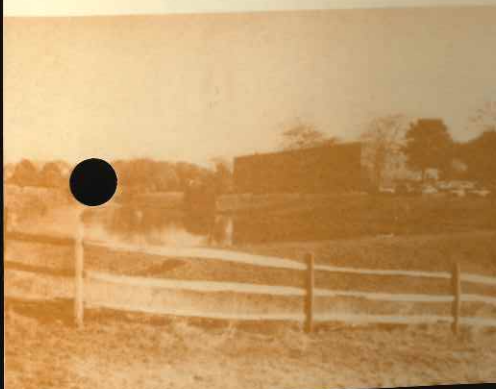
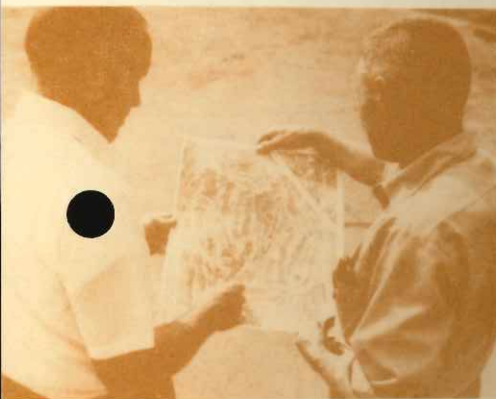
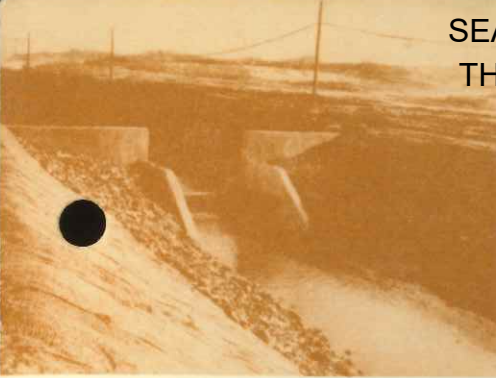
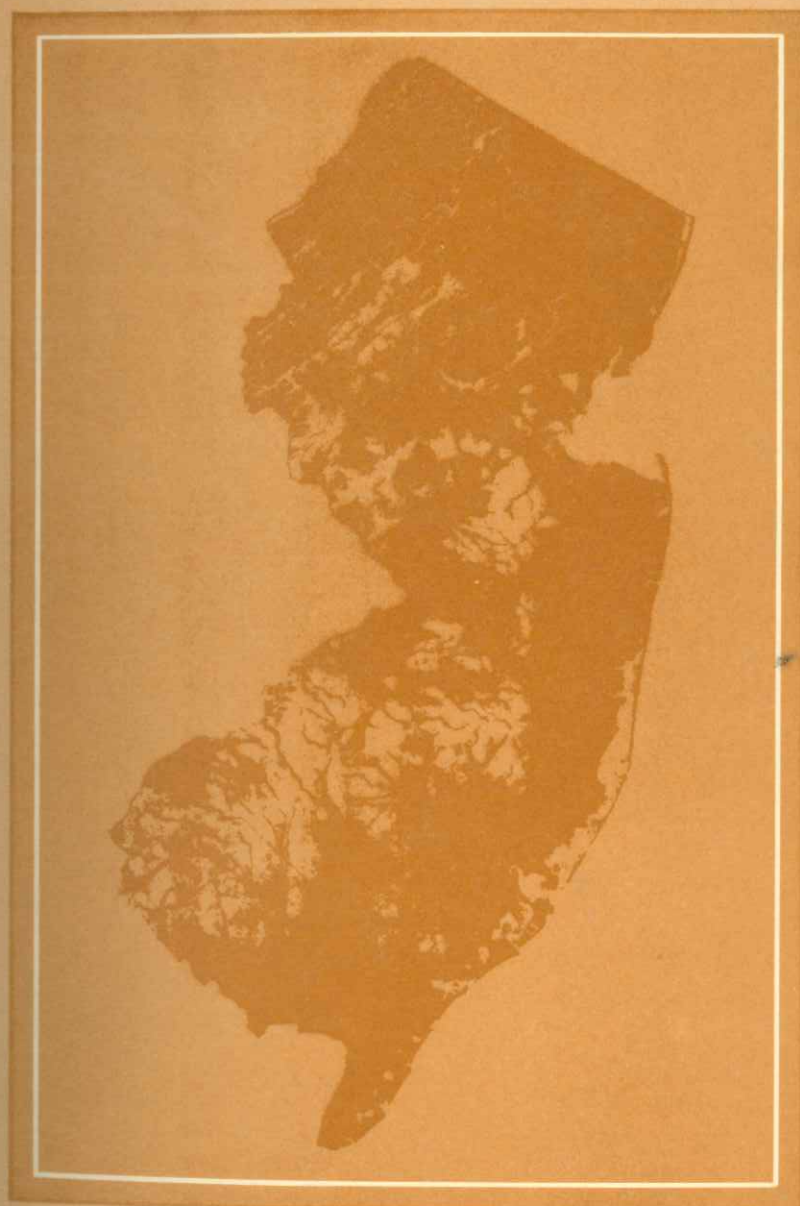




