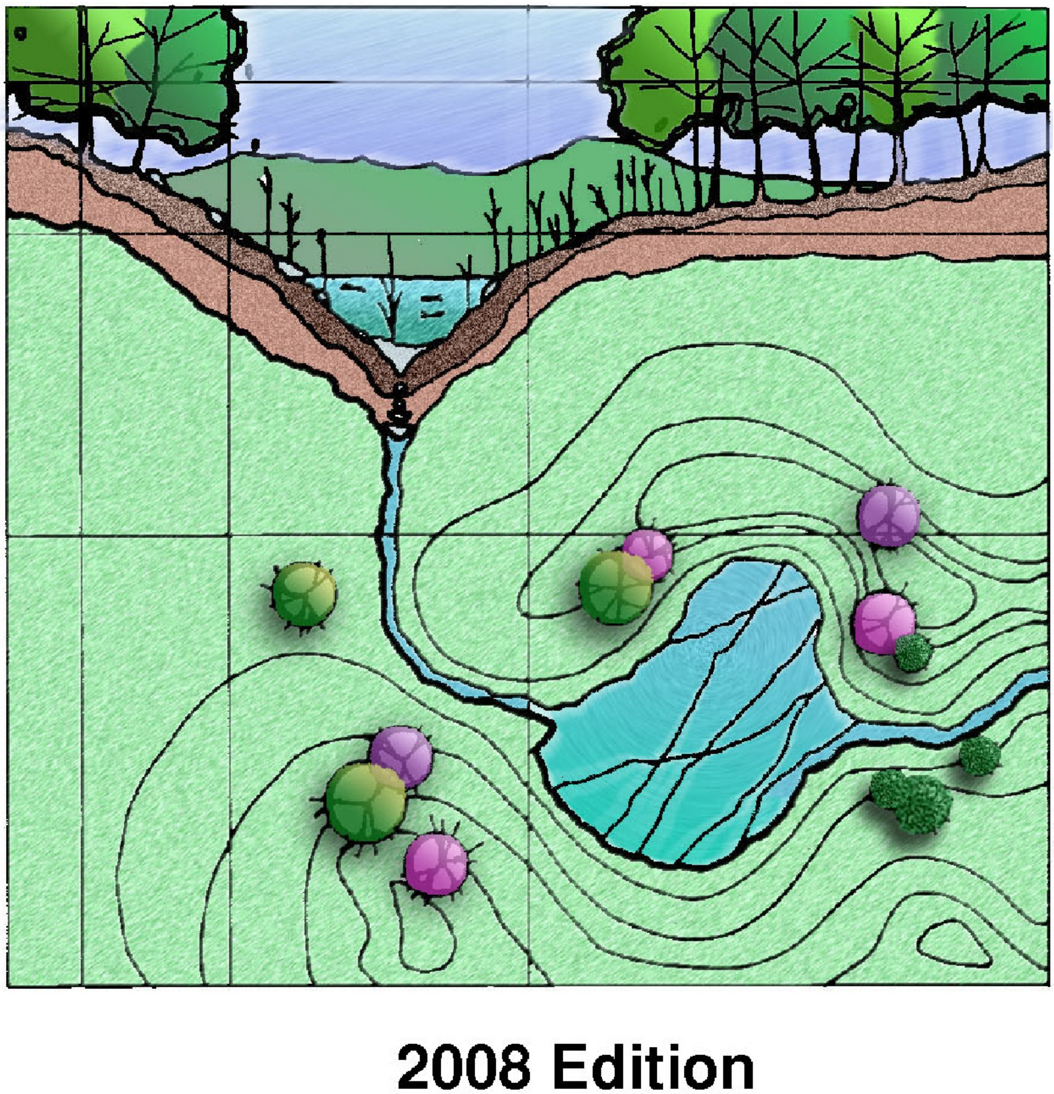
NEW JERSEY DEPARTMENT OF TRANSPORTATION

SOIL EROSION AND SEDIMENT CONTROL STANDARDS



2008 Edition

State of New Jersey

Department of Transportation

SOIL EROSION AND SEDIMENT CONTROL STANDARDS

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Acknowledgements

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Special acknowledgement and appreciation is given to our colleagues at New Jersey Department of Agriculture and New Jersey Department of Environmental Protection for their technical assistance and guidance in the development and revision of these Standards.

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1.0 INTRODUCTION

The Soil Erosion and Sediment Control Act of 1975 and the 1979 amendments require that all construction projects that disturb 5000 S.F. (465 m^2) of earth or more shall include measures to protect the environment from soil erosion and sedimentation. Complying with this mandate, the Department of Transportation in conjunction with the Department of Environmental Protection and the State Soil Conservation Committee has developed the Vegetative and Engineering Standards in this manual.

Current environmental laws and regulations now require more stringent procedures for controlling soil erosion and sedimentation on construction projects. Accordingly, the Department has revised its 2008 Standard Specifications in an effort to improve the Department's soil erosion control program. In addition to metrication of units, these revisions include modifications to the existing soil erosion and sediment controls, and the establishment of new control measures and construction procedures in order to provide the controls necessary to meet the environmental regulations.

Because of the importance that strict control provides to protect the environment, the revised soil erosion and sediment control requirements have been allocated their own section in the New Jersey Department of Transportation Standard Specifications for Roadway and Bridge Construction.
In addition to the establishment of soil erosion and sediment controls, the need for continuous maintenance of these items during construction is essential. To ensure ongoing and effective maintenance of the temporary soil erosion control items, pay items shall be included in the projects to provide specific payment to contractors for maintaining the soil erosion and sediment controls in good working order.

The Department of Transportation will certify to the appropriate Soil Conservation District that the appropriate standards are included in each project, and will be used during construction to comply with the intent of the Act to protect the environment from the effects of soil erosion and sedimentation. The standards were developed for, and are applicable for use, only on NJDOT projects and/or projects within NJDOT Right of Way.

2.0 PURPOSE

It is the purpose of these standards to supply the engineer with information helpful in designing soil erosion and sediment control measures for both temporary and permanent conditions.

There may be occurrences when the results produced by following these standards are not a reasonable solution and/or consistent with exercising good engineering judgment in the prevention of soil erosion. Therefore, the engineer shall check to assure that the proposed control feature is reasonable for the given situation.

The engineer may elect to design a soil erosion feature that is consistent with the intent of these standards but not described in this manual. In the event that there is cause to design a soil erosion feature not described in these standards, or there is a question concerning the appropriateness of any erosion control measure, the engineer shall contact the NJDOT Soil Erosion and Sediment Control subject matter experts and/or the Manager of the Bureau of Landscape Architecture and Environmental Solutions for guidance and approval.

2.1 Accommodation of New Erosion and Sediment Control Products

In order to accommodate the proliferation of new products and materials being introduced into the erosion control industry, the proposed New Jersey Department of Transportation Standards for Soil Erosion and Sediment Control utilize a performance basis for product and material selection. This means that any new product which can demonstrate and meet a minimum level of performance and/or meet minimum design specifications may be approved for use as indicated below. While the previous Standards incorporated performance and/or design/manufacture criteria, enhancements and additions have been made in these standards, which create more flexibility in using new products and materials.

For example, the proposed Grass Waterway standard contains specifications for erosion control “blanket” materials, which are based on the results of testing, conducted by the Texas Department of Transportation hydraulics laboratory. Texas DOT now publishes ratings for products used in open vegetated channels, which convey stormwater. The Standards propose to adopt the DOT performance criteria for use in open channel design standards such as grass waterways and diversions. In this example, any material from any manufacturer which has been tested and rated by Texas DOT for use in a grass-lined channel will be accepted for use in New Jersey within the limits established by the Texas DOT for that product.

2.1.2 Other Standards that include Performance, Design, Material or Manufacturing Criteria

Acid Soil Management
All Standards for Vegetative Stabilization
Topsoiling
Mulch Only Stabilization
Channel Stabilization
Conduit Outlet Protection
Detention Basins
Dewatering
Dust Control
Grade Stabilization Structures
Lined Waterways
Sediment Basins
Slope Protection
Soil Bioengineering
Stabilized Construction Access
Storm Sewer Inlet Protection
Stream Crossings
Subsurface Drainage
Floating Turbidity Barriers
Underground Detention Facilities
Dry Wells
Multi-Chamber Catch Basins

Off-Site Stability
Parking Lot Storage
Riprap
Rooftop Storage
Sand Filters
Vegetative Filter Strips
Wet Ponds

Any product or material which meets the criteria established in a particular standard will be acceptable for use in New Jersey Department of Transportation projects until and unless the product or material is proven ineffective through actual field use.

Questions regarding the acceptability of a product or material should be directed to the Department of Transportation's Bureau of Landscape Architecture and Environmental Solutions for consideration and approval for use on New Jersey DOT construction projects. New products may be conditionally approved pending verification by actual use in erosion control projects in New Jersey, and pending inclusion in the New Technology and Products List or a future Qualified Products List.

3.0 VEGETATIVE STANDARDS

3.1. STANDARDS FOR TEMPORARY VEGETATIVE COVER FOR SOIL STABILIZATION

3.1.1 Definition

Establishment of temporary vegetative cover on exposed soils for the life of the individual contract.

3.1.2 Purpose

To temporarily stabilize the soil and reduce damage from wind and water erosion until permanent stabilization is accomplished.

3.1.3 Where Applicable

On exposed soils that have the potential for causing off-site environmental damage, including but not limited to cut and fill slopes, roadway boxes, topsoil storage piles, detention basins or during project shutdown.

3.1.4 Methods and Materials

Materials for fertilizing and seeding shall conform to the requirements listed below:

- Fertilizer
- Seed Mixture - Type F

The fertilizer for establishing turf shall be limited to one selection throughout the project. Fertilizer shall have a commercial designation of 5-10-5, 10-20-10 or any 1-2-1 ratio fertilizer containing a minimum of 5% nitrogen, 10% available phosphoric acid (P_2O_5) and 5% soluble potash (K_2O). Fertilizer shall be applied in the quantity necessary to supply sixty (60) pounds per acre of nitrogen (70 kg/ha). Thirty (30) pounds shall be placed at the time of seeding with an additional application of thirty (30) pounds approximately six months after seeding, or as agreed with NJDOT. All seeded areas shall be fertilized and straw mulched as specified in the standards for stabilization with permanent vegetation.

Seeding shall be completed whenever possible from March 1 to May 15 and from August 15 to October 15 when weather and soil conditions are suitable. Seeding which cannot be completed during these periods may be performed at other times, when weather and soil conditions are suitable.

<u>TYPE F SEED</u>

KIND OF SEED	MINIMUM PURITY, %	MINIMUM GERMINATION, %	RATE
PERENNIAL RYEGRASS	95	90	100 lbs/ac (110 kg/ha)

3.2 STANDARDS FOR PERMANENT VEGETATIVE COVER FOR SOIL STABILIZATION

3.2.1 Definition

Establishment of permanent vegetative cover on exposed soils where perennial vegetation is needed for long-term protection.

3.2.2 Purpose

To permanently stabilize the soil, assuring conservation of soil and water and to enhance the environment.

3.2.3 Where Applicable

On exposed soils that have a potential for causing off-site environmental damage, such as permanent cut or fill slopes, detention basins, median areas and infield areas.

3.2.4 Methods and Materials

Tree and shrub planting beds shall not be fertilized or seeded if planting is to occur in the same construction stage as permanent soil stabilization. Materials for fertilizing and seeding shall conform to the requirements of the appropriate landscape materials listed below:

- Limestone, pulverized
- Fertilizer
- Seed Mixtures
- Grain Seed
- Straw Mulch

When the soil to be seeded has a pH value of less than 5.8, sufficient pulverized limestone shall be added to change the soil pH value to 6.5. All areas to be seeded shall meet the specified finish grades and shall be free of any stones, rocks, roots, wires, clods, and other debris measuring 2 inches (50 mm) or more in any dimension.

Recommended amounts of total oxides (calcium and magnesium) to raise the pH of a 4 inch (100 mm) layer of different soil textural classes to approximately 6.5 are as follows:

3.2.5 Soil Textural Class

Pounds of Oxides Per Acre

Soil (pH)	Loamy Sand	Sandy Loam	Loam	Silt Loam
5.7	300	600	900	1200
5.3- 5.6	600	1035	1500	1800
4.9- 5.2	900	1500	2100	2400
4.5- 4.8	1200	1800	2700	3000
4.1- 4.4	1500	2100	3300	3600

Kilograms of Oxides Per hectare (continued)

Soil (pH)	Loamy Sand	Sandy Loam	Loam	Silt Loam
5.7	0.3	0.7	1.0	1.3
5.3- 5.6	0.7	1.2	1.7	2.0
4.9- 5.2	1.0	1.7	2.4	2.7
4.5- 4.8	1.3	2.0	3.0	3.4
4.1- 4.4	1.7	2.4	3.7	4.0

The laboratory shall stipulate the above requirements for the total amounts of magnesium and calcium oxides based on tests run on the soil samples submitted.

Within the limits set forth under materials, the contractor may select the fertilizer he will use. The fertilizer for establishing turf shall be limited to one selection throughout the project. Fertilizer shall be applied in the quantity necessary to yield 60 pounds of nitrogen per acre (70 kg/ha), 30 pounds per acre (35 kg/ha) at the time of seeding and an additional application of 30 pounds per acre (35 kg/ha) approximately six months after seeding. It is preferred that this second application be made during the months of March or September.

Type A seed mixture shall be sown at the rate of 100 pounds per acre (110 kg/ha) throughout the project.

Type A-3 seed mixture shall be sown at the rate of 100 pounds per acre (110 kg/ha) throughout the project.

Type A-4 seed mixture shall be sown at the rate of 100 pounds per acre (110 kg/ha) throughout the project.

Type B seed mixture shall be sown at the rate of 100 pounds per acre (110 kg/ha) on sandy dry soils occasionally subject to salt water.

Type D seed mixture shall be sown at the rate of 150 pounds per acre (110 kg/ha) in residential and other areas of refined turf, as determined by the engineer.

Wetland seed mixture shall be sown at the rate of 100 pounds per acre (110 kg/ha) in residential and other areas of refined turf, as determined by the engineer

Areas to be seeded shall be friable and shall conform to the prescribed lines and elevations. All seeded areas shall be mulched the same day or as reasonably practical but no later than 7 days, as approved.

Shrub and ground cover plantings shall be mulched separately.

Seeding shall be completed whenever possible from March 1 to May 15 and from August 15 to October 15 when weather and soil conditions are suitable. Seeding which cannot be completed during these periods may be performed at other times when, in the opinion of the engineer, weather and soil conditions are suitable.

Limestone, Pulverized

Pulverized limestone shall be composed of not less than 85% of calcium and magnesium carbonates and not less than 40% calcium and magnesium oxides.

Fertilizer

Fertilizer for establishing turf shall have a commercial designation of 5-10-5 or 10-20-10 or any 1-2-1-ratio fertilizer containing a minimum of 5% nitrogen,10% available phosphoric acid (P_2O_5), and 5% soluble potash (K_2O).

If the fertilizer is to be applied with a mechanical spreader in the dry form, a minimum of 75% shall pass a No. 8 (2.36 mm) sieve and a minimum of 75% shall be retained on a No. 16 (1.18 mm) sieve, and the maximum free moisture content shall be 2 %.

Fertilizer for establishing sod shall be any 1-2-2-ratio fertilizer containing a minimum of 5% nitrogen, 10% available phosphoric acid (P_2O_5), and 10% soluble potash (K_2O). (5-10-10, 10-20-20, etc.)

All fertilizers shall be uniform in composition, free flowing and suitable for application.

All grass seed in the following mixtures shall be certified seed.

Type A Seed Mixture

Basic Highway Mix - used to encourage natural vegetation			
KIND OF SEED	MINIMUM PURITY (%)	MINIMUM GERMINATION (%)	TOTAL WEIGHT OF MIXTURE (%)
Kentucky Bluegrass	85	75	20
Red Fescues (Creeping or Chewings)	95	80	35
Kentucky 31	95	80	20
Redtop	92	85	10
Perennial Ryegrass	98	85	10
White Clover	97	90	5

Type A-3 Seed Mixture

Basic Highway Mix - used as basic seed mix for normal seed bed conditions			
KIND OF SEED	MINIMUM PURITY (%)	MINIMUM GERMINATION (%)	TOTAL WEIGHT OF MIXTURE (%)
Tall Fescue	95	80	60
Kentucky Bluegrass	85	75	10
Chewings Fescue	95	85	20
Perennial Ryegrass	98	85	10

Type A-4 Seed Mixture

KIND OF SEED	% OF TOTAL WEIGHT OF MIXTURE
Spreading Fescue	30
Chewings or Hard Fescue	30
Kentucky Bluegrass	30
Perennial Ryegrass	10

Type B Seed Mixture

Used with sandy dry soils occasionally subject to salt water.			
KIND OF SEED	MINIMUM PURITY (%)	MINIMUM GERMINATION (%)	TOTAL WEIGHT OF MIXTURE (%)
Redtop	92	85	15
Red Fescues (Creeping or Chewings)	95	80	40
Blackwells Switchgrass	95	85	15
Weeping Love Grass	95	85	10
Perennial Ryegrass	98	85	5
Kentucky 31	95	80	15

Type D Seed Mixture

Used in residential areas and where refined turf is needed.			
KIND OF SEED	MINIMUM PURITY (%)	MINIMUM GERMINATION (%)	TOTAL WEIGHT OF MIXTURE (%)
Kentucky Bluegrass	85	75	50
Red Fescues (Creeping or Chewings)	95	85	35
Redtop	92	85	5
Perennial Ryegrass	95	90	10

Straw Mulch

Areas shall be mulched with straw uniformly spread in a layer 1 to 1½ inches (25 to 40 mm) thick, loose measurement, and shall be bound in place with one of the following: synthetic plastic emulsion, fiber mulch, or vegetable-based gel.

All mulch shall be left in place and allowed to disintegrate with the exception that excessive amounts of straw shall be removed when necessary.

Straw

Straw shall be the threshed, unrotted stalks of oats, rye, barley or wheat, relatively free from seeds, noxious weeds and other foreign material.

Synthetic Plastic Emulsion

High polymer synthetic plastic emulsions of mulch binder shall be miscible with all normally available water when diluted to any proportion. After adequate drying, the synthetic plastic binder shall no longer be soluble or dispersible in water, but shall remain tacky until the grass seed has germinated. The plastic binder shall be physiologically harmless and shall not have any phototoxic or crop damaging properties. The manufacturer's recommendations for rate of application shall be followed.

Fiber Mulch

Fiber Mulch material shall be made from wood or plant fibers containing no growth or germination-inhibiting materials. The manufacturer's recommendations for rate of application shall be followed.

Vegetable-Based Gels

Vegetable-based gel materials, which can be classified as naturally occurring powder based hydrophilic additives formulated to provide gels, which, when applied under satisfactory curing conditions, shall form membrane networks of water insoluble polymers. The vegetable gel shall be physiologically harmless and shall not have phototoxic or crop-damaging properties. The manufacturer's recommendations for rates of application shall be followed.

3.3 STANDARDS FOR STABILIZATION WITH MULCH ONLY

3.3.1. Definition

Stabilization of exposed soils with non-vegetative mulching materials.

3.3.2 Purpose

To protect exposed soil surfaces from erosion damage and to reduce off-site environmental damage.

3.3.3 Where Applicable

This practice is applicable to areas subject to erosion, where the season and other conditions are not suitable for growing an erosion-resistant cover or where stabilization is needed for a short period until more suitable protection can be applied, such as cut and fill slopes, or any newly excavated highly erodible soil.

3.3.4 Methods and Materials

Areas shall be mulched with straw uniformly spread in a layer 1 to 1 ½ inches (25 to 40 mm) thick, loose measurement, and shall be bound in place with one of the following: as synthetic plastic emulsion, fiber mulch, or vegetable based gel.

All mulch shall be left in place and allowed to disintegrate except that excessive amounts of straw shall be removed when necessary.

Straw

Straw shall be the threshed, unrotted stalks of oats, rye, barley or wheat relatively free from seeds, noxious weeds and other foreign material.

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Vegetable Based Gels

Vegetable based gel materials, which can be classified as naturally occurring powder-based hydrophilic additives formulated to provide gels, which, when applied under satisfactory curing conditions, shall form membrane networks of water insoluble polymers. The vegetable gel shall be physiologically harmless and shall not have phototoxic or crop-damaging properties. The manufacturer's recommendation for rates of application shall be followed.

3.4 STANDARDS FOR PERMANENT STABILIZATION WITH SOD

3.4.1 Definition

Establishment of permanent vegetation using topsoil, 4 inches thick (100 mm), and sod.

3.4.2 Purpose

To permanently stabilize the soil with an immediate aesthetic covering, thus assuring conservation of soil and water, and to enhance the environment.

3.4.3 Where Applicable

On exposed soils that have a potential for causing off-site environmental damage where a quick vegetative cover is desired on small defined areas such as between curb and sidewalks, residential areas and areas directly adjacent to inlets.

3.4.4 Methods and Materials

Prior to placing the sod, 4 inches (100 mm) of topsoil shall be placed in accordance with Standards 3-5.

Immediately before placing the sod, a 1-2-2 ratio fertilizer applied at a rate necessary to yield 50 pounds (60 kg) of nitrogen per acre (ha), and pulverized limestone, if necessary, shall be incorporated into the topsoil.

The sod shall be harvested, and within 36 hours, delivered and placed on a 4 inch (100 mm) thick bed of topsoil. Sod shall be laid with staggered joints and pressed closely together. The ends of sod strips shall be matched so that the ends and sides always lay flush with each other, Sod shall be pressed into the underlying soil by hand tamping and rolling and thoroughly watered.

Watering shall be performed as necessary until a firm root mass is established. Each watering shall be performed until water infiltrates through the root zone and into the topsoil zone. The method of watering shall be performed in a manner that provides equal distribution and coverage to all areas sodded.

Sod shall not be transplanted when the moisture content (excessively wet or dry) may adversely affect its survival. If the upper ½ inch (10 mm) of topsoil is dry, the soil shall be lightly moistened immediately prior to laying the sod.

The finished surface shall be smooth, even, and to the prescribed lines and contour. (At the time of acceptance all sod shall be alive, healthy and established).

On slopes, placing sod shall start at the bottom. At the top of slopes the upper edge of the sod strips shall be turned into the soil and covered with topsoil. On slopes steeper than 3H:1V, sod shall be held in place with pegs driven flush with the surface of the sod. The pegs shall be not more than 1 foot (300 mm) apart. No less than 2 pegs shall be used for each strip of sod.

Pasture sod, consisting of sod from pastures or meadows, which may have been grown primarily for forage, is not acceptable.

When the item “stripping” is included on the project and the material to be stripped is found to be acceptable for use as topsoil, topsoiling shall include the preparation and placement of the topsoil stripped from the site as well as the furnishing and placement of topsoil required in excess of that obtained from stripping.

When the item “stripping” is not included on the project or stripped material is found to be unacceptable, topsoiling shall include the furnishing and placement of topsoil obtained from outside the limits of the project.

Topsoil shall conform to the requirement specified. Shaping and dressing shall include grading to required lines and elevations, the removal of all stones 2 inches (50 mm) or larger in any dimension and the removal of all other debris such as wires, cables, tree roots, pieces of concrete, clods, lumps, and other unsuitable material.

Topsoil in excess of the quantity required for the project shall be stored in neatly graded storage piles for future use.

Storage piles of topsoil and areas from which stored topsoil has been removed, within the right of way limits of the project, shall be fertilized and seeded.

Sod

Sod shall be machine cut at a uniform soil thickness of ⅝ inch (16 mm), plus or minus ¼ inch (6 mm) at the time of cutting. Measurement for thickness shall exclude top growth, and thatch. Individual strips of sod shall be of a uniform width and length. Broken strips and torn or uneven strips may be rejected. Standard size strips of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from the upper 10% of the strip.

Sod shall be Kentucky Bluegrass Blend or Kentucky Bluegrass-Fescue Blend, inspected and certified by the New Jersey Department of Agriculture and free of noxious weeds and excessive amounts of weedy plants.

Topsoil

Topsoil used for topsoiling obtained from stripping within the limits of the project or furnished from outside the project shall contain no stones, lumps, roots or similar objects larger than 2 inches (50 mm) in any dimension, and shall have a pH value of not less than 5.8. When the pH value of the topsoil is less than 5.8 it shall be increased by applying pulverized limestone at a rate necessary to attain a pH value of 6.5.

Material stripped from the following sources shall not be considered suitable for use as topsoil:

- Soils having a pH value less than 4.1 or greater than 7.0.
- Chemically-contaminated soils.
- Areas from which the original surface has been stripped and/or covered over, such as borrow pits, open mines, demolition sites, dumps and sanitary landfills.
- Wet excavation.

3.5 STANDARDS FOR TOPSOILING

3.5.1 Definition

Topsoiling entails the distribution of suitable quality soil on areas to be vegetated.

3.5.2 Purpose

To provide an adequate growing medium for the establishment of permanent perennial vegetative cover for long term erosion control.

3.5.3 Where Applicable

On exposed soil areas.

3.5.4 Methods & Materials

Shaping and dressing shall include grading to required lines and elevations, the removal of all stones 2 inches (50 mm) or larger in any dimension and the removal of all other debris such as wires, cables, tree roots, pieces of concrete, clods, lumps and other unsuitable material.

Topsoil shall be spread in a uniform layer that will produce the prescribed settled thickness. Prior to placing topsoil, subsoil determined to be compacted by equipment shall be scarified 6-12" except on roadway embankments.

Topsoil in excess of the quantity required for the project shall be stored in neatly graded storage piles for future use.

Storage piles of topsoil and areas from which stored topsoil has been removed, within the right of way limits of the project, shall be fertilized and seeded.

<u>Topsoil</u>

Topsoil obtained from stripping within the limits of the project or furnished from outside the project shall contain no stones, lumps, roots or similar objects larger than 2 inches (50 mm) in any dimension, and shall have a pH value of not less than 5.8. When the pH value of the topsoil is less than 5.8, it shall be increased by applying pulverized limestone at a rate necessary to attain a pH value of 6.5.

Material stripped from the following sources shall not be considered suitable for use as topsoil:

- Soils having a pH less than 4.1 or greater than 7.0.
- Chemically-contaminated soils.
- Areas from which the original surface has been stripped, and/or covered over such as borrow pits, open mines, demolition sites, dumps and sanitary landfills.
- Wet excavation.

3.6 STANDARDS FOR SELECTION AND PLANTING OF NATIVE AND NATURALIZED VINES, SHRUBS AND TREES FOR CRITICAL AREA PLANTING

3.6.1 Definition

Plants to aesthetically enhance and restore disturbed soils to natural condition.

3.6.2 Where Applicable

Graded or cleared areas subject to erosion, where a permanent, long-lived vegetative cover other than turf is desired.

NATIVE OR ACCEPTABLE EXOTIC PLANT MATERIAL

Although this is by no means a complete listing of the available plant material in these categories, it does include most of which is commonly used throughout the State of New Jersey. In natural areas, for example along stream banks, native species are preferred. The services of a Landscape Architect or a Horticulturalist should be utilized for the selection of plant material.

DECIDUOUS TREES

Latin Name	**Common Name**
Acer rubrum & varieties	Red Maple or Swamp Maple
Acer saccharum	Sugar Maple
Aesculus hippocastanum	Horsechestnut
Carya ovata	Shagbark Hickory
Celtis occidentalis	Common Hackberry
Fagus grandifolia	American Beech
Fagus sylvatica & varieties	European Beech
Fraxinus americana & varieties	White Ash
Fraxinus pennsylvanica lanceolata & varieties	Green Ash
Ginkgo biloba (grafted male) & varieties	Ginkgo or Maidenhair Tree (grafted male)
Gleditsia triacanthos & varieties	Honeylocust
Larix decidua	European Larch
Liriodendron tulipifera	Tuliptree, Tulip Poplar
Liquidambar styraciflua	Sweetgum
Nyssa sylvatica	Black Gum
Platanus acerifolia	London Plane Tree
Populus alba Bolleana	Bolleana Poplar
Quercus alba	White Oak
Quercus coccinea	Scarlet Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus rubra	Red Oak, Northern red oak
Salix babylonica	Babylon Weeping Willow
Tilia americana	American Linden
Tilia cordata varieties	Littleleaf Linden
Tilia tomentosa	Silver Linden
Zelkova serrata	Japanese Zelkova

SMALL DECIDUOUS TREES

Latin Name	Common Name
Acer campestre	Hedge Maple
Acer ginnala	Amur Maple
Amelanchier canadensis	Shadblow Serviceberry
Betula varieties	Birch
Carpinus betulus	European Hornbeam
Carpinus caroliniana	American Hornbeam
Cercis Canadensis	Redbud
Cornus florida	Flowering Dogwood
Cornus kousa	Japanese Dogwood
Cornus mas	Cornelian Cherry Dogwood
Cotinus coggygria	Smokebush
Crataegus species	Hawthorn species
Hibiscus syriacus	Shrub Althea
Magnolia virginiana	Sweetbay Magnolia
Malus varieties	Crabapples
Oxydendron arboreum	Sorrel Tree or Sourwood
Prunus varieties	Cherries
Salix caprea	Goat Willow
Salix discolor	Pussy Willow

SHRUBS

Latin Name	Common Name
Aronia arbutifolia	Red Chokeberry
Aronia arbutifolia brilliantissima	Brilliant Chokeberry
Chaenomeles lagenaria	Flowering Quince
Clethra alnifolia and varieties	Summersweet Clethra
Cornus varieties	Dogwood
Forsythia intermedia & varieties	Border Forsythia
Forsythia suspensa	Weeping Forsythia
Hamamelis varieties	Witchhazel
Ilex glabra	Inkberry
Ilex verticillata	Winterberry Holly
Kalmia latifolia	Mountain Laurel
Lindera benzoin	Spicebush
Myrica pensylvanica	Northern Bayberry
Rhododendron maximum	Rosebay Rhododendron
Rhus varieties	Sumac
Rosa varieties (except for Rosa multiflora)	Rose (except for multiflora rose)
Syringa vulgaris	Common Lilac
Vaccinium corymbosum	Highbush Blueberry
Viburnum varieties	Viburnum
Hydrangea quercifolia	Oakleaf hydrangea
Ligustrum varieties	Privet
Ilex varieties	Holly
Juniperus varieties	Junipers
Lonicera varieties	Honeysuckle

Sambucus Canadensis	American Elder
Taxus varieties	Yew
Spiraea varieties	Spirea

EVERGREEN TREES

Latin Name	**Common Name**
Abies concolor	White Fir
Ilex opaca	American Holly
Juniperus virginiana	Eastern Red Cedar
Picea abies	Norway Spruce
Picea species	Spruce
Pinus strobus	White Pine
Pinus species	Pine
Pseudotsuga taxifolia	Douglas Fir

GROUND COVERS VINES

Latin Name	**Common Name**
Campsis radicans	Trumpetcreeper
Euonymus fortunei vegetus	Wintercreeper Euonymus
Hedera helix	English Ivy
Juniperus conferta	Shore Juniper
Juniperus horizontal plumosa	Andorra Juniper
Parthenocissus quinquefolia	Virginia Creeper
Parthenocissus tricuspidata	Japanese Creeper
Vitis sp.	Grapes sp.

Time of Planting

Broadleaf and coniferous evergreen trees, shrubs, vines and ground covers shall be planted between March 1 and May 15 and between August 15 and December 1 or as approved by NJDOT. Deciduous trees, shrubs, vines and perennials shall be planted between March 1 and May 15 and between October 15 and December 1 or as approved by NJDOT .

Planting Beds

Existing vegetation within proposed planting beds shall be sprayed during the growing season with glyphosate at the manufacturer's recommended rates. All vegetation within proposed planting beds shall be removed and the surface raked and neatly edged. All beds shall be treated with a pre-emergence herbicide such as Trifuralin or its equivalent prior to the placing of any mulching materials. The application of herbicides shall comply with the requirements and procedures of N.J.A.C.7:30-1 et seq. Planting beds in areas flatter than 4:1 shall, in addition to the above, be cultivated to a depth of 6 inches (150 mm).

Planting Pits

Planting pits shall not remain open more than 10 days in advance of planting on slopes steeper than 4:1.

In medians or other areas close to the roadway where a hazardous condition may result, planting pits shall not remain open beyond the close of the working day unless adequate precautions are taken to warn of their presence and protect the public from injury.

Supporting Trees

All trees 1 inch (25 mm) or more in caliper or more than 3 feet (0.9 meters) high shall be staked or guyed immediately after planting. Multi-stemmed, shrub-like trees, within this caliper and height range, need not be staked.

The following trees shall be staked with one post placed, where possible, on the side of the tree away from the road and set not less than 24 inches (610 mm) in the ground and 9 inches (225 mm) from the tree trunk :

Deciduous trees, except Salix (Willow), 1 to 1 ½ inches (25 to 40 mm) caliper, inclusive.

Cone type (pyramidal) trees, 3 to 5 feet (0.9 to 1.5 meters) high.

Columnar evergreen trees, 4 to 7 feet (1.25 to 2 meters) high, inclusive.

The following trees shall be staked with two posts placed on opposite sides of the trees and set not less than 24 inches (610 mm) in the ground. The posts shall be placed at the perimeter of the ball.

Deciduous trees over 1 ½ to 2 ½ inches (40 to 60 mm) caliper, inclusive.

All Salix (Willow) trees, regardless of height or caliper, bare root, or balled and burlapped.

Columnar evergreen trees, over 7 to 9 feet (2 to 2.7 meters) high, inclusive.

Exceptions to supporting trees shall be requested for approval by NJDOT.

Replacement Planting

The requirements for making replacements shall be the same as required for initial planting except for the following:

Existing backfill may be reused.

Wood Chips, if salvageable may be reused. Existing wood chips shall be completely removed before any earth is excavated for replacement planting. Topsoil shall not be permitted for reuse if it contains wood chip mulch.

At the time plant replacements are made, the contractor shall also remove all weeds and debris from all planting areas.

Replacement plants shall be staked and guyed, in accordance with this section of the guidelines unless waived by NJDOT.

At the time of the acceptance of the replacements, all planting areas throughout the project shall be free of weeds and debris and in a condition as specified for final acceptance.

Replacement of evergreen materials shall be made from March 1 to May 15 and from August 15 to December 1 or as approved by NJDOT. Replacement of deciduous material shall be made from March 1 to May 15 and from October 15 to December 1 or as approved by NJDOT.

Two weeks prior to the conclusion of the one year plant replacement period, all stakes, guys and guy wires shall be removed by the contractor, except for replacement plants.

Containerized Plant Material

Immediately prior to planting containerized plant material, the root mass shall receive three vertical cuts, spaced equidistantly about the perimeter. Each cut, about ½ inch (15 mm) deep, shall begin at the top of the root mass and continue to the bottom.

Protecting Trees

Tree protectors shall be installed to a height of 2 feet above the ground surface on all newly planted Malus and Crataegus species to prevent damage from bark consuming rodents.

Watering

The initial watering at the time of planting shall be at the rate of 15 gallons (70 liters) per square yard (s.m.) of plant pit area. All plants shall be watered once a week thereafter until the project is finalized. Each watering, after the first, shall provide 5 gallons (25 liters) of water per square yard (s.m.) in the plant pit basin.

More than one watering per week may be required during planting operations or during periods of excessive dryness
.

3.7 STANDARDS FOR TREE PROTECTION DURING CONSTRUCTION

3.7.1 Definition

Protection of desirable trees from environmental and mechanical injury and soil compaction during construction activities.

3.7.2 Purpose

To protect desirable trees that have value for erosion and sediment control, shade, aesthetics, songbirds, other wildlife, dust control, noise abatement and oxygen production.

3.7.3 Where Applicable

On new development of sites containing valuable trees.

3.7.4 Methods and Materials

Inventory the development site and clearly mark the trees to be saved. Consider relocating streets, houses or other structures if necessary and feasible.

A. Criteria useful in determining the trees to save:

(1) Freedom from disease and rot : healthy trees.

(2) Life span of tree - i.e. birch is short-lived while sugar maple and oaks are long-lived.

Aesthetic values - such as autumn foliage, flowering habits, bark and crown appearance, type of fruit, etc.

(3) Wind firmness - trees that have been growing in a close stand may blow over easily if unprotected.

(4) Wildlife values - Oaks, hickories and dogwoods have high food value.

(5) Shade - summer temperatures are generally 10 degrees cooler under stands of hardwoods than under pines or cedars.

(6) Sudden exposure - to direct sunlight and ability to withstand radiated heat from proposed building and pavement.

(7) Space needed - for future growth and relationship to electric and telephone lines, water, sewer or gas lines, driveways, etc.

B. Criteria for protecting remaining trees:

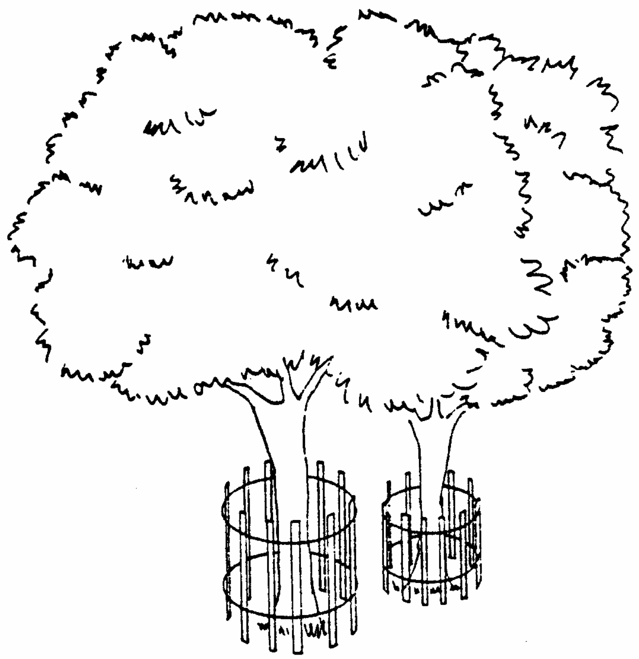
(1) Surround trees within 25 feet (7.5 meters) of a building site to prevent mechanical injury with fencing or other barrier installed at the drip line of the tree branches. See Figure 3.7-1.

(2) Boards shall not be nailed to trees during construction operations.

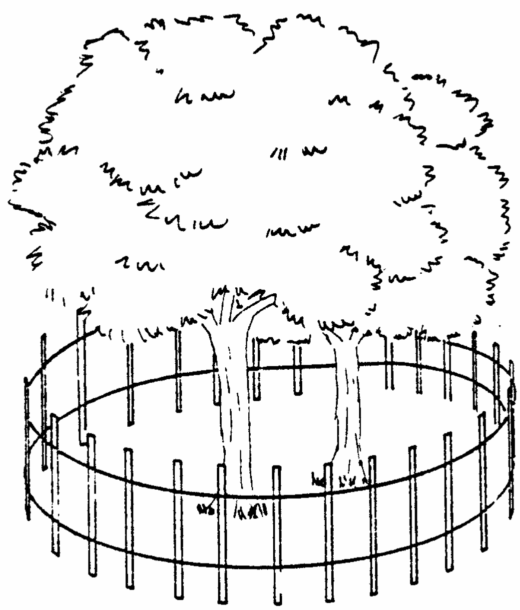
(3) Roots should not be cut in an area inside the drip line of the tree branches. Care for serious injury should be prescribed by a professional forester or certified tree expert.

(4) Tree limb removal, where necessary, will be done according to ANI A300 and ANSI z133.1.

FIGURE 3.7-1 TREE PROTECTION DURING CONSTRUCTION



Unacceptable placement of fencing for tree protection



Acceptable placement of fencing for tree protection at drip line of tree canopy

3.8 STANDARDS FOR MAINTAINING VEGETATION

3.8.1 Definition

The perpetuation of vegetative cover.

3.8.2 Purpose

To assure the continuing function of the vegetative cover in the conservation of soil and water and the enhancement of the environment. It is usually less costly to carry on a maintenance program than it is to replace or repair vegetation after an extended period of neglect.

3.8.3 Where Applicable

On areas where existing vegetation protects or enhances the environment.

3.8.4 Methods and Materials

A maintenance program anticipates requirements and accomplishes work when it can be done efficiently and with least expense to insure adequate vegetative cover.

Maintenance should occur on a regular basis, consistent with favorable plant growth, soil and climatic conditions. This involves regular seasonal work for mowing, fertilizing, liming, watering, pruning, fire control, weed and pest control, reseeding and timely repairs. The degree of maintenance depends upon the category of the vegetation and land; i.e. improved, semi-improved and unimproved grounds.

Maintenance programs should include the following:

A. Grass shall be mowed when it attains the height of 10-12 inches (250 to 300 mm). The grass and other volunteer growth shall be mowed to a height of 3 to 4 inches (75 to 100 mm). Hand mowing methods and light equipment, in areas where the use of heavy equipment might be injurious to the turf or soil, may be required. Where the cuttings resulting from the mowing operation are excessive, the cuttings shall be removed.

B. Fertilizer should be applied as needed to maintain a dense stand of desirable species. Frequently mowed areas and those on sandy soils will require more fertilization.

C. Lime requirement should be determined by soil testing every 2 or 3 years. Fertilization increases the need for liming.

D. Weed invasion may result from abusive mowing and inadequate fertilization and liming. Brush invasion is a common consequence of lack of mowing. The amount of weeds or brush that can be tolerated in any protective planting depends upon the land category and its intended use. Drainage ways are subject to rapid infestation by weeds and woody plants. These should be controlled if they reduce drainage way efficiency to the point of jeopardizing the road or its appurtenances or constitute a hazard or nuisance. Control of weeds or brush is accomplished by using herbicides or mechanical methods.

E. Pest and disease controls are more necessary on improved areas than on unimproved areas.

F. Fire hazard is greater where dry vegetation has accumulated. The taller the vegetation, the greater the hazard.

3.9 STANDARDS FOR TOPSOIL STABILIZATION MATTING

3.9.1 Definition

Placement of a non-vegetative woven mat fastened to exposed soil.

3.9.2 Purpose

Topsoil stabilization matting is used as a mechanical aid to protect the soil from erosion during the critical period of vegetative establishment.

It is easier to lay and hold in place against wind. It has the tensile strength and weight to resist water flow and erosion.

3.9.3 Where Applicable

All swales in medians and sidewalk areas having a profile of 1½% or steeper. Double the width for a distance of 50 feet (15 meters) away from the inlet. The single width should terminate 25 feet (7.5 meters) away from the upgrade inlet when a berm is constructed to retain the water at the inlet. If there is a danger of the water running past the inlet, the matting should be laid from inlet to inlet. Wide flat cross section medians may require the use of two or more overlapping strips of matting to handle the volume of water properly, especially when roadways are designed on separate profiles, one higher than the other.

Other areas where topsoil stabilization matting should be considered is as follows:

- Long runs with grades of 1½% or steeper to inlets in islands within interchanges.
- Ditches in which sod and sometimes concrete would have previously been specified.
- Intercepting ditches at the end of high cut slopes.

3.9.4 Methods and Materials

Before the matting is placed in position the soil must be smooth, soft and free of depressions, clods, mounds, stones, or other debris which will prevent the matting from making complete contact with the soil. After the soil has been properly shaped, fertilized and seeded, the matting shall be laid out flat, and anchored securely with staples, so that the matting will be in contact with the soil. When soil stabilization matting is required in swales of medians, the matting may be installed in multiple widths.

When jute matting or erosion blankets are being laid, the higher ends shall be turned under 6 inches (150 mm) and buried in a vertical position. Where jute matting or erosion blankets are laid end to end, the adjoining ends shall be laid so that the uphill strip overlaps the downhill strip. The upper end of each downhill strip shall be buried 6 inches (150 mm) deep in vertical position with the uphill strip overlapping for a distance of 6 inches (150 mm) to form a smooth shingle-like effect. When adjoining rolls of jute matting or erosion blankets are laid parallel to one another, the matting shall overlap from 3 to 6 inches (75 to 150 mm). When excelsior matting is being laid, the material shall be unrolled in the direction of the flow of water. Where strips of excelsior matting are laid end to end, the adjoining ends shall be butted snugly. When adjoining rolls of excelsior matting are laid parallel to one another, the matting shall be butted snugly.

Bulging seams in either matting material shall be cut and joints formed as described above.

Staples shall be placed along the outer edges of the matting and in a parallel row down the center of the strip. Staples shall be spaced 24 to 26 inches (600 to 650 mm) apart in the rows except along overlapping edges where they shall be 12 to 13 inches (300 to 325 mm) apart. Staples shall be driven at an angle of approximately 30 degrees uphill from horizontal.

In addition to the above requirements, staples shall be placed 12 inches (300 mm) apart across the matting at 50 feet (15 m) intervals and at critical locations such as at inlets, check slots (if required), overlapping joints and ends. The staples shall be driven flush with the surface of the matting and care shall be taken so as not to form depressions or bulges in the surface of the matting. If any staples become loosened or raised, or if any matting becomes loose, torn or undermined, satisfactory repairs shall be made immediately.

Topsoil Stabilization Matting

Soil stabilization matting may be either jute, or excelsior, mulch blanket, turf reinforcement mat or mechanically bonded fiber matrix conforming to the requirements specified below:

Jute Mat

Jute mat shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn, 48 inches ± 1.0 (1.2 m ± 0.025) in width, and weighing an average of 1.2 pounds per linear yard (0.60 kilograms per linear meter) of cloth with a tolerance of ± 5%, with approximately 78 warp ends per width of cloth and 45 weft ends per linear yard of cloth. The yarn shall be of a loosely twisted construction having an average twist of not less than 1.6 turns per inch (63 turns per meter) and shall not vary in thickness by more than one half its normal diameters.

Excelsior Mat

Excelsior mat shall be wood excelsior, 48 inches ± 1.0 (1.2 m ± 0.025) in width

and weighing 0.8 pounds per square yard (0.43 kilograms per square meter) ± 5%,. The excelsior material shall be covered with biodegradable netting to facilitate handling and to increase strength.

Erosion Control Mulch Blanket

Provide a machine-produced mat of organic, biodegradable mulch material, such as straw, coconut fiber, or other approved materials that is covered on both sides with a 1/2 × 1/2-inch photodegradable polypropylene mesh netting. Ensure that the mesh contains an accelerant that will cause breakdown of the mesh within 6 months. Ensure that Erosion Control Mulch Blanket conforms to the property values specified in Table 3.9-1.

Table 3.9-1
Requirements for Erosion Control Mulch Blanket*

Property	**Minimum Requirement**	**Test Method**
Mass per Unit Area of Blanket	0.5 lb/yd^2	ASTM D 5261
Performance @ shear stress of 1.75 lb/ft^2	acceptable	ASTM D 6460
Breaking Force	75 lb/ft	ASTM D 5035

Turf Reinforcement Mat (TRM)

Provide a machine-produced, 3-dimensional matrix of UV stabilized, pre- or post-consumer, non-degradable synthetic fibers, filaments, nettings, and/or wire mesh designed for permanent and critical hydraulic applications where design discharge velocities and shear stresses exceed the limits of mature, natural vegetation. Ensure that the TRM provides sufficient thickness, strength and void space to allow soil filling or retention and the development of vegetation within the matrix. Ensure that the TRM conforms to the property values specified in Table 3.9-2.

Table 3.9-2
Requirements for Turf Reinforcement Mat (TRM)*

Property	Minimum Requirement	Test Method
Thickness	0.25 in.	ASTM D 6525
Performance @ shear stress of 10.0 lb/ft^2	acceptable	ASTM D 6460
Breaking Force	175 lb/ft	ASTM D 6818
UV Stability @ 500 hours	80%	ASTM D 4355

Mechanically Bonded Fiber Matrix (MBFM)

Provide a hydraulically applied, flexible erosion control blanket composed of long strand, thermally processed wood fibers, crimped, interlocking fibers, and performance enhancing additives. Ensure that the MBFM requires no curing period, and upon application, forms an intimate bond with the soil surface, creating a continuous, porous, absorbent erosion resistant blanket that allows for rapid germination and accelerated plant growth.

Ensure that the MBFM conforms to the property values specified in Table 3.9-3.

Table 3.9-3
Requirements for Mechanically Bonded Fiber Matrix (MBFM)*

Property	Test Method	Minimum Requirements
Physical		
Mass Per Unit Area	ASTM D 6566	11.5 oz/yd^2
Thickness	ASTM D 6525	0.19 in
Percent Light	ASTM D 6567	99%
Penetration		
Water Holding Capacity	Proposed ASTM WK2652	1500%
Color (fugitive dye)	Observed	Green
Endurance		
Functional Longevity	Observed	1 yr
Performance		
Cover Factor (6 in/hr event)	ECTC Test Method No. 2	0.0066
Percent Effectiveness	ECTC Test Method No. 2	99.34%
Shear Stress	ECTC Test Method No. 3	1 lb/ft^2

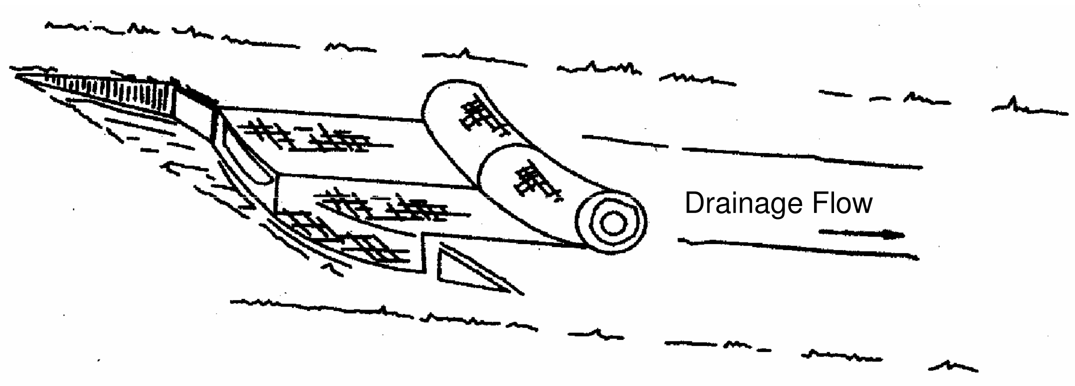
* Specifications were developed from the "Erosion Control Technology Council" specifications for Rolled Erosion Control Products

Staples

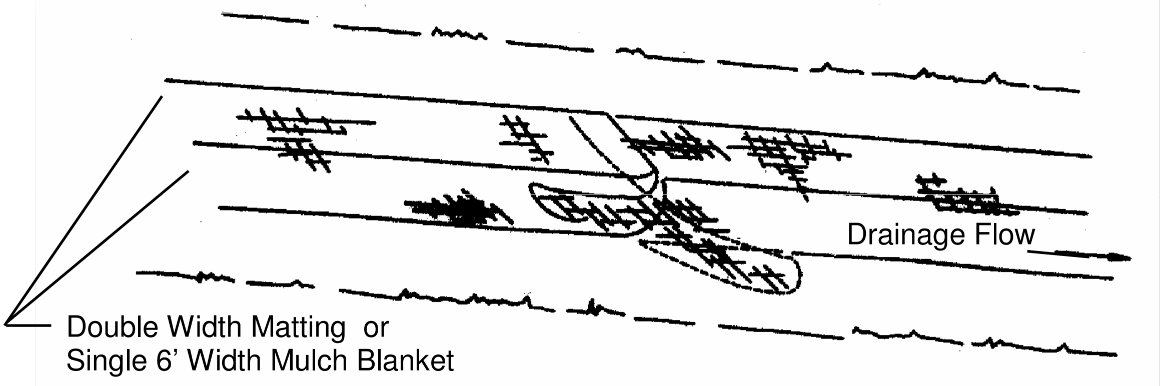
Staples for anchoring soil stabilization matting shall be made of 12 inch-lengths (300 mm) of No. 25 plain iron wire.

FIGURE 3.9-1 TOPSOILING STABILIZATION MATTING

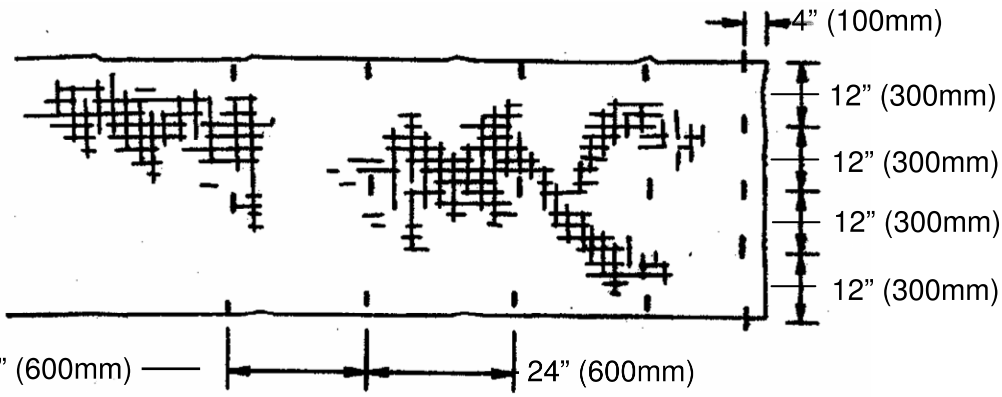
Double width matting in swale, use 3'-6" (1050 mm) overlap where two or more strips are required, and staple on 2' centers



Bury top end of matting in a 6" (150 mm) trench.
Tamp trench full of soil.
Secure with row of staples, 12" (300 mm) maximum spacing 4" (100 mm) down from trench.

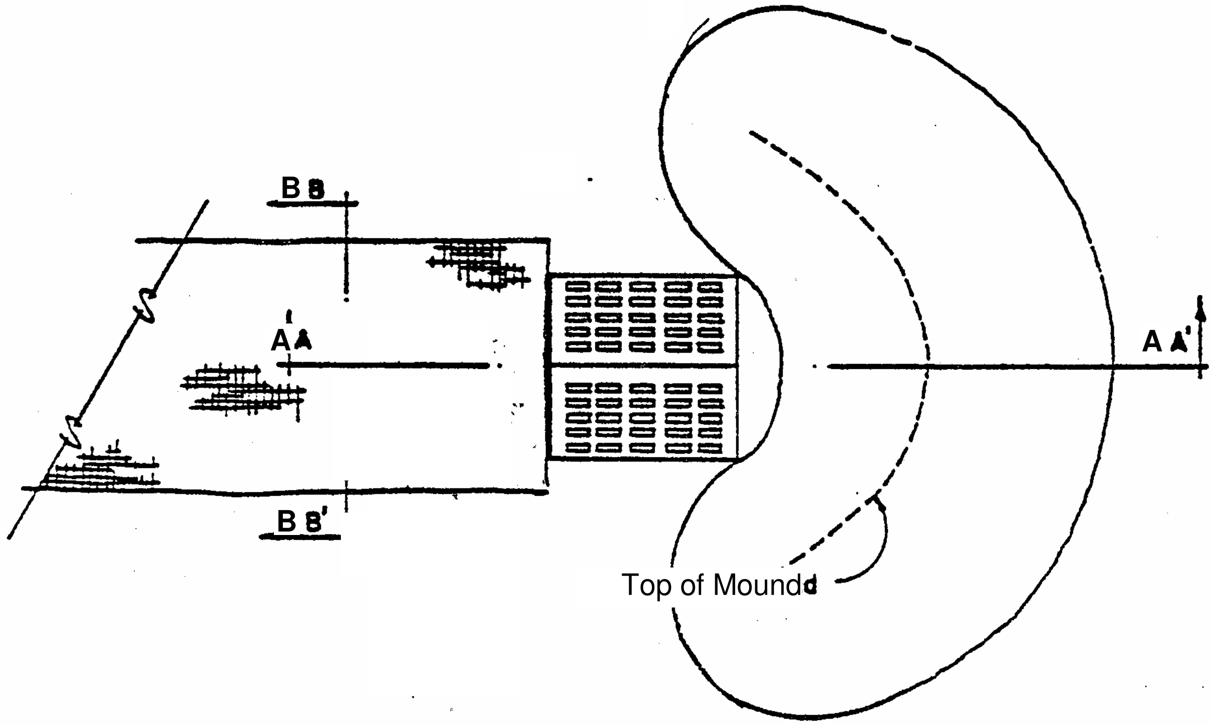


Overlap: Bury upper end of lower strip as per above detail.
Overlap end of top strip 6" (150 mm) and staple either side of joint.

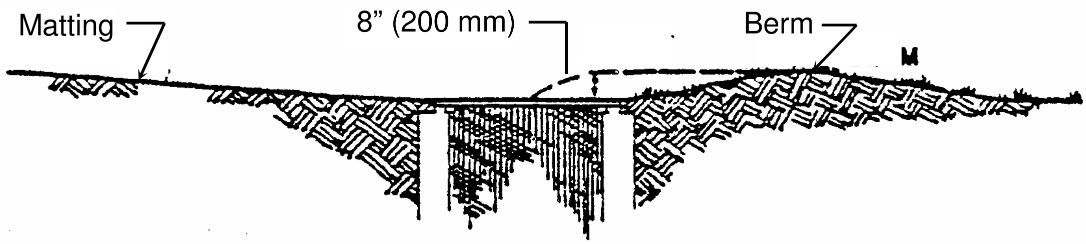


Secure Matting with staples spaced 24" (600 mm) apart along the sides and down the center. At the ends of the matting and at 50 - foot (15 m) intervals, staples shall be placed 12" (300 mm) apart across the width.

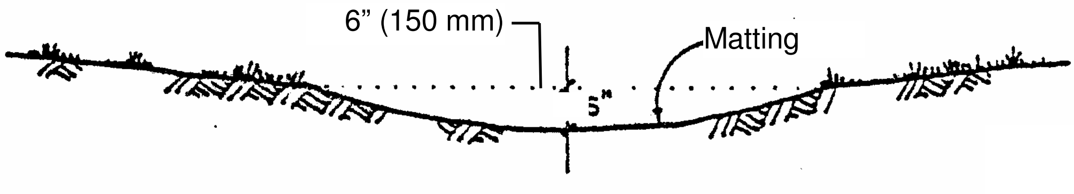
FIGURE 3.9-2 TOPSOILING STABILIZATION MATTING



PLAN: SOIL STABILIZATION MATTING, INLET & MOUND



SECTION A-A



SECTION B-B

N.T.S.

3.10 STANDARDS FOR PREPARATION OF EXISTING SOIL

3.10.1 Definition

Preparation of existing soil for seeding.

3.10.2 Purpose

To provide a seed bed for permanent vegetation in areas that are existing grade and not to be regraded for construction.

3.10.3 Where Applicable

On existing soil where natural vegetation is not providing adequate vegetative cover to prevent soil erosion; i.e. where topsoil has been stored, or where a different type of vegetative cover is desired from the existing condition.

The surface of the existing soil to be prepared shall first be cleared of all stumps, brush, weeds and debris. It shall be cultivated to a depth of 3 to 4 inches (75 to 100 mm) to prepare a seed bed. The entire area shall be brought to a smooth surface, free from any depressions that would collect water. If necessary, additional topsoil shall be used to fill depressions. Where depressions exceed 8 inches (200 mm) in depth, subsoil shall be added and covered with 4 inches (100 mm) of topsoil that shall be graded to provide a satisfactory surface contour.

All waste material and debris resulting from preparation of existing soil shall be disposed in accordance with all federal, state, and local laws and regulations.

Topsoil

Topsoil shall conform to the requirements as specified under the standards for Topsoiling.

3.11 STANDARDS FOR MANAGEMENT OF HIGH ACID PRODUCING SOILS

3.11.1 Definition

Identifying high acid producing soil, which may be exposed during excavation and land grading activities, and practices for its burial. High acid producing soils are soils with a pH of 4.0 or less or containing iron sulfide.

3.11.2 Purpose

To prevent or limit exposure of acid producing soils, and spreading of soil by equipment or rainfall on and off site and to minimize erosion, sedimentation and acid leachate-related damages.

By exposure to air, soils containing iron sulfide, characterized by pyrite or marcasite nuggets or green sands, chemical oxidation occurs producing sulfuric acid and resulting soil pH levels to fall to pH 4.0 and lower. Sulfuric acid increases the solubility of metals, which can become toxic to aquatic life or land vegetation, or can reach undesirable concentrations in potable water supplies. Most vegetation is incapable of growth at this pH level and so soil is left bare and vulnerable to erosion. Adjacent land and receiving waters will be negatively impacted by the acid leachate. Calcium-containing materials such as sidewalks, culverts and other structures and some metallic materials are also susceptible to degradation. Agricultural limestone applied at rates of 8 tons per acre has resulted in only a temporary buffering effect and “liming-only” is, therefore, not considered an acceptable mitigation practice.

3.11.3 Where Applicable

This practice is applicable to any high acid producing soil materials. Such materials have been found in the Coastal Plain areas of Burlington, Camden, Gloucester, Mercer, Middlesex, Monmouth, Ocean and Salem Counties. (See attached NJ Map of Acid Producing Soil)

The prompt burial of acid producing deposits below 1 foot (300mm) of soil with a pH of 5.0 or more reduces the availability of oxygen and, therefore, the rate at which acid is produced.

When excavation is being considered, pre-construction borings should be taken to a depth 1 foot greater than the proposed depth of excavation. The entire length of such borings should be examined for the possible presence of acid-producing deposits. Acid-producing deposits are typically found in gray, dark brown, black or sometimes in greenish-tinged soils.

High acid producing soil may be present in undisturbed soil at varying depths including near - surface excavations or deep disturbances. Its presence on a site may be extensive or limited in the soil profile. High acid producing soils are commonly black, dark brown, gray or greenish with silvery pyrite or marcasite nuggets or flakes. Alternatively, sandy soils or reddish, yellowish or light to medium brown soil materials are usually free of high acid producing minerals.

As a general guideline, pre-construction borings should be spaced 200 feet (60 meters) apart. This spacing may be modified as local geological conditions warrant. If acid producing soils are encountered unexpectedly during construction, (or are suspected as being present), proper procedures for testing, handling and disposing of them shall be employed.

3.11.4 Methods and Materials

1. Limit the excavation area and exposure time when high acid producing soils are encountered. The area of acid producing deposits exposed should be no larger then that which is absolutely necessary for the construction of the project.

2. Topsoil stripped from the site shall be stored separately from temporarily stockpiled high acid producing soils.

3. Stockpiles of high acid producing soils should be located on level land to minimize movement and acid runoff from the site, especially when this material has high clay content.

4. High acid producing soil to be temporarily stockpiled more than 30 days should be covered with properly anchored, heavy grade sheets of polyethylene where possible. If not possible, stockpiles should be covered with a minimum of 4 to 6 inches (100mm to 150mm) of wood chips to minimize erosion of the stockpile. Silt fence or other erosion barrier shall be installed at the toe of slope to contain movement of the stockpiled soil. Topsoil shall not be applied to the stockpiles to prevent topsoil contamination with high acid producing soil.

5. High acid producing soils with a pH of 4.0 or less, or containing iron sulfide, (including borrow from cuts) shall be ultimately placed or buried and covered with limestone applied at the rate of 10 tons per acre or 460 pounds per 1000 sq. ft. of surface area (9 metric tons per 4047 sq. meter or 537 kg per 92 sq. meter) and covered with a minimum of 12 inches (300mm) of settled or compacted soil with a pH 5.0 or higher, except as follows:

   A. Areas where trees or shrubs are to be planted shall be covered with a minimum of 24 inches (600 mm) of soil with a pH 5.0 or more.
   B. Disposal areas shall not be located within 24 inches (600mm) of any surface of a slope or bank, such as berms, stream banks, ditches and others to prevent potential lateral leaching damages including seepage of acidic water.

6. Equipment used for movement of high acid producing soils should be cleaned at the end of each day to prevent spreading of high acid soil materials to other parts of the site, into streams or stormwater conveyances, and to protect machinery from accelerated corrosion.

7. Non-vegetative erosion control practices (stone tracking pads, strategically placed limestone check dams, silt fence, wood chips) should be installed to limit the movement of high acid producing soils from, around, or off the site.

8. Following burial or removal of high acid producing soil and the topsoiling and seeding of the site, monitoring should continue for approximately 6 to 12 months to assure that there is adequate stabilization and that no high acid soil problems emerge. If problems still exist, the affected area must be treated as indicated in item #5 above to correct the problem.

3.11.5 General Mitigation Standards

1. Acid-producing deposits (including soil contaminated with such deposits and contaminated soil washed from construction equipment) should not be exposed for more than eight hours except where absolutely necessary for the construction of the project. If such deposits must be exposed for more than eight hours, such deposits should be covered with heavy grade polyethylene sheets properly anchored or 4-6 inches (100mm to 150mm) of wood chips.

   Long term, 60 days or longer, storage of acid producing soils should be covered with Pulverized limestone at the rate of 30 tons per acre (34 mega grams per hectare), 1375 pounds per 1,000 square feet (620 kg per 90 sm.) and then covered with a minimum of 1 foot of settled topsoil (free of acid-producing deposits) within one week after exposure, or before the pH of a well-mixed sample from the uppermost 2 inches (50mm) of the exposed deposit drops to 4.0, whichever occurs first.

2. Every effort should be made to minimize the spreading or mixing of acid-producing deposits (including soil contaminated with such deposits) onto or into soil free of such deposits (on or off the construction site). No construction should take place during rainstorms or while the ground is saturated to prevent spreading acid-producing deposits over uncontaminated soil or into waterways. If acid-producing deposits must be stockpiled on top of soil heretofore free of such deposits, the area used for stockpiling should be minimized and covered with heavy grade polyethylene sheets. Erosion and sediment control measures should be applied where acid-producing deposits are exposed or stockpiled to prevent or reduce the movement of acid-producing material into watercourses or onto uncontaminated soil.

3. Permanent vegetation should be established as soon as possible under the direction of a soils specialist or agronomist, who by training or experience is familiar with the problems of revegetating acid producing deposits. The topsoil should be tested for pH, the presence of iron sulfide and an incubated lime test if pH is below 4.0. The pH of the surface layer of soil must be raised to at least 5.0 before seeding or planting. Seeding should always be accompanied by mulching.

4. Temporary vegetative cover should not be used for stabilization of acid-producing deposits unless the liming and topsoil application requirements of Item 1, and the surface soil pH requirements of item 3 are first met. Otherwise, temporary stabilization of acid-producing deposits should be accomplished with “mulch only” 4-6 inch (100 to 150mm) thick or covered with heavy grade polyethylene sheets. No more than eight hours should elapse before the application of mulch or polyethylene sheets.

5. Excavated material should be returned to trenches or pits in the order of its removal, i.e., lower material first, followed by upper material. However, if acid-producing deposits are found only in the upper material, then the upper material should be returned first. This exception also applies to the following sentences.

Where acid-producing deposits are stockpiled on uncontaminated soil, not protected with heavy grade polyethylene sheets, the top 2 inches (50 mm) where such deposits are stockpiled should be scraped off and buried along with the “lower material”. The surplus material resulting from a permanent grade reduction, placement of pipes or other structures, and soil scraped from areas under temporary stockpiles of acid-producing deposits, should be substituted with an equal quantity of deeper material, which in turn should be removed to a suitable disposal site. After backfilling the deeper material, pulverized limestone should be spread over the top of the material, at the rate of 10 tons per acre (12 mega grams per hectare). 460 pounds per 1000 square feet (210 kg per 90 sq. meter), before the application of the surface layer of soil.

6. The above procedure is applicable only in well-drained areas. The top layer of soil, free of acid-producing deposits stripped and stockpiled should then be replaced. If necessary, additional quantities of topsoil should be imported to ensure at least 1 foot (300 mm) deep cover of soil which is free of acid-producing deposits. The amount of net fill that may be placed by regulation in flood plains must also be complied with.

3.11.6 Mitigation Procedures along Watercourse Channels

If construction would expose acid-producing deposits (to air or surface waters) within watercourse channels, along watercourse banks, or within the 150 foot stream buffers, the period of exposure should be held to a minimum and measures should be taken to cover such deposits to prevent the accelerated oxidation of such deposits. This requirement applies regardless of length of exposure.

1. Spread 12” (300 mm) of soil free of acid-producing deposits over the exposed deposit surface for areas to be fertilized, seeded and mulched and 24” minimum for an area which will be planted. The pH of such soil should be 5.0 or greater.

2. Compact the soil that has been spread pursuant to Item #1 above. If vegetation is to be used to stabilize the watercourse banks (see Item #3 below), the soil shall not be compacted to a bulk density exceeding 1.7 grams per cubic centimeter, and the liming and pH requirements of Items #3 and #5 of the General Mitigation Standards shall be met.

3. Since the oxidation of sulfide minerals and resulting generation of acid commences as the acid-producing deposits are exposed, the soil layer should be applied promptly to the newly exposed deposits within or along the channel. To accomplish this, channel excavation should proceed (where necessary) in stages along the successive reach lengths of the channel, scheduled in such a way that no newly exposed acid-producing deposits remain exposed longer than one week, or the time required for the pH of a well-mixed sample from the uppermost 2 inches (50 mm) of the deposit to drop to pH 4.0, whichever is less.

In some places it may not be practical to cover the acid-producing deposits with a soil-limestone mixture in the manner described above because of steep slopes or because of running water that cannot be diverted during construction. In such cases, plastic liners may be utilized, placing them over the newly exposed acid-producing deposits with suitable protection. Any fill material placed over the plastic liner should be free of acid-producing deposits. (The fill would be held in place over the liner by, concrete walls, or other permanent design features.)

Whenever it is proposed to seal acid-producing deposits with an artificial liner (e.g., plastic or specially prepared bentonite), the liner:

1) Shall be suitably acid-resistant and durable;
2) Shall be protected from erosion and washout;
3) Shall be protected from puncture and tearing due to vehicular or foot traffic, plant growth, ,sharp objects, vandalism, or other causes;
4) Shall be impermeable or very slowly permeable to water movement; and
5) Shall not release to ground or surface water appreciable quantities of toxic substances leached from the liner or resulting from the chemical or physical deterioration of the liner.

Concrete and asphalt are not suitable liners. However, use of concrete protected by liners from corrosion due to acid-producing deposits, may be given consideration.

3.11.7 Chemical Testing for Acid-Producing Deposits

Testing of the soil for pH and sulfate should be performed in the field or laboratory during preconstruction investigations and during construction to identify the presence of acid-producing deposits. (These tests are especially useful for identifying deposits containing very small crystals of pyrite or marcasite that cannot be recognized by ordinary means in the field). Strictly speaking, these tests give positive results only when the samples from an acid-producing deposit have oxidized to some extent. When the results of both tests are positive, the presence of acid-producing deposits is confirmed.

However, negative results in field tests do not prove the absence of acid-producing deposits since the samples may not have undergone appreciable oxidation before the field tests were performed. When results are positive in one of the two field tests, or for other reasons deposits are suspected to be acid-producing, additional samples should be brought to the laboratory so that the tests may be repeated on laboratory-oxidized samples. This applies particularly when in a field test the pH value in calcium chloride solution is between 3.0 and 4.0.

The same soil samples should not be used for both tests. Instead, soil samples should be mixed and divided into two parts, one part to be tested for pH and the other to be tested for sulfides.

3.11.8 Disposal of Acid- Producing Deposits

Acid-producing deposits (including soil contaminated with such deposits) that are not backfilled and covered in accordance with the above standards should be disposed of on or off the construction site in a suitable manner and location. Acid-producing deposits should not be discharged into watercourses, indiscriminately spread over uncontaminated soil, or sold or distributed as topsoil or topsoil amendments suitable for plant growth. Instead, such deposits should be buried at least 2 feet (600mm) beneath the land surface, in such a manner that the cover material is not subject to accelerated erosion. Stockpiles of acid-producing deposits awaiting burial should be covered with pulverized limestone at the rate of 30 tons per acre (1375 pounds per 1000 square feet) and then covered with a minimum of 12 inches (300 mm) of compacted soil free of acid-producing-deposits within one week after exposure, or before the pH of a well-mixed sample from the uppermost 2 inches (50 mm) of the deposits drops to pH 4.0 or less, whichever occurs first. Whenever practical, the deposit should be buried the same day it is excavated. The stockpiles shall be stabilized with permanent vegetation.

3.12 STANDARDS FOR DUNE STABILIZATION

3.12.1 Definition

Controlling surface movement of sand dunes or shifting sand by vegetative or mechanical means

3.12.2 Purpose

To reduce wind erosion and the encroachment of shifting sands, to provide a barrier against tide water, and to make the areas useful for other purposes.

3.12.3 Water Quality Enhancement

Reduces wind erosion, sand movement by storms and tides and facilitates dune building at ocean, bay frontal and back bay areas.

3.12.4 Where Applicable

Along ocean and bay shorelines where blowing sands and storm waters may cause erosion damage. Stay at least 100 feet (30 meters) (horizontal distance) from mean high tide water line (MHT).

3.12.5 Methods and Materials

Sand dunes naturally form on barrier islands, shorelines exposed directly to the ocean, and inland sand deposits. The source of this wind born sand is the ocean or its bays. These parallel ridges of sand form perpendicular to prevailing winds and grow toward its source of sand. Periodic storm events and human activity continually alter their development and original configuration. Once developed, the sand dunes provide protection from moderate storms and tides. The existence and maintenance of vegetation on dunes provides a network of root and foliage, which holds unconsolidated sand in place. American beach grass is the dominant, naturally occurring, vegetation of the frontal dunes of New Jersey. When beach grass is established with structural resources and other dune species, a formidable well-anchored storm barrier is established.

1. VEGETATION

A. Materials: The foliage of most sand dune species filters sand from the wind. The reduction of wind velocity near the dune's surface by vegetation allows sand to be deposited. The root mass of these plant species of the sand dunes is typically deep and extensive, anchoring the dunes to their foundation. When possible certified cultivars, which have been tested on similar sites, should be utilized.

1. Cultivar releases recommended for NJ sand dunes; all cultivars listed below were released by the USDA, Natural Resources Conservation Service Cape May Plant Material Center, located in Cape May Courthouse NJ. www.nj.nrcs.usda.gov

a. ‘Cape' **American Beachgrass** *(Ammophila breviligulata)*
b. ‘Atlantic’ **Coastal Panicgrass** *(Panicum amarum var. amarulum)*
c. ‘Avalon’ **Saltmeadow Cordgrass** *(Spartina patens)*

d. ‘Wildwood’ **Bayberry** (*Myrica pensylvanica*)
e. ‘Ocean View' **Beach Plum** (*Prunus maritima*)
f. ‘Sandy’ **Rugosa Rose** (*Rosa rugosa*)

2. Non-Cultivar releases suitable for NJ sand dunes

a. Switchgrass *(Panicum virgatum)*
b. Bitter Panicgrass *(Panicum amarum)*
c. Seacoast Little Bluestem *(Schizachyrium scoparium* var.*littorale)*
d. Seaside Goldenrod *(Solidago sempervirens)*
e*. Eastern* Red Cedar *(Juniperus virginiana)*
f. Japanese Black Pine *(Pinus thunbergiana)*

B. Establishment

1. American Beachgrass - Beachgrass is successionally classified as a pioneering type species; it is the hardiest species capable of surviving the harsh environmental conditions of the frontal dunes. For initially stabilizing a dune system, this species is the most reliable and commercially available option. Once established it rapidly spreads by a rhizomatous root system, developing a soil binding network of interwoven roots.

Planting Dates	October 15 to April 1; under non frozen soil conditions
Planting Unit	a minimum of two stems (culms) per hole
Method	hand placement, or use of a vegetable or tree planter
Size	16 to 18 inch (400mm to 450mm) long stems, > ¼ inch (6.25mm) in diameter
Depth	approximately 8 inches (200mm) deep (≥ 7" (175mm) but ≤ 9" (225mm) is acceptable)
Spacing	severe sites = 12" X 12" (300mmx300mm) normal sites = 18" X 18" (450mmx450mm) stable sites =24" X 24" (600mmx600mm)

Notes:

- Plant ≥ 100 feet (30 meter) (horizontal distance) from the mean high tide water line to ensure success
- Plant a minimum of 10 parallel rows; stagger (off-set) rows to maximize protection
- Firm soil around plants to eliminate air pockets
- If utilizing dredged fill, allow salts to leach out before planting and allow rains to compact sands.

Coastal Panicgrass - This warm season bunch-like grass is a post-stabilization species thriving from the crest of the frontal dune to inland sites. It is the only dune stabilization species that has been directly seeded onto the sand dunes successfully. Potted plants and stem divisions can also be successfully established on these severe sites. The annual foliage emerges from a deep fibrous perennial root system with short lateral rhizomes. This species can be successfully planted with or over-seeded into stands of American beachgrass. The same plant and seed establishment techniques outlined below also pertain to Switchgrass, Seacoast Little Bluestem, and Seaside Goldenrod.

Seeding Dates:	over seeding:	April 1 to May 1
	dormant seeding:	November 1 to April 15
	planting transplants:	April 1 to May 15

Planting Unit:	single bare-root or containerized seedling or division; 12 -18 inches (300mm-450mm) tall
Seeding rate:	8 to 12 lbs. of Pure Live Seed (PLS) per acre (8.9 kg to 13.3 kg) of Pure Live Seed (PLS) per hectare
Depth:	plants: 2 inches (50 mm) deeper than the nursery depth seed: drilled 1 ½ to 2 ½ inches (40 mm-65 mm) deep
Method	plants: hand-placed, or use a vegetable or tree planter seed: hand or mechanically-operated drill or seeder
Spacing:	plants: 4' X 4' (1.2 x 1.2 meter) seed: 3' to 10' (0.9 to 3 meter) row spacing

3. Saltmeadow Cordgrass - Although typically associated with tidal salt marshes, this cordgrass also naturally occurs in the secondary and back dune areas. Predominantly inhabiting inter-dune troughs and low blow-out areas, it is dominant in these micro-sites since most other sand dune species can not tolerate wet to saturated soil conditions. The trailing rhizomes of saltmeadow cordgrass are slender, but form dense mats near the surface. It is vegetatively established on normal sites using freshly harvested stems (culms) or containerized plants on severe locations.

Planting Date	May 1 to June 15
Planting Unit	3 to 5 live stems placed bare-root or containerized
Depth	2 inches (50 mm) below the nursery-grown depth
Method	hand-placed or use a vegetable planter
Size	> 12 inches (300mm)

Spacing 18 to 36 inches (450mm to 900mm) depending on the severity of the planting site

Notes:

- Utilize this species in low elevation sites of sand dunes which are frequently inundated. .

4. Shrubs and Trees - Medium-sized shrubs and small trees naturally dominate the back dune zone of New Jersey's barrier islands. The shrubs begin to co-inhabit the mid secondary dunes. Once extensive stands of bayberry, beach plum, pitch pine and other woody species covered these islands where houses now stand. These shrub species, which are well adapted to the dune ecosystem, are capable of either layering or root suckering. The trees and shrubs of the sand dunes have deep tap root systems for supplying adequate moisture and nutrients. Each species utilized for back dune stabilization has its own unique attributes Beach plum has a colorful bloom in spring, which yields a tasty succulent cherry like fruit. Bayberry roots have nodules, which enable it to fix atmospheric nitrogen similar to legumes; it also produces aromatic fruit and leaves. The thorny stems of Rugosa Rose are useful in directing pedestrian traffic along established access trails. This rose species also blooms from late spring to early fall, then gives rise to a bright red fruit. The pines and junipers, which are adapted to sand dunes, provide the visual appeal of evergreens in the back dunes. The major function of tree and shrub vegetation on sand dunes is still the permanent solid structural stabilization. All of the trees and shrubs of the sand dunes produce viable seed, but intentional establishment occurs using bare-rooted or potted seedlings.

Planting Date March 15 to April 15; unless soil is frozen

Planting Unit 1/0 or 2/0 bare-root seedlings or containerized transplants

Depth 2 inches (50mm) below the nursery grown depth

Method hand placement or using a tree planter

Size > 12 inches (300mm) tall

Spacing 4 to 6 feet (1.2 to 1.8 meter) apart; offset (stagger) rows for maximum protection

Notes:

- To ensure establishment (first 2 years) all competing vegetation must be removed from within 2 feet (0.6 meter) of each plant; it is important not to fertilize the surrounding vegetation which will potentially out compete the tree or shrub

C. Maintenance

1. Fertilizer

Date May through July; no sooner than 30 days after planting

Rate: ≤ 50 lbs. of nitrogen (N) per acre (56kg/hectare)≤ 25 lbs of phosphorus (P)(28kg/hectare) and 25 lbs. Potassium (K) per acre (28kg/hectare)

Frequency

- Apply N for the first two years after planting, then as needed to maintain stem density and plant health.
- Single or split applications are acceptable if not applied before May 1 or after July 30. Split applications must be at least 30 days apart.
- It is only necessary to apply (P) and (K) in alternate years.

Recommended Formulations

- 10-10-10, 20-10-10, 15-10-10, etcetera. are acceptable as long as the maximum rates per nutrient are not exceeded.
- Time-released fertilizers are encouraged that will provide the target amounts of the primary nutrients per acre.

Notes:

- Fertilize dune grass planting by mechanical or broadcast application, except where woody species are planted. Only apply fertilizer within the drip line of shrubs and trees or excessive herbaceous growth will out compete newly established trees and shrubs. Where woody plants are established, fertilizer may be broadcast applied.

2. Replanting

Like a chain, a dune system is no stronger than its weakest link. Uniform, unbroken dune lines are essential to the protection a system can provide.

- Uncontrollable events (i.e. storms, construction, etc.) may damage sand dunes. If such damage occurs between October and April replant within a month. If the damage occurs from May to September, utilize the sand fencing or excavation procedures listed below, then plant during the recommended establishment period.

D. Dune Crossing Areas

Where foot or vehicular traffic is expected on dunes, it is recommended that a curvilinear path be constructed to direct traffic. These paths can be constructed with boards or be of a gravel base and should be bordered by sand fence to funnel the traffic to and from the beach.

2. SAND FENCING: A quick and effective way to build temporary sand dunes is with the use of sand fencing (standard snow fence). Utilizing lines of fencing and wooden posts, fencing should be oriented parallel to the beach at approximately 140 feet (42 meters) (horizontal distance) from mean high tide. A source of sand is necessary for this technique to be effective, but it is not limited by time of establishment.

A. Materials

1. Fencing

   - Standard 4 ft. (1.2 meters) slatted-wood snow fencing; wood must be decay- free
   - Polyvinyl fencing material with 50% porosity may be used as an alternative.
   - Four wire ties (> 12 gauge) must be used to secure fencing to each post.

2. Posts.

   - Wooden posts must be > 6 ½ feet (2 meters) long, with a minimum diameter of 3 inches (75 mm); typical lengths range from 7 to 8 feet (2.1 to 2.4 meters).
   - The posts should be made from black locust, Eastern red cedar, Atlantic white cedar, or other species of similar durability and strength.
   - Space posts 10 feet (3 meters) apart, and set them > 3 feet (0.9 meters) deep.

B. Technique

1. Position - orientation of fence line should be parallel to waterline of the beach and at least 140 feet (42 meters) (horizontal distance) from mean high tide (MHT). (see figure 3.12-2).

2. Height - with adequate sand sources, dune elevations can be increased annually by at least 4-foot increments (1.2 meters) (approximately the maximum height of the fencing; this can be increased with vegetation). The maximum dune height that is attainable will range from 12 to 15 feet (3.6-4.5 meters), but is greatly influenced by prevailing wind velocities and sand grain size.

3. Installation - weave fencing in front of and behind alternating posts to attain maximum strength.

4. Number of Rows - when the distance to the MHT waterline is 100 feet (30 meters) or more, 2 parallel rows spaced 30 to 40 feet (9 to 12 meters) apart are ideal but single rows with 30 foot (9 meters) perpendicular spurs, spaced 40 feet (12 meters) apart are also acceptable if space is less than 100 feet (30 meter) from the MHT, and a protective dune is desired. A zigzag pattern may also be considered. Where there is less than one foot from the MHT, it may not be feasible to build dunes.

5. Replacement - sand will typically fill fencing to ¾ of its total height at a maximum. Upon reaching maximum fence capacity, additional lines of fence can be added until maximum planned dune height is reached. Replace damaged fencing and posts within one month of storm damage to maintain a contiguous dune line.

   Notes:

   - This method is more expensive per lineal foot than building dunes with vegetation alone, but less expensive than using earth-moving machinery to construct dunes.
   - Although dune height can be increased faster, it is limited by the fence height and ability to continually add more lines of fencing.

- Planting parallel rows of vegetation on either side of fences is usually more effective than either vegetation or fencing techniques alone.
- When complementing fencing with vegetation, do not plant closer than 10 feet (3 meters) and no further than 15 feet (4.5 meters) from the fence lines. Vegetative strips should be about 20 feet (6 meters) wide (see figures 3.12-2 & 3.12-3).
-

6. MECHANICAL EXCAVATION

- With the use of various earth-moving machines, temporary excavated sand dunes are quickly created.
- Since time is required for settling and cohesion to occur, such dunes are often short-lived and only provide minimal protection to the public and private resources located behind them.
- This method is often useful in the repair of storm-damaged sand dunes during the fall and winter months. Any blow-out areas can be quickly filled.
- Front-end loaders of all sizes can be used. Various grading machines are also useful. Pumped sand from offshore dredging can be shaped and positioned with machinery.

FIGURE 3.12-1 TYPICAL BARRIER ISLAND CROSS SECTION

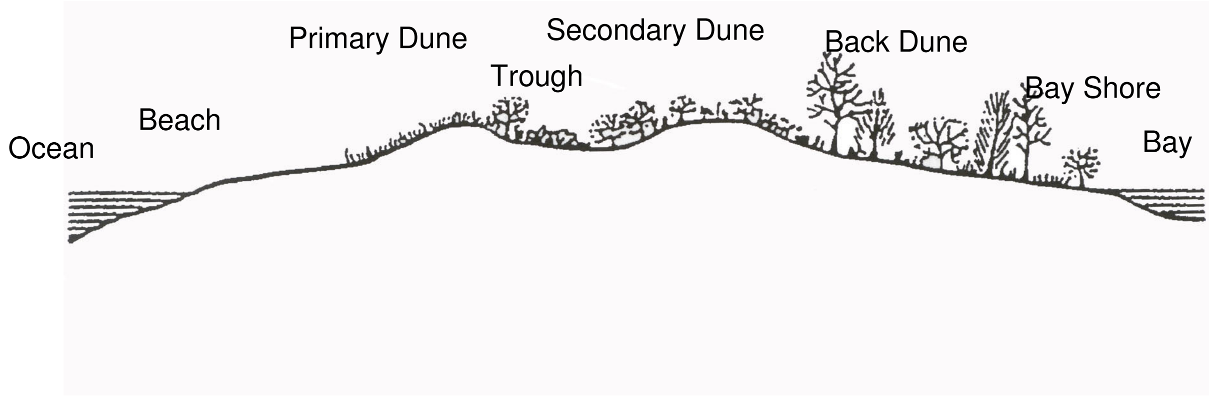


FIGURE 3.12-2 COMBINATION OF SAND FENCE AND VEGETATION FOR DUNE BUILDING

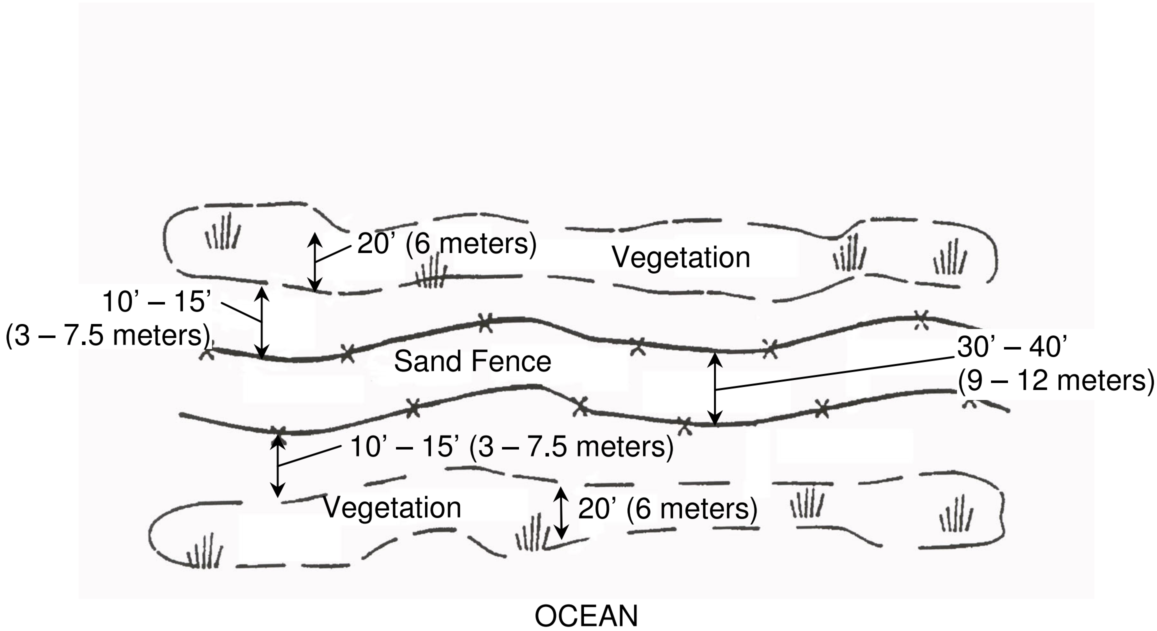
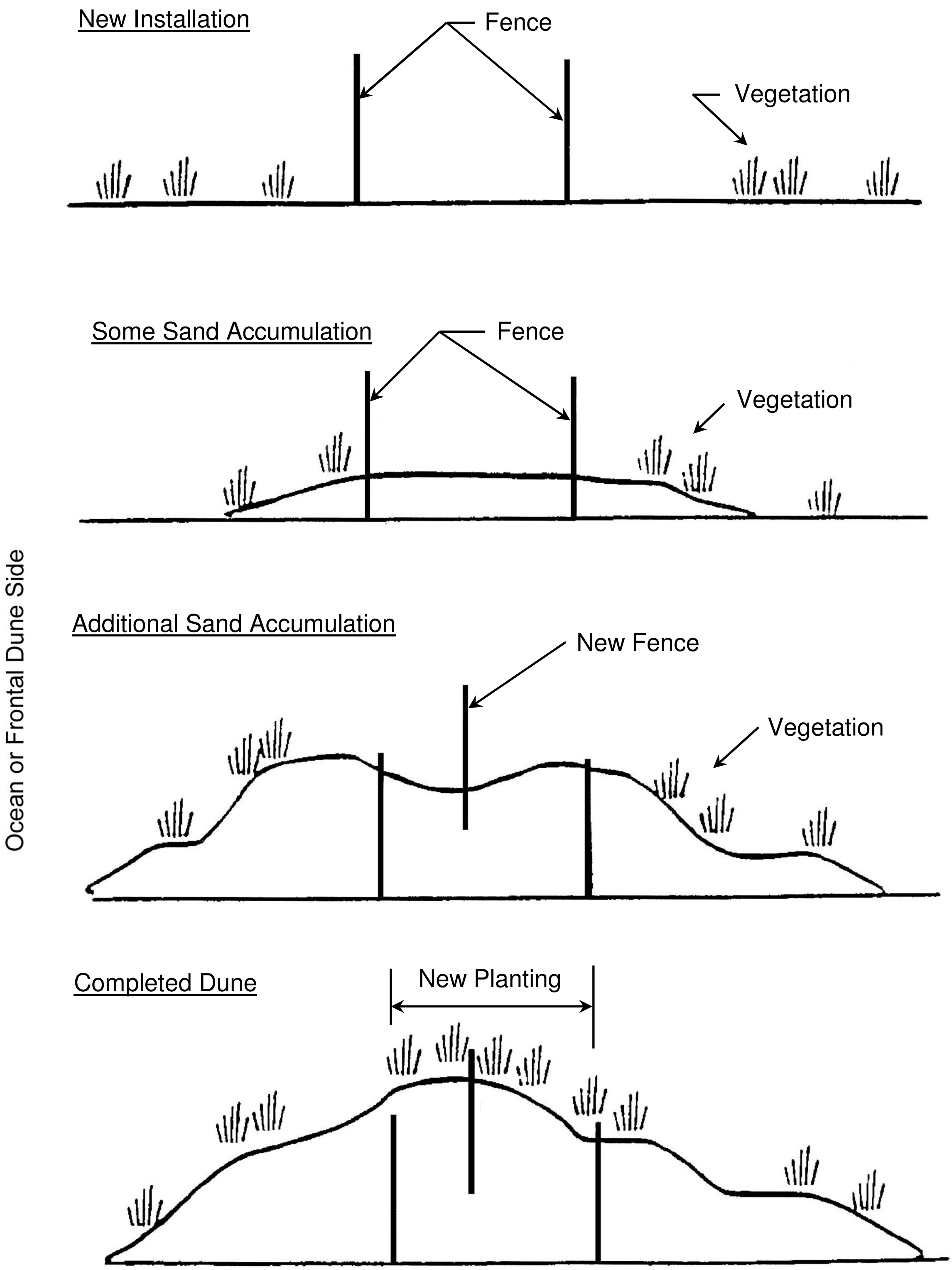


FIGURE 3.12-3 TYPICAL CROSS SECTION PRODUCED BY A COMBINATION OF SAND FENCE AND VEGETATION



4.0 ENGINEERING STANDARDS

4.1 STANDARDS FOR LAND GRADING

4.1.1 Definition

The reshaping of the ground surface by grading to planned elevations that are determined by topographic survey and layout.

4.1.2 Purpose

The purpose of land grading is to provide more suitable sites for land development, to improve surface drainage, and to control soil erosion.

4.1.3 Conditions Where Practice Applies

This practice is applicable where grading to planned elevations is practical and where it is determined that grading is needed. Grading that involves the disturbance of vegetation over large areas shall be avoided. It may be necessary to provide for temporary stabilization of large areas.

4.1.4 Planning Criteria

The grading plan and installation shall be based upon adequate topographic surveys and investigations. The plan shall show the location, slope, cut, fill, and finish elevation of the surfaces to be graded. The plan shall also include auxiliary practices for safe disposal of runoff water, slope stabilization, soil erosion control, and drainage. Facilities such as waterways, ditches, diversions, grade stabilization structures, retaining walls, and subsurface drains should be included where necessary.

Soil erosion control measures shall be designed and installed in accordance with the applicable standard contained herein.

The development and establishment of the plan shall be based on the following:

1. Before beginning any earthwork, side ditches shall be excavated and stabilized and perimeter controls (silt fence, etc.) installed.

2. Slopes greater than 25 feet (7.5 meters) in height shall be excavated and stabilized in stages of equal increments not to exceed 15 feet (4.5 meters).

3. The cut face of earth excavations and fills shall be no steeper than the safe angle of repose for the materials encountered and flat enough for proper maintenance.

4. The permanently exposed faces of earth cuts and fills shall be vegetated or otherwise protected from soil erosion.

5. Provisions shall be made to safely conduct sediment-free surface water to storm drains or suitable watercourses and to prevent surface runoff from damaging cut faces and fill slopes.

6. Subsurface drainage shall be provided in areas having a high water table, to intercept seepage that would adversely affect slope stability, building foundations, or create undesirable wetness. See Standards for Subsurface Drainage (Section 4.17).

7. Adjoining properties shall be protected from excavation and filling operations.

8. Fill shall not be placed adjacent to the bank of a stream or channel, unless provisions are made to protect the hydraulic, biological, aesthetic, and other environmental functions of the stream.

9. At the end of each workday, temporary berms (earth) and slope drains (Section 4.5) shall be constructed along top edge(s) of the embankment to intercept surface runoff.

4.1.5 Installation Requirements

Timber, logs, brush, rubbish, rocks, stumps, and vegetative matter, which will interfere with the grading operation or affect the planned stability of fill areas shall be removed and disposed of according to the plan.

Topsoil shall be stripped and stockpiled in amounts necessary to complete finish-grading of all exposed areas requiring topsoil. See Standards for Topsoiling (Section 3.5).

Fill material shall be free of brush, rubbish, timber, logs, vegetative matter and stumps in amounts that will be detrimental to constructing stable fills.

All fills shall be compacted sufficiently for their intended purpose and as required to reduce slipping, soil erosion, or excessive saturation.

All disturbed areas shall be left with a neat and finished appearance and shall be protected from soil erosion. See Vegetative Standards (Sections 3.1 to 3.5, 3.8 to 3.10).

Trees to be retained shall be protected if necessary in accordance with the Standards for Tree Protection During Construction (Section 3.7).

<u>Construction Sequence – Cut Section:</u>

Excavate and stabilize berm, side and outlet ditches.

Perform Stage I excavation. Topsoil, permanently seed, and mulch slope of this stage.

Perform Stage II excavation. Topsoil, permanently seed, and mulch slope of this stage.

Perform final excavation. Topsoil, permanently seed, and mulch slope of this stage. Repair any damage done to previous stages.