*Standards for*

# *Soil Erosion and Sediment Control in New Jersey*



## **DISCLAIMER**

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Mr. Minervini was not and is not affiliated with the State Soil Conservation Committee or the New Jersey Association of Conservation Districts, and was not asked by this Committee or Association to prepare this searchable PDF file.

S T A N D A R D S  
for  
SOIL EROSION AND SEDIMENT CONTROL IN NEW JERSEY  
APRIL 1987

Vegetative and Structural Standards, pages 3.1.1 to 4.20.2 inclusive, are promulgated as "Standards" pursuant to the Soil Erosion and Sediment Control Act of 1975 as amended, (NJSA 4:24-42), and New Jersey Administrative Code, (NJAC 2:90-1.1 et seq.).

by the

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## FOREWORD AND ACKNOWLEDGEMENTS

The extensive development of land in the State of New Jersey, our nation's most densely populated State, has often been accompanied by damage to our natural resources. One of the most serious damages is the erosion of soil by both wind and water. When soil is displaced unintentionally in this manner, problems are usually created in the area where the soil comes from and in the area where it is deposited. If a waterway or drainage facility is involved, silting of the stream or drainage facility occurs. The cost of correcting the resulting physical damage, pollution, and inconvenience is much greater than the cost of preventing soil erosion in the beginning. Fortunately, the technology for preventing soil erosion is well established and planners, engineers, developers, contractors and others are able to utilize this technology for both public and private benefit. The New Jersey State Soil Conservation Committee has responded to the need for control of such problems and is pleased to present the fifth edition of these Standards for public use.

Initially developed and published as guidelines and tools to prevent serious problems, these Standards are now the basis for implementing the Soil Erosion and Sediment Control Act of 1975 and its subsequent amendments. Virtually all major land disturbance activities are now required by State law to secure soil conservation district certification of a plan for control of soil erosion and sedimentation to prevent soil loss and offsite damages. The Standards, officially promulgated in accordance with the above mentioned Act, provide the basis for such plan certification by each of the soil conservation districts throughout the State.

The State Soil Conservation Committee wishes to acknowledge the expertise and assistance of the technical committee for continuing review and development of these standards listed on page ii. These experts and agency and association leaders have contributed extensively to the quality of this document.

Special acknowledgement is extended to officials of the Soil Conservation Service of the United States Department of Agriculture who have provided the primary basis for each of the Standards and guidelines incorporated herein. Developed through research and practical application, these technical devices, systems and practices have withstood the tests of trial and time and have been utilized throughout the nation for many years.

Special acknowledgement is also extended to the New Jersey Association of Conservation Districts which has cooperated in this effort and has published this fifth edition for distribution to the using public. Copies are available for purchase through each of the Soil Conservation Districts listed in Appendix E.

Samuel R. Race, Secretary  
State Soil Conservation Committee  
April 1987

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APRIL 1987

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## INTRODUCTION

Virtually all land disturbance activities in the state, such as construction of housing and industrial developments, highways, pipelines, land grading, and mining or quarrying activities, are required by NJSA 4:24-39 et seq. to incorporate control of soil erosion and sedimentation. The subsequent reduction of soil losses on construction sites and the reducing of associated damages from sedimentation results in substantial savings to the community, the contractors, the developer and to the landowner as well as providing for enhancement of the environment. The contractor who controls soil erosion during construction also promotes good will in the community.

While erosion and sediment control are important on all sites, particular attention should be given to areas of steep topography and highly erodible soils. Also the larger the disturbed area and the longer it is left unstabilized, the more serious the problem becomes.