<u>Construction Sequence – Fill Section:</u>

Excavate and stabilize side ditches and/or install proposed controls at the toes of slope.

Place Stage I embankment. Place temporary seeding and mulch, or topsoil and permanently seed and mulch slope of this stage.

Place Stage II embankment. Place temporary seeding and mulch, or topsoil and permanently seed and mulch slope of this stage.

Place final embankment. Place topsoil, permanent seed and mulch on the slope of this stage and on the entire slope if not previously done.

4.2. STANDARDS FOR DUST CONTROL

4.2.1 Definition

The control of dust on construction sites and roads

4.2.2 Purpose

The purpose of dust control is to prevent blowing and movement of dust from exposed soil surfaces, reduce on-site and off-site damage, health hazards, and improve traffic safety.

4.2.3 Where Applicable

This practice is applicable to areas subject to dust blowing and movement where on-site and off-site damage is likely without treatment. Consult with local municipal ordinances on any restrictions.

4.2.4 Planning Criteria

The following methods should be considered for controlling dust:

Mulches - See Standards of Stabilization with Mulch Only (Section 3.3).

Vegetative Cover - See Standard for: Temporary Vegetative Cover (Section 3.1), Permanent Vegetative Cover (Section 3.2), and Permanent Stabilization with Sod (Section 3.4).

Spray-On Adhesives - On mineral soils (not effective on muck soils). Keep traffic off these areas.

TABLE 4.2-1

Spray-On Adhesives	Water Dilution	Nozzle Type	Apply gallons/acre liters/hectare
Anionic Asphalt Emulsion	7:1	Coarse Spray	11225 1200
Latex Emulsion	12.5:1	Fine Spray	2200 235
Resin in Water	4:1	Fine Spray	2800 300

Tillage - To roughen surfaces and bring clods to the surface. This is a temporary emergency measure that should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches (300mm) apart, and spring-toothed harrows are examples of equipment that may produce the desired effect.

Sprinkling - Site is sprinkled until the surface is wet.

Barriers - Solid board fences, snow fences, burlap fences, crate walls, bales of hay, and similar material can be used to control air currents and soil blowing.

Calcium Chloride - Shall be in the form of loose, dry granules or flakes fine enough to feed through commonly-used spreaders at a rate that will keep surface moist but not cause pollution or plant damage. If used on steeper slopes, then use other practices to prevent washing into streams, or accumulation around plants.

Stone - Cover surface with crushed stone or coarse gravel.

4.3. STANDARDS FOR STABILIZED CONSTRUCTION DRIVEWAY

4.3.1 Definition

A stabilized pad of crushed stone located at points where traffic will be entering or leaving a construction site

4.3.2 Purpose

The purpose of a stabilized construction entrance is to reduce the tracking or flowing of sediment onto public s.

4.3.3 Conditions Where Practice Applies

A stabilized construction entrance applies to points of construction ingress and egress, where sediment may be tracked, or flow off, the construction site.

4.3.4 Design Criteria

Stone Size - Use ASTM C-33, size No. 2. Use clean crushed angular stone.
Thickness - Not less than 6 inches (150 mm).
Width - Not less than full width of points of ingress or egress.
Length - 50 feet (30 meter) minimum.

At all locations, subsurface drainage gravel filter, and geotextile fabric shall be installed before installing the stabilized construction entrance.

TABLE 4.3-1 LENGTHS OF CONSTRUCTION EXITS ON SLOPING ROADBEDS

% Slope of Roadway	Length of Stone Required	
	Coarse Grained Soils	Fine Grained Soils
0 to 2%	50 ft. (15 m)	100 ft. (30 m)
2 to 5%	100 ft. (30 m)	200 ft. (60 m)
>5%	Entire surface stabilized with FABC base course	

Where a stabilized construction exit traverses between two buildings, it shall be stoned the entire length of the entire length of the right –of -way. Mountable stone berms placed across the widths of the exit may also be required at the transition point between paved and non-paved areas to trap sediments which are carried by storm water flowing along the curb line.

Individual lot entrance and egress - After interior roadways are paved, individual lot ingress/egress points may require a stabilized construction entrance consisting of No. 2 stone (1½" to 2½ inches) to prevent or minimize tracking of sediments. Width of the stone ingress/egress shall be equal to lot entrance width and shall be a minimum of 10 feet (3 meters) in length. If space is limited, vehicle tires may be washed with clean water before entering a paved area. A wash station must be located such that wash water will not flow onto paved roadways or into unprotected storm drainage systems or water bodies.

When the construction access exits onto a major roadway, a paved transition area may be installed between the major roadway and the stoned entrance to prevent loose stones from being transported out onto the roadway by heavy equipment entering or leaving the site.

4.3.5 Maintenance

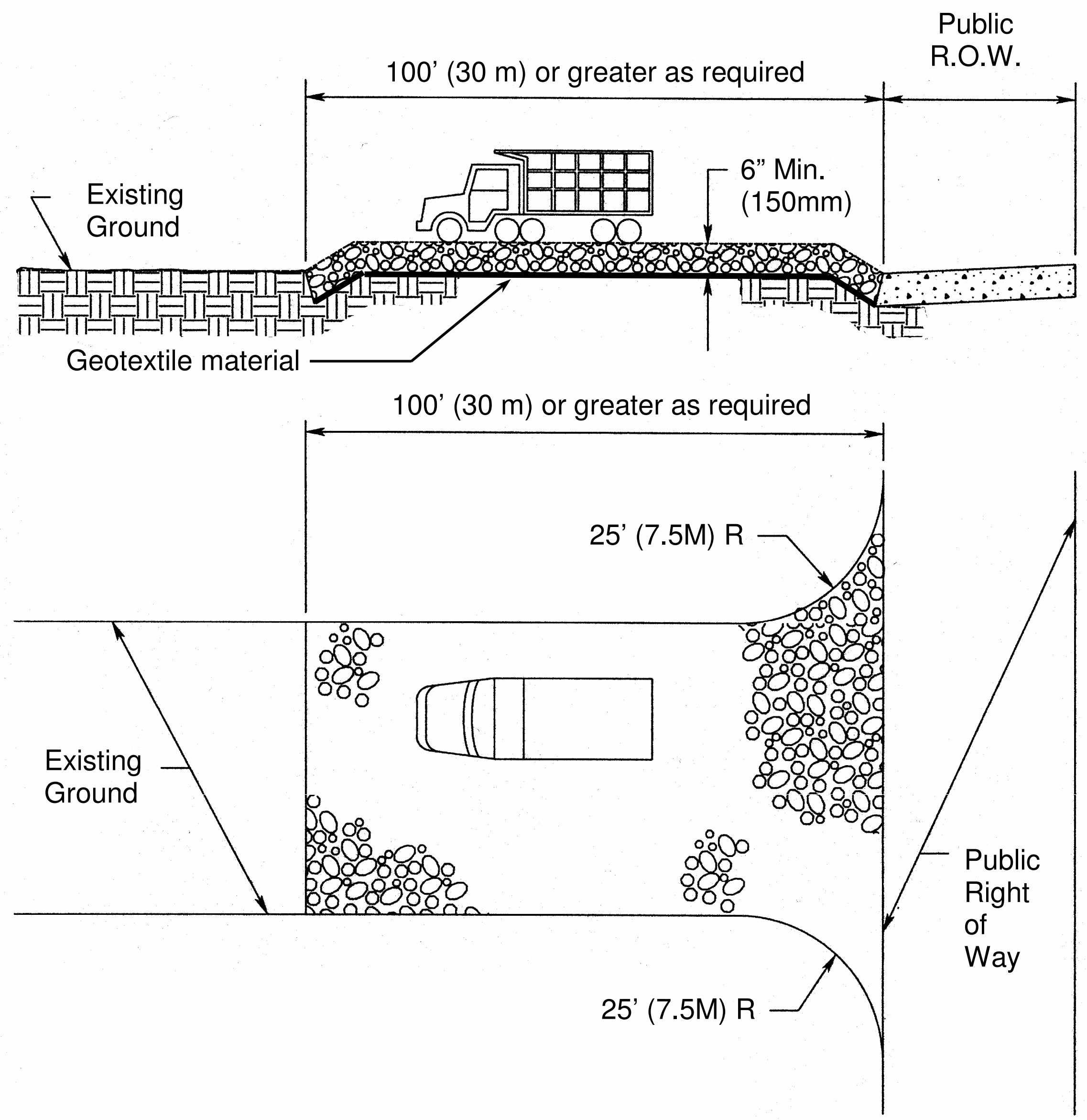
The entrance shall be maintained in a condition that will prevent tracking or flowing of sediment onto public Right-of-Way. This may require periodic top dressing with additional stone or additional length as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment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

Where accumulation of dust/sediment is inadequately cleaned or removed by conventional methods, a power broom or street sweeper will be required to clean paved or impervious surfaces. All other access points, which are not stabilized, shall be blocked off.

TABLE 4.3-2 GRADING REQUIREMENTS FOR COARSE AGGREGATES

		Amounts Finer Than Each Sieve							
Size No.	Nominal Size	3.6” (90 mm)	3” (75 mm)	2.5” (63 mm)	2” (50 mm)	1.5” (37.5 mm)	1” (25 mm)	0.75” (19 mm)	0.5” (12.5 mm)
2	2.5” to 1.5” (63-37.5 mm)	...	100	90-100	35-70	0-15	...	0-5	...
3	2” to 1” (50-25 mm)	...	...	100	90-100	35-70	0-15	...	0-5

FIGURE 4.3-1 STABILIZED CONSTRUCTION DRIVEWAY



Profile and Plan View (N.T.S.)

Note: Provide appropriate transition between the Stabilized Construction Entrance and the Public Right of Way.

4.4 STANDARDS FOR TRAFFIC CONTROL

4.4.1 Definition

The control of on-site construction traffic (construction equipment, service vehicles, autos, etc.) during development of a parcel of land

4.4.2 Purpose

The purpose of traffic control is to minimize land disturbance.

4.4.3 Where Applicable

Any area where vehicular traffic disturbs the land to the extent of reducing protective vegetation, compacting soil, or otherwise deteriorating the environment.

4.4.4 Planning Criteria

Restrict construction traffic to predetermined routes according to types and numbers of vehicles anticipated. Markers or temporary fencing may be helpful.

Avoid damage to waterways by construction of suitable crossing facilities and avoid traffic in or along streams.

Predetermine steep banks and vegetative areas to be avoided by traffic.

Traffic during wet weather should be minimized.

Sediment from tire washing operations shall be retained on site. Water shall be conveyed to a stable outlet and not allowed to enter water bodies without first being filtered through a sediment basin or other device. (i.e. filter bags) to remove sediment.

4.5 STANDARDS FOR RUNOFF DIVERSION

4.5.1 Definition

A ditch or berm constructed across the slope

4.5.2 Scope

This standard covers the installation of diversions with drainage areas up to 100 acres (40 hectare).

Temporary

Temporary diversions are installed as an interim measure to protect or facilitate some phase of construction. They usually have a life expectancy of one year or less. The failure hazard is low.

Permanent

Permanent diversions are installed as an integral part of an overall water management and disposal system, which will remain in place for the protection of property

4.5.3 Purpose

The purpose of this practice is to divert water from areas where it is in excess to sites where it can be used or disposed of safely.

4.5.4 Conditions Where Practice Applies

This practice applies to sites where runoff is damaging, such as:

1. Low lying areas
2. Cut or fill slopes or steeply sloping land
3. Critical sediment source areas in construction sites
4. Buildings, residences, and streets
5. Active gullies or other erodible areas.

Permanent diversions are not applicable below high sediment producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions.

4.5.5 Design Criteria

Dimensions for ditch runoff diversions and berm runoff diversions shall be constructed based on the information contained in the following tables. Where the drainage area exceeds 2 ½ acres (4 hectares), the runoff diversion shall be designed based on peak discharge value determined by the following method using a 2-year design storm frequency.

Rational Method - for peak discharge of uniform drainage areas as outlined in the Technical Manual for Land Use Regulation Program Bureaus of Inland and Coastal Regulations Stream Encroachment Permits, N.J. Dept. of Environmental Protection, Trenton, N.J. September 1997 or subsequent editions.

Capacity and Freeboard

Peak discharge values shall be determined by the following:

1. Rational Method – for peak discharge of uniform drainage areas as outlined in Technical Manual for Land Use Regulation Program Bureaus of Inland and Coastal Regulations Stream Encroachment Permits, N.J. Dept. of Environmental Protection, Trenton, N.J. September 1997 or subsequent editions.

2. USDA-NRCS Technical Releases No. 55 or Technical Release No. 20.

3. U.S. Army Corps of Engineers HEC-1

Other methods, which produce similar results to the models, listed above.

TABLE 4.5-1 BERM SECTION DESIGN

	Drainage area of $\leq$5 acres (2 hectares)	Drainage area of 5 to10 acres (2-4 hectares)
Berm Height (A)	20 inches (500 mm)	40 inches (1000 mm)
Berm Width (B)	24 inches (600 mm)	40 inches (1000 mm)
Flow Width (C)	48 inches (1200 mm)	72 inches (1800 mm)
Flow Depth (D)	8 inches (200 mm)	16 inches (400 mm)

TABLE 4.5-2 STABILIZATION FOR DITCH OR BERM

	Type of Treatment	
Grade	5 acres (2 hectares) or less	5-10 acres (2-4 hectares)
0.5% - 5%	Seed used with topsoil stabilization matting	Seed used with topsoil stabilization matting
5.1% - 8%	Seed used with topsoil stabilization matting	Lined 6 to 9 inches (150-225 mm
8.1% - 10%	Lined 6 to 9 inches (150-225 mm) See Section 4.22	Engineered Design

Graded Right of Way

Where the diversion is a temporary diversion to direct water off a graded Right-of-Way onto stable areas, and the only area draining toward the diversion is the Right of Way; the following spacing, and the diversion size given for drainage area of 5 Acres (2 hectares) or less (Tables 4.5-1 and 4.5-2), may be used instead of preparing individual designs for each diversion.

FIGURE 4.5-1 GENERAL LAYOUT OF ROADBED DIVERSIONS

TABLE 4.5-4 DIVERSION SPACING FOR GRADED RIGHT OF WAY

Road Grade (%)	Approximate Distance (in feet) between diversions	Approximate Distance (in meters) between diversions
1	400	122
2	245	75
5	125	38
10	78	24
15	58	18
20	47	14
25	40	12
30	35	11

Velocity

The maximum permissible velocity for design flow will be determined by the most erodible soil texture exposed and the type of vegetation expected and maintained in the channel. As a stable design, the diversion shall meet the following permissible velocity and shall not be designed above 90% of critical flow (Froude number = 0.90). The following table will be used in selecting maximum permissible velocities:

TABLE 4.5-5 MAXIMUM PERMISSIBLE VELOCITIES

	MAXIMUM PERMISSIBLE VELOCITY (feet/sec.)		
	CHANNEL CONDITION		
SOIL TEXTURE	Bare Soil*	Vegetated. **	Sod. ***
Sand	1.75	2.0	3.0
Silt loam, sandy loam, loamy sand, loam, and muck	2.0	2.0	3.0
Silty clay loam, sandy clay loam	2.5	2.5	4.0
Clay, clay loam, sandy clay, silty clay	2.5	3.0	5.0

	MAXIMUM PERMISSIBLE VELOCITY~ (meters/sec.)		
	CHANNEL CONDITION		
SOIL TEXTURE	Bare Soil*	Vegetated. **	Sod. ***
Sand	0.5	0.6	0.9
Silt loam, sandy loam, loamy sand, loam, and muck	0.6	0.6	0.9
Silty clay loam, sandy clay loam	0.6	0.76	1.2
Clay, clay loam, sandy clay, silty clay	0.76	0.9	1.5

~Maximum Permissible Velocities are based on flow of clear water.

*Temporary Diversions

**Vegetated Channels - The minimum capacity and maximum velocity shall be determined by using the appropriate vegetative retardance factors listed below. See Appendix A-6 for examples and charts for use in design. Maximum permissible velocities for vegetated channels may be increased by 3 ft/sec. (0.9 m/sec.) except for sands for sections where erosion control mat is installed according to manufacturer's recommendations. Erosion control mat is defined as a flexible mat of synthetic monofilaments bonded together to form a three-dimensional web, highly resistant to environmental and chemical degradation.

***On well-drained to excessively-drained soils, most cool-season sod types will not survive without continued irrigation. Placement of sod in such areas must be approved by NJDOT.

TABLE 4.5-6 VEGETATIVE RETARDANCE FACTORS

For Determining Minimum Capacity	For Determining Maximum Allowable Velocity
D	E

Bare Channels - The minimum capacity and maximum velocity shall be determined by using Manning's formula with an "n" value of 0.025.

Cross Section

The shape of the ditch cross section shall be such that the runoff diversion can be properly maintained with modern equipment. The ditch should preferably be trapezoidal in shape.

The side slopes for permanent diversions shall not be steeper than 3H;1V for maintenance purposes, and preferably 4H:1V Where frequent crossings are expected, slopes should be flatter. The back slope of the ridge is not to be steeper than 3H:1V and preferably 4H:1V. The ridge shall include a settlement factor equal to 5 % of the height. The minimum top width of the diversion ridge after settlement is to be 4 feet (1220 mm) at the design water elevation.

In determining the cross section for the temporary runoff diversions, consideration should be given to soil type, frequency of operation, and type of equipment that is anticipated to be crossing the diversion. In no case shall slopes be steeper than 1:1.5.

The top of the constructed berm shall not be lower at any point than the design elevation plus the specified overfill for settlement.

Location

Runoff diversion locations shall be determined by outlet conditions, topography, land use, soil type, and length of slope. Consideration must be given to the effects caused by changing natural watercourses and putting additional flow into a watercourse. Diversions with blocked ends may be used provided adequate pipe outlets are provided.

Grade

Channel grade may be uniform or variable. Uniform grades are normally better. The allowable velocity for soil type and vegetative cover will determine maximum grade. Diversions with blocked ends may be used provided adequate pipe outlets are installed.

Profile(s) and cross-section(s) of all runoff diversions shall be submitted on the Soil Erosion and Sedimentation Control Plan.

Protection Against Sedimentation

When the movement of sediment into the runoff diversion ditch is a significant problem:

1. Land treatment or structural measures shall be installed to stabilize the source of sediment, or trap the sediment. Refer to the Standard For Temporary Stone Outlet Sediment Traps (Section 4-11).

2. If it is not possible to stabilize or trap the sediment, a filter strip of close-growing grass shall be maintained above the runoff diversion ditch. The filter permanent cover and strip width measured from the center of the ditch shall be at least one-half the ditch top width plus 15 feet (4.6 meters).

Outlet

Each diversion must have an adequate, stable outlet. The outlet may be: a grassed, stone centered, or lined waterway; a vegetated or paved area; a grade stabilization structure; a storm sewer; a stable watercourse; a tile outlet; or an open channel.

The outlet, in all cases, must be stable and convey water to disposal point where damage will not result. The outlet structures shall be located so as to discharge onto an already stabilized area or into a stable watercourse. Constructed vegetative outlets must be established prior to diversion construction. Sedimentation of the water course is not allowed.

Temporary Stone Outlet Structure

A temporary stone outlet structure for a diversion may be used only where the contributing watershed is less than 5 acres (2 hectares). The minimum length, in feet (meters), of the crest of the stone outlet structure shall be equal to six times the number of acres (hectares) of the contributing drainage area. The crest of the stone outlet structure shall be level and at least 6 inches (150 mm) lower than the lowest elevation of the top of the diversion. The stone shall be crushed stone and be 4 to 8 inches (100-200 mm) in diameter except for a 1 foot (300 mm) thick blanket of 2" inches (50 mm) diameter stone on the upstream face.

The temporary stone outlet structure shall be located so as to discharge onto an already stabilized area or into a stable watercourse. The stone structures shall be embedded into the soil a minimum of 4 inches (100 mm).

FIGURE 4.5-2 PROFILE OF DIVERSION OUTLET

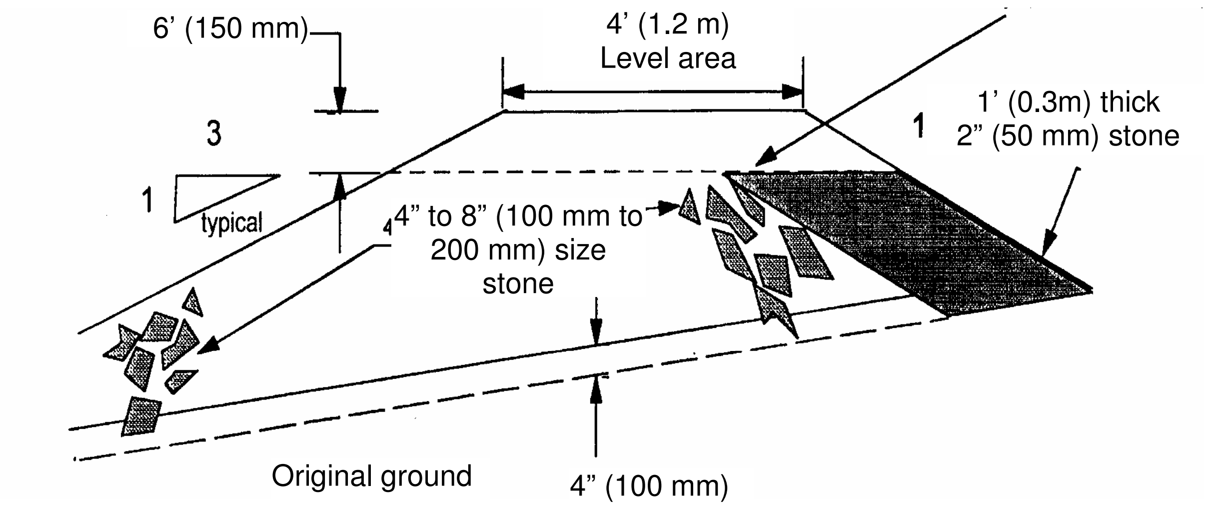
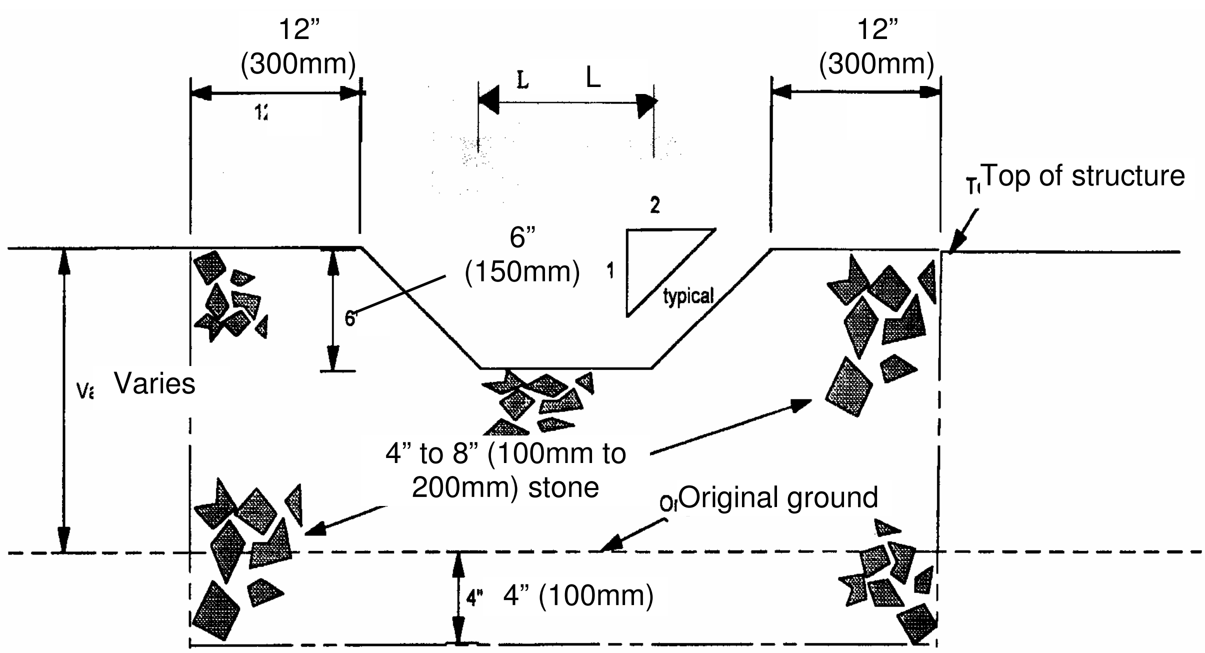


FIGURE 4.5-3 CROSS SECTION - END VIEW



Permanent Cover and Erosion Protection

A permanent vegetative cover shall be established on all diversions in accordance with the Standard for Permanent Vegetative Cover for Soil Stabilization (Section 3.2), or Standard for Permanent Stabilization with Sod (Section 3.4). Where the season and other conditions may not be suitable for growing permanent soil erosion-resistant cover, soil erosion protection will be provided in accordance with the Standard for Temporary Vegetative Cover for Soil Stabilization (Section 3.1), or Standard for Stabilization with Mulch Only (Section 3.3).

Diversions that are not designed to have a permanent vegetative cover shall be designed for bare ditch velocities and with flat side slopes to prevent ditch and side slope erosion. Diversions that are designed to have a permanent vegetative cover shall be seeded from the toe of the back slope to the upstream side of the designed ditch width, plus any required filter strip. Other areas disturbed by runoff diversion construction shall also be seeded.

Installation Requirements

All trees, brush, stumps, or other objectionable material shall be removed so they will not interfere with construction or proper functioning of the runoff diversion. All ditches or gullies that must be crossed shall be filled and compacted prior to, or as part of the construction. Fence rows and other obstructions that will interfere with construction or the successful operation of the runoff diversion shall be removed.

Vegetation shall be removed and the base for the ridge thoroughly disced before placement of fill.

The minimum constructed cross-section is to meet the design requirements.

The top of the constructed berm shall not to be lower than the design elevation plus the specified amount for settlement.

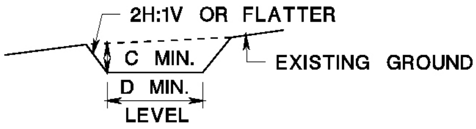
Fertilizing, seeding, and mulching shall conform to the requirements in the Standard for Permanent Vegetative Cover for Soil Stabilization (Section 3.2).

If there is no sediment protection provided on temporary diversions, it should be anticipated that periodic clean out may be required.

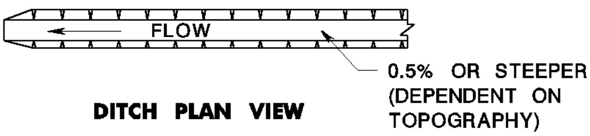
Construction operations shall be carried out in such a manner that soil erosion and air and water pollution will be minimized. State and local laws shall be complied with.

FIGURE 4.5-4 Temporary Runoff Diversion Details

	DITCH A (5 AC OR LESS)	DITCH B (5 – 10 AC)
DITCH DEPTH (C)	1'-0"	1'-0"
DITCH WIDTH (D)	4'-0"	6'-0"

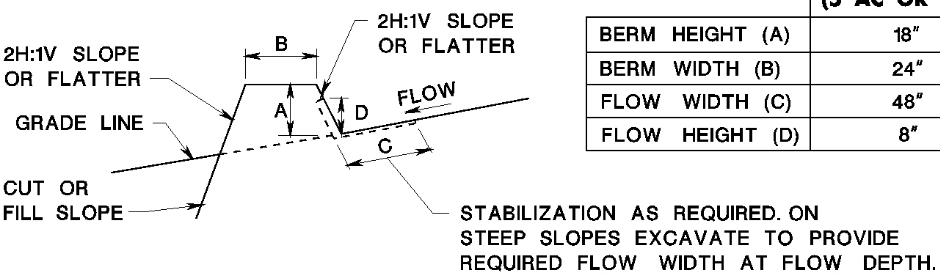


DITCH CROSS SECTION



DITCH PLAN VIEW

	BERM A (5 AC OR LESS)	BERM B (5 – 10 AC)
BERM HEIGHT (A)	18"	36"
BERM WIDTH (B)	24"	36"
FLOW WIDTH (C)	48"	72"
FLOW HEIGHT (D)	8"	15"



BERM CROSS SECTION

NOTE:

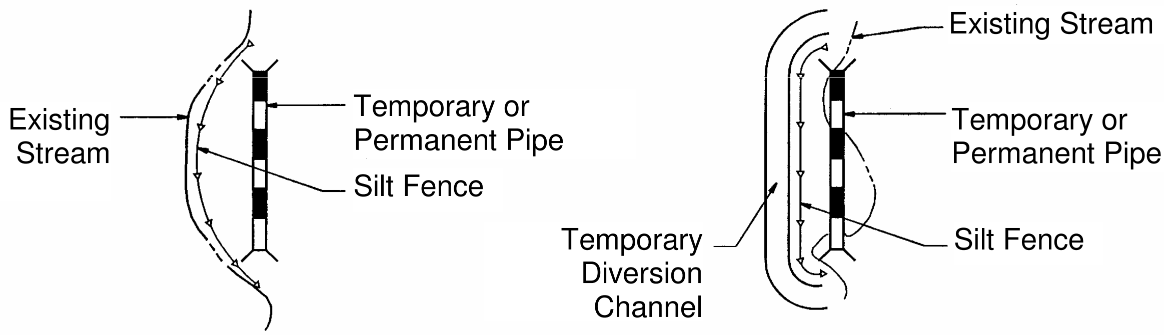
FIELD LOCATION SHOULD BE ADJUSTED AS NEEDED TO UTILIZE A STABILIZED OUTLET.

STABILIZATION FOR DITCH OR BERM

TYPE OF TREATMENT	GRADE	A - (5 AC OR LESS)	B - (5 - 10 AC)
1	0.5 - 5.0%	SEED USED WITH TOPSOIL STABILIZATION MATTING	SEED USED WITH TOPSOIL STABILIZATION MATTING
2	5.1 - 8.0%	SEED USED WITH TOPSOIL STABILIZATION MATTING	LINED 6"- 9" RIPRAP
3	8.1 - 20.0%	LINED 6"- 9" RIPRAP	ENGINEERED DESIGN

TEMPORARY RUNOFF DIVERSION

FIGURE 4.5-5 STREAM DIVERSION



METHOD A PERFERRED

METHOD B

Construction Sequence:	Construction Sequence:
1. Install silt fence along existing stream in area of proposed pipe construction.	1. Install silt fence along existing stream in area of temporary diversion channel.
2. Construct pipe system.	2. Construct temporary diversion channel and line with geotextile and temporary.
3. Divert stream flow into pipe.	3. Divert stream flow into temporary channel.
4. Continue with construction staging.	4.Continue sequence from step 2, method A.

4.6 STANDARDS FOR SLOPE PROTECTION STRUCTURES

4.6.1 Definition

The structures to safely conduct surface runoff from the top of a slope to the bottom of the slope

4.6.2 Purpose

The purpose of slope protection structures is to convey storm runoff safely down existing slopes and cut and fill slopes to minimize soil erosion.

4.6.3 Conditions Where Practice Applies

Slope protection structures shall be used where concentrated water will cause excessive soil erosion on existing and/or recent cut and fill slopes. Temporary structures shall be left in place until adequate vegetation and the permanent drainage system have been installed. Permanent structures are part of the drainage system.

4.6.4 Design Criteria

Open Flumes

Flumes shall be adequately designed to convey runoff water concentrations safely down steep slopes based on a 10-year frequency storm, the rational method for uniform drainage area up to one-half of a square mile, or sized in accordance with the requirements of Tables 4.6.1 and 4.6.2.

Protection against scour at the discharge end of the open flume shall be provided in the form of an energy dissipater or other measures such as rock revetment, plunge pool or SAF stilling basin. The Saint Anthony Falls (SAF) stilling basin forces a hydraulic jump, by the use of baffle blocks and an end sill, to dissipate energy

The flume shall be lined with Portland cement concrete, bituminous concrete or comparable material and reinforced where necessary.

Outlet protection shall be provided in accordance with the Conduit Outlet Protection Standard (Section 4.18).

Recommended dimensions for flumes are defined as follows:

1. *b* - is the bottom width of the paved down slope section of a trapezoidal or rectangular flume. The minimum bottom widths and associated maximum drainage areas shall conform to Table 4.6.2.

2. *T* - is the top width of parabolic flumes. The minimum top widths and maximum drainage areas shall conform to Table 4.6.1.

3. *H* - is the height of the dike at the entrance to the structure and shall be a minimum of 2 ½ feet (760 mm).

4. *d* - is the depth of the paved down slope section and shall be a minimum of 10 inches (250 mm) for the trapezoidal or rectangular flumes. The depths of parabolic flumes shall be as shown in Table 4.6.1.

5 .L - is the length of the inlet and outlet paved sections and each shall be a minimum of 6 feet (1.8 meters).

The above dimensions are illustrated in Figure 4.6-1.

If a minimum of 75% of the drainage area will have a good grass or woodland cover throughout the life of the structure, the drainage areas listed in Tables 4.6.1 and 4.6.2 may be increased by 50%. If a minimum of 75% of the drainage area will have a good mulch cover throughout the life of the structure, the drainage area listed in Tables 4.6.1 and 4.6.2 may be increased by 25%.

Flumes with dimensions and associated drainage areas other than those shown in this standard shall be designed on an individual job basis. Capacities shall be determined by acceptable hydrologic and hydraulic computations, as noted under Temporary Slope Drains of this Standard.

TABLE 4.6-1 FLUMES WITH PARABOLIC SECTIONS

Flow Depths Equal 1 ft		Flow Depths Equal 1.5 ft	
Top Width (feet)	Drainage Area (acres)	Top Width (feet)	Drainage Area (acres)
4	3	4	4
6	4	6	5
8	5	8	6
10	6	10	7
12	7	12	8
14	8	14	10
		16	11

Flow Depths Equal 300 mm		Flow Depths Equal 460 mm	
Top Width (meter)	Drainage Area (hectare)	Top Width (meter)	Drainage Area (hectare)
1.2	1.2	1.2	1.6
1.8	1.6	1.8	2.0
2.4	2.0	2.4	2.0
3.0	2.4	3.0	2.8
3.7	2.8	3.6	3.2
4.3	3.2	4.3	4.0
		4.9	4.4

Dikes are to be 2 ½ feet (760 mm) in height above flume entrance

TABLE 4.6-2

BOTTOM WIDTHS AND DRAINAGE AREAS FOR
FLUMES WITH TRAPEZOIDAL AND RECTANGULAR SECTIONS

Trapezoidal Flume (Flow Depth = 10 in)		Rectangular Flume (Flow Depth = 10 in)	
Bottom Width (feet)	Drainage Area (acres)	Bottom Width (feet)	Drainage Area (acres)
2	7	2	3
4	10	4	5
6	13	6	10
8	16	8	13
10	19	10	16
12	24	12	20

Trapezoidal Flume (Flow Depth = 250 mm)		Rectangular Flume (Flow Depth = 250 mm)	
Bottom Width (meter)	Drainage Area (hectares)	Bottom Width (meter)	Drainage Area (hectares)
0.6	2.8	0.6	1.2
1.2	4.0	1.2	2.0
1.8	5.3	1.8	4.0
2.4	6.5	2.4	5.3
3.0	7.7	3.0	6.5
3.7	9.7	3.7	8.1

Dikes to be 2 ½ feet (760 mm) in height above flume entrance

Temporary Slope Drains

A rigid or flexible conduit used before a permanent drainage structure is installed to convey concentrations of runoff from the top to bottom of undisturbed slopes.

Pipe Drops

The design capacity shall be as required to pass peak runoff from a 10-year frequency storm. Peak discharge values shall be determined by the following:

1. Rational Method – for peak discharge of uniform drainage areas as outlined in Technical Manual for Land Use Regulation Program Bureaus of Inland and Coastal

Regulations Stream Encroachment Permits, N.J. Dept. of Environmental Protection, Trenton, N.J. September 1997 or subsequent editions.

1. USDA-NRCS (SCS) Technical Release No. 55, Technical Release No. 20 or other officially approved methodology.

Pipe capacities may be determined from charts found in chapter 6 of the "Engineering Field Manual," or other accepted sources.

A heavy-duty fabric or other material may also be used as a temporary or interim structure, as shown in Figure 4.6-3. Use of fabric in drains is not recommended during the winter months. Standard metal end sections shall be used. Outlet protection shall be provided by riprap or other means.

Diversion dikes or deep curb cuts shall be used in conjunction with temporary slope drains. The dike height above the pipe inlet invert shall be adequate to contain a water elevation sufficient to cause full pipe flow plus an allowance of at least ½ foot (150 mm) for freeboard. A minimum water depth of 1.8 times the pipe diameter above pipe inlet invert is required to assure full pipe flow.

Installation Requirements

1. The structure shall be placed on undisturbed soil or well-compacted fill.

2. The cut or fill slope shall not be steeper than 1.5H:1.0V and should not be flatter than 20:1.

3. Adequate vegetative protection per vegetation standards and drainage works shall be installed.

4. Open Flume:

   a. The top of the earth dikes shall not be lower at any point than the top of the lining at the entrance of the structure.

   b. The lining shall be placed beginning at the lower end and proceeding up the slope to the upper end. The lining shall be well-compacted and free of voids.

   c. The entrance floor at the upper end of the structure shall have a slope toward the outlet of ¼ to 1-½ inches per foot (6 mm-40 mm per meter).

5. Hood Inlet Pipe Drops:

   a. The pipe shall be embedded in the embankment to a depth that will insure stability.

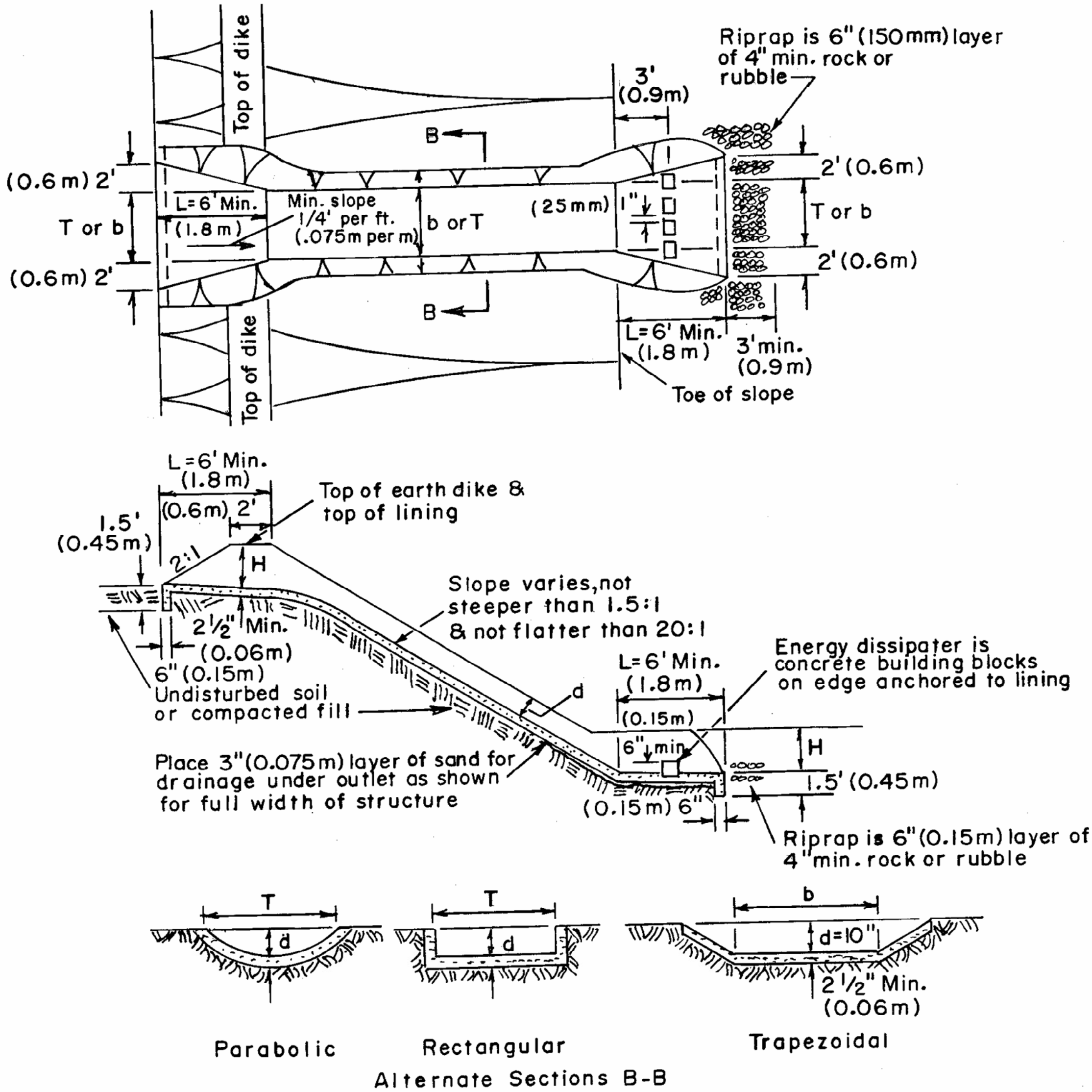
   b. Protection measures of concrete or shall be installed at the inlet and outlet as needed to protect against soil erosion.

   c. The pipe may be smooth or corrugated and shall be of the required strength and durability.

d. Backfill shall be carefully placed in layers and tamped to insure adequate compaction.

6. Outlet Protection in accordance with the Conduit Outlet Protection Standard (Section 4.18).

FIGURE 4.6-1 TYPICAL OPEN FLUME



Notes:

1. Lining shall be Portland cement concrete, bituminous concrete or comparable material, reinforced where necessary.
2. Some type of energy dissipater, such as the one shown above, must be used to prevent erosion at the outlet.
3. The paved down slope section should have side slopes as required by construction methods.
4. The Standard for Conduit Outlet Protection 4.18 shall also apply.

FIGURE 4.6-2 BANK PROTECTION STRUCTURE

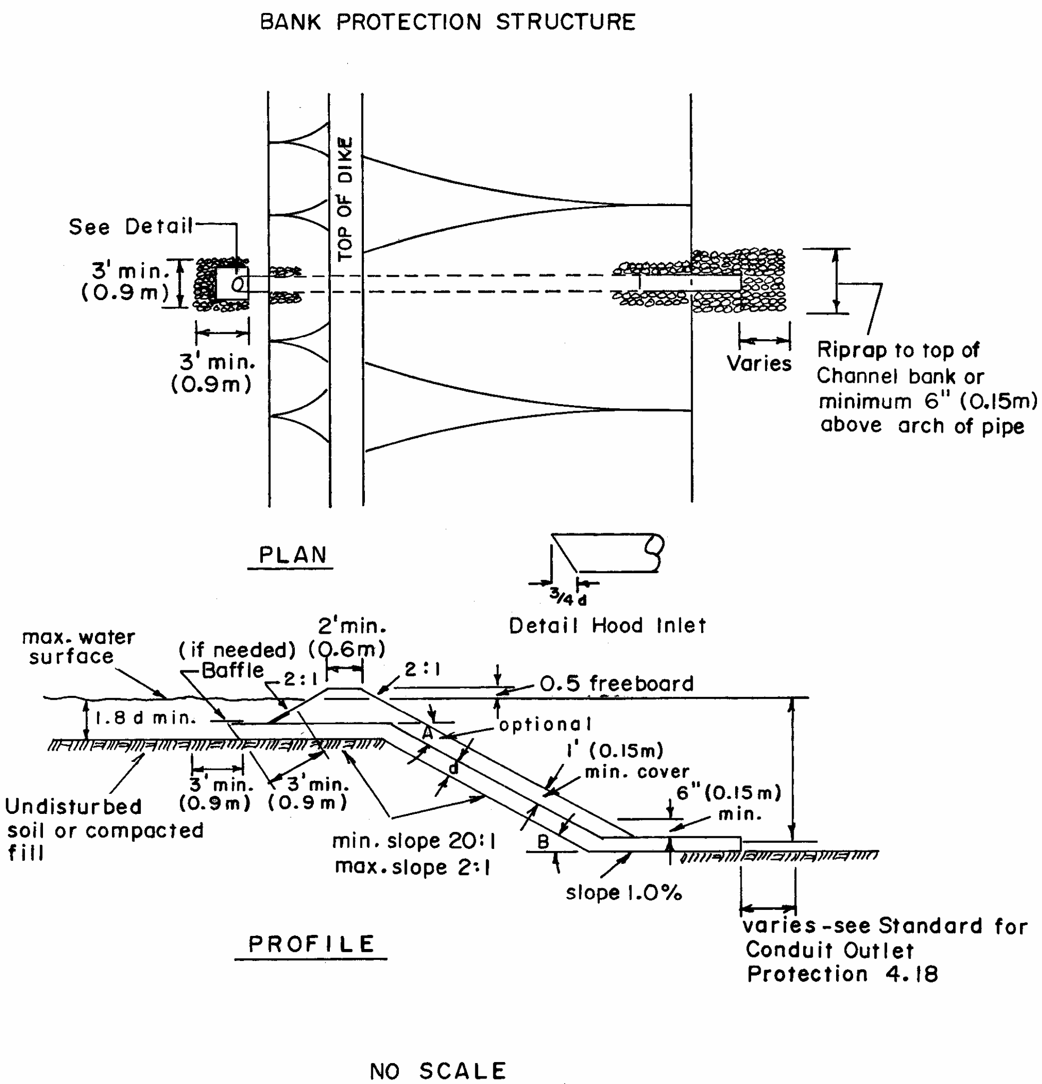
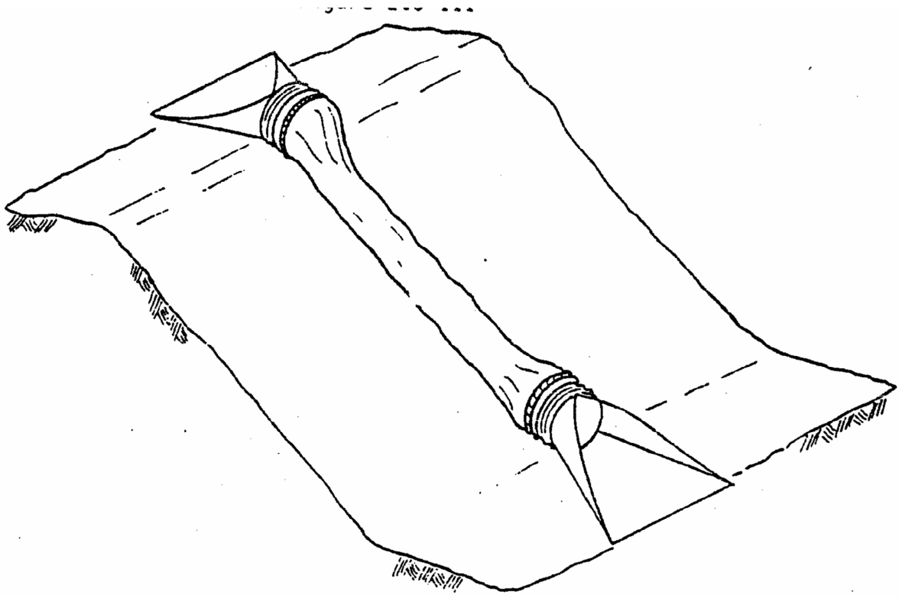


FIGURE 4.6-3 FLEXIBLE DOWN DRAIN

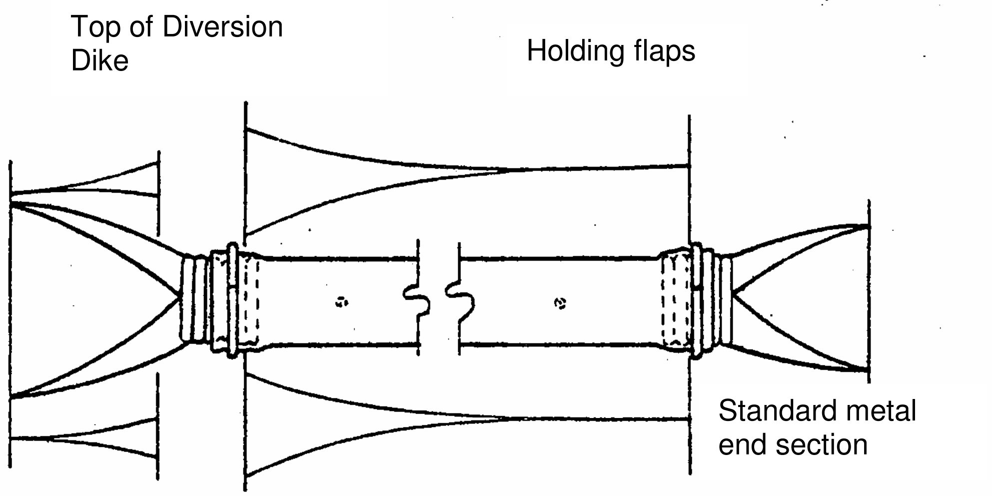


Flexible Down Drain - Isometric

4.6.5 Maintenance

The fabric down drain should be inspected for clogging or damage after each storm. In below freezing weather, check to ensure that sides of collapsed down drain are not frozen together. Do not allow placement of any material on collapsed down drain. Inlet section should be checked for indications of piping along metal sections. Anchors should be resecured as necessary.

FIGURE 4.6-4 FLEXIBLE DOWNDRAIN



PLAN VIEW

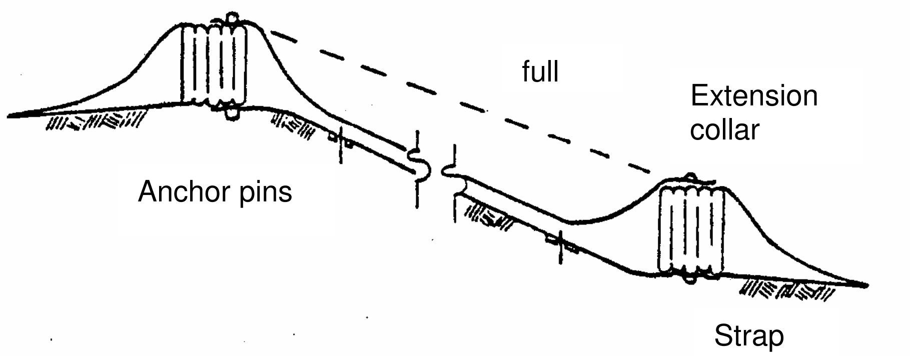
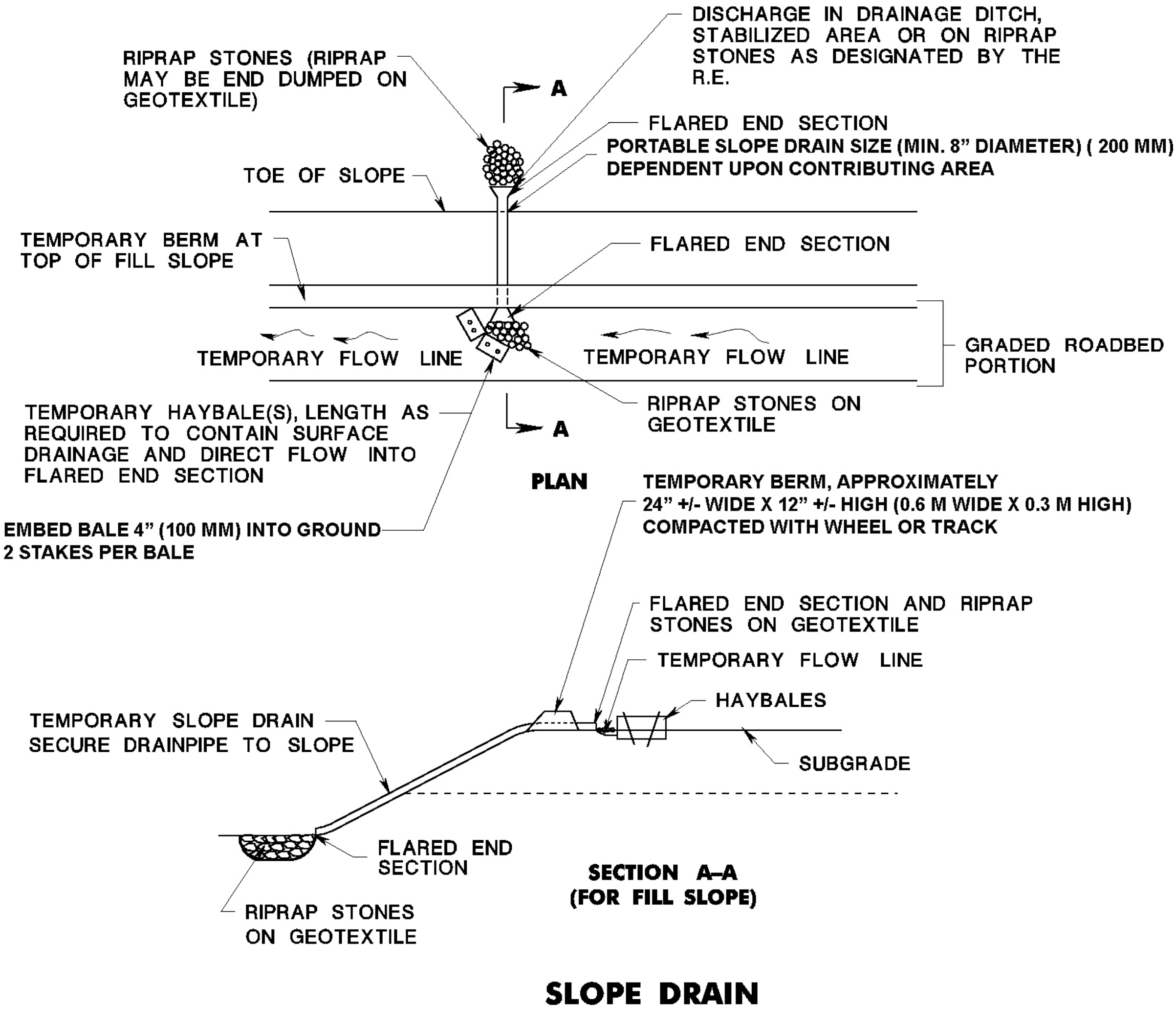


FIGURE 4.6-5 TEMPORARY SLOPE DRAIN



4.7 STANDARDS FOR SEDIMENT BARRIER

4.7.1 Definition

A temporary barrier installed across or at the toe of a slope or where the existing ground slopes towards the highway.

4.7.2 Purpose

The purpose of a sediment barrier is to intercept and retain small amounts of sediment from unprotected areas of limited extent.

4.7.3 Conditions Where Practice Applies

The sediment barrier shall be used where:

1. No other practice is feasible;
2. There is no concentration of water in a channel or other drainage way above the barrier;
3. Soil erosion would occur in the form of sheet and rill erosion.

4.7.4 Design Criteria

A. All types of sediment barriers:

   1. Contributing drainage area is less than 1 acre (0.4 hectare) and the length of slope above the barrier is less than 150 feet (45 meters).
   2. The slope of the contributing drainage area for at least 30 feet (9 meters) adjacent to the barrier shall not exceed 5%.
   3. The barrier shall be constructed so water cannot bypass the barrier around the ends.
   4. Inspection shall be frequent and repair or replacement shall be made promptly as needed.
   5. The barrier shall be removed when it has served its usefulness so as not to block or impede storm flow or drainage.

B. Requirements for bale barrier (Figures 4.7-1, 2):

   1. Bales shall be made of straw, hay, or other acceptable vegetative material.
   2. All bales shall be securely tied and staked on the contour.
   3. Bales shall be placed in a row with ends tightly abutting the adjacent bales.
   4. Each bale shall be embedded in the soil a minimum of 4 inches (100 mm).

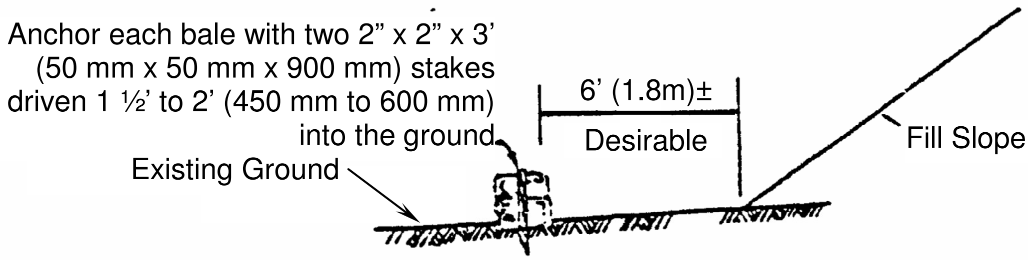
5. Bales shall be securely anchored in place by two wooden stakes 2 x 2 inches (50 x 50 mm) driven through each bale a depth of 20 to 24 inches (500 to 600 mm) into the ground. The first stake in each bale shall be driven toward previously laid bale to force bales together (Figure 4.7-2).

C. Requirements for stone outlet section (Figure 4.7-3):

1. The stone outlet shall be placed on geotextile with 1:2 side slopes and a height equal to that of the hay bales.

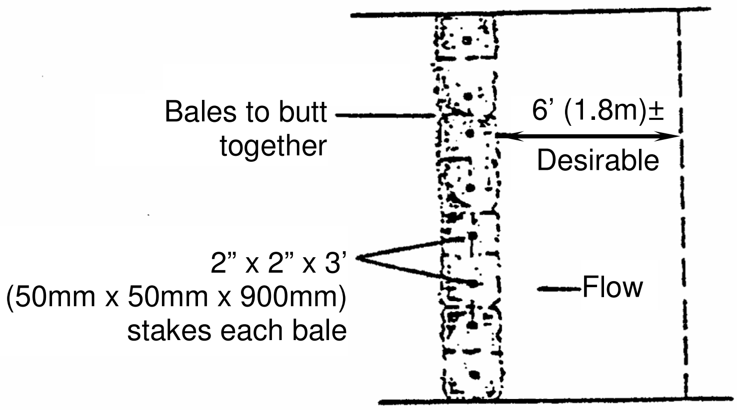
2. The stone outlet shall consist of 6 to 9 inch diameter (150 mm to 225 mm) , placed equal to the width of the hay bale with coarse aggregate size no. 2 placed upstream of the stones.

FIGURE 4.7-1 BALED HAY EROSION CHECKS



Elevation

Note: Embed bales 4 to 6 inches (100mm to 150mm) and angle first stake towards previously laid bale.



Plan

Notes:

- To be used where the existing ground slopes away from the highway embankment as called for on plans.
- Measurement and payment will be by the bale in place. Bales will be allowed to rot in place so there will be no removal item. There will be no provisions for maintenance other than replacement of a bale if required.
- Sediment barrier spacing shall be less than 150 feet (45 meters and have a contributory drainage area of less than 1 acre (0.4 hectare).

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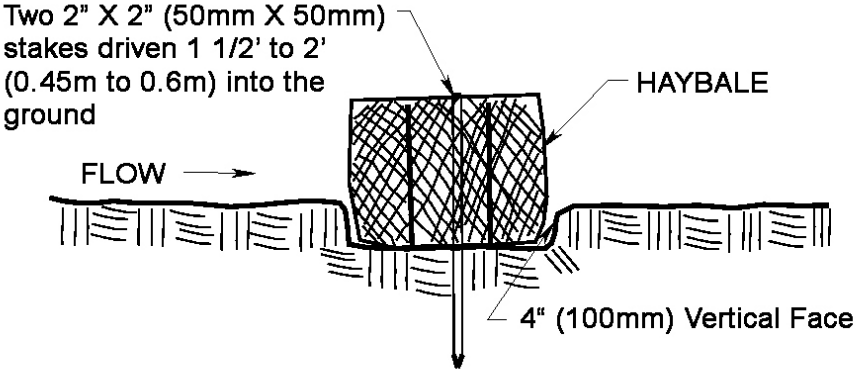
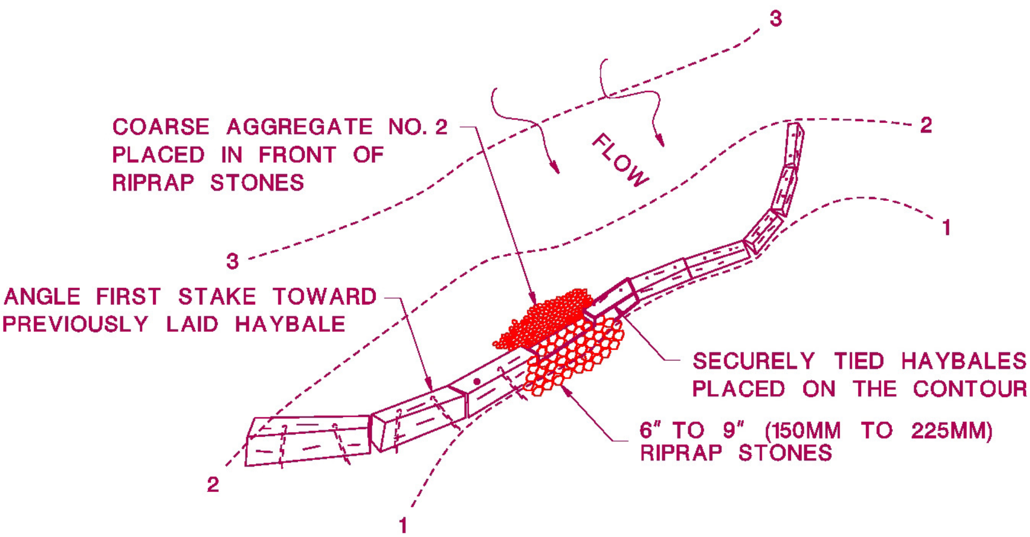
FIGURE 4.7-2 EMBEDDING DETAIL



EMBEDDING DETAIL



HAYBALE PLACEMENT AND ANCHORING DETAIL WITH STONE OVERFLOW SPILLWAY

4.8 STANDARDS FOR SEDIMENT BASIN

4.8.1 Definition

A barrier, dam, excavated pit, or dugout constructed across a waterway or at other suitable locations to intercept and retain sediment.

Basins created by construction of dams or barriers are referred to as "Embankment Sediment Basins" and those constructed by excavation as "Excavated Sediment Basins." Basins resulting from both excavation and embankment construction are classified as "Embankment Sediment Basins" where the depth of water impounded against the embankment at emergency spillway elevation is 3 feet (0.9 m) or more.

4.8.2 Scope

The standard covers the installation of sediment basins on sites where:

1. Failure of the sediment basin should not, within reasonable expectations, result in loss of life.

2. Failure of the sediment basin would not result in damage to homes, commercial or industrial buildings, main highways, or railroads; or interrupt the use or service of public utilities.

3. The drainage area is 320 acres (130 hectares) or less.

4. The effective height of the dam is 20 feet (6 meters) or less. The effective height of the dam is defined as the difference in elevation in between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam becomes the upper limit.

Sediment basins that are not within the above scope shall be designed to meet the criteria in Earth Dams and Reservoirs, Technical Release No. 60 (TR60) by the USDA-NRCS.

In addition to the criteria set forth in this Standard, the rules and regulations established by the New Jersey Department of Environmental Protection, Division of Engineering and Construction, Dam Safety, shall apply for all structural criteria. Flood Hazard Area Regulations N.J.A.C. 7:13-1.1 et. Seq. may also apply.

4.8.3 Purpose

The purpose of a sediment basin is to:

- Preserve the capacity of reservoirs, ditches, canals, diversions, storm sewers, waterways, and streams.
- To prevent undesirable deposition on bottom-lands and developed areas.
- To trap sediment originating from critically eroding areas and construction sites.
- To reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, and stone.

4.8.4 Conditions Where Practice Applies

This practice applies where physical conditions, land ownership, or construction operations preclude the treatment of the sediment source by the installation of erosion control measures to keep soil and other material in place, or when a sediment basin offers the most practical solution to the problem.

4.8.5 Design Criteria

<u>Sediment Basin Location</u>

The basin shall be designed to accommodate the individual storm runoff and sediment accumulation from the basin's total drainage area.

The basin should be located as much as possible:

a. To intercept only runoff from disturbed areas;
b. To minimize disturbance from its own construction;
c. To obtain maximum storage benefits from the terrain;
d. For ease of clean out of the trapped sediment;
e. To minimize interference with other construction activities and construction of utilities.

Sediment basins should not be located in a flood plain, wetland, or wetland transition area (unless a permit was obtained to impact that area already).
If a sediment basin is used for dewatering, the return water shall not be discharged to an unprotected potion of a stream. NJDEP prefers the water to be returned to an area of the stream that is protected by a turbidity barrier.

<u>Sediment Basin Volume</u>

The volume in the sediment basin below the crest elevation of the emergency spillway shall be the larger of:

- The volume necessary to obtain 70% trap efficiency at the start of the basin's useful life,

  or

- The volume necessary to provide sediment storage capacity and provide for temporary stormwater runoff storage from a 2-year frequency, 24-hour duration, Type III storm, The volume is determined by the Modified Rational Method up to 20 acres (8 hectares), as described in Special Report 43 by the American Public Works Association—<u>Practices in Detention of Urban Stormwater or by the currently adopted NRCS distribution</u> for a 2-year frequency storm.

<u>Principal Spillway Crest Evaluation</u>

The principal spillway crest elevation shall be the lower of 1 foot (0.3 m) below the emergency spillway crest elevation or the elevation that provides, between the crest of the principal spillway and the crest of the emergency spillway, the required temporary floodwater storage for a 2-year frequency, 24-hour duration, Type III storm.

Flood routing to determine the required temporary floodwater storage for a 2-year frequency, 24-hour duration, Type III storm shall be done using the approximate methods in the USDA-

NRCS Field Handbook, the approximate methods in the USDA-NRCS Urban Hydrology for Small Watersheds (TR55), TR-20, or other generally accepted methods of flood routing.

The modified rational method on a drainage basin up to 20 Acres (8 hectares), as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater, is also applicable.

Trap Efficiency

Trap efficiency is the amount in percent of the sediment delivered to the sediment basin that will remain in the basin. The sediment basin shall have adequate volume below the crest of the emergency spillway to have an actual trap efficiency of at least 70% at the start of its useful life using Curve 4.8.1 and with:

C = total capacity of the sediment basin up to the crest elevation of the emergency spillway in acre feet (cubic meters).

I = average annual surface runoff from Figure 4.8-1 converted to units of acre feet (cubic meters).

For a normally dry sediment basin, the actual trap efficiency is reduced 10% where the incoming sediment is predominately silt, clay, or fine-grained sediment. Therefore, enter Curve 4.8.1 with 80% trap efficiency to achieve 70% actual trap efficiency. For a normally dry sediment basin, the actual trap efficiency is reduced 5% where the incoming sediment is sand or coarse- grained. Therefore, enter Curve 4.8.1 with 75% trap efficiency to achieve 70% actual trap efficiency.

Sediment Storage Capacity

The sediment storage capacity of a sediment basin shall equal the volume of sediment expected to be trapped at the site during the planned useful life of the sediment basin. Where it is determined that periodic removal of sediment is practicable, the sediment storage capacity may be proportionately reduced. Planned periodic removal of sediment shall not be more frequent than once a year. The capacity shall be determined by one of the following methods:

1. Provide sediment storage based on the following formula and figures:

$$V = (DA)(A)(DR)(TE)(1/\gamma_S)(2{,}000 \text{ lbs./ton})(1/43560 \text{ sq. ft./Ac.})$$

Where:

V= the volume of sediment trapped in acre feet/yr. (m^3/year).
DA= the total drainage area in acres (hectares).
A = the average annual erosion in tons per acre (megagram/hectare/year). See Table 4.8-1

TABLE 4.8-1 AVERAGE ANNUAL EROSION (A)

LAND USE	AVERAGE ANNUAL EROSION	
Wooded areas	0.2 tons/acre/year	0.45 M_g/hectare/year
Developed urban areas, grassed areas, pastures, hay fields	1.0 tons/acre/year	2.25 M_g/hectare/year
Clean tilled cropland	10 tons/acre/year	225 M_g/hectare/year
Construction Areas	50 tons/acre/year	1125M_g/hectare/year

DR = the delivery ratio determined from Curve 4.8-2.
TE = the trap efficiency as determined above (using curve 4.8-1).

γ= the estimated sediment density in the sediment basin in lbs/cubic feet (Table 4.8-2).

γ_s = the submerged density in a wet sediment pool.

γ_a - the aerated density in a normally dry sediment pool.

TABLE 4.8-2 SEDIMENT DENSITY

SOIL TEXTURE (English units)	γ_s Submerged (lbs/cu. ft.)	γ_a. Aerated (lbs/cu. ft.)
Clay	40-60	60-80
Silt	55-75	75-85
Clay-Silt Mixtures equal parts	40-65	65-85
Sand-Silt Mixtures equal parts	75-95	95-100
Clay-Silt-Sand Mixtures equal parts	50-80	80-100
Sand	85-100	85-100
Gravel	85-125	85-125
Poorly Sorted Sand & Gravel	95-130	95-130

SOIL TEXTURE (Metric units)	γ_s Submerged (k_g/m^3)	γ_a Aerated (k_g/m^3)
Clay	640-960	960-1280
Silt	880-1200	1200-1360
Clay-Silt Mixtures equal parts	640-1040	1040-1360
Sand-Silt Mixtures equal parts	1200-1520	1520-1600
Clay-Silt-Sand Mixtures equal parts	800-1280	1280-1600
Sand	1360-1600	1360-1600
Gravel	1360-2000	1360-2000
Poorly Sorted Sand & Gravel	1520-2080	1520-2080

3. Provide sediment storage based on the same procedure as in #2 above except determine (A) using the Universal Soil Loss Equation (Appendix A-3) with on-site conditions.

Shape and Depth

The length, width, and depth are measured at the principal spillway crest elevation. The basin configuration shall be such that the effective flow length is equal to at least two times the effective flow width. This basin shape may be attained by selecting the basin site, by excavating the basin to the required shape or by installing of one or more baffles.

The minimum width shall be: $W = 10\sqrt{Q_5}$

where: W = the width in meters.
Q_5 = peak discharge from a 5 year frequency storm in m^3/s.

The average depth shall be at least 4 feet (1.2 meters).

When downstream damage may be severe, the minimum width should be:

$W = 10\sqrt{Q_{25}}$

where: Q_{25} = peak discharge from a 25 year frequency storm in m^3/s.

The average depth shall be at least 4 feet (1.2 meters).

Foundation Cutoff for Embankment Sediment Basin

A foundation cutoff constructed with relatively impermeable materials shall be provided for all embankments. The minimum depth of the cutoff shall be 3 feet (0.9 meters). The cutoff trench, as a minimum, shall extend up both abutments to the emergency spillway crest elevation. The minimum bottom width shall be 4 feet (1.2 meters), but wide enough to permit operation of 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 kept free from standing water during the backfilling operations.

Seepage Control

Seepage control is to be included if seepage may create swamping downstream; or if needed to insure a stable embankment; or if special problems require drainage for a stable dam. Seepage control may be accomplished by foundation, abutment, or embankment drains, reservoir blanketing, or a combination of these and other measures.

Foundation

The area on which an embankment is to be placed shall consist of material that has sufficient bearing strength to support the embankment without excessive consolidation.

Earth Embankment

Top width - The minimum top widths of embankments are shown in Table 4.8-3. When the embankment top is to be used as a public road, the minimum width, guide rails, or other safety measures are to meet the requirements of the responsible road authority. The minimum top width will be increased as necessary to accommodate construction equipment.

TABLE 4.8-3

Total Height of Embankment (feet)	Total Height of Embankment (meters)	Minimum Top Width (feet)	Minimum Top Width (meters)
< 20	< 6	10	3
20-24	6-7.3	12	3.6

For dams which raise the water elevation 5 feet (1.5 meters) or greater in height as defined in NJAC 7:20, the rules and regulations established by the New Jersey Department of Environmental Protection, Division of Engineering and Construction, Dam Safety, shall apply for all structural criteria. Flood Hazard Area Regulations NJAC 7:13-1.1 et. seq. may also apply.

Side Slopes - The combined upstream and downstream side slopes of the settled embankment shall not be less than 5:1 with neither slope steeper than 2:1. Slopes must be designed to be stable in all cases.

Freeboard - The minimum elevation of the top of the settled embankment shall be increased by the amount needed to insure that after all settlement has taken place, the height of the dam will equal or exceed the design height. This increase shall not be less than 10% when compaction is by hauling equipment or 5% if compactors are used, except where detailed soil testing and laboratory analysis shows that a lesser amount is adequate.

Compaction - The compaction requirements shall be specified.

Embankments other than earth fill

Sediment basins with effective heights of less than 5 feet (1.5 meters) may use materials other than earth for the embankment. These embankments shall be structurally sound, and have hydraulic characteristics that will safely handle the principal and emergency spillway design storm.

Principal Spillway -The minimum pipe size shall be 8 inches (200 mm) for corrugated or helical pipe and 6 inches (150 mm) for smooth wall pipe. All joints shall be watertight.

Inlets for Pipe Conduits - The inlet shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent flotation. The inlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. The inlet materials shall be subject to the same limitations and requirements as pipe conduits.

1. Watertight Riser - The riser shall be completely watertight except for the inlet at the top and one hole 4-inch (100 mm) or less in diameter to dewater the basin.

2. De-watering the Sediment Basin - Sediment basins with a permanent pool of water trap sediment more effectively than basins that are normally dry and usually create less of a mosquito problem and safety hazard. Therefore, a sediment basin with a permanent pool is usually a better design than a normally-dry sediment basin.

   If a normally-dry or partially-dry sediment basin is planned, the basin shall be dewatered by a 4 inch (100 mm) diameter or smaller hole in the riser, or by the use of subsurface drains or by a combination of these two methods.

If the sediment basin is dewatered by using a hole in the riser, pipe size shall be minimum 8 inches (200 mm) for corrugated or helical pipe and minimum 6 inches (150 mm) for smooth wall pipe.

Pipe Conduits - Sediment basins shall have pipe conduits with required appurtenances except where a structural spillway is used.

1. The materials and installation for pipe conduits for excavated sediment basins shall meet the local municipality requirements for culverts or storm sewers.

2. Conduits for embankment sediment basins shall meet the following requirements:

   a. The pipe shall be capable of withstanding the external loading without yielding, buckling, or cracking.

   b. The elevation of the hole shall be the elevation that results in 50% actual trap efficiency in the basin. The value for C used to determine the 50% actual trap efficiency is the capacity of the basin between the bottom of the hole and crest elevation of the emergency spillway.

   c. The sediment shall be removed from the basin when the sediment reaches the elevation of the bottom of the hole.

If the sediment basin is de-watered by using a subsurface drain, it shall be in accordance with the Standard for Subsurface Drainage (Section 4.17).

Appendix A7 shows several methods for dewatering a sediment basin.

Pipe Drop Inlet - Where the pipe is designed for pressure flow:

1. The weir length shall be adequate to prime the pipe below the emergency spillway elevation.

2. For pipe on less than critical slope, the drop inlet shall be at least 2D deep, where D is the conduit diameter.

3. For pipe on critical slope or steeper, the drop inlet shall be at least 5D deep, where D is the conduit diameter.

Antivortex Devices - Sediment basins with the principal spillway designed for pressure flow are to have adequate antivortex devices.

Trash and Safety Guards - An appropriate guard shall be installed at the inlet. The guard shall prevent clogging of the pipe by trash and reduce the safety hazard to people. The guard shall be a type that will not plug with leaves, grass, or other debris.

Outlets for Conduits - The outlets shall be structurally sound and made from materials compatible with the conduit. The outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. Protection against scour at the discharge end of the spillway shall be provided. Measures may include an impact basin, conduit outlet protection, rock , excavated plunge pools, or use of other generally accepted methods (see Section 4.18).

Antiseep Collars - Antiseep collars are not required for excavated sediment basins. Pipe conduits for embankment sediment basins shall be provided with antiseep collars.

The following criteria are to be used to determine the size and number of antiseep collars:

V = projection of the antiseep collar.
L = length of the conduit within the zone of saturation, measured from the downstream size of the riser to the toe drain or point where phreatic line intercepts the conduit, whichever is shorter.
n = number of antiseep collars.

The ratio of the length of the line of seepage (L + 2n V) to L is to be not less than 1.15. Antiseep collars should be equally spaced along that part of the barrel within the saturated zone at distances of not more than 25 feet (7.6 meters).

The antiseep collars and their connections to the pipe shall be watertight. The collar material shall be compatible with pipe materials.

Emergency Spillways

Emergency spillways are provided to convey large floods safely past sediment basins.

An emergency spillway must be provided for each sediment basin, unless the principal spillway is large enough to pass the routed emergency spillway design storm and the trash that comes with it, without overtopping the dam. A closed conduit principal spillway having a conduit with a cross-sectional area of 3 square feet (0.28 square meter) or more, and an inlet which will not clog, and an elbow designed to facilitate the passage of trash, is the minimum size and design that may be utilized without an emergency spillway.

1. Excavated Sediment Basins - Excavated sediment basins may utilize the natural ground or the fill for the emergency spillway if the downstream slope is 5:1 or flatter, has existing vegetation, or is immediately protected by sodding, rock , asphalt lining, concrete lining, or other equally effective protection. The spillway shall meet the capacity requirement for embankment sediment basins.

2. Embankment Sediment Basins - Embankment sediment basins shall meet the following requirements:

   a. Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 4.8-4 less any reduction creditable to conduit discharge and detention storage.

      When discharge of the principal spillway is considered in calculating outflow through the emergency spillway, the crest elevation of the inlet shall be such that full flow will be generated in the conduit before there is discharge through the emergency spillway. The emergency spillway shall safely pass the peak flow or the storm runoff shall be routed through the reservoir.

      If routed, the routing shall start with the water surface at the elevation of the crest of the principal spillway. The flood routing may be done using the approximate methods in the USDA-NRCS Engineering Field Manual; the USDA-NRCS Technical Release 55 or 20; the Modified Rational Method up to 20 acres (8 hectares), and as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater; or other accepted methods of emergency spillway flood routing.

TABLE 4.8-4 MINIMUM DESIGN STORM

DRAINAGE AREA (acres)	FREQUENCY (years)	MINIMUM DURATION (hours)
less than 20	10	24
21-49	25	24
greater than 49	100	24

DRAINAGE AREA (hectares)	FREQUENCY (years)	MINIMUM DURATION (hours)
less than 8	10	24
8-20	25	24
greater than 20	100	24

*For use by USDA-NRCS methods only.

b. Velocity - Emergency spillways are to provide for passage of the design flow at a safe velocity to a point downstream where the dam will not be endangered. The maximum permissible velocity in the exit channel shall be 4 feet (1.2 meters) per second for vegetated channels in soils with a plasticity index of 10 or less and 6 feet per second (1.8 meters per second) for vegetated channels in soil with a plasticity index greater than 10. For exit channels with erosion protection other than vegetation, the velocities shall be in the safe range for the type of protection used.

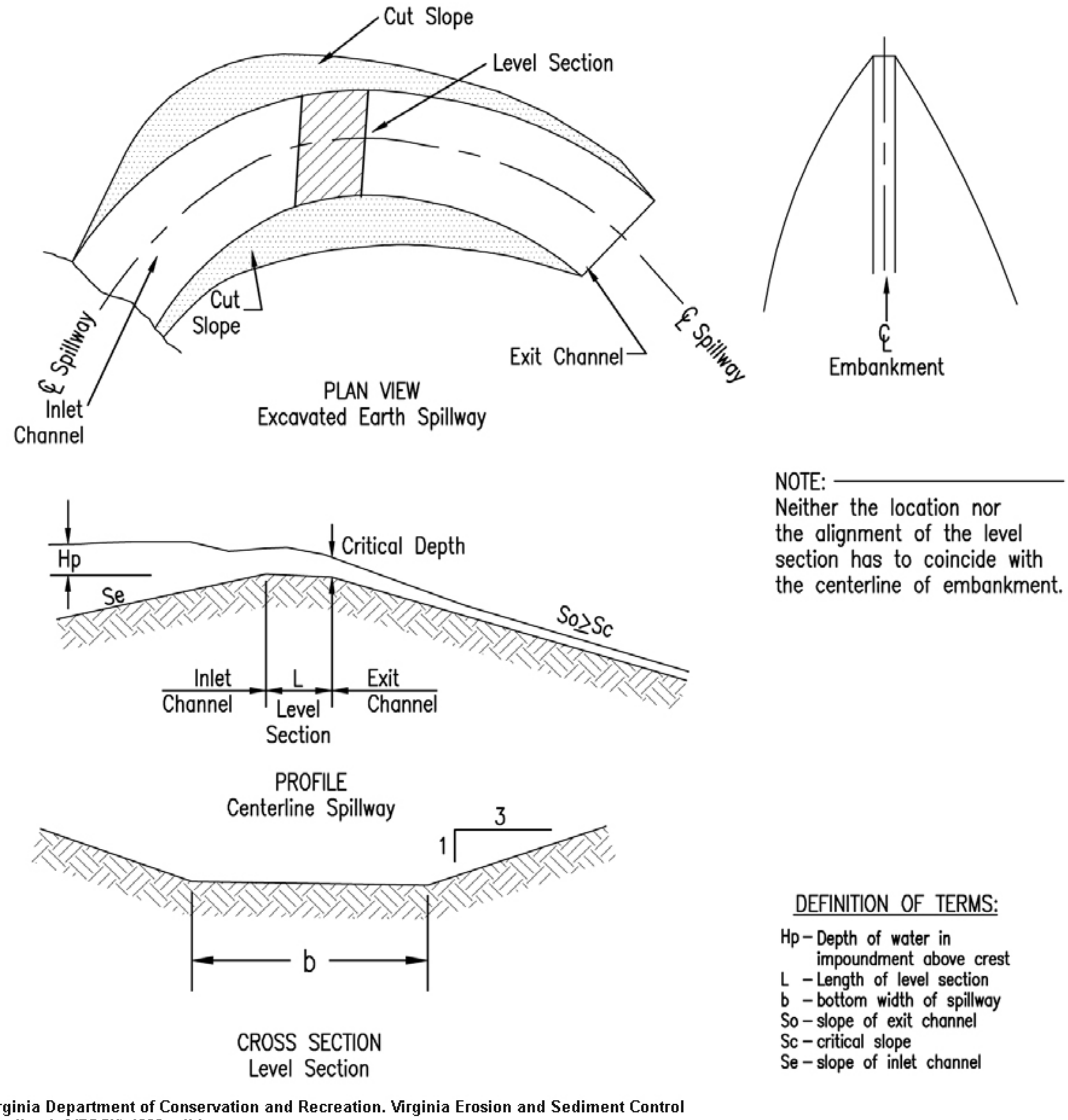
c. Cross Sections - Emergency spillways shall be trapezoidal and will be located in undisturbed earth. The side slopes shall be 2:1 or flatter. The bottom width shall be 10 feet (3 meters) or wider. The embankment requirement determines elevation differences between crest of the emergency spillway and settled top of dam.

d. Component Parts - Emergency spillways are open channels and consist of an inlet channel, control section, and an exit channel. The emergency spillway should be as long as possible to provide protection from breaching (Figure 4.8-1).

(1) Inlet channel - the inlet channel shall be level and straight for at least 20 feet (6 meters) upstream of the control section. Upstream of the level area, it may be graded back towards the pond to provide drainage. The alignment of the inlet channel may be curved upstream of the straight portion.

(2) Exit channel - The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities. The exit channel shall carry the design flow downstream to a point where the flow will not discharge on the toe of the dam. The design flow should be contained in the exit channel without the use of dikes. If a dike is necessary, it shall have 2:1 or flatter side slopes, 8 feet (2.4 meters) top width minimum, and be high enough to contain the design flow 1 foot (300 mm) plus 1 foot (300 mm)of freeboard.

Figure 4.8-1 Sediment Basin Emergency Spillway



Virginia Department of Conservation and Recreation. Virginia Erosion and Sediment Control Handbook (VESCH) 1992 edition.

Structural Spillways Other Than Pipe

Structural spillways other than pipe shall have structural designs based on sound engineering data with acceptable soil and hydrostatic loadings as determined on an individual site basis.

When used as a principal spillway, they shall pass the storm runoff from a 2-year, 24-hour duration storm without flow through the emergency spillway and shall not be damaged by the emergency spillway design storm. When used as an emergency spillway, they shall pass the storm runoff from the appropriate storm in Table 4.8-4.

Vegetation

The dam, emergency spillway, spill and borrow areas, and other disturbed areas above crest of the principal spillway shall be stabilized in accordance with the Standards for Temporary or Permanent Vegetative Cover (Section 3.1 or 3.2), whichever is applicable.

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, adjacent to a stream, floodplain, wetland or wetland transition area.

The plans shall also show the method of removal of the sediment basin after the drainage area is stabilized, and shall include the stabilizing of the sediment basin site. Water lying over the trapped sediment shall be removed from the basin by pumping, cutting the top of the riser, or other appropriate method prior to removing or breaching the embankment. Sediment shall not be allowed to flush into the stream or drainage way.

Safety

Sediment basins attract children and can be very dangerous. They may be fenced or otherwise made inaccessible to persons or animals unless deemed unnecessary due to the remoteness of the site or other circumstances. In any case, local ordinances and regulations regarding health and safety must be adhered to. This portion of the Standard is for guidance only.

Maintenance

The plans shall indicate who is responsible for operation and maintenance during the life of the sediment basin. A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the structure to insure that the structure functions properly. This plan shall provide requirements for at least annual inspection, operation, and maintenance of individual components, including outlets. It shall be prepared during design and shall specify who is responsible for maintenance. Adequate access must be provided for maintenance. Any additional requirements of the NJDEP shall be met where applicable.

CURVE 4.8-1 TRAP EFFICIENCY OF RESERVOIRS

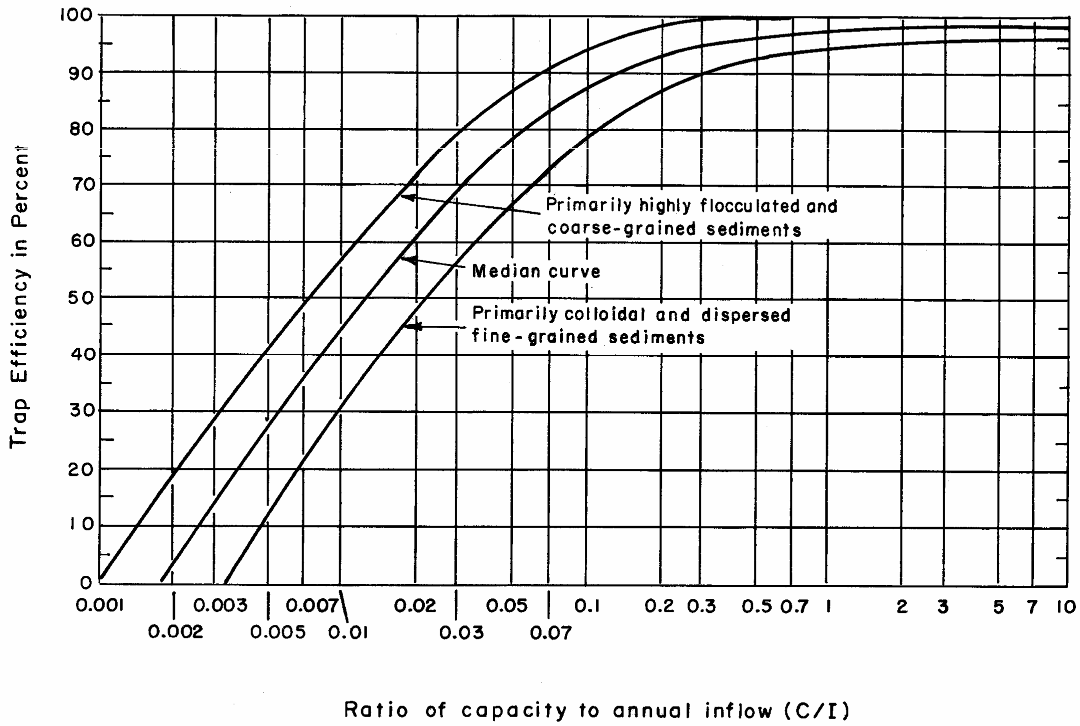
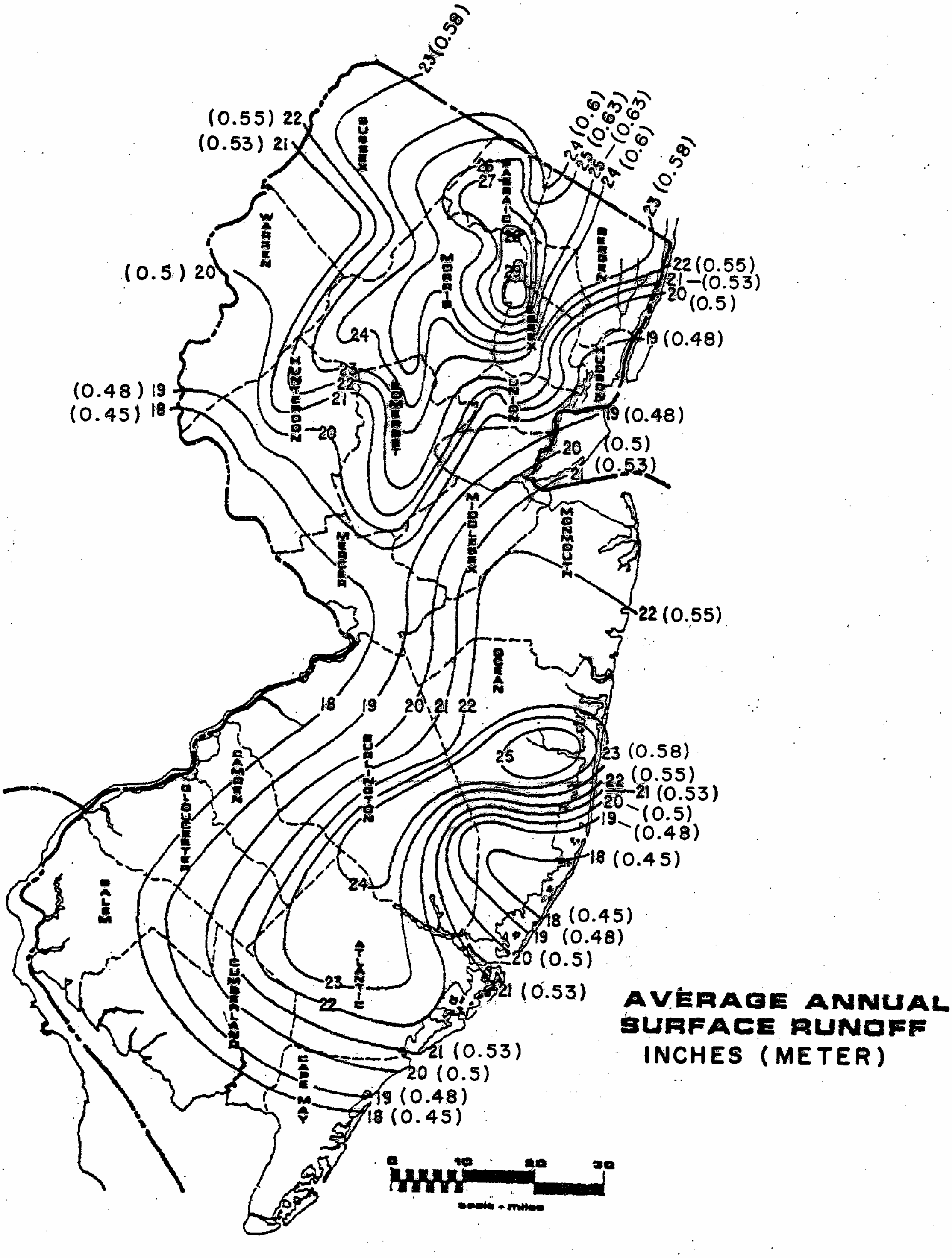


FIGURE 4.8-2 AVERAGE ANNUAL SURFACE RUNOFF – INCHES (METERS)


AVERAGE ANNUAL
SURFACE RUNOFF
INCHES (METER)
SUSSEX
WARREN
PASSAIC
BERGEN
MORRIS
ESSEX
HUDSON
HUNTERDON
SOMERSET
UNION
MIDDLESEX
MERCER
MONMOUTH
OCEAN
BURLINGTON
CAMDEN
GLOUCESTER
SALEM
CUMBERLAND
ATLANTIC
CAPE MAY
23 (0.58)
(0.55) 22
(0.53) 21
(0.5) 20
(0.48) 19
(0.45) 18
24 (0.6)
25 (0.63)
25 (0.63)
24 (0.6)
23 (0.58)
22 (0.55)
21 (0.53)
20 (0.5)
19 (0.48)
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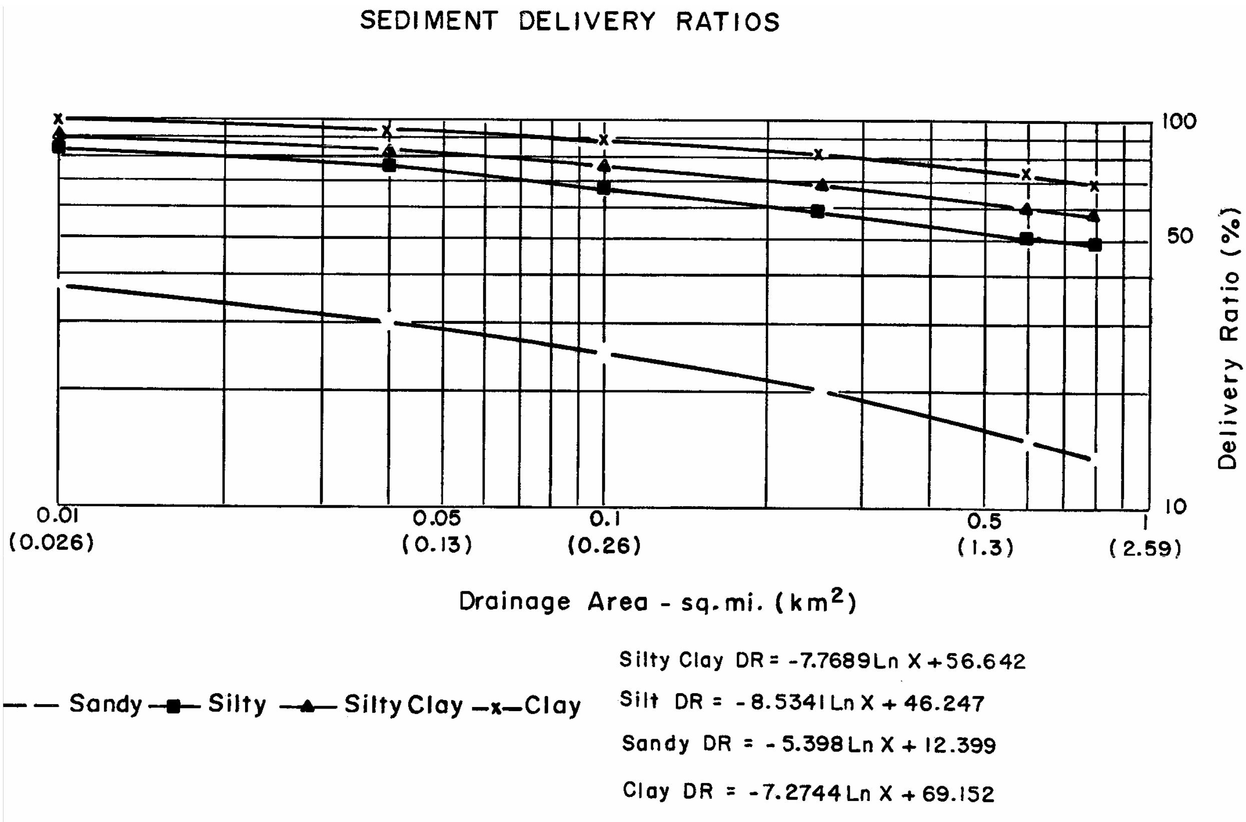
18 (0.45)
0 10 20 30

CURVE 4.8-2 SEDIMENT DELIVERY RATIOS



4.9 STANDARDS FOR DETENTION BASIN FOR CONTROL OF DOWNSTREAM EROSION

4.9.1 Definition

A basin providing for temporary storage of stormwater and for its controlled release.

Basins created by construction of dams or barriers are referred to as "Embankment Basins" and those constructed by excavation as "Excavated Basins." Basins resulting from both excavation and embankment construction are classified as "Embankment Basins" where the depth of water impounded against the embankment at emergency spillway elevation is 3 feet (0.9 m) or more.

4.9.2 Scope

This standard covers the installation of all detention basins (sometimes referred to as retention basins).

4.9.3 Purpose

Detention basins are an available option to reduce soil erosion damages downstream by controlling the release from flows of predetermined frequencies. They may also permit the use of more economical channel improvements or stabilizing structures in the channel downstream and reduce environmental hazards and pollution.

4.9.4 Conditions Where Practice Applies

This practice applies if there is a potential for increased downstream soil erosion due to construction at development sites, or from other land use changes, or if local ordinances require storm detention basins. The increased downstream soil erosion may be caused by increased runoff volume, and/or increased peak discharge. If the detention basin is also intended to comply with the provisions of the Stormwater Management Act of 1981, or any revisions thereto, regulations promulgated by NJDEP pursuant to that Act should apply. Where Infiltration Basins are proposed, the existence of a stable condition at the emergency discharge area must be provided, and for offsite stability analysis it must be assumed that infiltration will not reduce the peak runoff for a 10-year storm.

4.9.5 Design Criteria

Structural aspects of detention basins shall be as stipulated by applicable state requirements. In addition, it must be shown for the peak outflow, as determined by:

1. Modified Rational Method USDA-NRCS Technical Release No.55 or Technical Release No.20.

2. U.S. Army Corps of Engineers HEC-1.

3. Other methods which produce similar results to the models listed above, that there will be no soil erosion and sedimentation problems offsite. A detailed hydraulic analysis of the detention basin shall be submitted.

Design Storms

The peak discharge from the 2-year and 10-year frequency storm shall be analyzed. Frequency, duration, and distribution shall be as defined in the USDA-NRCS (SCS) Technical Release 55. No increase in peak discharge caused by construction operations or changes in land use shall be allowed unless the increase in peak discharge does not result in increased potential for erosion.

The peak runoff may be determined by the Rational Method for areas up to ½ square mile (1.3 km^2).

Design storm and volume may be determined by the modified rational method on drainage basins up to 20 acres (8 hectares), as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater.

If there is an overall stormwater management plan for the watershed that considers soil erosion, downstream peak flow increases that are compatible with the overall plan may be allowed. In some cases, more restrictive NJDEP Stormwater Management regulations may be applicable.

Outlets for Conduits

Protection against scour at the discharge end of the spillway shall be provided in accordance with the Standard for Conduit Outlet Protection (Section 4-18), or by suitable hydraulic structures proven effective by properly documented research.

Vegetation

The dam, emergency spillway, spoil and borrow areas, and other disturbed areas above the crest of the principal spillway shall be vegetated in accordance with the Standard for Permanent Vegetative Cover for Soil Stabilization (Section 3.2). All cut or fill slopes should be flat enough to accommodate the proposed operation and maintenance equipment.

Safety

Detention basins attract children and can be very dangerous. They may be fenced or otherwise made inaccessible to persons or animals unless deemed unnecessary due to the remoteness of the site or other circumstances. In any case, local, county, or state regulations regarding health and safety must be adhered to. This portion of the Standard is for guidance only.

Ownership

Ownership and responsibility for operation and maintenance of the detention basin must be determined during the design and must be shown on the plans. To be effective over a long period of time, the structure must be properly maintained. Detention basins should normally be owned by a unit of government that accepts responsibility for the structure and can obtain the money necessary to do operational and maintenance work.

Operation and Maintenance

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the structure to insure that the structure functions properly. This plan shall provide requirements for at least annual inspection, operation, and maintenance of individual components, including outlets. It shall be prepared during design and shall specify who is responsible for maintenance. Adequate access must be provided for maintenance. Any additional requirements of the NJDEP and shall be met where applicable.

4.10 SILT FENCE

4.10.1 Definition

A silt fence is a temporary sediment barrier made of woven, synthetic (permeable) filtration fabric stretched across supporting posts (steel or wood), which is installed to allow water to pass through while holding the soil.

4.10.2 Purpose

The purpose of a silt fence is to prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing storm water runoff and causing the deposition of sediment at the structure. Silt fence encourages sheet flow and reduces the potential for development of rills and gullies. Silt fence is typically installed along streams, lakes and hillsides. Silt fence decreases the velocity of sheet flows and filters runoff as it passes through the filter fabric resulting in relatively sediment-free water passing through the fence. It is not necessary to use these at locations where runoff enters the sites. It is also used for inlet protection and within dry retention ponds to filter runoff prior to discharge.

Silt Fence can be used together with other erosion control measures, such as gravel and hay bales. The useful life of silt fence is about one year.

4.10.3 Conditions

Silt fence should be installed where sheet flow runoff can be stored behind the barrier without damaging the barrier or the submerged area behind the barrier.

Silt fence should not be installed across streams, ditches, waterways, or other concentrated flow areas.

4.10.4 Design Criteria and Site Selection

All silt fence should be installed along the contour, never up or down a slope, to produce proper impounding and far enough away from toe of slope to provide adequate impounding area (min. of 5 to 7 feet (1.8 meters)) away from toe of slope recommended). Ends of fence should be angled up slope to collect runoff; fence should not extend more than 2 feet (0.6 meters) above grade.

Where all sheet flow runoff is to be stored behind the fence (where no storm water disposal system is present), maximum slope length behind a silt fence should not exceed those shown in Table 4.10.1. The drainage area should not exceed ¼ acre (0.1 hectare) for every 100 feet (30 meters) of silt fence.

Posts can be wood or metal material dependent on design and ground conditions. They should be placed on downstream side of fence.

Maximum length of each section of silt fence should be 133 feet (40 meters). Long runs of silt fence are more prone to failure than short runs.

Silt fence should be installed in ‘J’ hook or ‘smile’ configuration (see Figure 4.10-7), with maximum length of 130 feet (40 meters), along contours allowing an escape path for impounded water (minimizes overtopping of silt fence structure).

Size of drainage area should be no greater than 0.25 acre (0.1 hectare) per 100 feet (30 meters) length of silt fence and maximum flow path length above silt fence should be no greater than 100 feet (30 meters).

Maximum slope gradient above the silt fence should be no greater than 2H:1V and for use in swales, gradient should be less than 2% and drainage area less than 2 acres (0.8 hectare).

Table 4.10-1 Criteria for Silt Fence Placement

Land Slope (%)	Maximum Slope Length Above Fence (feet)	Maximum Slope Length Above Fence (meter)
<2	100	30.0
2 to 5	75	22.5
5 to 10	50	15.0
10 to 20	25	7.5
>20*	15	4.5
*In areas where the slope is greater than 20%, a flat area length of 10 feet (3meter) between the toe of the slope and the fence should be provided Ref.: Georgia Soil and Water Conservation Commission		

Requirements for silt fence and Heavy Duty Silt Fence:

Silt Fence – Silt Fence consists of geotextile fabric at least 3 feet wide to provide for a 2 feet high fence after 1 foot of fabric is buried in the existing soil. This 36-inch wide (0.9 meter) filter fabric should be used on projects where the life of the project is six months or greater.

Fence posts shall be spaced 6 feet (2 meters) center-to-center or closer. They shall extend at least 2 feet (600 mm) into the ground and extend at least 2 feet (600 mm) above ground. Posts shall be constructed of hardwood with a minimum diameter thickness of 1½ inches (40 mm).

Heavy Duty Silt Fence - Heavy Duty Silt Fence consists of geotextile fabric at least 4-feet wide to provide for a 3 foot high fence after 1 foot of fabric is buried in the existing soil. Heavy Duty Silt Fence is 4 feet (1.2 meters) wide with wire reinforcement. The wire reinforcement is necessary because the height of the fabric allows almost three times the flow rate as silt fence. Heavy Duty silt fence should be used where runoff flows or velocities are particularly high or where slopes exceed a vertical height of 10 feet (3 meters).

A metal fence with 6-inch (150 mm) or smaller openings and at least 3 feet (0.9 meter) high may be utilized, fastened to the fence posts, to provide reinforcement and support to the geotextile fabric where space for other practices is limited and heavy sediment loading is expected.

A geotextile fabric, recommended for such use by the manufacturer, shall be buried at least 12 inches (300 mm) deep in the ground. The fabric shall extend at least 3 feet (0.9 meter) above the ground. The fabric must be securely fastened to the posts using a system consisting of wire ties, hog rings, or metal fasteners (nails or staples) and a high strength reinforcement material placed between the fastener and the geotextile fabric. The fastening system shall resist tearing away from the post. Overlap a section of fabric a minimum of 18 inches and then join the section to create a continuous fence.

The fabric shall incorporate a drawstring in the top portion of the fence for added strength. It should be used were it is specified in plans for any areas with erosion potential too severe for regular silt fence. Along stream buffers and other sensitive areas, two rows of Heavy Duty Silt Fence may be used.

Table 4.10-2 contains specific information concerning specification requirements for the two types of material.

Construction Specifications and Construction Consideration

Silt fence should be placed on the contour. On slopes with grades greater than 7%, the silt fence should be located at least 5 to 7 feet (1.5 to 2.1 meters) beyond the base. Turn the ends of the silt fence upslope so that storm water will not bypass the silt fence. The impounded depth should be at least 12 inches (300 mm), but no more than the height of the silt fence. The bottom edge of silt fence must be entrenched and backfilled to be effective.

The silt fence should be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth should be spliced together only at a supporting post, with a minimum 6-inch overlap (150 mm) and securely sealed.
See Figure 4.10-5 for splicing requirements.

Install fence posts at a slight angle toward the anticipated runoff source. Post installation should start at the center of the low-point (if applicable) with remaining posts spaced 6 feet (1.8 m) apart for silt fence and 4 feet (1.2 meters) apart for Heavy Duty Silt Fence. Silt fences can be used with both wood and steel posts. Steel posts and 4 inches by 4 inches (100 m by 100 m) Wood posts should be used with Heavy Duty Silt fence due to the flow capacity of the fabric. See Table 3 in Figure 4.10-8, for post size and fastener requirements. See Figure 4.10-8 for fastener placement.

Dig a trench 6 inches deep and 6 inches wide (150mm x 150mm). Drive support posts of 2 feet (600mm) into the ground, spaced a maximum of 6 feet (1.8 meters) apart. The trench should follow the contour of the slope. Pound fence stakes or posts on the down slope side of the trench. Lay the silt fence fabric bottom edge into the trench and backfill the trench.

At silt fence junctions, put the fence posts (with fabric attached) side-by-side and turn the posts one full circle (360 degrees) around each other to form a junction without gaps.

Heavy Duty Silt Fence includes wire mesh, as a reinforcement to silt fence fabric, attached to the upstream side of posts. Wire mesh should be placed between the posts and filter fabric to provide additional strength and support reinforcement. Extend the filter fabric to the base of trench and attach over wire mesh. A batten shall be attached at each post to sandwich the silt fence fabric and the wire mesh between the batten and the post.

Filter fabric for Heavy Duty Silt Fence should be cut from a continuous roll to avoid joints. If joints are necessary, the fabric shall be wrapped around the batten with a minimum overlap of 6 inches (200 mm) prior to attaching the batten to the post.

Silt fence wire mesh and battens should be attached to posts with heavy-duty staples, tie wires, hog rings, nails, or rust resistant screws. It should be dug into a trench at least 6 inches (150 mm) deep to prevent undercutting of fence by runoff. Trench backfill should be compacted.

Inspection

Inspect silt fence before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches (12.5 mm) or greater, and at least once every fourteen calendar days. Where sites have been temporarily or permanently stabilized, such inspections may be conducted only once per month.

Maintenance

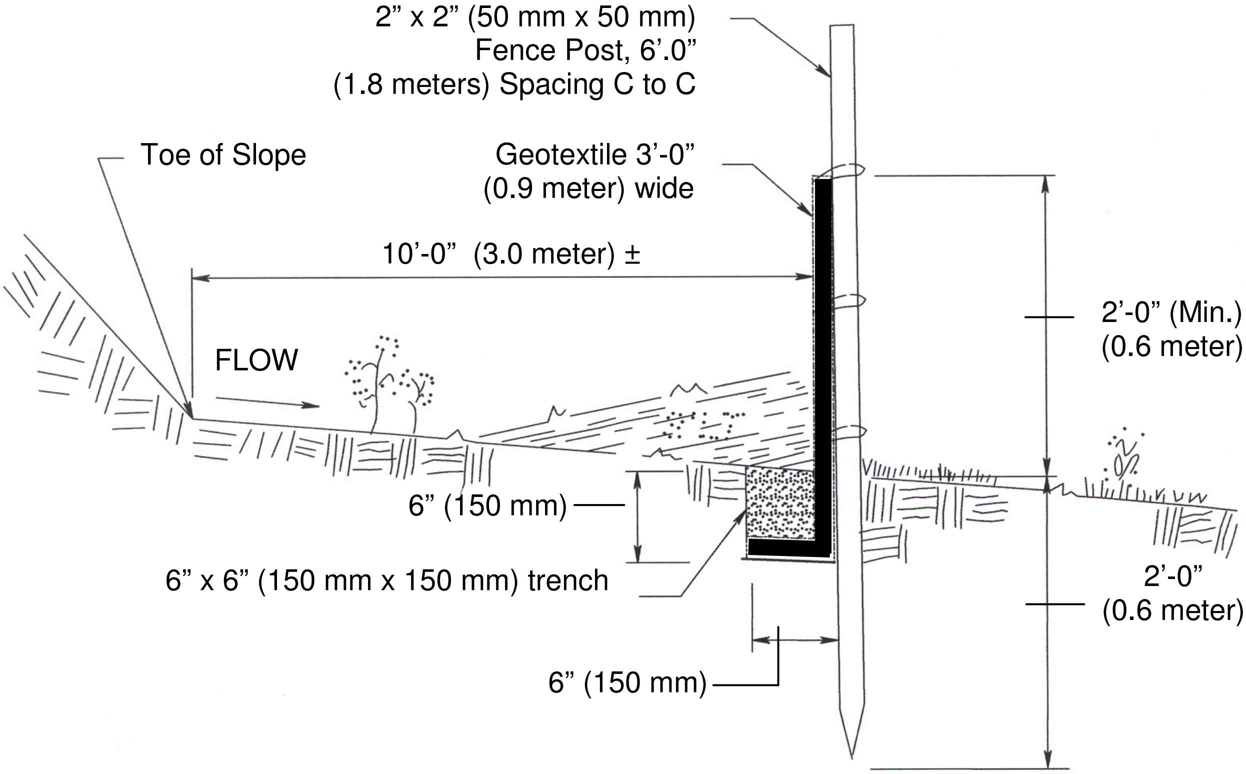
Filter fabric should be replaced whenever it has deteriorated to such an extent that the effectiveness of the fabric is compromised (approximately six months). Silt fence should remain in place until disturbed areas have been permanently stabilized. All sediment accumulated at the fence should be removed and properly disposed of before the fence is removed. Maintain the silt fence by removing sediment when it is ½ the height of the silt fence.

Table 4.10-2 Silt Fence Specifications

TYPE FENCE	Silt Fence	Heavy Duty Silt Fence
Tensile Strength (Lbs. Min.) [1] (ASTM D-4632)	Warp – 120 Fill - 100	Warp – 260 Fill – 180
Elongation (% Max.) (ASTM D-4632)	40	40
AOS (Apparent Opening Size) (Max. Sieve Size) (ASTM D-4751)	#30	#30
Flow Rate (Gal/Min/Sq. Ft.) (GDT-87)	25	70
Ultraviolet Stability [2] (ASTM D-4632 after 300 hours weathering in accordance with ASTM D-4355)	80	80
Bursting Strength (PSI Min.) (ASTM D-3786 Diaphragm Bursting Strength Tester)	175	175
Minimum Fabric Width (Inches)	36	36

1 Minimum roll average of five specimens.
2 % of required initial minimum tensile strength.

FIGURE 4.10-4 SILT FENCE



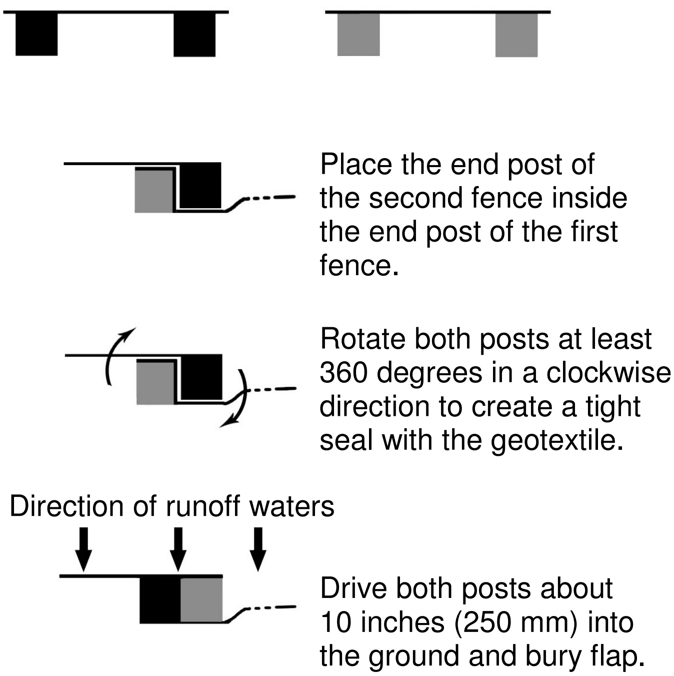
Notes:

- Geotextile to be fastened securely to fence post by using wire ties or hog rings. Use 4 to 6 fasteners per post.

- Bury bottom foot of geotextile (300 mm) and tamp in place.

- Ends of individual rolls of geotextile shall be securely fastened to a common post by wrapping each end of the geotextile around the post twice and attaching as specified in the note above (first bullet). Splicing of individual rolls shall not occur at low points.

Figure 4.10-5 ATTACHING TWO SILT FENCES



ATTACHING TWO SILT FENCES

CD-212-1.2

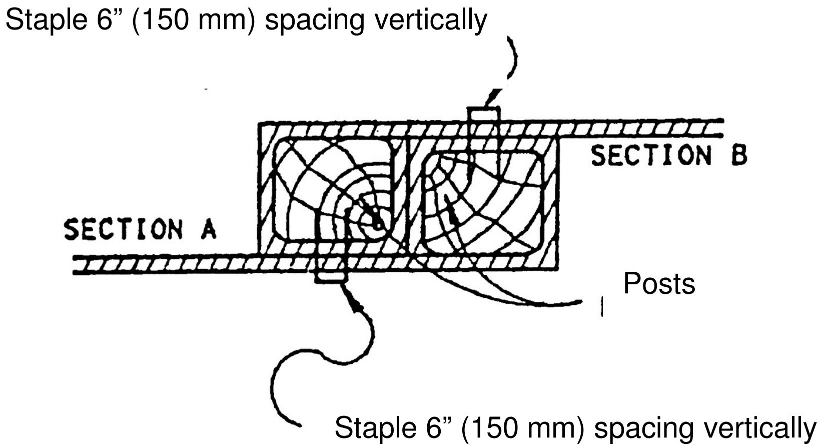
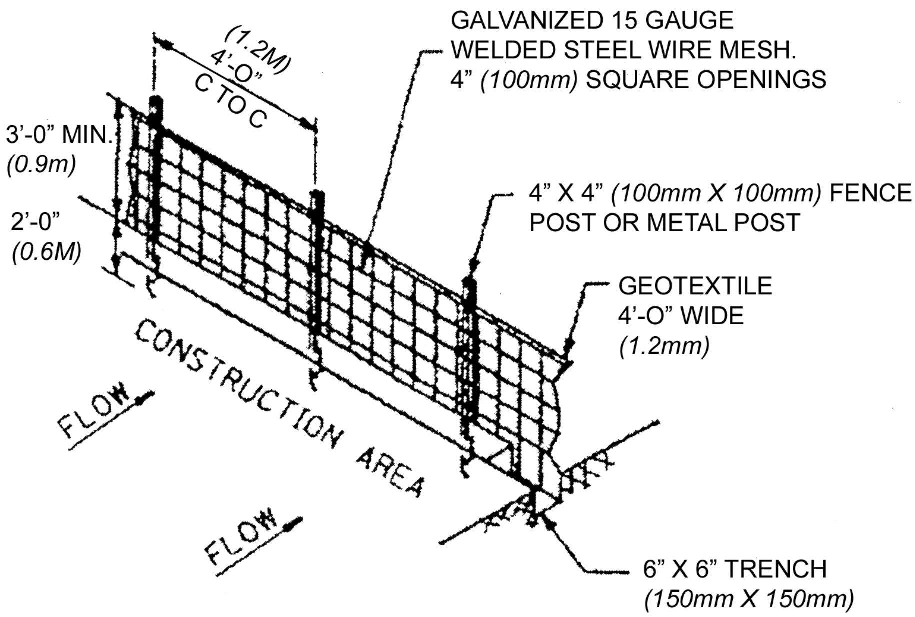


Figure 4.10-6 HEAVY DUTY SILT FENCE



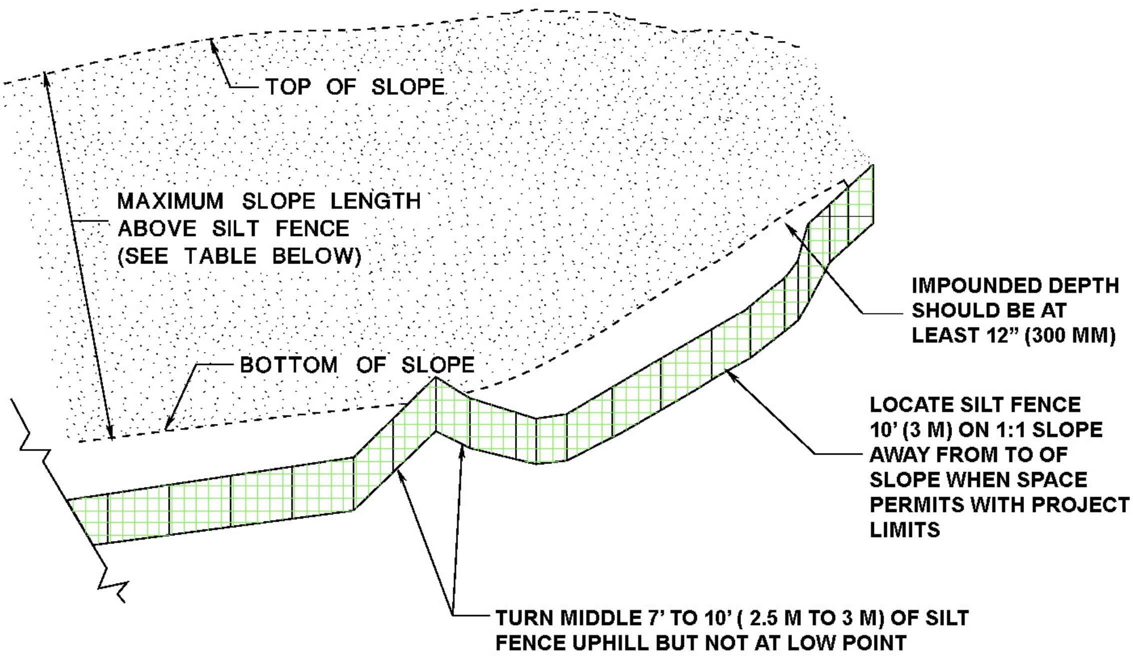
Notes:

Geotextile to be fastened securely to wire mesh and fence post by use of staples, nails, wire ties or hog rings. Use 4 to 6 fasteners per post. (Figure 4.29-8).

Bury bottom foot of geotextile (300 mm) and tamp in place.

Ends of individual rolls of geotextile shall be securely fastened to a common post by wrapping each end of the geotextile around the post twice and attaching as specified in the note above.(first bullet) Splicing of individual rolls shall not occur at low points.

Figure 4.10-7 SILT FENCE ON A STEEP OR LONG GRADE



CRITERIA FOR SILT FENCE PLACEMENT

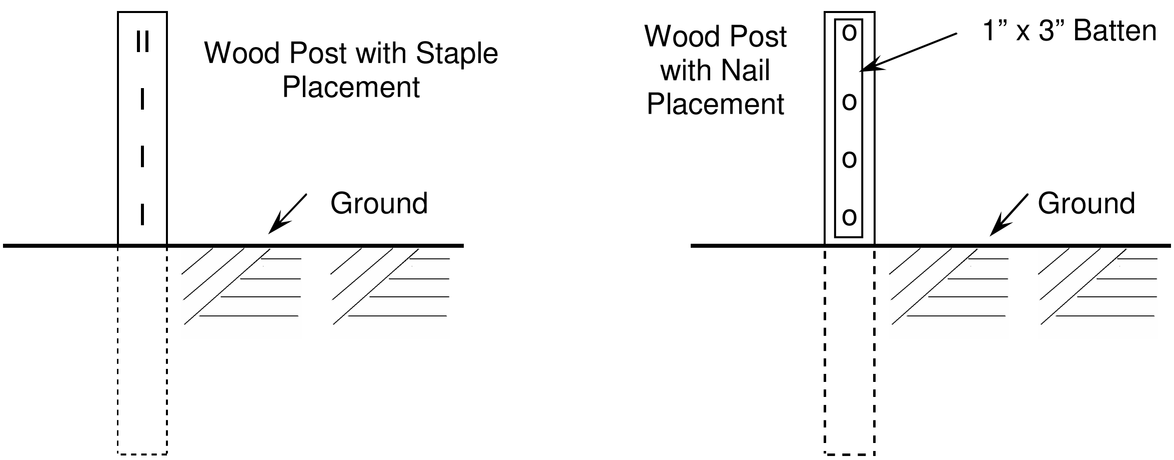
Figure 4.10-8 POST SIZE AND FASTENER REQUIREMENTS

POST SIZE			
	Minimum Length	Type of Post	Size of Post
Silt Fence	4’ (1.2 meters)	Soft Wood Oak Steel	3” (75 mm) diameter or 2”x2” (50 mm x 50 mm) 1 ½” x 1 ½” (40 mm x 40 mm) 1.3 lbs/ft (2 kg/meters) min.
Heavy Duty Silt Fence	4’ (1.2 meters)	Steel Wood	1.3 lbs/ft (2 kg/meters) min. 4” x 4” (100 mm x 100 mm)

FASTENERS FOR WOOD POSTS				
	Gauge	Crown	Legs	Staples/Post
Wire Staples	17 minimum.	¾” (20 mm) wide	½ “ (13 mm) long	5 minimum
	Gauge	Length	Button Heads	Nail/Post
Nails	14 minimum.	1” (25mm)	¾” (20mm)	4 minimum

Note: Filter fabric may also be attached to the post by wire ties, hog rings, and pockets

Fastener Placement



4.11 STANDARDS FOR TEMPORARY STONE OUTLET SEDIMENT TRAP

4.11.1 Definition

A small temporary ponding area, formed by the construction of a stone and coarse aggregate control outlet, and a sediment trap basin.

4.11.2 Purpose

The purpose of temporary stone outlet sediment traps is to reduce the velocity of concentrated stormwater flows and to detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

4.11.3 Conditions Where Practice Applies

This practice should be limited to use in small drainage areas. If the contributing drainage area is greater than 5 acres (2 hectares), refer to Standard for Sediment Basins (Section 4.8). The sediment trap may be built independently or in conjunction with a temporary diversion berm; however, it should not be used beyond its maximum useful life of about 18 months.

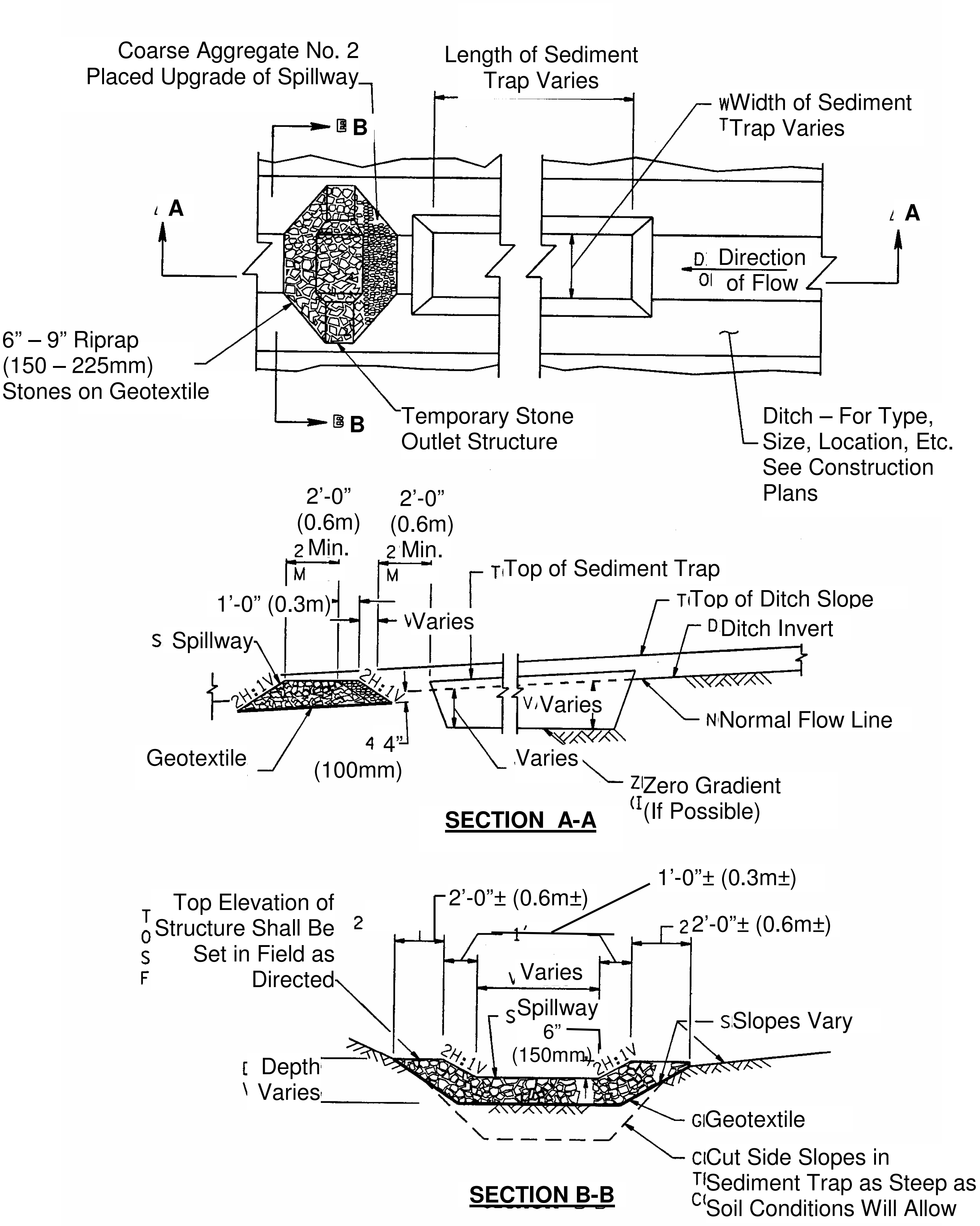
4.11.4 Design Criteria

Sediment Traps (Figure 4.11-1) shall be designed to provide a minimum initial storage volume of 2 cy./ac. (3.7 m^3/ hectare) of drainage area, measured from the low point of the ground to the crest of the gravel outlet. The side slopes of the sediment trap may be cut as steep as soil conditions will allow. Sediment should be removed from the basin when the volume is reduced by 50%. In sizing the sediment trap, potential sediment load and frequency of maintenance should be taken into consideration.

The outlet structure for the sediment trap is designed in the same manner as the temporary stone check dam (Section 4-10), and shall be located downstream of the sediment trap.

The minimum length of the outlet structure shall be 2.5 feet (750 mm) for each hectare of the contributing drainage area. The center of the outlet structure shall be 6 inches (150 mm) lower than the outer edges. The maximum height of the outlet structure shall not exceed 5 feet (1.5 meters) as measured from the low point.

FIGURE 4.11-1 TEMPORARY STONE OUTLET SEDIMENT TRAP



4.12 STANDARDS FOR STORM SEWER INLET SEDIMENT PROTECTION

4.12.1 Definition

A temporary barrier and settling facility installed at a storm sewer inlet.

4.12.2 Purpose

The purpose of inlet sediment protection is to intercept and retain sediment, thus preventing the entrance of sediment into the storm sewer system.

4.12.3Conditions Where Practice Applies

1. Contributory drainage area is 3 acres (1.2 hectares) or less

2. At a location where there is overland flow onto the roadway

3. At an inlet that will remain susceptible to sediment infiltration for an extended period of time

4. Where a traffic hazard or flooding problem will not be created.

4.12.4 Design Criteria

1. Inlet Filter:

   A. For a new or existing non-curb inlet, an inlet filter bag shall be used that provides for emergency overflow to avoid flooding.

   B. For a new or existing curb inlet, geotextile fabric shall be placed under the grate and wrapped around a 2” X 4” laid flat or on edge along the curb casting allowing for emergency overflow or an inlet filter bag shall be used that provides for emergency overflow to avoid flooding.

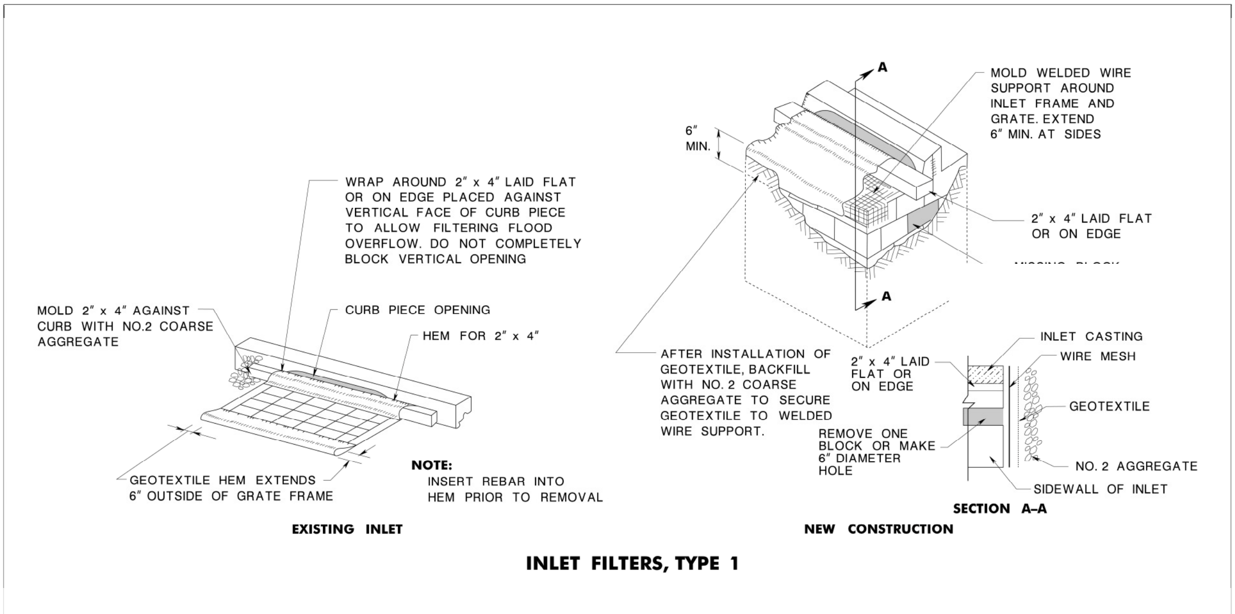
2. Inlet Sediment Trap:

   A. Silt fence shall encircle three sides of the drainage inlet structure (see Section 4.10 for silt fence detail).

   B. Coarse aggregate No. 2 shall be placed on geotextile fabric at open end of silt fence (Figure 4.12-3).

   C. Size of temporary stone inlet is to be determined by the engineer.

FIGURE 4.12-1 INLET FILTER TYPE 1



INLET FILTER TYPE 2

Inlet filter bag is used to prevent silt and sediment from entering the storm drain. The cone-shaped bag is designed to fit into the storm drain under the grate; made from a high-strength, high-flow, woven geotextile or nylon thread sewn by a double-needle machine.

Inlet filter bags collect and trap sediment and debris entering catch basins from either grated or curb inlets. Inlet filter bags are inexpensive, reusable and an effective method to collect and dispose of most construction site runoff sediments and debris before entering storm drainpipes. Inlet filter bags are custom made to fit frame and grate systems, including casting-specific curb openings and associated basin oddities.

Inlet filter bags store collected sediments and debris in the basins, offering a simple method of removal and disposal for pollutants. An overflow feature with post-installation maintenance reduces the above ground ponding or flooding.

Available sizes are 2 feet by 2 feet (600 mm by 600 mm), 2 feet by 3 feet (600 mm by 900 mm) and 2 feet by 4 feet (600 mm by 1200 mm), in 18-inch (450 mm) and 36-inch (900 mm)depths, and 18 inches by 42 inches by 18 inches (450 mmx1050 mmx450 mm) manufactured to fit the opening of each inlet.

FIGURE 4.12-2 INLET FILTER TYPE 2

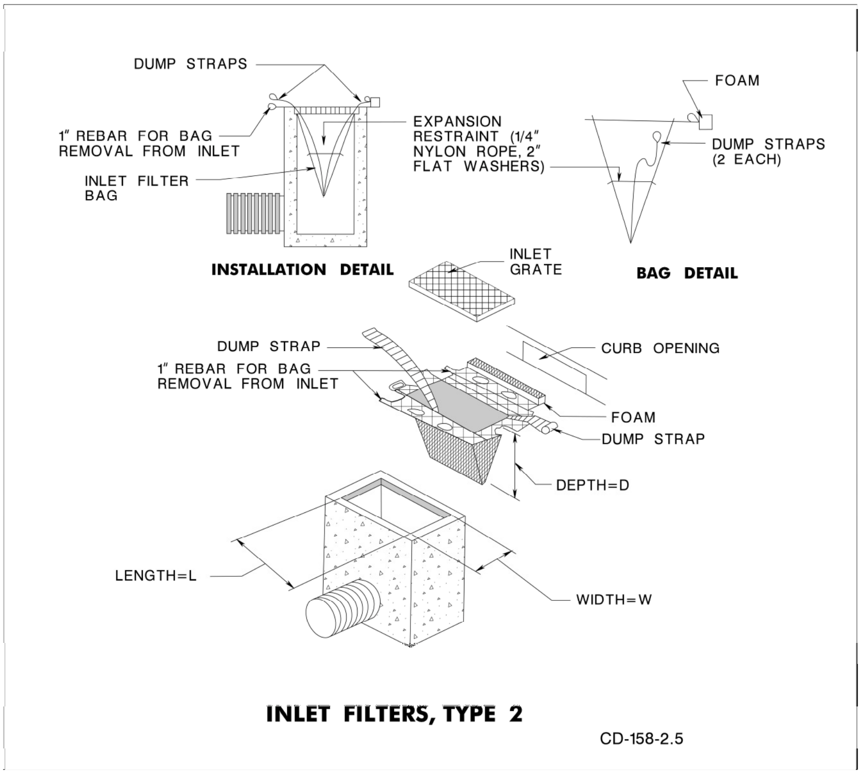
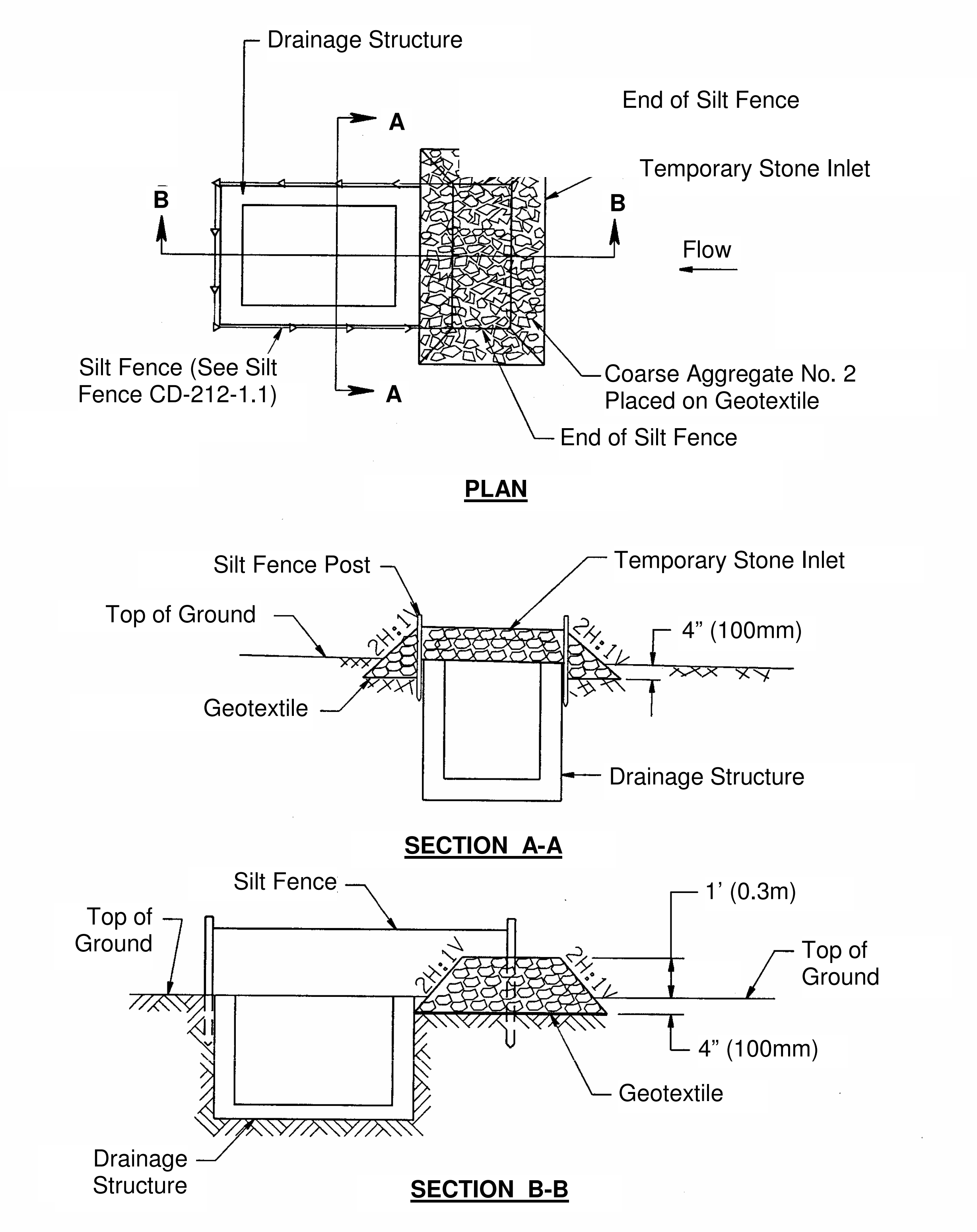


FIGURE 4.12-3 INLET SEDIMENT TRAP



4.13 STANDARDS FOR FLOATING TURBIDITY BARRIER

4.13.1 Definition

A temporary floating barrier at streams or waterways within the construction site

4.13.2 Purpose

The purpose of a floating turbidity barrier is to prevent the siltation of streams or waterways that pass through or around the construction site.

4.13.3 Conditions Where Practice Applies

Floating turbidity barriers shall be used whenever construction operations are directly located in a stream or watercourse, or where a drainage pipe that may carry silt is discharged into a stream or waterway, or where on-site control measures are not effective or feasible.

4.13.4 Design Criteria

1. Barrier material shall be a 0.01-inch thick (0.25 mm) polyethylene plastic sheet, or a suitable alternative to fit existing condition as approved by the engineer.

2. Weights shall be at 10 feet (3 meters) intervals along the entire length. They shall be 5 pounds (2 kilograms) and extend 12 inches (300 mm) below the bottom of the material.

3. Floats shall be at 5 feet (1.5 meters) intervals; there shall be two floats at each location, one on either side of the material.

4. Rope shall be ¼ inch (6 mm) nylon or manila.

4.13.5 Placement

1. Barrier will be set on a 50 feet (15 meters) radius from the point of discharge when discharging through a conduit. If the radius cannot be accommodated, barrier shall be placed in accordance with #.3 below.

2. Barrier will extend parallel to the channel bank(s) for the full length of the work area for shoreline disturbances and will be tied into the shoreline at each end.

3. Barrier will extend across the entire channel when work is performed within the channel.

FIGURE 4.13-1 PLACEMENT OF FLOATING TURBIDITY BARRIER

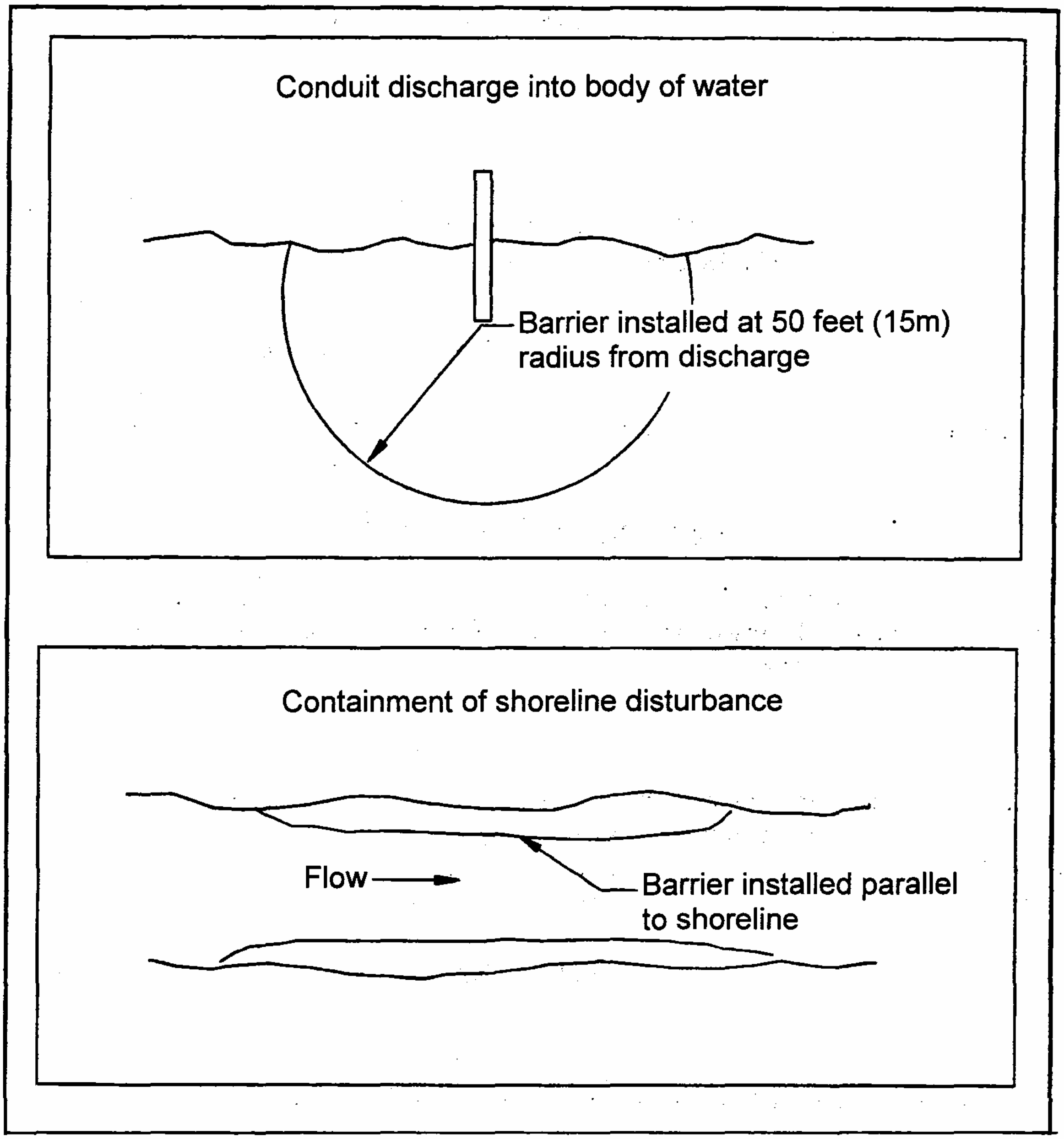
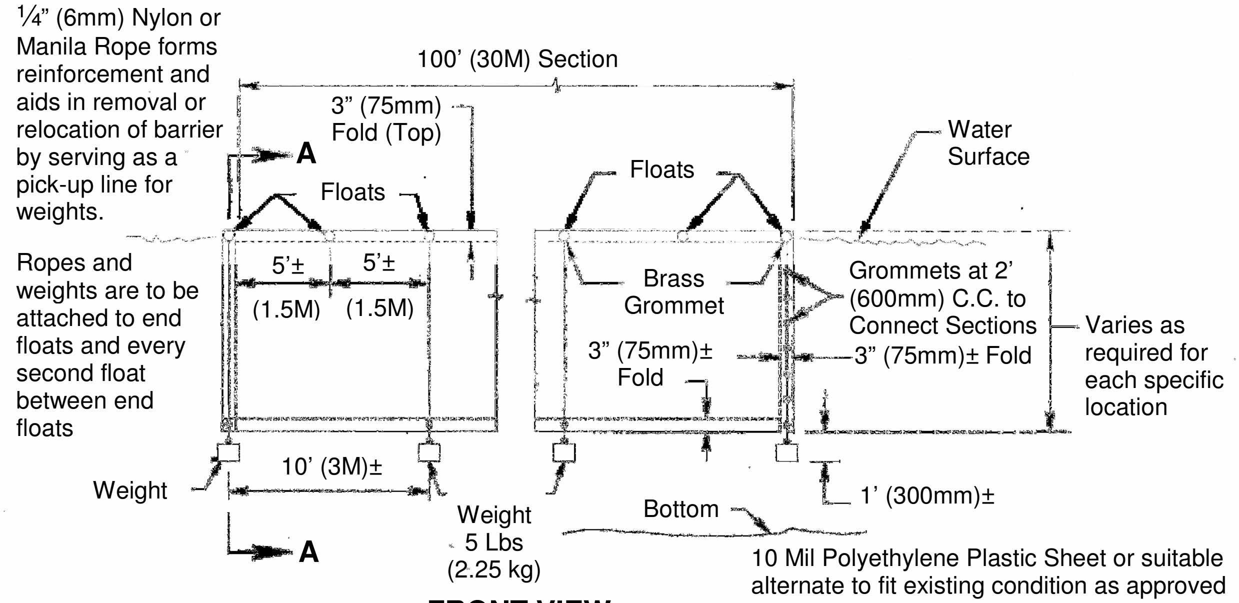
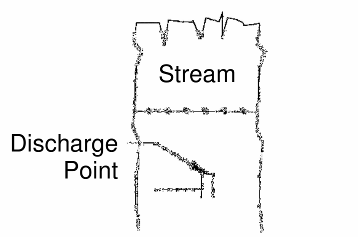


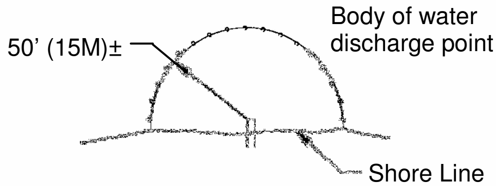
FIGURE 4.13-2 FLOATING TURBIDITY BARRIER



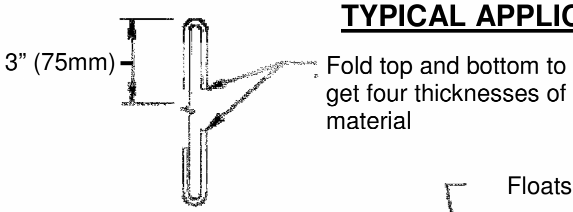
FRONT VIEW



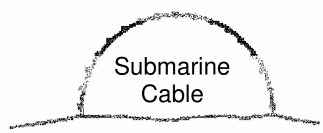
TYPICAL APPLICATION



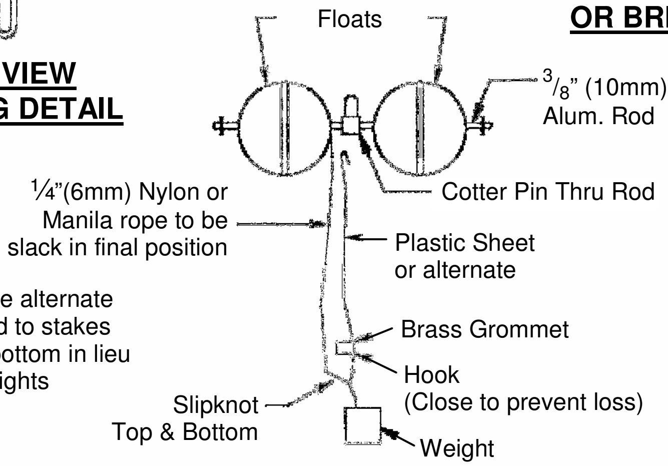
TYPICAL APPLICATION



SIDE VIEW FOLDING DETAIL



WET EXCAVATION OR BRIDGE STRUCTURE (WET)



Note: Suitable alternate may be fastened to stakes driven into the bottom in lieu of floats and weights

Section A - A

General Notes:

Place Silt Barrier to prevent drifting of silt caused by discharge of Storm Sewers during construction, dredging or filling operations.

Exact placement of Silt Barrier shall be so as to effectively control silt dispersion under the conditions present on a particular project.

The details shown on this sheet are suggested methods, only. Alternate solutions and usage of materials, may be used as approved.

4.14 STANDARDS FOR PARKING LOT STORAGE

4.14.1 Definition

The temporary storage of runoff on a parking lot

4.14.2 Purpose

The purpose of parking lot storage is to reduce soil erosion and downstream flooding by temporary storage of runoff.

4.14.3 Conditions Where Practice Applies

This practice applies if there is increased downstream soil erosion due to construction at development sites, or from other land use changes. The increased downstream soil erosion may be caused by such factors as increased runoff volume, increased peak discharge, reduced time of concentration, or reduced natural storage.

4.14.4 Design Criteria

General

Parking lot storage areas can be used to control runoff from paved areas. Most parking lot storage areas include small ponding areas that have an increased curb height, an outlet control structure, and an emergency overflow. This practice generally is used to control runoff from areas less than 3 acres (1.2 hectares) in size. The parking lot design and installation grades must insure positive flow to the storage area. The storage area must be nearly level, but the slope must be steep enough to facilitate drainage. Positive drainage must be provided to prevent frost damage. Trash guards must be provided to prevent clogging of the outlet control structure. Generally, ponding on the parking lot must not exceed 6 inches (150 mm) in areas where cars and light trucks are to be parked, or 10 inches (250 mm) where heavy trucks are to be parked. Emergency overflow outlets must be provided. Such auxiliary practices as porous pavement and vegetative strips may be used in or adjacent to parking lots to permit infiltration.

Design Storms

The peak discharge from the 2-year and 10-year frequency storms shall be analyzed. Increase in peak discharge, generated by construction operations and changes in land use, shall be unacceptable, unless the increase does not result in a greater potential for soil erosion.

Some of the items to be considered in determining if there is an increased potential for downstream soil erosion are:

1. the timing of peak flows from sub-watersheds;
2. the increased duration of large flows;
3. the stability of the downstream areas;

4. the distance downstream that the peak discharges are increased.

If there is an overall flood plain management system that considers soil erosion, downstream peak flow increases that are compatible with the overall flood plain management system, may be allowed.

Outlet Control Structure Capacity

The minimum pipe size shall be 6 inches (150 mm). The outlet control structures and the temporary flood storage below the emergency overflow must handle the runoff from the design storms without flow through the emergency overflow. Flood routing shall be done using:

1. the approximate methods in the USDA-NRCS Engineering Field Manual
2. Modified Rational Method as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater.
3. USDA-NRCS Technical Release No. 55 or Technical Release No. 20.
4. U.S. Army Corps of Engineers HEC-1
5. other methods which produce similar results to the models listed above

Ownership

Ownership and responsibility for operation and maintenance of the parking lot storage, after the site is completed, must be determined during design. To be effective over a long period of time, parking lot storage must be properly maintained. Parking lot storage should normally be owned by a unit of government that accepts responsibility for the parking lot storage, and can obtain the money necessary for operation and maintenance work.

If the parking lot storage is not owned by a unit of government, there should be a legally binding and easily enforceable document requiring the owner to operate and maintain the parking lot storage so that the benefits to the public of installing the parking lot storage are received over its intended life.

Operation and Maintenance

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for parking lot storage to insure that it functions properly. This plan shall provide requirements for inspection, operation, and maintenance of the parking lot storage, including outlets. It shall be prepared during design and shall specify who is responsible for maintenance. Adequate access must be provided for maintenance.

4.15 STANDARDS FOR ROOFTOP STORAGE

4.15.1 Definition

The temporary storage of runoff on a roof, normally a flat roof

4.15.2 Purpose

The purpose of rooftop storage is to reduce soil erosion and downstream flooding by temporary storage of runoff.

4.15.3 Conditions Where Practice Applies

This practice applies if there is increased downstream soil erosion due to construction at development sites or from other land use changes. The increased downstream soil erosion may be caused by such factors as increased runoff volume, increased peak discharge, reduced time of concentration, or reduced natural storage.

4.15.4 Design Criteria

<u>Structural Design</u>

The roof shall be structurally sound and capable of holding retained stormwater as well as wind and snow loads. Requirements for structural stability are outside the scope of this standard and shall be determined by the building designer.

<u>Design Storms</u>

The peak discharge from the 2-year and 10-year frequency storms shall be analyzed. Increases in peak discharge generated by construction operations and changes in land use shall be unacceptable, unless the increase does not result in a greater potential for soil erosion.

Some of the items to be considered in determining if there is an increased potential for downstream soil erosion are:

1. the timing of peak flows from sub-watersheds;

2. the increased duration of large flows;

3. the stability of the downstream areas;

4. the distance downstream that the peak discharges are increased.

If there is an overall floodplain management system that considers soil erosion, downstream peak flow increases that are compatible with the overall floodplain management system may be allowed.

<u>Detention Ring Design</u>

An adequate number of roof drains shall be provided. Emergency overflow measures shall be provided to prevent overloading if roof drains or detention rings become plugged.

Detention rings, or other flow restrictors, shall be placed around all roof drains on roofs to be used for storage. The required number of holes or the size of openings in the rings shall be computed on the basis of the area of roof drainage per detention ring and the design storm criteria. Maximum time of storage on the roof shall not exceed 24 hours.

Ownership

To be effective over a long period of time, rooftop storage must be properly maintained. There should be a legally binding and easily enforceable document requiring the building owner to operate and maintain the rooftop storage so that the benefits to the public of installing rooftop storage are received over the life of the practice.

Operation and Maintenance

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the rooftop storage to insure that it functions properly. This plan shall provide requirements for inspection, operation, and maintenance of the rooftop storage, including outlets. It shall be prepared during design and shall specify who is responsible for maintenance. Adequate access must be provided for maintenance.

4.16 STANDARDS FOR UNDERGROUND TANKS

4.16.1 Definition

The temporary storage of runoff in a buried structure

4.16.2 Purpose

The purpose of underground tanks is to reduce downstream soil erosion and flooding by temporary storage of runoff.

4.16.3 Conditions Where Practice Applies

This practice applies if there is increased downstream soil erosion due to construction at development sites or from other land use changes. The increased soil erosion may be caused by increased runoff volume, increased peak discharge, reduced time of concentration, or reduced natural storage.

4.16.4 Design Criteria

<u>Structural Design</u>

Underground tanks shall be designed to prevent failure due to internal or external pressures including hydrostatic uplift pressure and imposed surface loads (such as vehicles operated on or adjacent to the tank). Criteria for structural design are outside the scope of this standard, but shall be based on sound and accepted engineering principles.

<u>Design Storms</u>

The peak discharge from the 2-year and 10-year frequency storms shall be analyzed. Increases in peak discharge, generated by construction operations and changes in land use shall be unacceptable, unless the increase does not result in a greater potential for soil erosion.

Some of the items to be considered when determining potential for downstream soil erosion are:

1. the timing of peak flows from sub-watersheds;

2. the increased duration of large flows;

3. the stability of the downstream areas;

4. the distance downstream that the peak discharges are increased.

If there is an overall flood plain management system that considers soil erosion, downstream peak flow increases that are compatible with the overall flood plain management system, may be allowed.

Outlet Capacity

The minimum outlet pipe size shall be 5 inches (130 mm). The outlet and the temporary storage in the tank must handle the runoff from the design storms. Flood routing may be done using:

1. the approximate methods in the USDA-NRCS Engineering Field Manual

2 Modified Rational Method as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater

2. USDA-NRCS Technical Release No. 55 or Technical Release No. 20

3. U.S. Army Corps of Engineers HEC-1

4. other methods which produce similar results to the models listed above

The maximum time of storage shall not exceed 3 days.

General

In acidic or sulfuric soils, tank materials shall be non-reactive with the soil or measures shall be taken to protect the tank from the soil. Provisions shall be made to prevent debris from entering the tank. Debris collectors shall be placed so that the need for maintenance can be readily detected and cleaning operations easily performed. The bottom of the tank shall be on a slight grade to insure complete drainage of the tank. Access must be provided to the tank to permit removal of sediment and other debris.

Ownership

Ownership and responsibility for operation and maintenance of the underground tank, after the site is completed, must be determined during design and should be shown on the plans. To be effective over a long period of time, the underground tank must be properly maintained. Tanks should normally be owned by a unit of government that accepts responsibility for the tank and can obtain the money necessary to do operation and maintenance work. If the underground tank is not owned by a unit of government, there should be a legally binding and easily enforceable document requiring the owner to operate and maintain the tank so that the benefits to the public of installing the tank are received over its intended life.

Operation and Maintenance

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the underground tank to insure that it functions properly. This plan shall provide requirements for inspection, operation, and maintenance of the tank, including outlets. It shall be prepared during design and shall specify who is responsible for maintenance. Adequate access must be provided for maintenance.

4.17 STANDARDS FOR SUBSURFACE DRAINAGE

4.17.1 Definition

Removal of water through the soil by conduit, such as tile, pipe, or tubing, installed beneath the ground surface to collect and convey drainage water.

4.17.2 Purpose

The purpose of subsurface drainage is to improve vegetation by lowering the water table, intercepting and preventing water movement into a potentially wet area, relieving artesian pressures, reducing surface runoff, serving as an outlet for other drains, and replacing natural subsurface drainage patterns interrupted by construction operations.

4.17.3 Conditions Where Practice Applies

Drains shall be used in areas having a high water table where benefits of lowering groundwater or controlling surface runoff justify the installation of such a system.

The soil shall have enough depth and permeability to permit installation of an effective system. On-site investigations are required before installation.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity and quality of effluent to be disposed of with consideration of possible damages above or below the point of discharge.

4.17.4 Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Design Inflow

The design inflow can be determined by the use of the method described in reference (9) of Appendix A6, the use of Table 4.17-1, or by other accepted methods.

TABLE 4.17-1 INFLOW RATES FROM DIFFERENT SOIL TEXTURES [1,2]

SOIL TEXTURE	UNIFIED SOIL CLASSIFICATION	INFLOW RATE PER 300m of LINE in m^3/s	INFLOW RATE PER 1000 feet of LINE in f^3/s
Coarse Sand and Gravel	GP, GW, SP, SW	0.0042 to 0.0283	0.15 to 1.00
Sandy or Gravelly Loam	SM, SC, GM, GC	0.0020 to 0.0071	0.07 to 0.25
Silt Loam	CL, ML	0.0011 to 0.0028	0.04 to 0.10
Clay and Clay Loam	CL, CH, MH	0.0006 to 0.0057	0.02 to 2.20

[1]Required inflow rates for interceptor lines on sloping land should be increased by 10% for slopes 2% to 5%; 20% for slopes 5% to 12%; and 30% for slopes over 12%.

[2]For complete drainage systems, use the lower value in the above table for the given soil texture.

Unified Soil Classification System; from American Society for Testing and Materials, 1985

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO.200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO.4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO.200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

<u>Size of Drain</u>

The size of drains shall be computed by applying Manning's formula. The minimum size drain shall be equivalent to a 4-inch (100 mm) diameter pipe.

<u>Depth, Spacing, and Location</u>

The depth, spacing, and location of the drain shall be based on site conditions including soils, groundwater conditions, topography, and outlets.

Minimum Velocity and Grade

In areas with no siltation hazard, the minimum grades shall be 0.1%. Where it is determined that a siltation hazard exists, velocity of not less than 1.4 ft/s (0.43 m/s) shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for prevention of siltation by filters or collection and removal of silt by use of silt traps.

Maximum Grade and Protection

On sites where topographic conditions require the use of drain lines on grades steeper than 2% or where design velocities will be greater than indicated in Table 4.17-2, special measures shall be used. These measures shall be specified for each job based on the particular conditions of the job site. Possible protective measures include the following:

1. Lay the drains so as to secure a tight fit with the inside of one section matching that of the adjoining section.

2. Wrap open joints with Geotextile filter.

3. Select the least erodible soil available for hand placing on sides and top of conduit, which must be tamped before backfilling. Tamped thickness of this material over conduit shall be a minimum of 2 inches (50 mm).

4. For continuous pipe or tubing with perforations, completely enclose the pipe with geotextile filter material or properly graded sand and gravel as specified under filters and filter materials.

5. Install relief vents where changes in grade exceed 5%.

TABLE 4.17-2 MAXIMUM. PERMISSIBLE VELOCITY IN DRAINS WITHOUT PROTECTIVE MEASURES

SOIL TEXTURE	VELOCITY f/s	VELOCITY m/s
Sandy Loam	2.5	0.76
Silt and Silt Loam	4.0	1.22
Silty Clay Loam	5.0	1.52
Clay and Clay Loam	6.0	1.83
Coarse Sand and Gravel	8.0	2.44

Materials for Drains

Drains include conduits of clay, concrete, bituminized fiber, metal, plastic, or other materials of acceptable quality. The conduit shall meet strength and durability requirements of the site.

Loading

The allowable loads on 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.

Filters and Filter Material

Suitable filters shall be used, where required by site conditions, to prevent sediment accumulation in the conduit. The characteristics of the soil materials at drain depth and the velocity of flow in the conduit shall determine the need for a filter.

Not less than 3 inches (80 mm) of filter material shall be used for sand-gravel filters.

Envelopes shall be used around drains where necessary to improve flow characteristics of groundwater into the conduit.

Installation Requirements

All drains shall be laid to line and grade, and covered with not less than 3 inches (80 mm) of approved hand placed backfill and/or filter material. The upper end of all drain lines shall be closed with concrete or other durable material unless connected to a structure.

Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur, and so that the filter material, after backfilling, will meet the requirements of the design.

The gap between drain pipe joints shall not exceed ¼ inch (6 mm) for mineral soils or ½ inch (13 mm) for organic soils. Openings wider than these shall be covered with geotextile or other suitable material.

If the conduit is to be placed in a rock-trench, or where rock is exposed in the bottom of the trench, the rock shall be removed below grade deep enough so that the trench may be backfilled, compacted, and bedded so that the conduit is not less than 2 inches (50 mm) from rock.

When an iron sulfide chemical reaction causes sealing of joints or perforations, the drain shall be enclosed in a clean sand-gravel filter. Riser pipes for flushing the line shall be provided at intervals not to exceed 500 feet (152 meters).

A recommended method of installation is to place filter material to a depth of 3 inches (80 mm) under the drain, and cover the drain and filter with a sheet of plastic. The filter shall be designed to prevent the material in which the installation is made from entering the drain. Not more than 10% of the filter shall pass the No. 60 (250 micrometer) sieve.

4.18 STANDARDS FOR CONDUIT OUTLET PROTECTION

4.18.1 Definition

Conduit outlet protection consists of a soil erosion resistant section between a conduit outlet and a stable downstream channel.

4.18.2 Purpose

The purpose of conduit outlet protection is to provide a stable area at the outlet of a conduit, so that the exit velocity is reduced to a level consistent with a stable condition in the downstream channel.

4.18.3 Conditions Where Practice Applies

This practice applies to all conduit outlets.

4.18.4 Design Criteria

Determination of Needs

The need for conduit outlet protection shall be determined by the information given in Table 4.18-1 and by comparing the allowable velocity for the soil onto which the conduit is discharging with the velocity in the conduit; the need for outlet protection can be determined. The velocity in the conduit shall be that which occurs during passage of the conduit design storm or the 25-year frequency storm, whichever is greater. When the velocity in the conduit exceeds the allowable velocity for the soil, conduit outlet protection shall be used.

TABLE 4.18-1 ALLOWABLE VELOCITY FOR VARIOUS SOILS

SOIL TEXTURE	ALLOWABLE VELOCITY f/s	ALLOWABLE VELOCITY m/s
Sand	1.75	0.53
Sandy Loam	2.5	0.76
Silt Loam (high lime clay)	3.0	0.91
Sandy Clay Loam	3.5	1.07
Clay Loam	4.0	1.22
Clay, Fine Gravel, Graded Loam to Gravel	5.0	1.52
Cobbles	5.5	1.66
Shale (non-weathered)	6.0	1.83

A. Horizontal Riprap Apron:

Apron Dimensions

1. The length of the apron, L_a, shall be determined from the formula:

$$L_a = \frac{k_1 q}{D_o^{1/2}} + 7 D_o$$ If TW < ½ D_o

$$L_a = \frac{k_2 q}{D_o^{1/2}}$$ If TW >½ D_o

   Where D_o is the maximum inside culvert height in feet (meters), W_o is the maximum inside culvert width, TW is the Tail water width, q is the unit discharge in cubic feet (meters) per second for the conduit design storm or the 25 year storm, whichever is greater. k is a constant value and is given in Table 4.18-2.

2. Where there is no well-defined channel immediately downstream of the culvert outlet, the width, W, in feet (meters) of the outlet end of the apron shall be as follows:

   For tail water elevation greater than or equal to the elevation of the center of the pipe,

   $W = 3\ W_o + 0.4\ L_a$. (Figure 4.18-1)

   For tail water elevation less than the elevation of the center of the pipe,

   $W = 3\ W_o + L_a$. (Figure 4.18-1)

   Where L_a is the length of the apron determined from the formula and W_o is the culvert width, in feet (meters), The width of the apron at the culvert outlet shall be at least 3 times the culvert width.

3. Where there is a well-defined channel downstream of the culvert outlet, the bottom width of the apron shall be at least equal to the bottom width of the channel. The height of the lining shall extend the greater of at least 1 foot (0.3 m) above the tail water elevation but no less than two thirds of the vertical culvert dimension above the culvert invert.

4. For multiple culvert outlets:

   a. When the spacing between the culverts is less than of the width of the culvert, the riprap size and apron dimensions for one culvert shall accommodate all culverts.

   b. When the spacing between the culverts is greater than of the width of the culvert, the riprap size and apron dimensions shall be 25% larger than the dimensions for one culvert.

c. For culverts of varying diameters or discharge, check riprap size and apron length for each. Use the largest values. Increase the length and riprap values by 25% if spacing between the culverts is greater than 1/4 of the width of the culverts. Width shall accommodate all culverts. (Figure 4.18-2)

5. The side slopes shall be 1:2 or flatter.

6. The bottom grade shall be 0.0% (level).

7. There shall be no overfall at the end of the apron or at the end of the culvert.

B. **Riprap**:

1. The median stone diameter, d_{50}, in mm, shall be determined from the formula:
For areas where TW cannot be computed, use TW=0.2D_o

$$d_{50} = \frac{K_3}{TW}\left(\frac{Q}{D_o}\right)^{4/3}$$

where $q = \frac{Q}{W_o}$ and where Q, and D_o, are as defined under apron dimensions and TW is tail water depth above the invert of culvert, given in English units.

TABLE 4.18-2 CONSTANT "K" VALUES FOR RIPRAP

CONFIGURATION	HORIZONTAL RIPRAP APRON LENGTH		RIPRAP- MEDIAN STONE DIAMETER
Condition	TW < ½ D_o	TW > ½ D_o	
Equation	$L_a=(K_1q/D_o^{1/2})+7D_o$	$L_a=K_2q/D_o^{1/2}$	$D_{50}=(K_3/Tw)q^{1.33}$
Constant	K_1 = 1.8	K_2 = 3	K_3 = 0.02
Circular Culvert	3.260	5.440	3.510
Elliptical Culvert	1.657	0.994	0.00722
Box Culvert	35.100	58.500	0.8265

C. Preformed Scour Hole

Preformed scour holes may be utilized, as depicted in Figure 4.18-3, where conditions dictate the impractical use of flat aprons. The median stone diameter, d_{50}, in feet (mm), shall be determined from the following formulas:

$$d_{50} = \frac{k_4}{TW}\left(\frac{Q}{D_o}\right)^{4/3}$$ Where $Y={}^1/_2 D_o$

$$d_{50} = \frac{k_5}{TW}\left(\frac{Q}{D_o}\right)^{4/3}$$ Where $Y= D_o$

Y=depth of scour hole below culvert invert

Scour hole permits both vertical and lateral expansions and turbulence, therefore rock sizes are smaller than for the horizontal apron.

Lining thickness and gradation requirements are the same as for the horizontal apron.

In confined outlets, the height of lining above the pipe invert must meet the same requirements as for the horizontal apron.

The use of scour holes shall comply with county or local ordinances, which would restrict the use of such devices due to possible problems with mosquito breeding.

TABLE 4.18-3 CONSTANT "K" VALUES FOR SCOUR HOLE

CONFIGURATION	PREFORMED SCOUR HOLE	
Condition	$Y = ½ D_o$	$Y = D_o$
Equation	$D_{50} = (K_4Tw)q^{1.33}$	$D_{50} = (K_5T_w)q^{1.33}$
Constant	$K_4 = 0.0125$	$K_5 = 0.0082$
Circular Culvert	0.0274	0.180
Elliptical Culvert	0.00564	0.0037
Box Culvert	1.291	0.847

Downstream Protection

The conduit discharge shall not cause soil erosion in the downstream channel, or aggravate conditions in the downstream channel. The designer shall furnish calculations to show that the conditions downstream will not be degraded as a result of the proposed construction.

Riprap Requirements

1. Fifty percent, by weight, of the riprap mixture shall be smaller than the median size stone designated as d_{50}. The largest stone size in the mixture shall be 1.5 times the d_{50} size. The riprap shall be reasonably well-graded.

2. A minimum d_{50} stone size of 6 inches (150 mm) shall be used.

3. The thickness of lining, filter, and quality shall meet the requirements in the Standard for (Section 4.19).

4. Properly designed concrete paving may be substituted for riprap.

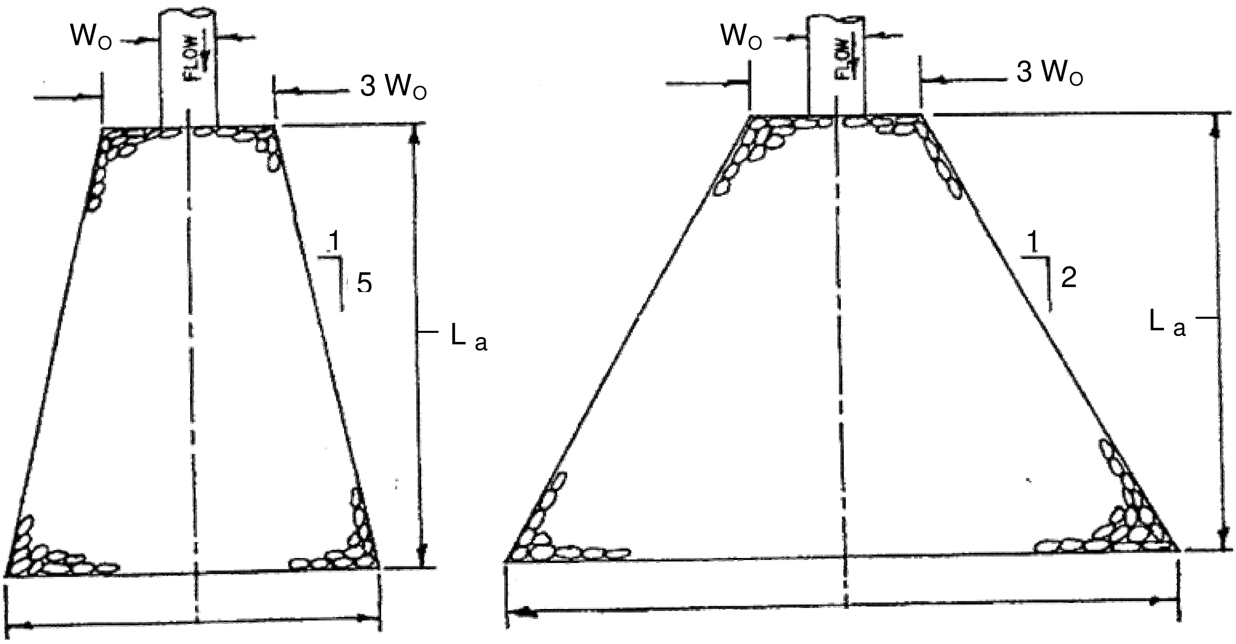
5. Gabions or concrete revetment blocks may be substituted for if the d_{50} size calculated above is less than or equal to the thickness of the gabions or concrete revetment blocks. Design life of gabions is estimated to be ten (10) years. Gabions shall be filled with 4 to 7 inch (100 mm to 180 mm) angular shaped rock.

Installation Requirements

1. No bends or curves at the intersection of the conduit and apron, or at the scour hole, will be permitted.

2. There shall be no overfall from the end of the apron to the receiving channel.

FIGURE 4.18-1 CONFIGURATION OF CONDUIT OUTLET PROTECTION



$W = 3\ W_O + 0.4\ L_a$

Tail water $\geq 0.5\ D_O$

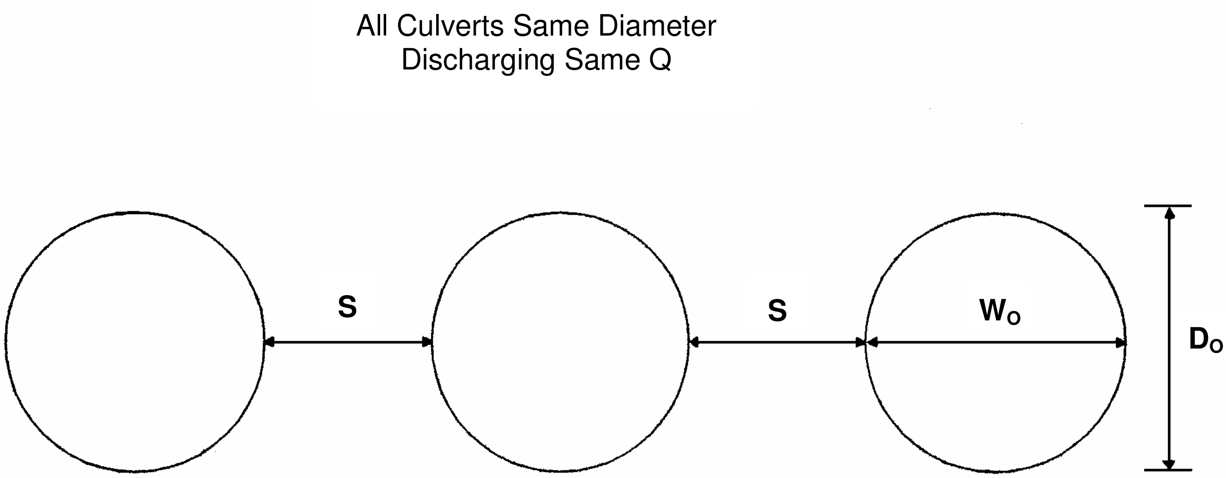
$W = 3\ W_O + L_a$

Tail water $< 0.5\ D_O$

References:

Fletcher, B.P. and Grace, J.S. Jr., Practical guidance for estimating and controlling erosion at culvert outlets, 1972, Corps of Engineers Research Report H-72-5, Waterways Experiment Station, Vicksburg, Mississippi.

FIGURE 4.18-2 GUIDANCE FOR MULTIPLE CULVERT OUTLETS



For $S < \frac{1}{4} W_O$ Size riprap & length for 1 pipe.
Width shall accommodate all culverts.

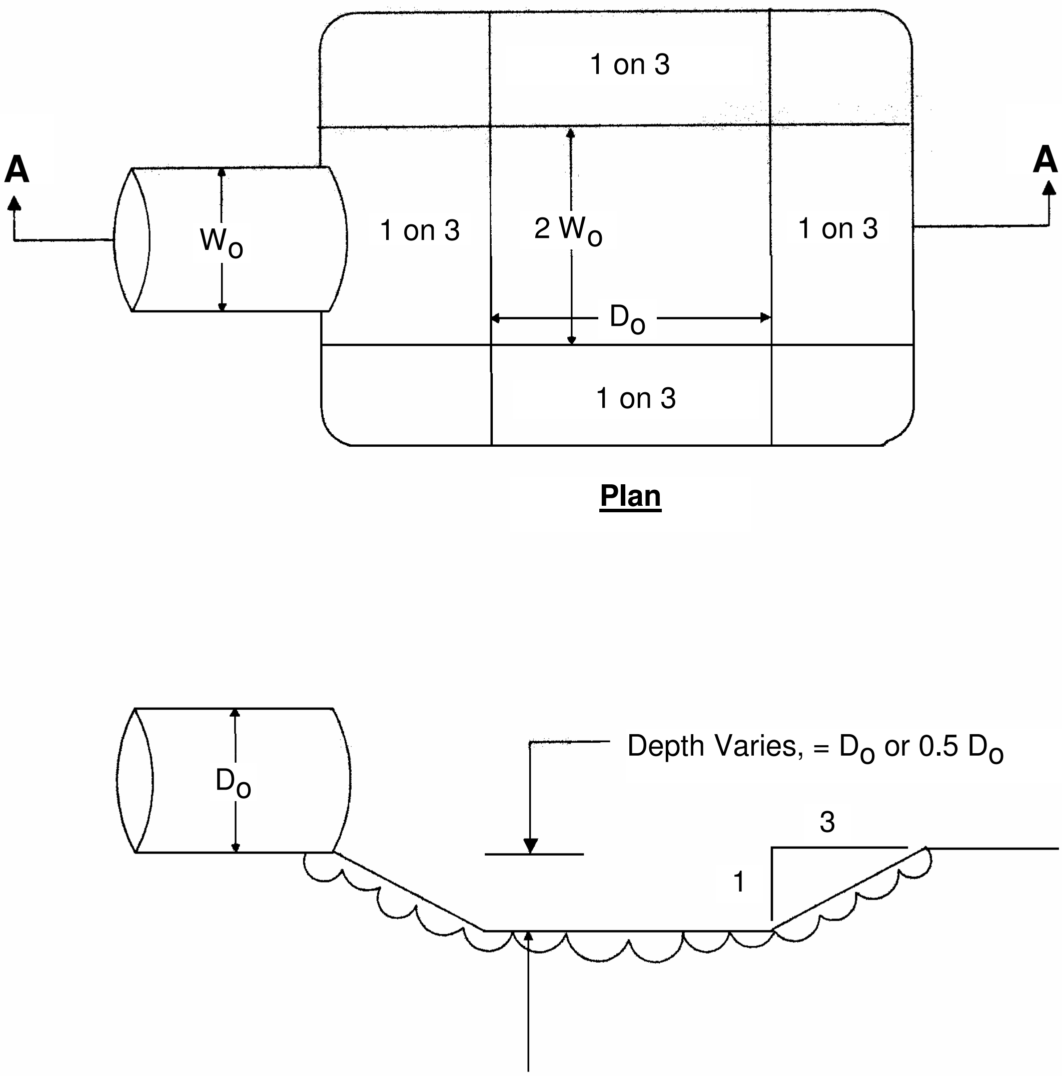
For $S \geq \frac{1}{4} W_O$ Size riprap & length for 1 pipe and
increase values by 25%.

For culverts of varying diameters or discharge, check riprap size and apron length for each. Use the largest values. Increase length and riprap values by 25% if spacing is greater than $\frac{1}{4} W_O$. Width shall accommodate all culverts.

Where S is the Spacing between the culverts in feet (meters), D_o is the maximum inside culvert height in feet (meters), W_o is the maximum inside culvert width in feet (meters).

FIGURE 4.18-3 PREFORMED SCOUR HOLE

Preformed Scour Hole



SECTION A-A

4.19 STANDARDS FOR RIPRAP

4.19.1 Definition

A layer of loose rock, aggregate, bagged-concrete, gabions, or concrete revetment blocks placed over an erodible soil surface

4.19.2 Purpose

The purpose of riprap is to protect the soil surface from the erosive forces of water.

4.19.3 Conditions Where Practice Applies

This practice applies to soil-water interfaces where the soil conditions, water turbulence and velocity, expected vegetative cover, and groundwater conditions are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at such places as channel banks and/or bottoms, roadside ditches, and drop structures. This Standard applies to slopes less than 10 %.

4.19.4 Design Criteria

Design Storm

The riprap shall be designed to be stable when the channel is flowing at the design discharge or the 25-year frequency storm discharge, whichever is greater.

Capacity shall be determined by the following methods:

1. Rational Method - for peak discharge areas as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, September 1997, or any revisions thereto.

2. USDA-NRCS (SCS) Technical Release No. 55, Technical Release No. 20, Hec-1, or other officially approved methodology.

3. U. S. Army Corp of Engineers. – Hec-1.

4. Other official approved methodology.

Riprap Size and Location

Riprap shall be sized using the design procedures in this Standard or the "National Cooperative Highway Research Program Report No. 108, Tentative Design Procedure for Riprap-Lined Channels." These procedures are for determining a design stone size, such that the stone is stable under the design flow conditions. The design stone size is the d_{50} stone diameter.

Erosive forces of flowing water are greater in bends than in straight channels. If the riprap size (d_{50}) computed for bends is less than 10% greater than the riprap size (d_{50}) for straight channels, then the riprap size for straight channels shall be considered adequate for bends. Otherwise, the larger riprap size shall be used in the bend. The riprap size to be used in a bend shall extend upstream from the point of curvature and downstream from the point of tangency a distance equal to five times the channel bottom width, and shall extend across the bottom and up both sides of the channel.

Riprap for banks shall extend up the banks to the level of the design storm or the top of bank, whichever is lower.

In channels where no riprap or paving is required in the bottom, but is required on the banks, the toe of the bank riprap shall extend below the channel bottom a distance at least 8 times the maximum stone size, but in no case more than 3 feet (900 mm). The only exemption to this would be if there was a non-erodible hard rock bottom.

Riprap Gradation

The riprap shall be composed of a well-graded mixture such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes, but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

The designer, after determining the riprap size that will be stable under the flow condition, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of vandalism shall be considered by the designer in selecting a riprap size.

Thickness of Riprap Lining

Construction techniques, discharge, size of channel, sizes and graduation of riprap, etc., should be taken into consideration when determining the thickness of riprap lining. The thickness of riprap lining shall meet the following criteria:

1. a thickness of at least two times the d_{50} size with a minimum d_{50} stone size of 6 inches (150 mm)
2. riprap shall be placed on a 6 inches (150 mm) layer of course aggregate No. 57 placed on synthetic geotextile fabric.

Geotextile Fabric

The synthetic geotextile fabric is placed under the riprap lining to reduce the effects of leaching. Leaching is the process by which the finer base materials beneath the riprap are picked up and carried away by the turbulence that penetrates the interstices of the riprap.

Synthetic geotextile fabric shall meet the following criteria:

1. For geotextile fabric adjacent to granular materials containing 50% or less by weight of fines (Minus No. 200 material) (Minus 75 Micrometer material):

   a. $\frac{\text{85\% size of material (mm)}}{\text{EOS}^{*}\text{ (mm)}} > 1$

   b. open area not to exceed 36%.

2. For geotextile fabric adjacent to all other soils:

a. AOS* no larger than the opening in the U.S. Standard 212 Micrometer sieve and no smaller than the opening in the U.S. Standard 150 Micrometer sieve.

b. for non-woven fabric, AOS no larger than the opening in the sieve.

*EOS, Apparent Opening Size, is defined as the number of the U.S. Standard sieve having openings closest in size to the geotextile fabric openings.

Geotextile fabric shall meet the U.S. Army Corps of Engineers Guide Specifications, CW02215 -B6, for strength. Riprap that is 12-inch (300 mm) and larger shall not be dumped directly onto geotextile fabric unless the manufacturer recommends such use for the fabric. If 12-inch (300 mm) and larger riprap is used, a 4-inch (100 mm) minimum layer of gravel shall be placed on the geotextile fabric. The other alternative is to place the riprap directly on the geotextile by hand or by using the bucket of the equipment.

Where seepage forces exist or where hydrostatic pressures may be developed in the base soil, the permeability of the geotextile shall be 10 times the permeability of the base soil.

Quality

Stone for riprap shall consist of fieldstone or quarry stone of an approximate rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 lbs/ft^3 (2400 $k_g/m^{3)}$ and otherwise meets the requirements of this Standard.

Bagged Concrete

Bagged concrete is made up of bags filled with concrete and placed next to each other. The consistency of the concrete shall be as stiff as necessary yet able to be discharged from the mixer and the process of bagging will permit. The bags shall be filled three-quarters full with concrete and shall be laid in close contact, with staggered joints and tied ends turned in.

Bagged concrete may be used when all the following conditions are met:

1. The design storm, riprap size and location, and geotextile fabric criteria for riprap are met.

2. The weight of the filled bags is at least equal to the weight of the maximum stone size required for rock riprap.

3. Settlement or lateral movements of foundation soils is not anticipated.

4. Ice conditions are not severe.

5. A geotextile fabric is used.

6. Slopes somewhat steeper than 2H:1V(1:2) may be permitted under special circumstances.

Gabions

Gabions are baskets formed of wire mesh and filled with cobbles or coarse gravel. A thinner version of gabions is known as a Reno mattress.

Gabions may be used when all the following conditions are met:

1. The design storm shall be the same as that required for riprap. Riprap size and location, geotextile fabric, and quality criteria shall be as outlined below.

2. The design water velocity does not exceed that given below:

TABLE 4.19-1 GABION THICKNESS

GABION THICKNESS (ft)	GABION THICKNESS (mm)	MAXIMUM VELOCITY (ft/sec.)	MAXIMUM VELOCITY (meters/sec.)
0.50	150	6	1.8
0.75	230	11	3.4
1.0	300	14	4.3

3. The Manning's "n" value used for gabions shall be 0.025.

4. The gabions are not exposed to abrasion from sand or gravel transported by moving water.

5. Plastic coated gabions shall be used.

6. The rock used to fill the gabions shall be 4 to 7 inches, (100 to 180 mm) angular, block-shaped rock.

7. All gabions or Reno mattresses placed against the bottom of a channel shall be underlain by a geotextile fabric designed according to the limits outlined in Table 4.19-2.

TABLE 4.19-2 ALLOWABLE SLOPE FOR VARIOUS SOILS

SOIL TEXTURE	EROSIVE VELOCITY (ft/s)	MAX. ALLOWABLE BOTTOM SLOPE USING A GEOTEXTILE FABRIC[1] (ft/ft)
Sandy Loam	2.5	0.029
Silt Loam	3.0	0.041
Sandy Clay Loam	3.5	0.056
Clay Loam	4.0	0.074
Clay, Fine Gravel, Graded Loam to Gravel	5.0	0.115
Cobbles	5.5	0.139

SOIL TEXTURE	EROSIVE VELOCITY (m/s)	MAX. ALLOWABLE BOTTOM SLOPE USING A GEOTEXTILE FABRIC[1] (m/m)
Sandy Loam	0.76	0.029
Silt Loam	0.91	0.041
Sandy Clay Loam	1.1	0.056
Clay Loam	1.2	0.074
Clay, Fine Gravel, Graded Loam to Gravel	1.5	0.115
Cobbles	1.7	0.139

[1]For bottom slopes steeper than those shown, a properly designed gravel filter shall be placed under the gabions.

Concrete Revetment Blocks

Concrete revetment blocks are precast interlocking or cabled concrete grids designed for soil stabilization.

Concrete revetment blocks may be used when all the following conditions are met:

1. the design storm shall be the same as that required for riprap

2. the water velocity does not exceed 9 ft/s (2.7 m/s)

3. the Manning's "n" value used for concrete revetment blocks shall be 0.027, unless otherwise recommended by manufacturer's literature

4. a geotextile fabric is used in accordance with manufacturer's recommendations

Recommended Design Procedure for Riprap-Lined Channels

This design of riprap-lined channels is from the "National Cooperative Highway Research Program Report No. 108, Tentative Design Procedure for Riprap-Lined Channels. It is based on the Tractive Stress Method, and covers the design of riprap in two basic channel shapes: trapezoidal and triangular.

NOTE: This procedure is for uniform flow at normal depth in channels and is not to be used for design of riprap energy dissipation devices immediately downstream from such high velocity devices as pipes and culverts. See the Standard for Conduit Outlet Protection (Section 4.18).

The method in Report No. 108 (design procedure beginning on p. 18) gives a simple and direct solution to the design of trapezoidal channels, including channel carrying capacity, channel geometry, and the riprap lining.

This procedure is based on the assumption that the channel is already designed and the remaining problem is to determine the riprap size that would be stable in the channel. The designer would first determine the channel dimensions by the use of Manning's equation. The "n" value for use in Manning's equation is obtained by estimating a riprap size and then determining the corresponding "n" value for the rip rapped channel from $n = 0.0395\ (d_{50})^{1/6}$, where d_{50} is in inches (mm), or by using Curve 4.19-1, below, where d_{50} is in inches (mm).

MEDIAN RIPRAP SIZE, d_{50} (mm)

When the channel dimensions are known, the riprap can be designed (or an already completed design may be checked) as follows:

Trapezoidal Channels

1. Calculate the b/d ratio and enter Curve 4.19-3 to find the P/R ratio.

2. Enter Curve 4.19-4B with S_b, Q, and P/R to find median riprap diameter, d_{50}, for straight channels.

3. Enter Curve 4.19-1 to find the actual "n" value corresponding to the d_{50} from step 2. If the estimated and actual "n" values do not reasonably agree, another trial must be made.

4. For channels with bends, calculate the ratio B_s/R_o, where B_s is the channel surface width and R_o is the radius of the bend. Enter Curve 4.19-5 and find the bend factor, F_b. Multiply the d_{50} for straight channels by the bend factor to determine riprap size to be used in bends. If the d_{50} for the bend is less than 1.1 times the d_{50} for the straight channel, then the size for straight channel may be used in the bend; otherwise, the larger stone size calculated for the bend shall be used. The riprap shall extend across the full channel section and shall extend upstream and downstream from the ends of the curve a distance equal to five times the bottom width.

5. Enter Curve 4.19-6 to determine maximum stable side slope of riprap surface. In Curve 4.19-6, the side slope is established so that the riprap on the side slope is as

stable as that on the bottom. If for any reason it is desirable to make the side slopes steeper than what is given by Curve 4.19-6, the size of the riprap can be increased and the side slopes made steeper by using the following procedures:

a. Compute d_{50} and maximum stable side slope as above.

b. Enter Curve 4.19-2 with the computed side slope to determine K for that side slope.

c. Enter Curve 4.19-2 with the desired side slope to determine K'.

$$d_{5'0} = d_{50}\frac{k}{k'}$$

d. Compute riprap size for desired slope by the formula:

6. Maximum side slopes, 2:1 (1:2).

Triangular Channels

1. Enter Curve 4.19-4A with S_b, Q, and Z and find the median riprap diameter, d_{50}, for straight channels.

2. Enter Curve 4.19-1 to find the actual "n" value. If the estimated and actual "n" values are not in reasonable agreement, another trial must be made.

3. For channels with bends, see step 4 under Trapezoidal channels.

Example:

Given:
Trapezoidal channel
Q = 100 cfs (2.83 m^3/s)
S = 0.01 ft/ft (0.01 m/m)
Side slopes = 2.5H:1V (1:2.5)
Z = 2.5/1 = 2.5
Mean bend radius, R_o = 25 feet (7.6 meters).
n = 0.033 (estimated, and used to design the channel to find that b = 6 feet (1.8 meters) and d = 1.8 feet (0.54 meters).
Type of rock available is crushed stone.

Solution:
Straight channel reach
b/d = 6/1.8=3.33 (1.8/0.54 = 3.33).
From Curve 4.19-3, P/R = 13.0.
From Curve 4.19-4B, d_{50} = 3.4 in (90 mm)
From Curve 4.19-1, n (actual) = 0.032, which is reasonably close to the estimated n of 0.033

Use 6 inches (150 mm) as minimum riprap size and 12 inches (300 mm) as riprap layer thickness with a filter fabric.