Natural vegetation covers and protects most of our lands from erosion. Its removal necessitates application of alternative protective measures. Establishment of mechanical structures engineered to control water runoff, the application of artificial protective cover, or the rapid reestablishment of vegetation are among the methods suitable to control erosion and sedimentation.

The purpose of these Standards is to help those responsible for construction to control soil movement. The comprehensive erosion control techniques and devices which follow have been developed in cooperation with professional and technical personnel representing agencies and groups concerned with land disturbance activities and the control of soil erosion and sedimentation to provide this help. Interpretative assistance in their application and use is available through the soil conservation district where the land disturbance will take place. A district directory is included in Appendix E.



GUIDELINES  
FOR SOIL EROSION AND SEDIMENT CONTROL

Effective soil erosion and sediment control planning requires careful evaluation of the following factors prior to developing the plans for the specific site. The key planning objective is to retain soil on the site and minimize delivery of sediment offsite:

I. Factors to be considered in planning:

- a. erodibility of soils - information on soils characteristics may be found in the USDA "Soil Survey" available for most counties.
- b. existing drainage patterns.
- c. presence of steep slopes, stream corridors and other critical site factors.
- d. quality of existing vegetation to act as a buffer during construction.
- e. minimum area to be cleared.
- f. protection of roadway access points from tracking sediments.
- g. need for protecting conduit outlets with riprap.
- h. stabilization of excess excavated materials to be deposited offsite.

When considering offsite impacts of the proposed project it must be demonstrated by an offsite stability analysis that a stable condition exists at all points of water discharge for the 2 and 10 year design storm. If the existing offsite conditions are currently unstable it must be demonstrated that the project will not aggravate such conditions. Where Infiltration Basins are proposed for stormwater management, a stable emergency discharge area must be provided.

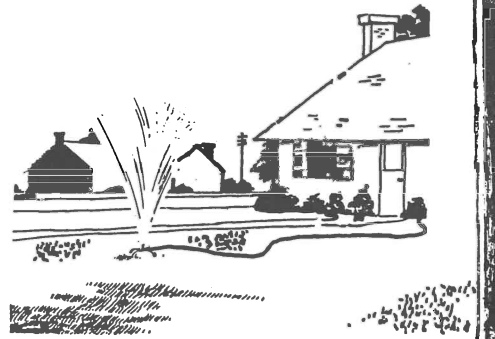
II. Factors to be considered in erosion control plan design -

- a. the grades, maximum slope and maximum area to be disturbed at one time should be based on:
  1. soil erodibility
  2. geology
  3. rainfall data
  4. proposed establishment of vegetation
  5. proposed maintenance
- b. the sequence of construction and the installation of erosion controls including:
  1. site clearing
  2. topsoil stripping
  3. interim control installation
  4. construction of structures/project phase
  5. maintenance of controls, etc.
- c. controls designed to achieve the following:
  1. interception of runoff from long, sloping sites and delivery to stable area
  2. stabilization by use of temporary vegetation
  3. sediment filtration via preserving buffer strips
  4. stabilized stockpiled soil
  5. control soil losses at
    - i. driveway entrances/exits
    - ii. streams, rivers, natural drainage ways
    - iii. large, cleared areas subject to wind erosion

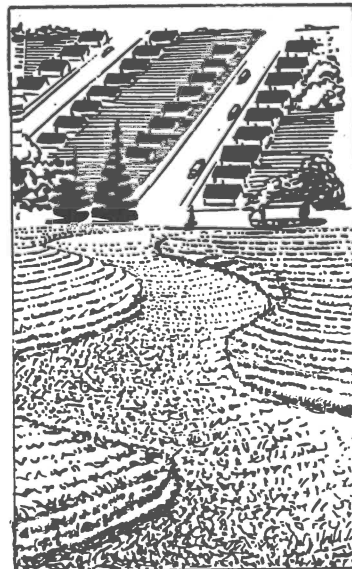


III. Factors to be considered during construction:

- a. implementation of erosion control plans in a timely manner
- b. careful adherence to the construction sequence
- c. frequent inspection and maintenance of erosion controls
- d. timely removal of sediment from basins, removal of temporary structural controls and installation of permanent vegetation at project completion.



## VEGETATIVE STANDARDS





STANDARD  
FOR  
TEMPORARY VEGETATIVE COVER FOR SOIL STABILIZATION

Definition

Establishment of temporary vegetative cover on soils exposed for periods of two to 12 months.

Purpose

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

Where Applicable

On exposed soils that have the potential for causing off-site environmental damage.

Methods and Materials

I. Site Preparation

- A. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and mulch anchoring. All grading should be done in accordance with Standards for Land Grading, p. 4.11.
- B. Install needed erosion control practices or facilities such as diversions, grade stabilization structures, channel stabilization measures, sediment basins, and waterways. See Standards 4.2 through 4.16.

II. Seedbed Preparation

- A. Apply limestone and fertilizer according to soil test recommendations such as those offered by Rutgers University Soil Testing Laboratory. Soil sample mailers are available from the local Cooperative Extension Service office. If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 500 pounds per acre or 11 pounds per 1,000 square feet of 10-20-10 or equivalent. If seed is drilled over banded fertilizer, the rate of fertilizer is reduced 50 percent. Apply limestone (equivalent to 50 percent calcium plus magnesium oxides) as follows:

| SOIL TEXTURE                           | TONS/ACRE | LBS./1,000 SQ. FT. |
|----------------------------------------|-----------|--------------------|
| Clay, clay loam, and high organic soil | 3         | 135                |
| Sandy loam, loam, silt loam            | 2         | 90                 |
| Loamy sand, sand                       | 1         | 45                 |

Pulverized dolomitic limestone is preferred for most soils south of the New Brunswick-Trenton line.

- B. Work lime and fertilizer into the soil as nearly as practical to a depth of 4 inches with a disc, springtooth harrow, or other suitable equipment. The final harrowing or disking operation should be on the general contour. Continue tillage until a reasonably uniform seedbed is prepared.
- C. Inspect seedbed just before seeding. If traffic has left the soil compacted, the area must be refilled as above.
- D. Soils high on sulfides or having a pH of 4 or less should be mulched only. See Standards for Stabilization with Mulch Only, p. 3.3.1.

III. Seeding

- A. Select seed from recommendations in Table 3.1-1.

TABLE 3.1-1

## TEMPORARY SEEDING RATES AND DATES

| SPECIES                          | SEEDING RATES<br>(pounds) |                      | OPTIMUM SEEDING DATE 1/<br>Based on Plant Hardiness Zone 3/ |                       |                        | OPTIMUM<br>SEED<br>DEPTH 2/<br>(Inches) |
|----------------------------------|---------------------------|----------------------|-------------------------------------------------------------|-----------------------|------------------------|-----------------------------------------|
|                                  | Per<br>Acre               | Per 1,000<br>Sq. Ft. | ZONE 5                                                      | ZONE 6                | ZONE 7                 |                                         |
| Annual ryegrass                  | 40                        | 1.0                  | 3/15-6/1<br>8/1-9/15                                        | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 | 0.5                                     |
| Perennial ryegrass               | 40                        | 1.0                  | 3/15-6/1<br>8/1-9/15                                        | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 | 0.5                                     |
| Oats                             | 86                        | 2.0                  | 3/15-6/1<br>8/1-9/15                                        | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 | 1.0                                     |
| Barley                           | 96                        | 2.2                  | 3/15-6/1<br>8/1-9/15                                        | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 | 1.0                                     |
| Pearl millet                     | 20                        | 0.5                  | 6/1-7/1                                                     | 5/15-7/15             | 5/1-8/1                | 1.0                                     |
| Sudangrass                       | 30                        | 0.7                  | 6/1-7/1                                                     | 5/15-7/15             | 5/1-8/1                | 1.0                                     |
| Millet (German or<br>(Hungarian) | 30                        | 0.7                  | 6/1-7/1                                                     | 5/15-7/15             | 5/1-8/1                | 1.0                                     |
| Weeping lovegrass                | 5                         | 0.2                  | 6/1-7/1                                                     | 5/15-7/15             | 5/1-8/1                | 0.25                                    |

1/ May be planted throughout summer if soil moisture is adequate or can be irrigated

2/ Twice the depth for sandy soils

3/ Plant Hardiness Zone (see map, p. 3.2.6)

Zone 5 - Portions of Sussex and Warren Counties

Zone 6 - Portions of Bergen, Camden, Essex and Gloucester, all of Hunterdon, portions of Mercer and Middlesex, all of Morris and Passaic, portions of Somerset, Sussex, Union and Warren Counties