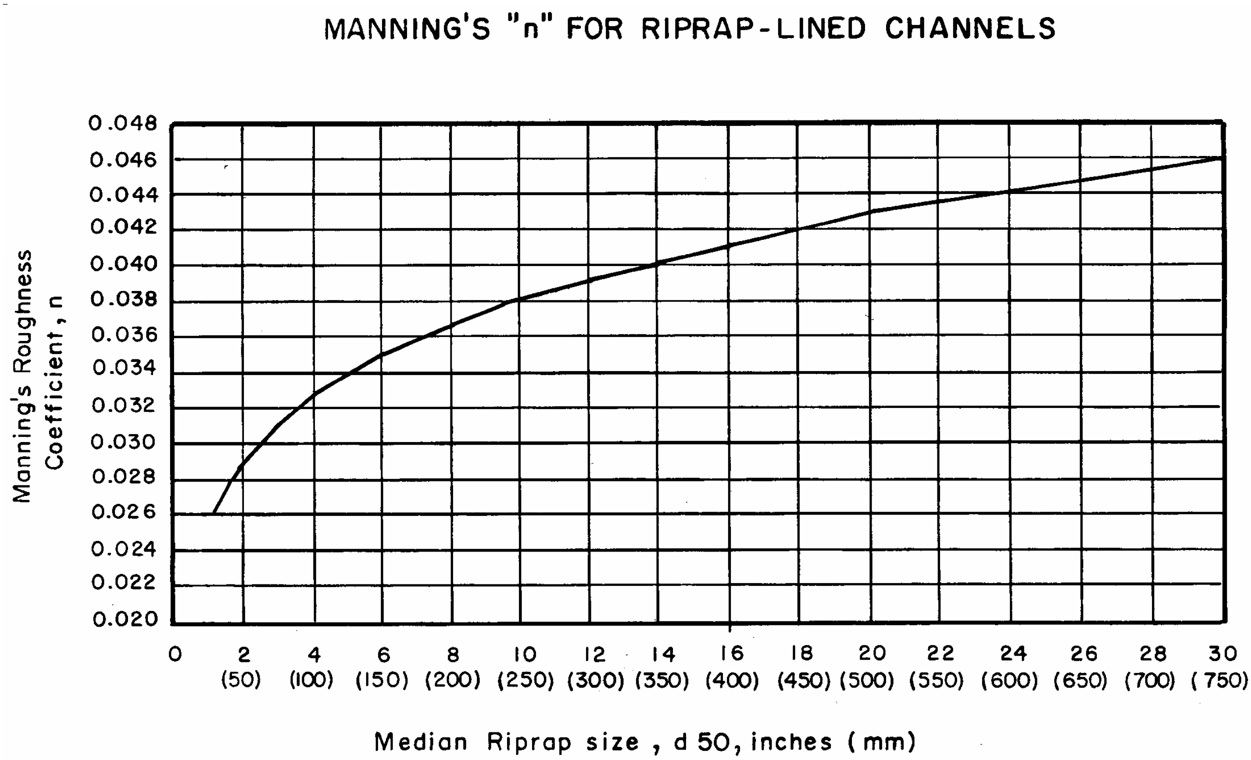
<u>Channel bend</u>
$B_s = b + 2zd = 1.8 + (2)(2.5)(0.54) = 4.5$ meter
$B_s/R_o = 4.5/7.6 = 0.60$.
From Curve 4-19-5, $F_B = 1.33$
$F_B = 1.33 > 1.1$, therefore, the bend factor must be used.
Riprap size in bend, d_{50} = 90 mm x 1.33 = 120 mm

The heavier riprap for the bend shall extend upstream and downstream from the ends of the bend a distance of (5)(6) =30 feet (5)(1.8) = 9 meter

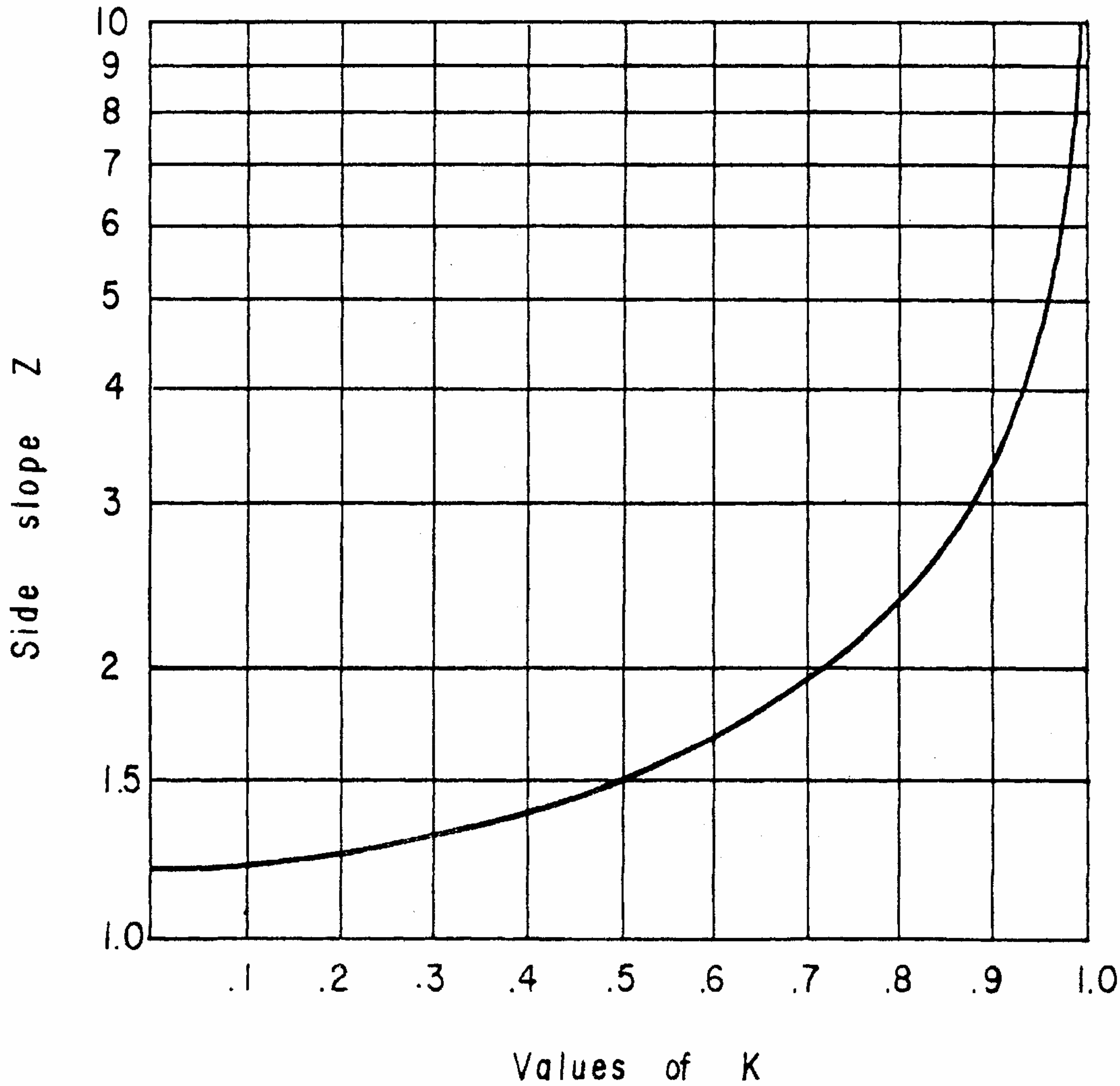
From Curve 4.19-6, it can be found that the riprap for d_{50} = 3.6 inches (90 mm) and 4.8 inches (120 mm) will both be stable on a 2.5H:1V side slope (1:2.5).

<u>Use 6 inches (150 mm) as minimum riprap size and 12 inches (300 mm) as riprap layer thickness with a filter fabric.</u>

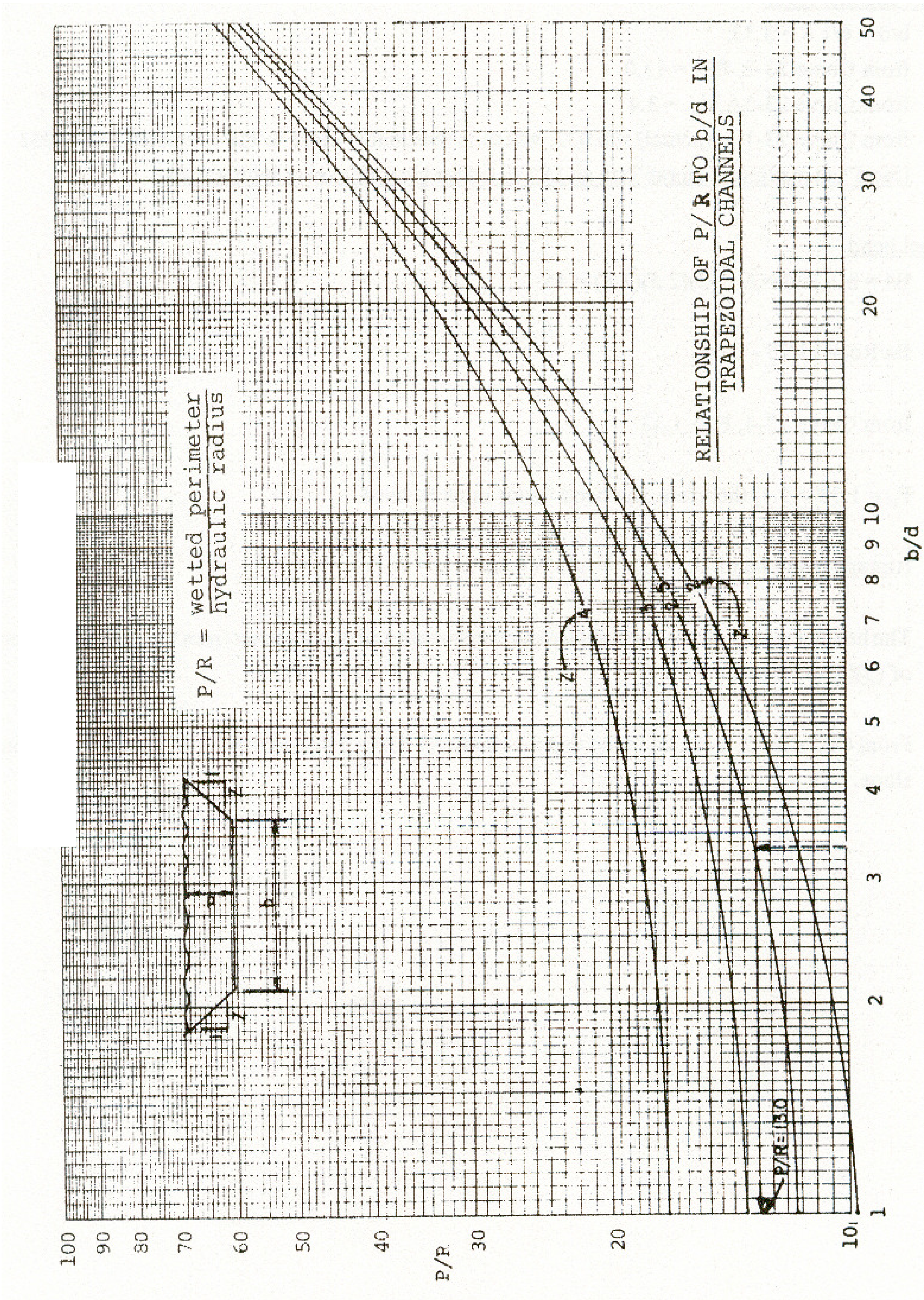
<u>CURVE 4.19-1 MANNING'S "n" FOR RIPRAP-LINED CHANNELS</u>



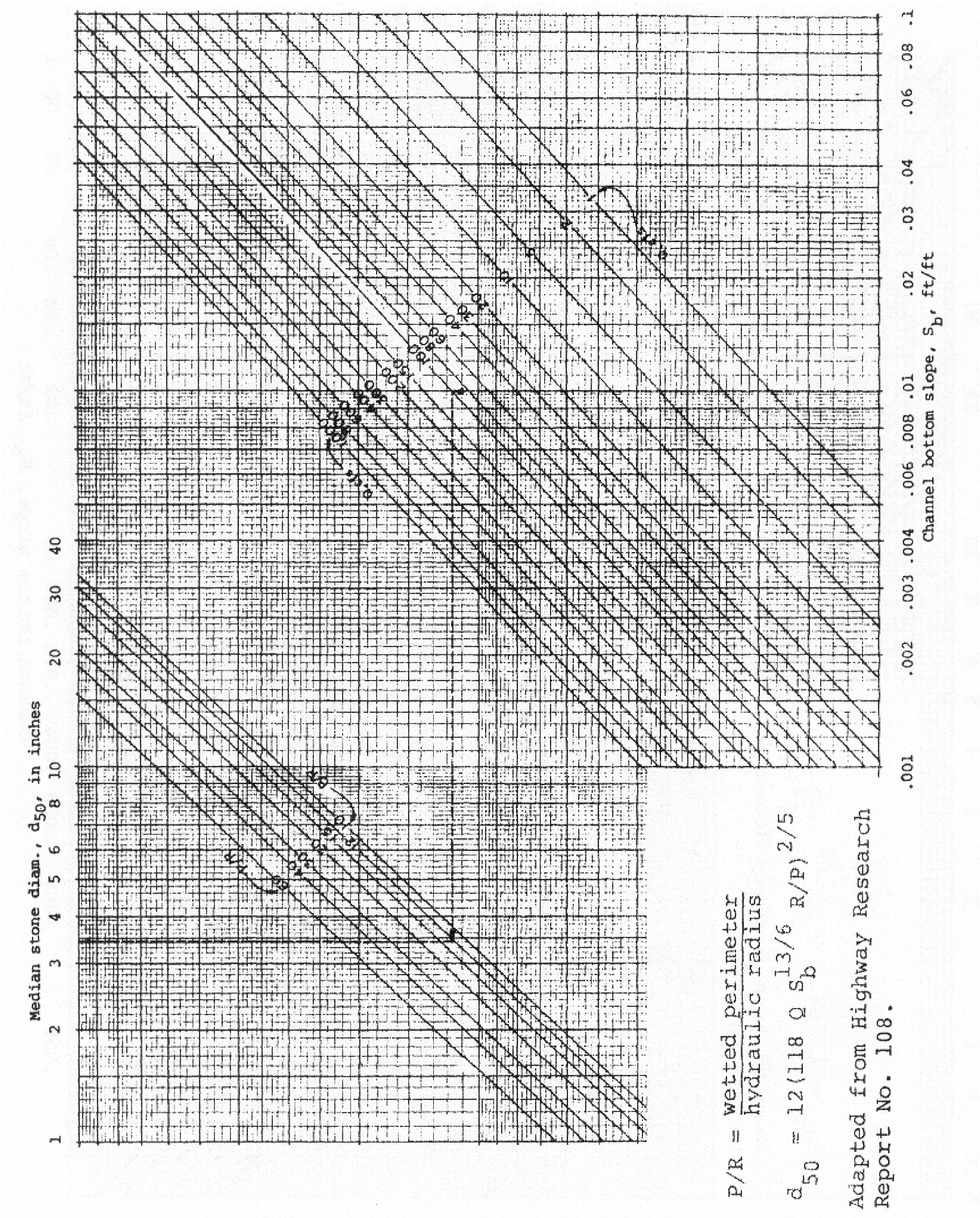
CURVE 4.19-2



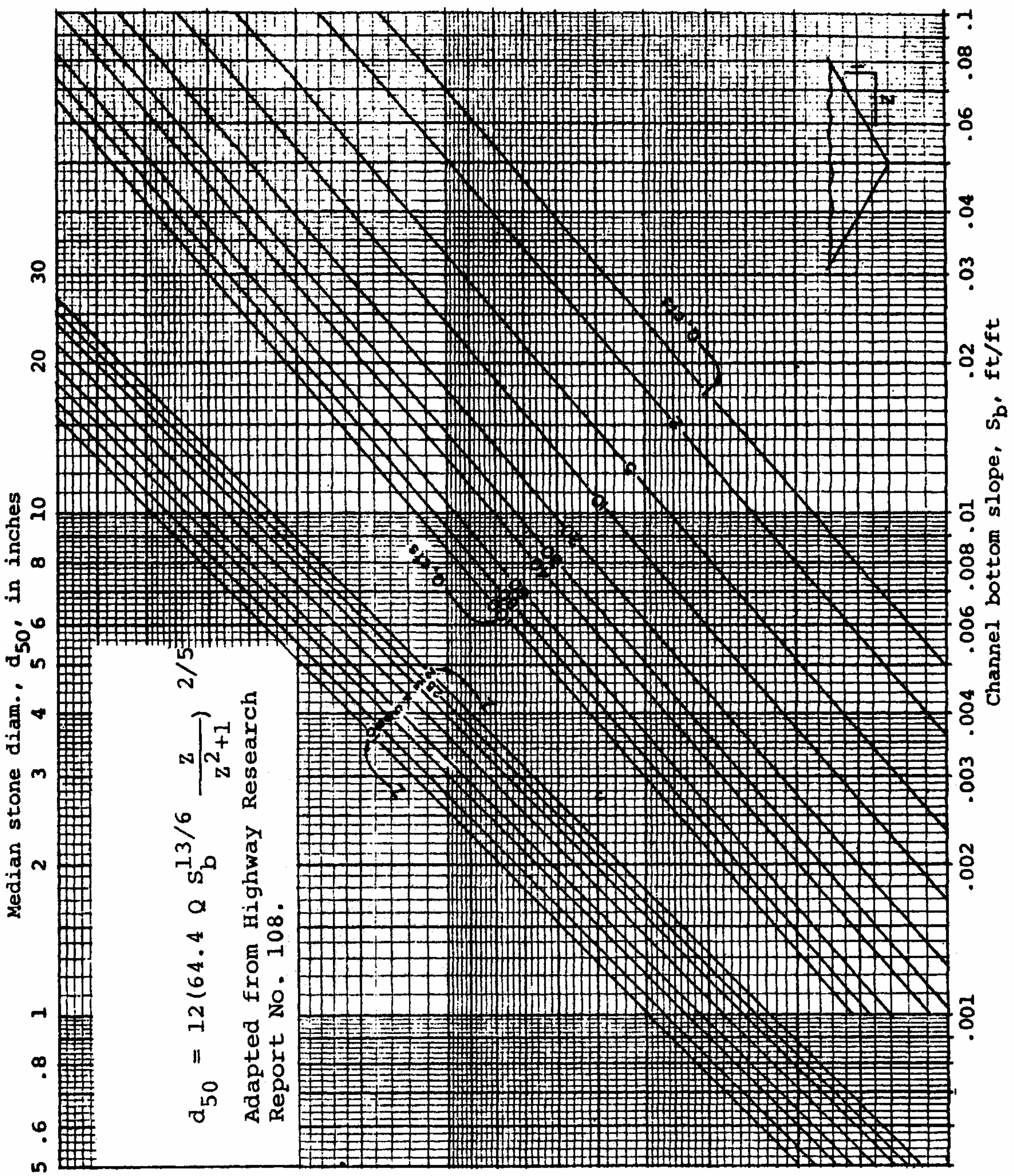
CURVE 4.19-3 RELATIONSHIP OF P/R RATIO TO b/d IN TRAPEZOIDAL CHANNELS



CURVE 4.19-4A MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRAPEZOIDAL CHANNEL



CURVE 4.19-4B MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRIANGULAR CHANNELS

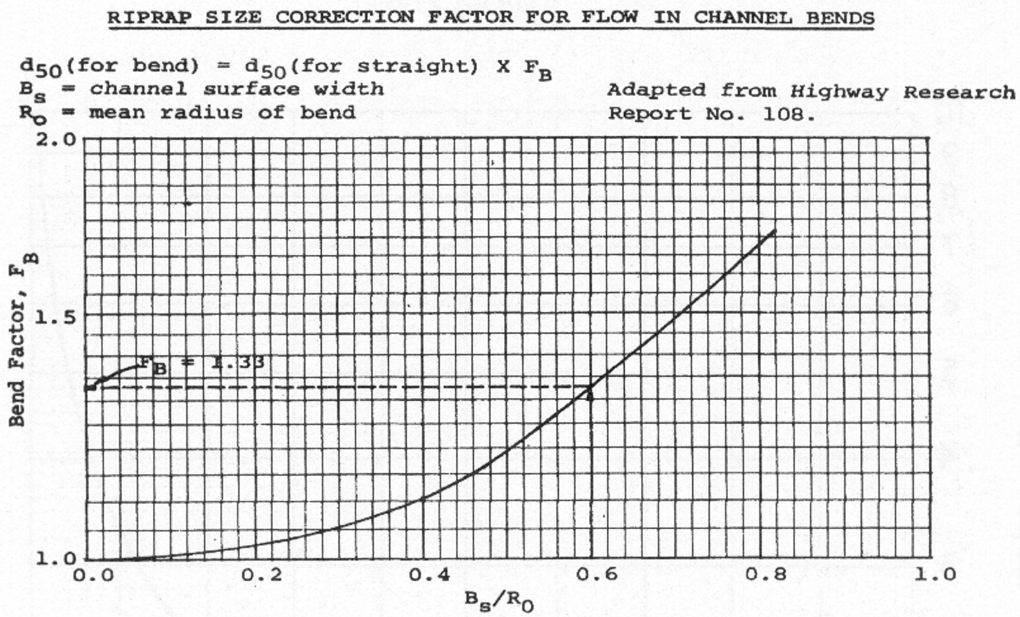


CURVE 4.19-5 RIPRAP SIZE CORRECTION FACTOR FOR FLOW IN CHANNEL BENDS

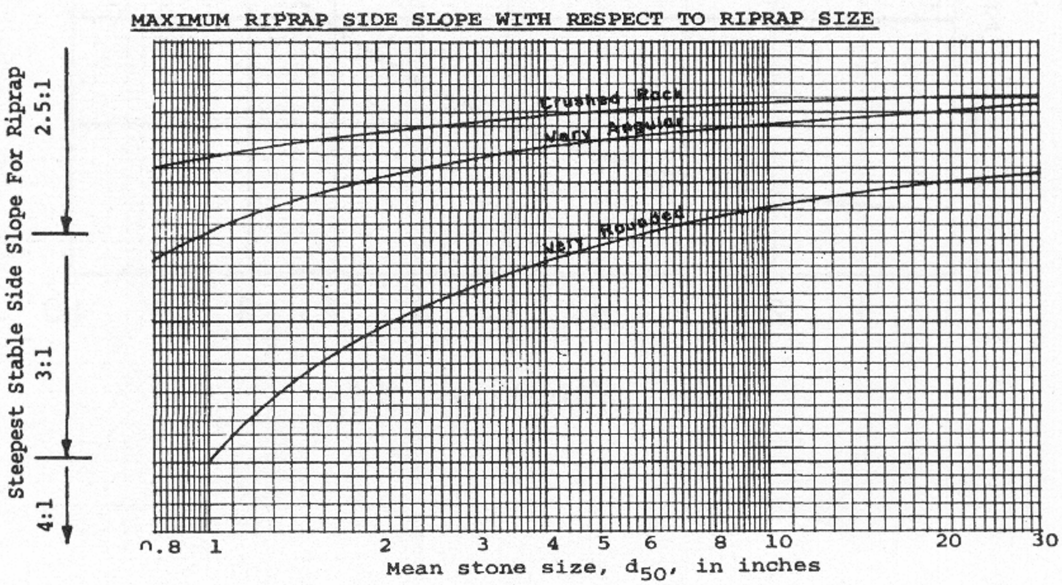
AND

CURVE 4.19-6 MAXIMUM RIPRAP SIDE SLOPE WITH RESPECT TO RIPRAP SIZE

Curve 4.19-5



Curve 4.19-6



Riprap Shoreline Protection

Condition where practice applies

This design procedure applies to riprap protection of shorelines surrounding open bodies of water, such as lakes, bays, estuaries, etc. against the erosive action of surface waves. It is not intended as a design procedure for the protection of embankments of channels. Refer to the beginning of this standard for open channel riprap design.

Design Procedure

1. find wind speed from Figures 4.19-1 or 4.19-2 (figures are based on the 10 or 25-year return period). In general, use a 25-year return period unless a higher risk of failure is acceptable.
2. find wave height from Table 4.19-3, 4.19-4, 4.19-5 or 4.19-6. Fetch length is the distance across open water in the prevailing wind direction.
3. find rock weight (in lbs) from Table 4.19-7, 4.19-8 and 4.19-9.
4. find rock size (d_{50}) from Curve 4.19-7. Note: curve is calibrated for rock with a specific gravity of 2.6, or a unit weight of 165 lbs/ft^3 (2643 kg/m^3.) Table 4.19-9,Correction for unit weight, will correct for rock with a different unit weight.

Riprap is to be installed according to limits established for depth, filter material, and slope, as outlined earlier in this standard.

Example:

Given:

25-year storm event, fetch length of 1 mile (1.6 kilometers), depth of 5 feet (1.5 meters), installation slope of 1:3, and stone unit weight = 160 lbs/ft^3 (2563kg/m^3)
Find:

1. from figure 4.19-2, wind speed for central New Jersey for the 25-year design storm is 75 mph (120km/h).
2. from Table 4.19-3, wave height is 2.0 feet (0.6 meters) for a fetch length of 1.0 mile (1.6 kilometers) and average depth of 5.0 feet (1.5 meters).
3. from Table 4.19-7, the estimated required weight of stone based on wave height is 50 lbs (23 kilograms). (per piece).
4. from Table 4.19-8, the correction factor for a slope of 1:3 is 0.7.
5. from Table 4.19-9, the correction factor for stone unit weight of 160 lbs/ft^3 (2563 kg/m^3) is 1.1.
6. the required stone weight is: 50x0.7x1.1 = 38.5 lbs (17.5 kg). (per piece).
7. from Curve 4.19-7, the d_{50} stone size for 38.5 lbs (17.5 kg) is 9.3 inches (232 mm), or 9 inches (230 mm).

FIGURE 4.19-1 FASTEST-MILE (KM) WIND SPEEDS: 10-YEAR RETURN PERIOD

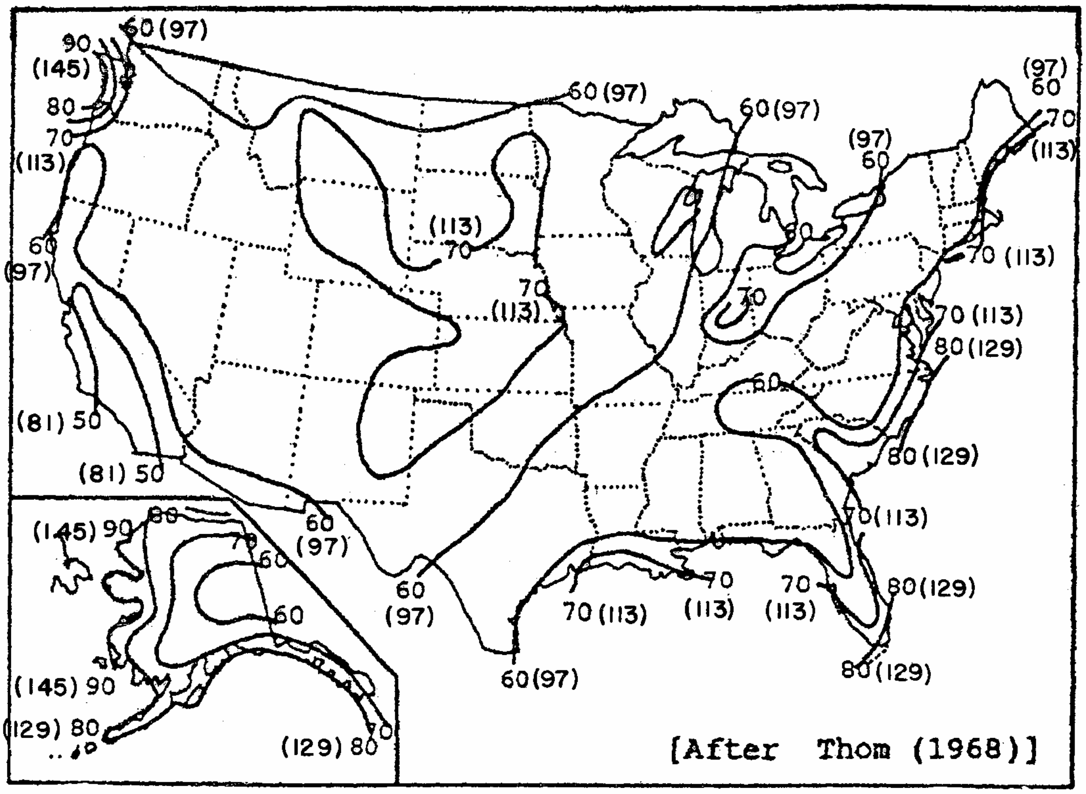


FIGURE 4.19-2 FIGURE 4.19-2 FASTEST-MILE (KM) WIND SPEEDS: 25-YEAR RETURN PERIOD

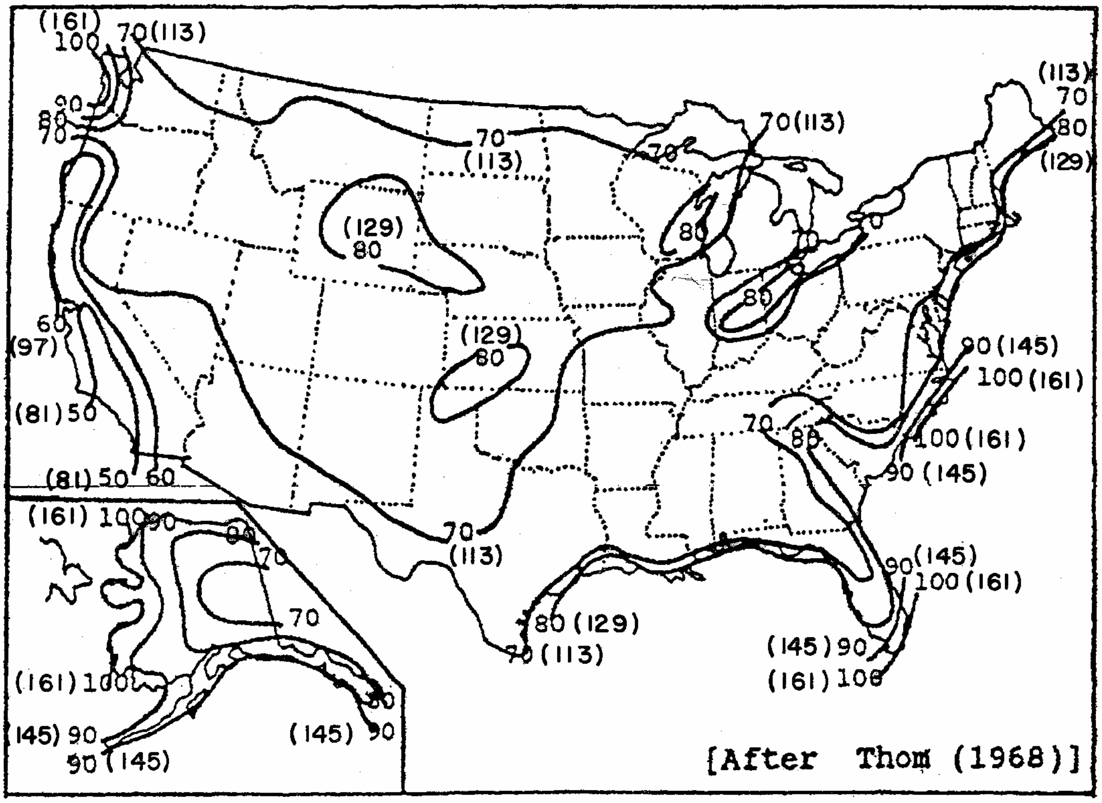


Table 4.19-3 WIND-GENERATED WAVE HEIGHTS AND (PERIODS) FETCH LENGTHS WITH AVERAGE DEPTHS = 5 FEET															
	Fetch Length in Miles														
	0.5	1.0	1.5.	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
Wind Speed Mph															
10	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
	(0.8)	(1.6)	(2.4)	(3.2)	(4.0)	(4.8)	(5.6)	(6.4)	(7.2)	(8.0)	(8.8)	(9.6)	(10.4)	(11.2)	(12.0)
20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	(1.0)	(1.0)	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
30	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
40	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)
50	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	(2.0)	(2.0)	(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)
55	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(2.0)	(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)
60	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(2.0)	(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)
65	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)
70	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
75	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
80	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)

Table 4.19-4 WIND-GENERATED WAVE HEIGHTS AND (PERIODS) FETCH LENGTHS WITH AVERAGE DEPTHS = 10 FEET															
Fetch Length in Miles															
	0.5	1.0	1.5.	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
Wind Speed Mph															
10	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
	(0.8)	(1.6)	(2.4)	(3.2)	(4.0)	(4.8)	(5.6)	(6.4)	(7.2)	(8.0)	(8.8)	(9.6)	(10.4)	(11.2)	(12.0)
20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0
	(1.0)	(1.0)	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
30	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)
40	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)
50	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)
55	1.5	2.0	2.5	2.5	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
60	2.0	2.5	2.5	2.5	2.5	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)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
65	2.0	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
70	2.0	2.5	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
75	2.5	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
80	2.5	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)

Table 4.19-5
WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 15 FEET

	Fetch Length in Miles														
	0.5	1.0	1.5.	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
Wind Speed Mph															
10	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
	(0.8)	(1.6)	(2.4)	(3.2)	(4.0)	(4.8)	(5.6)	(6.4)	(7.2)	(8.0)	(8.8)	(9.6)	(10.4)	(11.2)	(12.0)
20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0
	(1.0)	(1.0)	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
30	0.5	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0
	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)
40	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5
	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)
50	1.5	2.0	2.0	2.0	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
55	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4.0
	(2.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
60	2.0	2.5	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
65	2.0	2.5	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)
70	2.5	3.0	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.5	4.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)
75	2.5	3.0	3.5	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)
80	2.5	3.5	3.5	4.0	4.0	4.5	4.5	4.5	4.5	4.5	4.5	5.0	5.0	5.0	5.0
	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)

Table 4.19-6 WIND-GENERATED WAVE HEIGHTS AND (PERIODS) FETCH LENGTHS WITH AVERAGE DEPTHS = 20 FEET															
	Fetch Length in Miles														
	0.5	1.0	1.5.	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
Wind Speed Mph															
10	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0
	(1.0)	(1.0)	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
20	0.5	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0
	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)
30	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	3.0	3.0	3.0
	(2.0)	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)
40	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5
	(2.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
50	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	4.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)
55	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.5	4.5
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)
60	2.0	3.0	3.0	3.5	4.0	4.0	4.0	4.0	4.5	4.5	4.5	5.0	5.0	5.0	5.0
	(3.0)	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)
65	2.5	3.0	3.5	4.0	4.0	4.5	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.5
	(3.0)	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)
70	2.5	3.5	4.0	4.0	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.5	5.5	5.5	5.5
	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)
75	3.0	3.5	4.0	4.5	4.5	5.0	5.0	5.0	5.0	5.5	5.5	5.5	5.5	6.0	6.0
	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)
80	3.0	4.0	4.5	4.5	5.0	5.0	5.5	5.5	5.5	5.5	5.5	6.0	6.0	6.0	6.0
	(3.0)	(4.0)	(4.0)	(4.0)	(4.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)	(5.0)

TABLE 4.19-7 Estimated Weight of Armor Stone		TABLE 4.19-8 Correction for Slope		TABLE 4.19-9 Correction for Unit Weight	
Wave Height (H) ft (m)	Estimated Weight (W) lb (kg)	Slope ft/ft (m/m)	Correction Factor (K_1)	Unit Weight (W_r) lb/ft^3 (kg/m^3)	Correction Factor (K_2)
0.5 ().15)	1 (0.45)	1:2	1.0	120 (1922)	4.3
1.0 (0.3)	10 (4.5)	$1{:}2^{1}/_{2}$	0.8	130 (2108)	2.8
1.5 (0.45)	20 (9)	1:3	0.7	135 (2163)	2.4
2.0 (0.6)	50 (22.70)	$1{:}3^{1}/_{2}$	0.6	140 (2243)	2.0
2.5 (0.75)	100 (45.40)	1:4	0.5	145 (2323)	1.7
3.0 (0.9)	160 (72.64)	$1{:}4^{1}/_{2}$	0.4	150 (2403)	1.5
3.5 (1.05)	260 (118)	1:5	0.4	155 (2483)	1.3
4.0 (1.20)	390 (177)	$1{:}5^{1}/_{2}$	0.4	160 (2563)	1.1
4.5 (1.35)	550 (250)	1:6	0.3	165 (2643)	1.0
5.0 (1.50)	750 (341)			170 (2723)	0.9
5.5 (1.65)	1000 (454)			175 (2804)	0.8
6.0 (1.80)	1300 (590)			180 (2884)	0.7
6.5 (1.95)	1650 (749)			185 (2964)	0.6
7.0 (2.10)	2100 (953)			190 (3044)	0.6

Example

Given: The wave height (H) is 3.0 feet (0.9 meters) and the structure slope is 1 on 3 (1 Vertical on 3 Horizontal) and one cubic foot of rock weighs 155 lbs (70kg) (W_r)

Find: The required weight of armor stone (W) from the tables (arrows)

W = 160 lbs x 0.7 x 1.3 = 145 lbs

W = 72.64 kg x 0.7 x 1.3 = 66 kg

CURVE 4.19-7 d_{50} STONE SIZE BY STONE WEIGHT, LBS (KG.)
(for stone weighing 165 lbs. /ft^3)

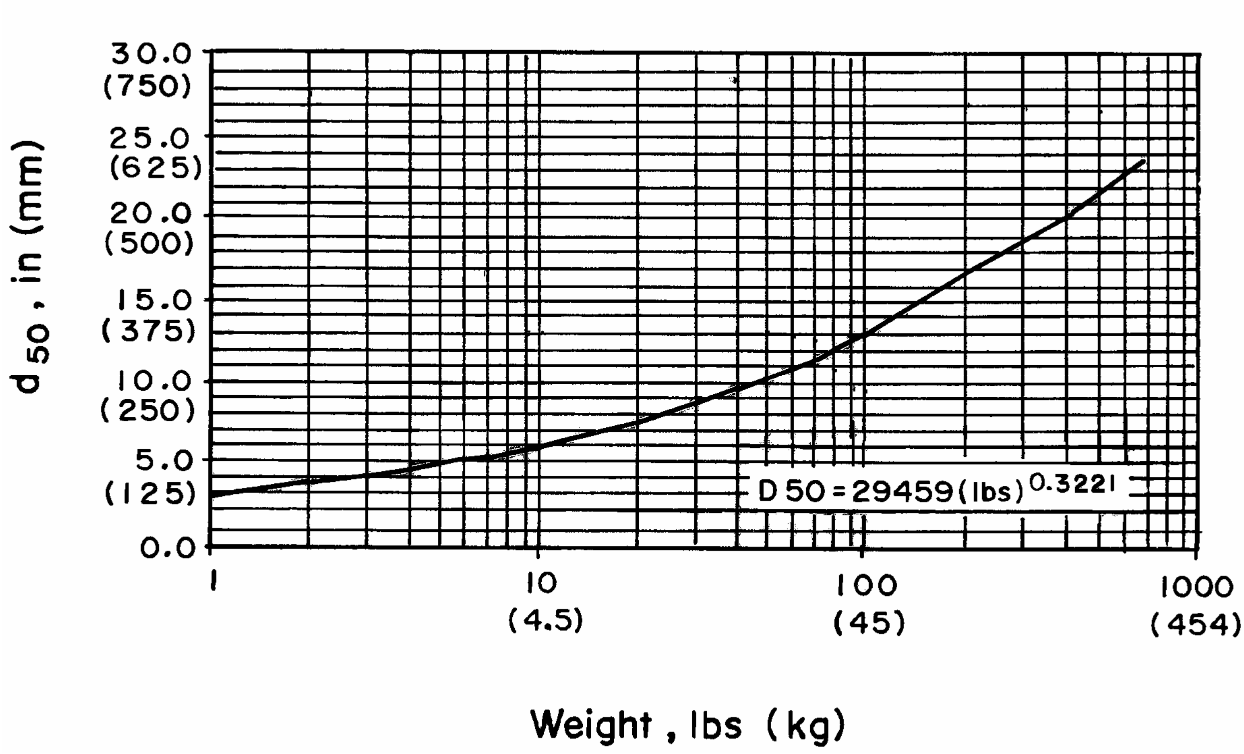
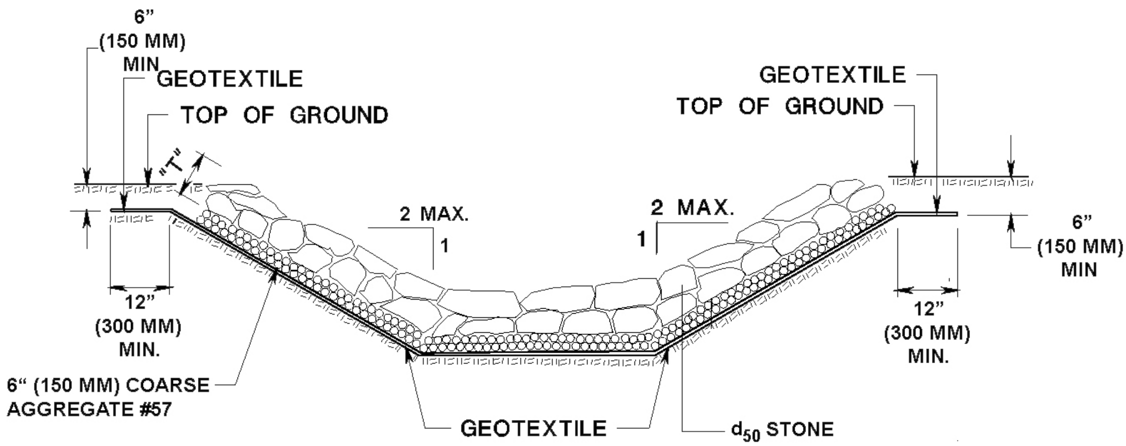
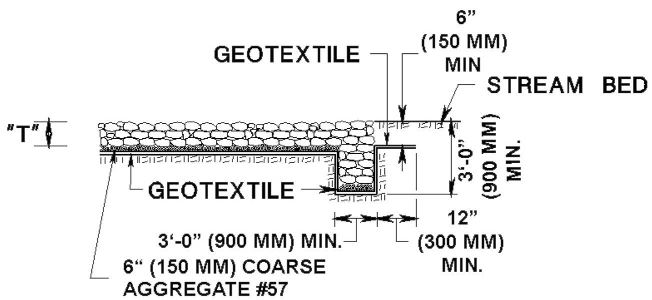


FIGURE 4.19-3 CHANNEL LINER & END TREATMENT FOR CHANNEL LINER



CHANNEL PROTECTION



END TREATMENT FOR CHANNEL PROTECTION

"T" = $2d_{50}$ with filter layer

d_{50} = Stone size calculated

4.20 STANDARDS FOR CHANNEL STABILIZATION

4.20.1 Definition

Stabilizing a channel, either natural or artificial, in which water flows with a free surface

4.20.2 Purpose

The purpose of channel stabilization is so that open channels are constructed or stabilized to be non-erodible and provide adequate capacity for the conveyance of flood water, draining, other water management purposes, or any combination thereof.

4.20.3 Conditions Where Practice Applies

This standard applies to the construction and stabilization of open channels and existing streams or ditches regardless of drainage area. It does not apply to diversions or grassed waterways. **Stream channelization is not allowed without a New Jersey Department of Environmental Protection Coastal or Freshwater Wetlands permit.**

4.20.4 Design Criteria

Planning

The alignment and design of channels shall give careful consideration to the preservation of valuable fish and wildlife habitat. Trees of significant value for wildlife habitat shall be preserved whenever possible.

Where channel construction will adversely affect a significant fish or wildlife habitat, mitigation measures should be included in the plan. Mitigation measures may include pools, riffles, flats, cascades, or other similar provisions.

As many trees as possible are to be left after considering the requirements for construction, operation, and maintenance. See Standard for Tree Protection During Construction (Section 3.7).

Realignment

The realignment of channels shall be kept to an absolute minimum.

Channel Capacity

The capacity for open channels shall be determined by the designer and/or the appropriate regulatory authority.

Capacity shall be determined by the following methods:

1. Rational Method - for peak discharge areas as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, September 1997, or any revisions thereto.

2. USDA-NRCS (SCS) Technical Release No. 55, Technical Release No. 20, Hec-1, or other officially approved methodology.

Hydraulic Requirements

Manning's formula shall be used to determine the velocity in the channel. The "n" values shall be determined according to the specifications found in Appendix A-8.

Every reach shall be individually designed unless all reaches are designed on the worst cases for velocity and capacity (lowest allowable velocity, steepest slope).

Channel Side Slopes

Channel side slopes in earth shall be 2:1 (1:2) or flatter unless the design, using the procedures in Appendix A3, shows that a steeper side slope is stable. Channel side slopes of materials other than earth shall be of a stable design.

Channel Stability (General)

All channel construction, improvement, and modification shall be in accord with a design which results in a stable channel.

Characteristics of a stable channel are:

1. It neither aggrades nor degrades beyond tolerable limits;
2. The channel banks do not erode to the extent that the channel cross section is changed appreciably;
3. Excessive sediment bars do not develop;
4. Excessive soil erosion does not occur around culverts and bridges or elsewhere;
5. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel;

The determination of channel stability considers bankfull flow. Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cut through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

Channel Stability drainage area 1 square mile (2.6 $km^{2)}$) or less

1. Permanent

   Channels in this category shall be considered stable if the actual velocity is less than the allowable velocities shown in Table 4.20-1. The actual velocity is defined as the velocity developed during the lesser of the following events:

   a. bankfull discharge

   b. 10-year frequency storm peak discharge

2. Temporary (90 days or less) Bypass Channel

   Channels in this category shall be considered stable if the actual velocity is less than the allowable velocities shown in Table 4.20-1. The actual velocity is defined as the velocity developed during the 2-year frequency peak discharge.

TABLE 4.20-1 ALLOWABLE VELOCITY FOR VARIOUS SOIL TEXTURES

SOIL TEXTURE	ALLOWABLE VELOCITY (ft/sec.)	ALLOWABLE VELOCITY (m/sec.)
Sand	1.75	0.53
Sandy Loam	2.5	0.76
Silt Loam (high lime clay)	3.0	0.91
Sandy Clay Loam	3.5	1.07
Clay Loam	4.0	1.22
Clay, Fine Gravel, Graded Loam to Gravel	5.0	1.52
Cobbles	5.5	1.68
Shale (non-weathered)	6.0	1.83

Channel Stability-drainage area greater than 1 square mile (2.6 km^2)

Channels must be stable under conditions existing immediately after construction (as-built condition) and under conditions existing during effective design life (aged-condition). Channel stability shall be determined for discharges under these conditions as follows:

1. As-built condition - bankfull flow, design discharge, or 10-year frequency flow, whichever is smallest, but not less than 50% of design discharge.

2. Aged-condition - bankfull flow or design discharge, whichever is larger, except that it is not necessary to check stability for discharges greater than the 100-year frequency.

Stability checks are not required if the actual velocity is 1.75 fps (0.53 meters per second) or less.

Linear crossing of existing channels by pipelines and similar devices do not require a stability analysis of the channel provided the final cross sectional area of the stream remains the same.

Where vegetation can be rapidly established by natural or artificial means, the allowable as-built velocity (regardless of type stability analysis) in the newly constructed channel may be increased by a maximum of 20%. The 20% adjustment does not apply to the allowable velocity for aged-condition. This increase is justified only if:

1. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion-controlling vegetation,

2. Species of erosion-controlling vegetation adapted to the area and proven methods of establishment are known, and

3. The channel design includes detailed plans for establishing vegetation on the channel side slopes.

For newly constructed channels in fine-grained soils and sands, the "n" values shall be determined according to specifications in Appendix A-8 and shall not exceed 0.025. The "n" value for channels to be modified by clearing and snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

The above stability checks will be made using either tractive stress of allowable velocity procedures given in Appendix A-8. The choice of method will depend upon the grain size and cohesiveness of the soil being checked. The following will be used as a guide in choosing the method:

1. Tractive Stress - see Appendix A-8

   a. Coarse grained soils
   b. Fine grained noncohesive soils (PI <10)

2. Allowable Velocity - see Appendix A-8

   a. Coarse grained soils (Tractive Stress method recommended)
   b. Fine grained cohesive soils (PI >10)
   c. Fine grained noncohesive soils (PI <10) (Tractive Stress method recommended)

Stability checks should be made for each significant soil horizon present. Soil sampling and testing is required to determine the grain size distribution and plasticity index of each material to be checked.

Channel Linings and Structural Measures

Where channel velocities exceed allowable velocities, the channel must be stabilized.

Channels may be stabilized by using one or more of the following methods:

1. Rock Riprap Lining shall be designed using the procedures given in Standard for Riprap (Section 4.19).

2. Concrete Lining shall be designed according to currently accepted guides for structural and hydraulic adequacy. They must be designed to carry the required discharge and to withstand the loading imposed by site conditions. Concrete lining shall be reinforced where required.

3. Grade Stabilization Structures can be used where excessive grades exist. The structures provide for one or more drops along the channel profile to reduce the channel slope. They may be constructed of concrete, rock, masonry, steel, gabions, aluminum, or treated timber. See Standard for Grade Stabilization Structure (Section 4.23).

The structures must be designed hydraulically to adequately carry the channel discharge and designed structurally to withstand loadings imposed by the site conditions. Appendix A-10 Ref.#8 provides procedures for use in the design of these structures.

Energy Dissipaters are employed to force hydraulic jump and its associated turbulence to occur at a location where suitable protection can be provided against bank scour and channel erosion. Construction of energy dissipaters is normally at the base of chutes or drop structures and they are usually an integral part of the design of the structure. Sills, baffles, floor blocks, or other obstructions to channel flow may serve as energy dissipaters.

4. Soil Bioengineering may be given consideration for channel stabilization. These techniques are not to be used when a structural design is required for safety, etc. See Standards for Soil Bioengineering for additional design guidance, Section 4.26

Installation Requirements

1. All trees, brush, stumps, and other objectionable materials that would interfere with the construction or proper functioning of the channel shall be removed.

2. Where possible, trees shall be left standing, brush and stumps shall not be removed, and channels shall be excavated from one side, leaving vegetation on the opposite side.

3. Construction plans shall specifically detail the location and handling of spoils.

4. Seeding, fertilizing, and mulching shall conform to the Standard for Permanent Vegetative Cover for Soil Stabilization (Section 3.2).

5. Vegetation shall be established on all disturbed areas immediately after construction, weather permitting. If weather conditions are such as to cause a delay in the establishment of vegetation, the area shall be mulched in accordance with the Standard for Stabilization with Mulch Only (Section 3.3).

4.21 STANDARDS FOR GRASSED WATERWAY

4.21.1 Definition

A natural or constructed watercourse shaped or graded in earth materials and stabilized with suitable vegetation for the safe conveyance of runoff water.

4.21.2 Purpose

The purpose of the grassed waterway is to provide for the conveyance of excess surface water without damage by soil erosion or flooding.

4.21.3 Conditions Where Practice Applies

This practice applies to sites with drainage areas less than 200 acres (81 hectares) where concentrated runoff requires vegetative protection or stone center lining to control soil erosion. The slope of the waterway must be less than 10%. Some of the other practices that may be required with this practice are: (1) grade control structures, (2) subsurface drainage to permit the growth of suitable vegetation and to eliminate wet spots, (3) a section stabilized with stone or other material within the waterway, or (4) buried storm drain to handle frequently occurring storm runoff, base flow, or snowmelt.

4.21.4 Design Criteria

Capacity

Peak discharge values shall be determined by the following:

1. Rational Method - for peak discharge of uniform drainage areas as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, August 1984.

2. USDA-NRCS (SCS) Technical Release No. 55.

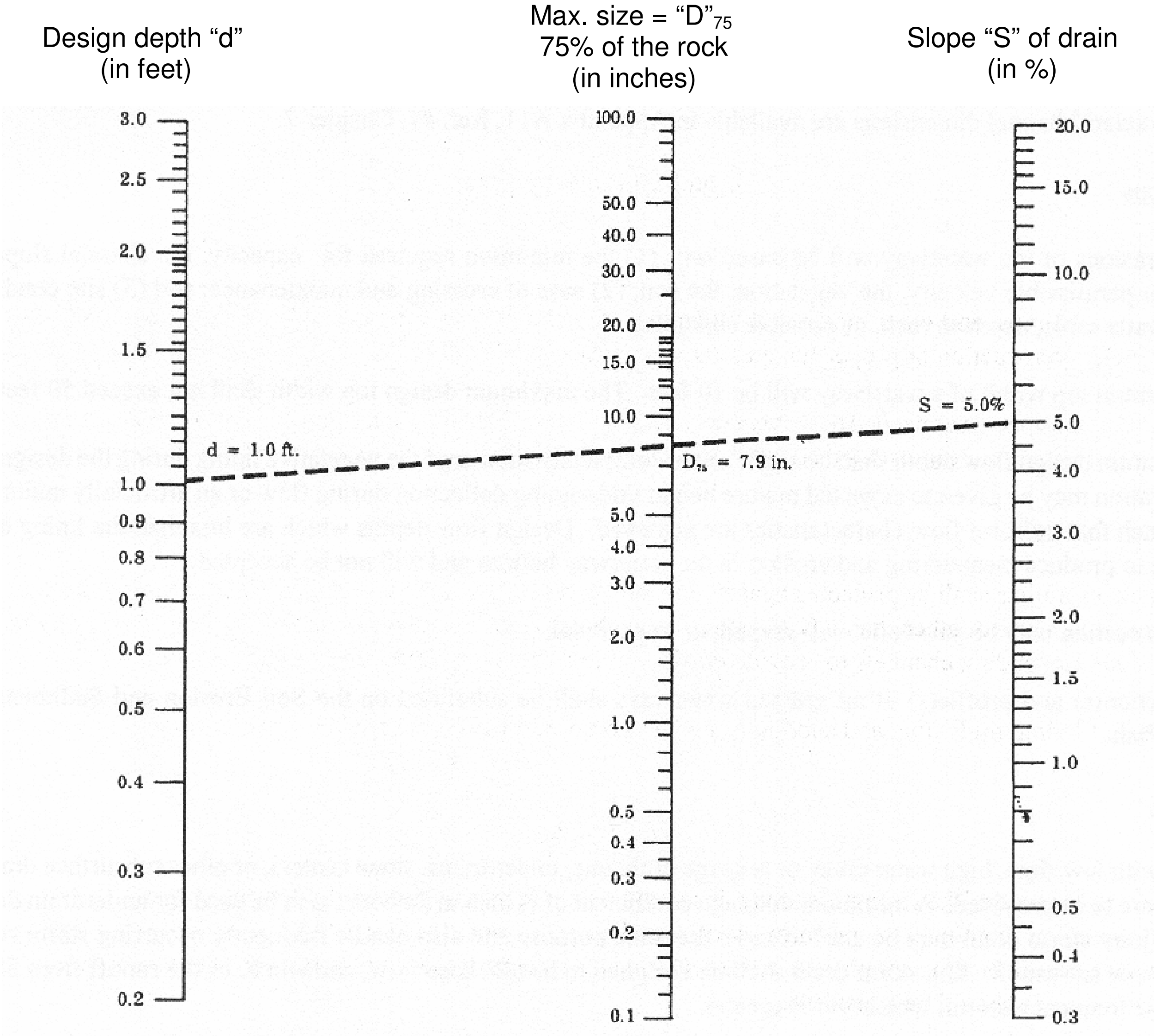
The minimum capacity shall be that required to convey the peak runoff expected from a 10-year frequency storm.

Velocity

The maximum allowable velocity for design flow will be determined by the most erodible soil texture exposed and the type of vegetation expected and maintained in the channel. Table 4.21-1 will be used in selecting the maximum permissible velocities:

FIGURE 4.21-1 DESIGN OF STONE CENTER LINING FOR WET OR LOW FLOW CONDITIONS

Where a stone lining is needed due to seepage, low flow, high water table, etc., stone size shall be based on the maximum design flow (10-year storm event minimum) to be conveyed and shall be installed to a depth equal to the design flow depth for a 1-year, 24-hour storm. The stone shall be **EMBEDDED FLUSH** with the waterway surface. The following nomograph may be used to determine the D_{75} stone size for the center lining:



Example: "d" = 1.0 foot, "S" = 5%

Place straight edge at "d" value in "Design Depth" column and at "S" value in "Slope" column. Read rock size in middle column, 7.9 inches; round to 8 inches.

For Design:

25% of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75% or less should be of well graded material, smaller than 8 inches, including sufficient sands and gravels to fill the voids between the larger rock.

TABLE 4.21-1 MAXMUM ALLOWABLE VELOCITIES FOR VARIOUS SOILS

SOIL TEXTURE	MAXIMUM PERMISSIBLE VELOCITY[1]			
	Vegetated Channels[2]		Sod Channels[3]	
Sand, Silt Loam, Sandy Loam, Loamy Sand, and Muck	2.0 (ft/sec.)	0.61 (m/sec.	3.0 (ft/sec.)	0.91 (m/sec.)
Silty Clay Loam, Sandy Clay Loam	2.5 (ft/sec.)	0.76 (m/sec.	4.0 (ft/sec.)	1.22 (m/sec.)
Clay, Clay Loam, Sandy Clay, Silty Clay	3.0 (ft/sec.)	0.91 (m/sec)	5.0 (ft/sec.)	1.52 (m/sec.)

[1]Maximum allowable velocities are based on flow of clear water.

[2]Maximum allowable velocities for vegetated channels may be increased by 3 feet (0.91 meter) per sec. except for sands for sections where erosion control mat is installed according to manufacturer's recommendations. Erosion control mat is defined as a flexible mat of synthetic monofilaments bonded together to form a three dimensional web, highly resistant to environmental and chemical degradation.

[3]On well-drained to excessively-drained soils, most cool season sod types will not survive without continued irrigation. Placement of sod in such areas must be approved by the NJDOT.

TABLE 4.21-2 Classification of Flexible Channel Liners by Texas DOT

"Class 2" Flexible Channel Liner Designation	Allowable Shear Stress (psf)	Allowable Soil Loss[2] (Soil deformation, inches	Incremental increase in velocity (fps)
Type "E"	0 to 2	0.453	1.0
Type "F"	0 to 4	0.394	1.5
Type "G"	0 to 6	0.394	2.0
Type "H"	0 to 8	0.315	3.0

Classification of Flexible Channel Liners by Texas DOT

"Class 2" Flexible Channel Liner Designation[1]	Allowable Shear Stress (kg/m^2)	Allowable Soil Loss[2] (Soil deformation, mm.)	Incremental increase in velocity (m/s)
Type "E"	0 to 9.76	11.51	0.31
Type "F"	0 to 19.53	10.0	0.46
Type "G"	0 to 29.30	10.0	0.61
Type "H"	0 to 39.06	8.0	0.92

[1] Designation defined by current Texas Department of Transportation, Hydraulics and Erosion Control Laboratory, Field Performance Testing of Selected Erosion Control Products. 1995 or Current Evaluation Cycle

[2] Distance measures loss of contact between liner and soil

There shall be no increase in allowable velocity beyond that indicated for sod if the design life of the flexible channel liner is less than the planned service life of the grassed waterway.

Vegetative Retardance Factors and Manning's "n" Value

The minimum capacity and maximum velocity shall be determined by using the appropriate vegetative retardance factors listed below. See Appendix A-6 for example and charts for use in design.

1. to determine the minimum capacity use a vegetative retardance factor of "D".
2. to determine the maximum allowable velocity use a vegetative retardance factor of "E".

Dimensions

The dimensions of the waterway will be based on: (1) the minimum required for capacity, the channel slope, the maximum permissible velocity, the vegetation, the soil; (2) ease of crossing and maintenance; and (3) site conditions such as water table, depth to rock, or possible sinkholes.

The minimum top width of a waterway shall be 10 feet (3 meters). The maximum design top width shall not exceed 50 feet (15 meters). The cross section may be parabolic or trapezoidal.

Cross-section(s) and profile(s) of all grassed waterways shall be submitted on the Soil Erosion and Sedimentation Control Plan.

Drainage

In areas with low flow, high water table, or seepage problems, underdrains, stone centers, or other subsurface drainage methods are to be provided. A minimum drainage coefficient of ½ inch (13 millimeters) in 24 hours is to be used for underdrain design. An open joint storm drain may be used to serve the same purpose and also handle frequently occurring storm runoff, base flow, or snowmelt. The storm drain shall be designed to handle base flow, snowmelt, or the runoff from at least a 1-year frequency storm, whichever is greater.

Outlet

The outlet must handle the design flow without flood damage. The outlet must be stable for the 10-year storm.

Permanent Vegetative Cover

A permanent vegetative cover shall be established on all grassed waterways in accordance with the Standard for Permanent Vegetative Cover for Soil Stabilization (Section 3.2) or Standard for Permanent Stabilization with Sod (Section 3.4). Where the season and other conditions may not be suitable for growing permanent erosion resistant cover, erosion protection shall be provided in accordance with the Standard for Temporary Vegetative Cover for Soil Stabilization (Section 3.1) or Standard for Stabilization with Mulch Only (Section 3.3). The seeding shall extend to at least the design top width.

Installation Requirements:

Construction

Trees, brush, stumps, and other material in objectionable amounts are to be cleared and disposed of so as not to interfere with construction or proper functioning of the waterway.

Fills are to be compacted as needed to prevent unequal settlement that will cause damage in the completed waterway. Where deep cuts are made into the subsoil, consideration should be given to adding organic soil amendments or topsoil.

Vegetative Lining

Waterways or outlets shall be protected against soil erosion by vegetative means as soon after construction as practical and before diversions or other channels are allowed release. Consideration should be given to the use of a flexible channel liner or sodding channels to provide erosion protection as soon after construction as possible.

Routine maintenance of the vegetative lining, including mowing, liming, and fertilizing, must be performed to ensure that the waterway continues to perform as designed (see the Standard for Maintaining Vegetation, Section 3-8) If maintenance cannot be performed or will not be planned, an alternate means of waterway stabilization or means of runoff conveyance should be considered.

4.22 STANDARDS FOR LINED WATERWAY

4.22.1 Definition

A watercourse with an erosion resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to design flow depth. The earth above the permanent lining shall be vegetated or otherwise protected.

4.22.2 Scope

This standard applies to waterways with linings of non-reinforced, cast-in-place concrete; flagstone mortared in place; rock riprap or similar permanent linings. This standard does not apply to grassed waterways with stone centers. The maximum capacity of the lined waterway flowing at design flow depth shall not exceed 100 cfs (2.83 cubic meters per second).

4.22.3 Purpose

The purpose of lined waterways is to provide for safe disposal or runoff without damage by soil erosion or flooding, in situations where grassed waterways would be inadequate.

4.22.4 Conditions Where Practice Applies

This practice applies where the following conditions exist:

1. The water velocity is such that lining is required to control soil erosion in the waterway.

2. Wetness, prolonged base flow, or seepage, would prohibit establishment of erosion-resistant vegetation.

3. The location is such that damage from use by people, vehicles, or animals precludes use of vegetated waterways.

4. High value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

5. Soils are highly erodible, highly acidic, or other soil or climatic conditions preclude using vegetation.

6. On slopes greater than 10%, the Standard for Slope Protection Structures (Section 4.6) shall apply.

4.22.5 Design Criteria

<u>Capacity</u>

The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year frequency storm. Capacity shall be computed using Manning's formula or water surface profile model such as HEC RAS or WSP2 with a coefficient of roughness "n" as follows: (see Table 4.22-1)

TABLE 4.22-1 MANNING'S' "n" VALUE

LINING	"n" VALUE
Concrete	
Trowel Finish	0.012-0.014
Float Finish	0.013-0.017
Gunite	0.016-0.022
Flagstone	0.02-0.025
Gabion	0.025
Riprap	See Standard for Riprap

Velocity

Maximum design velocity shall be as shown below in Table 4.22-2. Except for short transition sections, slopes in the range of 0.90 to 1.10 of the critical slope must be avoided unless the channel is straight. Velocities exceeding ‘critical’ will be restricted to straight reaches.

TABLE 4.22-2 MAXIMUM DESIGN VELOCITY*

DESIGN FLOW DEPTH (ft)	MAX. VELOCITY (ft/sec.)
0-0.5	25
0.5-1.0	15
> 1.0	10

DESIGN FLOW DEPTH (mm)	MAX. VELOCITY (m. /sec.)
0-150	7.62
150-300	4.57
>300	3.05

* NRCS, NHCP Code 468, July 2002

Lined waterways with velocities exceeding critical shall discharge into an energy dissipater to reduce velocity to less than critical.

Cross-Section

The cross-section shall be triangular, parabolic, or trapezoidal. Monolithic concrete may be rectangular.

Freeboard

The minimum freeboard for lined waterways shall be 0.25 feet (76 mm) above design flow depth in areas where erosion resistant vegetation cannot be grown adjacent to the lined side slopes. No freeboard is required where good vegetation can be grown and is maintained.

Side Slope

Steepest permissible side slopes, horizontal to vertical will be as follows: in Table 4.22-3

TABLE 4.22-3 PERMISSIBLE SIDE SLOPES

LINING	STEEPEST PERMISSIBLE SIDE SLOPE
Non-Reinforced Concrete hand placed, formed concrete height of lining 1.5 ft. (460 mm) or less	 Vertical
Hand-Placed, Scoured Concrete or mortared-in-place flagstone height of lining less than 2 ft. (610 mm) height of lining more than 2 ft. (610 mm)	 1:1 1:2
Reinforced Slip Form Concrete height of lining less than 3 ft. (915 mm)	 1:1
Rock Riprap	1:2

Lining Thickness

Minimum lining thickness shall be as follows:

1. Concrete - 4 inches (100 mm)
2. Concrete Block – 6 inches (150 mm)
3. Cabled Concrete.- 6 inches (150 mm)
4. Rock riprap - as per Standard for Riprap
5. Flagstone - 4 inches (100 mm) including mortar bed

Related Structures

Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements for the site.

Filters or bedding

For non-reinforced concrete flagstone linings, installation shall be made only on low shrink-swell soils that are well-drained or where subgrade drainage facilities are installed.

Filters or bedding to prevent piping, soil erosion, reduce uplift pressure, and collect water shall be used and designed in accordance with National Cooperative Highway Research Program Report 108, Tentative Design Procedures for Riprap-Lined Channels Soil

Conservation Service procedures, or other generally accepted methods. Weep holes and drains shall be provided as needed.

Concrete or Mortar

Concrete or mortar shall meet New Jersey Department of Transportation Standard Specifications, Ref. #10 of Appendix A-10.

Rock Riprap or Flagstone

Stone used for riprap or flagstone shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement.

4.23 STANDARDS FOR GRADE STABILIZATION STRUCTURE

4.23.1 Definition

A structure (drop, chute, etc.) to control the grade and head cutting in natural or artificial channels.

4.23.2 Scope

This standard applies to all types of grade stabilization structures. It also applies to structures installed to lower the water from a surface drain or a waterway to a deeper channel to control soil erosion, head cutting, or channel grade. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels.

4.23.3 Purpose

The purpose of grade stabilization structures is to stabilize the grade and control soil erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to reduce environmental and pollution hazards.

4.23.4 Conditions Where Practice Applies

This standard applies to areas where the concentration and flow velocity of water requires structures to stabilize the grade, or to control gully erosion in channels. Special attention shall be given to maintaining or improving habitat for fish and wildlife and to maintaining or improving the natural stream flow characteristics, where applicable.

4.23.5 Design Criteria

Structures

The structure must be designed so that it is stable after installation. The crest of the inlet must be set at an elevation that stabilizes the upstream channel. The outlet must be set at an elevation level that results in a stable structure. Structures must not create unstable conditions upstream or downstream.

Structure Embankments

Embankments used with structures must meet the following requirements:

Foundation - The area on which an embankment is to be placed shall consist of material that has sufficient bearing strength to support the embankment without excessive consolidation.

Top width - The minimum top width shall be as follows:

TABLE 4.23-1 EMBANKMENT TOP WIDTH

HEIGHT OF EMBANKMENT		TOP WIDTH	
up to 20 feet	up to 6 meters	10 feet	3 meters
20-24 feet	6-7 meters	12 feet	3.6 meters

Side slopes - The combined upstream and downstream side slopes of the settled embankment shall not be less than 5:1, with neither slope steeper than 2 vertical:1 horizontal. Slopes must be designed to be stable in all cases, even if flatter side slopes are required.

Freeboard - The minimum elevation of the top of the settled embankment shall be 1 foot (300 mm) above the maximum water surface upstream during the total capacity design storm.

Settlement - The design height of the embankment shall be increased by the amount needed to insure that after all settlement has taken place, the height of the embankment will equal or exceed the design height. This increase shall not be less than 5%, except where detailed soil testing and laboratory analysis shows a lesser amount is adequate.

Length - If natural ground elevation is used for an emergency spillway, the constructed top elevation of the embankment shall extend at least 40 feet (12 meters) in both sides of the structure.

Structure Spillways

Chute and drop spillways shall be designed according to the principles set forth in the Engineering Field Handbook for Conservation Practices, The National Engineering Handbook, and other applicable USDA-NRCS (SCS) publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 4.23-2 or 4.23-3, as applicable, less any reduction because of detention storage.

Entrances to chutes and drop spillways will be protected against the force of flowing water at the interface between the structure's entrance walls and the earthen embankment. Acceptable methods include riprap and keying of the entrance walls into the embankment. Channels must not enter these structures at an angle where the energy will be dissipated in a bend.

Full flow structures are structures where the structure spillway plus an emergency spillway, if used, carry all the flow from the watershed. Typical full flow structures are drop spillways and rock chutes.

Island structures are structures where flows larger than the structure spillway design flow spread out, and the larger flows are not significantly carried by the structure spillway. Typical island structures are pipe drop and hooded inlets.

TABLE 4.23-2 MINIMUM CAPACITY OF FULLFLOW STRUCTURES

DRAINAGE AREA (Acres)	VERTICAL DROP (Feet)	SPILLWAY DESIGN STORM (years)	CAPACITY DESIGN STORM (years)	MINIMUM DURATION (hours)
< 250	5 or less	5	10	24
< 500	10 or less	10	25	24
All other	All other	25	100	24

DRAINAGE AREA (Hectares)	VERTICAL DROP (Meters)	SPILLWAY DESIGN STORM (years)	CAPACITY DESIGN STORM (years)	MINIMUM DURATION (hours)
< 100	1.5 or less	5	10	24
<200	3 or less	10	25	24
All other	All other	25	100	24

TABLE 4.23-3 MINIMUM CAPACITY OF ISLAND STRUCTURES

DRAINAGE AREA (Hectares)	VERTICAL DROP (Meters)	SPILLWAY DESIGN STORM (years)	CAPACITY DESIGN STORM (years)	MINIMUM DURATION (hours)
< 100	1.5 or less	1	10	24
<200	3 or less	1	25	24
all other	all others	1-year or channel design cap., whichever is greater	50	24

DRAINAGE AREA (Acres)	VERTICAL DROP (Feet)	SPILLWAY DESIGN STORM (years)	CAPACITY DESIGN STORM (years)	MINIMUM DURATION (hours)
< 250	5 or less	1	10	24
<500	10 or less	1	25	24
all other	all others	1-year or channel design cap., whichever is greater	50	24

Total Capacity Design Storm

All structures shall have the capacity to pass the peak flow expected from the minimum design storm for total capacity in Tables 4.23-2 and 4.23-3, as applicable, less any reduction because of detention storage. This may be accomplished by using a structure spillway or a combination of structure spillway and emergency spillway. There shall not be damage to, or erosion of the structure spillway or emergency spillway during passage of the total capacity design storm. Water flowing through an emergency spillway during the total capacity design storm must re-enter the channel without erosion.

Emergency spillways may use natural ground or be constructed. Minimum design flow depth for natural ground emergency spillways is 0.3 feet (90 mm). (See figure 4.23-1)

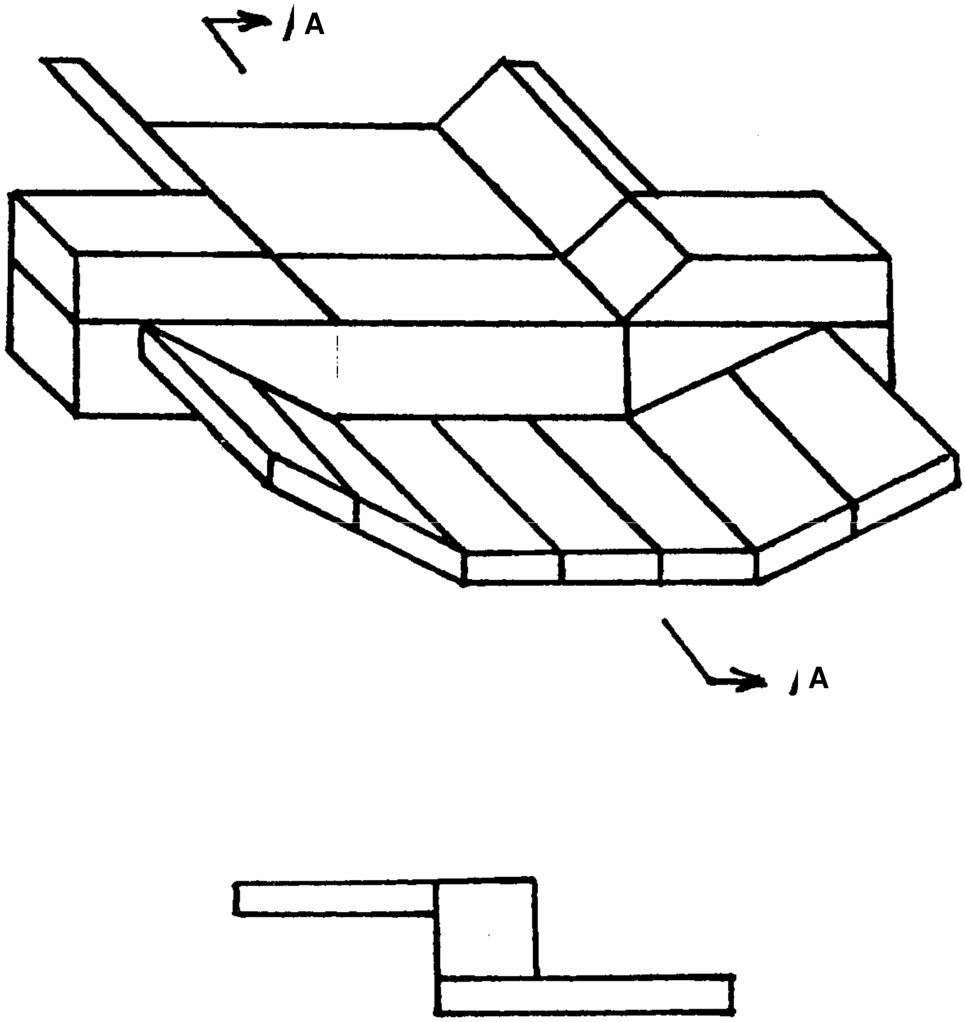
Toe Wall Drop Structures

Toe wall drop structures may be used if the vertical drop is 4 feet (1.2 meters) or less, flows are intermittent, and downstream grades are stable.

Road Culvert Box Inlets

The minimum capacity of drop boxes to culverts shall be as specified in Tables 4.23-2 or 4.23-3, as applicable, or as required by the responsible road authority, whichever is greater.

FIGURE 4.23-1 SCHEMATIC OF DROP GRADE STRUCTURE



SECTION A-A

4.24 STANDARDS FOR OFF-SITE STABILITY ANALYSIS

4.24.1 Definition

A condition below and beyond the immediate limits of the site property where the soil and related natural resources are subject to damage directly or indirectly by the discharge of the stormwater run off.

4.24.2 Purpose

To protect and maintain the stability and integrity of natural resources on downstream or off-site property due to changes in the rate and volume of stormwater runoff associated with construction activity and of land development.

4.24.3 Conditions Where Practices Applies

For purposes of analysis, two areas of concern shall be addressed: (1) at the point of discharge and (2) downstream of the discharge point (which requires a watershed-based analysis).

Technical criteria for demonstrating off-site stability include consideration of proximity to a defined waterway, site topography (slope), soil texture, vegetative cover and other factors. Where the potential for erosive forces from stormwater runoff exceeds the threshold of acceptability as defined below, the plan shall provide for the construction of a stabilized channel, installation of a conduit to a stable condition or other types of hydraulic improvements to the channel.

The Standard for Offsite Stability does not address discharges to cultivated land, specifically in Table 4.24-1. Soils which are routinely disturbed through the practice of cultivation (tilling, planting, harvesting, etc.)do not possess the characteristics of "natural land" assumed by the offsite stability model, and therefore shall not be considered a viable option for the point discharge of stormwater.

The designer must use alternative methods to ensure that erosion will not occur as a result of the proposed discharges. The resolution of satisfying this requirement for offsite stability lies with the applicant, design engineer, and the landowner impacted by the stormwater discharge.

4.24.4 Watershed Level Analysis below the Point of Discharge

A watershed analysis may be required in addition to an analysis of the point of discharge when discharging to a receiving channel or body of water. A watershed analysis will help to ensure that erosion will not occur beyond the point of discharge as a result of introducing the post development hydrograph into the system.

In general, stability may be met by reducing post-development peak flows to 50% and 75% of pre-development peak flows for the 2 and 10-year storm events. The scope and scale of the analysis shall be appropriate to the scale of the project and post development peak discharge rate and volume. Of particular concern are hydraulic control points (culverts, bridges, etc.); bends in streams and sudden changes in channel cross sections downstream of the discharge point. Two approaches for analyzing stormwater discharge on a watershed basis are:

1. Utilize an existing watershed or regional stormwater management plan to verify the proposed discharge will not cause erosion downstream of the discharge point. The model should reflect the current conditions in the watershed.

2. Perform a new watershed analysis. Modeling multiple watersheds, routing stormwater structures and modeling water surface profiles shall be done, as necessary, to determine pre and post-development velocities in channels and through surfaces.

In the event the analysis determines that the post development runoff must be controlled prior to discharge, some form of detention may be required. Refer to the Standard for Detention Basin, for control of Downstream Erosion Sec. 4.9 for design requirements.

The practice of infiltration is desirable where feasible. However, the Standards do not recognize such installations as an acceptable means to demonstrate offsite stability. When infiltration practices are installed at upslope locations a back-up design must be provided which will ensure off-site stability in the event of infiltration failure.

4.24.5 Point of Discharge — Methods for Demonstrating Stability

1. Where there is no well-defined waterway below the point of discharge. Stability cannot be demonstrated by the allowable velocity method since there can be no determination where the runoff will concentrate. A landform not previously subject to concentrated water flow will be become unstable.

   Stability can be demonstrated by one of the following alternatives:

   a. Retain pre-existing runoff characteristics. Do not increase the amount and rate of runoff for the development and do not concentrate flows.

   b. Where there is no well-defined channel, no sandy condition, no trees or brush to substantially concentrate the flows, it can be reasonably assumed that the flow will disperse over a broad area. The combinations of velocities, slopes and soils in the following (Table 4.24-1) are considered stable for 10-year design storm.

Table 4.24-1 Non – Erosive Velocities for Point Discharges

Non Erosive Water Velocities from Point Discharges for Various Soils and Slopes (Short reaches of 300 feet or less)				
Soil Type	Vegetated		Bare	
	Velocity (fps)	Slope (%)	Velocity (fps)	Slope (%)
Sandy Loam	2.1	1.7	1.8	1.2*
Silt loam, loam	2.4	2.3	2.0	1.5
Sandy clay loam	3.0	3.5	2.5	2.4
Clay Loam	3.6	5.0	3.0	3.5
Graded loam to gravel	4.5	7.8	3.75	5.5

Non Erosive Water Velocities from Point Discharges for Various Soils and Slopes (Short reaches of 90 meters or less)				
Soil Type	Vegetated		Bare	
	Velocity (m/s)	Slope (%)	Velocity (m/s)	Slope (%)
Sandy Loam	0.64	1.7	0.55	1.2*
Silt loam, loam	0.73	2.3	0.61	1.5
Sandy clay loam	0.92	3.5	0.76	2.4
Clay Loam	1.10	5.0	0.92	3.5
Graded loam to gravel	1.37	7.8	1.14	5.5

*For slopes less than 1.2% in forested wetlands without cohesionless sand and no more than 150 feet (45 meters) in length, direct discharge is permitted provided the flows are less than 10 cfs (0.28m^3/s) for a 25-year storm event and the discharge is no greater than 2 fps (0.61m/s) for a 10-year storm in the final section of pipe.
Stability is demonstrated when the topography of the receiving area is at or below the slope indicated and where the following conditions are met:

i. The reliability of this model is limited to 10 cfs (0.28 m^3/s) or less for the twenty-five (25) year storm.

ii. Discharge locations shall contain perennial, erosion-resistant vegetation.

iii. Flow over the outlet shall be less than 0.5 cfs per feet. (0.014 m^3/s per meter). Designers shall not design excessive widths, which will cause flows to concentrate.

iv. To dissipate the energy of the flowing water and to maintain the structural integrity of the outlet structures, measures are installed at the conduit outlet such as preformed scour holes, impact basins or plunge pools. Level spreaders are not considered to be an acceptable design.

v. Topography shows broad uniform outlet area with no trees or substantial woody growth to cause concentration of flows.

vi. Peak discharge velocities (in the last pipe section) do not exceed 2 fps (0.61 m/sec) from a 10-year storm event discharging into flat wetlands.

c. Construct a channel or install a pipe to a stable condition (i.e. flat marsh, pond, lake, sizeable body of water, pit, etc.) See item 3, below.

2. Where there is a defined waterway or channel below the point of discharge:

   a. Retain pre-developed runoff characteristics. Do not increase the rate of runoff from development.

   b. Analyze the waterway or channel for stability under the planned rate of discharge using the Standard for Grassed Waterway, Sec. 4.21 or Standard for Channel Stabilization, Sec. 4.20, as appropriate. Peak flows from the 2 and 10-year storms shall be analyzed.

   c. Modify the waterway or channel, or install a pipe to a stable condition (i.e. flat marsh, pond, lake, sizeable body of water, etc.)

3. Where development and site conditions require the construction of a waterway or channel or installation of a pipe to a stable condition the following procedures may be utilized:

   a. Design a detention basin to bring the peak flow (Q) for the 2 and 10-year storm to 50% and 75% of the pre-development peak flows, respectively at the point of discharge (more stringent NJDEP Stormwater Regulations may apply). The Conduit Outlet Protection Standard, Sec. 4.18 shall be adhered to.

      The practice of infiltration is desirable where feasible. However, the Standards do not recognize such installations as an acceptable means to demonstrate offsite stability. When infiltration practices are installed at up-slope locations, a back-up design must be provided which will assure offsite stability in the event of infiltration failure.

   b. Install a channel stabilized pursuant to the Standard for Soil Bioengineering, Sec. 4.26.

   c. Pipe the stormwater runoff to a stable condition. When constructing a pipe through wetlands, an impervious trench shall be required. The pipe trench shall be compacted and filled with impervious material instead of the classic stone filled trench. The Conduit Outlet Protection Standard, Section 4.18, shall be adhered to. Consideration shall be given to the effects of an extended time of peak discharge duration as compared to the instantaneous peak discharge when detention is not used. Extended peak runoff may saturate the soil, destroy existing vegetation and loosen the soil to an eroding condition.

   d. Install a grassed waterway pursuant to the Grassed Waterway Standard, Sec. 4.21 to a stable condition.

   e. Construct a bare channel pursuant to the Standard for Channel Stabilization, Sec. 4.20 to a stable condition.

f. Install an armor-protected channel pursuant to the Standards for the Lined Waterway, Sec. 4.22 or Riprap, Sec. 4.19 to a stable condition.

4.24.6 Plan Requirements for Documenting Stability

In addition to a completely hydraulic and hydrologic analysis as described above, drawings must be submitted with the erosion control plan which shows the pre-developed drainage condition for the proposed point of discharge along with the time of concentration flow path.

4.25 STANDARD FOR TEMPORARY STREAM CROSSING

4.25.1 Definition

A temporary structural span installed across a watercourse to provide access for construction vehicles during construction. The structure will be in place for no more than one year and shall be removed prior to completion of construction.

4.25.2 Purpose

A temporary stream crossing is designed to provide a means for construction vehicles to cross watercourses without moving sediment into the streams, damaging the streambed or channel, or causing flooding.

4.25.3 Condition Where Practice Applies

The temporary stream crossing shall be used to cross-streams with drainage area less than 1 square mile (2.59 km^2). Structures that must handle flow from larger drainage areas should be designed as permanent structures using generally accepted engineering practice.

4.25.4 Planning

Temporary stream crossings are necessary to prevent construction vehicles from damaging stream banks and tracking sediment and other pollutants into the watercourse. However, these structures are undesirable in that they represent a channel restriction, which can increase flooding upstream or washout during periods of high flow. Therefore, the temporary nature of the structure is stressed. The structure should be planned to be in service for the shortest practical period of time and to be removed as soon as their function has been completed.

This standard pertains primarily to 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 loadings from heavy construction equipment.

The preferred method for temporarily crossing a stream is a bridge made of wood, metal or other material, which can provide access across the stream. A bridge causes the least amount of disturbance to the streambed and banks. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interferences with fish passage and migration. The other method of temporarily crossing a stream is a culvert crossing consisting of stone and a section(s) of pipe. Temporary culverts are used where the channel is too wide for normal bridge construction or the anticipated loading of construction vehicles may prove unsafe for single span bridges. There is some disturbance to the streambed and banks during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

4.25.5 Design Criteria

1. Temporary Bridge Crossing

    a. Structures may be designed in various configurations and from various materials. However, the bridge must be able to withstand the anticipated loadings of the construction traffic. An example of a typical bridge crossing is shown in figure 4.25-1.

b. Crossing Alignment – The temporary stream 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 center of the line of the stream at the intended crossing location. Locate the temporary crossing so that environmental impacts are kept to a minimum.

c. The centerline of the roadway approaches on both sides of the crossing shall coincide with the crossing alignment centerline for a minimum of 50 feet (15 meters) from each bank of the stream crossed. If the physical right-of-way restraints preclude the 50 feet (15 meters) minimum, a shorter distance may be provided.

d. A water diversion such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (15 meters) (maximum) on either side of the stream crossing. This will prevent roadway surface runoff from directly entering the stream. The 50 feet (15 meters) is measured from the top of the stream bank. If the roadway approach is constructed with a reverse grade away from the stream, a diverting structure is not required. See the Standard for Runoff Diversion, Sec. 4.5, for roadbed diversions.

e. Perimeter soil erosion controls, such as a heavy silt fence, must be employed, when necessary, parallel to and along the banks of stream.

f. All crossings shall have one traffic lane. The minimum width shall be 12 feet (3.6 meters).

2. Temporary Culvert Crossing

a. Where culverts are installed, use ASTM C-33, size No.2 (2 ½ to 1 ½ inches) (62.5 mm to 37.5 mm) Coarse Aggregate or larger will be used to form the crossing. The depth of stone cover over the culvert shall be a minimum of 12 inches (300 mm) or as recommended by the pipe manufacturer for the design loading. Riprap shall be used to protect the sides of the stone from erosion. Typical culvert details are presented in figure 4.25-2.

b. As a minimum, the culvert shall be designed to pass the flow from a 2-year frequency, 24-hour duration storm without overtopping. In addition the culvert shall be designed to ensure that no erosion will result from the 10-year peak storm.

c. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 18 inches (450 mm).

d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.

e. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

f. The slopes of the culvert shall be at least 0.25 inch per foot (6.25 mm per meter).

g. Crossing Alignment – The temporary culvert crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

h. The centerline of the roadway approaches on both sides of the crossing shall coincide with the crossing alignment centerline for a minimum of 50 feet (15 meter) from each bank of the stream crossed. If the physical right-of-way restraints preclude the 50 feet (15 meters) minimum, a shorter distance may be provided.

i. The approaches to the structure shall consist of stone pads meeting the following specifications:

- Stone: ASTM C-33, size No. 2 (2 ½ to 1 ½ inches) (62.5 mm to 37.5 mm)
- Minimum thickness: 6 inches (150 mm)
- Minimum Width: equal to the width of the structure

j. A water diverting structure such as a dike or swale shall be constructed (across the roadway or both roadway approaches) 50 feet (15 meters) maximum on either side of the stream crossing. This will prevent roadway surface runoff from directly entering the stream. The 50 feet (15 meters) is measured from the top of the stream bank. If the roadway approach is constructed with a reverse grade away from the stream, a diverting structure is not required. See the Standard for Runoff Diversion, Sec. 4.5 for roadbed diversions.

FIGURE 4.25-1 STREAM CROSSING – TEMPORARY BRIDGE

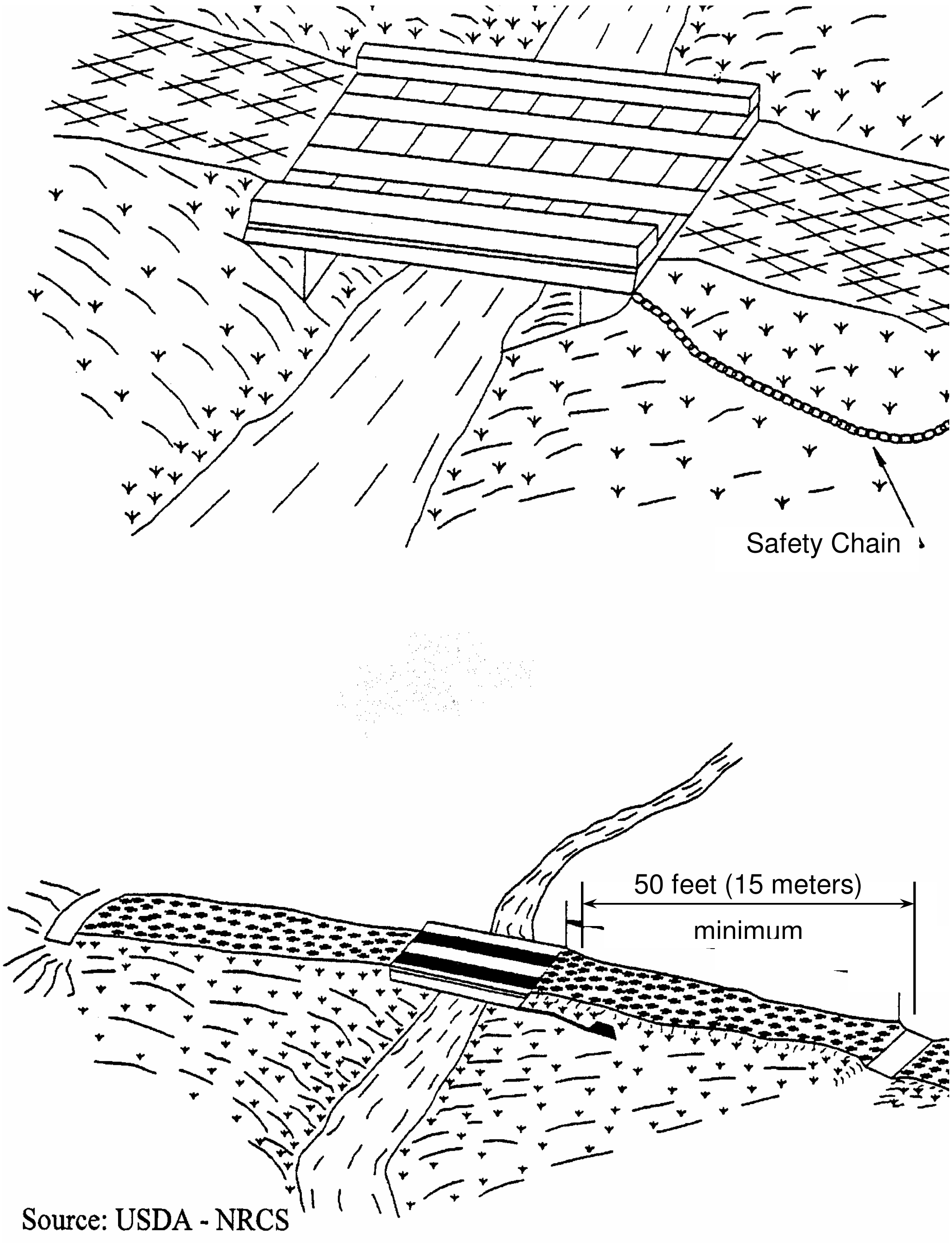
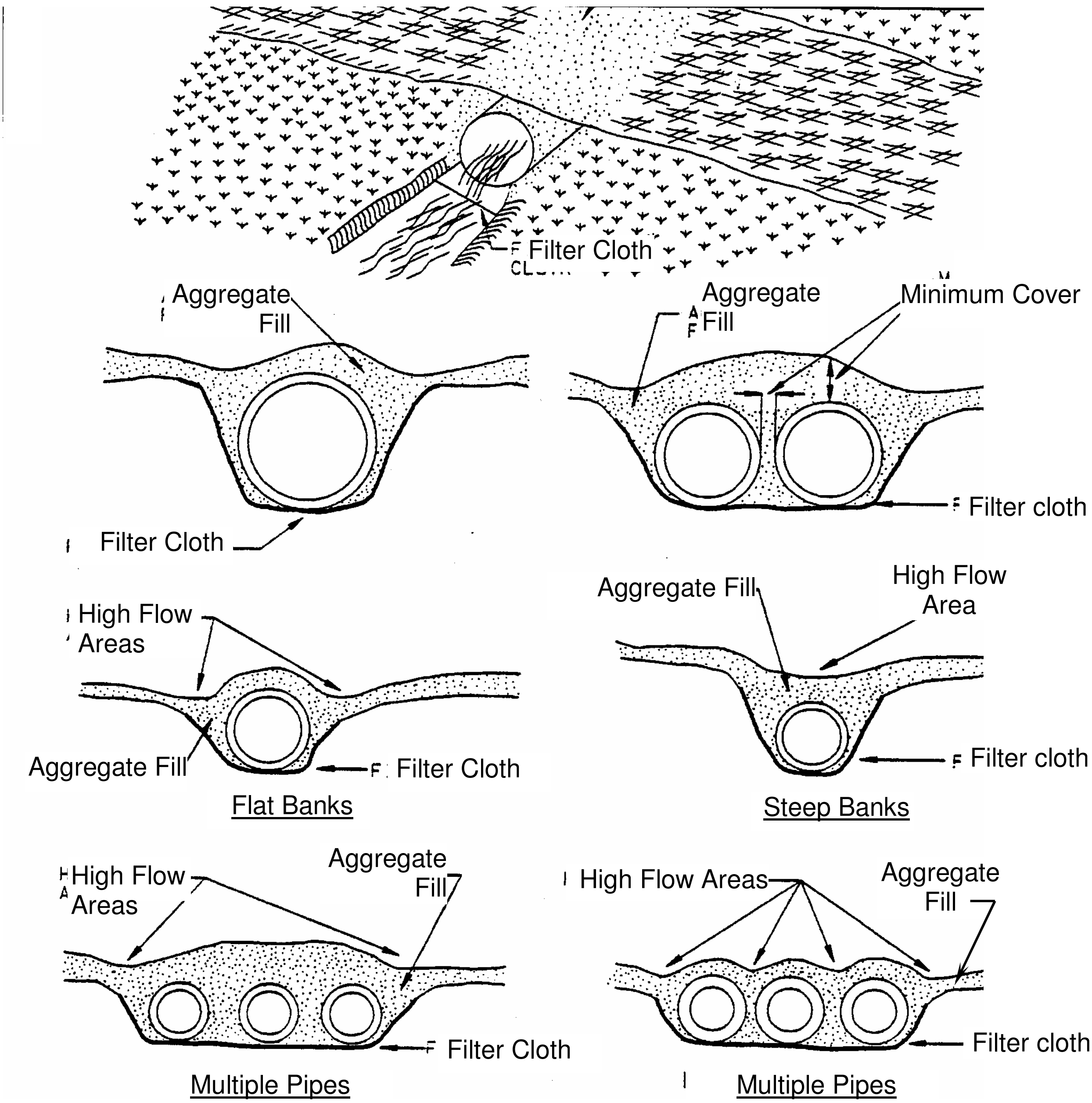


FIGURE 4.25-2 STREAM CROSSING – CULVERT INSTALLATION



4.25.6 Construction Specifications

1. Temporary Bridge Crossing

   a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

   b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.

   c. Abutments shall be placed parallel to and on stable banks.

   d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 feet (2.4 meters) (as measured from 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 feet (2.4 meters) width of the channel. However, no footing, pier, or bridge support will be permitted within the channel for waterways that are less than 8 feet (2.4 meters) wide.

   e. Stringers shall be either logs, sawn timber, pre-stressed concrete beams, metal beams, or other approved materials.

   f. 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.

   g Run planking (optional) shall be securely fastened to the length of the span. One run plank may be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

   h. Curbs or fenders may be installed along the outsides of the deck. Curbs or fenders are an option, which will provide additional safety.

   i. 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.

   j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance.

   k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.

   l. Final cleanup 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 wetland or flood plain of the stream. Removal of the bridge and clean up of the area shall be accomplished without construction equipment working in the waterway channel.

2. Temporary Culvert Crossing

   a. Clearing and excavation of the streambed and banks shall be kept to a minimum.

   b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration. In addition, no construction or removal of a temporary access culvert will be permitted during the following periods critical to spawning along such waters as identified in the Department of Environmental Protection's report entitled <u>Classification of New Jersey Waters as related to their Suitability for Trout:</u>

i. Brook Trout/Brown Trout Production Watercourses:	September 15 though March 15, inclusive
ii. Rainbow Trout Production Watercourses:	February 1 through April 30, inclusive
iii. Trout Production Watercourses:	September 15 though March 15, inclusive
iv. Trout Stocked Watercourses, or within 1 mile (1.61 km) upstream of Trout Stocked Watercourses and Trout Maintenance Watercourses: inclusive,	March 15 through June 15

   Waivers of the timing restrictions may be granted if approved, in writing, by the New Jersey Department of Environmental Protection's Division of Fish and Wildlife.

   c. Filter cloth shall be placed on the streambed and stream banks prior to the placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of 6 inches (150 mm) and a maximum of 1 foot (300 mm) beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability. <u>This requirement should not be confused with the installation of conduit outlet protection (item F. below).</u>

   d. The culvert(s) shall extend a minimum of 1 foot (0.3 meter) beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet (12 meters) in length.

   e. The culvert(s) shall be covered with a minimum of 1 foot of aggregate. If multiple culverts are used, they shall be separated by at least 12 inches (300 mm) of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossing shall confirm with the aggregate requirements cited in part "i" under "Temporary Culvert Crossing."

   f. The Standard for Conduit Outlet Protection Sec.4.18 shall be addressed for the temporary culvert. The 10-year design storm peak shall be used for apron and stone sizing.

g. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and clean up of the area shall be accomplished without construction equipment working in the waterway channel.

h. Upon removal of the structure, the stream shall immediately be shaped up to its original cross-section and properly stabilized. Restoration may include the application of the Soil Bioengineering techniques where applicable. See the standard for Soil Bioengineering, Sec. 4.26.

4.25.7 Maintenance

Both structures shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

4.26 STANDARDS FOR SOIL BIOENGINEERING

4.26.1 Definition

The use of live, woody and herbaceous plants to repair slope failures and to increase slope stability. Living plant material may be used alone or in combination with structural components such as rock, wood, concrete or geotextiles.

4.26.2 Purpose

To integrate structural and vegetative techniques to stabilize or protect banks of streams, lakes, shorelines, excavated channels, and uplands slopes; to prevent the loss of land or damage to facilities adjacent to the banks; to maintain the capacity of the channel; to reduce sediment loads causing downstream damages and/or pollution; and to protect and enhance water quality.

4.26.3 Conditions Where Practices Applies

Soil bioengineering techniques are generally appropriate for treatment of slopes, eroded stream banks, surface erosion, shallow mass wasting, cut and fill slope stabilization; earth embankment protection (other than dams), and small gully repair**.** They are not to be considered when public safety is at risk such as when substantial mechanical and or structural designs are required.

Descriptions of methods for installing individual Soil Bioengineering systems may be found in USDA Natural Resources Conservation Service Engineering Field Handbook (EPH), Chapter 16 Streambank and Shoreline Protection and Chapter 18 Upland Slope Protection.

4.26.4 Design Criteria

1. PLANNING

   Flow Chart No. 4.26-1 Soil Bioengineering Application Decision Chart shall be used to determine if Soil Bioengineering Techniques alone are appropriate for correcting existing erosion problems or for preventing future erosion of shorelines, upland slopes, or stream channels. Bioengineering techniques may be used singularly or in combination with one another or in combination with other erosion control techniques, such as riprap bank protection. The following conditions must be evaluated to help ensure a proper soil bioengineering design:

   - Soil type and moisture availability
   - Stream bed stability
   - Slope stability
   - Surface runoff (diversion may be necessary to ensure success – see Standard for Diversions, Sec.4.5)

   - Availability of bioengineering materials
   - Effects of mature vegetation on stream hydraulics, including up and downstream of the treatment area

- Time of year for installation (installation of all woody vegetation shall be performed during the during planting season only)
- Cause of the loss of existing vegetation (ice damage, fire, invasive species etc.)

2. <u>ENGINEERING</u>

Grading:

Steep, unstable slopes and deep undercuts in banks will require extensive grading to achieve a stable slope or will require structural measures such as crib walls, riprap, or wire-mesh baskets. For planting purposes only, the steepest acceptable slope is 1.5 horizontal to 1.0 vertical. Slope stability analysis or design shall be subject to municipal, county and state regulations. All newly graded banks shall be protected from
overbank flow in accordance with the Standard for Diversions, Sec. 4.5

Channel Realignment:

The realignment of channels (change in location or cross-sectional geometry) shall be kept to an absolute minimum unless realignment is the subject of the soil erosion and sediment control plan.

Channel Capacity:

Peak discharge and/or hydrographs for capacity shall be determined by the following methods:

1. Rational Method – for peak discharge of uniform drainage areas as outlined in <u>Technical Manual for Land Use Regulation Program, Bureau of Inland and Coastal Regulations Stream Encroachment Permits,</u> Trenton, N.J. September 1997 or subsequent editions

2. NRCS Technical Release No. 55 or No. 20

3. U.S. Army Corps of Engineers HEC-1

4. Other methods, which produce similar results to the models, listed above.

Hydraulic Requirements:

Manning's formula (where appropriate) or a water surface profile analysis shall be used to determine the velocities in the channels. Resistance (Manning's "n") values shall be estimated using Table 4.26-1. Flow Chart No. 4.26-2 Soil Bioengineering In-Stream Design Chart shall be followed for stream channel designs.

Design storm requirements for stability analysis shall be in accordance with the Standard for Channel Stabilization, Sec. 4.20. An aged condition shall analyze capacity at vegetative maturity.

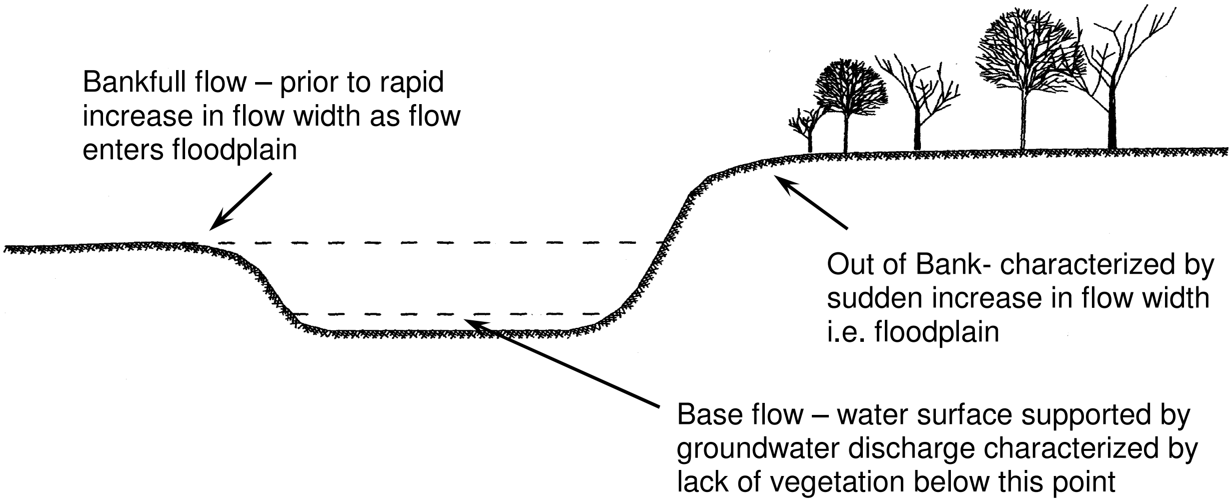
TABLE 4.26-1 ESTIMATING MANNING'S "n" FOR SOIL BIOENGINEERING PRACTICES

Bioengineering System	**Manning's "n" values***	
	Installation Condition (Stability)	Mature Condition (Capacity)
Conventional vegetation (use of the retardance method is required for designing grass lining)	0.025	0.055
Live Staking Live Facines (wattling bundles) Branchpacking Brushmattress Live Cribwall (similar to wire-mesh baskets in hydraulic effects)	0.025	0.1
Joint Planting	see standard	see standard

* Does not consider channel alignment, obstructions etc. Based on non-gravel soils. See Appendix 8, supplement "A" for additional guidance for selecting "n" values.

<u>Figure 4.26-1 Terminology in Channel Flow Descriptions</u>

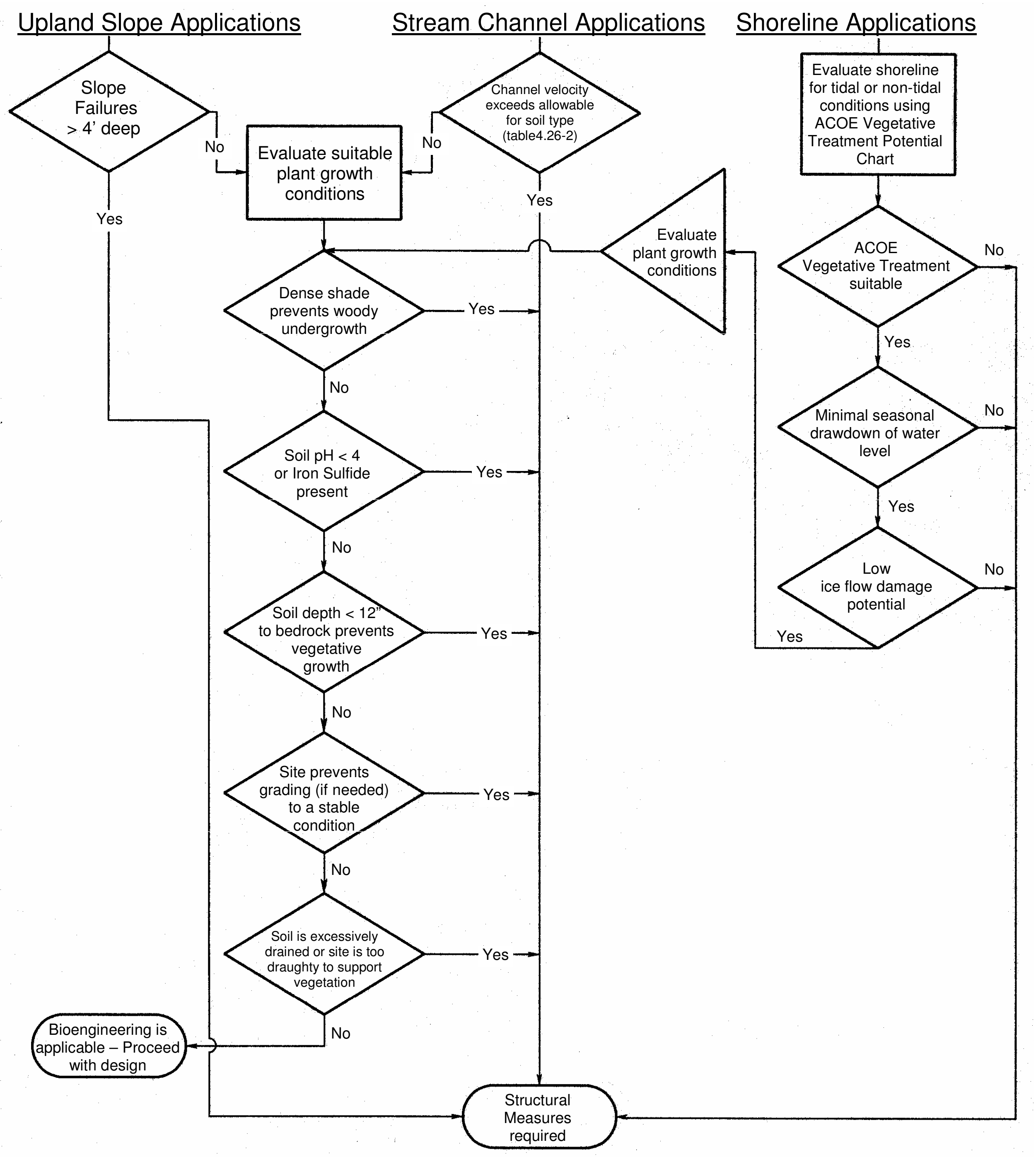
Channel Flow descriptions in Bioengineering Practices



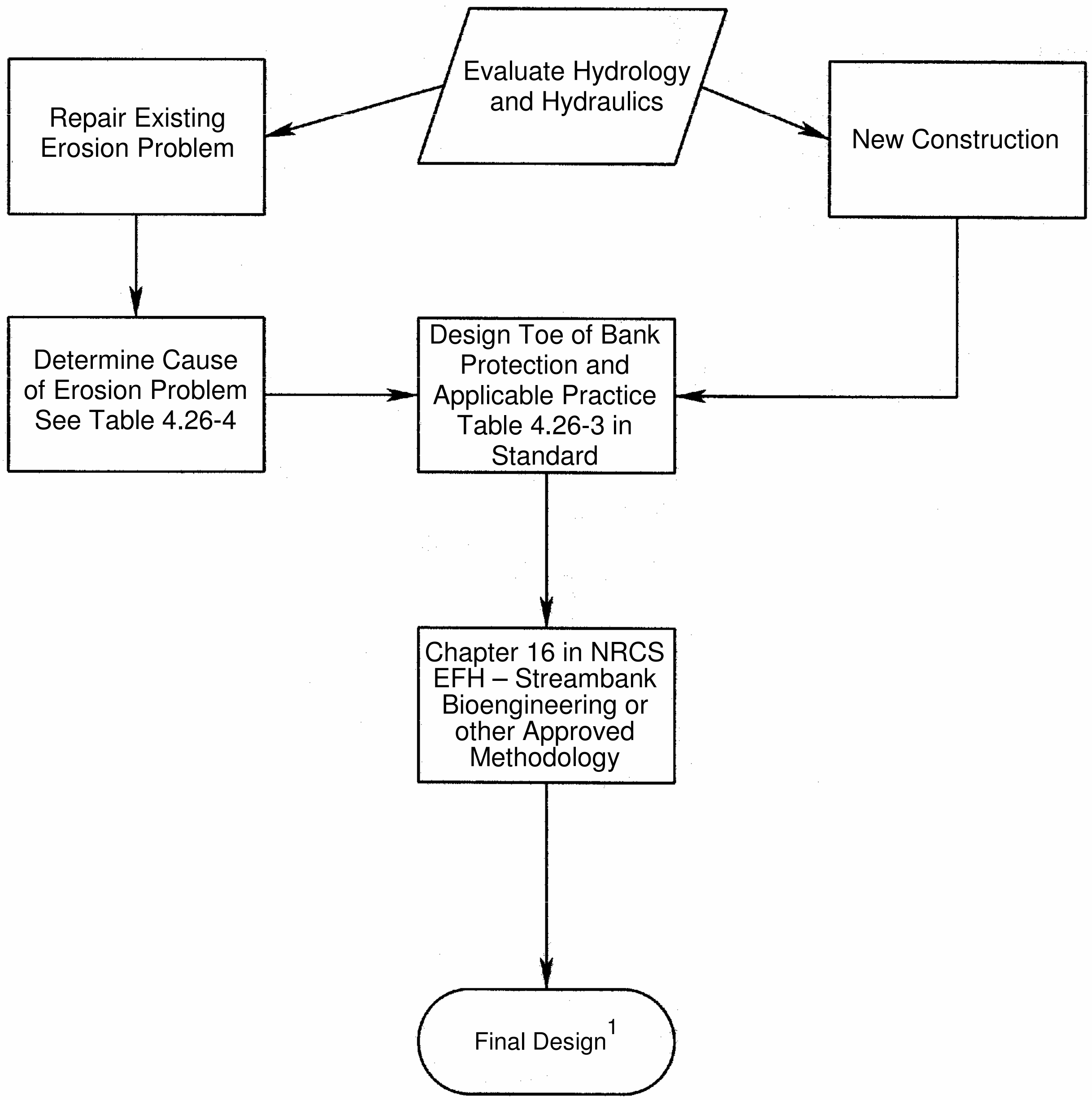
Maximum allowable velocities for bankfull and out of bank discharges (fig. 4.26-1) shall be based on allowable soil velocities found in Table 4.26-2. These velocities are based on the use of acceptable erosion control matting in conjunction with the bioengineering system. Every reach shall be individually designed unless all reaches are designed for the worst cases for velocity and capacity (lowest allowable velocity, steepest slope). Bioengineering designs must begin and end in a stable channel section.

Toe Protection at Base Flow Elevation – Toe protection is to be provided on all stream bank stabilization projects. Methods of providing toe protection may consist of a fiber roll revetment (coir log) adequately anchored or a structural revetment such as rock riprap. Fiber roll revetments have a design life of 5 years and are suitable for sites where there is a high probability that vegetation, once established, will be adequate for stabilizing the toe zone. In general, this will be in lower velocity channels where adjacent reaches indicate vegetation alone will be adequate. Riprap for toe protection shall be designed using the bankfull or design discharge velocity using procedures in the Standard for Riprap, Sec. 4.19.

FLOW CHART 4.26-1 SOIL BIOENGINEERING APPLICATION CHART



FLOW CHART 4.26-2 SOIL BIOENGINEERING IN-STREAM DESIGN CHART



[1]Final design may need to include diversion of overland flows from slopes

Table 4.26-2 Maximum Allowable Velocities for Bioengineering Systems

Soil Texture	Velocity (fps) with matting[1]	Velocity (mps) with matting[1]
Sand	2	0.6
Silt loam, sandy loam, loamy sand, loam and muck	5	1.5
Silty clay loam, sandy clay loam	5.5	1.7
Clay, clay loam, sandy clay, silty clay	6	1.8

[1] All Soil Bioengineering Application designs shall incorporate an erosion control blanket or flexible channel liner over seeded areas and shall be integrated into the measure in accordance with USDA EFH Chapters 16 and/or 18. The flexible channel liner shall be selected based on the design requirements for the planned bioengineering application.

Table 4.26-3 Summaries of Streambank/Upland Slope Bioengineering Protection Measures

System Type	**Zone of Application[1]** -Base Flow -Base to Top -Out of Bank	**Types of erosion problems for which the system is suitable**	**Comments and Restrictions**
Live stake	Base to Top Out of Bank	Bank scour, overbank runoff	Suitable for small, simple erosion problems when used in conjunction with other systems. $^4/_{5's}$ of height of stake should be installed in the ground.
Live fascine	Base to Top, Out of Bank	General bank scour,, overbank runoff	Useful for moderate to severe erosion;, should not be used on bank faces longer than 15 ft (4.5m), after sloping.
Branchpacking	Base to Top, Out of Bank	Local bank scour, gullies eroded by overbank runoff	Restricted for repair of small sites (maximum depth of 4.0 ft. (1.2 m)
Vegetated Geogrid	All Zones	Toe erosion, local bank scour	Useful on steep slopes (up to 0.5H:1V) where space is limited/generally restricted to heights not exceeding 6 ft. (1.8 m) overall.
Live cribwall	All Zones	Local bank scour, toe erosion (requires structural to protection)	
Joint planting	Base to Top, Out of Bank	See riprap standard	See riprap standard
			Chart is continued on page 203

System Type	Zone of Application[1] -Base Flow -Base to Top -Out of Bank	Types of erosion problems for which the system is suitable	Comments and Restrictions
Brushmattress	Base to Top, Out of Bank	Local and general bank scour; debris gouging	Generally used on 3H: 1V graded slopes restricted to sites of 50 linear ft. (15 m) or less
Conventional vegetation	Base to Top, Out of bank	Local and general bank scour	See Table 26-2 for velocity restrictions
Tree revetment	Base to Top	General bank scour	Provides temporary protection, susceptible to damage by flooding debris and beavers
(incl. Wire-mesh baskets)	All Zones	Local and general bank scour, toe erosion	All headcutting and general bed degradation by erosion must have armored protection
Coir (coconut fiber) Logs	Base, Base to Top	Toe erosion	Must be $^2/_3$'s submerged in water to be an effective rooting medium.

[1] See Figure 4.26-1 for description of zones.

3. VEGETATION

Plant materials will be viable woody or herbaceous vegetation. The plant materials will be obtained from commercial sources or in the case of woody cuttings, may be harvested from native stands during the dormant period. (November-April).

Plant Adaptation Zones:

Base Flow Zone (Toe Zone) – Too wet to grow vegetation or where side slopes meet channel bottom (intermittent streams). Select vegetation that develops an extensive root system and tolerates extended saturation. This includes Obligate and Facultative Wet herbaceous and woody plants.

Above Base flow to top of bank or 2-year storm elevation (Bank Zone) – Area between level base flow and top of bank or 2-year storm elevation. Select vegetation which tolerates wetting and drying soils. This includes Facultative and some Facultative Wet grasses, forbs, and shrubs.

Out of Bank.(Terrace Zone) – Select vegetation that tolerates drought.. This may include some Facultative and most Facultative Upland plants.

A. Plant Material Specifications:

* Rooted seedlings – Plants shall be at least 12 inches (300 mm) long. The root system shall have approximately the mass equal to the top portion.

* Unrooted cuttings – Cuttings shall be 8 inches to 12 inches (200 mm-300 mm) in length and ¼ inch to ½ inch (6.25 mm-12.5 mm) in diameter.

* Live stake – cuttings shall be 2.0 feet to 3.0 feet (0.6 meter to 0.9 meter) in length and ½ inch to 2.0 inches (12.5 mm to 50 mm) in diameter.

* Live brush – Live brush will consist of the whole above ground portion of willow, red osier dogwood, or other hardwood species which root easily from cuttings. Plants shall be 4 to 8 feet (1.2 meters to 2.4 meters) in height and free of disease. When there is a shortage of live, dormant brush, up to 30% of nonrooting species may be mixed randomly with the rooting species. Brush will be cut by shears or saw, not by ax.

* Herbaceous plants – Grasses, sedges, and rushes shall be provided in multiple-culmed pots having a minimum of two stems per pot. Stems shall have a minimum length of 6"(150mm)

B. Plant Selection – See Table 4.26-5 for specific species adaptations:

1. Herbaceous plant materials to be used in the coir fiber rolls shall consist of a mixture of the following:

Asclepias incarnata – Swamp milkweed -
Acorus calamus/americanus – Sweet Flag
Calamagrostis spp. – Bluejoint reedgrass
Carex spp. – Sedges
Cinna arundinacea – Wood reedgrass .
Distichlis spicata – Seashore saltgrass .
Eupatorium purpureum – Joe-Pye weed
Glyceria spp. – Mannagrasses
Iris versicolor – Blueflag iris
Juncus spp. – Rushes
Lobelia cardinalis – Cardinal Flower
Pontederia cordata – Pickerel
Sagittaria latifolia – Duckpotato
Scirpus spp – Bulrushes
Sparganium spp.-Burreed
Spartina spp – Cordgrasses

2. Woody plants shall consist of bareroot plants or unrooted cuttings and stems (whips) of hardwood shrub species which root easily. The plant materials may come from nursery sources or existing local stands, or a combination of the two. Plant Materials suitable for use as rooted or unrooted cuttings include:

Cephalanthus occidentalis – Buttonbush
Baccharis halimifolia – Groundsel bush

Cornus amomum – Silky Dogwood
Cornus sericea – Red osier Dogwood
Salix purpurea – ‘Streamco’ Purple osier Willow
Salix cottetii – ‘Bankers’ Dwarf Willow
Salix exigua – Sandbar Willow
Salix discolor – Pussy Willow
Sambucus canadensis – Elderberry
Viburnum dentatum – Southern Arrowwood
Viburnum lentago – Nannyberry
Viburnum prunifolum – Blackhaw Viburnum

C. Plant Materials suitable for use only as bareroot or containerized plants include:

Alnus rugosa – Speckled Alder
Alnus serrulata – Smooth Alder spp.
Amorpha fruitcosa – Indigobush
Aronia arbutifolia – Red Chokecherry
Clethra alnifolia – Sweet Pepperbrush
Cornus racemosa – Gray Dogwood
Ilex verticillata – Winterberry Holly
Lindera benzoin – Spicebush
Physocarpus opulifolius – Ninebark
Prunus pumila var. depressa – Dwarf sand cherry
Rhododendron viscosum – Swamp azalea
Rosa palustris – Swamp rose
Spiraea tomentosa – Steeplebush

D. Supplemental Grass Mixtures

Grass species suitable for stabilizing disturbed areas that are somewhat poorly to poorly drained are:

SPECIES	COMMON NAME	REMARKS[1]
Agrostis alba	Redtop	SP, I, CG
Agrostis palustris	Creeping bentgrass	P, I, CG
Andropogon glomeratus	Lowland broom sedge	P, N, WG
Dichanthelium clandestinum	Deertongue	P, N, WG
Echinochloa crusgalli	Japanese millet	A, T, WG
Elymus virginicus	Wild rye	P, N, CG
Lolium perenne[2]	Perennial ryegrass	SP, I, CG
Lotus corniculatus[3,4]	Birdsfoot trefoil	P, I, CL
Panicum virgatum	Switchgrass	P, N, WG
Poa trivialis	Rough bluegrass	P, I, CG
Trifolium repens[4]	White/Ladino clover	SP, I, CL

. [1]P – Perennial
A – Annual
I – Introduced
N – Native

CG – Cool-season grass
WG – Warm-season grass
CL – Cool-season legume
SP – Short-lived perennial

[2]Perennial ryegrass may be substituted for redtop in all mixes except Mix # 7.

[3]Birdsfoot trefoil is not well adapted to the coastal plain. Use only in northern and central New Jersey.

[4]Need specific legume inoculant.

Note: Warm-season grass seeding rates are based on Pure Live Seed (PLS).

Suitable seeding mixtures and recommended seeding rates for various site conditions:

<u>Seed Mix 1:</u>
Cool-season mix suitable for shady sites.

*	Redtop	1 lb./ac. (1.2 kg/hectare)
*	Hard Fescue	40 lbs./ac. (45 kg/hectare)
*	Rough Bluegrass	15 lbs./ac. (18 kg/hectare)

<u>Seed Mix 2:</u>
Warm-season mixture suitable for highly acid soils. Provides excellent wildlife value.

*	Blackwell Switchgrass	15 lbs./ac. (16.82 kg/hectare) PLS
*	Tioga Deertongue	10 lbs./ac. (11.21 kg/hectare) PLS
*	Japanese Millet (nurse)	8 lbs./ac. (8.97 kg/hectare) PLS

<u>Seed Mix 3:</u>
All native mixture suitable for somewhat acid soils. Provides good to excellent wildlife value.

*	Blackwell Switchgrass and/or	10 lbs./ac. (11.21 kg/hectare) PLS
*	Broom Sedge	12 lbs./ac. (13.45 kg/hectare) PLS
*	Tioga Deertongue	5 lbs./ac. (5.61 kg/hectare) PLS
*	Wild Rye	5 lbs./ac. (5.61 kg/hectare) PLS

Use a nurse crop such as oats or rye.

<u>Seed Mix 4:</u>
Turf grass mixture suitable for moist, shady areas.

*	Rough Bluegrass	25 lbs./ac. (28.03 kg/hectare)
*	Perennial Ryegrass	15 lbs/ac. (16.82 kg/hectare)
*	Creeping Bentgrass	10 lbs./ac. (11.21 kg/hectare)

Optional:

*	White Clover or	5 lbs./ac. (5.61 kg/hectare)
*	Birdsfoot Trefoil	8 lbs./ac. (8.97 kg/hectare)

Seed Mix 5:

Mixtures for providing quick, semi permanent cover in areas where natural succession is encouraged. Excellent wildlife value.

*	Redtop	2 lbs./ac. (2.24 kg/hectare)
*	Japanese Millet	8 lbs./ac. (8.97 kg/hectare)
*	White/Ladino Clover	5 lbs./ac. (5.61 kg/hectare)

Seed Mix 6:

Shotgun mix (for those extremely complex sites)

*	Tioga Deertongue	15 lbs./ac. (16.82 kg/hectare) PLS
*	Redtop or	3 lbs./ac. (3.36 kg/hectare) PLS
*	Perennial Ryegrass	5 lbs./ac. (5.61 kg/hectare) PLS
*	Wild Rye	10 lbs./ac. (11.21 kg/hectare) PLS
*	Switchgrass	8 lbs./ac. (8.97 kg/hectare) PLS
*	Broom Sedge	12 lbs./ac. (13.45 kg/hectare) PLS

Wildflowers tolerant of wet conditions:

* Aqailega Canadensis – Eastern Columbine
* Chrysanthemum leucanthemum – Ox-eye Daisy
* Hesperis [1]matronalis – Dame's Rocket
* Lupinus perennis – Perennial Lupine
* Myostis sylvatica – Forget-Me-Not
* Rudbeckia hirta – (Golden Jubilee) Black-eyed Susan

Table 4.26-4: Types of Erosion and Causes of Erosion	
Type of Erosion	Causes
Toe erosion and upper bank failure	Removal of unconsolidated or noncohesive lower materials, especially bank failure along outside bends. Widespread toe erosion may be associated with bed lowering.
General bed degradation (Bed scour over extended channelization, reaches)	Changes in stream gradient due to factors such as lowering of stream base level due to lake or tailwater fluctuations or stream relocation. Increased stream discharge is due to flow diversion or watershed changes such as urbanization.
Headcutting	In streams undergoing bed degradation, headcuts often develop at locations where more resistant material outcrop in the stream channel. Headcuts may develop at a stream mouth when base level is lowered suddenly due to dredging, erosion, or draining of a lake.
Middle and upper general bank scour	Increased discharge resulting from watershed changes; increased flow velocities caused by reduction in channel roughness or increased gradients; removal or loss of bank vegetation.
Local streambank scour	Scour of local lenses or deposits of unconsolidated material; erosion by secondary currents caused by flow obstructions and channel irregularities; loss of bank vegetation.
Local bed scour	Local bed scour may be caused by channel construction, flow obstructions such as debris dams or flow deflectors, or trapping of sediment in reservoirs or sediment traps. Some scour generally occurs below culverts.
Piping	Piping develops when fines are removed by water flowing laterally under the surface. Extensive pipe development requires 1) rapid infiltration, 2) steep hydraulic gradients, and 3) zones of concentrated flow. Piping may occur in stratified soils where vertical movement is restricted by sudden reduction in hydraulic conductivity between strata or where poorly compacted soil around buried pipes provides conduits for water movement.
Overbank runoff	Failure to provide adequate means of directing concentrated flows from overbank areas in the channel.

Table 4.26-5 Shrubs Suitable for Soil Bioengineering Systems

Species	Habitat	Bank Zone	Root Form	Shade Tolerance	Flood Tolerance	PH Range	Comments
Alnus Serrulata **Smooth Alder**	Non-tidal	Toe	Rooted	Medium	Regular	3.5 - 7.5	Nitrogen fixer weak wooded
Amorpha Fruitcosa **False indigo**	Tidal fresh Moist woods	Lower-mid	Rooted	Low	Seasonal	6.0 - 8.5	Req. full sun Drought tolerant
Aronia Arbutifolia **Red Chokeberry**	Non-tidal	Lower-mid	Rooted	Medium	Irregular Seasonal	5.1 - 6.5	Drought tolerant
Aronia melanocarpa **Black Chokeberry**	Non-tidal	Mid-upper	Rooted	Low	Irregular Seasonal	5.1 - 6.5	Drought tolerant
Baccharis halimifolia **Groundsel bush**	Tidal Tidal fresh	Mid-upper	Rooted Unrooted	High	Seasonal	7.0 – 8.5	M/F separate plants
Cephalanthus occidentalis **Buttonbush**	Non-tidal Tidal fresh	Toe	Rooted Unrooted	High	Permanent	6.1 – 8.5	Tolerates brief drought
Clethra alnifolia **Sweet pepperbush**	Tidal Non-tidal	Mid-upper	Rooted	High	Seasonal	4.5 – 6.5	
Cornus amomum **Silky dogwood**	Streambanks Pond edges	Lower-mid	Rooted Unrooted	Medium	Seasonal	5.5 – 8.5	Drought tolerant
Cornus racemosa **Gray dogwood**	Streambanks Pond edges	Lower-mid	Rooted Unrooted	High	Seasonal	5.5 – 8.5	Drought tolerant
Cornus serecia **Redosier dogwood**	Streambanks Pond edges	Toe-mid	Rooted Unrooted	Medium	Seasonal	5.5 – 8.5	Drought tolerant
Ilex deciduas **Possumhaw**	Forested wetlands Pond edges	Lower-mid	Rooted Unrooted	High	Irregular	4.0 – 6.0	M/F separate plants
Ilex glabra **Inkberry**	Forested wetlands Sandy woods	Mid-upper	Rooted	High	Irregular Inundation	4.5 – 6.0	M/F separate plants. Resists salt spray
Ilex verticillata **Winterberry holly**	Tidal fresh Forested wetlands	Lower-mid	Rooted	High	Seasonal	4.5 – 8.0	Drought tolerant
Itea virginica **Virginia sweetspire**	Forested wetlands Streambanks	Toe	Rooted	High	Regular	5.0 – 7.0	Tolerates some salt
Iva frutescens **Hightide bush**	Tidal brackish	Lower	Rooted	Low	Regular	6.0 – 7.5	Tolerates 15ppt salt
Leucothe racemosa **Leucothe**	Forested wetlands Moist woods	Lower-mid	Rooted	High	Regular	5.0 – 6.0	Tolerates some dry-down
Lindera benzoin **Spicebush**	Seasonal wetlands Floodplain	Lower-mid	Rooted	High	Seasonal	4.5 – 6.5	Tolerates some drought
Lyonia ligustrina **Maleberry**	Open woods	Lower-mid	Rooted	Low	Seasonal	4.0 – 6.0	Acid tolerant
Magnolia virginiana **Sweetbay magnolia**	Stream borders Forested wetlands	Lower-mid	Rooted	High	Irregular / Seasonal	4.0 – 6.5	Tolerates infreq. flooding by salt
Myrica cerifera **Wax myrtle**	Tidal fresh Brackish swales	Mid-upper	Rooted	High	Regular	4.0 – 6.0	Tolerates 10ppt salt. N-fixing
Myrica pennsylvanica **Bayberry**	Tidal fresh Brackish Nontidal	Mid-upper	Rooted	High	Irregular-seasonal	5.0 – 6.5	Tolerates drought. N-fixer
Physocarpus opulifolius **Ninebark**	Streamsides Wood edges	Low-mid	Rooted	Medium	Seasonal		
Prunus pumila var. depressa **Dwarf sand cherry**	Streamsides Sandbars	Mid-upper	Rooted	Low	Irregular	6.5 – 8.5	Native to Del. River Groundcover
Rhododendron viscosum **Swamp azalea**	Forested wetlands	Toe-low	Rooted	Medium	Seasonal -irregular	4.0 – 6.0	Susceptible to disease
Rosa palustris **Swamp rose**	Tidal fresh Forested wetlands Streambank	Toe-low	Rooted	Low	Seasonal -irregular		

Rhus typhina/galbra **Staghorn/Smooth sumac**	Disturbed banks / Dry sites	Upper	Rooted	Low	Irregular	6.1 – 7.0	Tolerates some drought
Salix X cottetii **"Bankers" Dwarf willow**	Streambanks	Toe -mid	Unrooted Rooted	Medium	Regular-permanent		Introduced male hybrid. Noninvasive
Salix exigua **Pussy willow**	Streambanks Forested wetlands	Toe -mid	Unrooted Rooted	Medium	Regular-permanent	6.6 – 7.5	
Salix exigua **Sandbar willow**	Streambanks Sandbars	Toe	Unrooted Rooted	Low	Regular-permanent		
Salix purpurea **"Streamco" purpleosier willow**	Streambanks	Toe-upper	Unrooted Rooted	Medium	Regular-permanent	6.0 – 7.0	Introduced noninvasive shrub
Sambucus **Canadensis Elderberry**	Tidal fresh Nontidal Wet meadow	Low-mid	Rooted Unrooted	High	Irregular-seasonal	6.0 – 8.0	Some salt tolerance. Tolerates drought
Spirqea alba/tomentosa **Meadowsweet**	Forested wetlands	Mid-upper	Rooted	Low	Irregular	5.1 – 6.0	
Viburnum dentatum **Southern arrowwood**	Tidal fresh Nontidal Forested wetlands	Mid-upper	Rooted Unrooted	Medium	Seasonal	5.1 – 7.0	Tolerates drought
Viburnum lentago **Nannyberry**	Forested wetlands	Mid-upper	Rooted Unrooted	Medium	Seasonal r		
Viburnum prunifolium **Blackhaw viburnum**	Forested wetlands	Upper	Rooted Unrooted	Medium	Irregular	6.5 – 7.0	
Viburnum trilobum **Am. Cranberry bush**	Forested wetlands	Lower-mid	Rooted Unrooted	Low	Irregular-seasonal	6.0 – 7.5	Tolerates drought

Notes:

- Habitat:
  Native habitat of the plant.

- Bank zone:
  Toe – elevation of baseflow
  Lower to mid – from base to two-year flood elevation
  Upper – above two-year elevation to flood plain

- Root form:
  Rooted – use bare-root plants or small containers.
  Unrooted – use dormant cuttings/brush

- Shade Tolerance:
  Low – requires full sun
  Medium – tolerates partial shade and full sun
  High – tolerates full shade and full sun

- Flood tolerance:
  Permanent – tolerates inundation or saturation 76-100% of the growing season.
  Regular – tolerates inundation or saturation 26-75% of growing season.
  Seasonal – tolerates inundation or saturation 13-25% of the growing season.
  Irregular – tolerates inundation or saturation 5-12% of the growing season.

- pH range:
  Preferred range for successful plant establishment.

Shoreline Stabilization

The Vegetative Treatment Potential (VTP) as shown in Table 4.26-6 shall be evaluated for all shoreline protection measures. Bioengineering treatments involving vegetation may only be considered where the Treatment Potential Scale indicates excellent to very good site conditions. Vegetative measures alone are not suited to sites where wave heights are greater than 1.5 feet (450mm) and beach slopes are steeper than 12H to 1V. Fiber roll revetments or structural stabilization measures such as rock riprap, and offshore wave dissipater berms shall be considered for use in combination with vegetation where site conditions are not suited to vegetation alone. Fiber roll revetments have a design life of 5 years and are suitable for sites where there is a high probability that vegetation, once established, will be adequate for stabilizing the shoreline. In general, this will be in low energy situations, where adjacent reaches indicate vegetation alone will be adequate. Riprap for shoreline stabilization shall be designed using procedures in the Standards for Riprap, Section 4.19.

TABLE 4.26-6 SOIL BIOENGINEERING VEGETATIVE TREATMENT POTENTIAL (VTP) FOR PONDS AND LAKE SHORES

Shoreline Variables	**Directions For Use**: Enter the applicable VTP rating (bold number) in the last column. Add the total of the VTP ratings and compare with the Treatment Potential (TP) scale below.					**VTP**
1. **Fetch:** Average distances in miles of open water measured perpendicular to the shore and 45 degrees either side of perpendicular to shore.	Less than 0.5 miles (0.81 km) **8**	0.5 to 1.4 miles (0.81-2.25 km) **7**	1.5 to 3.4 miles (2.42-5.48 km) **4**	3.5 to 4.9 miles (5.64-7.9 km) **2**	Over 5.0 miles (8.05 km) **0**	
2. **General slopes of shoreline:** for a distance of 200 yards (0.18 km) on each side of a planting site.	Coves **8**	Irregular shoreline **3**		Headland or straight shoreline **0**		
3. **Shoreline orientation:** General geographic direction the shoreline faces.	Any less than ½ mile (0.81km) fetch **5**	West to North **3**	South to West **2**	South to East **1**	North to East **0**	
4. **Boat traffic:** Proximity of site to recreational and commercial boat traffic.	None **5**	1-10 per week within ½ mile (0.81km) of shore **3**	More than 10 per week within ½ mile (0.81km) of shore **2**	1-10 per week within 100 yards (0.18km) of shore. **1**	More than 10 per week within 100 yards (0.18km) of shore. **0**	

Cumulating of VTP for variables 1, 2, 3 and 4
Treatment Potential (TP) Scale: if TP is:

Between	And	Potential of site to be successfully stabilized with soil bioengineering is
23	26	Excellent
20	22	Very Good
16	19	Good
13	15	Fair
below 13		Poor

4.27 STANDARD FOR DEWATERING

4.27.1 Definition

The removal and discharge of sediment laden water from an excavated area, construction site or sediment basin.

4.27.2 Purpose

To properly remove suspended sediments and water from excavated areas through filtration and /or settlement prior to discharging water to a receiving watercourse or body.

4.27.3 Conditions Where Practice Applies

During construction, excavated facilities need to be dewatered to facilitate or complete the construction process. The water pumped out of the excavated areas contains sediments that must be removed prior to discharging to receiving bodies of water. This standard does not address the removal of groundwater through well points etc. Dewatering Basins within the ROW and outside of undisturbed wetland areas and outside of areas affected by roadway construction.

This standard describes the following practices for the removal of sediment-laden waters from excavation areas:

Removable pumping stations
Sump pits
Portable sedimentation tanks
Silt control bags

4.27.4 Design Criteria

1. Removable Pumping Stations are used when long durations of pumping are required. The number of removable stations and their locations shall be shown on the plans and shall conform to detail 4.27-1. Water pumped from the station shall be discharged into a sediment basin or suitable filter area.

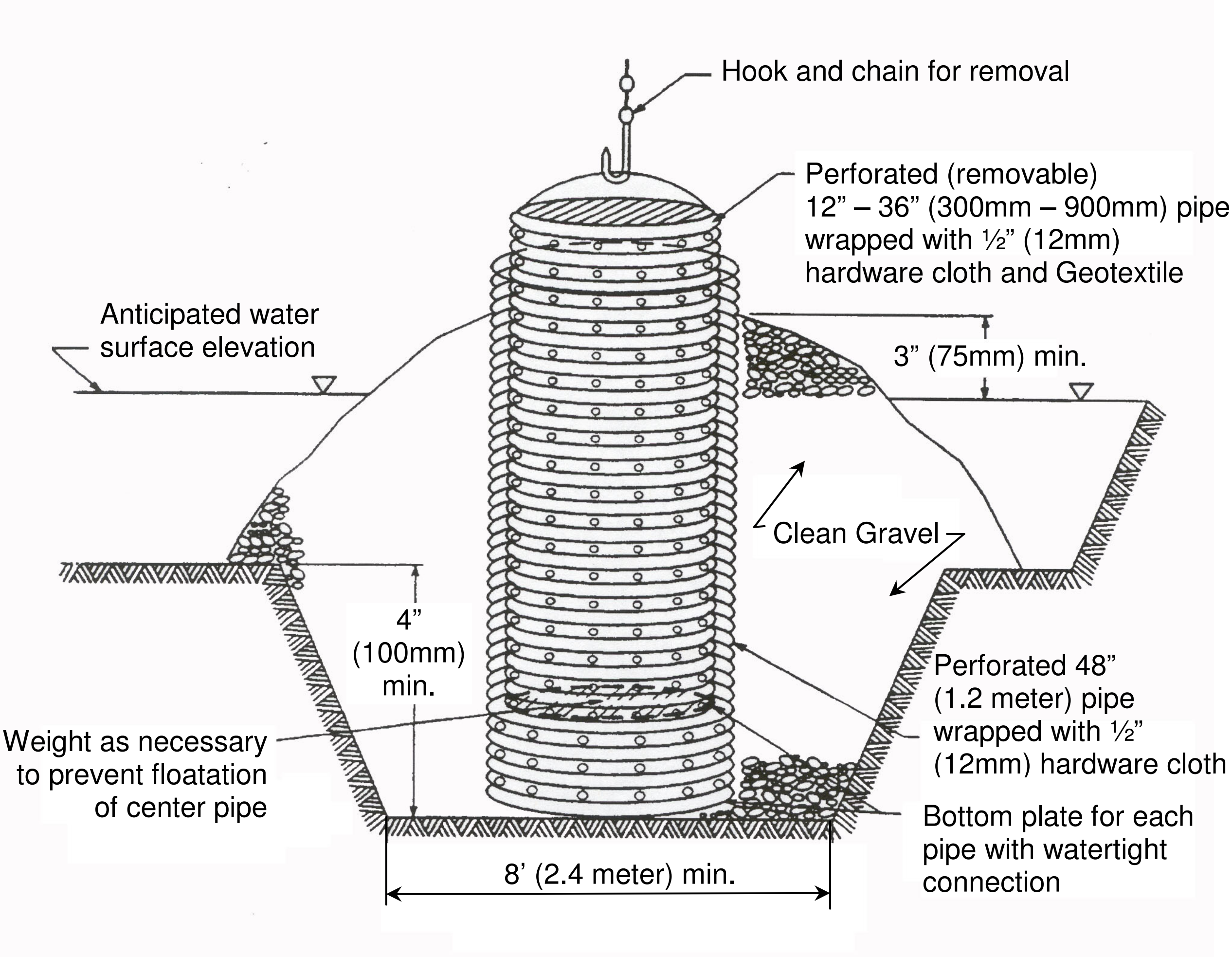
4.27.5 Construction Specifications

A. 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 to prevent erosion.

B. 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.

C. See Detail 4.27-1 for additional specifications.

DETAIL 4.27-1 REMOVABLE PUMPING STATION



Elevation (Cut Away)

Construction Specifications:

1. The outer pipe should be 48" (1.2 meter) diameter or shall, in any case be at least 4" (100mm) greater in diameter than the center pipe. The outer pipe shall be wrapped with ½" (12mm) hardware cloth to prevent backfill material from entering the perforations.

2. After installing the outer pipe, backfill around outer pipe with 2" (50mm) aggregate.

3. The inside stand pipe (center pipe) should be constructed by perforating a corrugated or PVC pipe between 12" (300mm) and 36" (900mm) in diameter. The perforations shall be ½" x 6" (12mm x 150mm) slits or 1" (25mm) diameter holes 6" (150mm) on center. The center pipe shall be wrapped with ½" (12mm) hardware cloth first, than wrapped again with Geotextile Class E.

4. The center pipe should extend 12" to 18" (300mm to 450mm) above the anticipated water surface elevation or riser crest elevation when dewatering a basin.

2 Sump Pits are temporary pits which are used to remove excess water while minimizing sedimentation. The number of sump pits and their locations shall be included on the plans. Pits may be relocated to optimize use but discharges must be coordinated with the local conservation district. The design must conform to the general criteria outlined on detail 4.27-2.

A perforated vertical standpipe is wrapped with ½" (12.7mm) hardware cloth and Geotextile fabric 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 ASTM C 33 stone (1½" (38mm) maximum diameter). Water is then pumped from the center or the standpipe to a suitable discharge area such as into a sediment basin or suitable filter.

3. Sediment Tank / Silt Control Bags are containers through which sediment laden water is pumped to trap and retain the sediment. A sediment tank or a silt control bag is to be used on sites where excavation are deep, and space is limited and where direct discharge of sediment laden water to stream and storm drainage system is to be avoided.

Construction Specifications

A. Location: Containers (tanks or bags) shall be located for ease of clean-out and disposal of the trapped sediment and to minimize interference with the construction activities and pedestrian traffic. Bags shall not be placed directly into receiving waters.

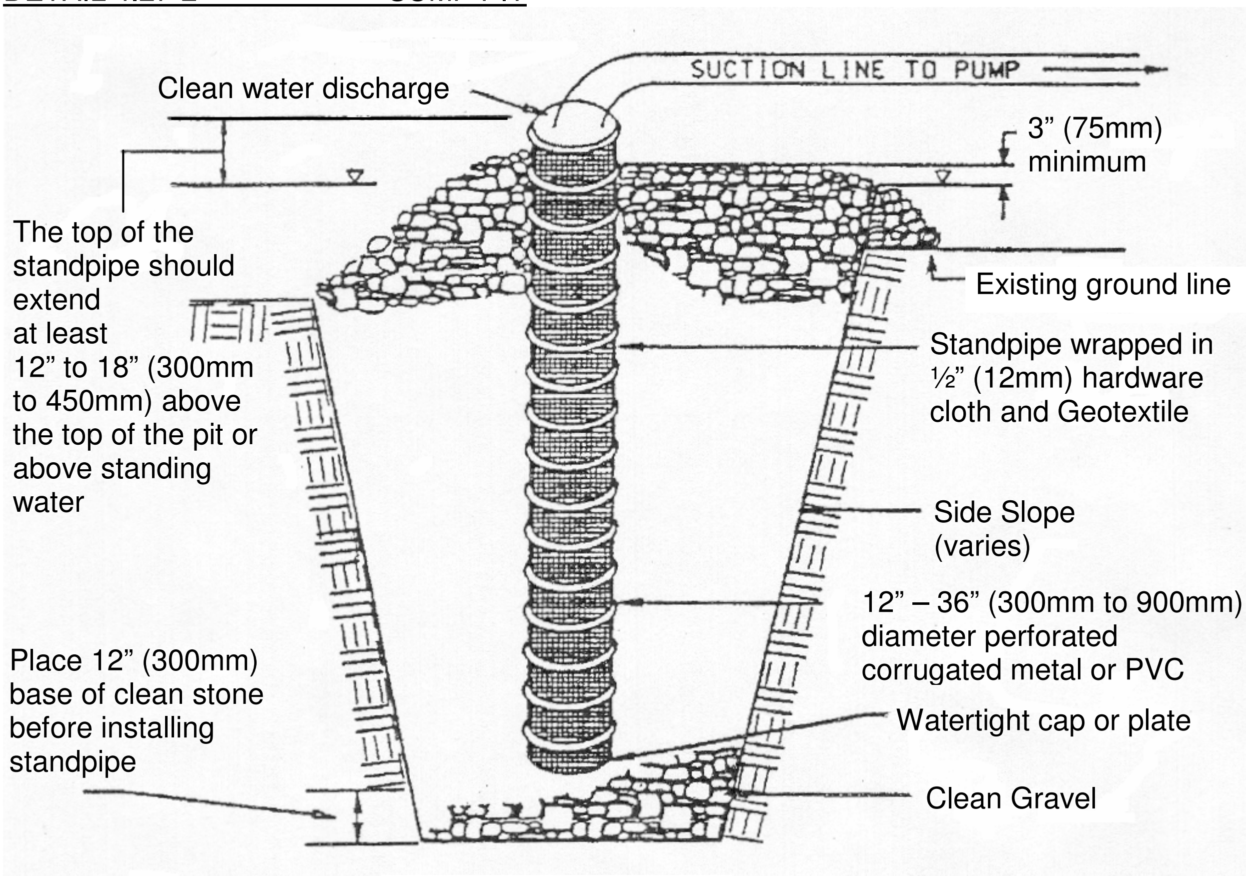
B. Tank size: The following formula should be used in determining the storage volume of the tank: 1 cubic foot of storage for each gallon per minute (1cubic meter of storage for each 135 liter per min.) of pump discharge capacity. Typical tank configuration is shown on Detail 4.27-3. Tanks may be connected in series to increase effectiveness.

C. Tanks consist of two concentric circular pipes (CMP), attached to a watertight base plate. The inner CMP is perforated with 1-inch (25 mm) holes on 6" (150 mm) centers and is wrapped with Geotextile and hardware cloth. Pumped water is discharged into the inner CMP's. A discharge line is attached to the outer CMP and draws filtered water from the annulus between the two concentric CMP's. The discharge line may be connected to another tank where it drains to the inner CMP of the second tank. This series connection may be continued indefinitely.

D. Sediment Control Bags must be located away from receiving waters and disposed of according to manufacturer's instructions. See Detail 4.27-4.

4. Temporary Filters for Small Impoundments: For small quantities of ponded water such as may be found in shallow excavations (small trenches, manhole installations, etc.) a sediment filter may be constructed using combinations of hay bales, small clean stone and filter fabric. This method is limited to small quantities of trapped surface water (pumping of well points is excluded from this standard) and where sediments are not highly colloidal in nature.

DETAIL 4.27-2 SUMP PIT



CROSS SECTION

Construction Specifications:

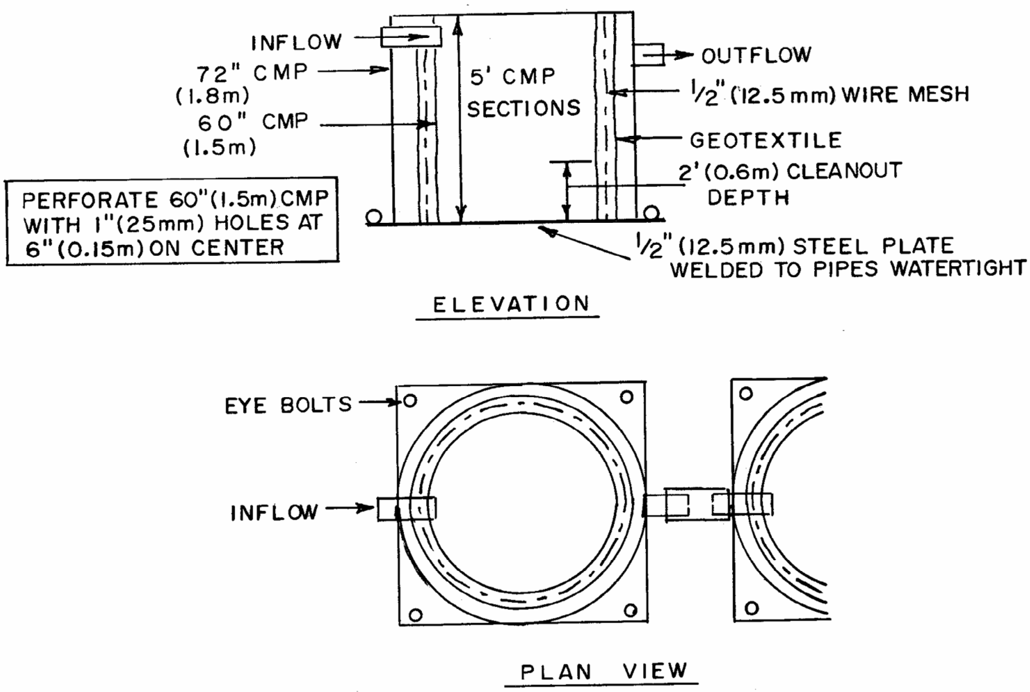
1. Pit dimensions are variable, with the minimum diameter being 2 times the standpipe diameter.

2. The standpipe should be constructed by perforating a 12” to 24” (300mm to 600mm) diameter corrugated or PVC pipe. Then wrapping with ½” (12mm) hardware cloth and Geotextile fabric. The perforations shall be ½” x 6” slits (12mm to 150mm) or 1” (100mm) diameter holes.

3. A base of filter material consisting of clean gravel or ASTM C33 stone should be placed in the pit to a depth of 12” (300mm). After installing the standpipe, the pit surrounding the standpipe should than be backfilled with the same filter material.

4. The standpipe should extend 12” to 18” (300mm to 450mm) above the lip of the pit or the riser crest elevation (basin dewatering only) and the filter material should extend 3” (75mm) minimum above the anticipated standing water elevation.

DETAIL 4.27-3 PORTABLE SEDIMENT TANK



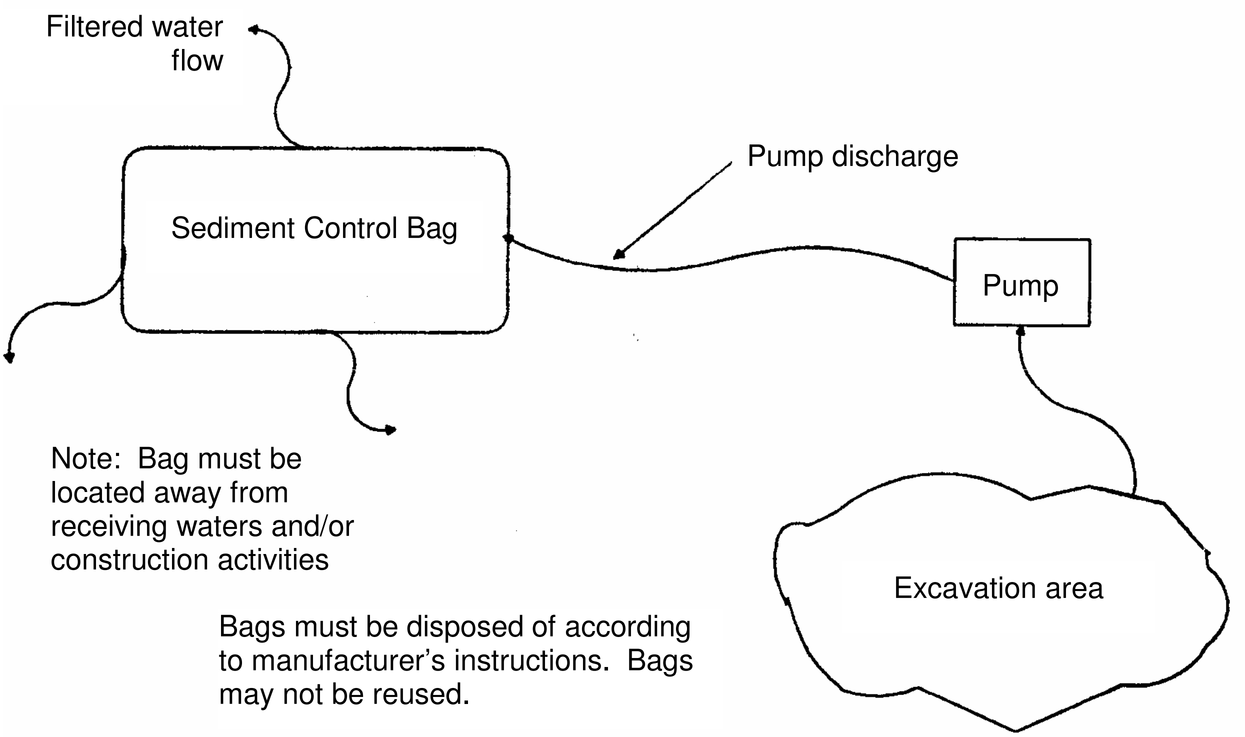
Construction Specifications:

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 (0.028 meters of storage for each 3.785 liters per minute of pump discharge capacity).

2. An example of a typical sediment tank is shown above. Other container design can be used if the storage volume is adequate and approval is obtained from the local conservation district.

3. Tanks may be connected in series.

DETAIL 4.27-4 SEDIMENT CONTROL BAG FOR DEWATERING



4.28 STANDARD FOR CUT TO FILL SLOPE TREATMENT

4.28.1 Definition

Treatment of the critical transition area of cut to fill

4.28.2 Purpose

Treatment to preserve the transition from cut to fill.

4.28.3 Conditions Where Practice Applies

Protection should be designed when there is a ditch on a cut section of roadway that transitions to a fill section.

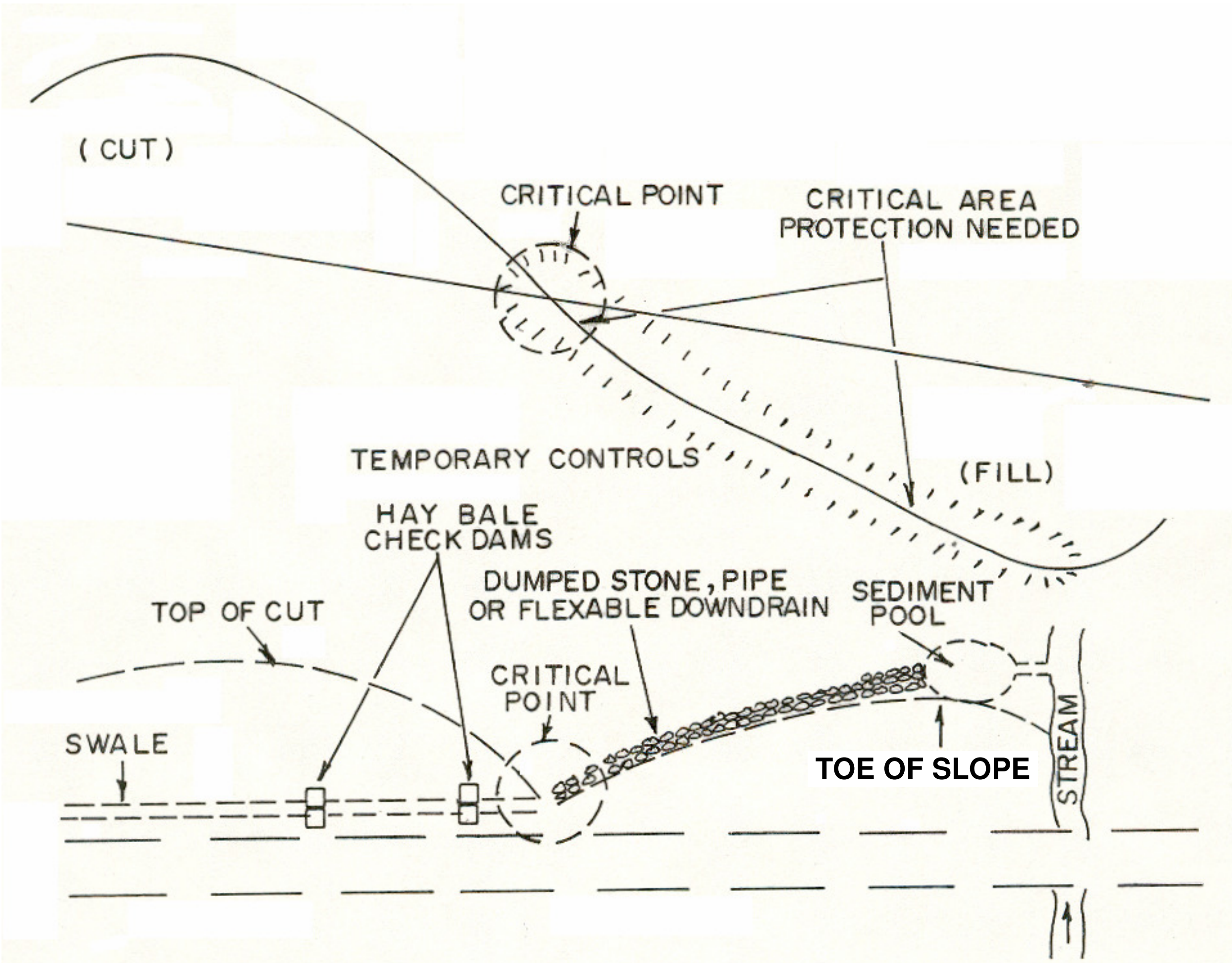
4.28.4 Design Criteria

1. Dumped stones shall be placed a distance of 10 feet (3 meters) up the cut section and continue down through the transition for a distance of 25 feet (7.5 meters).

2. Hay bales shall be placed along the cut section ditch.

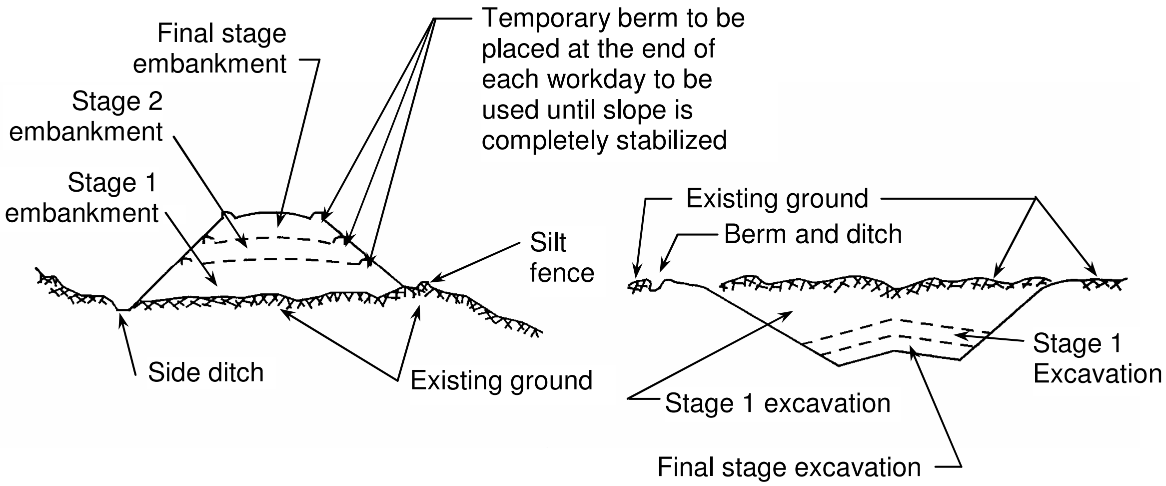
3. A sediment pool shall be required if the ditch outlets into a stream or waterway.

FIGURE 4.28-1 CUT TO FILL SLOPE TREATMENT



Embankment: Before beginning any earthwork, excavate and stabilize side ditches and install perimeter controls (silt fence, etc.). Slopes greater than 25 feet (7.5 meters) in height shall be excavated and stabilized in stages of equal increments not to exceed 15 feet (4.5 meters).

At the end of each work day temporary berms (earth) and slope drains shall be constructed along the top edge(s) of the embankment to intercept surface runoff



CD 212-3.1

Phasing Plan-Fill Section

Construction Sequence:

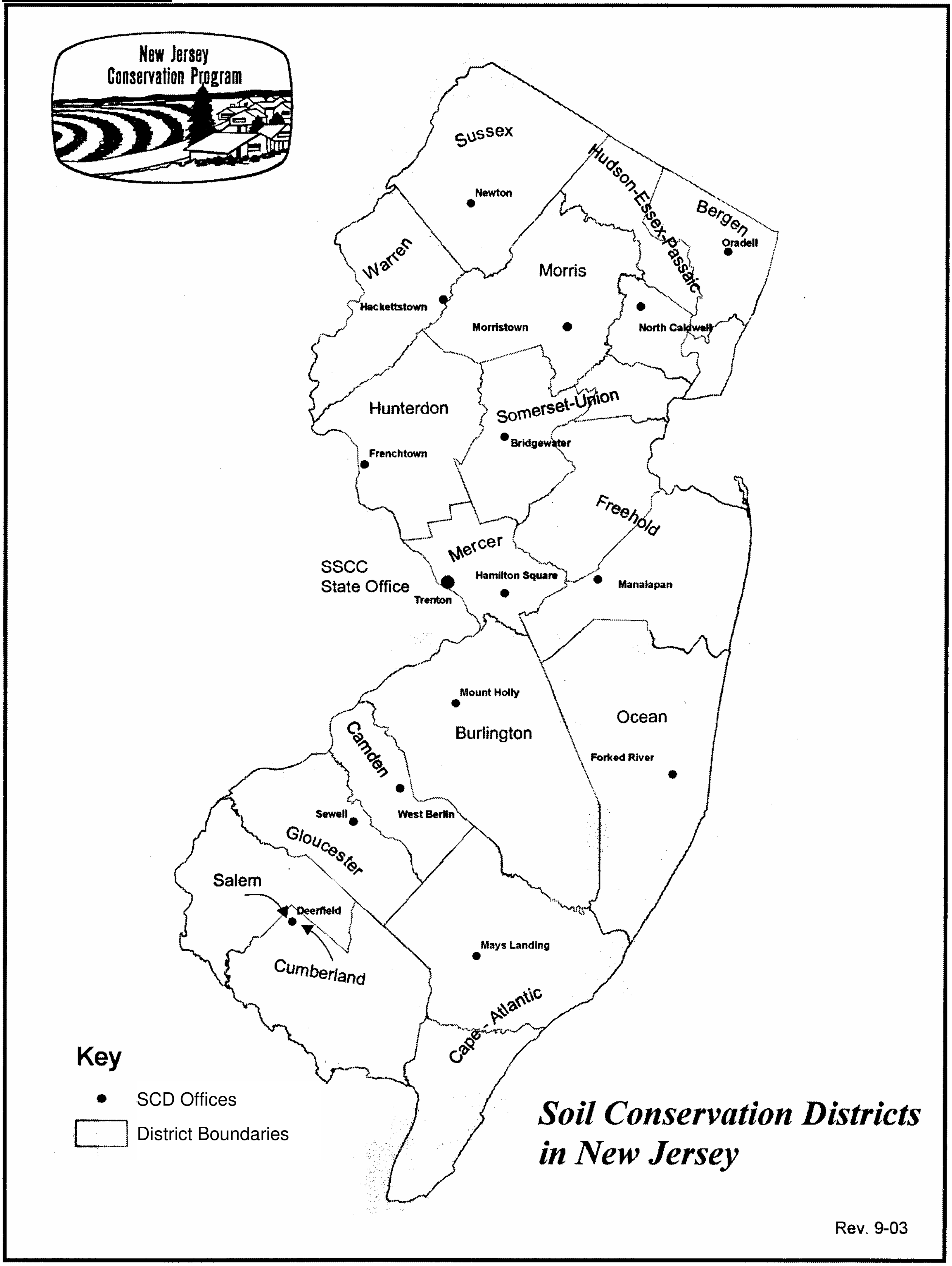
1) Excavate and stabilize side ditches and/or install proposed controls at the toes of slope.
2) Place stage 1 embankment. Place temporary seeding and mulch, or topsoil and permanently seed and mulch slope of this stage.
3) Place stage 2 embankment. Place temporary seeding and mulch or topsoil and permanently seed and mulch slope of this stage.
4) Place final stage embankment. Place topsoil, Permanently seed and mulch on the slope at this stage and on the entire slope if not previously done.

Phasing Plan-Cut Section

Construction Sequence:

1) Excavate and stabilize berm, side and outlet ditches.
2) Perform stage 1 excavation. Place topsoil, permanently seed, and mulch slope of this stage.
3) Perform stage 2 excavation. Place topsoil, permanently seed, and mulch slope at this stage.
4) Perform final stage excavation. Place topsoil, permanently seed and mulch slope at this stage.
Repair any damage done to previous stages.

APPENDIX A-1



SOIL CONSERVATION DISTRICTS IN NEW JERSEY

DISTRICT	ADDRESS	TELEPHONE NUMBERS	FAX NO.
BERGEN	700 Kinderkamack Road, Suite 106 Oradell 07649	201-261-4407 or 973-538-1552 *	201-261-7573
BURLINGTON	1971 Jacksonville-Jobstown Road Columbus 08022	609-267- 7410 or 609-267-0811 *	609-267-3347
CAMDEN	423 Commerce Lane Suite 1 W. Berlin 08091	856-767-6299 or 856-267-0811 *	856-767-1676
CAPE-ATLANTIC	Atlantic County Office Bldg. 6260 Old Harding Highway Mays Landing 08330	609-625-3144 or 856-205-1225*	609-625-7360
CUMBERLAND-SALEM	PO Box 144,1516 Route 77 Deerfield 08313	856-451-2422 or 856-205-0396*	856-451-1358
FREEHOLD (Monmouth & Middlesex)	4000 Kozloski Road P.O.Box 5033 Freehold 07728-5033	732-683-8500 or 732-462-1079*	732-683-9140
GLOUCESTER	14 Parke Place Suite C Sewell 08080	856-589-5250 or 856-769-2790*	856-256-0488
HUDSON, ESSEX & PASSAIC	15 Bloomfield Avenue North Caldwell 07006	973-364-0786 or 973-538-1552 *	973-364-0784
HUNTERDON	687 Pittstown Road Frenchtown 08825	908-788-9466 or 908-782-4614 Ext 3*	908-788-0795
MERCER	508 Hughes Drive Hamilton Square 08690	609-586-9603 or 908-852-2567 ext3 *	609-586-1117
MORRIS	Court House, PO Box 900 Morristown 07960 (Location- 560 W. Hanover Avenue Morris Township)	973-285-2953 or 973-538-1552 *	973-285-8345
OCEAN	714 Lacey Road Forked River 08731	609-971-7002 or 609-267-0811 ext 115	609-971-3391
SOMERSET -UNION	Somerset County 4-H Center 308 Milltown Road Bridgewater 08807	908-526-2701 or 908-782-4614 Ext. 3*	908-526- 7017
SUSSEX	186 Halsey Road, Suite 2 Newton 07860	973-579-5074 or 908-852-2576 Ext 3*	973-579-7846

WARREN	224 Stiger Street Hackettstown 07840	908-852-2579 or 908-852-2576 Ext 3*	908-852-2284

* Natural Resources Conservation Service Field Office

STATE SOIL CONSERVATION COMMITTEE
NEW JERSEY DEPARTMENT OF AGRICULTURE
PO BOX 330. TRENTON. NEW JERSEY 08625
TELEPHONE: 609-292-5540 FAX: 609-633-7229

APPENDIX A-2

GLOSSARY

Acre-feet - An engineering term used to denote a volume 1 acre in area and 1 foot in depth.

Acid Soil - (high acid producing) Soil containing iron sulfide material, which on exposure to air, results in the production of sulfuric acid and is accompanied by pH levels falling to 3 or below. Treatment with limestone only provides a short - term buffering effect with burial at a minimum of 12 inches of non - acid producing soil, is the only effective treatment.

Aggrade -The alteration of a channel caused by the deposition of sediment.

Allowable Velocity - the velocity of flowing water within a defined channel or landform, which will not scour and transport surface soil. Non-scouring velocities differ with different soil types.

Anti-Seep Collar - A device constructed around a pipe or other conduit placed through a dam, dike, or levee for the purpose of reducing seepage losses and piping failures.

Anti-Vortex Device - A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.

Barrel - See conduit.

Borrow Area - A source of earth fill materials used in the construction of embankments or other earth fill structures

Bottomlands - A term often used to define lowlands adjacent to streams (flood plains in rural areas).

Box Inlet Drop Spillway - A form of principal spillway.

Cabled Concrete - Blocks of concrete (typically 1' x 1') strung together with a non-corroding metal cable. Used for lining of waterways, shorelines etc.

Cantilever Outlet - A discharge pipe extending beyond its support.

Cascades or Bedrock - Section of stream without pools, consisting primarily of bedrock with little rubble, gravel, or other such material present. Current usually more swift than in riffles.

Channel - A natural stream that conveys water; a depth or channel excavated for the flow of water.

Chute Spillway - A form of principal spillway

Conduit - A closed facility used for the conveyance of water

Cool Season Mixture - Grasses or legumes which maximize growth at temperatures below 85 degrees F.

Cover Crop - A crop grown primarily for the purpose of protecting soil between periods of permanent vegetative cover.

Cradle - A device usually concrete, used to support a pipe conduit or barrel.

Crimper - (mulch anchoring coulter tool) A tractor drawn implement, somewhat like a disc harrow designed to push or cut some broadcast, long fiber mulch, such a straw, into the soil 3 to 4 inches so as to anchor it to the soil.

Cutoff Trench - A long narrow excavation constructed along the centerline of a dam, dike, levee, or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.

Degrade -The alteration of a channel caused by the erosion and scour of the channel bottom.

Design High Water - The elevation of the water surface as determined by the flow conditions of the design floods.

Design Life - The period of time for which a facility is expected to perform its intended function.

Diversion - A channel with or without a supporting ridge and the lower side constructed across or at the bottom of a slope for the purpose of intercepting surface runoff.

Dune - A mound or ridge of sand, which has been formed by wave or wind action.

Embankment - A man-made deposit of soil, rock, or other materials used to form an impoundment.

Emergency Spillway - A vegetated earth channel used to safely convey flood discharges in excess of the capacity of the principal spillway.

Energy Dissipater - A device used to reduce the energy of flowing water.

Erosion - Detachment and movement of soil or rock fragments by water, wind, ice and gravity.

Field Capacity - The amount of water retained in a soil after it has been saturated and has drained freely. It is usually expressed as a percentage of the oven dry weight of the soil. Also called field moisture capacity.

Filter Blanket - A layer of sand, gravel, or synthetic fabric designed to prevent the movement of fine-grained soils.

Filter Strip - A strip of planted or indigenous vegetation used to filter pollutants from surface runoff before reaching a body of water or stormwater management structure

Flat - Section of stream with current too slow to be classed as riffle and too shallow to be classed as a pool. Stream bottom usually composed of sand or finer materials, with coarse rubble, boulders, or bedrock occasionally evident.

Flexible Channel Liner - An open-textured, three-dimensional rolled product manufactured from non-degradable materials, which is laid on the prepared soil surface to act as a substrate for the establishment of grass cover in open waterways.

Flood Plain - The relatively flat area adjoining the channel of a natural stream which has been or may be hereafter covered by floodwater.

Flood Routing - Determining the changes in the rise and fall of flood water as it proceeds downstream through a valley or through a reservoir.

Flume - A device constructed to convey water on steep grades lined with erosion-resistant materials.

Freeboard - The vertical distance between the elevation of the design high water and the top of the dam, dike, levee, or diversion ridge.

Froude Number - The ratio of inertial to gravity forces in flowing water. It is used to classify the flow as supercritical, critical or supercritical (e.g. N_f > l, N_f = 1 or N_f < l) froude number is expressed as:

$N_f = \frac{V_{channel}}{\sqrt{2gd}}$ Where d is the hydraulic flow depth

Geotextile - A broad range of "fabric" type materials, which contain or filter soil or water. Fabrics may be permeable or impermeable and may or may not be degradable.

Grade Stabilization Structure - A structure for the purpose of stabilizing the grade of a watercourse, thereby preventing further head cutting or lowering of the channel grade.

Grading - Any stripping, cutting, filling, stockpiling, or any combination thereof which shall include the land in its cut or filled condition.

Grassed Waterway - A natural or constructed channel, usually broad and shallow, covered with erosion resistant vegetation, and used to conduct surface water.

Hood Inlet - A pipe entrance wherein the top edge of the pipe is extended ¾'s of the diameter beyond the bottom invert cut on an angle.

Hydraulic Conductivity - A coefficient describing the rate at which water can move through a permeable medium.

Hydrograph - A graph which illustrates the discharge, velocity, or other properties of water, with respect to time, for a given point or a stream or in a drainage system.

Hydroseeding - The application of seed fertilizer liquid slurry to the soil surface of the prepared seedbed using an apparatus consisting of a storage tank, pump and hose.

Inoculants - A peat carrier impregnated with bacteria and applied in powder or slurry form to legume seed at the time of planting, which forms a symbiotic relationship enabling legumes to utilize atmospheric nitrogen for plant growth. Most legumes require specific bacteria.

Impact Basin - A device used to dissipate the energy of flowing water. Generally constructed of concrete in the form of a depressed and partially submerged vessel and may utilize baffles to dissipate velocities.

Land - Any ground, soil or earth including marshes, swamps, drainage ways, and areas not permanently covered by water.

Liquid Limit - The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

Liquid Mulch Binder - Organic, synthetic, and asphaltic based materials which are physiologically harmless to plant growth and will not result in a phytotoxic effect. Liquid Mulch Binder is mixed with water and applied to straw, hay mulch, or salt hay, to anchor mulching materials together and prevent movement.

Manning's Formula - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Wherein "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.

Mulching - The application of plant residue or other suitable materials to the land surface to conserve moisture, hold soil in place, aid in establishing plant cover and minimize temperature fluctuation.

Mulch Netting - Paper, jute, cotton or plastic netting materials applied to seeded and mulched areas, usually on slopes or critical areas to prevent erosion and promote seedling establishment.

Mulch Blanket - Plastic netting lined with straw or excelsior fibers, placed and anchored onto seeded areas, usually on slopes or critical areas to prevent erosion and promote seedling establishment.

Outlet - Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Peak Discharge -The maximum instantaneous flow from a given storm condition at a specific location.

Pelletized Mulch - Compressed and extruded paper or wood fiber product which may contain copolymers, tackifiers, fertilizer, and coloring agents, applied in a dry form to seedbed and activated with water to form a mulch mat. Uniform distribution and adequate initial watering of the mulch is critical to optimum results.

pH - A measure of acidity or basicity of soil with pH 7 being neutral and pH 6.5 being a desirable degree of soil acidity for growth of grasses and legumes. Basicity above pH 7 is rare in eastern U.S. soils.

Pipe Drop - A circular conduit used to convey water down steep grades.

Plant Hardiness Zone - Geographic regions differentiated by climate and growing conditions.

Plasticity Index - The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic Limit - The moisture content at which a soil changes from a semisolid to a plastic state.

Plunge Pool - A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.

Pool - Section of stream deeper and usually wider than normal with appreciably slower current than immediate upstream or downstream areas, and possessing adequate cover (sheer depth or physical condition) for protection of fish. Stream bottom is usually a mixture of silt and coarse sand.

Preformed Scour Hole - An area at the outlet end of a storm drain at an elevation essentially the same as the outlet invert which has been excavated and lined with stone which provides both vertical and lateral expansion downstream of the outlet to permit dissipation of excess kinetic energy in turbulence.

Principal Spillway - Generally constructed of permanent material and designed to regulate the normal water level, provide flood protection and/or reduce the frequency of operation of the emergency spillway.

Pure Live Seed - The desired amount of any warm season grass seed to be planted for temporary and permanent stabilization, which excludes the weight of inert matter, non- viable and undesirable seed as expressed on the seed tag. A practical adjustment is made by multiplying the weight of the bag of seed x percent purity x percent germination = the amount of pure live seed contained in the bag.

Rational Formula - Q=CIA. Where "Q" is the peak discharge measured in cubic feet per second, "C" is the runoff coefficient reflecting the ratio of runoff to rainfall, "I" is the rainfall intensity for the duration of the storm measured in inches per hour, and A is the area of the contributing drainage area measured in acres.

Retention Basin - A stormwater management basin which provides storage for a permanent pool of water below the stormwater management storage volume elevation.

Ridge - The bank or dike constructed on the downslope side of a diversion.

Riffle - Section of stream containing gravel and/or rubble, in which surface water is at least slightly turbulent and current is swift enough that the surface of the gravel and rubble is kept fairly free from sand and silt.

Riprap - Angular broken rock placed on earth surfaces, such as the face of a dam or the channel of a stream for protection against the action of water.

Riser - The inlet portion of a drop inlet spillway that extends vertically from the pipe conduit barrel and control the water surface.

Scour Hole - See preformed scour hole.

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.

Sediment Basin - A depression formed by the construction of a barrier or dam built at suitable locations to retain rock, sand, gravel, silt, or other material.

Soil - 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.

Soil Bioengineering - The use of native plant species together with natural materials (rocks, logs, and vegetative byproducts such as coconut fiber) and hydrologic, hydraulic and soil engineering principles, to provide restoration to stream banks, slopes, and open water shorelines which are subject to the forces of wind and water erosion.

Soil Horizon - A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

Spillway - A form of principal spillway.

Stability - A condition within a channel or on a landform such that flowing water will not erode the soil surface.

Stabilized Center Section - an area in the bottom of a grassed waterway protected by stone, asphalt, concrete, or other materials to prevent erosion.

Storm Frequency - An expression or measure of how often a hydrologic event of given size or magnitude should, on an average, be equaled or exceeded. The average should be based on a reasonable sample.

Straight Drop Spillway - A form of principal spillway.

Straw - The natural dry stem and related material threshed of its seed.

Tailwater - The depth of the receiving water at the end of the apron.

Temporary Protection - Stabilization of erodible or sediment-producing areas.

Toe Drain - A drainage system constructed in the downstream portion of an earth dam or levee to prevent excessive hydrostatic pressures.

Trash Rack - A device used to prevent debris from entering a spillway or other hydraulic structure.

Topdressing - The application of additional nitrogen-based fertilizer to vegetation as a follow-up to initial fertilizer applications to help combat nitrogen deficiency.

Underdrains - pipelines of tile with open joints or perforated pipe used for the collection of subsurface water.

Unified Soil Classification System - A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

Uplift Forces - Vertical pressures acting upward on a structure, usually caused by a buoyant condition.

Vegetative Protection - Stabilization of erosive or sediment-producing areas by covering the soil with:

a. Permanent seeding, producing long-term vegetative cover;

b. Short-term seeding, producing temporary vegetative cover; or

c. Sodding, which is placement of cultivated sod onto prepared topsoil causing instant soil stabilization

Velocity - The rate of flow measured in feet per second.

Warm Season Mixture - Grasses or legumes, which maximize growth at temperatures below 85 degrees F.

Waterway - A natural course or constructed channel for the flow of water. See grassed waterway.

Watershed - a geographic area defined by topographic high points such that precipitation falling within the boundaries of the high points drains to a single outlet, such as a mouth of a stream, lake, or river.

Appendix A-3

THE UNIVERSAL SOIL LOSS EQUATION *

Appendix A1

THE UNIVERSAL SOIL LOSS EQUATION *

Determining Sediment Yield from Construction Sites and Development

Introduction

Sediment, a common term for eroded soil, is the most massive pollutant of surface water. Our growing population and high standards of living require construction of more houses, shopping centers, highways, waterways, and other facilities that involve clearing of vegetation and massive movement of soil. These activities expose the soil directly to the erosive actions of rain and flowing water. As a result, an enormous amount of soil is lost from these sites causing high turbidity to the water that carries it and damaging the site where it is finally deposited.

The Universal Soil Loss Equation, commonly known as the USLE, is a valuable technique for estimating erosion rates and evaluating various conservation practices for controlling erosion and sedimentation (deposition).

The Soil Erosion - Sedimentation Process

Since soil erosion and sedimentation by water are complex processes, a better understanding of them provides a sound basis for developing improved predictions and control methods. Soil erosion and sedimentation by water include detachment from the soil mass, transport downslope, and subsequent deposition. Soil is detached by raindrop impact and runoff shear forces, but man's activities that loosen and pulverize soil often promote accelerated erosion. Downslope transportation of eroding soil particles is primarily by channelized runoff. Generally, three distinct forms of erosion are seen in the upland areas. These are sheet erosion, rill erosion and gully erosion. Sheet erosion, also known as inter rill erosion, takes place uniformly between rills or gullies. Sheet erosion results primarily from raindrop impact. The erosive potential of rain depends on its raindrop size, fall velocity and total mass at impact. Unless the soil surface is protected against raindrop impact by vegetation, mulches, or other cover, these raindrops can detach great quantities of soil and cause serious unnoticed inter rill erosion.

Rill erosion is much more noticeable than inter rill erosion. It is primarily the result of soil detachment by concentrated runoff; it causes intensive soil movement from a limited part of the land surface. Rills, which are small channels that can be easily smoothed, may first develop due to topographic variations, tillage marks, or random irregularities on the land surface. Rills carry both runoff from inter rill areas and the rain that falls directly on them. Rill erosion increases rapidly as the slope steepens or lengthens and runoff rate increases.

Gully erosion is massive removal of soil by large concentrations of runoff. Gullies often start as rills and enlarge until they cannot be crossed by vehicles such as trucks and tractors. If permitted to form, gullies may yield tremendous volumes of sediment.

*Pages A1.1-A1.20 written by Dr. Devah Borah and presented at Cook College, Rutgers University, Sediment and Erosion Control Short Course, Spring 1986.

The quantity and size of material transported is a function of runoff velocity and turbulence, and these increase as the slope steepens and the flow increases. The larger the eroding material, the greater must be the flow velocity and turbulence to transport it. When the velocity or turbulence decreases, some of the eroded sediment may deposit. The largest and densest particles settle first while the finer particles are carried farther downslope or downstream.

Estimating Sediment Yield

The rate of sheet erosion depends on several factors as follows: (1) rainfall energy and intensity, (2) soil erodibility, and (3) land slope and length of slope or topography, (4) condition of the soil surface and land management practices in use and (5) surface cover involved such as grass, woodland, crops, pavement or no cover at all. These factors may be assigned quantitative values to be used for computing soil loss by the Universal Soil Loss Equation, E = RK (LS) CP, where E is the estimated soil loss from sheet erosion in tons per acre per year. See ref. (3).

R, the rainfall factor, is the number of erosion index in a normal year`s rain. The erosion index is a measure of the erosive force of specific rainfall. See figure A1-I for values of R.

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. See Table A1-2a, A1-2b or A1-2c for values of K and (KR), the product of K and R, for New Jersey soils.

L, the slope length factor, is the ratio of soil loss from the field gradient to that from a 9 percent slope. See Table A1-3 for values of (LS) for various slope gradient and length combinations.

C, the cropping management factor, is the ratio of soil loss from a field with specified cropping management to that from the fallow condition on which the factor K is evaluated. This factor is also called the cover index and can be used to represent the effect of land cover or treatment that may be used to protect the construction site. See table

A1-4 for values of the soil cover index Cc for treatment that may be used to protect construction sites.

P, the erosion control practice factor, is the ratio of soil loss with the contour strip cropping or terracing to that with straight row farming up and down the slopes. The condition of the soil surface, particularly at construction sites, can also be reflected in the practice factor. See Table A1-5 for soil surface condition factors Pc for construction sites.

The value E may also be modified by a factor M shown on Table A1-6. M may be used to estimate the soil loss for a portion of a year and a portion of another year or more. The use of this factor provides a means of estimating the average soil loss on a critical sediment source area that will remain as such for a portion of a year or during the performance time of a construction contract.

The factor R is equal to the average annual value of the erosion index EI when the equation is being used to estimate average annual soil loss. This value of the equation may be modified to reflect soil loss probability and individual storm losses. Estimates of average soil loss, based on probability and single storm losses, can be made by multiplying the equation by the factors shown in Table A1-8. These factors reflect an alteration in the value of R and, therefore, the erosive effect of rainfall. They do not account for such things as snow melt, freezing, thawing and snow cover.

Detailed definitions and explanations for each of these factors are contained in Reference (3).

The soil information contained in Tables A1-2a, A1-2b and A1-2c are of general nature, useful for planning purposes. It should be used, without verification, for evaluation of construction sites for erosion control. Where erosion may be expected during construction involving earth moving, on-site investigations should include information on soils to be exposed as follows: (1) field identification and classification for both agriculture textures and the unified system, (2) sampling for grain size distribution, Atterburg limits and laboratory classification, and (3) in-place density as determined by a volumeter and the speedy moisture tester or other means.

The soil grain size is useful in determining the value of practices for the control of erosion and particularly sediment. For example, sediment basins will not be very effective for trapping very fine sediment. Soils made up of a high percentage of material with the grain size of 0.05 mm or less have a slow settling velocity in water. Material with a 0.05 mm grain size has a settling velocity close to 0.006 feet per second. This means that, theoretically, a detention time of about 15 minutes is required to settle out 0.05 mm material in 5 feet of still water.

Soil loss computed by the universal loss equation represents gross sheet erosion. This value plus erosion from the rilling, gullies and other sources is the gross erosion. To obtain sediment yield at the point downstream, the gross erosion must be adjusted downward by a delivery rate factor in percent equal to the ratio of sediment yield at the damage area to gross erosion. Delivery rates vary somewhere between 10 percent and 90 percent depending on conditions that tend to trap sediment between the source and the damage area.

Water pollution in the form of turbidity or discoloration may be as damaging to water supplies or swimming areas as the accumulation of sediment. Turbid water may be the result of algae or other organisms but generally it is caused by the fine silt or clay particles held in suspension. The very fine, divided clay particles found in some soils are difficult to control and may take months to settle out in still water.

Downstream damage from sediment depends on the following conditions:

1. Distance from the construction site to the nearest stream, pond or reservoir along with the condition of the vegetation and the slope of the area between the site and the stream of the reservoir. Areas with flat slopes and dense vegetation will tend to filter out sediment.

2. Once the sediment gets into a stream, the distance downstream to the damage point, such as a pond or water supply intake, is important. Also to be considered is the stream channel gradient and the flood plain width. Wide flat flood plains with dense vegetation will trap more sediment than steep narrow valleys.

3. The use of the stream or reservoir must be considered. It is very important to keep sediment out of streams used for fishing, recreation or water supply.

4. Another factor that should be considered is the size of the construction area and the length of time it will be bare of vegetative cover and subject to erosion. The total sediment expected should be compared with the capacity of the damage area to sustain sediment. If the total sediment to be expected from the site during the entire construction period is greater than can be tolerated in the damage area, considerable effort should be made to reduce it. If this cannot be done, arrangements to alleviate the damage should be made. These arrangements may include cleanout of ponds and reservoirs or restoration of stream channels.

A look at the Soil Loss Equation will show the factors over which man can exercise some control. These are lengths of slope, exposure time, and the total area exposed. Slope length is contained in the equation as part of the (LS) factor and its effect on soil loss can be evaluated. The length of time and time of year of soil loss from different size areas, can also be estimated.

"LS" Factor for Composite Slopes

LS values given in Table A1-3 predict the average soil loss for the entire length of a slope. Such a slope length is measured from the point where surface flow originates (usually the top of the ridge) to the outlet channel or a point down slope where deposition begins. When a slope steepens or flattens significantly toward the lower end, or is composed of a series of convex and concave segments, its overall average gradient and length do not correctly indicate the topographic effect on soil loss. Neither can successive slope segments be evaluated as independent slopes when runoff flows from one segment to the next. For irregular slopes values read from the aforementioned table must be adjusted to account for effects of the gradient changes.

The irregular slope is divided into a small number of equal-length segments in such a manner that, for practical purposes, the gradient within each segment can be considered uniform. The LS values corresponding to the steepness of each of the slope segments are read from table A1-3. While reading these values, the entire length of the irregular slope is taken. These LS values are multiplied by the corresponding factors given in the following table (Wischmeier, 1974). Each individual product is an estimate of LS value for the corresponding slope segment and the average of the products is an estimate of the effective LS value for the entire irregular slope. The procedure is valid only for situations where upslope deposition is not possible.

FACTORS TO ADJUST "LS" VALUES FOR COMPOSITE SLOPES

Segment No. (Top to Bottom)	Adjustment Factors for Given Number of Equal-length Segments			
	2	3	4	5
1	0.71	0.58	0.50	0.45
2	1.29	1.06	0.91	0.82
3		1.37	1.18	1.06
4			1.40	1.25
5				1.42

"C" Values for Various Mulches Table A1-4 gives C values and slope-length limits or various nonseeded and seeded mulches used in controlling soil erosion. This table is taken from Meyer and Ports (1976). By using these values in the USLE, the effectiveness of various mulches can be determined in controlling soil erosion.

Sediment Delivery Ratio

Since the USLE predicts only the soil loss by rill and inter rill erosion from the field-size areas, sediment yields from larger areas of watersheds must be estimated by adding additional erosion from gullies and streambanks along the flow path and subtracting eroded soil that is deposited at the base of a slope and elsewhere within the watershed. If additional gully or channel-type erosion is significant, it should be estimated and added to the predicted upland erosion to give the gross erosion occurring in the watershed above the location of interest. Deposition of eroded soil is accounted by simply using a sediment delivery ratio which is defined as the ratio of the sediment leaving the watershed to the estimated gross erosion on the watershed. Delivery ratios are generally much less than 1, because most natural slopes tend to flatten along their lower portions, which encourages deposition, and heavy vegetation often traps sediment below the upland slopes. However, urban erosion sources often lack locations where deposition is likely to occur and, in such cases, the delivery ratio will approach 1. Figure 2-4-2 gives delivery ratios for different soil texture and drainage areas. A general guide to sediment delivery ratios from construction sites is given as follows:

Guide To Delivery Ratio For Sediment From Construction Sites

Damage Area Condition (Reservoir, Stream reach or other area that could be damaged by sediment)	Estimated Delivery rates (1)
Less than 300 feet from the down slope boundary of the construction site.	.90
More than 300 feet down slope from the Construction site but not downstream any appreciable distance.	.70
Less than 1 mile downstream from the Construction site (stream flows through Or less than 300 feet from the slope Boundary of site)	.60
Damage area more than 1 mile downstream	.50 or less

1. New Jersey State Soil Conservation, "Sediment Pollution and Erosion Control Guide for Resource Conservation", Technical Guide, 1971. The values are based on judgment only. They should be considered as a general guide.

The Universal Soil Loss Equation has been widely adapted for use in estimating erosion rates and selecting sediment control practices for urban areas. It is a valuable design tool when properly applied, but its misuse can cause serious problems.