Zone 7 - Atlantic, portion of Bergen, all of Burlington, Cape May and Cumberland, portions of Essex and Gloucester, all of Hudson, portion of Middlesex, all of Monmouth, Ocean and Salem and portion of Union County

- B. Apply seed uniformly by hand, cyclone (centrifugal) seeder, drop seeder, drill, cultipacker seeder, or hydroseeder. The latter may be justifiable for large, steep areas where conventional vehicles cannot travel. Mulch shall not be included in the tank with the seed. Except for drilled, hydroseeded or cultipacked seedings, seed shall be incorporated into the soil, to a depth of 1/4 to 1/2 inch, by raking or dragging. Depth of seed placement may be 1/4 inch deeper on coarse textured soil.
- C. After seeding, firming the soil with a corrugated roller will assure good seed-to-soil contact, restore capillarity, and improve seedling emergence. This is the preferred method. When performed on the contour, sheet erosion will be minimized and water conservation on site will be maximized.

#### IV. Mulching

Mulching is required on all seeding. Mulch will insure against erosion before grass is established and will promote faster and earlier establishment. (The existence of vegetation sufficient to control soil erosion shall be deemed compliance with this mulching requirement.)

- A. Mulch materials should be unrotted small grain straw, hay free of seeds, or salt hay to be applied at the rate of 1-1/2 to 2 tons per acre (70 to 90 pounds per 1,000 square feet), except that where a crimper is used instead of a liquid mulch-binder (tackifying or adhesive agent), the rate of application must be double the lower rate. Mulch chopper-blowers must not grind the material.
- B. Spread uniformly by hand or mechanically so that approximately 75% to 95% of the soil surface will be covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000 square foot sections and distribute 70 to 90 pounds within each section.

- C. Mulch anchoring should be accomplished immediately after placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon the size of the area, steepness of slopes, and costs.
1. Peg and Twine - Drive 8 to 10 inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross and a square pattern. Secure twine around each peg with two or more round turns.
  2. Mulch Nettings - Staple paper, jute, cotton, or plastic nettings to the soil surface. Use a degradable netting in areas to be mowed.
  3. Crimper (mulch anchoring tool) - A tractor-drawn implement, somewhat like a disc-harrow, especially designed to push or cut some of the broadcast long fiber mulch 3 to 4 inches into the soil so as to anchor it and leave part standing upright. This technique is limited to areas traversable by a tractor, which must operate on the contour of slopes. Straw mulch rate must be 3 tons per acre. No tackifying or adhesive agent is required.
  4. Liquid Mulch-Binders - May be used to anchor salt hay or straw mulches.
    - a. Applications should be heavier at edges where wind catches the mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance.
    - b. Use one of the following:
      - (1) Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2).  
Apply 0.04 gal./sq.yd. or 194 gal./acre on flat slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gal./sq. yd. or 363 gal./acre.
      - (2) Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800).  
Apply 0.04 gal./sq. yd. or 194 gal./acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gal./sq. yd. or 363 gal./acre.
      - (3) Synthetic or Organic binders - binders such as Curasol, DCA-70, Petro-set, and Terra-Tack may be used at rates recommended by the manufacturer to anchor mulch materials.
- NOTE: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.
- D. Wood-fiber or paper-fiber mulch at the rate of 1,500 pounds per acre may be applied by a hydroseeder. Use is limited to flatter slopes and during optimum seeding periods in spring and fall.



STANDARD  
FOR  
PERMANENT VEGETATIVE COVER FOR SOIL STABILIZATION

Definition

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

Purpose

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

Where Applicable

On exposed soils that have a potential for causing off-site environmental damage.

Methods and Materials

I. Site Preparation

- A. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance. All grading should be done in accordance with Standards for Land Grading, p. 4.11.
- B. Install needed erosion control practices and facilities such as diversions, grade stabilization structures, channel stabilization measures, sediment basins, and waterways. See Standards 4.2 through 4.16.

II. Seedbed Preparation

- A. Apply limestone and fertilizer according to soil test recommendations such as those offered by Rutgers University Soil Testing Laboratory. Soil sample mailers are available from the local Cooperative Extension Service office. If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 500 pounds per acre or 11 pounds per 1,000 square feet of 10-20-10 or equivalent. In addition, 300 pounds 38-0-0 per acre or equivalent of slow release nitrogen may be used in lieu of topdressing (see page 3.2.7, Section IV). Apply limestone (equivalent to 50 percent calcium plus magnesium oxides) as follows: <sup>1/</sup>

| SOIL TEXTURE                           | TONS/ACRE | LBS./1,000 SQ. FT. |
|----------------------------------------|-----------|--------------------|
| Clay, clay loam, and high organic soil | 4         | 180                |
| Sandy loam, loam, silt loam            | 3         | 135                |
| Loamy sand, sand                       | 2         | 90                 |

Pulverized dolomitic limestone is preferred for most soils south of the New Brunswick-Trenton line.