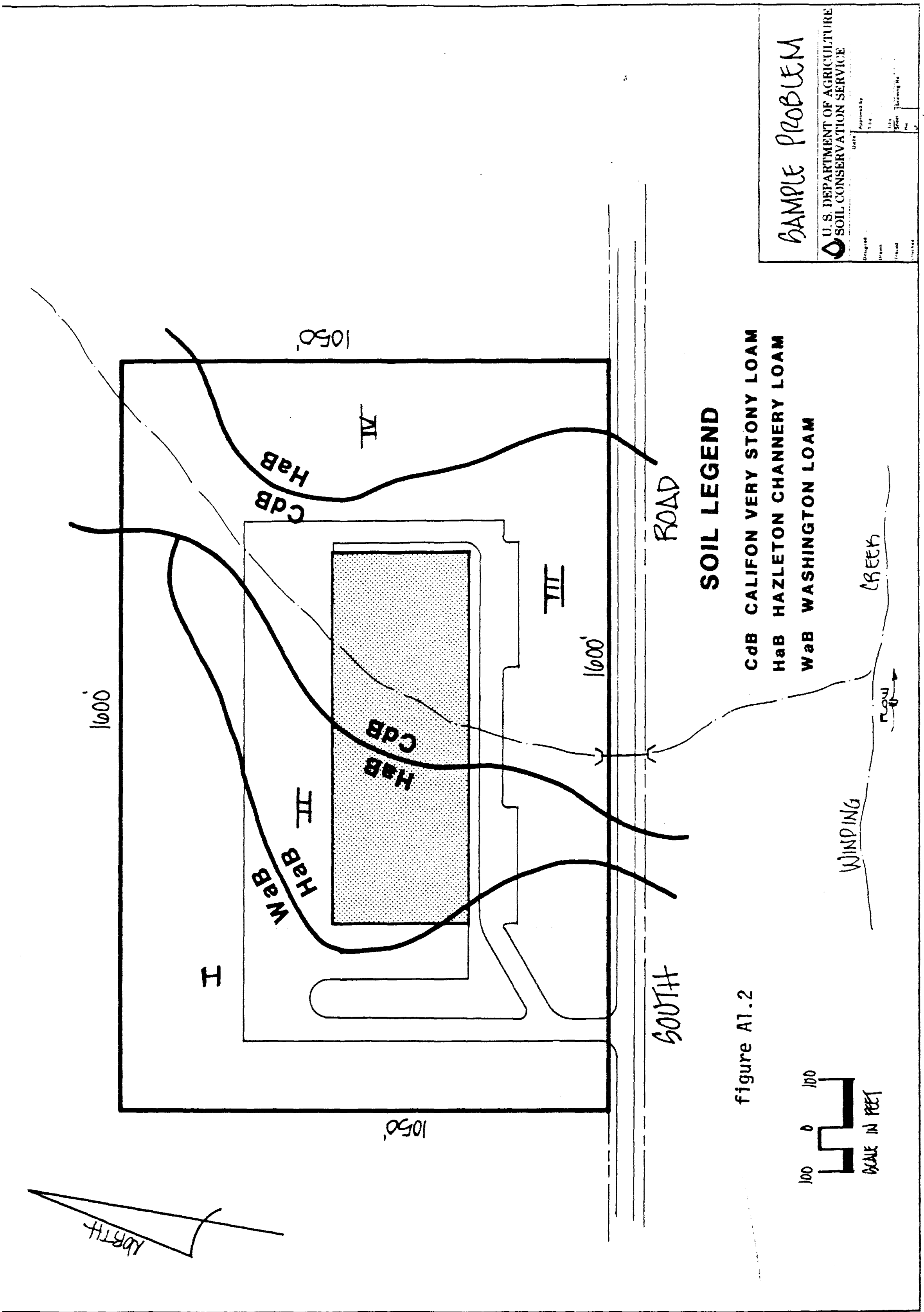


figure A1.2

Revised April 1987

Universal Soil Loss Equation

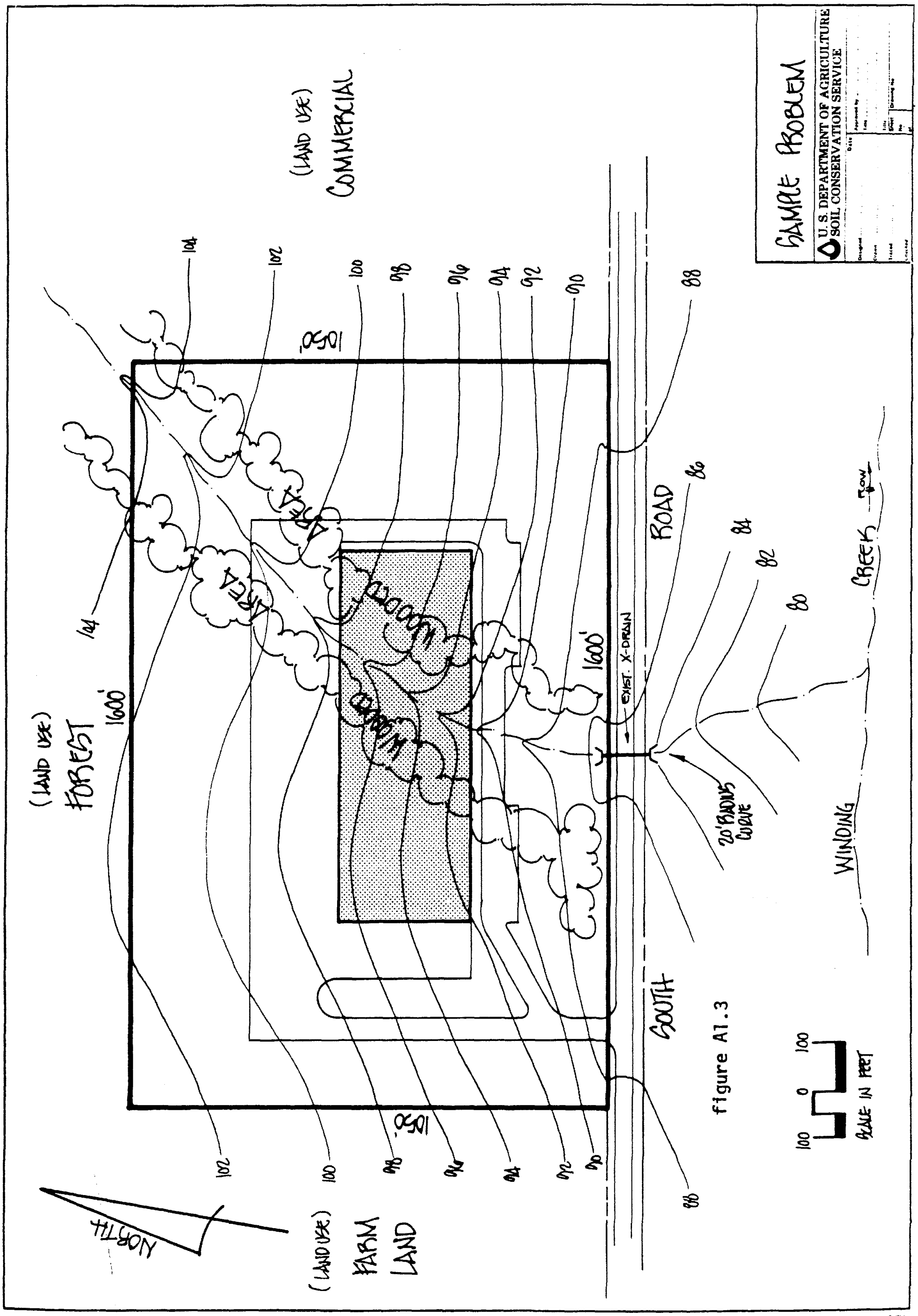

SAMPLE PROBLEM
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
(LAND USE) COMMERCIAL
(LAND USE) FOREST
(LAND USE) FARM LAND
NORTH
AREA
WOODED
ROAD
SOUTH
CREEK
FLOW
WINDING
EXIST. X-DRAIN
20' RADIUS CURVE
1600'
1050'
104
102
100
98
96
94
92
90
88
86
84
82
80
SCALE IN FEET
100
0
100
Revised April 1987
Universal Soil Loss Equation

figure A1.3

Sample Problem

Consider the following sample construction site. The site is located in the land resource area 148 of New Jersey. The land will be prepared for construction and will be exposed during an eighteen-month construction period starting from April 1 and ending on September 30 of next year. Assume that the upper edge of the site is a ridge so that there will be no overland flow contributing from the outside areas.

1. Required: For this site find the weighted soil erodibility factor.

Solution: Estimate the soil erodibility factor "K" as follows

Sub Area	Soil Series	Soil[1] Profile (inches)	Area "a" (ac)	K (t/ac)	Area in Subarea "A" (ac)	Weighted[1] K in subarea $\frac{ak}{A}$ (t/ac)	AK tons
I	WaB	0-9	10.4	0.28			
		9-52	4.1	0.32	14.5	0.29	4.2
II	HaB	0-6	1.7	0.17			
		6-56	5.1	0.15	6.8	0.16	1.1
III	CdB	0-10	6.9	0.17			
		10-50	5.7	0.30[2]	12.6	0.23	2.9
IV	HaB	0-6	4.7	0.17	4.7	0.17	0.8
				Total:	38.6		9.0

Weighted $K = \frac{\sum AK}{\sum A}$ = 9/38.6 = 0.23 t/ac (answer)

Note:

The soil interpretation record of each soil series is used. In absence of these records, Table A1-2 can be used. Since the construction site has several soil series with different surface areas (Figure A1.2) and different K values, the composite K

[1]Assumed that the building and parking area is leveled around 95-ft contour

[2] (0.32 + 0.28)/2 = 0.30

[1]Assumed that the building and parking area is leveled around 95-ft contour

[1] (0.32 + 0.28)/2 = 0.30

value must be weighted. Also, the soil profile which will be exposed for construction will be different at different locations (Figure A1.3). These differences must also be accounted for by further weighing.

NJ0045 SOIL INTERPRETATIONS RECORD

MLRA(S): 144A, 140
REV. [illegible], 5-81
TYPIC FRAGIUDULTS, FINE-LOAMY, MIXED, MESIC

CALIFON SERIES
STONY

THE CALIFON SERIES CONSISTS OF DEEP, MODERATELY WELL AND SOMEWHAT POORLY DRAINED SOILS ON UPLANDS. THEY FORMED IN GLACIAL TILL OR COLLUVIAL MATERIAL. TYPICALLY THESE SOILS HAVE A DARK BROWN VERY STONY LOAM SURFACE LAYER 10 INCHES THICK. THE SUBSOIL LAYERS FROM 10 TO 23 INCHES ARE STRONG BROWN LOAM AND CLAY LOAM. A VERY FIRM AND BRITTLE MOTTLED FRAGIPAN FROM 23 TO 50 INCHES IS MAINLY STRONG BROWN AND YELLOWISH-BROWN LOAM. THE SUBSTRATUM FROM 50 TO 75 INCHES IS YELLOWISH-BROWN SANDY LOAM. SLOPES RANGE FROM 0 TO 15 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
0-10	STV-L	ML	A-4, A-6	3-10	80-100	60-95	55-90	50-70	30-30	[illegible]
10-23	L, CL, GR-L	ML, SM-SC, CL, CL-ML	A-4, A-6	3-10	85-100	60-95	55-90	45-70	25-40	[illegible]
23-50	L, CL, GR-SL	SM, ML, CL, SC	A-4, A-6, A-2	3-10	85-100	65-95	40-90	35-70	25-40	3-15
50-60	SL, CL, GR-LS	SM, ML, CL, SC	A-2, A-4, A-1, A-6	3-10	75-95	65-95	35-90	15-75	15-40	3-15

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
0-10			0.6-2.0	0.14-0.20	4.5-5.5	-	LOW	.32	3	-		HIGH	HIGH
10-23			0.6-2.0	0.10-0.20	4.5-5.5	-	LOW	.32					
23-50			0.06-0.2	0.06-0.10	4.5-5.5	-	LOW	.28					
50-60			0.6-2.0	0.14-0.18	4.5-5.5	-	LOW	.28					

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			1.5-2.5	PERCHED	NOV-MAY	-		>60		-		C	HIGH

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	SEVERE-WETNESS, PERCS SLOWLY
SEWAGE LAGOON AREAS	0-2%: SLIGHT 2-7%: MODERATE-SLOPE 7+%: SEVERE-SLOPE
SANITARY LANDFILL (TRENCH)	SEVERE-WETNESS
SANITARY LANDFILL (AREA)	SEVERE-WETNESS
DAILY COVER FOR LANDFILL	0-8%: FAIR-LARGE STONES, SMALL STONES 8-15%: FAIR-SLOPE, LARGE STONES, SMALL STONES

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	SEVERE-WETNESS
DWELLINGS WITHOUT BASEMENTS	SEVERE-WETNESS, FROST ACTION
DWELLINGS WITH BASEMENTS	SEVERE-WETNESS
SMALL COMMERCIAL BUILDINGS	0-8%: SEVERE-WETNESS, FROST ACTION 8-15%: SEVERE-SLOPE, WETNESS, FROST ACTION
LOCAL ROADS AND STREETS	SEVERE-FROST ACTION
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	0-8%: MODERATE-LARGE STONES, SMALL STONES, WETNESS 8-15%: MODERATE-SLOPE, LARGE STONES, WETNESS

REGIONAL INTERPRETATIONS

CONSTRUCTION MATERIAL (B)

ROADFILL	POOR-FROST ACTION
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	POOR-LARGE STONES

WATER MANAGEMENT (B)

POND RESERVOIR AREA	0-3%: MODERATE-SEEPAGE 3-8%: MODERATE-SEEPAGE, SLOPE 8+%: SEVERE-SLOPE
EMBANKMENTS DIKES AND LEVEES	SEVERE-PIPING, WETNESS
EXCAVATED PONDS AQUIFER FED	SEVERE-NO WATER
DRAINAGE	LARGE STONES, PERCS SLOWLY, WETNESS
IRRIGATION	LARGE STONES, PERCS SLOWLY, WETNESS
TERRACES AND DIVERSIONS	LARGE STONES, PERCS SLOWLY, ROOTING DEPTH
GRASSED WATERWAYS	LARGE STONES, PERCS SLOWLY, ROOTING DEPTH

CALIFON SERIES
STONY

NJ0045

RECREATIONAL DEVELOPMENT (C)

CAMP AREAS	0-8%: MODERATE-WETNESS, LARGE STONES 8-15%: MODERATE-SLOPE, WETNESS, LARGE STONES	PLAYGROUNDS	0-6%: SEVERE-SMALL STONES, WETNESS 6+%: SEVERE-SLOPE, SMALL STONES, WETNESS
PICNIC AREAS	0-8%: MODERATE-WETNESS 8-15%: MODERATE-SLOPE, WETNESS	PATHS AND TRAILS	MODERATE-WETNESS, LARGE STONES

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY NIRR.	CAPABILITY IRR.	PASTURE (AUM) NIRR.	PASTURE (AUM) IRR.	NIRR.	IRR.	NIRR.	IRR.	NIRR.	IRR.	NIRR.	IRR.	NIRR.	IRR.	NIRR.	IRR.	NIRR.	IRR.
0-8%	[illegible]		[illegible]															
3-15%	[illegible]		[illegible]															

WOODLAND SUITABILITY (C)

CLASS-DETERMINING PHASE	ORD SYM	EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	TREES TO PLANT
0-15%	30	SLIGHT	SLIGHT	SLIGHT	SLIGHT		YELLOW-POPLAR NORTHERN RED OAK WHITE OAK BLACK OAK WHITE ASH		EASTERN WHITE PINE NORWAY SPRUCE YELLOW-POPLAR

WINDBREAKS

CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY (C)

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
0-3%	V. POOR	POOR	GOOD	GOOD	GOOD	-	POOR	POOR	POOR	GOOD	POOR	
3-8%	V. POOR	POOR	GOOD	GOOD	GOOD	-	POOR	V. POOR	POOR	GOOD	V. POOR	
8-15%	V. POOR	POOR	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	POOR	GOOD	V. POOR	

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				

POTENTIAL PRODUCTION (LBS./AC. DRY WT)					
FAVORABLE YEARS					
NORMAL YEARS					
UNFAVORABLE YEARS					

FOOTNOTES
A ESTIMATES OF ENGINEERING PROPERTIES BASED ON TEST DATA OF 1 PEDON FROM MORRIS COUNTY, NEW JERSEY.
B RATINGS BASED ON GUIDE FOR INTERPRETING ENGINEERING USES OF SOILS, NOV. 1971.
D RATINGS BASED ON NORTHEAST REGIONAL CRITERIA, MARCH 1966.
C RATINGS BASED ON SOILS MEMOS 69, OCT. 1968; 26, SEPT. 1967; OR 74, JAN. 1972.

NJ0032 SOIL INTERPRETATIONS RECORD

MLRA(S): 144A
REV. WCK, 9-79
ULTIC HAPLUDALFS, FINE-LOAMY, MIXED, MESIC

WASHINGTON SERIES
STONY

THE WASHINGTON SERIES CONSISTS OF DEEP, WELL DRAINED SOILS ON UPLANDS. THEY FORMED IN GLACIAL TILL. TYPICALLY THESE SOILS HAVE A DARK YELLOWISH BROWN VERY STONY LOAM SURFACE LAYER 9 INCHES THICK. THE STRONG BROWN SUBSOIL FROM 9 TO 17 INCHES IS LOAM AND FROM 17 TO 52 INCHES IS CLAY LOAM. THE SUBSTRATUM FROM 52 TO 72 INCHES IS BROWNISH YELLOW LOAM GRADING TO GRAVELLY SILT LOAM WITH DEPTH. BEDROCK IS AT 72 INCHES. SLOPES RANGE FROM 0 TO 35 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	STV-L, STV-SIL	CL, SC, SM, ML	A-4, A-6	2-15	80-90	70-80	60-70	40-60	25-40	3-15
9-52	CL, SICL, GR-L	CL, SC, ML, SM	A-4, A-6	0-5	75-100	60-95	50-90	35-85	25-40	3-15
52-72	CL, SIL, GR-L	CL, SC	A-4, A-6, A-2, A-1	0-15	75-95	35-95	30-85	15-75	25-35	8-15
72	UWB									

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	15-25	1.25-1.45	0.6-2.0	0.18-0.22	5.6-7.3	-	LOW	.28	4	-	1-4	MODERATE	LOW
9-52	25-35	1.30-1.60	0.6-2.0	0.16-0.20	5.6-7.3	-	LOW	.32					
52-72	15-30	1.40-1.65	0.6-6.0	0.12-0.16	5.6-7.3	-	LOW	.28					
72													

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			>6.0			-		>60		-		B	MODERATE

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	0-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
SEWAGE LAGOON AREAS	0-7%: SEVERE-SEEPAGE 7+%: SEVERE-SLOPE,SEEPAGE
SANITARY LANDFILL (TRENCH) 1	0-15%: SEVERE-SEEPAGE 15+%: SEVERE-SLOPE,SEEPAGE
SANITARY LANDFILL (AREA) 1	0-15%: SEVERE-SEEPAGE 15+%: SEVERE-SLOPE,SEEPAGE
DAILY COVER FOR LANDFILL	0-8%: FAIR-TOO CLAYEY,SMALL STONES 8-15%: FAIR-SLOPE,SMALL STONES,TOO CLAYEY 15+%: POOR-SLOPE

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	0-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITHOUT BASEMENTS	0-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITH BASEMENTS	0-8%: SLIGHT 8-15%: MODERATE-SLOPE 15+%: SEVERE-SLOPE
SMALL COMMERCIAL BUILDINGS	0-4%: SLIGHT 4-8%: MODERATE-SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	0-8%: MODERATE-FROST ACTION 8-15%: MODERATE-SLOPE,FROST ACTION 15+%: SEVERE-SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	0-8%: MODERATE-LARGE STONES,SMALL STONES 8-15%: MODERATE-SLOPE,LARGE STONES, SMALL STONES 15+%: SEVERE-SLOPE

REGIONAL INTERPRETATIONS

CONSTRUCTION MATERIAL (B)

ROADFILL	0-25%: POOR-LOW STRENGTH 25+%: POOR-SLOPE,LOW STRENGTH
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	0-15%: POOR-LARGE STONES,SMALL STONES 15+%: POOR-SLOPE,LARGE STONES,SMALL STONES

WATER MANAGEMENT (B)

POND RESERVOIR AREA	0-3%: MODERATE-SEEPAGE 3-8%: MODERATE-SLOPE,SEEPAGE 8+%: SEVERE-SLOPE
EMBANKMENTS DIKES AND LEVEES	MODERATE-PIPING
EXCAVATED PONDS AQUIFER FED	SEVERE-NO WATER
DRAINAGE	0-3%: FAVORABLE 3+%: SLOPE
IRRIGATION	0-3%: FAVORABLE 3+%: SLOPE
TERRACES AND DIVERSIONS	0-8%: FAVORABLE 8+%: SLOPE
GRASSED WATERWAYS	0-8%: FAVORABLE 8+%: SLOPE

WASHINGTON SERIES   NJ0032
STONY

RECREATIONAL DEVELOPMENT (C)

CAMP AREAS	0-8%: MODERATE-LARGE STONES,SMALL STONES, DUSTY 8-15%: MODERATE-SLOPE,LARGE STONES, SMALL STONES 15+%: SEVERE-SLOPE	PLAYGROUNDS	0-6%: SEVERE-SMALL STONES,LARGE STONES 6+%: SEVERE-SLOPE,LARGE STONES,SMALL STONES
PICNIC AREAS	0-8%: MODERATE-SMALL STONES,LARGE STONES, DUSTY 8-15%: MODERATE-SLOPE,SMALL STONES, LARGE STONES 15+%: SEVERE-SLOPE	PATHS AND TRAILS	0-15%: MODERATE-LARGE STONES,SMALL STONES, DUSTY 15-25%: MODERATE-SLOPE,LARGE STONES, SMALL STONES 15+%: SEVERE-SLOPE

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-3%	5S		-		-		-		-		-		-		-			
3-25%	6S		-		-		-		-		-		-		-			
25-35%	6E																	

WOODLAND SUITABILITY (C)

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	TREES TO PLANT
0-15%	1O	SLIGHT	SLIGHT	SLIGHT	SLIGHT		NORTHERN RED OAK	85	EASTERN WHITE PINE
15-35%	1R	SLIGHT	MODERATE	SLIGHT	SLIGHT		YELLOW-POPLAR	95	EUROPEAN LARCH
									BLACK WALNUT
									YELLOW-POPLAR
									NORWAY SPRUCE

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
	NONE							

WILDLIFE HABITAT SUITABILITY (C)

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
0-8%	V. POOR	POOR	GOOD	GOOD	GOOD	-	POOR	V. POOR	POOR	GOOD	V. POOR	-
8-35%	V. POOR	POOR	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	POOR	GOOD	V. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				

POTENTIAL PRODUCTION (LBS./AC. DRY WT):					
FAVORABLE YEARS					
NORMAL YEARS					
UNFAVORABLE YEARS					

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON TEST DATA OF 10 PEDONS FROM PENNSYLVANIA.
B RATINGS BASED ON NSH, PART II, SECTION 403, 3-78.
C RATINGS BASED ON SOILS MEMO 26, SEPT. 1967 AND REGIONAL CRITERIA. SITE INDEX VALUES + OR -5 OR MORE.
D WILDLIFE RATINGS BASED ON SOILS MEMO 74, JAN. 1972.
1 EXCESSIVE PERMEABILITY RATE MAY ALLOW POLLUTION OF GROUND WATER.

SOIL INTERPRETATIONS RECORD

[illegible]

MLRA(S): 147, 148, 126, 127, 124 — HAZLETON SER
[illegible] 9-83
TYPIC DYSTROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC

THE HAZLETON SERIES CONSISTS OF DEEP, WELL DRAINED SOILS ON UPLANDS. THEY FORMED IN MATERIAL WEATHERED FROM SANDSTONE. TYPICALLY, THESE SOILS HAVE A DARK BROWN SANDY LOAM SURFACE LAYER, 6 INCHES THICK. THE SUBSOIL BETWEEN 6 AND 32 INCHES IS REDDISH-YELLOW TO STRONG BROWN CHANNERY AND VERY CHANNERY SANDY LOAM. THE SUBSTRATUM FROM 32 TO 56 INCHES IS [illegible]-YELLOW VERY CHANNERY SANDY LOAM. SANDSTONE BEDROCK IS AT A DEPTH OF 56 INCHES. SLOPES RANGE FROM 0 TO 80 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
0-6	SL, L, FSL	ML	A-4	0-5	90-100	90-100	70-80	55-70	-	
0-6	CN-SL, CN-L	ML, GM, SM	A-2, A-4	0-15	60-85	60-80	60-75	35-55	-	
6-32	CN-SL, L, CNV-L	GM, SM, GL, GC	A-1, A-2, A-1	5-30	50-85	45-80	30-70	15-35	<30	NP-8
32-56	CN-L, CNV-SL, CNV-LS	GM, SM, GC, GC	A-1, A-2, A-4	5-40	55-85	35-75	30-65	15-35	<30	NP-8
56	UWB									

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 ERODIBILITY GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-6	7-18	1.20-1.40	2.0-6.0	0.10-0.16	3.6-5.5	-	LOW	.17	3	-	1-4	LOW	HIGH
0-6	7-18	1.20-1.40	2.0-6.0	0.10-0.14	3.6-5.5	-	LOW	.17					
6-32	7-18	1.30-1.60	2.0-20	0.08-0.12	3.6-5.5	-	LOW	.15					
32-56	5-15	1.20-1.40	2.0-20	0.04-0.12	3.6-5.5	-	LOW	.15					
56													

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			-		>40	HARD	-		B	[illegible]

SANITARY FACILITIES (B)

SEPTIC TANK ABSORPTION FIELDS	0-15%: SEVERE-POOR FILTER 15+%: SEVERE-POOR FILTER, SLOPE
SEWAGE LAGOON AREAS	0-7%: SEVERE-SEEPAGE 7+%: SEVERE-SLOPE, SEEPAGE
SANITARY LANDFILL (TRENCH)	0-15%: SEVERE-SEEPAGE, DEPTH TO ROCK 15+%: SEVERE-SLOPE, SEEPAGE, DEPTH TO ROCK
SANITARY LANDFILL (AREA)	0-15%: SEVERE-SEEPAGE 15+%: SEVERE-SLOPE, SEEPAGE
DAILY COVER FOR LANDFILL	0-15%: POOR-SMALL STONES 15+%: POOR-SLOPE, SMALL STONES

BUILDING SITE DEVELOPMENT (B)

SHALLOW EXCAVATIONS	0-8%: MODERATE-DEPTH TO ROCK, LARGE STONES 8-15%: MODERATE-DEPTH TO ROCK, SLOPE, LARGE STONES 15+%: SEVERE-SLOPE
DWELLINGS WITHOUT BASEMENTS	0-8%: MODERATE-LARGE STONES 8-15%: MODERATE-SLOPE, LARGE STONES 15+%: SEVERE-SLOPE
DWELLINGS WITH BASEMENTS	0-8%: MODERATE-LARGE STONES, DEPTH TO ROCK 8-15%: MODERATE-SLOPE, LARGE STONES, DEPTH TO ROCK 15+%: SEVERE-SLOPE
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-LARGE STONES 4-8%: MODERATE-SLOPE, LARGE STONES 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	0-8%: MODERATE-FROST ACTION, LARGE STONES 8-15%: MODERATE-SLOPE, FROST ACTION, LARGE STONES 15+%: SEVERE-SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	0-8% SL, L, FSL: MODERATE-DROUGHTY 0-8% CN: MODERATE-SMALL STONES, DROUGHTY 8-15% SL, L, FSL: MODERATE-SLOPE, DROUGHTY 8-15% CN: MODERATE-SLOPE, SMALL STONES 15+%: SEVERE-SLOPE

REGIONAL INTERPRETATIONS

CONSTRUCTION MATERIAL (B)

ROADFILL	0-15%: FAIR-AREA RECLAIM, THIN LAYER, LARGE STONES 15-25%: FAIR-SLOPE, AREA RECLAIM, THIN LAYER 25+%: POOR-SLOPE
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	0-15%: POOR-SMALL STONES 15+%: POOR-SLOPE, SMALL STONES

WATER MANAGEMENT (B)

POND RESERVOIR AREA	0-8%: SEVERE-SEEPAGE 8+%: SEVERE-SEEPAGE, SLOPE
EMBANKMENTS DIKES AND LEVEES	SEVERE-SEEPAGE, LARGE STONES
EXCAVATED PONDS AQUIFER FED	SEVERE-NO WATER
DRAINAGE	DEEP TO WATER
IRRIGATION	0-3%: LARGE STONES, DROUGHTY 3+%: LARGE STONES, DROUGHTY, SLOPE
TERRACES AND DIVERSIONS	0-8%: LARGE STONES, TOO SANDY 8+%: SLOPE, LARGE STONES, TOO SANDY
GRASSED WATERWAYS	0-8%: LARGE STONES, DROUGHTY 8+%: LARGE STONES, SLOPE, DROUGHTY

HAZLETON SERIES PA0080

RECREATIONAL DEVELOPMENT (B)

CAMP AREAS	0-8% SL,L,FSL: SLIGHT 0-8% CN: MODERATE-SMALL STONES 8-15% SL,L,FSL: MODERATE-SLOPE 8-15% CN: MODERATE-SLOPE,SMALL STONES 15+%: SEVERE-SLOPE	PLAYGROUNDS	0-2% SL,L,FSL: SLIGHT 2-6% SL,L,FSL: MODERATE-SLOPE 6+% SL,L,FSL: SEVERE-SLOPE 0-6% CN: SEVERE-SMALL STONES 6+% CN: SEVERE-SMALL STONES,SLOPE
PICNIC AREAS	0-8% SL,L,FSL: SLIGHT 0-8% CN: MODERATE-SMALL STONES 8-15% SL,L,FSL: MODERATE-SLOPE 8-15% CN: MODERATE-SLOPE,SMALL STONES 15+%: SEVERE-SLOPE	PATHS AND TRAILS	0-15%: SLIGHT 15-25%: MODERATE-SLOPE 25+%: SEVERE-SLOPE

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY		CORN (BU)		WHEAT (BU)		OATS (BU)		ALFALFA HAY (TONS)		GRASS-LEGUME HAY (TONS)		PASTURE (AUM)		CORN SILAGE (TONS)	
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-3%	1		125		45		75		4.5		3.5		8.0		25	
3-8%	2E		125		45		75		4.5		3.5		8.0		25	
8-15%	3E		115		40		70		4.5		3.5		8.0		23	
15-25%	4E		110		35		60		4.0		3.0		7.5		22	
25-35%	6E		-		-		-		-		-		7.0			
35+%	7E		-		-		-		-		-		-			

WOODLAND SUITABILITY (C)

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	TREES TO PLANT
0-15%	3F	SLIGHT	SLIGHT	SLIGHT	SLIGHT	MODERATE	NORTHERN RED OAK	70	JAPANESE LARCH
15-35% NORTH	3F	SLIGHT	MODERATE	SLIGHT	SLIGHT	MODERATE	YELLOW-POPLAR	80	EASTERN WHITE PINE
35+% NORTH	3F	MODERATE	SEVERE	SLIGHT	SLIGHT	MODERATE			NORWAY SPRUCE AUSTRIAN PINE BLACK CHERRY
15-35% SOUTH	4F	SLIGHT	MODERATE	MODERATE	SLIGHT	SLIGHT	NORTHERN RED OAK	60	JAPANESE LARCH
35+% SOUTH	4F	MODERATE	SEVERE	SEVERE	SLIGHT	SLIGHT	BLACK OAK	60	EASTERN WHITE PINE NORWAY SPRUCE AUSTRIAN PINE BLACK CHERRY

WINDBREAKS

CLASS-DETERMINING PHASE	SPECIES	TAT	SPECIES	TAT	SPECIES	TAT	SPECIES	TAT
ALL	SIBERIAN PEASHRUB	7	TATARIAN HONEYSUCKLE	8	AMUR HONEYSUCKLE	8	LILAC	8
	AUTUMN-OLIVE	9	WASHINGTON HAWTHORN	10	RADIANT CRABAPPLE	12	EASTERN REDCEDAR	14
	JACK PINE	16	AUSTRIAN PINE	18	RED PINE	18	EASTERN WHITE PINE	20

WILDLIFE HABITAT SUITABILITY (C)

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
0-8%	GOOD	GOOD	GOOD	GOOD	GOOD	-	POOR	V. POOR	GOOD	GOOD	V. POOR	-
8-15%	FAIR	GOOD	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	GOOD	GOOD	V. POOR	-
15-35%	POOR	FAIR	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	FAIR	FAIR	V. POOR	-
25-35%	V. POOR	FAIR	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	FAIR	FAIR	V. POOR	-
35+%	V. POOR	POOR	GOOD	GOOD	GOOD	-	V. POOR	V. POOR	POOR	FAIR	V. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE				
POTENTIAL PRODUCTION (LBS./AC. DRY WT): FAVORABLE YEARS						
NORMAL YEARS						
UNFAVORABLE YEARS						

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON TEST DATA OF 16 PEDONS FROM PENNSYLVANIA.
B RATINGS BASED ON NSH, PART II, SECTION 403, 3-78.
C RATINGS BASED ON SOILS MEMOS 26, SEPT. 1967; OR 74, JAN. 1972.

Solution:

"LS" for Subarea "A" (11.6 acres)

Segment No.	Slope %	"LS" form Table A1-3	Adjustment Factor	Segment "LS"
1	1	0.21	0.71	0.15
2	2	0.33	1.29	0.43
			Average LS:	0.29

Subarea A will have original slope

"LS" for Subarea "B" (27.0 acres)

Segment No.	Slope %	"LS" form Table A1-3	Adjustment Factor	Segment "LS"
1	1	0.27	0.45	0.12
2	2	0.41	0.82	0.34
3	0.2 *	0.17	1.06	0.18
4	0.2 **	0.17	1.25	0.21
5	5	1.70	1.42	2.41
			Average LS:	0.65

Weighted LS = [(0.29)(11.6) + (0.65)(27.0)]/38.6 = 0.54
(answer)

Note:
Subarea B will be reshaped for construction. Assume that the building area is almost horizontal around 96-ft. elevation.

3. Required: Estimate the annual soil erosion rate from the construction site without any control measure. At what rate will this sediment be arriving at the Winding Creek?

Solution:
1. Using the Universal Soil Loss Equation E = R K LS C P

R: from Figure A1-1, R value in Hunterdon County is 175

K: weighted K value previously calculated is 0.23 t/ac

1. (cont'd)

LS: weighted LS factor previously calculated is 0.54

C: no cover, therefore C is 1.0

P: no control practices, P = 1.0

2. The estimated average soil loss from sheet erosion (E) in tons per acre per year is:

E = (175) (0.23) (0.54) (1.0) (1.0)
22 tons/acre/year

3. The erosion from the entire site (sediment yield)

22 tons/acre/year X 38.6 acres = 849 tons/year

4. Delivery Ratio (DR): The Winding Creek is about 600 feet downstream of the construction site. Based on the values given previously assume DR = 0.7

5. Sediment reaching the Winding Creek is:

0.7 X 849 tons/year = 594 tons/year (answer)

4. Required: What would the soil erosion be for an extreme year of one in 20 years and for a major single storm of one in 20 years?

Solution:

1. Soil erosion for an extreme year of one in 20 years can be determined as follows:

a. Probability factor of one in 20 years (Table A1-8) is 1.7

b. Soil erosion for this year is 1.7 X 849 tons/year or 1443 tons/year (answer)

2. Soil Erosion for a major storm of one in 20 years can be determined as follows:

a. The factor in table A1-8 is 0.7, therefore the soil erosion for the storm is 0.7 X 849 tons/year or 594 tons/year (answer).

5. Required: What would the reduction of annual soil erosion be (in percent) if the slope length is divided into five
equal slope lengths by using diversions? What would the reduction be if straw or hay mulch at a rate of 1.5 T/ac
is properly used in each of the above slope length segments?

Solution:

1. Divide the slopes into five equal slope lengths (Figure A1-2) and determine the effect of the slope length change:

Each slope-length will be 210 feet. "LS" factor, as well as the erosion rate, for each slope-length is computed individually.

Erosion from Subarea A

Segment No.	Slope (%)	"LS" from Table A1-3	Area A (acres)	Annual Soil Loss ARKLS (tons/year)
1	1	0.16	2.32	14.9
2	1	0.16	2.32	14.9
3	2	0.25	2.32	23.3
4	2	0.25	2.32	23.3
5	2	0.25	2.32	23.3

Total from Subarea A is 100 tons/year

Erosion from Subarea B

Segment No.	Slope (%)	"LS" from Table A1-3	Area B (acres)	Annual Soil Loss ARKLS (tons/year)
1	1	0.16	5.4	34.8
2	2	0.25	5.4	54.3
3	0.2	0.10	5.4	21.7
4	0.2	0.10	5.4	21.7
5	5	0.78	5.4	169.5

Total from Subarea B is 302 tons/year

Therefore the total soil loss is 100 + 302 = 402 tons/year. The percent reduction would therefore be (849-409)/849 X 100 = 53 percent (answer)

2. The soil loss reduction from the slope length change and from adding mulch is as follows:

a. From table A1-4 for slopes that are < 5 percent and lengths less than 300 feet, the cropping management factor (C) is 0.12

b. Soil loss with straw or hay mulch (1.5 tons/year) on the five equal segments is 402 tons/year X 0.12 = 48 tons/year

c. Reduction of annual soil loss (849-48)/849 X 100 or 94 percent (answer)

6. Required: Assume that the only control measure adopted in this site is a sediment basin which will be constructed at the downstream edge of the property. For what sediment volume will this basin be designed?

Solution:

1. Since the sediment basin will be built at the downstream edge of the site, DR = 1.0

2. The rate of sediment which will enter the basin is 849 tons/year.

3. The adjustment factor, M (Table A1-6), for the 18 month construction period (April 1, 1986 to September 30, 1987):

April 1, 1986 to March 1, 1987: M = 0.98
March 1, 1987 to October 1, 1987 M = 0.82

Total M = 1.80

4. Total sediment which will arrive at the basin during the construction period is Et = 849 tons/year X 1.80 or 1528 tons.

5. Using Table A1-7, the saturated sediment volume for which the sediment basin will be designed is:

1528 X .00077 = 1.18 acre-feet
or
1528 X 1.24 = 1895 cu. yd. (answer)

FIGURE A1-1

R A I N F A L L E R O S I O N V A L U E S "R"

N E W J E R S E Y M A P

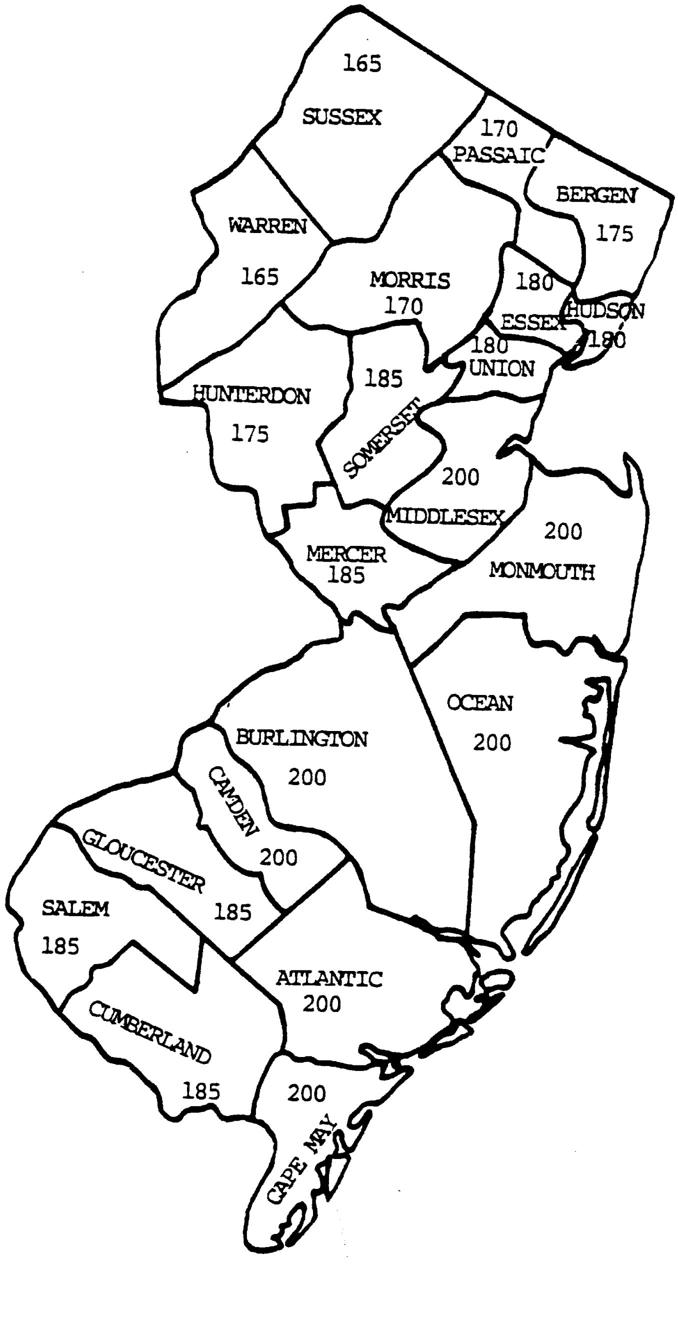


TABLE A1-1

USDA TEXTURE ABBREVIATIONS USED IN TABLE A1-2a, A1-2b, A1-2c

c	-	clay,clayey
ch	-	channery
co	-	coarse
e	-	extremely
f	-	fine
g	-	gravelly
k	-	cobbly
l	-	loam, loamy
m	-	muck
r	-	rocky
s	-	sand, sandy
sh	-	shaly
si	-	silt, silty
st	-	stony
v	-	very

SOIL-ERODIBILITY CLASSES

K	-	class
0.17 - 0.24	-	low
0.28 - 0.37	-	medium
0.43 - 0.49	-	high

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Adrian		0-42	m	Pt	--	--
		42-60	ls	SP-SM,SM	0.2	35
Albia		0-16	gl,estl	GM,GC,SC	0.24	42
		16-40	gl (pan)	GM,GC,SC	0.4	70
		40-60	gl	GM,GC,SC	0.3	53
Asbury		0-30	sil	GL,ML	[ii]	--
		30-60	ls,gls,vgls	SM,GM	--	--
Atherton		0-30	l	SM,SC,ML,CL	0.24	42
		30-60	scl	SM,SC	0.2	35
Bartley		0-11	l,g	ML,CL	0.32	56
		11-32	cl,l,scl	ML,CL	0.3	53
		32-42	sl,l	SM,SC	0.2	35
		42-60	sl,l,gsl,gl	SM,SC	0.2	35
Bath		0-28	l,sil	SM,SC	0.24	42
			gl,vstl	GM,GC	0.17	30
		28-48	l,sil	SM,SC	0.2	35
			gl,gsil	GM,GC	0.2	35
		48-60	gsl	SM,SC,GM,GC	0.2	35
Beatty		0-25	l	CL,ML	**2**	--
		25-60	ls,gls	SM,GM	--	--
Biddeford		0-8	ml	Pt	--	--
		8-18	sil	ML,CL	--	--
		18-44	sicl,c,cl	CL,CH	--	--
		44-60	sil,cl,sicl	ML,CL	--	--
Boonton		0-6	gl,estl	ML	0.20	35
		6-30	fsl,l,sil,gfsl,gl,gsil	ML,CL	0.2	35

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		30-45	fsl,sil,gfsl,gsil	ML,CL,SM,SC	0.2	35
		45-60	gsl	SM	0.2	35
Braceville		0-24	gsl	SM,GM	0.24	42
		24-36	g or vg, l,sl	SM,SC,GM	0.3	53
		36-60	stratified scg	SM,SP,SP-SM,GP	0.2	35
Bridgeville		0-30	sl,gl	SM	0.24	42
		30-60	gl,g,s	SM	0.2	35
Burnham		0-12	l,sil	ML,CL	0.32	26
		12-48	gl	ML,CL	0.3	53
		48-60	stone,g	SM,SC,GM,GC	0.2	35
Carlisle		0-60	m	Pt	--	--
Cattaraugus		0-20	fsl	SM,ML,CL	0.24	42
		20-60	gl	SM,ML,CL	0.17	30
Chatfield		0-28	l	ML,CL	0.17	30
		28+	gneiss bedrock			
Chenango		0-20	sl	SM	0.24	42
			gfsl,ksl	GM	0.17	30
		20-30	vgsl,gsl	SM,GM	0.2	35
		30-60	g,s,gls	GP-GM,GM	0.2	35
Chippewa		0-13	sil	ML,CL	0.32	
			chsil,estl	ML,CL	0.24	42
		13-50	l,chsil(pan)	ML,CL,GM	0.4	70
Colden		0-8	sil	ML,CL	0.43	75
		8-45	sicl	ML	0.4	70
Colonie		0-16	lfs,ls	SM,SP-SM	0.24	42

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		16-60	fs,ls,lfs	SM,SP-SM	0.2	35
Comly		0-11	sil	ML,CL	0.37	65
		11-20	sicl,l,sil	ML,CL,CH	0.4	70
		20-27	sicl(pan)	ML,CL,CH	0.5	88
		27-40	sil,l,sicl	ML,CL,CH	0.3	53
Coplay		0-10	sil	ML,CL	0.32	56
		10-60	sicl,cl	ML,CL	0.3	53
Cossayuna		0-24	l,vfsl	SM,ML,CL	0.24	42
			gl	SC,GM,GC	0.17	30
		24-48	g,gl (pan)	SC,GM,GC,SM,ML	0.3	53
		48-60	gsl	SM,GM	0.2	35
Crestmore		0-30	l,sil	ML,CL	0.32	56
		30+	bedrock			
Culvers		0-16	fsl	SM,ML,CL	0.28	49
			chsil	SM,ML,CL	0.20	35
		16-45	l	ML	0.3	53
			chsil	ML,CL,GM	0.3	53
Dutchess		0-60	sil,l,shl,shsil	GM,SM	0.20	35
Ellington		0-15	l,fsl	ML,SM	0.24	42
			gl,gsl	ML,SM	0.24	42
		15-38	l,sl	ML,SM	0.3	53
			gl,gsl	ML,SM	0.2	35
		38-60	s,gs	SM,SP-SM,GM	0.2	35
Fredon		0-7	l	ML,CL,SM	0.24	42
		7-30	sl,fsl	SM,ML,CL	0.3	53

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
			gsl,gfsl	SM,ML,CL	0.2	35
		30-60	s,g	GP-GM,SP-SM	0.2	35
Hackettstown		0-30	sl	SM	0.24	42
			gsl	SM,GM	0.17	30
		30-60	gls,gsl	SM,GM	0.2	35
Haledon		0-10	sil,gsil	ML,CL	0.32	56
		10-46	sil,l,fsl	ML,CL	0.3	53
			gsil,gl,gfsl			
		46-60	vfsl,sl,gvfsl,gsl	SM,SC	0.2	35
Halsey		0-24	l	ML,SM	0.24	42
		24-30	fsl,l,sl	SM	0.3	53
		30-60	g,gs,s & g	GP,GM,SM,SP	0.2	35
Hazen		0-12	gsl,gl	ML,CL	0.17	30
		12-32	gl	ML,CL	0.2	35
		32-60	g & S	SM	0.2	35
Hero		0-10	l	SM,ML,CL	0.24	42
		10-24	fsl,gsl	SM	0.2	35
		24-60	s,gs	SM,GM	0.2	35
Hibernia		0-25	l	ML,CL,SM,SC	0.37	65
			gl,stl,vstl	ML,CL,SM,SC	0.32	56
		25-36	l,scl,sl,	ML,CL,SM,SC	0.3	53
			gl,gscl,gsl	SM,SC,GM,GC	0.3	53
		36-72	gls,gsl,kls	SM,GM	0.2	35
Holyoke		0-17	rsil	ML,CL	0.24	42
		17+	Bedrock			
Hoosic		0-15	gl,gsl	SM,GM,ML,CL	0.17	30
		15-26	gsl,vgsl	GM,SM,ML,CL	0.2	35

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		26-60	s & g	SW,GW,SM,GM,	0,2	35
				SP,GP		
Kendaia		0-8	sil,l,fsl	ML	0.28	49
		8-20	sil,l	ML,ML-CL	0.4	70
				ML-CL,ML,SM	0.4	70
				ML-CL,ML,SM	0.3	53
				GM-GC		
Kistler		0-14	shsil	ML,CL	0.24	42
		14-24	vshsil	ML,CL,GM	0.2	35
		24+	slate bedrock			
Lackawana		0-26	l	ML,CL	0.24	42
			chsil	ML,CL	0.17	30
		26-52	chl (pan)	ML,CL	0.3	53
Livingston		0-10	si,sicl	ML,CL	0.49	86
		10-50	sic	ML,CL,MH,CH	0.5	88
Lyons		0-9	vstsil	CL,ML,SM,SC	0.28	49
		9-18	sil,fsl,sicl	SM,SC,GM,GC	0.4	70
				ML,CL		
		18-40	fsl,cl	SM,SC,ML,CL	0.4	70
		40-60	gl	ML,CL,GM,GC	0.3	53
Marksboro		0-10	l	ML,CL	0.24	42
			gl	ML,CL,SM,SC	0.24	42
		10-40	l,gsl	SM,SC	0.4	70
Menlo		0-22	l	ML,CL	0.24	42
			gl	ML,CL	0.24	42
		22-40	gl (pan)	SM,SC	0.5	88
Middlebury		0-10	fsl	SM,SC,M	0.24	42

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		10-50	fsl,sil	SM,SC,ML	0.4	70
Minoa		0-30	sil,fsl	ML,CL,SC	0.28	49
		30-60	lfs,sil,lvfs	SM	0.2	35
Nassau		0-7	shsil,chsil,vsil	SM,GM	0.20	35
		7-16	chsil,vchsil	SM,SC,GM,GC	0.2	35
			shsil,vshsil			
		16+	shale bedrock			
Netcong		0-60	fsl,sl	SM,SC	0.24	42
Norwich		0-6	sil	ML,CL	0.32	56
			vstsil	ML,CL	0.28	49
		6-30	chsicl	ML,CL	0.3	53
		30-60	vchsil	ML,CL	0.3	53
Oquaga		0-16	vstsl,estl	SM	0.20	35
		16-26	stsl	SM	0.3	53
		26+	Bedrock			
Otisville		0-10	sl,gsl,gls	SM,SP-SM,GP-GM	0.17	30
		10-60	gls,gs	SM,SP-SM,GM	0.2	35
				GP-GM		
Palmyra		0-18	sil,gfsl	ML,CL	0.24	42
		18-24	sil	ML,CL	0.2	35
		24-40	g & s	SM	0.2	35
Parsippany		0-7	sil	ML,CL	0.43	75
		7-34	cl,sicl,sic	ML,CL,CH	0.4	70
		34-60	sicl,cl,l	ML,CL,CH	0.4	70
Paulina		0-21	l,shl	ML,CL	0.28	49
		21-38	shl	ML,CL	0.2	35

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Phelps		0-21	fsl	SM	0.24	42
		21-45	sl	SM	0.3	53
		45-50	g & s	SM	0.2	35
Pompton		0-28	sl,fsl	SM	0.24	42
		28-60	s & g	SM,GM	0.2	35
Preakness		0-12	sl,l	SM	0.28	49
		12-30	sl	SM	0.2	35
		30-60	ls,sl	SM,SP-SM	0.2	35
			gls	GM,SP-SM	0.2	35
Raynham		0-28	sil	ML,CL	0.49	86
		28-60	sil,vfsl	ML,CL	0.4	70
Red Hook		0-10	fsl	SM,SC	0.24	42
		10-35	sil	ML,CL	0.4	70
		35-60	ls	SM	0.4	70
Rhinebeck		0-12	sil,sicl	ML,CL,OL	0.49	86
		12-30	sicl,sic	CL,ML	0.4	70
		30-40	sicl,sil,vfsl	CL,ML	0.5	88
Ridgebury		0-16	sl,fsl,l	SM,ML,SC	0.24	42
		16-40	gl,gsl	SM,SC	0.3	53
		40-60	gs,s	SM,GM	0.2	35
Riverhead		0-9	sl	SM,SC	0.28	49
			gsl	SM,SC	0.20	35
		9-34	fsl,slgsl	SM,SC	0.3	53
		34-60	ls,s,gls,gs	SP-SM,SM,GP-GM	0.2	35
				GM		
Rockaway		0-30	l	ML,SM,SC	0.24	42

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
			gsl,gl,vstl,	ML,SM,SC	0.17	30
			vstsl,estsl			
		30-60	gsl	SM,SC	0.2	35
Rockport		0-10	shsil	ML,CL	0.20	35
		10-36	sicl,sic	ML,CL,MH,CH	0.4	70
		Rock				
Roe		0-10	shsil	ML,CL	0.24	42
		10-36	l,sil	ML,CL	0.3	53
		36-60	fs	SM	0.2	35
Scio		0-40	sil	ML,CL	0.49	86
		40-60	sl	SM	0.3	53
Sloan		0-45	sil,sicl	ML,CL		
		45-60	gsl	SM		
Stephensburg		0-19	shl	ML	0.28	49
		19-26	vshl	GM,SM	0.2	35
			shale bedrock			
Swartswood		0-30	gfsl,gls,vstsl,	SM,SC	0.17	30
		30-60	gfsl (pan)	SM,SC	0.3	53
Townsbury		0-13	l	SM,ML	0.24	42
			vstl	SM,ML	0.17	30
		13-36	l	SM,ML,SC	0.4	70
			gl	SM,ML,SC	0.2	53
		30-60	gsl	SM	0.2	35
Tunkhannock		0-18	gl,vgl	SM,GM,ML	0.17	30
		18-32	vgsl	GM,SM	0.2	35
		32-60	s,gs	SM,GMSP.GP	0.2	35
Unadilla		0-10	vfsl	ML,CL	0.49	86

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		10-60	sil,vfsl	ML,CL	0.4	70
		60-70	g & s	SP-SM,GP-GM,	0.3	53
				GW-GM		
Valois		0-60	shl	ML,CL	0.17	30
Wallkill		0-8	sil	OL,CL,ML,SM,SC	0.32	56
		8023	sil	CL,ML,SM,SC	0.4	70
		23-60	much & peak	OL,Pt	0.4	70
Washington		0-9	l,sil	ML,CL	0.32	56
			vstl	ML,CL	0.28	49
		9-60	l,sicl,cl	ML,CL	0.3	53
Wassaic		0-14	sil,l	ML,CL	0.32	56
			gl,gsl	SM,SC,GM,GC	0.24	42
		14-23	l,sl	SM,SC,ML,CL	0.3	53
			gsil	GM,GC	0.2	35
		23+	Bedrock			
Wayland		0-7	sil	OL-ML,CL	0.32	56
		7-38	sil	ML,CL	0.5	88
		38-50	stratified	ML,CL,SC,SM,GM,	0.4	70
			sil & fsl	GC		
Wellsboro		0-11	sil,fsl,l	SM,ML,CL	0.28	49
			chsil	SM,ML,CL	0.20	35
		11-22	l,sil	ML,CL	0.3	53
		22-60	fsl,sil,gl	SM,SC,ML,CL	0.3	53
			(pan)			
Whippany		0-9	sil	ML,CL	0.43	75
		9-60	sil,sicl,sic,c	ML,CL,CH	0.4	70

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 144, R= 175

Soil Series (Alpha Listing)	Local[i] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Whitman		0-10	fsl,sl,lvfsl	OL,SM,ML	0.24	42
			vstl,estsl		0.24	42
		10-40	fsl,sl,l	SM,ML-CL	0.2	35
		40-60	gsl	SM		
Woodglen		0-10	l	ML,CL	0.49	86
		10-36	sicl,c	ML,CL,MH,CH	0.4	70
		36-60	l,cl	ML,CL	0.4	70
Wooster		0-32	l,sil,cl	ML,CL	0.32	56
			gl,chl,gsil	ML,CL	0.3	53
			chsil,gcl,chcl			
		32-60	l,sil,chl,chsil	ML,CL,SM,SC	0.3	53
			gl,gsil			
Wurtsboro		0-18	fsl	SM,SC	0.24	42
			gfsl	SM,SC	0.17	30
		18-60	fsl (pan)	SM,SC	0.3	53
			gfsl	SM,SC	0.2	35

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Abbottstown		0-20	sil	ML,CL	0.43	75
		20-38	sil (pan)	ML,CL	0.4	70
		38-48	shsil	ML,CL	0.4	70
			shl	SM,GM	0.3	53
Amwell		0-10	sil	ML,CL,SC	0.32	56
			gsil	ML,CL<SC	0.28	49
		10-23	sil,sicl,gsil	ML,CL	0.3	53
		23-41	gsicl,ksicl	ML,CL	0.3	53
			vgsil	GM,GC	-	-
		41-53	kfsl,gsil	ML,CL,GC	0.3	53
			vgsl			
Annandale		0-10	l	ML,SM	0.28	49
			gl	SM	0.24	42
		10-32	l,cl,scl	ML,CL	0.4	70
			gl,gcl,gscl	ML,CL	0.3	53
		32-44	same as 7-32 inches with pan		0.5	88
		44-60	sl	SM,ML	0.3	53
			gsl	SM,GM	0.2	35
Athol		0-10	gl	SM	0.32	56
		10-38	sicl,cl	ML,CL	0.3	53
			gcl	SM,SC	0.3	53
		38-60	sicl,cl	ML,CL	0.3	53
			gsl,gl	SM,SC,GM,GC	0.3	53
Bartley		0-11	l,g	ML,CL	0.32	56
		11-32	cl,l,scl	ML,CL	0.3	53
		32-42	sl,l	SM,SC	0.2	35
		42-60	sl,l,gsl,gl	SM,SC	0.2	35
Beddington		0-9	shsil	ML,CL	0.32	56
		9-35	shsil,shl	ML,CL	0.2	35

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
			sil	ML,CL	0.3	53
		35-66	vshl,vshsil	ML	0.2	35
			shsil	CL	0.3	53
		66-72	wesh	GM	0.2	35
Berks		0-8	shsil,chsil	GM,GC,ML	0.24	42
		8-20	sh to vshsil	SM,GM,GC	0.2	35
		20-30	vshsil	GM,GC,SM	0.2	35
		30+	shattered		0.2	35
Birdsboro		0-16	sil,l	ML,CL,SM	0.28	49
		16-48	sicl,cl	CL,ML,SM	0.3	53
		48-60	sl,s,g	GM,GC,SM,GW	0.2	35
			sicl,l	CL,ML	0.3	53
Bowmansville		0-8	sil	ML,CL	0.43	75
		8-32	sil,l,scl	ML,CL	0.4	70
		32-60	sil,scl,sl,	ML,CL	0.4	70
			s,g		0.3	53
Bucks		0-21	sil	ML,CL	0.32	56
		21-36	sicl,sil	ML,CL,MH	0.4	70
		36-52	shsil,vshsil	ML,CL,GM,GC	0.2	35
Califon		0-10	l	ML,SM	0.28	49
			gl,gsil,vstl	SM	0.24	42
		10-32	l,cl,scl	ML,CL	0.4	70
			gl,gcl,gscl	ML,CL	0.3	53
		32-44	same as 10-32 but with pan		0.5	88
		44-60	sl	SM,ML	0.3	53
			gsl	SM,GM	0.2	35
Chalfont		0-18	sil	ML,CL	0.43	75
			vstsil	ML,CL	0.37	65
		18-50	sil,sicl	ML,CL	0.6	105
		50-60	shsil,shl	ML,GM	0.6	105

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Cokesbury		0-15	l	ML,CL,SM	0.32	56
			gl,vstl,estl	SM,SC	0.24	42
		15-25	cl,sicl	ML,CL	0.4	70
		25-48	l,sl	ML,SM	0.5	88
		48-60	gl	SM,SC	0.4	70
Croton		0-18	sil	ML,CL	0.43	75
			vstsil	ML,CL	0.37	65
		18-36	sil,sicl	ML,CL,CH	0.5	88
		36-48	shsil,shsicl	ML,CL,SMSC	0.4	70
		48+	Shale			
Doylestown		0-20	sil	ML,CL	0.43	75
		60-48	sil	ML,CL	0.6	105
			shl	GM,GC	0.4	70
Duffield		0-10	sil	ML,CL	0.32	56
			vsil,vrsil	ML,CL	0.28	49
		10-36	sicl	ML,CL,MH,CH	0.3	53
		36-60	sicl	ML,CL	0.4	70
			shsil	ML,CL	0.3	53
Dunellen		0-15	l,sl	ML,SM	0.24	42
			gl,gsl	ML,SM	0.24	42
		15-38	l,sl	ML,SM	0.3	53
			gl,gsl	ML,SM	0.2	35
		38-60	s,gs	SM,SP-SM,GM	0.2	35
Edneyville		0-11	estl,gl,stl, vstl	ML,SM	0.24	42
		11-39	sl,l,scl	ML,SM,SC	0.4	70
			gsl,gl,gscl	ML,SM,SC	0.3	53
		39-65	gsl	SM,GM	0.2	35
Hazleton		0-9	chl,vstl	SM,GM	0.24	42
		9-40	chl	SM,GM	0.20	35

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		40-50	vchl	GM	0.20	35
Klinesville		0-13	shsil,shl, shsil,vshsil	GM,SM,SC,ML	0.20	35
		13-18	vshsil,vshsl Shale,	GM,GP	0.2	35
Lamington		0-10	sil	ML,CL	0.43	75
		10-23	sil,sicl	ML,CL	0.4	70
		23-45	cl,sil,l	ML,CL	0.4	70
		45-60	s,sl,sil	SM,SP-SM,ML	0.3	53
Lansdale		0-14	l,sl	SM,SC,ML,CL	0.28	49
			chl,vstl	SM,SC,ML,CL	0.24	42
		14-30	scl,sl	SM,SC	0.3	53
			l	ML,CL	0.4	70
		30-45	chsil,gsl	ML,CL	0.3	53
		35-60	chsl,gsl,fsl	SM,SC	0.2	35
Lansdowne		0-10	l,sil	ML,CL	0.43	75
		10-26	cl,sicl	CL,CH	0.4	70
		26-40	l,sicl	ML,CL	0.4	70
		40-60	shsicl	ML,CL	0.4	70
Lawrenceville		0-28	sil	ML,CL	0.49	86
		28-60	sil	ML,CL	0.6	105
			sl,vfsl	SM,SC	0.6	105
Legore		0-8	gl	SM,GM	0.20	35
		8-24	cl	ML,MH,CL	0.3	53
			gcl,gl,gsicl	SM,SC	0.2	35
		24-66	l,sil,sicl	ML,CL	0.3	53
			gl,vgl,gcl	SM-SC	0.2	35
Lehigh		0-14	sil	ML,CL	0,43	75
			chsil,vstsil	ML,CL	0.37	65
		14-20	chsicl	ML,CL	0.4	70

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		30-41	chsicl,vchsil	ML,CL,GM	0.3	53
		41+	Shale			
Meckesville		0-10	gl	ML,CL	0.28	49
		10-31	cl,l,scl, sicl (g)	ML,CL,SC	0.4	70
		31-38	l	ML,CL	0.4	70
		38-60	l,scl,(g,k)	ML,CL,SM,SC	0.3	53
Mount Lucas		0-9	sil	ML,CL	0.32	56
			vstsil	ML,CL	0.28	49
		9-32	l,cl,scl,sicl	ML,CL	0.3	53
		32-60	l	ML	0.4	70
			sl	SM-SC	0.3	53
Neshaminy		0-14	sil	ML,CL	0.32	56
			vstsil,gsil	ML,CL	0.28	49
		14-54	l	ML	0.3	53
			scl,sl	SM,SC	0.3	53
		54+	Diabase			
Nixon		0-12	sil,l,sl	ML,CL,SM	0.28	49
		12-45	sil,sicl,cl	ML,CL	0.4	70
		45-60	sl,sil,s	SM,ML	0.3	54
			gsil,gs	SM,ML	0.2	35
Norton		0-14	sil,l	ML	0.32	56
		14-63	sicl	ML,CL	0.4	70
		63-70	sil	ML	0.4	70
			vgl,shl	GM	0.3	53
Parker		0-40	vgl,vgsl,gsl,kl estsp	SM,GM,GP	0.17	30
		40-60	vstl,vstls, stsl,stls	GM	0.20	35
Parsippany		0-9	l,sicl,sil	ML	0.43	75

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		9-50	sicl,cl	ML,CL	0.5	88
		50-60	sicl,cl	ML,CL,CH	0.4	70
Pattenburg		0-7	l,gl,vgl	ML,SM,GM	0.32	56
		7-30	vgl,l,cl,scl	ML,GM,SM,SC	0.3	53
		30-60	gl,vgl,gsl,vgsl	GM,SM	0.2	35
Penn		0-8	l	ML	0.32	56
			shsil	ML,CL	0.28	49
		8-30	sil	ML,CL	0.4	70
			shsil,sicl	SC-SM	0.3	53
		30+	Shale			
Pope		0-12	fsl	SM	-	-
		12-46	fsl,l	SM,SC	-	-
		46-60	s,sl,gs,gsl, vgs,vgsl	SP-SM,SM,GP-GM	-	
Quakertown		0-16	sil	ML	0.32	56
			chsil	ML	0.28	49
		16-32	sicl	ML,CL	0.3	53
		32-48	chsil,cl	ML,CL	0.3	53
		48+	Sandstone Bedrock			
Raritan		0-14	sil	ML,CL	0.43	75
		14-43	cl,sicl	ML,CL,CH	0.3	53
		43-60	stratified	SM,SC	0.2	35
			s,fsl	SP,SM	0.2	35
			c,sil,l	ML,CL,CH	0.3	53
			g	GM	0.3	53
Readington		0-12	sil	ML,CL	0.43	75
		12-40	sil,sicl	SM,SC,ML,CL	0.4	70
		40-50	sil	ML,CL	0,4	70
			v,sh,sil	GM	0.3	53
		50+	Shale			

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 148, R= 175

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Reaville		0-13	sil	ML,CL	0.43	75
			shsil	ML,CL	0.37	65
		13-23	shsil	ML,CL	0.3	53
				GM,GC	0.3	53
		23+	Shale and Silstone Bedrock			
Riverhead		0-9	sl	SM,SC	0.28	49
			gsl	SM,SC	0.20	35
		9-34	fsl,slgsl,gfsl	SM,SC	0.3	53
		34-60	ls,s,gls,gs	SP-SM,SM,GP-GM	0.2	35
Rowland		0-44	sil,l	ML,CL	0.43	75
			sicl	SM,SC	0.4	70
		44-60	stratified	SM,GM	0.3	53
			s & g	SP,GM	0.2	35
			sil	ML	0.4	70
Tioga		0-9	fsl	ML,CL,SM	0.49	86
		9-24	sil,l,fsl	ML,CL,SM	0.4	70
		24-60	vgls	SM,GM	0.2	35
Turbotville		0-50	l,sil	ML,CL	0.43	75
		50-60	l,sl	ML,SM	0.3	53
Washington		0-9	l,sil	ML,CL	0.32	56
			vstsl	ML,CL	0.28	49
		9-60	l,sicl,cl	ML,CL	0.3	53
Watchung		0-9	sil	ML,CL	0.43	75
		9-46	c,cl,sicl	ML,CL,CH	0.4	70
		46-60	sil,sicl,l	ML,CL	0.4	70
Whippany		0-10	sil	ML,CL	0.43	75
		10-60	sic,c,sicl	ML,CL,CH,MH	0.5	88

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
Adelphia		0.14	sl.fsl.l	ML.CL.SM.SC		64
		14-37	l.scl.fsl	SM.SC.ML.CL	0.4	80
		37-60	sl.ls	SM	0.2	40
Atsion		0-16	s.fs	SP.SP-SM		34
		16-60	s.ls	SP.SP-SM	0.2	40
Aura		0-13	sl.l	SM.ML.CL		86
			gl.gsl	SM.SC		60
			ls	SP-SM.SM		40
		13-59	scl	SM.SC	0.4	80
			gscl.gsl	GM.GC	0.3	60
		59-72	scl.sl	SM.SC	0.4	80
			gsl.gcl	SM.SC.GM.GC	0.3	60
			ls	SP-SM	0.2	40
Barclay		0-14	fsl.lfs	SM		98
		14-40	vfsl.fsl	SM	0.4	80
		40-60	fs.lfs	SM.SP-SM	0.3	60
Bayboro		0-14	sl.l.sil	ML		74
		14-64	c.cl.sic	CH.CL.MH	0.2	40
Berryland		0-12	s.fs	SP.SP-SM		34
		12-72	s.ls.sl	SP.SP-SM	0.2	40
Bertie		0-14	sil.l	ML.CL		74
		14-40	sil.sicl.l	ML.CL	0.4	80
		40-60	stratified sl.l.ls	SM.SC.ML	0.3	60
			gsl	SM	0.2	40
Bibb		0-28	sl to sicl	ML.CL.SM		64
		28-60	highly	SM.GM.CL		40
Chillum		0-28	sil	ML.CL		64
		28-60	gscl,gl	SM,SC	0.3	60

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
			gsl	GM	0.2	40
Colemantown		0-14	l	ML.CL.SM		86
		14-30	sc.scl	CL.CH.MH	0.4	80
		30-60	sl.cl.scl	SC.ML.CL	0.4	80
Collington		0-13	sl.fsl	SM.SC.ML		56
			ls	SM		40
		13-32	scl.cl.sl.l	SC.SM.ML.CL	0.4	80
		32-60	sl.ls	SM.SC	0.2	40
Colts Neck		0-14	sl	SM		56
			ls	SM		40
		14-34	scl.sl.l	SM.SC	0.4	80
		34-60	sl	SM	0.3	60
Donlonton		0-12	fsl	ML.CL.SM.SC		86
		12-40	sc.cl.sic	CH.CL.ML	0.4	80
		40-60	sc.sicl.cl.ls	SM.SC.ML.CL	0.3	60
Downer		0-16	sl	SM.SP-SM		56
			ls	SM		40
		16-30	sl	SM	0.3	60
		30-60	s.ls	SP.SP-SM	0.2	40
Dragson		0-14	fsl.sl.lfs	SM.SC.ML		56
		14-30	sl.scl	SM.SC.CL	0.3	60
		30-60	ls.lfs	SM	0.2	40
Elkton		0-10	sil.sl.l	ML.CL.SM		86
		10-36	sic.c	CH.CL.MH	0.4	80
		36-60	sic.sicl.scl.c	SC.SM.CL.CH.	0.4	80
Evesboro		0-60	ls.s.fs	SM.SP		34
Fallsington		0-14	sl.fsl.l	SM.SC.ML		56
		14-35	scl.sl	SM.SC.ML	0.3	60
		35-50	s.ls.sl	SM.SP-SM	0.2	40
Fort Mott		0-24	s.ls	SP-SM.SM		40
		24-40	sl	SM	0.3	60
		40-60	s	SP-SM.SM	0.2	40

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR	
Freehold		0-14	fsl.sl.l	SM.ML		56	
			ls.lfs	SM		40	
		14-32	sl.scl	SM.SC	0.4	80	
		32-60	stratified ls.fsl	SM	0.2	40	
Freneau		0-60	sl.l	SM.ML		56	
Galestown		0-60	ls.s	SM.SP		34	
Hammonton		0-18	sl	SM		56	
			ls	SP-SM.SM		40	
		18-36	sl	SM	0.3	60	
		36-60	s.ls.gs.gls	SP-SM.SM	0.2	40	
Holmdel		0-14	fsl.sl.l.lfs	SM.ML		56	
		14-36	sl.scl.l	SM.SC	0.4	80	
		36-60	ls.sl	SM	0.2	40	
Howell		0-14	fsl.l	SM.ML.CL		86	
		14-35	cl.sicl	CL	0.4	80	
		35-60	c.sic.sicl	MH.ML.CL	0.3	60	
Keansburg		0-30	sl.fsl.l	SM.ML.SC		56	
		30-60	sl.l	SM	0.3	60	
Keyport		0-10	sil.l.fsl.sl	SM.ML		86	
		10-44	c.sic.cl	CL.CH.MH	0.4	80	
		44-72	sicl.sic	CL.ML.MH	0.4	80	
Sandy Substratum[iii]		44-72	scl.sl	SM.SC.ML.CL	0.3	60	2/
Klei		0-40	ls.fs	SM.SP-SM.SP		34	
		40-60	ls.fs.lfs.sl	SM.SP-SM.SP	0.2	40	
Kresson		0-10	l.sl.ls.fsl	ML.CL.SM.SP-		86	
		10-45	sc.scl	ML.MH.CL.CH	0.4	80	
		45-60	sl.l	SM.SC.ML.CL	0.3	60	
Lakehurst		0-60	s.fs	SP.SP-SM		34	
Lakeland		0-60	ls.lfs.s	SM.SP		34	
Lenoir		0-10	sil.l.fsl	SM.ML		86	
		10-60	sicl.c.sic.cl	CL.CH.ML.MH	0.4	80	

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR	
Sandv Substratum**3**		40-72	scl.sl	SM.SC.ML.CL	0.3	60	2/
Leon		0-16	s	SP.SP-SM		34	
		16-60	s.ls	SP.SP-SM	0.2	40	
Lenoir		0-10	l.sil	ML.CL		86	
		10-40	c.sic.cl	CL.CH.MH	0.4	80	
		40-60	cl.sicl	CL.MH.ML	0.4	80	
Lincroft		0-60	ls.s	SM.SP-SM		34	
Marlton		0-14	sl.fsl	SM.SC		86	
		14-45	sc.scl	ML.CL.MH.CH	0.4	80	
		45-60	sl.scl	SM.SC.CL.ML	0.4	80	
Matapeake		0-16	sil.fsl.l	ML-SM.CL		64	
		16-34	sil.sicl	ML.CL	0.4	80	
		34-60	s.ls.sl.l gs	SM.SC.CL.ML	0.3	60	
Matawan		0-20	sl.ls.fsl	SM.SC		64	
		20-60	cl.scl.sc.sl	CL.SC.SM	0.4	80	
Mattapex		0-14	sil.l	ML.CL		74	
		14-40	sicl.sil.cl	ML.CL	0.4	80	
		40-60	sl.ls.s.l. gs	SM.SC.CL.ML	0.2	40	
Matlock		0-10	1	ML.CL		86	
		10-35	sc.scl	ML.CL.MH.CH	0.4	80	
		35-60	sl.l	SM.SC.ML	0.3	60	
Monmouth		0-11	fsl.l.lfs	SM.SC.ML.CL		86	
		11-40	SC.SCL	CL.SC	0.4	80	
		40-60	sl.scl.sc	SM.SC	0.3	60	
Nixonton		0-14	fsl.lfs	SM		98	
		14-40	vfsl.fsl	SM	0.4	80	
		40-60	lfs.ls	SM.SP-SM	0.2	40	
Osier		0-60	s.fs.ls.lfs	SM.SP-SM		34	
Othello		0-14	sil.l.fsl.sicl	ML.CL		74	
		14-34	sicl.sil	ML.CL	0.4	80	

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		34-60	sl.ls.scl	SM.SC.CL	0.3	60
Pasquotank		0-30	vfsl.fsl	ML.SM		98
		30-60	vfsl.sl.ls	ML.SM	0.2	40
Pemberton		0-24	s.ls	SM.SP-SM		40
		24-34	sl	SM.SC	0.2	40
		34-60	s.ls	SM.SP-SM	0.2	40
Plummer		0-46	s.fs.ls.lfs	SM.SP-SM		34
		46-60	sl.scl	SM.SC		60
Pocomoke		0-28	sl.l.fsl.ls lfs	SM.ML		56
		28-60	ls.s	SM.SP-SM	0.2	40
Portsmouth		0-26	sil	ML.CL		56
		26-60	fs.cos	SP.SP-SM	0.2	40
Rutlege		0-18	ls.lfs	SM.SP-SM	0.17	34
		18-60	s.fs.ls.lfs	SP-SM.SP.SM	0.2	40
St. Johns		0-12	s	SP.SP-SM		34
		12-72	s.ls.sl.gs	SP.SP-SM	0.2	40
Sassafras		0-14	fsl.l.sl	SM.ML		56
			ls.lfs	SM		40
			gsl	SM.SP		48
		14-36	scl.sl.l	SM.SC.CL.ML	0.3	60
		36-60	sl.ls.fsl	SM	0.2	40
			gsl.gls	SM.SP.SP-SM	--	--
Shrewsbury		0-14	sl.fsl.l	SM.ML		56
		14-30	scl.sl	SC.SM.CL	0.3	60
		30-60	s.ls.sl	SM.SP-SM	0.2	40
Tinton		0-24	s.ls	SM.SP-SM		40
		24-60	s.ls	SM.SC.SP-SM		40
Weeksville		0-14	fsl	ML.SM		98
		14-44	sil.fsl	ML.SM	0.4	80
		44-60	vfsl.fsl.scl	ML.CL.SM	0.4	80
Westphalia		0-14	fsl.lfs	SM.ML		98

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY
LAND RESOURCE AREA 149, R= 200

Soil Series (Alpha Listing)	Local [1/] Mapping No.	Typical Profile (inches)	USDA Texture Range	Unified System	K	KR
		14-28	fsl.lfs. vfsl	SC.SM.ML	0.4	80
		28-60	fs.lfs.fsl	SM.ML.SP-SM	0.3	60
Woodsmansie		0-17	s	SM.SP-SM		40
		17-30	sl	SM.SC	0.2	40
		30-60	s.ls.sl	SM.SP-SM	0.2	40
Woodstown		0-14	sl.fsl.l	SM.SC.ML		56
			ls	SM		40
		14-36	scl.l.sl	SM.CL.SC.ML	0.4	80
		36-60	s.ls.sl	SM.SP-SM	0.2	40
			gsl.gls	SM.SP-SM		

TABLE A1-3

VALUES OF THE TOPOGRAPHIC FACTOR "LS"

Length of Slope (L) Ft.	Percent Slope (S) 0.2	0.3	0.4	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	40.0	50.0	60.0
20	.05	.05	.06	.06	.08	.12	.18	.21	.24	.30	.44	.61	.81	1.0	1.3	1.6	1.8	2.6	4	6	8	10
40	.06	.07	.07	.08	.10	.15	.22	.28	.34	.43	.63	.87	1.2	1.4	1.8	2.2	2.6	3.5	5	8	11	15
60	.07	.08	.08	.08	.11	.17	.25	.33	.41	.52	.77	1.0	1.4	1.8	2.2	2.6	3.0	4.5	6	10	14	18
80	.08	.08	.09	.09	.12	.19	.27	.37	.48	.60	.89	1.2	1.6	2.1	2.6	3.0	3.6	5.5	7	11	16	21
100	.08	.09	.09	.10	.13	.20	.29	.40	.54	.67	.99	1.4	1.8	2.4	2.9	3.5	4.2	6.0	8	13	18	23
110	.08	.09	.10	.10	.13	.21	.30	.42	.56	.71	1.0	1.5	2.0	2.5	3.0	3.7	4.5	6	9	14	19	25
120	.09	.09	.10	.10	.14	.21	.30	.43	.59	.74	1.0	1.6	2.1	2.6	3.3	4.0	4.6	7	9	14	20	26
130	.09	.09	.10	.11	.14	.22	.31	.44	.61	.77	1.2	1.6	2.2	2.8	3.4	4.1	4.9	7	9	15	20	27
140	.09	.10	.10	.11	.14	.22	.32	.46	.63	.80	1.2	1.7	2.3	2.9	3.6	4.3	5.1	7	10	15	21	29
150	.09	.10	.11	.11	.15	.23	.32	.47	.66	.82	1.2	1.8	2.4	3.0	3.7	4.5	5.3	8	10	16	23	30
160	.09	.10	.11	.11	.15	.23	.33	.48	.68	.85	1.2	1.9	2.5	3.1	3.9	4.7	5.5	8	10	17	24	31
180	.10	.10	.11	.12	.15	.24	.34	.51	.72	.90	1.4	1.9	2.6	3.3	4.1	5.0	6.0	9	12	18	26	33
200	.10	.11	.11	.12	.16	.25	.35	.53	.76	.95	1.4	2.1	2.8	3.6	4.4	5.3	6.3	9	12	18	27	35
300	.11	.12	.13	.14	.18	.28	.40	.62	.93	1.2	1.8	2.7	3.6	4.5	5.6	6.8	8	12	16	25	35	45
400	.12	.13	.14	.15	.20	.31	.44	.70	1.0	1.4	2.0	3.2	4.2	5.4	6.7	8.0	10	14	19	30	42	54
500	.13	.14	.15	.16	.21	.33	.47	.76	1.2	1.6	2.2	3.7	4.9	6.2	7.6	9.2	11	16	21	34	47	61
600	.14	.15	.16	.17	.22	.34	.49	.82	1.4	1.6	2.4	4.1	5.4	6.9	8.5	10.3	12	16	24	38	53	68
700	.15	.16	.17	.18	.23	.36	.52	.87	1.4	1.8	2.6	4.5	5.0	7.5	9.3	11.3	13	18	26	41	58	75
800	.15	.16	.17	.18	.24	.38	.54	.92	1.6	2.0	2.8	4.9	6.4	8.2	10.1	12.2	14	20	28	45	58	81
900	.16	.17	.18	.19	.25	.39	.56	.96	1.6	2.0	3.0	5.2	6.9	8.8	10.8	13.1	16	22	30	48	67	87
1000	.16	.18	.19	.20	.26	.40	.57	1.0	1.6	2.2	3.0	5.6	7.4	9.3	11.6	14.0	17	24	32	51	72	93

When the length of slope exceeds 400 feet and (or) percent of slope exceeds 24 percent, soil loss estimates are speculative as these values are beyond the range of research data.

Table A1-4

C Values and Slope-Length Limits for Various Mulches \1

Type	T/ac	Slope %	C Value	Max Length
1. No Mulch or Seeding	---	All	1.0	---
2. Straw or Hay tied	1.0	≤5	.20	200
		6-10	.20	100
	1.5	≤5	.12	300
		6-10	.12	150
	2.0	≤5	.06	400
		6-10	.06	200
		11-15	.07	150
		16-20	.11	100
		21-25	.14	75
		26-33	.17	50
		34-50	.20	35
3. Crushed Stone (1/4"- 1 1/2")	135	≤15	.05	200
		16-20	.05	150
		21-33	.05	100
		34-50	.05	75
	240	≤20	.02	300
		21-33	.02	200
		34-50	.02	150
4. Woodchips	7	≤15	.08	75
		16-20	.08	50
	12	≤15	.05	150
		16-20	.05	100
		21-33	.05	75
	25	≤15	.02	200
		16-20	.02	150
		21-33	.02	100
		34-50	.02	75

Table A1-4

C Values and Slope-Length Limits for Various Mulches \1

Type	T/ac	C Value: Through First 6 Weeks of Growing	C Value: After 6 Weeks of Growth
5. Temporary (grain or fast growing grass)	NONE	.70	.10
	Straw 1 T/ac	.20	.07
	Straw 1.5 T/ac	.12	.05
	Straw 2.0 T/ac	.06	.05
6. Permanent Seeding, 2nd Year		--	.01
7. Sod		.01	.01

\1 Based on research data and field experience; prepared at a workshop of personnel from USDA Agriculture Research Service, Soil Conservation Service and various Maryland State and local agencies

TABLE A1-5

PRACTICE FACTOR Pc FOR SURFACE CONDITION FOR CONSTRUCTION SITES

SURFACE CONDITION WITH NO COVER	Factor Pc*
Compact and smooth, scraped with bulldozer or scraper up and down hill	1.3
Same condition, except raked with bulldozer root rake up and down hill	1.2
Compact and smooth, scraped with bulldozer or scraper across the slope	1.2
Same condition, except raked with bulldozer root rake across the slope	0.9
Loose as a disced plow layer	1.0
Rough irregular surface equipment, tracks in all directions	0.9
Loose with rough surface greater than 12" depth	0.8
Loose with smooth surface greater than 12" depth	0.9

*Values based on estimates

TABLE A1-6

ADJUSTMENT FACTOR M FOR ESTIMATING MONTHLY AND PORTIONS OF ANNUAL SOIL LOSS FOR NEW JERSEY

Starting	ENDING MONTHS											
Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Jan	0	0.02	0.04	0.06	0.10	0.20	0.35	0.55	0.76	0.86	0.93	0.97
Feb	0.98	0	0.02	0.04	0.08	0.18	0.33	0.53	0.74	0.84	0.91	0.95
Mar	0.96	0.98	0	0.02	0.06	0.16	0.31	0.51	0.72	0.82	0.89	0.93
Apr	0.94	0.96	0.98	0	0.04	0.14	0.29	0.49	0.70	0.80	0.87	0.91
May	0.90	0.92	0.94	0.96	0	0.10	0.25	0.45	0.66	0.76	0.83	0.87
June	0.80	0.82	0.84	0.86	0.90	0	0.15	0.35	0.56	0.66	0.73	0.77
July	0.65	0.67	0.69	0.71	0.75	0.85	0	0.20	0.41	0.51	0.58	0.62
Aug	0.45	0.47	0.49	0.51	0.55	0.65	0.80	0	0.21	0.31	0.38	0.42
Sept	0.24	0.26	0.28	0.30	0.34	0.44	0.59	0.79	0	0.10	0.17	0.21
Oct	0.14	0.16	0.18	0.20	0.24	0.34	0.49	0.69	0.90	0	0.07	0.11
Nov	0.07	0.09	0.11	0.13	0.17	0.27	0.42	0.62	0.83	0.93	0	0.04
Dec	0.03	0.05	0.07	0.09	0.13	0.23	0.38	0.58	0.79	0.89	0.96	0

All dates in the table are as of the 1st of each month, read from left to right.
M=1.0 for one full year.

Example: Given KR=70. (LS) = 1.2 What is soil loss for month of July?

E_t=70 x 1.2=84.0 tons per acre per year.

E_t for July=84x0.2=17 tons per acre for July on the average

What is the soil loss if construction begins on the first of May and sod is established on disturbed areas by September 1st?

E_t May to Septmeber=84 x 0.66=55 tons per acre.

TABLE A1-7

APPROXIMATE WEIGHTS OF SOILS IN LBS. PER CUBIC FT. AND CONVERSION FACTORS

Soils	Volume Wt. lb./cu. ft.	Conversion Factors Ac. Inches	Ac. Ft.	Tons to Cu. Yds.
Sands and loamy sands	110	0.005	0.00042	0.67
Sandy loam	105	0.0052	0.00044	0.71
Fine sandy loam	100	0.0055	0.00046	0.74
Loam	90	0.0061	0.00051	0.82
Silt loam	85	0.0065	0.00054	0.87
Silty clay loam	80	0.0069	0.00057	0.93
Clay loam	75	0.0073	0.00061	0.99
Silty, sandy clay and clay	70	0.0079	0.00066	1.06
Aerated Sediment	80*	0.0069	0.00057	0.93
Saturated Sediment	60*	0.0092	0.00077	1.24

*These are the approximate aerated and saturated weights to be used at damage sites. (Streams or reservoirs)

NEW JERSEY 24 HOUR RAINFALL FREQUENCY DATA

Rainfall amounts in inches

County	1 year	2 year	5 year	10 year	25 year	50 year	100 year
Atlantic	2.8	3.3	4.3	5.2	6.5	7.6	8.9
Bergen	2.8	3.3	4.3	5.1	6.3	7.3	8.4
Burlington	2.8	3.4	4.3	5.2	6.4	7.6	8.8
Camden	2.8	3.3	4.3	5.1	6.3	7.3	8.5
Cape May	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Cumberland	2.8	3.3	4.2	5.1	6.4	7.5	8.8
Essex	2.8	3.4	4.4	5.2	6.4	7.5	8.7
Gloucester	2.8	3.3	4.2	5.0	6.2	7.3	8.5
Hudson	2.7	3.3	4.2	5.0	6.2	7.2	8.3
Hunterdon	2.9	3.4	4.3	5.0	6.1	7.0	8.0
Mercer	2.8	3.3	4.2	5.0	6.2	7.2	8.3
Middlesex	2.8	3.3	4.3	5.1	6.4	7.4	8.6
Monmouth	2.9	3.4	4.4	5.2	6.5	7.7	8.9
Morris	3.0	3.5	4.5	5.2	6.3	7.3	8.3
Ocean	3.0	3.4	4.5	5.4	6.7	7.9	9.2
Passaic	3.0	3.5	4.4	5.3	6.5	7.5	8.7
Salem	2.8	3.3	4.2	5.0	6.2	7.3	8.5
Somerset	2.8	3.3	4.3	5.0	6.2	7.2	8.2
Sussex	2.7	3.2	4.0	4.7	5.7	6.6	7.6
Union	2.8	3.4	4.4	5.2	6.4	7.5	8.7
Warren	2.8	3.3	4.2	4.9	5.9	6.8	7.8

TABLE A1-8

FACTORS FOR MODIFYING THE SOIL LOSS EQUATION TO OBTAIN ESTIMATES BASED ON PROBABILITY AND SINGLE STORM SOIL LOSS

Probability		Single Storm	
One Year In	Factor	Exceeded Once In (Years)	Factor
2	0.9	1	0.2
5	1.25	2	0.3
20	1.70	5	0.4
		10	0.5
		20	0.7

Example: The average annual soil loss from a critical sediment source area was computed to be 100 tons per acre per year.

One year in 5 this loss could be: 100 x 1.25 = 125 tons per acre, or one year in 20 the loss could be: 100 x 1.7 = 170 tons per acre.

A single storm that may take place once in 10 years could cause a soil loss of 100 x 0.5 = 50 tons per acre. If the single storm is one that occurs once in 2 years, the loss might be: 100 x 0.3 = 30 tons per acre.

Notes:

i. Mapping units may be inserted on the basis of the local county soil survey.

ii. Alluvial soil, unassigned.

iii. Data for sandy substratum.

APPENDIX A-4

MAINTENANCE OF EROSION CONTROL MEASURES

Maintenance is the work required to keep practices in place or to restore them to their original physical and functional condition.

Maintenance as it applies to this section is divided into two periods; that which is necessary to allow for continuing performance of erosion controls during the construction period and long term maintenance, following completion of construction, for the life of structural measures.

Maintenance During Construction Phase

All structural measures for control of soil erosion and sedimentation must have timely maintenance if the measures are to endure and efficiently perform their design function. Particular attention should be given to temporary structures.

Sediment barriers such as silt fence and hay bales can accumulate large quantities of sediment, particularly after a heavy storm. The same is true for storm sewer inlet protection, which should be frequently inspected for blockage.

Construction entrances composed of loose aggregate may become impacted with sediments scoured from the tires of construction vehicles. When soil begins to track onto paved surfaces, the aggregate must be replaced or new aggregate added on top of the old.

Maintenance Following Completion of Construction

At the completion of construction and final stabilization responsibility for lifetime maintenance of structural measures is usually transferred to a subsequent owner such as the homeowner, municipality, homeowner association, etc. A comprehensive maintenance program should be prescribed for use by those who will accept such responsibility .All structures should be inspected at least semi-annually and following intensive rainfalls.

Maintenance items should include but not be limited to those shown for each of the following examples:

Channel Linings (include slope protection structures)

Check for: Cracking; spalling; deterioration from freezing, salt or chemicals; channel obstructions; scour at inlet and outlet.

Corrective Action: Cracks should be sealed, protective coatings applied when needed, and modification or riprap repairs made where and when necessary.

Earth Channels (including diversions and waterways)

Check for: Points of scour or bank failure and deposition; rubbish or channel obstruction; rodent holes; excessive wear from play, traffic or settling.

Corrective Action: Remove sediment deposition and undesirable plant growth such as woody vegetation, weeds, etc. Repair damages from scour, rodents and loss of freeboard.

Dams and Spillways

Check for: Cracks, damage from wave action, rodents, undesirable vegetation growth, and obstructions to principal and emergency spillways. Check gates, trash racks, metal work, anchors, conduits and appurtenances for damage from corrosion, ice and debris. Check for unauthorized modifications, tampering or vandalism.

Corrective Action: Fill and reseed eroded areas or riprap; removal of obstructions should be performed on a timely basis. Valves and gates should be cleaned, lubricated and operated through their full range.

Maintenance and inspection of dam and outlet structures may be subject to the requirements of the New Jersey State Dam Safety Standards, NJAC 7:20.

Water Quality Practices: Various structures and practices are designed to treat storm water runoff by filtering in some manner. Practices such as sand filters and vegetative filter strips can become clogged with debris and sediment and will loose their ability to treat runoff. Periodic inspection and cleaning is needed to maintain filtration capacity. Other types of treatment practices rely on settlement of suspended solids, such as on-line storm sewer devices and wet or extended detention ponds. Over time, debris and sediment may accumulate in these devices and reduce the available volume needed to treat runoff. Periodic inspection and removal of debris is needed to maintain functioning.

Vegetative Maintenance: Vegetation is used as both a temporary and permanent erosion control practice. During establishment it is highly susceptible to damage both from natural and man-made causes. See the Standard for Maintaining Vegetation, Chapter 3-8 (in SE &SC Manual) for complete requirements.

APPENDIX A-5

STATE OF NEW JERSEY

SOIL EROSION AND SEDIMENT CONTROL ACT
CHAPTER 251, P. L. 1975[1]

4:24-39 SHORT TITLE

This act may be cited and referred to as the "Soil Erosion and Sediment Control Act."

L. 1975 C. 251, § 1 eff. Jan. 1, 1976

4:24-40 LEGISLATIVE FINDINGS

The Legislature finds that sediment is a source of pollution and that soil erosion continues to be a serious problem throughout the State, and that rapid shifts in land use, from agricultural and rural to nonagricultural and urbanizing uses, construction of housing, industrial and commercial developments, and other land disturbing activities have accelerated the process of soil erosion and sediment deposition resulting in pollution of the waters of the State and damage to domestic, agricultural, industrial, recreational, fish and wildlife, and other resource uses. It is, therefore, declared to be the policy of the State to strengthen and extend the present erosion and sediment control activities and programs of this State for both rural and urban lands, and to establish and implement, through the State Soil Conservation Committee and the Soil Conservation Districts, in cooperation with the counties, the municipalities and the Department of Environmental Protection, a Statewide comprehensive and coordinated erosion and sediment control program to reduce the danger from storm water runoff, to retard nonpoint pollution from sediment and to conserve and protect the land, water, air and other environmental resources of the State.

L. 1975, C. 251, § 2, eff. Ian. 1, 1976

4:24-41 DEFINITIONS

For the purposes of this act, unless the context clearly indicates a different meaning

a. "Application for Development means a proposed subdivision of land, site plan, conditional use, zoning variance, planned development or construction permit.

b. "Certification" means (1) a written endorsement of a plan for soil erosion and sediment control by the local Soil Conservation District which indicates that the plan meets the standards promulgated by the State Soil Conservation Committee pursuant to this act2, (2) that the time allotted in section 7 of this act has expired without action by the district or (3) a written endorsement of a plan filed by the State Department of Transportation with the district.

c. "District" means a Soil Conservation District organized pursuant to chapter 24 of Title 4 of the Revised Statutes.[3]

[1]As amended by C. 264, P.L. 77 and C. 459, P.L. 79

[2]Section 4:24-45

[3]Section 4:24-1 et. seq

d. "Disturbance" means any activity involving the clearing, excavating, storing, grading, filling or transporting of soil or any other activity, which causes soil to be exposed to the danger of erosion. "Erosion" means the detachment and movement of soil or rock fragments by water, wind, ice and gravity.

e. "Plan" means a scheme which indicates land treatment measures, including a schedule of the timing for their installation, to minimize soil erosion and sedimentation.

f. "Project" means any disturbance of more than 5,000 square feet of the surface area of land (I) for the accommodation of construction for which the State Uniform Construction Code would require a construction permit, except that the construction of a single-family dwelling unit shall not be deemed a "project" under this act unless such unit is part of a proposed subdivision, site plan, conditional use, zoning variance, planned development or construction permit application involving two or more such single - family dwelling units, (2) for the demolition of one or more structures, (3) for the construction of a parking lot, (4) for the construction of a public facility, (5) for the operation of any mining or quarrying activity, or (6) for the clearing or grading of any land for other than agricultural or horticultural purposes.

g. "Sediment" means solid material, mineral or organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water or gravity as a product of erosion.

i. "Soil" means all unconsolidated mineral and organic materials of any origin.

j. "Standards" means the standards promulgated by the committee pursuant to this act.

k. "Committee" means the State Soil Conservation Committee in the Department of Agriculture established pursuant to R.S. 4:24-3.

1. "Public facility" 'means any building; pipeline; highway; electricity, telephone or other transmission line; or any other structure to be constructed by a public utility, municipality, county or the State or any agency or instrumentality thereof.

L. 1975, C.251, §3eff. Jan.1, 1976, Amended by L.1977, C.264 § 2 eff. Oct. 18, 1977. Amended by L.1979, C. 459, § 1 eff. Feb.27, 1980.

4:24-42 STANDARDS FOR CONTROL OF SOIL EROSION AND-SEDIMENTATION, PROMULGATION, AMENDMENT AND REPEAL

The committee shall have the power, subject to the approval of the Secretary of Agriculture and the Commissioner of Environmental Protection to formulate, promulgate, amend and repeal standards for the control of soil erosion and sedimentation, pursuant to the Administrative Procedure Act, P.L. 1968, C. 410 (C. 52:14B-1 et seq.)

a. Such standards shall be based upon relevant physical and developmental information concerning the watersheds and topography of the State, including, but not limited to, data relating to land use, soil, slope, hydrology, geology, size of land area being disturbed, proximate water bodies and their characteristics.

b. Such standards shall include criteria, techniques and methods for the control of erosion and sedimentation resulting from land-disturbing activities for various categories of soils, slopes and land uses.

c. Such standards shall include standards of administrative procedure for the implementation of this act.

L 1975, C. 251, §4 eff. Nov. 12, 1975. Amended by L. 1979, C. 459, §2 eff. Feb. 27, 1980.