- B. Work lime and fertilizer into the soil as nearly as practical to a depth of 4 inches with a disc, springtooth harrow, or other suitable equipment. The final harrowing or discing operation should be on the general contour. Continue tillage until a reasonably uniform, fine seedbed is prepared. All but clay or silty soils and coarse sands should be rolled to firm the seedbed wherever feasible.
- C. Remove from the surface all stones two inches or larger in any dimension. Remove all other debris, such as wire, cable, tree roots, pieces of concrete, clods, lumps, or other unsuitable material.
- D. Inspect seedbed just before seeding. If traffic has left the soil compacted, the area must be retilled and firmed as above.

<sup>1/</sup> Acid soil conditions:

Soils having a pH of 4 or less or containing iron sulfide shall be covered with a minimum of 12 inches of soil having a pH of 5 or more before seedbed preparation. The added soil shall be limed as above.



### III. Seeding

- A. Select a mixture from Table 3.2-1 or use mixture recommended by the Cooperative Extension Service or Soil Conservation Service which is approved by the Soil Conservation District.
- B. Apply seed uniformly by hand, cyclone (centrifugal) seeder, drop seeder, drill, cultipacker seeder, or hydroseeder. The latter may be justifiable for large, steep areas where conventional vehicles cannot travel. Mulch shall not be included in the tank with the seed. Except for drilled, hydroseeded or cultipacked seedings, seed shall be incorporated into the soil, to a depth of 1/4 to 1/2 inch, by raking or dragging. Depth of seed placement may be 1/4 inch deeper on coarse textured soil.
- C. After seeding, firming the soil with a corrugated roller will assure good seed-to-soil contact, restore capillarity, and improve seedling emergence. This is the preferred method. When performed on the contour, sheet erosion will be minimized and water conservation on site will be maximized.

### IV. Mulching

Mulching is required on all seeding. Mulch will insure against erosion before grass is established and will promote faster and earlier establishment. (The existence of satisfactory permanent vegetation at the time of project or unit completion shall be deemed as compliance with this mulching requirement.)

- A. Mulch materials should be unrotted small grain straw, hay free of seeds, or salt hay to be applied at the rate of 1-1/2 to 2 tons per acre (70 to 90 pounds per 1,000 square feet), except that where a crimper is used instead of a liquid mulch-binder (tackifying or adhesive agent), the rate of application must be double the lower rate. Mulch chopper-blowers must not grind the material.
- B. Spread uniformly by hand or mechanically so that approximately 75% to 95% of the soil surface will be covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000 square foot sections and distribute 70 to 90 pounds within each section.
- C. Mulch anchoring should be accomplished immediately after placement to minimize loss by wind or water. This may be done by one of the following methods, depending upon the size of the area, steepness of slopes, and costs.
  1. Peg and Twine - Drive 8 to 10 inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross and a square pattern. Secure twine around each peg with two or more round turns.
  2. Mulch Nettings - Staple paper, jute, cotton, or plastic nettings to the soil surface. Use a degradable netting in areas to be mowed.
  3. Crimper (mulch anchoring tool) - A tractor-drawn implement, somewhat like a disc-harrow, especially designed to push or cut some of the broadcast long fiber mulch 3 to 4 inches into the soil so as to anchor it and leave part standing upright. This technique is limited to areas traversable by a tractor, which must operate on the contour of slopes. Straw mulch rate must be 3 tons per acre. No tackifying or adhesive agent is required.
  4. Liquid Mulch-Binders - May be used to anchor salt hay, hay, or straw mulches.
    - a. Applications should be heavier at edges where wind catches the mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance.
    - b. Use one of the following:
      - (1) Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2).  
Apply 0.04 gal./sq./yd. or 194 gal./acre on flat slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gal./sq. yd. or 363 gal./acre.

- (2) Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800).  
Apply 0.04 gal./sq. yd. or 194 gal./acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gal./sq. yd. or 363 gal./acre.
- (3) Synthetic or Organic binders - binders such as Curasol, DCA-70, Petro-set, and Terra-Tack may be used at rates recommended by the manufacturer to anchor mulch materials.

NOTE: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

- D. Wood-fiber or paper-fiber mulch at the rate of 1,500 pounds per acre may be applied by a hydroseeder. Use is limited to flatter slopes and during optimum seeding periods in spring and fall.

#### V. Irrigation (where feasible)

If soil moisture is deficient, and mulch is not used, supply new seedlings with adequate water (a minimum of 1/4 inch twice a day until vegetation is well established). This is especially true when seedlings are made in abnormally dry or hot weather or on droughty sites.

#### VI. Topdressing\*

- A. Spring seedlings will require an application of fertilizer such as 10-10-10 or equivalent at 400 pounds per acre or 10 pounds per 1,000 square feet between September 1 and October 15.
- B. Fall seedlings will require the above between March 15 and May 1.
- C. Mixtures dominated by Weeping lovegrass or legumes may not need topdressing.
- D. Bermudagrass should be topdressed before August 15.

\*If slow release nitrogen (300 pounds 38-0-0 per acre or equivalent) is used in addition to suggested fertilizer, this follow-up of topdressing is not mandatory.

TABLE 3.2-1

## SOILS, SEED MIXTURES, AND DATES FOR PERMANENT SEEDINGS FOR SOIL STABILIZATION

| SOILS & SITES                                                                                     | SEED MIXTURE <u>1/</u>                                         | MINIMUM SEEDING RATES <u>2/</u><br>(pounds)            |                   | OPTIMUM SEEDING DATES<br>Based on Plant Hardiness Zone <u>3/</u><br>(see page 3.2.6) |                       |                        |
|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------|-----------------------|------------------------|
|                                                                                                   |                                                                | Per Acre                                               | Per 1,000 Sq. Ft. | ZONE 5                                                                               | ZONE 6                | ZONE 7                 |
| A. Well to Excessively Well Drained                                                               | Normal Seeding Depth is from 1/4-1/2 inch except A-3, A-4, A-7 |                                                        |                   |                                                                                      |                       |                        |
| 1. Unmowed areas, e.g. landfills, rights of way, wildlife areas                                   | Weeping lovegrass<br>Sericea lespedeza                         | 2<br>20                                                | 0.1<br>0.5        | --                                                                                   | --                    | 3/1-8/1                |
| 2. Unmowed, coarse textured soils, wildlife areas; make good forage                               | Switchgrass                                                    | 25                                                     | 0.6               | 5/1-7/1                                                                              | 4/1-6/1               | 4/1-6/1                |
| 3. Unmowed areas                                                                                  | Weeping lovegrass<br>1/2-1", Crownvetch                        | 3<br>12                                                | 0.1<br>0.3        | --                                                                                   | --                    | 3/1-8/1                |
| 4. Best for coarse textured soils; suppresses woody growth; unmowed areas                         | Weeping lovegrass<br>1/2-1", flatpea                           | 3<br>30                                                | 0.1<br>0.7        | --                                                                                   | --                    | 3/1-8/1                |
| 5. Unmowed areas, e.g. road banks, gravel pits, etc.                                              | Perennial ryegrass<br>Crownvetch<br>Spreading fescue           | 25<br>12<br>25                                         | 0.6<br>0.3<br>0.6 | 3/15-6/1<br>8/1-9/15                                                                 | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 |
| 6. Landfills, coarse textured soils; unmowed areas                                                | Hard fescue/or<br>Sheep fescue<br>Perennial ryegrass           | 45<br>10                                               | 1.0<br>0.2        | 3/15-6/1<br>8/1-9/15                                                                 | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 |
| 7. Mowed areas, e.g. lawns, recreation areas                                                      | Bermudagrass<br>Zoysiagrass                                    | 12 Bushel<br>sprigs<br>spaced at<br>2' - 3'<br>centers |                   | --                                                                                   | --                    | 5/1-7/15               |
| B. Moderately to Well Drained                                                                     | Mixtures<br>A-1 through A-7<br>and the following:              |                                                        |                   |                                                                                      |                       |                        |
| 1. Low maintenance areas, e.g. detention basins, landfills, dikes, diversions (sun to open shade) | Tall fescue<br>Spreading fescue<br>Kentucky bluegrass          | 30<br>30<br>30                                         | 0.7<br>0.7<br>0.7 | 3/15-5/15<br>8/1-9/1                                                                 | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15 |
| 2. Unmowed areas (aesthetics not important)                                                       | Tall fescue<br>Sericea lespedeza                               | 25<br>20                                               | 0.6<br>0.4        | 3/15-6/1<br>--                                                                       | 3/1-5/15<br>--        | 2/15-5/1<br>8/15-10/15 |