4:24-43 CERTIFICATION OF PLAN BY DISTRICT: DEVELOPMENT OF PROJECT

Approval of an application for development for any project by the State, any county, municipality, or any instrumentality thereof shall be conditioned upon certification by the local district of a plan for soil erosion and sediment control. Any person proposing to engage in any project not requiring approval by the State, any county, municipality, or any instrumentality thereof shall, prior to commencing such project, receive certification by the local district of a plan for soil erosion and sediment control. Any public utility, municipality, county or the State or any agency or instrumentality thereof, other than the State Department of Transportation, which proposes a project shall, prior to the construction of such project submit to and receive certification by the district of a plan for soil erosion and sediment control. The State Department of Transportation shall certify a plan for any project that it proposes to construct and shall file such certification with the district. Certification by the Department of Transportation-shall is pursuant to soil erosion control standards developed jointly by the Department of Transportation the Department of Environrnental Protection and the committee and promulgated by the Department of Transportation.

L. 1975, C. 251, § 5 eff. Jan. 1, 1976. Amended by L. 1979, C. 459 § 3 eff. Feb. 27, 1980.

4:24-44 CERTIFICATION OF PLAN: CRITERIA: NOTICE.

The district shall certify such plan if it meets the standards promulgated by the committee pursuant to this act. The district shall provide written notice to the applicant indicating that:

a. The plan was certified;

b. The plan was certified subject to the attached conditions; or

c. The plan was denied certification with the reasons for denial stated.

L. 1975, C. 251, § 6 eff. Jan. 1, 1976

4:24-45 LIMITATION ON TIME FOR GRANT OR DENIAL OF CERTIFICATION

The district shall grant or deny certification within a period of 30 days of submission of a complete application unless, by mutual agreement in writing between the district and the applicant, the period of 30 days shall be extended for an additional period of 30 days. Failure of the district to grant or deny certification within such period or such extension thereof shall constitute certification. For purposes of this section, a major revision of the plan by the applicant shall constitute a new submission. L. 1975, C. 251, § 7 eff. Jan. 1, 1976

4:24-46 FEES

The district shall adopt a fee schedule and collect fees from applicants for the certification of plans and for on-site inspections of the execution of certified plans. Such fees shall bear a reasonable relationship to the cost of rendering such services.

L. 1975, C. 251, § 8 eff. Jan. 1, 1976

4:24-47 STOP-CONSTRUCTION ORDER: FAILURE TO COMPLY WITH CERTIFIED PLAN

The district or the municipality may issue a stop-construction order if a project is not being executed in accordance with a certified plan.

L. 1975, C. 251, § 9 eff. Ian. 1, 1976

4:24-48 EXEMPT MUNICIPALITIES

Any municipality, which adopts an ordinance that conforms to the standards promulgated pursuant to this act within 12 months of their promulgation and obtains the approval of the committee thereto, shall be exempt from sections 5 through 9 of this act[4] until such time as the local district determines that the municipality is not enforcing said ordinance.

[4] Sections 4:24-43 to 4:24-4

L. 1975, C. 251i § 10 eff. Jan. 1, 1976

4:24-49 CERTIFICATE OF OCCUPANCY FOR PROJECT: CONDITIONS FOR ISSUANCE

No certificate of occupancy for a project shall be issued by a municipality or any other public agency unless there has been compliance with provisions of a certified plan for permanent measures to control soil erosion and sedimentation.

L. 1975, C-251, § 11, eff. Jan.1, 1976. Amended by L.1979, C.459, § 10 eff. Feb.27, 1980

4:24-50 COUNTY PLANNING BOARD AS AGENT FOR DISTRICT

In those counties where the district does not maintain its central office, the Board of Freeholders may, by resolution, direct the county planning board to act as an agent of the district within that county and to administer the powers granted to the district pursuant to this act, until such time as a district is established within that county. The committee shall establish guidelines to implement this section.

L. 1975, C. 251, 12 eff. Jan. I, 1976

4:24-51 COOPERATION WITH AND AUTHORIZATION TO RECEIVE FINANCIAL AID FROM GOVERNMENTAL UNITS OR PRIVATE SOURCES

The districts and the committee are authorized to cooperate and enter into agreements with any Federal, State or local agency to carry out the purposes of this act. The districts and the committee are authorized to receive financial assistance from any Federal, State, county or other public or private source for use in carrying out the purposes of this act.

L. 1975, C. 251, § 13 eff. Jan. 1, 1976

4:24-52 STATE AID

The committee is authorized to make grants of State aid to districts and to municipalities to carry out the purposes of this act.

L. 1975, C. 251, § 14 eff. Jan. 1, 1976

4:24-53 VIOLATIONS: INJUNCTION: PENALTY: ENFORCEMENT if any person violates any of the provisions of this act, any standard promulgated pursuant to the provisions of this act, or fails to comply with the provisions of a certified plan, the municipality or the district may institute a civil action in the Superior Court for injunctive relief to prohibit and prevent such violation or, violations and said court may proceed in a summary manner. Any person who violates any of the provisions of this act, any standard promulgated pursuant to this act or fails to comply with the provisions of a certified plan shall be liable to penalty of not less than $25.00 nor more than $3,000.00 to be collected in a summary proceeding pursuant to the Penalty Enforcement Law (N.J.S. 2A:58-1 et seq.). The Superior Court, County Court, county district court and municipal court shall have jurisdiction to enforce said Penalty Enforcement Law. If the violation is of a continuing nature, each day during which it continues shall constitute an additional separate and distinct offense.

L. 1975, C. 251, § 15, eff. Jan. 1, 1976

4:24-54 LIBERAL CONSTRUCTION

This act shall be liberally construed to effectuate the purpose and intent thereof.

L. 1975, C. 251, § 15, eff. Jan. 1, 1976

4:24-55 SEVERABILITY

If any provision of this act or the application thereof to any person or circumstances is held invalid, the remainder of the act and the application of such provision to persons or circumstances other than those to which it is held invalid shall not be affected thereby.

L. 1975, C. 251, § 17, eff. Jan. 1, 1976

Related statutes codified elsewhere in N.J.S.A. 4:24

4:24-6.1 REVIEW AND APPROVAL, MODIFICATION OR REJECTION OF DECISIONS

The committee may, on its own motion or at the request of any person aggrieved by any decision by a local district, review and approve, modify or reject any such decision, as it deems appropriate.

L. 1979, C. 459 § 9, eff. Feb.27, 1980.

APPROPRIATION OF FUNDS BY COUNTIES

Any board of chosen freeholders may appropriate such funds as it deems necessary to the soil conservation district serving that county for the purpose of providing district services to the people of that county.

L. 1979, C. 459 § 4, eff. Feb. 27,1980.

4:24-17.7 LEGAL SERVICES TO DISTRICT BY ATTORNEY GENERAL

The Attorney General, on his own initiative, or the respective county counsel, with the approval of the board of chosen freeholders, may provide any and all legal services to any district.
L. 1979, C. 459 § 5, eff. Feb.27, 1980.

APPENDIX A-6

DIVERSION AND GRASSED WATERWAY

Example Design Problems and Charts

Diversion Example Problem:

A permanent diversion is to be constructed upslope of a house to divert runoff away from the house, and to protect it from surface water flooding. The diversion will outlet into a grassed waterway. The area upslope of the diversion is in woods, which will be preserved. The diversion will be constructed on Rockaway gravelly sandy loam and will be seeded to a lawn grass mixture. It will be a part of the backyard of the house and is expected to be mowed. It will have a grade of 1 percent.

Solution:

The required capacity is the runoff from a 50-year storm. The required freeboard is 0.5 feet from Section 4.5, the Standard for Diversions. Using the procedure in "Urban Hydrology for Small Watersheds, TR55," it was determined that the 50-year peak runoff rate from the watershed draining into the diversion is 20 cfs.

The grass will provide protection of the soil bed, thereby checking the erosion on the diversion. In comparison to a non-vegetated diversion, a grassed diversion will retard the flow of water. Manning's coefficient of roughness for a grassed diversion is related to the retardance. Retardance varies with the product of the mean velocity of flow and the hydraulic radius. The classification for the degree of retardance is based on the type of vegetation and condition of growth.

The maximum permissible velocity from Section 4.5 for a clay loam soil with vegetation in the channel is 3.0 feet per second (for purposes of this example, a flexible channel liner will not be used). In a back yard, vegetation in the diversion channel can be expected to be maintained.

The appropriate vegetative retardance factors are E & D. The height of the grass will range between 6 inches and less than 2 inches. Select side slopes of 5 to 1 for the channel and ridge so that the diversion can be mowed with a lawn mower. Failure to maintain the grass by periodic maintenance results in weeds and destruction of the grass cover leaving the channel bare in the winter.

During the period of establishing the grass, the diversion will gradually be stabilized under a condition of very low retardance. The diversion will not reach its maximum capacity until the grass cover is fully developed and well established. Therefore, the hydraulic design of a grassed diversion consists of two stages.

The first stage is to design the cross-section of the diversion for stability under very low retardance (E). Stability of the diversion is based on allowable velocity for the soil type as shown on Section 4.5

The second stage is to design the diversion for capacity under a higher retardance (D). The design of the cross-section of the diversion is now based on the capacity of the diversion to take the design flow (Q).

We now have:

> Grade of diversion = 1 %
> Design Capacity (Q) = 20 cfs
> Maximum allowable velocity = 3.0 fps
> Vegetative retardance factors = E and D
> Channel side slopes = 5 to 1

First, design for stability using retardance factor E. Enter Figure A6-4 with 3.0 fps and slope = 1.0%, find the maximum allowable R = 0.53.
The cross sectional flow area required is *Q/N* = 20/3 = 6.7 sq. ft.
Enter Figure A6-6 with A = 6.7 and R = 0.53, find bottom width equal to 5.0 feet and depth equal 0.8 feet.

Second, design for capacity using retardance factor D. A trial and error procedure is necessary for a trapezoidal channel with 5: 1 side slopes and 20-foot bottom width on a 1% grade with D retardance.

Trial #1

Try d = 1.0 feet, enter Figure A6-6
Find R = 0.62
A = 9 enter Figure A6-3
Find V = 2
Q = V A = (2) (9) = 18 cfs
Required 20 cfs capacity is larger.

Trial #2

Try d = 1.2 feet, repeat steps in Ist trial
Find R = 0.76
A = 13
V = 2.8
Q = 36.4 cfs is larger than required.

Trial #3

Try d=0.96 feet,
Find R = 0.64
A = 9.4

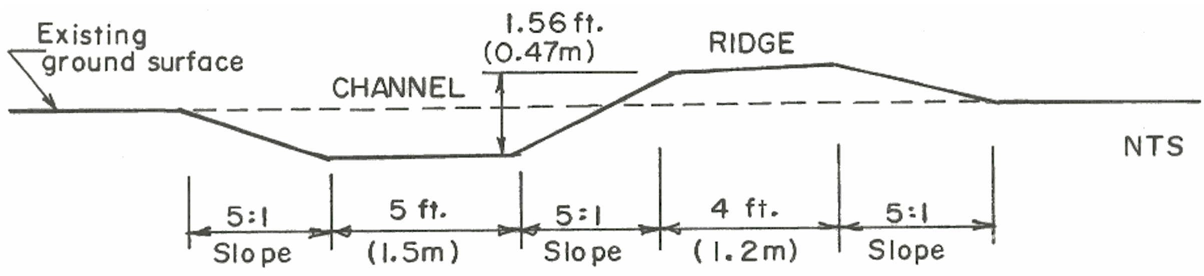
V = 2.13
Q = 20 cfs

Design Flow Dimensions

a. Grade = 1%
b. Side slopes = 5:1
c. Bottom width = 5 feet
d. Depth = 1.1 feet (required flow depth)

Constructed Diversion Dimensions

a. Grade = 1%
b. Side slopes of channel is 5 Horizontal: 1 Vertical both sides, back slope of ridge is 5 Horizontal: 1 Vertical and, for maintenance reasons, ridge top width is 4 feet from the standard.
c. Bottom width of the channel is 5.0 feet.
d. Depth from bottom of the channel to top of ridge is: 0.96 feet for flow depth plus 0.50 feet for freeboard plus 0.1 feet for settlement equals a constructed depth of 1.56 feet.



Waterway Example Problem:

A waterway is to be constructed to convey water through an apartment complex. It will be located in an area where the grass will be mowed at least once a year and needed fertilization and repairs will be made on an annual basis. From the soil survey report, the waterway will be constructed on Reaville silt loam. The waterway will have a grade of 0.5%. The peak flow from a 10-year frequency storm is 40 cubic fs.

Waterway Example Problem Solution:

The maximum permissible velocity from Section 4.21 for a silt loam with a good stand of vegetation is 2.0 feet per second. The appropriate retardance factors are E and D, since during the year the height of the grass will vary between 2 inches immediately after cutting and 10 inches when it has not been cut. A good stand of vegetation will be maintained by annual fertilization and maintenance. Select a parabolic shape for the waterway to keep low flows from meandering and to provide a shape, which is easy to mow, and transverse with equipment.

We now have:

Grade of the Waterway = 0.5%
Design Capacity = 40 cfs
Maximum allowable velocity = 2.0 fps
Vegetative Retardance factors = E and D
Channel Shape = parabolic

First, design for stability using the retardance factor E. Enter Figure A6-4 with V = 2.0 fps and slope = 0.5%, find maximum allowable R= 0.57 the cross sectional flow area required is Q / V =40/2 =20 sq ft. Enter Figure A6-14 with A = 20.0 and R = 0.57, find top width (t) = 35.7 feet and depth (d) = 0.84 feet

Second, design for capacity using retardance factor D. A trial and error procedure is necessary for a parabolic channel with the channel shape determined by d = 0.84 feet and t = 35.7 feet. Enter Figure A6-I5 and find a point on the pivot line. This point remains fixed for this channel.

After several iterations:

Try d = 1.06 feet for retardance factor D. From Figure A6-15 using the fixed point on the pivot line for this channel and d = 1.06 feet, find t = 40 feet. From Figure A6-14 find R = .70 and A = 28.2. Enter Figure A6-3 with R = 0.70 and S = 0.5% and find V = 1.42 fps. Then Q = VA = (1.42)(28.2) = 40 cfs.

This meets the required, Q of 40 cfs, therefore use these dimensions. The design channel dimensions are: Grade = 0.5% and Parabolic shape with a depth (d) = 1.06 feet and top width (t) = 40 feet.

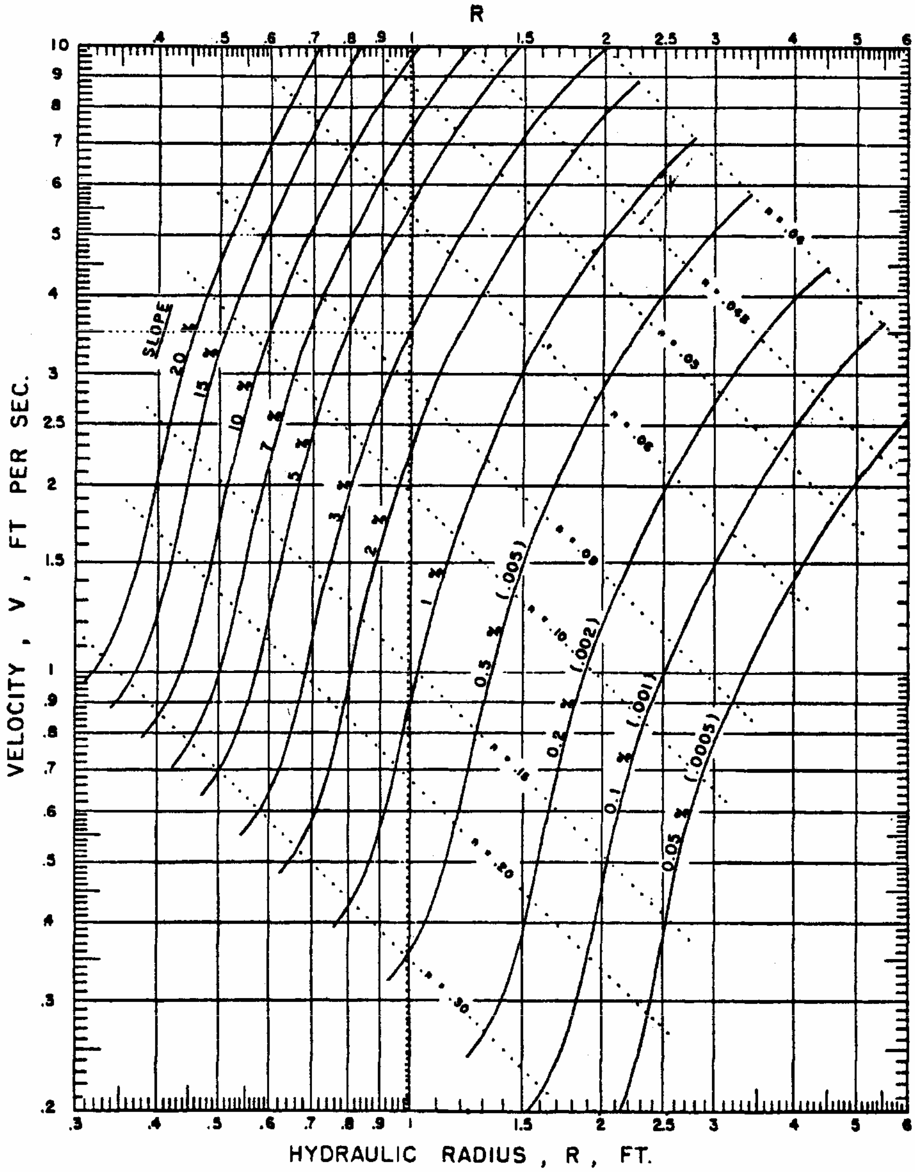


FIGURE A6-1

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE B (HIGH VEGETAL RETARDANCE)

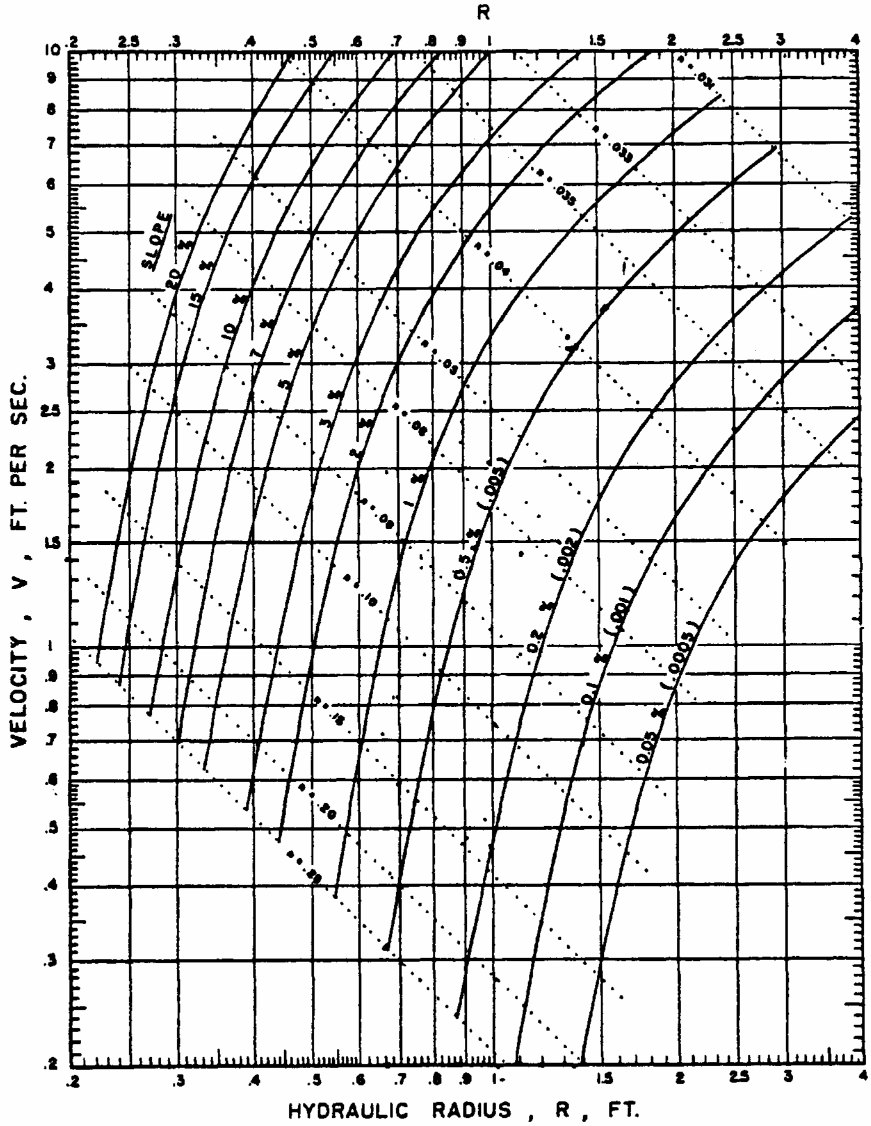


FIGURE A6-2

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE C (MODERATE VEGETAL RETARDANCE)

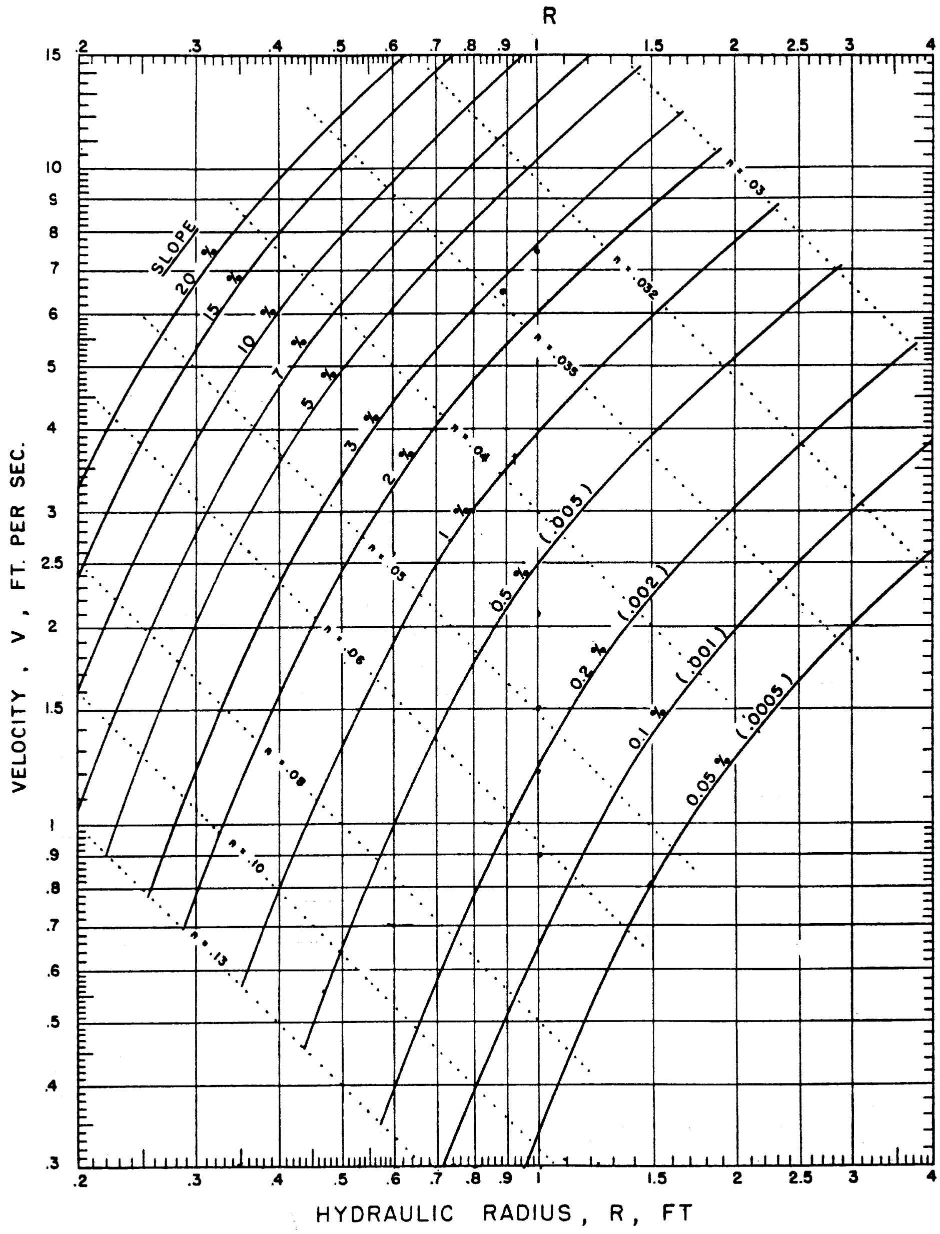


FIGURE A6-3

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE D (LOW VEGETAL RETARDANCE)

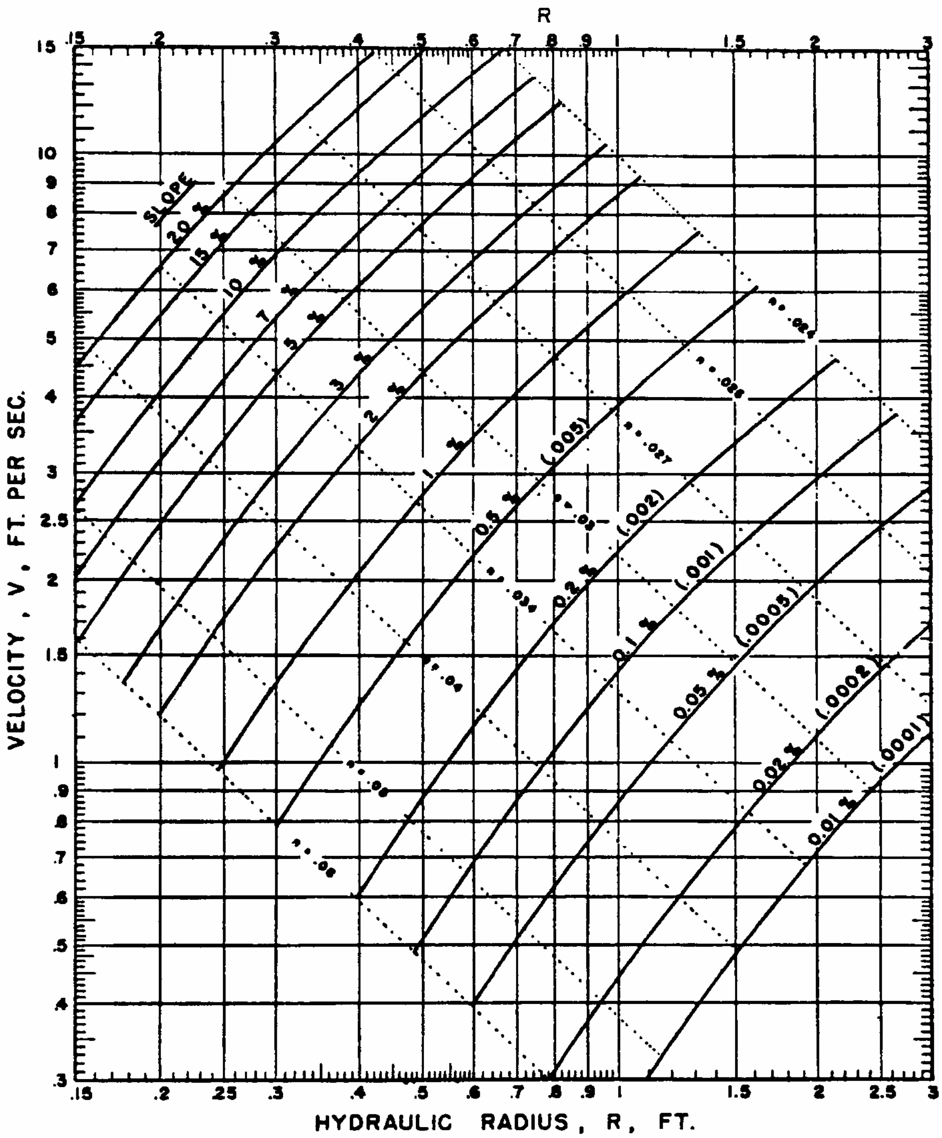


FIGURE A6-4

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE E (VERY LOW VEGETAL RETARDANCE

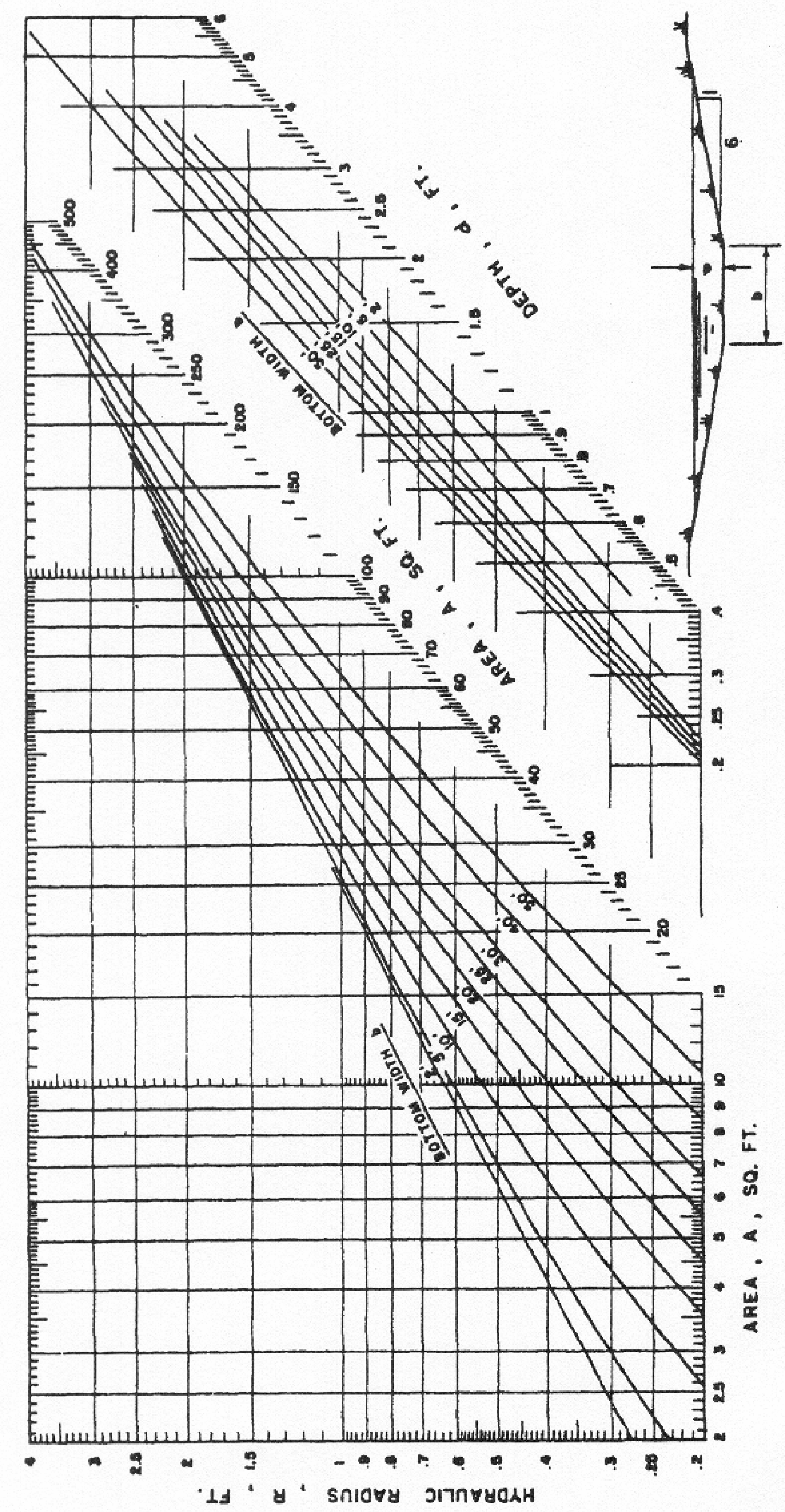


FIGURE A6-5

DIMENSIONS OF TRAPEZIODAL CHANNELS WITH 6 TO 1 SIDE SLOPES

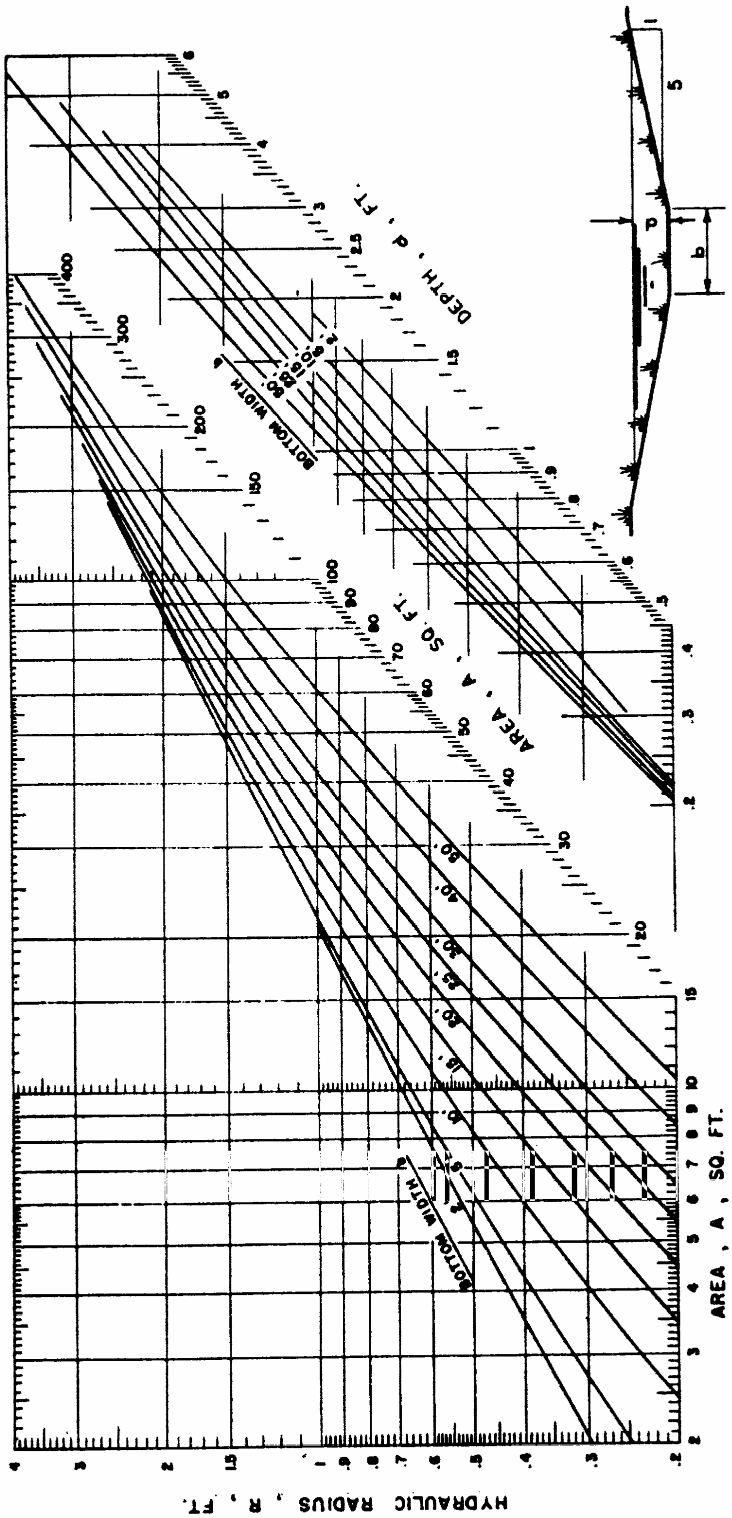


FIGURE A6-6

DIMENSIONS OF TRAPEZIODAL CHANNELS WITH 5 TO 1 SIDE SLOPES

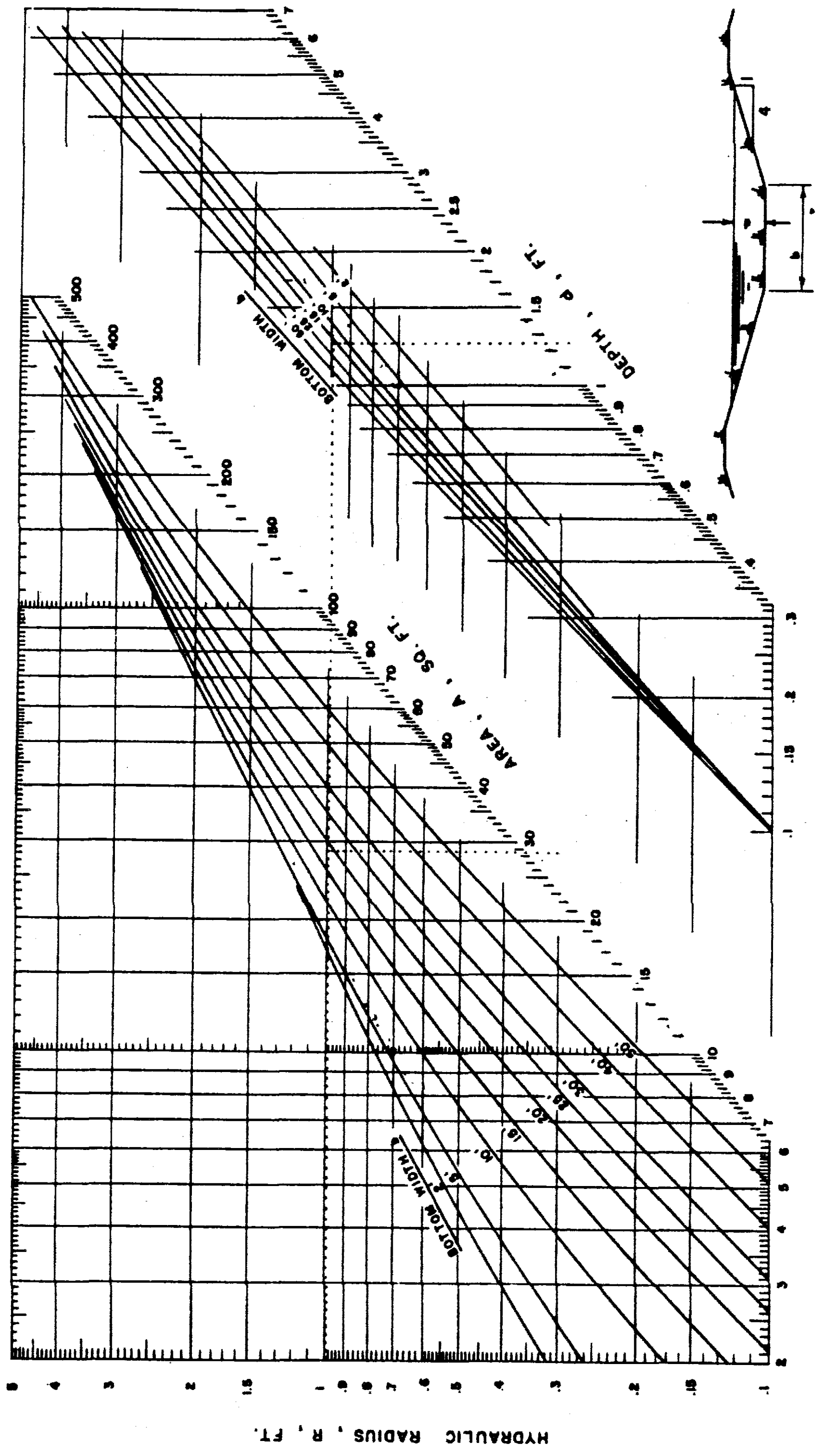


FIGURE A6-7

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 4 TO 1 SIDE SLOPES

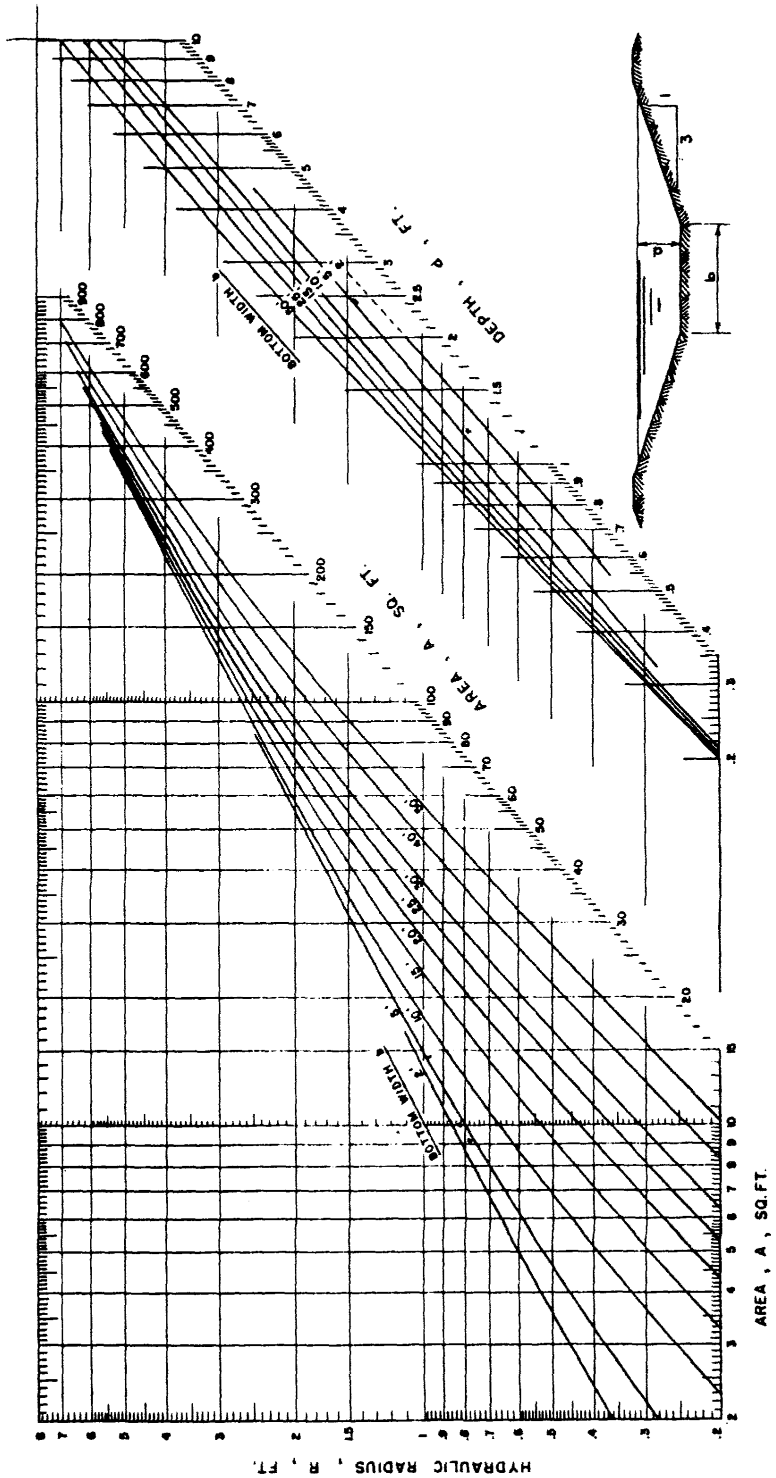


FIGURE A6-8

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 3 TO 1 SIDE SLOPES

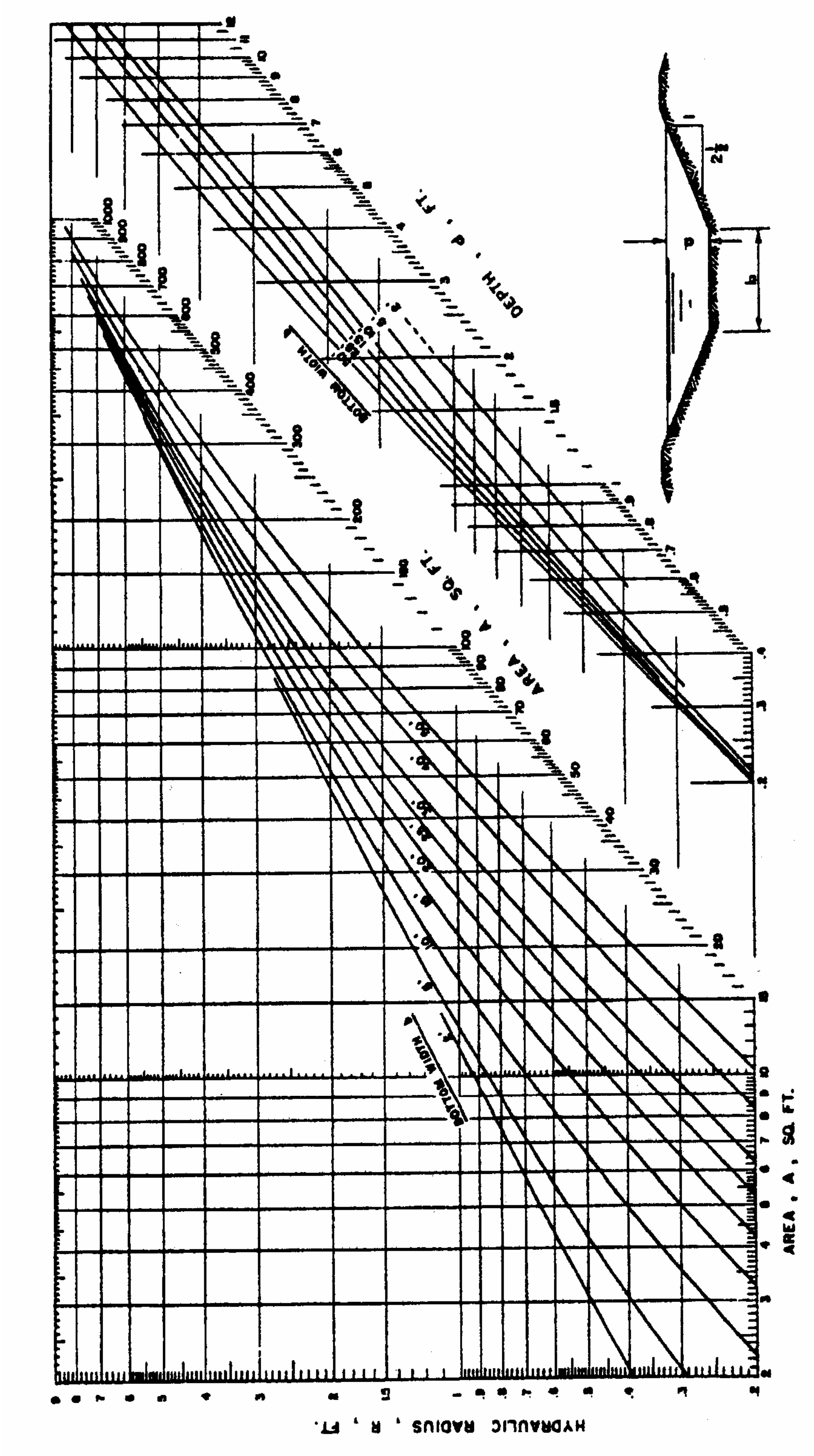


FIGURE A6-9

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 2-1/2 TO 1 SIDE SLOPES

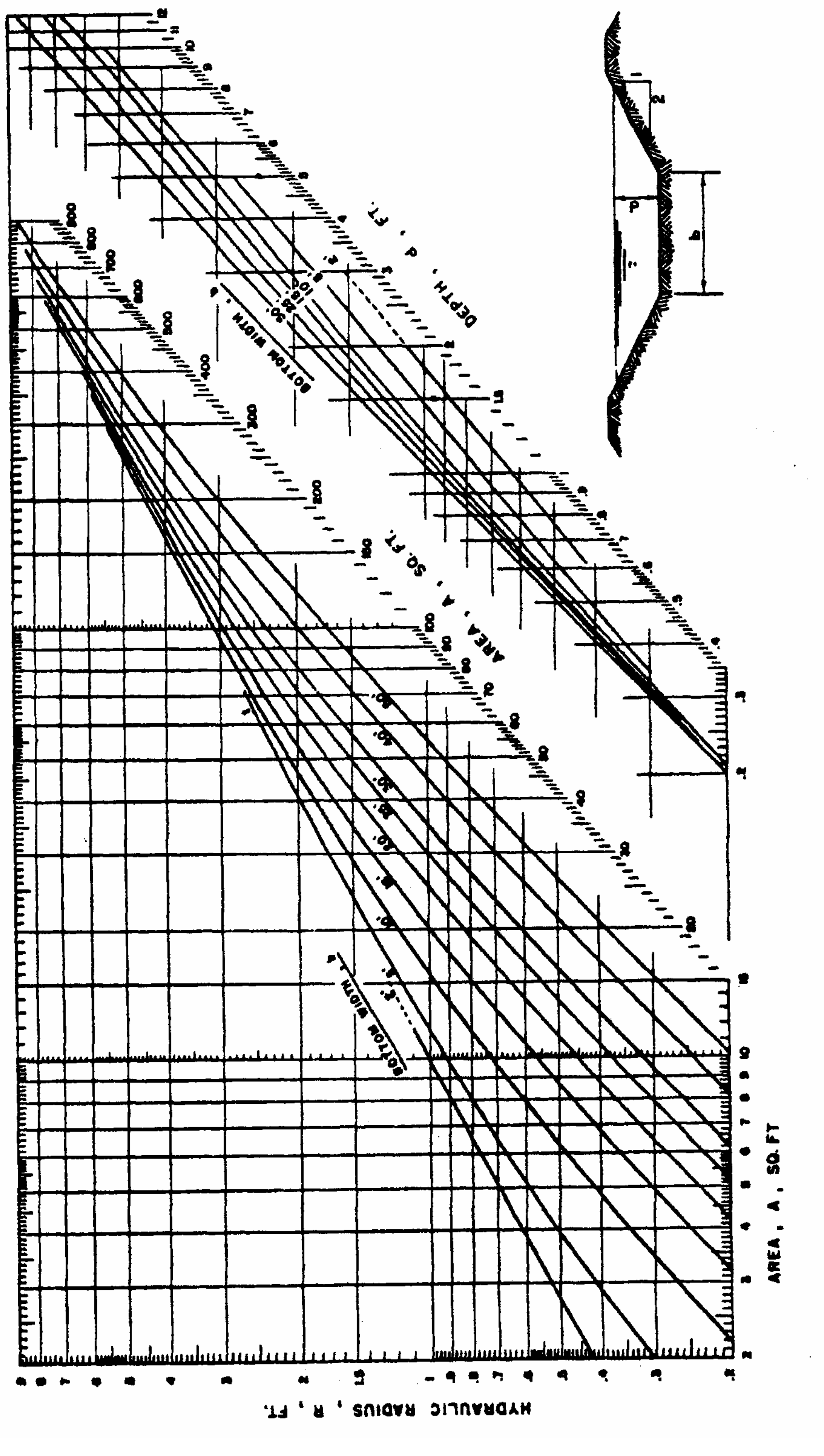


FIGURE A6-10

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 2 TO 1 SIDE SLOPES

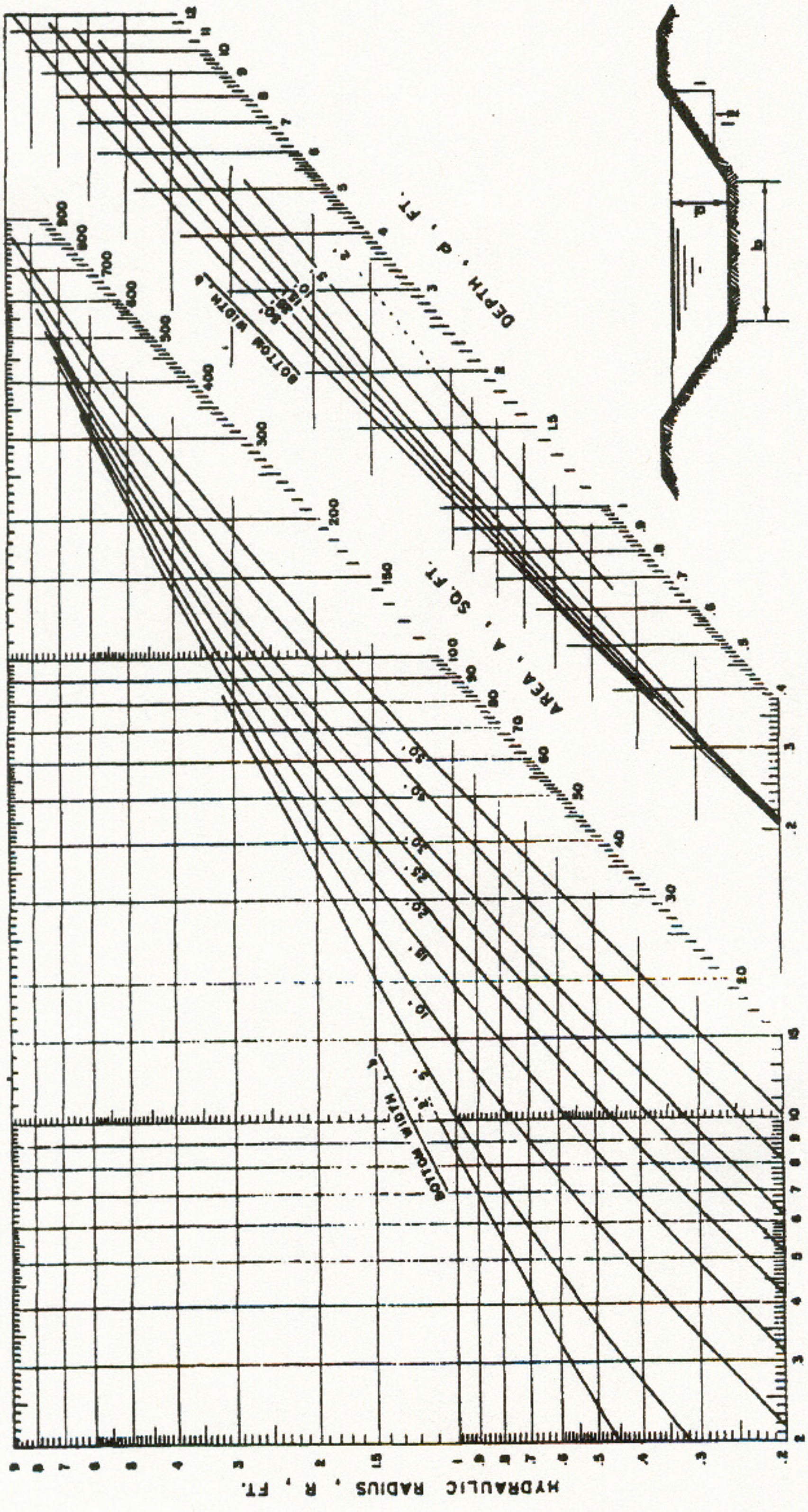


FIGURE A6-11

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 1-1/2 TO 1 SIDE SLOPES

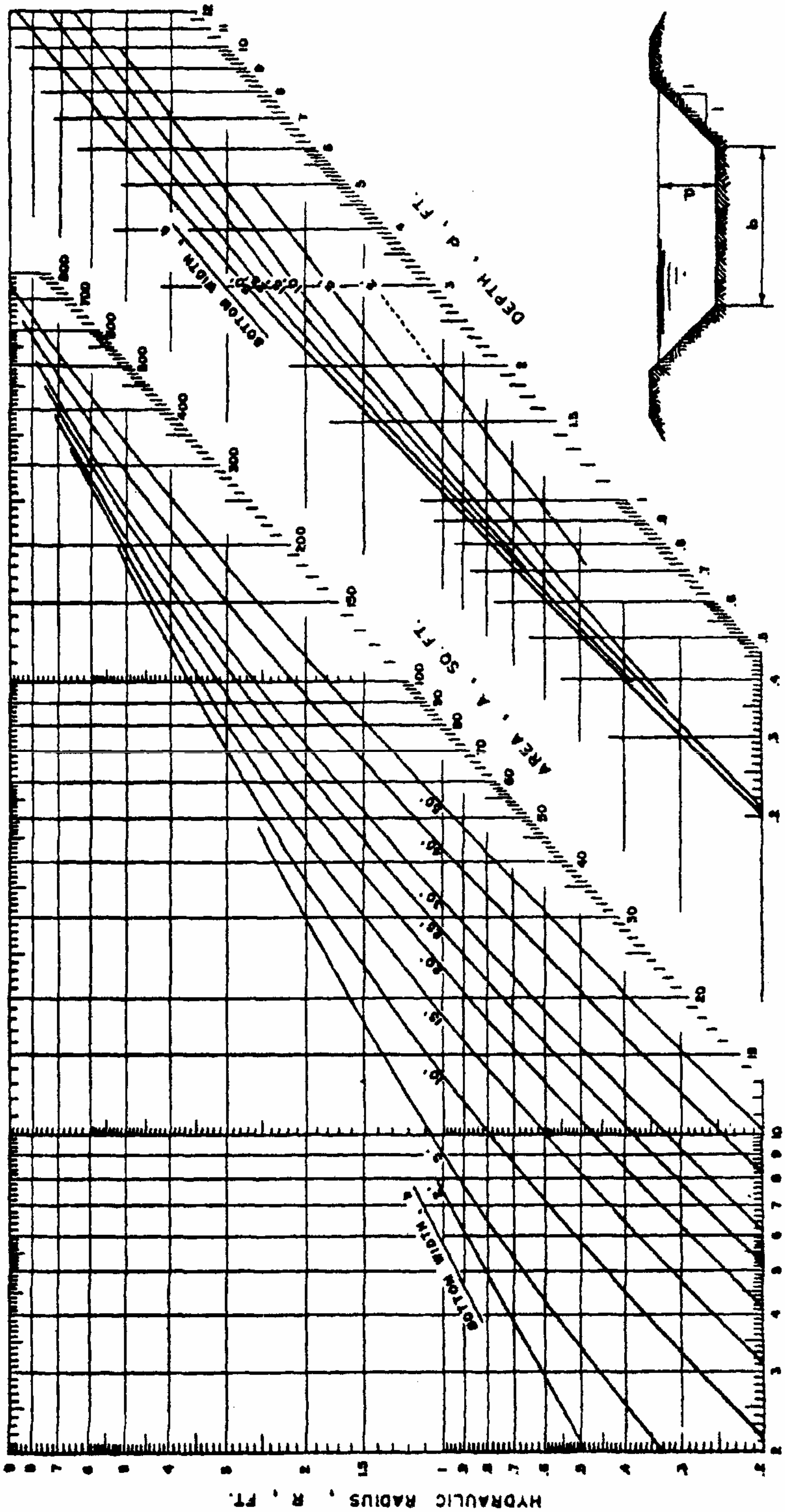


FIGURE A6-12

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 1 TO 1 SIDE SLOPES

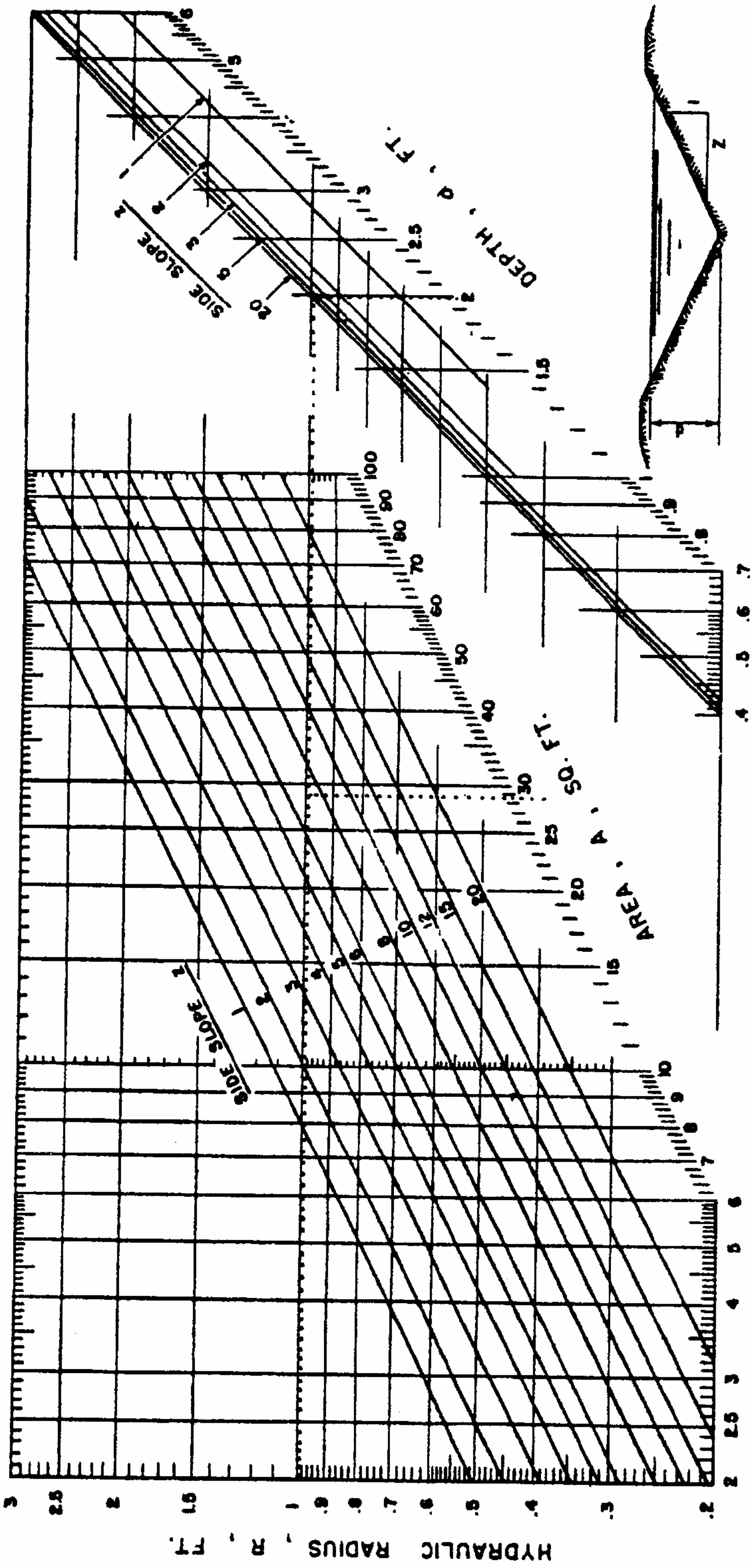
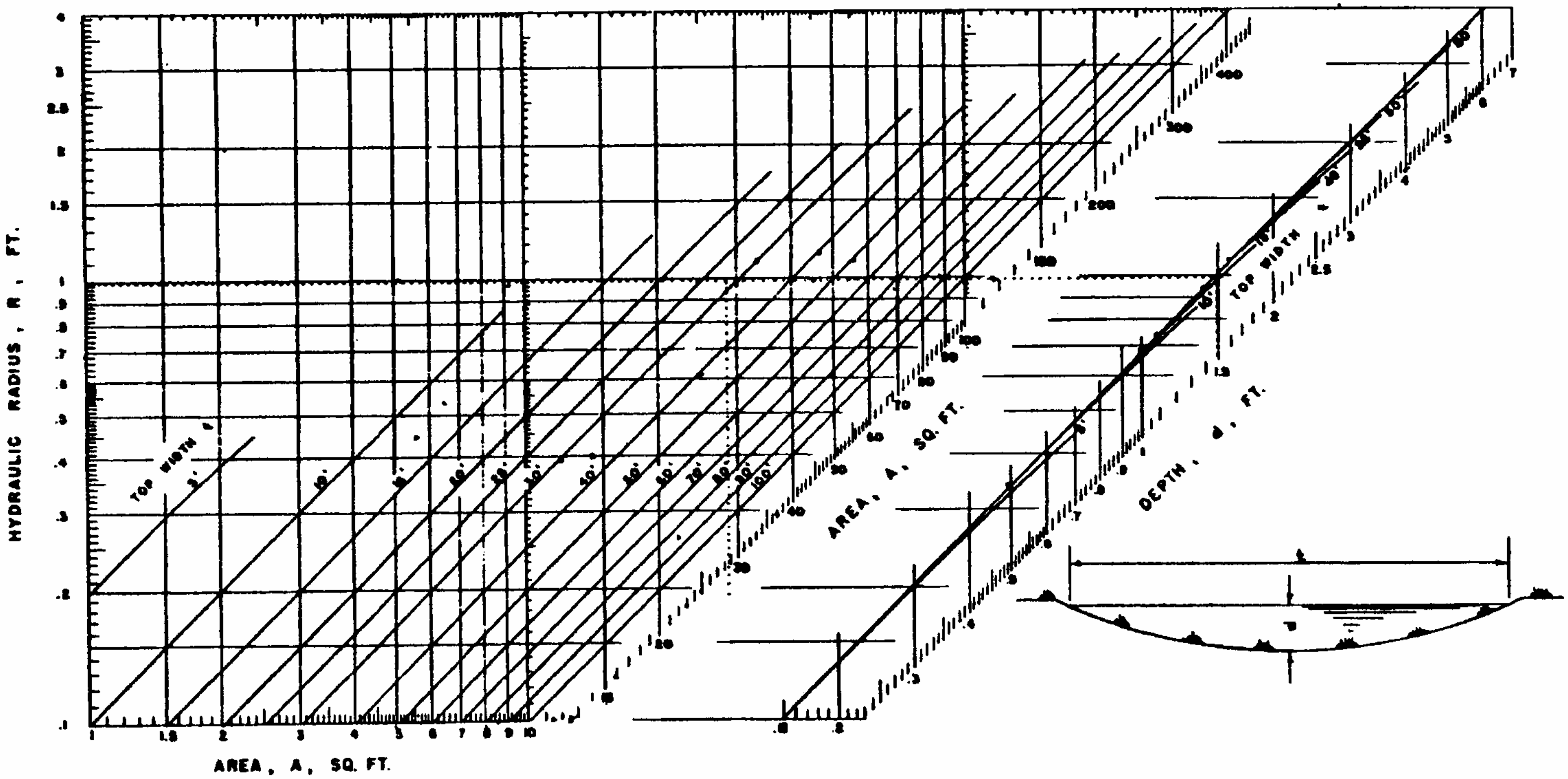


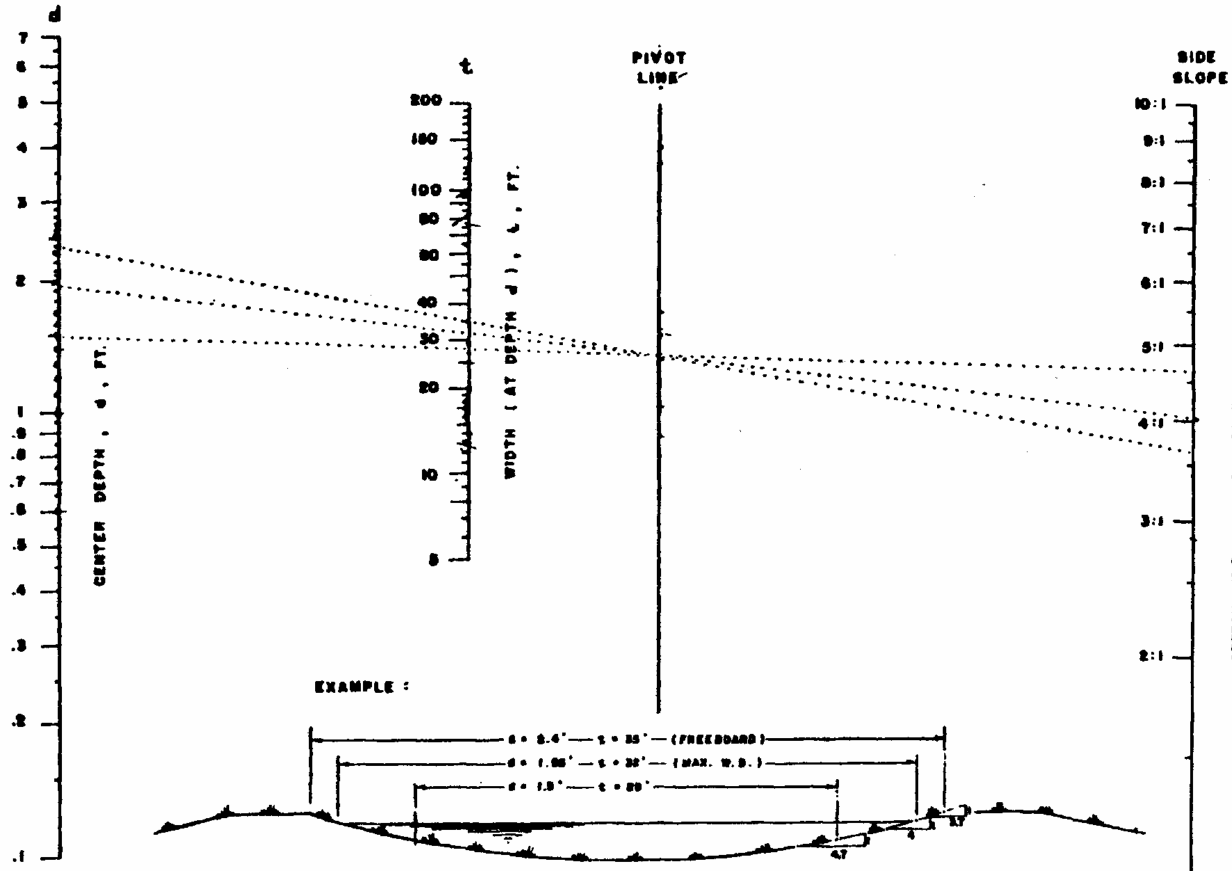
FIGURE A6-13
DIMENSIONS OF TRIANGULAR CHANNELS



NOTE: THIS CHART TO BE USED IN CONJUNCTION WITH THE NOMOGRAPHIC SOLUTION (FIG. A6-15)

FIGURE A6-14

DIMENSIONS OF PARABOLIC CHANNELS



NOTE: THIS CHART TO BE USED TO OBTAIN OTHER DIMENSIONS AFTER t AND d FOR MAXIMUM FLOW HAVE BEEN DETERMINED (FROM FIG. A6-14)

FIGURE A6-15

SOLUTION FOR DIMENSIONS OF PARABOLIC CHANNELS

APPENDIX A-7

DETERMINING VOLUME IN A SEDIMENT BASIN TO MEET TRAP EFFICIENCY, SEDIMENT STORAGE AND TEMPORARY FLOODWATER STORAGE REQUIREMENTS

Sample Problem #1

At Toms River in Ocean County, 100 acres drains into a planned sediment basin. Failure of the sediment basin at the planned site will not result in loss of life or damage to buildings, roads, railroads or utilities. Ten acres are to be cleared and developed into houses. Ninety acres are in woods and will not be disturbed during the life of the sediment basin. It is estimated it will take 18 months to develop the site. The sediment basin will be installed as the first item of construction and removed as the last item of construction. The owner estimates that the 10 acres to be developed will be bare for 12 months and under roofs, pavement, and sod for the last 6 months of construction. The soils are Woodmansie sand. The sediment pool will be normally dry.

I. Determine minimum basin volume to meet the 70% trap efficiency requirement. Set trap efficiency at 75% to meet actual trap efficiency requirement of 70% for a dry sediment pool with coarse sediment, as required by the standard in the section on Trap Efficiency.

Enter Curve 4.4-1 with 75%. Find C/I = 0.025 using curve for coarse-grained sediments. From Figure 4.4-1, average annual surface runoff for Toms River is 25 inches; I = (25 in) (1 ft/12 in) (100 ac)
I = 208.3 ac ft

C = (208.3 ac. ft.) (0.025)
C = 5.21 ac. ft. = minimum volume in the sediment basin below emergency spillway elevation to obtain 70% trap efficiency with a dry pool.

II. Determine minimum basin volume to meet the requirements for sediment storage and temporary floodwater storage.

1. Determine volume for sediment storage using Method 2 in the standard under Sediment Storage Capacity.

a. Determine, DA and A, Drainage Area and Average Annual Erosion

First year

Woods
(DA) (A) = 90 ac x 0.2 tons/ac/yr = 18 tons/yr

Construction Area
(DA) (A) = 10 ac x 60 tons = 600 tons/yr
(DA) (A) = 618 tons for the First year.

Second year

Woods (DA) (A) = 90 ac x 0.2 tons/ac/yr = 18 tons/yr
Urban Area
(DA) (A) = 10 ac x 1.0 tons/ac/yr = 10 tons/yr
(DA) (A) = (18 + 10) ($^1/_2$) = 14 tons for 2nd year
for six month life.
(DA) (A) = 6l8 + 14 = 632 tons for the life of the basin.

b. Determine DR, delivery ratio

100/640 = 0.16 sq mi from Figure 4.4-2 for a sandy soil, DR = 24%

c. Determine, density of the sediment. From Table 4.4-1 the density of aerated sand is 85-100 lbs/ cu ft., use 90 lbs/cu ft.

d. Determine minimum volume for sediment storage for the planned life of the structure.

V = (DA) (A) (DR) (TE) (1/) (2,000 lbs/ton)
(1/43,560 sq. ft./ac.)
V = (632) (0.24) (0.70) (1/90) (2,000) (l/43,560)
V = 0.054 Ac. ft.

2. Determine minimum volume for temporary floodwater storage.

a. The standard requires that we have at least 1 foot between the crest of the principal spillway and the crest of the emergency spillway and that the runoff from the 2-year frequency 24-hour duration storm not cause flow in the emergency spillway. See the sections in the standard on Sediment Basin Volume and Principal Spillway.

b. The 2-year 24-hour rainfall is 3.5 inches and the hydrologic soil group for Woodmansie sand is B from reference #1.

c. From reference #9, Urban Hydrology for Small Watersheds, the runoff curve number is 58. The runoff is 0.45 watershed inches from a 2-year 24-hour storm.

d. The size of principal spillway pipe selected will have an effect on the volume of temporary floodwater storage required. For this site we selected a 18 inch CMP riser with a 12 inch CMP outlet. From the site survey and the preliminary layout of the principal spillway we found that the capacity of the spillway is approximately 5 cfs.

e. Using the above principal spillway and the approximate flood routing methods in reference 1, we find that 0.2 watershed inches is required for temporary floodwater storage for the 2-year 24-hour storm.

f. The minimum volume for temporary floodwater storage using the 12 inch CMP principal spillway is 0.2 watershed inches or converting to ac.ft. is 1.67 ac.ft.

3. The minimum basin volume to meet the requirement for sediment storage capacity and temporary floodwater storage is 0.054 ac.ft + 1.67 ac.ft = 1.72 ac. ft.

III. The standard under Sediment Basin Volume requires that we provide volume for the larger of the two values calculated above under I and II.

The volume for 70% trap efficiency is 5.21 ac. ft. The volume for sediment and temporary floodwater storage is 1.72 ac. ft. Therefore, we must provide below the crest of the emergency spillway at least 5.21 ac. ft. of volume.

Sample Problem # 2:

Same as Sample Problem # 1, except location is Morristown and the soils are Parsippany silt loam.

I. Determine minimum basin volume to meet the 70% trap efficiency requirement. Set trap efficiency at 80% to meet actual trap efficiency requirement of70% for a dry sediment pool with fine sediment. From Curve 4.4-1, using curve for fine grained sediment, C/I = 0.12. From Figure 4.4-1, I = $23^1/_2$ inches for Morristown. I = ($23^1/_2$ inches) (1 ft/12 in.) (100 ac) = 196 ac. ft. C = 23.5 ac. ft. =minimum volume for 70% trap efficiency.

II. Determine minimum basin volume to meet the requirements for sediment storage and temporary flood water storage.

1. Determine volume for sediment storage using Method 2 in the standard under Sediment Storage Capacity.

a. (DA) (A) Same as in Sample Problem #1
(DA) (A) = 618 tons for the 1st year
(DA) (A) = 14 tons for the 2nd year

b. Determine, DR, delivery ratio.
The Parsippany soil is described in the soil survey report as a silt loam, clay loam or silty clay loam at different depths. Therefore, in Figure 4.4-2, use the curve for silty clay with 0.16 sq. mi. drainage area, DR = 72%.

c. Determine, density of sediment. = 80 lbs/cu ft, using Table 4.4-1 with clay-silt mixture with more silt than clay.

d. Determine minimum volume for sediment storage for the planned life of the structure.

V = (DA) (A) (DR) (TE) (1/) (2,000 lbs. /ton)
(1/43,560 sq. ft. /ac.)
V = (618 + 14) (0.72) (0.70) (1/80) (2,000) (1/43,560)
V = 0.18 ac. ft.

2. Determine minimum volume for temporary floodwater storage.

a. The standard requires that we have at least 1 foot between the crest of the principal spillway and the crest of the emergency spillway and that the runoff from the 2-year frequency 24-hour duration storm not cause flow in the emergency spillway. See the sections in the standard on Sediment Basin Volume and Principal Spillway.

b. The 2 year 24 hour rainfall is 3.3 inches and the hydrologic soil group for Parsippany silt loam is D, from Reference #1.

c. From Reference #9, Urban Hydrology for Small Watershed, the runoff is 1.42 watershed inches from a 2-year 24-hour storm.

d. The size of principal spillway pipe selected will have an effect on the volume of temporary floodwater storage required. For this site we selected a 18 inch CMP riser with a 12 inch CMP outlet. From the site survey and the preliminary layout of the principal spillway we found that the capacity of this spillway is approximately 5 cfs.

e. Using the above principal spillway and the approximate flood routing methods in Reference 1, we find that 0.9 watershed inches is required for temporary floodwater storage for the 2-year 24-hour storm.

f. The minimum volume for temporary floodwater storage using the 12-inch CMP principal spillway is 0.9 watershed inches or converting to ac. ft. is 7.5 ac. ft.

III. The standard under Sediment Basin Volume requires that we provide volume for the larger of the two values calculated above under I and II.

The volume for 70% trap efficiency is 23.5 ac. ft. The volume for sediment and temporary floodwater storage is 7.68 ac. ft. Therefore, we must provide below the crest of the emergency spillway at least 23.5 ac. ft. of volume.

Conclusions From Sample Problems

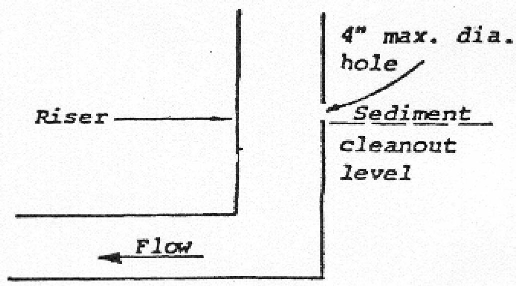
To have a reasonably sized sediment basin that is effective, two factors are critical. The total drainage area must be small and the sediment must be coarse textured, or the basin becomes excessively large.

The effect of sediment size is shown by the difference in basin size from Sample Problem #1 to #2. When changing from sand typical of South Jersey to silt clay typical of North Jersey, the minimum basin volume goes from 5.21 ac. ft. to 23.5 ac. ft.

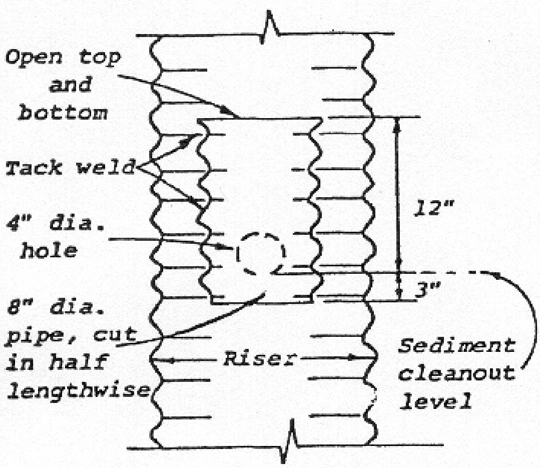
If the soils were silt and clay and the basin was located so that the only drainage area was the 10 disturbed acres, the minimum basin volume would be 2.3 ac. ft. With sand sediments and a 10 ac. drainage area, the minimum basin volume would be 0.5 ac. ft.

METHODS OF DEWATERING SEDIMENT BASINS

The dewatering methods shown here are inexpensive and operate automatically.

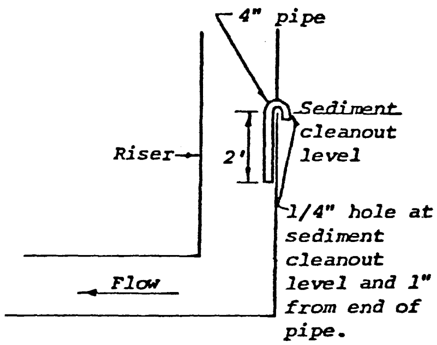
METHOD	COMMENTS
A.	
 CROSS-SECTION	Easy to construct May clog with trash Non-skimming Capable of draining down to sediment clean-out level

B. Same as "A" except for skimming device, detailed below:

 ELEVATION	Efficient skimmer Non-clogging Fairly easy to construct Capable of draining down to sediment cleanout level

METHOD | COMMENTS

C.

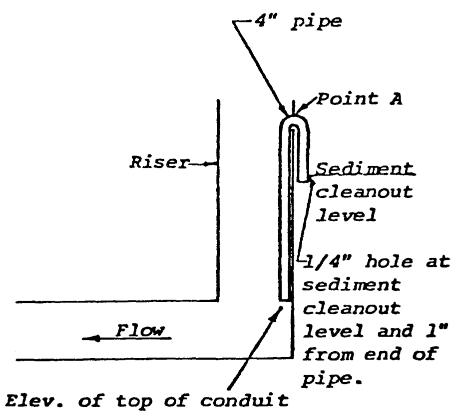


CROSS-SECTION

Efficient skimmer
Capable of always draining down to sediment cleanout level and below

Higher discharge rate than "A" or "B".

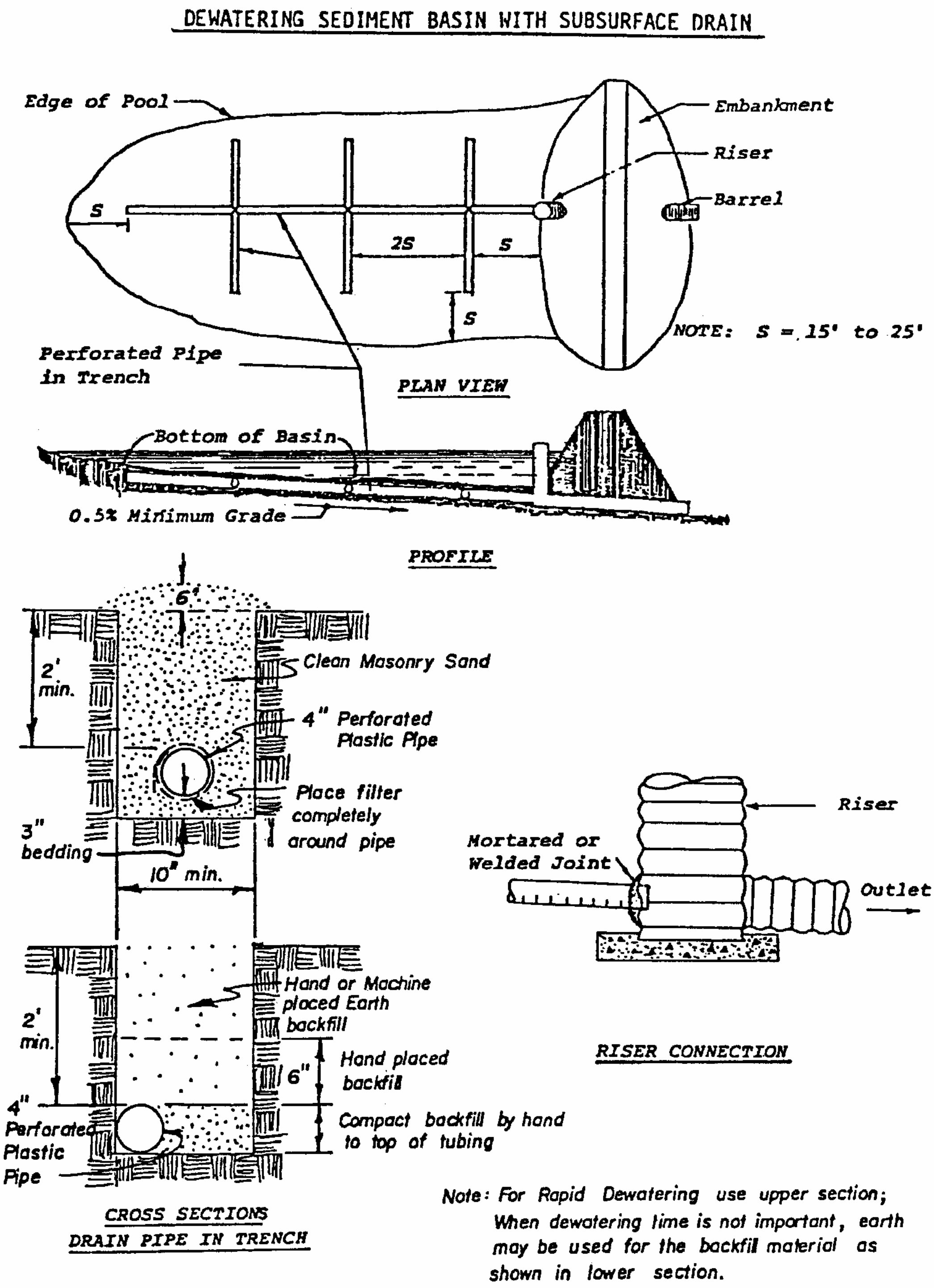
D.



CROSS-SECTION

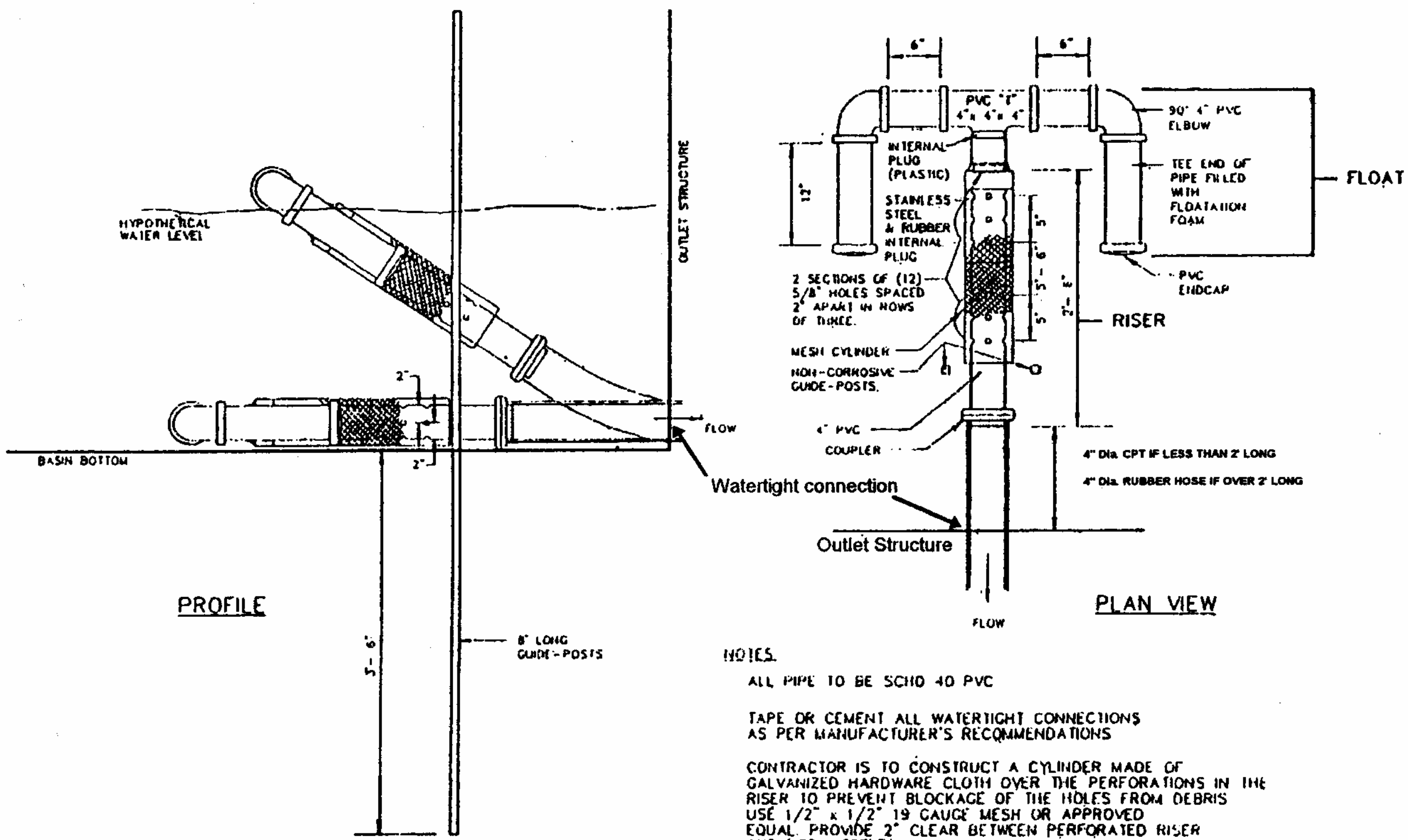
Efficient skimmer
Water must inundate point A to prime siphon. Therefore, small storms will not prime siphon and drain pool down to sediment cleanout level.

Higher discharge rate than "C"


DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN
Edge of Pool
Embankment
Riser
Barrel
S
2S
S
S
NOTE: S = 15' to 25'
Perforated Pipe in Trench
PLAN VIEW
Bottom of Basin
0.5% Minimum Grade
PROFILE
6"
2' min.
Clean Masonry Sand
4" Perforated Plastic Pipe
Place filter completely around pipe
3" bedding
10" min.
Riser
Mortared or Welded Joint
Outlet
Hand or Machine placed Earth backfill
2' min.
6"
Hand placed backfill
4" Perforated Plastic Pipe
Compact backfill by hand to top of tubing
RISER CONNECTION
CROSS SECTIONS
DRAIN PIPE IN TRENCH
Note: For Rapid Dewatering use upper section; When dewatering time is not important, earth may be used for the backfill material as shown in lower section.

Dewatering Sediment Basins with Skimmer

NOTE: ALL PIPE AND TUBING IS SIZED AS PER ORIFICE DIAMETER.
(EXAMPLE SHOWN IS FOR A FOUR INCH DIAMETER ORIFICE)



NOTES.

ALL PIPE TO BE SCHD 40 PVC

TAPE OR CEMENT ALL WATERTIGHT CONNECTIONS AS PER MANUFACTURER'S RECOMMENDATIONS

CONTRACTOR IS TO CONSTRUCT A CYLINDER MADE OF GALVANIZED HARDWARE CLOTH OVER THE PERFORATIONS IN THE RISER TO PREVENT BLOCKAGE OF THE HOLES FROM DEBRIS USE 1/2" x 1/2" 19 GAUGE MESH OR APPROVED EQUAL. PROVIDE 2" CLEAR BETWEEN PERFORATED RISER AND MESH ITSELF

FLOATING RISER IS TO BE REMOVED AFTER CONSTRUCTION OF PROJECT SUCH THAT BASIN CAN FUNCTION PROPERLY FOR DETENTION PURPOSES.

FLOATING RISER DETAIL

Dewatering with Skimmers:

Skimmer-type dewatering devices may be considered to improve sediment-trapping efficiency. Since skimmers operate at the surface of the ponded water, they will not draw sediment-laden water from the submerged volume of the basin. Skimmers are mechanically more complex and will require frequent inspection and maintenance in order to operate as designed. Skimmers may not work during winter months when surface waters freeze, preventing the skimmer from moving downward.

Skimmers must be removed once the sediment trapping function of the basin is completed and the basin is ready for permanent stormwater control.

When connecting the skimmer to the outlet structure where the outlet orifice is larger than the PVC pipe diameter, the orifice may require a temporary plate, reducer coupling or mortar plug to form a flexible, watertight connection.

APPENDIX A-8

CHANNEL STABILITY ANALYSIS PROCEDURE

Introduction

The evaluation or design of any water conveyance system that includes earth channels requires knowledge of the relationships between flowing water and the earth materials forming the boundary of the channel, as well as an understanding of the expected stream response when structures, lining, vegetation, or other features are imposed. These relationships may be the controlling factors in determining channel alignment, grade, dimensioning of cross section and selection of design features to assure the operational requirements of the system.

The methods included herein to evaluate channel stability against the flow forces are for bare earth. The magnitude of the channel instability needs to be determined in order to evaluate whether or not structural measures are needed. Where such practices or measures are required, methods of analysis that appropriately evaluate the stream's response should be used.

All terms used in this appendix are defined in the glossary, Section A-2.

<u>Allowable Velocity Approach</u>

<u>General</u>

This method of testing the erosion resistance of earth channels is based on data collected by several investigators.

Figure A4-1 shows "Allowable Velocities for Unprotected Earth Channels" developed chiefly from data by Fortier and Scobey al., Lane a2, by investigators in the U.S.S.R. a3, and others.

Stability is influenced by the concentration of fine material carried by the flow in suspension. There are two distinct types of flow depending on concentration of material in suspension.

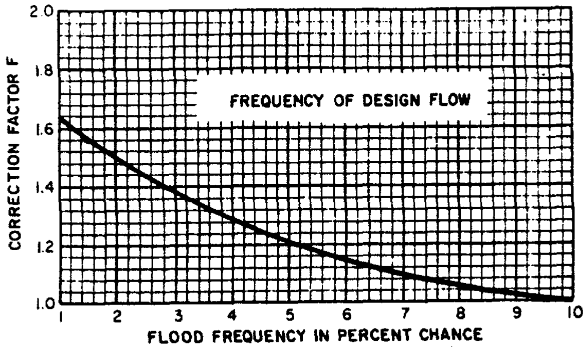
1. Sediment free flow is defined as the condition in which fine material is carried in suspension by the flow at concentrations so low that it has no effect on channel stability. Flows with concentrations lower than 1,000 ppm by weight are treated as sediment-free flows.

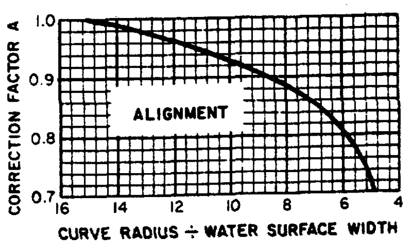
2. Sediment-laden flow is the condition in which the flow carries fine material in suspension at moderate to high concentrations so that stability is enhanced either through replacement of dislodged particles or through formation of a protective cover as the result of settling. Flows in this class carry sediment in suspension at concentrations equal or larger than 20,000 ppm by weight.

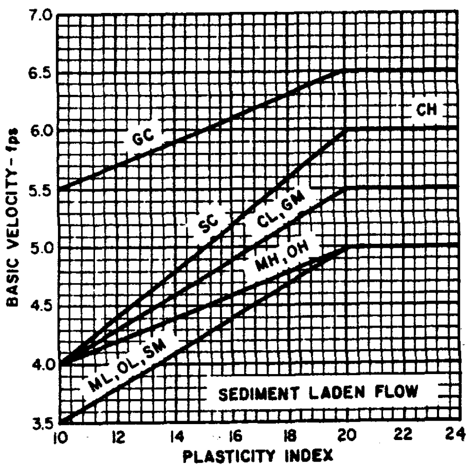
Sediment transport rates are usually expressed in tons per day. To covert those into concentration use the equation:

$C=370(Q_S/Q)$ (Eq. A8-1)

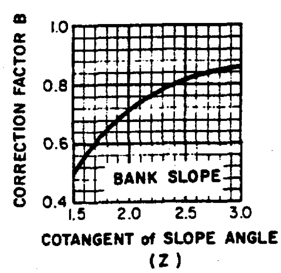
Depending on the type of soil, the effect of concentration of fine sediment (material smaller than 0.074 mm) in suspension on the allowable velocity is obtained from the curves in Figure A8-1.

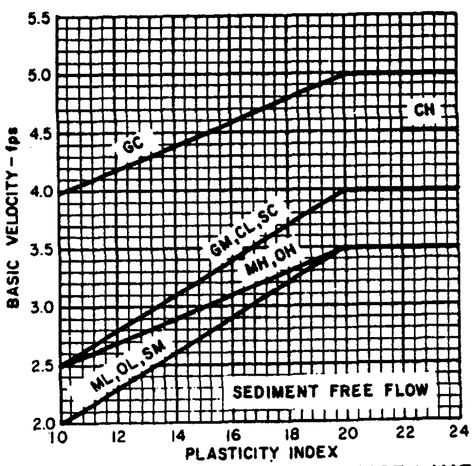




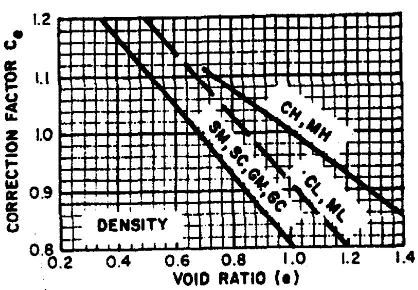


BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)





BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



If the suspended sediment concentration equals or exceeds 20,000 ppm by weight, use the sediment laden curve on Figure A8-1. If the suspended sediment concentration is 1,000 ppm or less by weight, use the sediment free curves on Figure A8- 1. A linear interpolation may be made between these curves for suspended sediment concentrations between 1,000 ppm and 20,000 ppm.

Adjustment in the basic velocity to reflect the modifying effects of frequency of runoff, curvature in alignment, bank slopes, density of bed and bank materials, and depth of flow are made using the adjustment curves on Figure A8-1.

The alignment factor, A, and the depth factor, D, apply to all soil conditions. The bank slope factor, B, applies only to channels in soils that behave as discrete particles. The frequency correction, F, applies only to channels in soils that resist erosion as a coherent mass. The density correction factor, Ce, applies to all soil materials except clean sands and gravels (containing less than 5 percent material passing size #200).

Figure A8-1 gives the correction factors (F) for frequencies of occurrence lower than 10 percent. Channels designed for less frequent flows using this correction factor should be designed to be stable at the 10 percent chance frequency discharge as well as at the design discharge.

If the soils along the channel boundary behave as discrete particles with D_{75} larger than 0.4 mm for sediment-laden flow or larger than 2.0 mm for sediment-free flow, the allowable velocity is determined by adjusting the basic velocity read from the curves on Figure A8-1 for the effects of alignment, bank slope, and depth. If the soils behave as discrete particles and D_{75} is smaller than 0.4 mm for sediment laden flow or 2.0 mm for sediment-free flow, the allowable velocity is 2.0 fps. For channels in these soils, no adjustments are to be made to the basic velocity of 2.0 fps.

In cases where the soils in the channel boundary resist erosion as a coherent mass, the allowable velocity is determined by adjusting the basic velocity from Figure A8-1 for the effects of depth, alignment, bank slope, frequency of occurrence of design flow, and for the density of the boundary soil materials.

Design Procedure for Allowable Velocity Approach

The use of the allowable velocity approach in checking the stability of earth channels involves the following steps:

1. Determine the hydraulics of the system. This includes hydrologic determinations as well as the stage-discharge relationships for the channel considered.

2. Determine the properties of the earth materials forming the banks and bed of the design reach and of the channel upstream.

3. Determine sediment yield to attain and calculate sediment concentration for design flow. In most cases, sediment-free conditions exist and should be used unless the designer can prove otherwise.

4. Check to see if the allowable velocity procedure is applicable.

5. Compare the design velocities with the allowable velocities from Figure A8-I for the materials forming the channel boundary.

Examples of Allowable Velocity Approach

Example 1

Given: A channel is to be constructed to convey the flow from a 2 percent chance flood. The hydraulics of the system indicate that a trapezoidal channel with 2: 1 side slopes and a 40 foot bottom width will carry the design flow at a depth of 8.7 feet and a velocity of 5.45 fps. Soil investigations reveal that the channel will be excavated in moderately rounded clean sandy gravel with a D_{75} size of 2.25 inches. Sampling of soils in the drainage area and estimate of erosion and sediment yield indicate that, on a an average annual basis, approximately 1000 tons of sediment finer than 1.0 mm and 20 tons of material coarser than 1.0 mm are available for transport in channel. The amount of abrasion resulting from the transporting of this small amount of sediment coarser than 1.0 mm is considered insignificant. Sediment transport computations indicate all of the sediment supplied to the channel will be transported through the reach. The sediment transport and hydrologic evaluations indicate the design flow will transport the available sediment at a concentration of about 500 ppm. The channel is straight except for one curve with a radius of 600 feet.

Determine:

1. The allowable velocity, V_a, and

2. The stability of the reach

Solution: Determine basic velocity from Figure A8-1, sediment-free curve because sediment concentration of 500 ppm is less than 1,000 ppm.

V_b=6 fps.

Depth correction factor, D = 1.22 (from Figure A8-1)

Bank slope correction, B = 0.72 (from Figure A8-1).

Alignment correction A,

Curve radius/water surface width = 600/74.8 = 8.02

A = 0.89 (from Figure A8-1).

Density correction, Ce, does not apply

Frequency correction, F, does not apply

V_a (straight reaches) = V_bDB = (6.7) (1.22) (0.72) = 5.88 fps

V_a (curved reaches) = V_bDBA = (6.7) (1.22) (0.72) (0.89) = 5.24 fps

The proposed design velocity of 5.45 fps is less than V_a = 5.88 fps in the straight reaches but greater than V_a = 5.24 fps in the curved reaches. Either the channel alignment or geometry needs to be altered or the curve needs structural protection.

Example 2

<u>Given:</u> A channel is to be constructed to convey the flow from a 2 percent chance flood. The hydraulics of the system indicate that a trapezoidal channel with 2: 1 side slopes and a 40 foot bottom width will carry the design flow at a depth of 8.7 feet and a velocity of 5.45 fps. The channel is to be excavated into a silty clay (CL) soil with a Plasticity Index of 18, a dry density of 92 lbs/ft^3, and a specific gravity of 2.71. Sediment transport evaluations indicate the design flow will have a fairly stable sediment concentration of about 500 ppm with essentially no bed material load larger than 1.0 mm. The channel is straight except for one curve with a radius of 600 feet. The 10 percent chance flood results in a depth of flow of 7.4 feet and a velocity of 4.93 fps.

Determine:

1. The allowable velocity, V_a, and

2. The stability of the reach.

Solution: Sediment concentration of 500 ppm is less than 1,000 ppm; therefore it is classed as sediment-free flow.

V_b = 3.7 fps (from Figure A8-1) for the 2 percent chance flood.

Depth correction, D = 1.22 (from Figure A8-1).

Density correction, compute e: $e = G\frac{\lambda_W}{\lambda_2} - 1 = \frac{(2.71)(62.4)}{92} - 1 = 0.83$

C_e = 1.0 (from Figure A8-1)

Frequency correction, F = 1.5 (from Figure A8-1)

Alignment correction A,

Curve radius/water surface width = 600/74.8 = 8.02

A = 0.89 (from Figure A8-1).

V_a (Straight reach) = V_bDC_eF = (3.7)(1.22)(1.0)(1.5) = 6.77 fps

V_a (Curved reach)=V_bDC_eFA=(3. 7)(1.22)(1.0)(1.5)(0.89) = 6.03 fps.

The design velocity is less than the allowable velocity for the 2 percent chance flow. Check the 10 percent chance flow velocity with no frequency correction against the allowable velocity for the 10 percent chance flow.

V_a (Straight reaches) = V_bDC_e = (3. 7)(1.19)(1.0) = 4.40 fps.

V_a (Curved reaches)=V_bDC_eA=(3. 7)(1.19)(1.0)(0.90) = 3.96 fps

The allowable velocity with no frequency correction is exceeded by the 10 percent chance flow velocity. Channel alignment, slope or geometry must be altered or the channel must be protected.

Tractive Stress Approach

General

The tractive force is the tangential pull of flowing water on the wetted channel boundary; it is equal to the total friction force that resists flow but acts in the opposite direction. Tractive stress is the tractive force per unit area of the boundary. The tractive force is expressed in units of pounds, while tractive stress is expressed in units of pounds per square foot. The tractive force in a prismatic channel reach is equal to the weight of the fluid prism multiplied by the energy gradient.

The tractive stress approach to channel stability analysis provides a method to evaluate the stress at the interface between flowing water and the materials in the channel boundary.

The method for obtaining the actual tractive stress acting on the bed or sides of a channel and the allowable tractive stress depends on the D_{75} size of the materials involved. When coarse-grained discrete particle soils are involved, Lane's a2. method is used. When fine-grained soils are involved, a method derived from the work of Keulegan and modified by Einstein a4. and Vanoni and Brooks, a5., is used. The separation size for this determination is D_{75} - ¼ inch.

Coarse-grained Discrete Particle Soils – D_{75}> ¼ inch -Lane's Method

A. Determination of Actual Tractive Stress

1. Actual tractive stress in an infinitely wide channel

Generally, Manning's roughness coefficient "n" reflects the overall impedance to flow including grain roughness, form roughness, vegetation, curved alignment, etc. Lane's a2 work showed that for soils with a D_{75} size between 0.25 inch (6.35 mm) and 5.0 inches (127 mm) the value of Manning's coefficient "n" resulting from the roughness of the soil particles is determined by:

$$n_t = \frac{(D_{75})^{1/6}}{39}$$ With D_{75} expressed in inches (Eq. A8-2)

The value of n_t determined by the equation above represents the retardance to flow caused by roughness of the soil grains.

The value of n_t can be used to compute st, the friction gradient associated with the particular boundary material being considered.

$$s_t = \left(\frac{n_t}{n}\right)^2 s_e$$ (Eq. A8-3)

The tractive stress acting on the soil grains in an infinitely wide channel is found by:

$$\tau_w = \gamma_\infty d s_t$$ (Eq. A8-4)

where the terms are as defined in the glossary.

2. Distribution of the tractive stress along the channel perimeter:

In open channels the tractive stresses are not distributed uniformly along the perimeter. Laboratory experiments and field observations have indicated that in trapezoidal channels the stresses are very small near the water surface and near the comers of the channel and assume their maximum value near the center of the bed. The maximum value on the banks occurs near the lower third point.

Figures A8-2 and A8-3 give the maximum tractive stresses in a trapezoidal channel in relation to the tractive stress in an infinitely wide channel having the same depth of flow and value of S_t.

3. Tractive stresses on curved reaches:

Curves in channels cause the maximum tractive stresses to increase above those in straight channels. The maximum tractive stresses in a channel with a single curve occur on the inside bank in the upstream portion of the curve and near the outer bank downstream from the curve. Compounding of curves in a channel complicates the flow pattern and causes a compounding of the maximum tractive stresses.

Figure A8-4 gives values of maximum tractive stresses based on judgment coupled with very limited experimental data. It does not show the effect of depth of flow and length of curve and its use is only justified until more accurate information is obtained. Figure A8-5, with a similar degree of accuracy, gives the maximum tractive stresses at various distances downstream from the curve.

B. Allowable Tractive Stress

The allowable tractive stress for channel beds, $_{Lb}$, composed of soil particles with discrete, single grain behavior with a given D_{75} is:

$\tau_{Lb} = 0.4D_{75}$ When $0.25in. < D_{75} < 5.0in.$ (Eq. A8-5)

The allowable tractive stress for channel sides, $_{Ls}$ is less than that of the same material in the bed of the channel because the gravity force aids the tractive stress in moving the materials. The allowable tractive stress for channel sides composed of soil particles behaving as discrete single grain materials, considering the effect of the side slope z and the angle of repose $_R$ with the horizontal is

$\tau_{Ls} = 0.4KD_{75}.....0.25in. < 5.0in.$ (Eq. A8-6)

Where: $K = \sqrt{\frac{z^2 - \cot^2 \phi_R ...}{1 + z^2}}$ (Eq.A8-7)

Figure A8-6 gives an evaluation of the angles of repose corresponding to the degree of angularity of the material. Figure A8- 7 gives values of K from Equation A8- 7.

When the unit weight γ_S of the constituents of the material having a grain size larger than the D_{75} size is significantly different than 160 lb/ft^3, the limiting tractive stress τ_{Lb} and τ_{Ls} as given by Equations (A8-5) and (A8-6) should be multiplied by the factor.

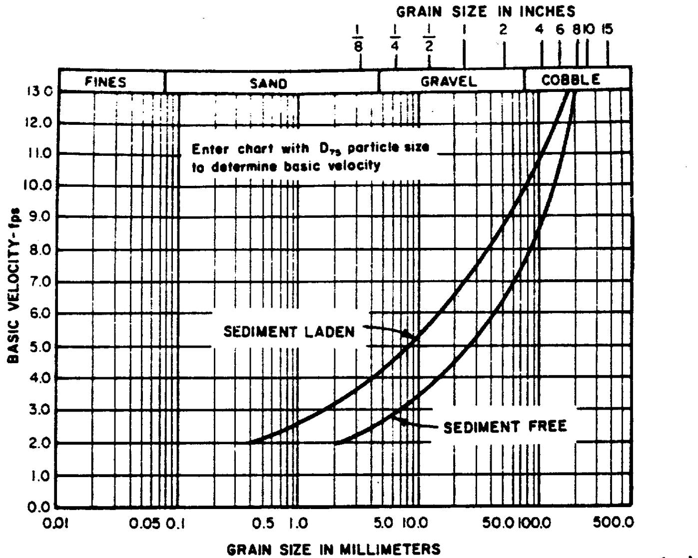
$$T = \frac{\gamma_S - \gamma_w}{97.6} \qquad \text{(Eq. A8-8)}$$

Fine Grained Soils - $D_{75} < {}^1/_4$ inch

A. Determination of Actual Tractive Stress

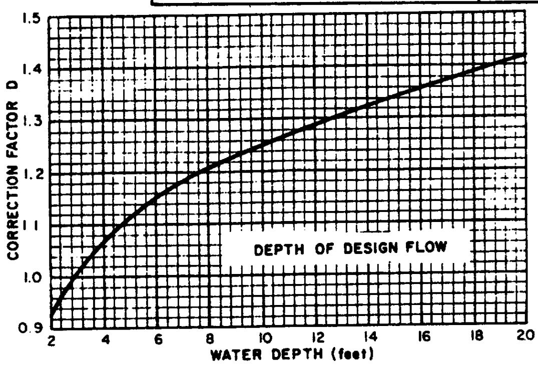
Reference tractive stress

The expression for reference tractive stress is: $t = \gamma_w R_t s_e$ (Eq. A8-9)



BASIC VELOCITY FOR DISCRETE PARTICLES OF EARTH MATERIALS (v_b)

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS	
CHANNEL BOUNDARY MATERIALS	ALLOWABLE VELOCITY
DISCRETE PARTICLES	
Sediment Laden Flow	
$D_{75} > 0.4$ mm	Basic velocity chart value x D x A x B
$D_{75} < 0.4$ mm	2.0 fps
Sediment Free Flow	
$D_{75} > 2.0$ mm	Basic velocity chart value x D x A x B
$D_{75} < 2.0$ mm	2.0 fps
COHERENT EARTH MATERIALS	
PI > 10	Basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps



NOTES:

1. In no case should the allowable velocity be exceeded when the 10% chance discharge occurs, regardless of the design flow frequency.
2. The maximum permissible velocity for bare sand channels is 1.75 fps.

FIGURE A8-1

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS

REFERENCE:
Bureau of Reclamation "Progress Report on Results of Studies on Design of Stable Channels" Hyd-352

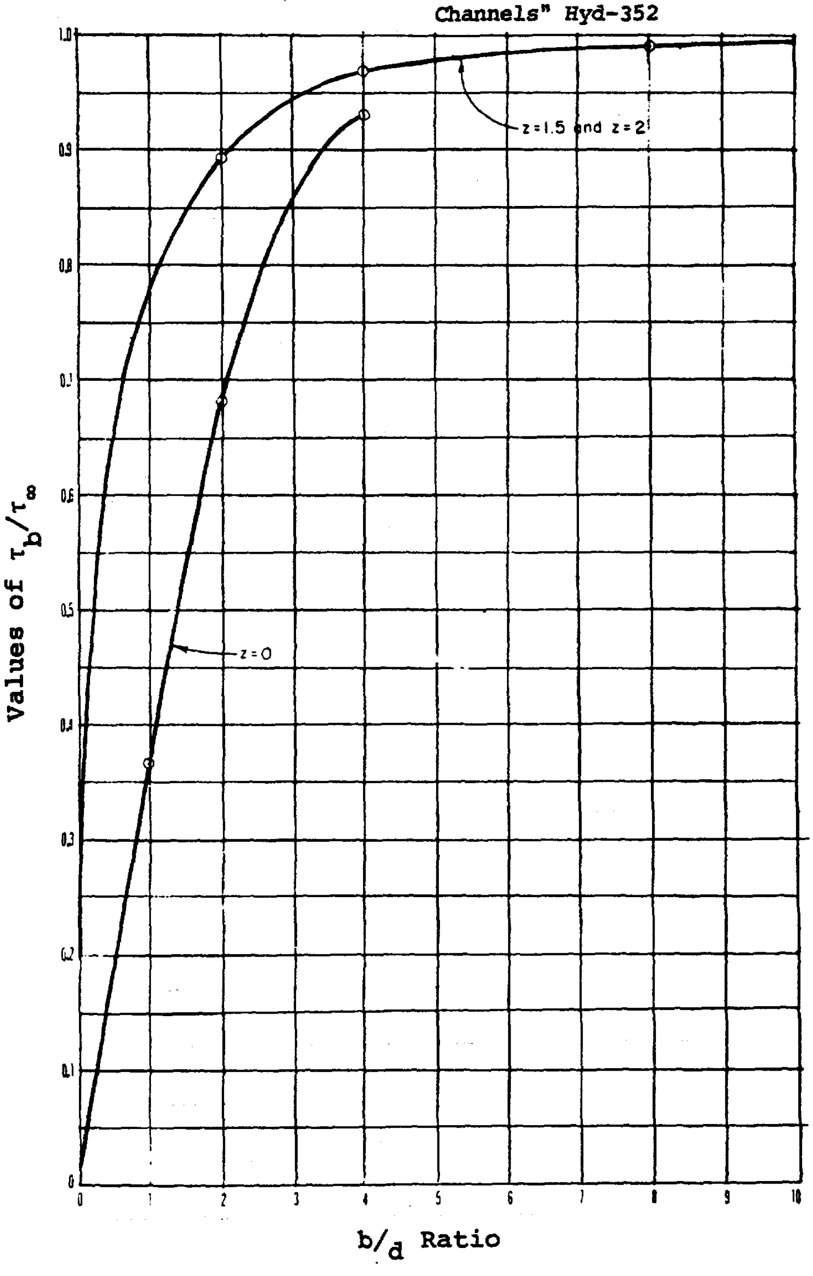


FIGURE A8-2

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS, τ_b, ON BED OF STRAIGHT TRAPEZOIDAL CHANNELS

REFERENCE
Bureau of Reclamation "Progress Report of Results of Studies on Design of Stable Channels" Hyd-352

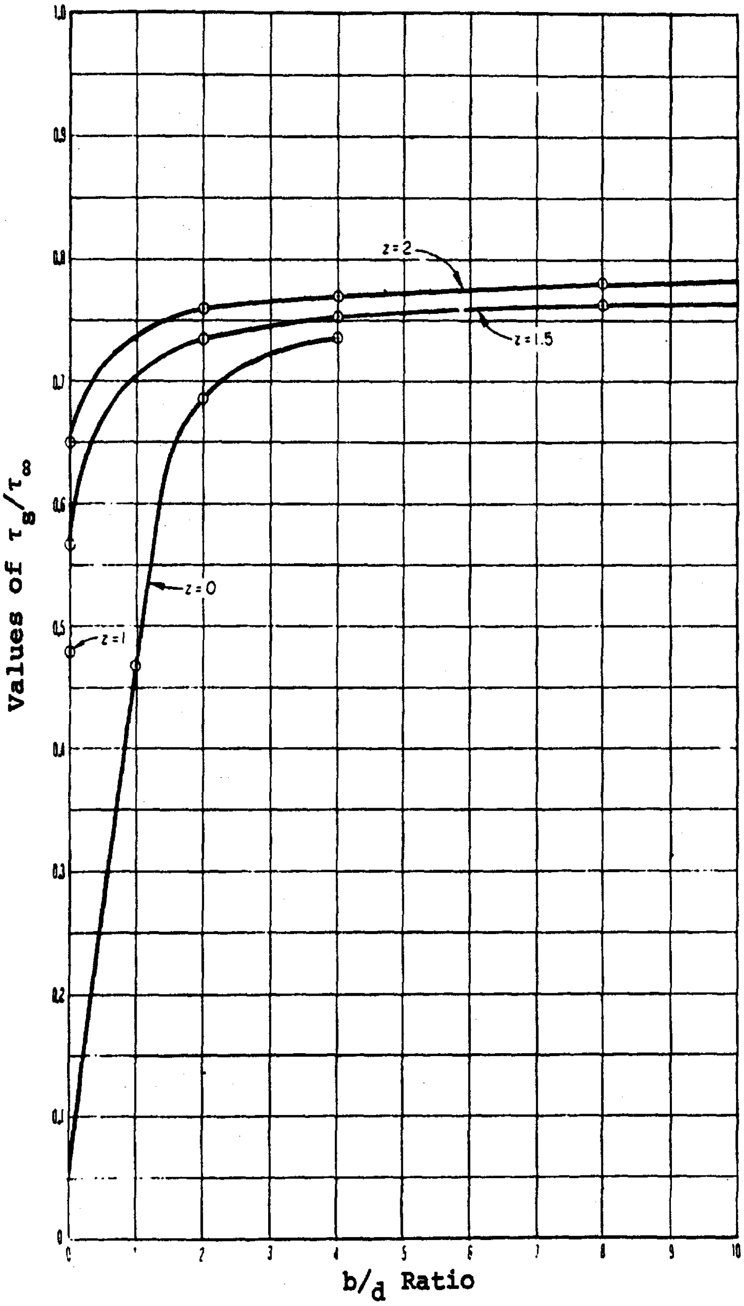


FIGURE A8-3

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS, τ_s, ON SIDES

REFERENCE:
Lane, Emory W., Design of Stable Channels Transaction, A S C E, vol. 120, 1955

Nece, R.E., Givler, G.A., and Drinker, P.A., Measurement of Boundary Shear Stress in an Open Curve Channel with a Surface Pitot Tube: M.I.T. Tech. note (no. 6), Aug. 1959

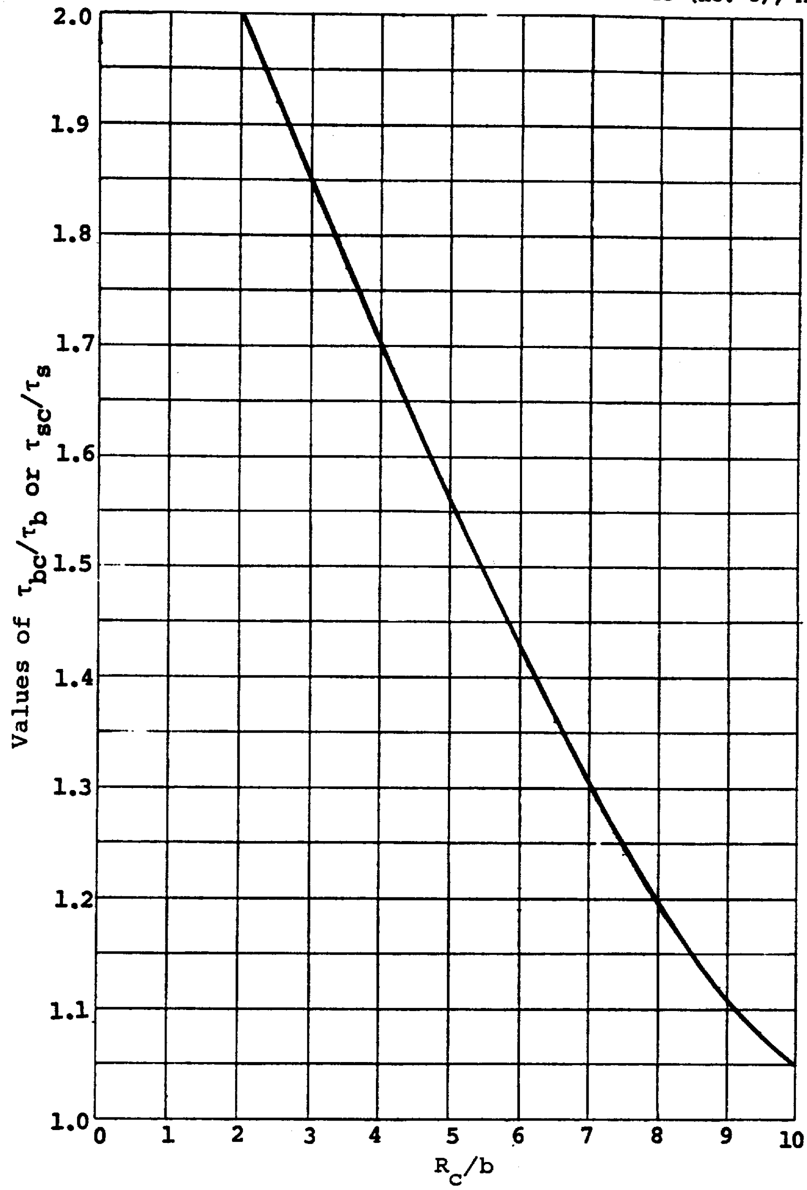


FIGURE A8-4

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS, τ_{bc} AND τ_{sc}, ON BED AND SIDES OF TRAPEZOIDAL CHANNELS WITHIN A CURVED REACH

REFERENCE
Nece, R.E., Givler, G.A., and Drinker, P.A., Measurement of Boundary Shear Stress in an Open Curve Channel with a Surface Pitot Tube: M.I.T. Tech note (no.6), Aug. 1959

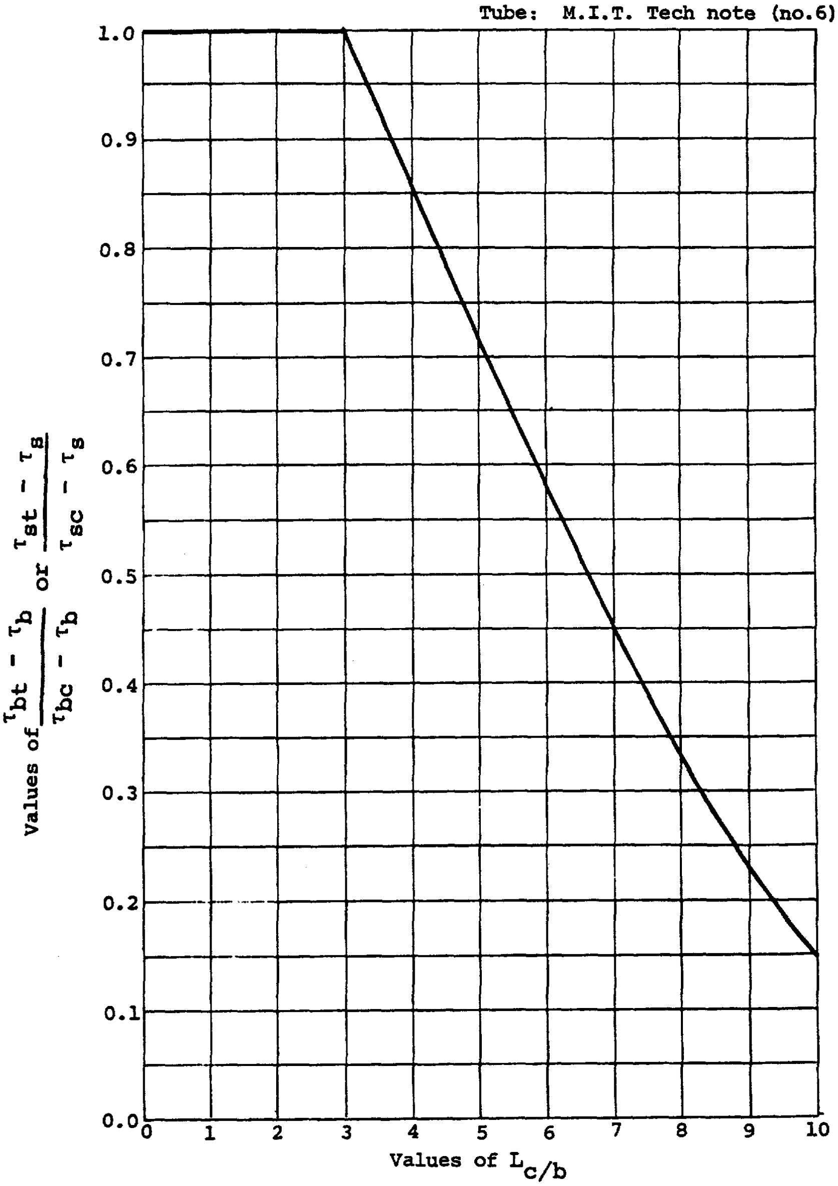


FIGURE A8-5

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESSES τ_{bt} AND τ_{st}, ON BED AND SIDES OF TRAPEZOIDAL CHANNELS IN STRAIGHT REACHES IMMEDIATELY DOWNSTREAM FROM CURVED REACHES

REFERENCE
Bureau of Reclamation Progress Report of Results of Studies on Design of Stable Channels
Hyd-352

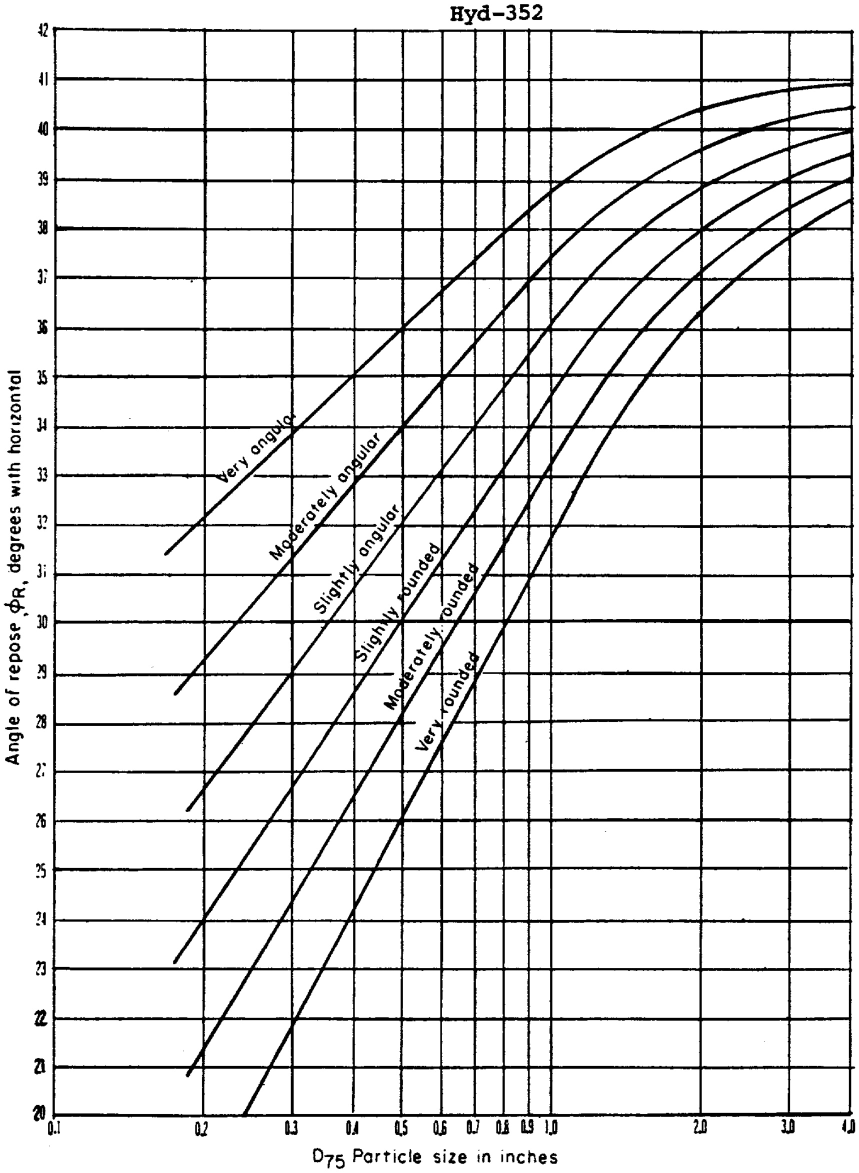


FIGURE A8-6

CHANNEL STABILITY; ANGLE OF RESPOSE, Φ_R, FOR NON-COHESIVE MATERIALS

REFERENCE:
Bureau of Reclamation "Progress Report on Results of Studies on Design of Studies Stable Channels"
Hyd-352

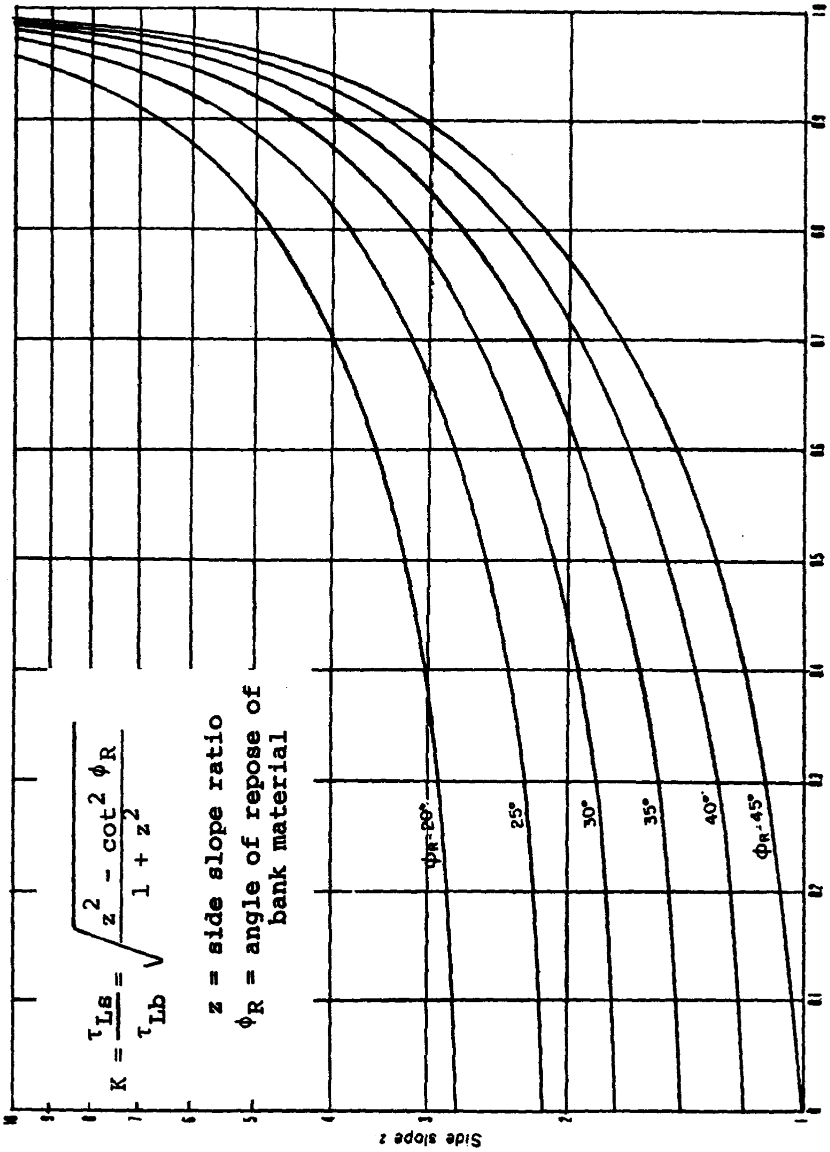


FIGURE A8-7

CHANNEL STABILITY; LIMITING TRACTIVE STRESS τ_{Ls} FOR SIDES OF TRAPEZOIDAL CHANNELS HAVING NON-COHESIVE MATERIALS

In a given situation y and s_e are known so that the only unknown is R_t. The value of R_t. can be determined from the logarithmic frictional formula developed by Keulegan and modified by Einstein a4.

$$\frac{v}{\sqrt{gR_t s_e}} = 5.75 \log(12.27 \frac{R_t x}{k_s}) \quad \text{(Eq. A8-10)}$$

Where: K_S is the D_{65} size in ft.

The factor x in Equation A8-I0 describes the effect on the frictional resistance of the ratio of the characteristic roughness length Ks to the thickness of the laminar sublayer. This thickness is determined from the equation:

$$\delta = \frac{11.6v}{\sqrt{gR_t s_e}} \quad \text{(Eq. A8-11)}$$

A relationship between x and k_s/δ has been developed empirically by Einstein a4, and represented by a curve. With the help of this curve and equations A8-10 and A8-11, the value of R_t can be determined provided that V, s_e, K_s and the temperature of the water are known. The computational solution for R_t follows an interactive procedure which is rather involved. Vanoni and Brooks a5 have developed a simpler graphical solution, and the basic family of curves that constitute it is shown in Figure A8-8. Figure A8-9 shows the extension of the curves outside the region covered in the original publication.

Figure A8-10 gives curves from which values of density and kinematics viscosity of the water can be obtained.

The computation of reference tractive stress (τ) is facilitated by following the procedure on page A8.20.

2. Distribution of the tractive stress along the channel perimeter:

In open channels the tractive stresses are not distributed uniformly along the perimeter. Laboratory experiments and field observations have indicated that in trapezoidal channels the stresses are very small near the water surface and near the comers of the channel and assume their maximum value near the center of the bed. The maximum value on the banks occurs near the lower third point.

The graphs in Figures A8-11 and A8-12 may be used to evaluate maximum stress values on the banks and the bed respectively. These figures are to be used along with τ, the reference tractive stress, to obtain values for the maximum tractive stress on the sides and bed of trapezoidal channels in fine-grained soils.

3. Tractive stresses in curved reaches:

Figures A8-4 and A8-5, used to determine the maximum tractive stresses in curved reaches for coarse-grained soils, may also be used to obtain these values for fine grained soils. The values for the maximum tractive stresses on the beds and sides, as determined above, are used in conjunction with these charts to obtain values for curved reaches.

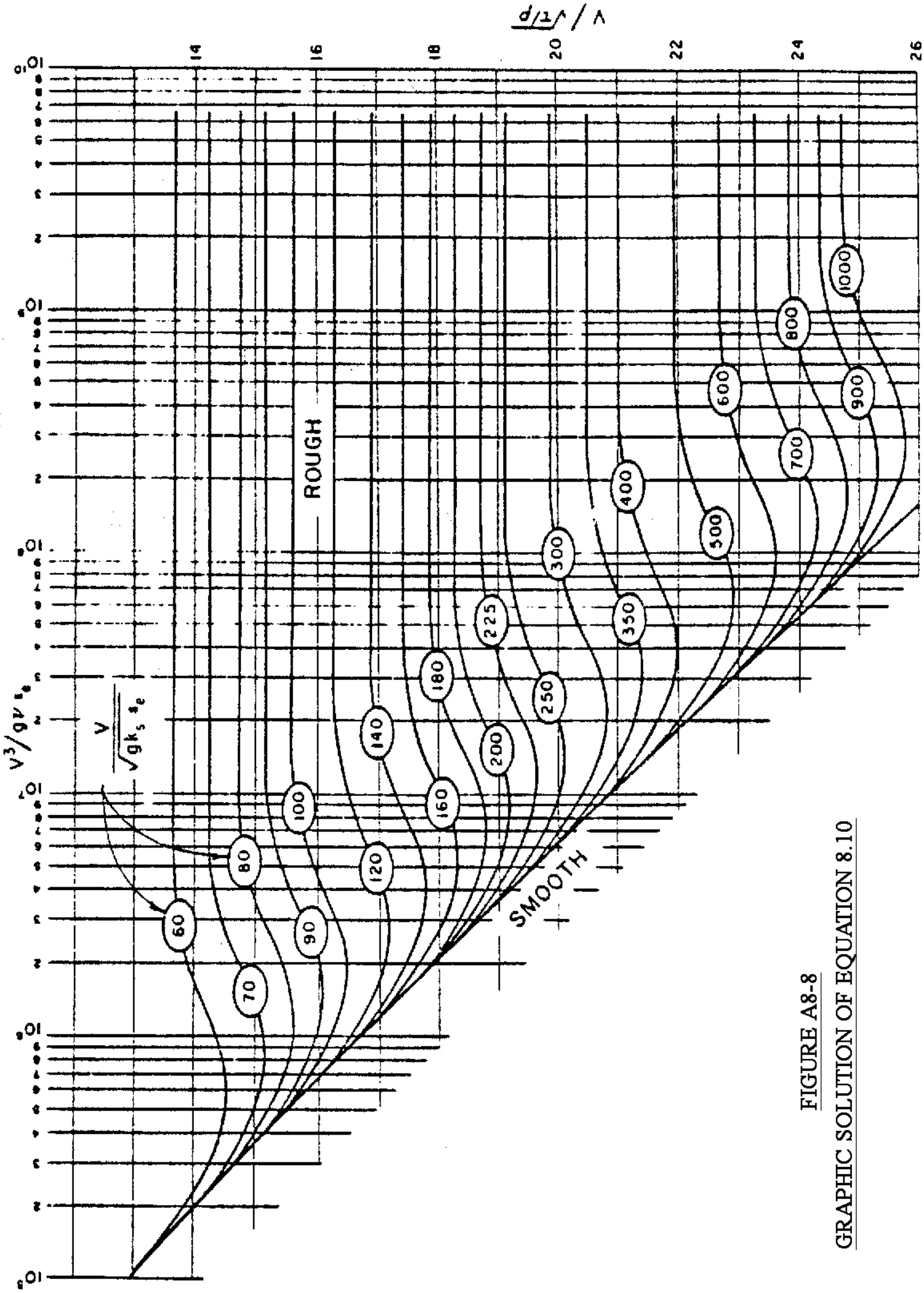


FIGURE A8-8
GRAPHIC SOLUTION OF EQUATION 8.10

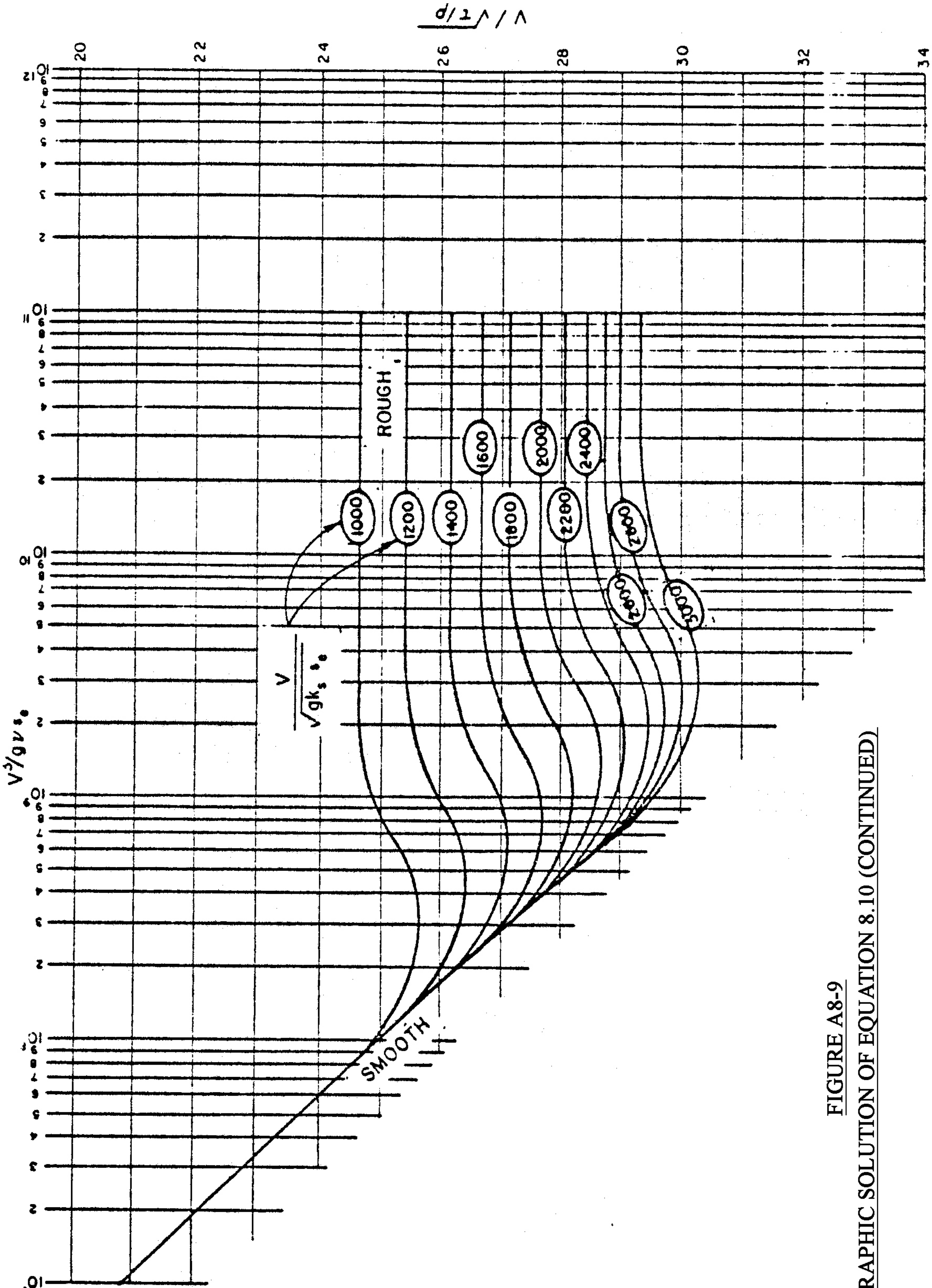
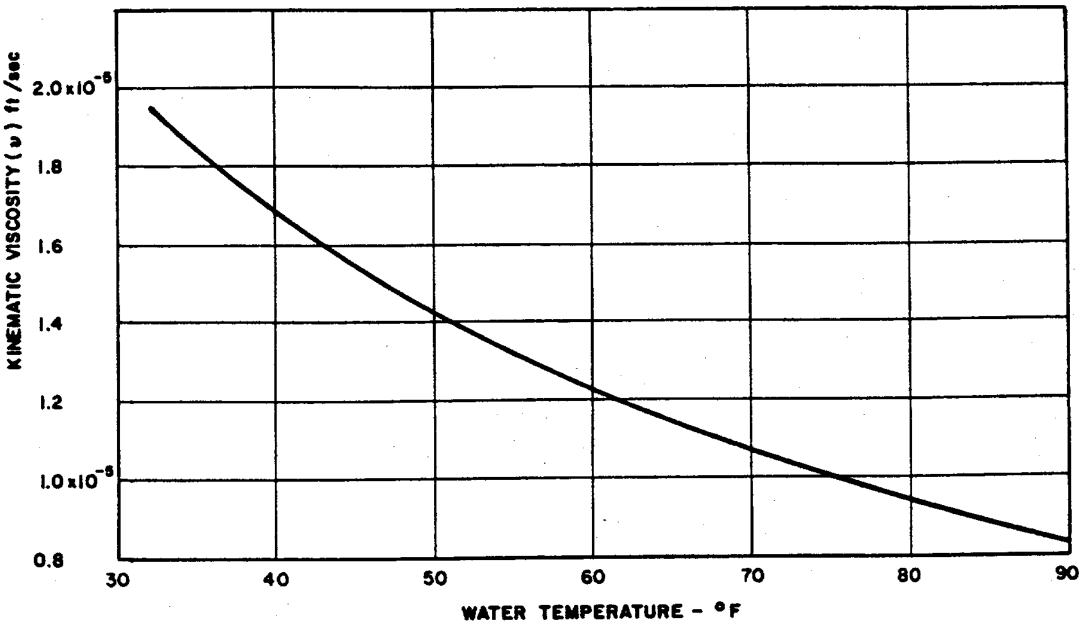


FIGURE A8-9

GRAPHIC SOLUTION OF EQUATION 8.10 (CONTINUED)



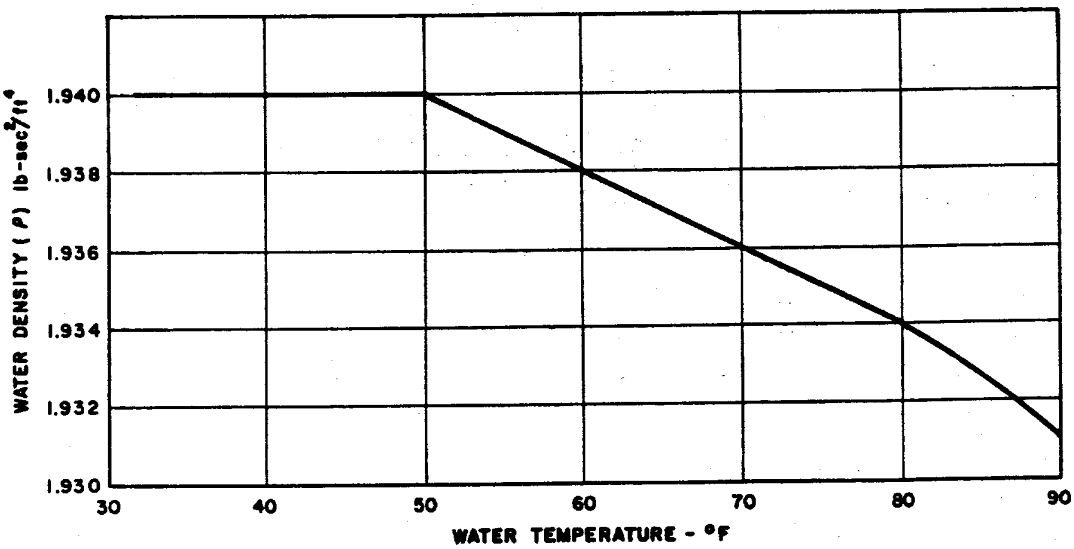


FIGURE A8-10

VALUES OF ρ AND ν FOR VARIOUS WATER TEMPERATURES

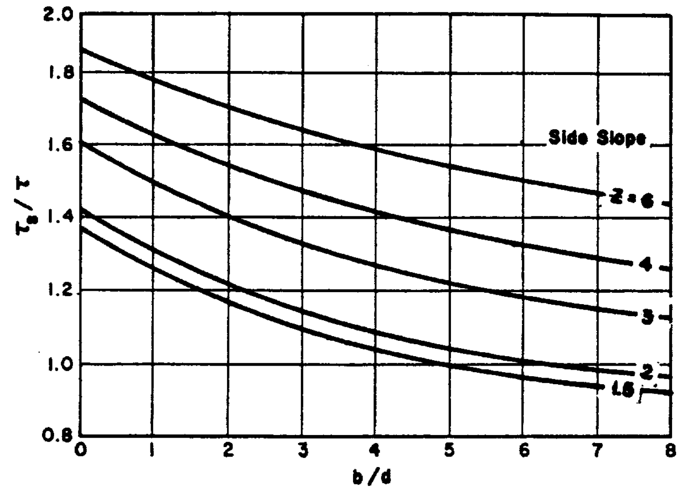


FIGURE A8-11
APPLIED MAXIMUM TRACTIVE STRESS, τ_s,
ON SIDES OF STRAIGHT TRAPEZOIDAL CHANNELS

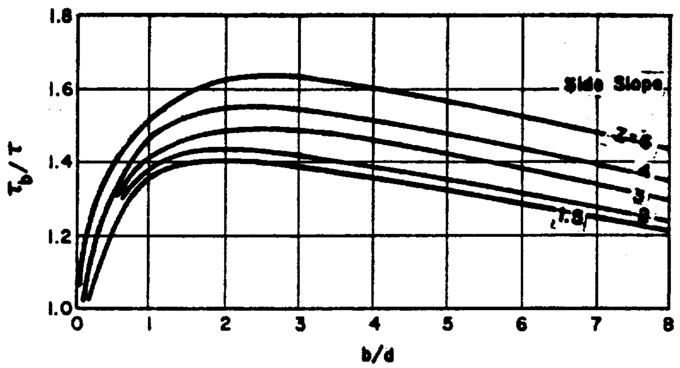


FIGURE A8-12
APPLIED MAXIMUM TRACTIVE STRESS, τ_b,
ON BED OF STRAIGHT TRAPEZOIDAL CHANNELS

Curves reproduced from "Tentative Design Procedure for Riprap Lined Channels" National Cooperative Highway Research Program Report No. 108

B. Allowable Tractive Stresses -Fine grained soils

The stability of channels in fine-grained soils (D_{75} <0.25") may be checked using the curves in Figure A8-13. These curves were developed by Lane a2. The curves relate the median grain size of the soils to the allowable tractive stress. Curve 1 is to be used when the stream under consideration carries a load of 20,000 ppm by weight or more of fine suspended sediment. Curve 2 is to be used for streams carrying up to 2,000 ppm by weight of fine suspended sediment. Curve 3 is for sediment-free flows (less than 1,000 ppm).

When the value of D_{50} for fine-grained soils is greater than 5 mm, use the allowable tractive stress values shown on the chart for 5 mm.

For values of D_{50} less than those shown on the chart (0.1 mm), use the allowable tractive stress values for 0.1 mm, However, if this is done, 0.1 mm should be used as the D_{65} size in obtaining the reference tractive stress.

<u>Procedure - Tractive Stress Approach</u>

The use of tractive stress to check the ability of earth channels to resist erosive stresses involves the following steps :

1. Determine the hydraulics of the channel. This includes hydrologic determinations as well as the stage-discharge relationships for the channel being considered.

2. Determine sediment yield to reach and calculate sediment concentration for design flow, or assume sediment free water.

3. Determine the properties of the earth materials in the boundary of the channel

4. Check to see if the tractive stress approach is applicable.

5. Compute the tractive stresses exerted by the flowing water on the boundary of the channel being studied. Use the proper procedure as established by the D_{75} size of the materials.

6. Check the ability of the soil materials forming the channel to resist the computed tractive stresses.

The computation for the reference tractive stress for fine grained soils is facilitated by using the following procedure:

1. Determine S_e and V: Evaluate Manning's "n" by the method described in Supplement A.

2. Enter the graphs in Figure A8-10 with the value of temperature in °F and read the density ρ, and the kinematics viscosity of the water υ.

3. Compute $\dfrac{V^3}{g\,\upsilon\, s_e}$

4. Compute $\dfrac{V}{\sqrt{g k_s s_e}}$

5. Enter the graph in Figure A8-8 (or Figure A8-9) with the computed values in steps 2 and 3 above and read the value of $\dfrac{V}{\sqrt{\tau / \rho}}$

6. Compute $\dfrac{v}{\sqrt{\tau / \rho}}$ from v and ρ

$$t = \frac{V^2 \rho}{(V / \sqrt{\tau / \rho})^2}$$ where the terms are defined in the glossary

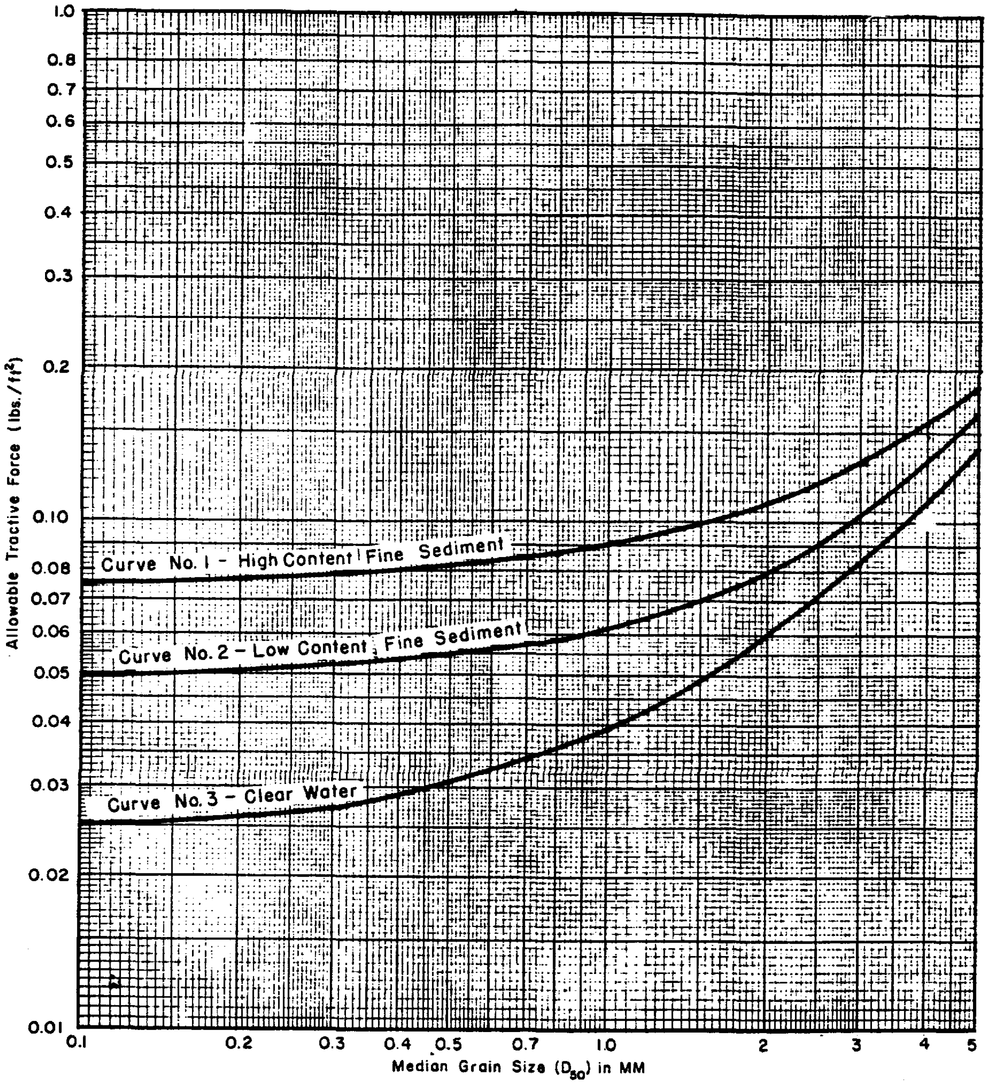


FIGURE A8-13

ALLOWABLE TRACTIVE STRESS -- NON-COHESIVE SOILS, $D_{75} < 0.25"$

REFERENCE: LANE, E. W., "DESIGN OF STABLE CHANNELS", TRANSACTIONS A.S.C.E., VOLUME 120

Examples - Tractive Stress Approach

Example 3

Given: The bottom width of the trapezoidal channel is 18 feet with side slopes of 1½H:1V. The design flow is 262 cfs at a depth of 3.5 feet and a velocity of 3.23 fps. The slope of the energy grade line is 0.0026. There is one curve in the reach, with a radius of 150 feet. The aged "n". Value is estimated to be 0.045. The channel will be excavated in GM soil that is nonplastic, with D_{75} = 0.90 inches (22.0 mm). The gravel is very angular.

Determine: The actual and allowable tractive stress.

Solution: Since D_{75} > ¼ inch uses the Lane method.

$n_t = (0.90)^{1/6}/39 = 0.0252$ (Eq. A8-1).

From Equation A8-3: s_t- $(n_t/n)^2 s_e = (0.025/0.045)^2\ 0.0026 = 0.00082$

actual $\tau_\infty = \gamma_w d s_t =$ (62.4) (3.5) (0.00082) = 0.179 psf.

b/d (ratio of bottom width to depth) = 18/3.5 = 5.14

From Figure A4-2 and A4-3 τ_s / τ_∞ = 0.76; τ_b / τ_∞ = 0.98.

R_c/b = (radius of curve/bottom width) = 150/18 = 8.33.

$\tau_{bc} / \tau_b = sc / s$ = 1.17 (Figure A8-4).

Actual τ_b = (0.179) (0.98) = 0.175 psf;

actual τ_s = (0.179) (0.76) = 0.136 psf

Actual τ_{bc} = {0.175) (1.17) = 0.205 psf;

actual τ_{sc} = (0.136) (1.17) = 0.159 psf

Solving for allowable tractive stress -

φR = 38.4º (Figure A8-6). K = 0.45 (Figure A8-7),

Allowable: τ_{Lb} = (0.4) (D_{75}) = (0.4)(0.90) = 0.36

Allowable: τ_{Ls} = 0.4 K D_{75} = (0.4) (0.45) (0.90) = 0.162

Comparing actual with allowable, the channel will be stable in straight and curved sections,

Example 4

Given: Bottom width of the trapezoidal section is 18 feet, side slopes are 1½: 1. Design flow is 262 cfs, with a depth of 3.5 feet at a velocity of 3.23 fps. Slope of the hydraulic grade line is 0.0026. The design temperature is 50°F. The channel will be cut in nonplastic SM soil, with a D_{75} size of 0.035 inches, a D_{65} size of 0.01075 inches (0.273 mm) and a D_{50} of 0.127 mm. The "n" value for the channel is 0.045. There are no curves in the reach. Sediment load is quite light in this locality, in the range of clear water criteria.
Determine: The actual tractive stress and the allowable tractive stress.

Solution: Since the D_{75} size is less than $^1/_4$ inch, use the reference tractive stress method.

$V = 1.42 \times 10^{-5}$ ft²/sec., $\rho = 1.940$ lb sec²/ft⁴ (Figure A8-10).

$V^3 / gv\, s_e = 3.23^3/ (32.2)(1.42 \times 10^{-5})(0.0026) = 2.83 \times 10^7.$

$$V / \sqrt{g k_s s_e} = 3.23 / \sqrt{(32.2)(0.01075/12)(0.0026)} = 373$$

$V / \sqrt{\tau / \rho} = 21.6$ (From Figure A8.8)

$$\tau = V^2 \rho / (V / \sqrt{\tau/\rho})^2 \qquad = (3.23^2)\, 1.94 / (21.6)^2 = 0.0434 \text{ psf.}$$

b/d (ratio of bottom width to depth) = 18/3.5 = 5.14

$\tau_s / \tau \approx 1.0 \qquad \tau_b / \tau = 1.31$ (From Figure A8-11 and A8-12)

Actual Tractive Stresses:

τ_s = (0.0434) (1.0) = 0.0434 psf; τ_b = (0.0434) (1.31) = 0.0569 psf

Allowable Tractive Stresses:

D_{50} = 0.127 mm; from Figure A4-13 and assuming clear water flow (curve No.3) the allowable tractive force is 0.025 psf. Both the bed and the banks of the channel are unstable.

GLOSSARY OF SYMBOLS

A - Alignment factor to adjust the basic velocity because of the effects of curvature of the channel

A - area of flow. (ft^2)

b - bottom width of a channel (feet).

b_T - water surface width (feet).

B - bank slope factor to adjust the basic velocity because of the effects of different bank slopes

C - sediment concentration in parts per million by weight.

C_1, C_2, C_3, C_4, C_5 - coefficients used to determine channel proportions and slope when using the modified regime equations.

C_e - Density factor to adjust the basic velocity because of variations in the density of soil materials in the channel boundary.

c_m - cohesion intercept at natural moisture (pst).

d - depth of flow (feet).

d_c - critical depth of flow (feet).

d_m - mean depth of flow (feet).

D - depth factor to adjust basic velocity because of the effects of the depth flow.

D_s - the particle diameter of which s% of the sample is smaller.

F - frequency factor to adjust the basic velocity because of the effect of infrequent flood flows.

F - Froude number = $\frac{V}{\sqrt{gd_m}}$

g - acceleration due to gravity (fps2)

G - specific gravity,

H_c - depth of tension crack (feet).

k_s - characteristic length of roughness element, for granular material; $K_s = D_{65}$ size in feet.

K - coefficient modifying tractive force for gravitational forces on coarse, noncohesive materials on channel sides.

n - Manning's coefficient.

n_t - Manning's coefficient for toughness of soil grains.

P - wetted perimeter

P_I - Plasticity index.

q_u - unconfined compressive strength

Q - discharge (cfs).

Q_s - Sediment transport rate (tons/day)

R - hydraulic radius (feet)

R_c - radius of curvature of central section of compound curve,

R_t - hydraulic radius associated with grain roughness of the soil.

S_o - slope of channel bottom.

S_c - critical slope.

S_e - energy gradient

S_t - rate of friction head loss because of tractive stress acting on bed and side materials.

V - average velocity (fps).

V_a - allowable velocity (fps).

V_b - basic velocity (fps).

V_c - critical velocity (fps).

W_T - top width of flow (feet)

x - factor-describing effect of ratio $\frac{k_s}{\delta}$ on flow resistance.

z - cotangent of side slope angle

T - factor to correct allowable tractive force for materials with D_{75} > 0.25" for unit weights different than 160 lbs/ft^3.

γ_d - unit weight of water (lbs/ft^3).

γ - dry unit weight (lbs/ft^3)

γ_m - moist unit weight (lbs/ft^3)

γ_s - unit weight of particles larger than 0.25" (lbs/ft^3),

γ_w - unit weight of water (62.4 lbs/ft^3)

δ - thickness of laminar sublayer = $\frac{11.6v}{\sqrt{gR_t s_e}}$

φ - angle of shearing resistance

φ_m - angle of shearing resistance at natural moisture content.

φ_r - angle of repose of coarse noncohesive materials.

v - kinematics' viscosity of water (ft^2/sec).

ρ - water density ($lb\text{-}sec2/ft^4$).

τ - reference tractive stress (psf).

τ_∞ - tractive stress in an infinitely wide channel (psf).

τ_b - maximum tractive stress on the channel bed (psf).

τ_s - maximum tractive stress on the channel sides (psf)

τ_{bc} - maximum tractive stress on the bed in a curved reach (psf).

τ_{sc} - maximum tractive stress on the sides in a curved reach (psf).

τ_{Lb} - allowable tractive stress along the bed. (psf)

τ_{Ls} - allowable tractive stress along the sides (psf).

SUPPLEMENT A

Method for Estimating Manning's "n"

This supplement describes a method for estimating the roughness coefficient "n" for use in hydraulic computations associated with natural streams, floodway and similar streams. The procedure proposed applies to the estimation of n in Manning's formula. This formula is now widely used; it is simpler to apply than other widely recognized formulas and has been shown to be reliable.

Manning's formula is empirical. The roughness coefficient "n" is used to quantitatively express the degree of retardation of flow. The value of "n" indicates not only the roughness of the sides and bottom of the channel, but also other types of irregularities of the channel and profile. In short, "n" is used to indicate the net effect of all factors causing retardation of flow in a reach of channel under consideration.

There seems to have developed a tendency to regard the selection of "n" for natural channels as either an arbitrary or an intuitive process. This probably results from the rather cursory treatment of the roughness coefficient in most of the more widely used hydraulic textbooks and handbooks. The fact is that the estimation of "n" requires the exercise of critical judgment in the evaluation of the surfaces of the channel sides and bottom; variations in shape and size of cross sections; obstructions; vegetation; and meandering of the channel.

The need for realistic estimates of "n" justifies the adoption of a systematic procedure for making the estimates.

Procedure for estimating n. The general procedure for estimating "n" involves; first, the selection of a basic value of "n" for a straight, uniform, smooth channel in the natural materials involved; then, through critical consideration of the factors listed above, the selection of a modifying value associated with each factor. The modifying values are added to the basic value to obtain "n" for the channel under consideration.

In the selection of the modifying values associated with the five primary factors, it is important that each factor be examined and considered independently. In considering each factor, it should be kept in mind that represents a quantitative expression of retardation of flow. Turbulence of flow can, in a sense, be visualized as a measure or indicator of retardance. Therefore, in each case, more critical judgment may be exercised if it is recognized that as conditions associated with any factor change so as to induce greater turbulence, there should be an increase in the modifying value. A discussion and tabulated guide to the selection of modifying values for each factor is given under the following procedural steps.

First Step. Selection of basic "n" value. This step requires the selection pf a basic "n" value for a straight, uniform, smooth channel in the natural materials involved. The selection involves consideration of what may be regarded as a hypothetical channel. The conditions of straight alignment, uniform cross section, and smooth side and bottom surfaces without vegetation should be kept in mind. Thus, the basic "n" will be visualized as varying only with the materials forming the sides and bottom of the channel. The minimum values of "n" shown by reported test results for the best channels in earth are in the range from 0.016 to 0.018. Practical limitations associated with maintaining smooth and uniform channels in earth for any appreciable period indicated that 0.02 is a realistic basic "n". The basic "n", as it is intended for use in this procedure, for natural or excavated channels, may be selected from the table below. Where the bottom and sides of a channel are of different materials, this fact may be recognized in selecting the basic "n",

CHARACTER OF CHANNEL	BASIC n
Channels in earth	0.020
Channels cut into rock	0.025
Channels in fine gravel	0.024
Channels in coarse gravel	0.028

Second Step. Selection of modifying value for surface irregularity. The selection is to be based on the degree of roughness or irregularity of the surfaces of channel sides and bottom. Consider the actual surface irregularity; first, in relation to the degree of surface smoothness obtainable with the natural materials involved, and second, in relation to the depths of flow under consideration. Actual surface irregularity comparable to the best surface to be expected of the natural materials involved calls for a modifying value of zero. Higher degrees of irregularity induce turbulence and call for increased modifying values. The table below may be used as a guide to the selection.

DEGREE OF IRREGULARITY	SURFACES COMPARABLE TO	MODIFYING VALUE
Smooth	The best obtainable for the materials involved.	0.000
Minor	Good dredge channels; slightly eroded or scoured side slopes of canals or drainage channels.	0.005
Moderate	Fair to poor dredged channels; moderately sloughed or eroded side slopes of canals or drainage channels.	0.010
Severe	Badly sloughed banks of natural channels; badly eroded or sloughed sides of canals or drainage channels; unshaped, jagged and irregular surfaces of channels	0.020

	excavated in rock.	

Third Step. Selection of modifying value for variations in shape and size of cross sections. In considering changes in size of cross sections, judge the approximate magnitude of increase and decrease in successive cross sections as compared to the average. Changes of considerable magnitude, if they are gradual and uniform, do not cause significant turbulence. The greater turbulence is associated with alternating large and small sections where the changes are abrupt. The degree of effect of size changes may be best visualized by considering it as depending primarily on the frequency with which large and small sections alternate, and secondarily on the magnitude of the changes.

In the case of shape variations, consider the degree to which the changes cause the greatest depth of flow to move from side to side of the channel. Shape changes causing the greatest turbulence are those for which shifts of the main flow from side to side occur in distances short enough to produce eddies and upstream currents in the shallower portions of those sections where the maximum depth of flow is near either side. Selection of modifying values may be based on the following guide:

CHARACTER OR VARIATIONS IN SIZE AND SHAPE OF CROSS SECTIONS	MODIFYING VALUE
Changes in size or shape occurring gradually	0.000
Large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side	0.005
Large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side	0.010 to 0.015

Fourth Step. Selection of modifying value for obstructions. The selection is to be based on the presence and characteristics of obstructions such as debris deposits, stumps, exposed roots, boulders and fallen and lodged logs. Care should be taken that conditions considered in other steps are not re-evaluated or double-counted by this step.

In judging the relative effect of obstructions, consider: the degree to which the obstructions occupy or reduce the average cross sectional area at various stages; the character of obstructions (sharp-edged or angular objects induce greater turbulence than curved, smooth-surfaced objects); the position and spacing of obstructions transversely and longitudinally in the reach under consideration. The following table may be used as a guide to the selection.

RELATIVE EFFECT OF OBSTRUCTIONS	MODIFYING VALUE
Negligible	0.000
Minor	0.010 to 0.015
Appreciable	0.020 to 0.030
Severe	0.040 to 0.060

Fifth Step. Selection of modifying value for vegetation. The retarding effect of vegetation is probably due primarily to the turbulence induced as the water flows around and between the limbs, stems and foliage, and secondarily to reduction in cross section. As depth and velocity increase, the force of the flowing water tends to bend the vegetation. Therefore, the ability of vegetation to cause turbulence is partly related to its resistance to bending force. Furthermore, the amount and character of foliage; that is, the growing season condition versus dormant season condition is important. In judging the retarding effect of vegetation, critical consideration should be given to the following: the height in relation to depth of flow; the capacity to resist bending; the degree to which the cross section is occupied or blocked out; the transverse and longitudinal distribution of vegetation of different types, densities and heights in the reach under consideration. The following table may be used as a guide to the selection:

VEGETATION AND FLOW CONDITIONS COMPARABLE TO:	DEGREE OF EFFECT ON n	RANGE IN MODIFYING VALUE
Dense growths of flexible turf grasses or weeds, of which Bermuda and bluegrasses are examples, where the average depth of flow is 2 to 3 times the height of vegetation. Supple seedling tree switches such as willow, cottonwood or salt cedar where the average depth of flow is 3 to 4 times the height of the vegetation.	Low	0.005 to 0.010
Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation. Stemmy grasses, weeds or tree seedlings with moderate cover where the average depth of flow is 2 to 3 times the height of vegetation	Medium	0.010 to 0.025
Brushy growths, moderately dense, similar to willows 1 to 2 years old, dormant season, along side slopes of channel with no significant vegetation along the channel bottom, where the hydraulic radius is greater than 2 feet. Turf grasses where the average depth of flow is about equal to the height of vegetation. Dormant season, willow or cottonwood trees 8 to 10 years old, intergrown with some weeds and brush, none of the vegetation in foliage, where the hydraulic radius is greater than 2 feet. Growing season, bushy willows about 1 year old intergrown with some weeds in full foliage along side slopes, no significant vegetation along channel bottom, where hydraulic radius is greater than 2 feet.	High	0.025 to 0.050
Turf grasses where the average depth of flow is less than one half the height of vegetation. Growing season, bushy willows about I year old,	Very High	0.050 to 0.100

intergrown with weeds in full foliage along side slopes; dense growth of cattails along channel bottom; any value of hydraulic radius up to 10 to 15 feet. Growing season; trees intergrown with weeds and brush, all in full foliage, any value of hydraulic radius up to 10 to 15 feet		

<u>Sixth step</u>. Determination of the modifying value for meandering of channel. The modifying value for meandering may be estimated as follows: Add the basic "n" for Step 1 and the modifying values of Steps 2 through 5 to obtain the subtotal of n_s,.

Let $_s$ = the straight length of the reach under consideration.

$_m$ = the meander length of the channel in the reach.

Compute modifying value for meandering in accordance with the following Table:

Ratio (*m l* s)	Degree of meandering	Modifying Value
1.0 to 1.2	Minor	0.000
1.2 to 1.5	Appreciable	0.15 n_s
1.5 and greater	Sever	0.30 n_s

Where lengths for computing the approximate value of *m/*s are not readily obtainable, the degree of meandering can usually be judged reasonably well.

<u>Seventh step</u>. Computation of "n" for the reach. The value of "n" for the reach is obtained by adding the values determined in Steps 1 through 6. An illustration of the estimation of "n" is given in Example 1.

<u>Example 1. Estimation of “n” for a reach.</u>

This example is based on a case where "n" has been determined so that comparison between the estimated and actual "n" can be shown.

Channel: Camp Creek dredged channel near Seymour, Illinois; see USDA Technical Bulletin No 129, Plate 29-C for photograph and Table 9, page 86, for data.

Description: Course straight; 661 feet long. Cross section, very little variation in shape; variation in size moderate, but changes not abrupt. Side slopes fairly regular, bottom uneven and irregular. Soil, lower part yellowish gray clay; upper part, light gray silty clay loam. Condition, side slopes covered with heavy growth of poplar trees 2 to 3 inches in diameter, large willows and climbing vines; thick growth of water weed on bottom; summer condition with vegetation in full foliage.

Average cross section approximates a trapezoid with side slopes about 1.5 to 1 and bottom width about 10 feet. At bankfull stage, average depth and surface width are about 8.5 and 40 feet respectively.

STEP	REMARKS	MODIFYING VALUES
1	Soil materials indicate minimum basic n	0.02
2	Description indicates moderate irregularity.	0.01
3	Changes in size and shape judged insignificant.	0.00
4	No obstructions indicated.	0.00
5	Description indicates very high effect of vegetation.	0.08
6	Reach described as straight.	0.00
	Total estimated n	0.11

USDA Technical Bulletin No.129, Table 9, page 96, give the following determined values for NJDOT for this channel: for average depth of 4.6 feet "n" = 0.095; for average depth of 7.3 feet n = 0.104.

Appendix A-9

Modified Rational Method

The Soil Conservation Service Technical Release No.55, (TR-55), Urban Hydrology for Small Watersheds methodology can determine peak flows from areas of up to five (5) square miles, provide a hydrograph for times of concentration of up to 2 hours, and estimate the required storage for a specified outflow. However, there is another method, which can estimate peak flows and the required storage. For small drainage areas up to one-half square mile, the Rational Method (Q=CIA, where Q is the runoff in cfs, "I" is the intensity of rainfall in inches/hour for the time of concentration of the drainage area, "A" is the area in acres, and "C" is a dimensionless runoff coefficient) can determine the peak flow rate only. The Modified Rational Method (MRM) as discussed in the American Public Works Association's Special Report 43 can give an approximate storage volume and triangular and trapezoidal hydrographs. This method is applicable for uniform areas up to twenty (20) acres.

THEORY

The area under a hydrograph equals the volume of runoff. For the Modified Rational Method, this area is equal to the peak discharge rate times the duration of the storm. Uniform rainfall intensity for the entire rainfall period is assumed here. This is highly unlikely.

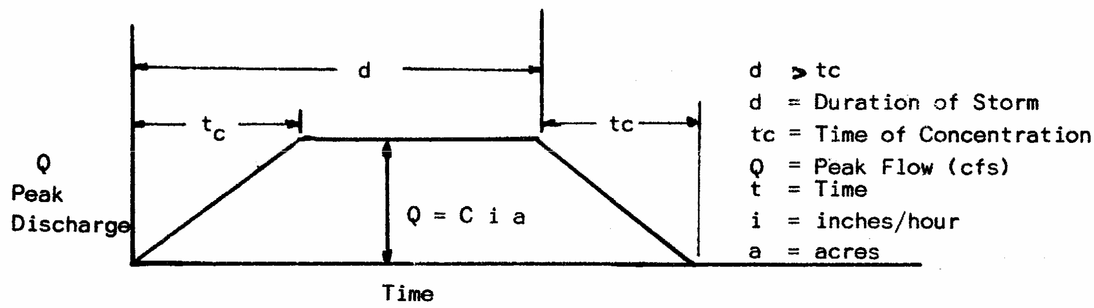
The MRM recommends that a coefficient be used in order to account for the antecedent moisture conditions of storms greater than those with a twenty-five (25) year recurrence intensity (Q=ca x c x i x a). This attempts to predict a more realistic runoff volume which is characteristic of higher frequency storms. The maximum product of ca x c cannot be greater than one.

Recommended Antecedent Precipitation Factors for the Rational Method

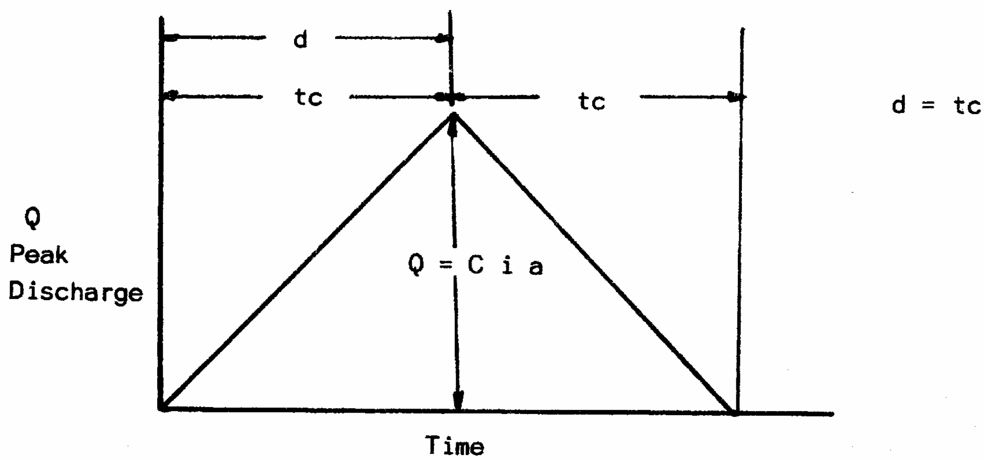
Recurrence Interval (years)	ca
2 to 10	1.0
25	1.1
50	1.2
100	1.25

The time of concentration (tc), which is the time of travel from the most remote point (in time of flow), determines the largest peak discharge. Therefore, there are two possible approximate hydrographs that can be used for runoff and storage requirements.

FIRST CASE: If the rainfall duration is greater than the tc, then the approximate hydrograph is a trapezoid.



SECOND CASE If the rainfall duration is equal to the time of concentration (assuming the tc is the same as in the first case), then the approximate hydrograph is a triangle.



To find the required volume, the MRM uses a trial method to find the critical storage for a given drainage area. For instance, the peak rate for a 25-year storm is the product of the runoff coefficient times the drainage area in acres times the intensity of a 25-year storm for a given time of concentration. However, the critical storage volume may be that of a different duration.

There are three steps in the MRM. The first step is to collect the physical data for the drainage area. This is the drainage area, the time of concentration, the runoff coefficient, and the allowable release rate. The second step is to obtain the proper recurrence interval for the design storm and the intensity-duration relationship for the design frequency. Then calculate a series off-peak flows and runoff volumes beginning with the time of concentration of the drainage area and for increased storm durations. The third step is to compute the release volume and the required storage until the maximum or critical storage is found.

EXAMPLE

First Step. A site to be developed has a ground cover of forest with light underbrush. The soil type for the site is Evesboro soil (sand), hydrologic soil group A. The predeveloped site drains into two drainage areas. The southern portion consists of 6.39 acres. The northern portion consists of 8.07 acres. In order to minimize the effect of increased storm water runoff downstream, possibly resulting in soil erosion and sedimentation damage, an onsite detention basin is proposed for the developed condition. Grading of the site will cause the southern drainage area to increase to 11.88 acres. Since the NJDEP curves do not contain the 2 year frequency, the intensity-duration curves for New York City were used in the analysis. A summary of the times of concentration and drainage areas is as follows:

<u>Southern Portion</u>

Storm (Years)	Predeveloped Condition					Postdeveloped Condition				
	Acres	tc	C	i	Q	Acres	tc	C	i	Q
2	8.07	0.35	0.22	2.5	4.4	11.88	0.25	0.7	2.9	24
10	8.07	0.35	0.22	4.0	7.1	11.88	0.25	0.7	4.7	39

Where tc is hours, i is inch/hour, and Q is cfs.

Second step. Stability is demonstrated offsite by analyzing the velocity for stormwater runoff for the two and ten-year storms over a defined waterway. These frequencies are chosen because of their high probability of occurrence. Outflow from a detention basin must meet the Conduit Outlet Protection, Slope Protection, and Channel Stabilization Standards. Stability to the point of discharge to a stream or body of water should be shown in all cases. In this example it was assumed that it was not possible to obtain drainage easement to accomplish this and therefore the discharge from the proposed outlet at the detention basin must match the predevelopment peak flow at that point. The allowable release rate is therefore the predevelopment peak flow for the 2 and 10-year frequency storms at the proposed point of discharge.

tc = 10 minutes
C = 0.18 for the predeveloped drainage area at that point of future discharge
a = 0.93 acres (not 8.07 acres)

i = 5.5 inches per hour (10-year frequency)

Q = C x i x a
= 0.18 x 5.5 x 0.93
= 0.92 cfs predevelopment peak at the point of discharge which is the allowable release rate.

Third step. Construct a series of hydrographs for each selected duration of the storm as shown in figure A9.1, Modified Rational Method Hydrographs. The estimated critical storage for this site is 88,858 cubic feet. Since the inflow volume must equal the outflow volume of 98,794 cubic feet, the time to the end of the release rate is 30.3. To reach zero outflows approximately 0.5 hours must be added so the total dewatering time will be about 30.3 hours. The outflow hydrograph reaches maximum flow at the intersection with the falling limb of the hydrograph resulting from a storm with duration equal to the time of concentration.

Table A9.2: Storage Duration Values

Storage-Duration Values					
Duration Of Storm (hr) (1)	Intensity I (in/hr) (2)	Peak Flow Q (cfs) (3)	Volume Of Runoff (cu ft) (4)	Release Flow Volume (cu ft) (5)	Required Storage Volume (cu ft) (6)
0.25	4.8	39.9	35,925	828	35,097
0.50	3.4	28.3	50,894	1,656	49,238
0.75	2.7	22.5	60,624	2,484	58,140
1.00	2.3	19.1	68,856	3,312	65,544
1.50	1.7	14.1	76,341	4,968	71,373
2.00	1.4	11.6	83,825	6,624	77,201
3.00	1.1	9.1	98,794	9,936	88,858*
3.50	0.9	7.5	94,303	11,592	82,711

* Maximum Storage Volume Required.

Column (3) Peak Flow = Q = c i a
Example: 0.7 X 4.8 X 11.88 = 39.9 cfs

Column (4) Runoff Volume = Q (col. 3) X Duration of Storm (col. I) X 3600
Example: 39.9 cfs X 0.25 hrs X 3600 = 35,925 cu ft

Column (5) Release Volume = 0.92 cfs X Duration of Storm (col. I) X 3600
Example: 0.92 X 0.25 X 3600 = 828 cu ft

Column (6) Required Storage = Runoff Volume (col. 4) -Release Volume (col. 5)
Example: 35,925 -828 = 35,097

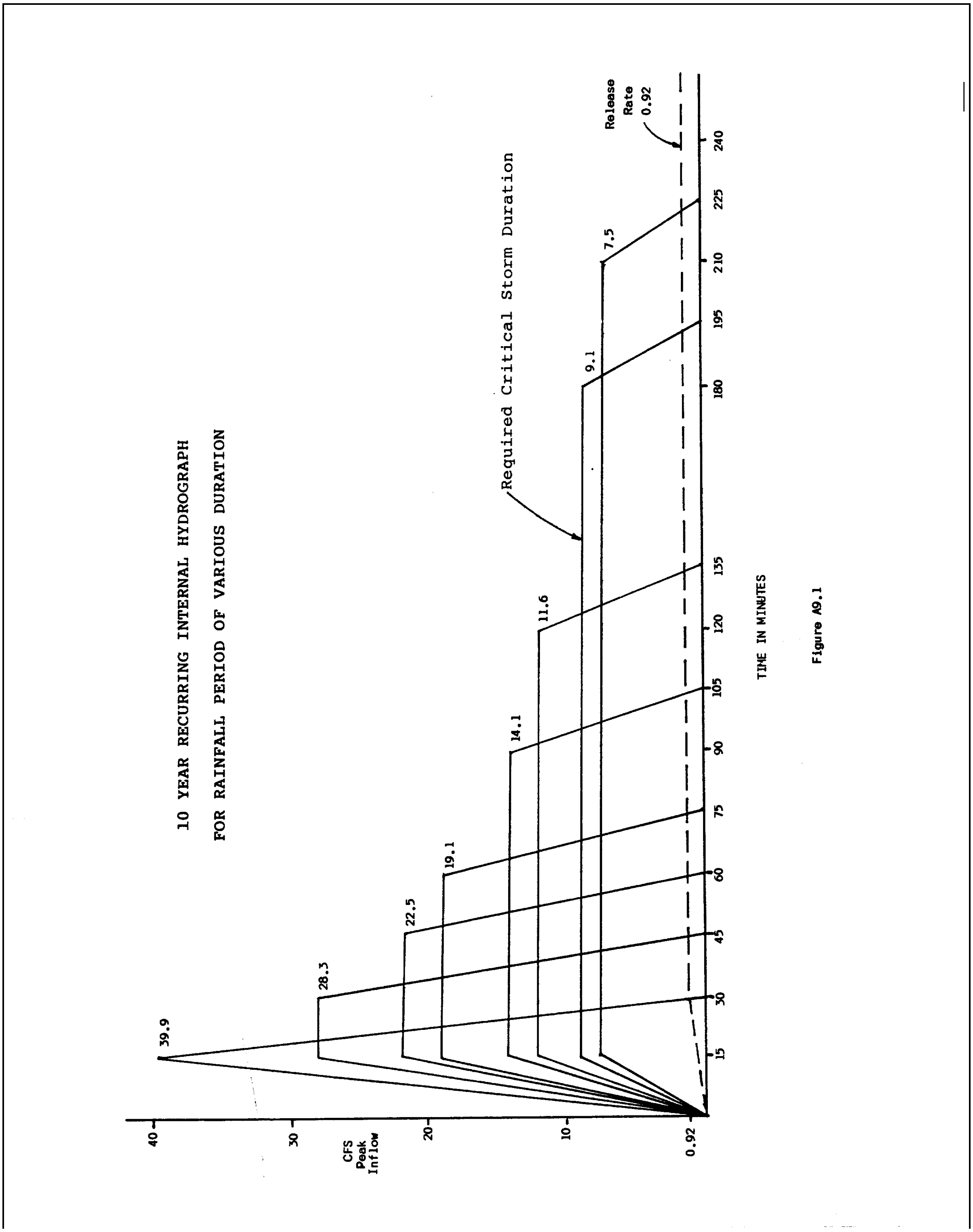

10 YEAR RECURRING INTERNAL HYDROGRAPH
FOR RAINFALL PERIOD OF VARIOUS DURATION
Required Critical Storm Duration
Release Rate 0.92
39.9
28.3
22.5
19.1
14.1
11.6
9.1
7.5
CFS Peak Inflow
40
30
20
10
0.92
15
30
45
60
75
90
105
120
135
180
195
210
225
240
TIME IN MINUTES

Figure A9.1

APPENDIX A-10 SOIL BIO-ENGINEERING

TABLE 4 - Types and Causes of Erosion

TYPES OF EROSION AND CAUSES OF EROSION	
Type of Erosion	**Causes**
Toe erosion and upper	Removal of unconsolidated or noncohesive lower materials, especially bank failure along outside bends. Widespread toe erosion may be associated with bed lowering.
General bed degradation (Bed scour over extended channelization, reaches)	Changes in stream gradient due to factors such as lowering of stream base level due to lake or tailwater fluctuations, stream or stream relocation. Increased stream discharge due to flow diversion or watershed changes such as urbanization.
Headcutting	In streams undergoing bed degradation, headcuts often develop at locations where more resistant materials outcrop in the stream channel. Headcuts may develop at a stream mouth when base level is lowered suddenly due to dredging, erosion or draining of a lake.
Middle and upper general bank scour	Increased discharge resulting from watershed changes; increased flow velocities caused by reduction in channel roughness or increases gradients; removal or loss of bank vegetation.
Local streambank scour	Scour of local lenses or deposits of unconsolidated material- ,erosion by secondary currents caused by flow obstructions and channel irregularities-, loss of bank vegetation.
Local bed scour	Local bed scour may be caused by channel constrictions, flow obstructions such as debris dams or flow deflectors, or trapping of sediment in reservoirs or sediment traps. Some scour generally occurs below culverts.

Piping	Piping develops when fines are removed by water flowing laterally under the surface. Extensive pipe development requires 1) rapid infiltration, 2) steep hydraulic gradients, and 3) *zones of* concentrated flow. Piping may occur in stratified soils where vertical movement is restricted by sudden reduction in hydraulic conductivity between strata or where poorly compacted soil around buried pipes provides conduits for water movement.
Overbank runoff	Failure to provide adequate means of directing concentrated flows from overbank areas into the channel.

Prepared by: Robbin B. Sotir- & Associates

Species	Habitat [1]	Bank Zone [2]	Root Form [3]	Shade [4] Tolerance	Flood [5] Tolerance	pH range [6]	Comments
Alnus serrulata **Smooth alder**	nontidal	toe	rooted	medium	regular	5.5-7.5	Nitrogen fixer weak wooded
Amorpha fruitcosa **False indigo**	tidal fresh moist woods	lower-mid	rooted	low	seasonal	6.0-8.5	Req. full sun Drought tolerant
Aronia arbutifolia **Red chokeberry**	nontidal	lower-mid	rooted	medium	irregular seasonal	5.1-6.5	Drought tolerant
Aronia melanocarpa **Black chokeberry**	nontidal	mid-upper	rooted	low	irregular seasonal	5.1-6.5	Drought tolerant
Baccharis halimifolia **Groundsel bush**	tidal tidal fresh	mid-upper	rooted, unrooted	high	seasonal	7.0-8.5	M/F separate plants
Cephalanthus occidentalis **Buttonbush**	nontidal tidal fresh	toe	rooted unrooted	high	permanent	6.1-8.5	Tolerates brief drought
Celthra alnifolia **Sweet pepperbush**	tidal nontidal	mid-upper	rooted	high	seasonal	4.5-6.5	
Cornus amomum **Silky dogwood**	streambanks pond edges	lower-mid	rooted unrooted	medium	seasonal	5.5-8.5	Drought tolerant
Cornus racemosa **Gray dogwood**	streambanks pond edges	lower-mid	rooted unrooted	high	seasonal	5.5-8.5	Drought tolerant
Cornus serecia **Redosier dogwood**	streambanks pond edges	toe-mid	rooted unrooted	medium	seasonal	5.5-8.5	Drought tolerant
Ilex decidua **Possumhaw**	forested wetlands pond edges	lower-mid	rooted unrooted	high	irregular	4.0-6.0	M/F separate plants
Ilex glabra **Inkberry**	forested wetlands sandy woods	mid-upper	rooted	high	irregular inundation	4.5-6.0	M/F separate plants. Resists salt spray
Ilex verticulata **Winterberry holly**	tidal fresh forested wetland	lower-mid	rooted	high	seasonal	4.5-8.0	Drought tolerant
Itea virginica **Virginia sweetspire**	forested wetland streambanks	toe	rooted	high	regular	5.0-7.0	Tolerates some salt
Iva frutescens **Hightide bush**	tidal brackish	lower	rooted	low	regular	6.0-7.5	Tolerates 15ppt salt
Leucothe racemosa **Leucothe**	forested wetland miost woods	lower mid	rooted	high	regular	5.0-6.0	Tolerates some dry-down
Lindera benzoin **Spicebush**	seasonal wetlands floodplain	lower-mid	rooted	high	seasonal	4.5-6.5	Tolerates some drought
Lyonia ligustrina **Maleberry**	open woods	lower-mid	rooted	low	seasonal	4.0-6.0	Acid tolerant
Magnolia virginiana **Sweetbay magnolia**	stream borders forested wetland	lower-mid	rooted	high	irregular/ seasonal	4.0-6.5	Tolerates infreq. flooding by salt
Myrica cerifera	tidal fresh	mid-	rooted	high	regular	4.0-6.0	tolerates 10 ppt

Wax myrtle	brackish swales	upper					salt. N-fixing
Myrica pennsylvanica **Bayberry**	tidal fresh brackish nontidal	mid-upper	rooted	high	irregular-seasonal	5.0-6.5	Tolerates drought. N-fixer
Physocarpus opulifolius **Ninebark**	streamsides wood edges	low-mid	rooted	medium	seasonal		
Prunus pumila var. depressa **Dwarf sand cherry**	streamsides sandbars	mid-upper	rooted	low	irregular	6.5-8.5	native to Del. River. groundcover
Rhododendron viscosum **Swamp azalea**	forested wetlands	toe-low	rooted	medium	seasonal-regular	4.0-6.0	susceptible to disease
Rosa palustris **Swamp rose**	tidal fresh forested wetland streambank	toe-low	rooted	low	seasonal-regular		
Rhus typhina/glabra **Staghorn/Smooth sumac**	disturbed banks/dry sites	upper	rooted	low	irregular	6.1-7.0	tolerates some drought
Salix X cottetii **'Bankers' Dwarf willow**	streambank	toe-mid	unrooted rooted	medium	regular-permanent		introduced male hybrid. noninvasive
Salix discolor **Pussy willow**	streambank forested wetland	toe-mid	unrooted rooted	medium	regular-permanent	6.6-7.5	
Salix exigua **Sandbar willow**	streambank sandbars	toe	unrooted rooted	low	regular-permanent		
Salix purpurea **'Streamco' purple osier** willow	streambank	toe-upper	unrooted rooted	medium	regular-permanent	6.0-7.0	introduced noninvasive shrub
Sambucus canadensis **Elderber**ry	tidal fresh non-tidal wet meadow	low-mid	rooted-unrooted	high	irregular-seasonal	6.0-8.0	some salt tolerance tolerates drought
Spirea alba/tomentosa **Meadowsweet**	forested wetland	mid-upper	rooted	low	irregular	5.1-6.0	
Viburnum dentatum **Southern arrowwood**	tidal fresh non-tidal forested wetland	mid-upper	rooted unrooted	medium	seasonal	5.1-7.0	tolerates drought
Viburnum lentago **Nannyberry**	forested wetland	mid-upper	rooted unrooted	medium	seasonal		
Viburnum prunifolium **Blackhaw viburnum**	forested wetland	upper	rooted unrooted	medium	irregular	6.5-7.0	
Viburnum trilobum **American. cranberrybush**	forested wetlands	lower-mid	rooted unrooted	low	irregular-seasonal	6.0-7.5	tolerates drought

Footnotes:

1. Habitat:
   Native habitat of the plant.

2. Bank zone:
   toe - elevation of baseflow
   lower to mid - from base to two year flood elevation
   upper - above two year elevation to flood plain

3. Root form:
   rooted - use bare-root plants
   unrooted - use dormant cuttings/brush

4. Shade Tolerance:
   low -requires full sun
   medium - tolerates partial shade and full sun
   high - tolerates full shade and full sun

5. Flood tolerance:
   permanent - tolerates inundation or saturation 76-100% of the growing season.
   regular - tolerates inundation or saturation 26-75% of growing season.
   seasonal - tolerates inundation or saturation 13-25% of the growing season.
   irregular - tolerates inundation or saturation 5-12% of the growing season.

6. pH range:
   preferred range for successful plant establishment.

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