TABLE 3.2-1 (continued)

|                                                                              |                                                                                |                      |                          |                                                            |                       |                                                       |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------|--------------------------|------------------------------------------------------------|-----------------------|-------------------------------------------------------|
| 3. Low maintenance areas, occasional mowing only                             | Tall fescue<br>Birdsfoot trefoil                                               | 45<br>10             | 1.0<br>0.2               | 3/15-6/1                                                   | 3/1-5/15              | --                                                    |
| 4. Mowed areas, e.g. recreation areas, lawns, etc. (sun and shade)           | Spreading fescue<br>Red fescue<br>Kentucky bluegrass<br>Perennial ryegrass     | 15<br>15<br>25<br>10 | 0.3<br>0.3<br>0.6<br>0.2 | 3/15-6/1<br>8/1-9/15                                       | 3/1-5/15<br>8/15-10/1 | 2/15-5/1<br>8/15-10/15<br>(shade and cool sites only) |
| 5. Mowed areas, e.g. lawns (sunny sites) (high maintenance, aesthetic areas) | Kentucky bluegrass (three cultivar blend)<br>Hard fescue<br>Perennial ryegrass | 60<br>20<br>10       | 1.4<br>0.4<br>0.2        | 3/15-6/1                                                   | 3/1-5/15              | --                                                    |
| C. Poorly to Somewhat Poorly Drained                                         | Mixtures B-1, B-3, B-4 and B-5 and the following:                              |                      |                          |                                                            |                       |                                                       |
| 1. Mowed and unmowed sunny wet areas, e.g. ditch banks, waterways            | Reed canarygrass<br>Redtop<br>Perennial ryegrass                               | 20<br>4<br>20        | 0.4<br>0.1<br>0.4        | 3/15-6/1<br>8/1-9/15                                       | 3/1-5/15<br>8/15-10/1 | 1/15-5/1<br>8/15-10/15                                |
|                                                                              |                                                                                |                      |                          | (Be sure that Reed canarygrass seed is from new seed crop) |                       |                                                       |

## NOTES:

1/ Seeding mixtures and/or rates not listed above may be used if recommended by the local Soil Conservation District, Soil Conservation Service; recommendations of the Cooperative Extension Service may be used if approved by the Soil Conservation District. Legumes (flatpea, crown-vetch, trefoil, lespedeza) should be mixed with proper inoculant prior to planting.

2/ Grass seed mixture checked by the chief of the Bureau of Seed Certification, New Jersey Department of Agriculture, Trenton, New Jersey, will assure the purchaser that the mixture obtained is the mixture ordered.

3/ Plant Hardiness Zone (see map, p. 3.2.6)

Zone 5 - Portions of Sussex and Warren Counties

Zone 6 - Portions of Bergen, Camden, Essex and Gloucester, all of Hunterdon, portions of Mercer and Middlesex, all of Morris and Passaic, portions of Somerset, Sussex, Union and Warren Counties

Zone 7 - Atlantic, portion of Bergen, all of Burlington, Cape May and Cumberland, portions of Essex and Gloucester, all of Hudson, portion of Middlesex, all of Monmouth, Ocean and Salem and portion of Union County

## RECOMMENDED CULTIVARS

### BERMUDAGRASS

Midland  
Midiron

### REED CANARYGRASS

Ioreed

### SWITCHGRASS

Blackwell

### PERENNIAL RYEGRASS

Repel  
Pennant  
Citation  
Diplomat  
Or other improved  
cultivars

### KENTUCKY BLUEGRASS

Kenblue  
Park  
Arboretum  
Touchdown  
America  
Baron

### CROWN VETCH

Penngift  
Chemung

### BIRDSFOOT TREEFOIL

Viking  
Empire

### CHEWING'S FESCUE

Banner  
Jamestown

### TALL FESCUE

Kentucky-31  
Rebel  
Falcon

### SPREADING FESCUE

Fortress  
Ensylva

### HARD FESCUE

Reliant  
Sparton

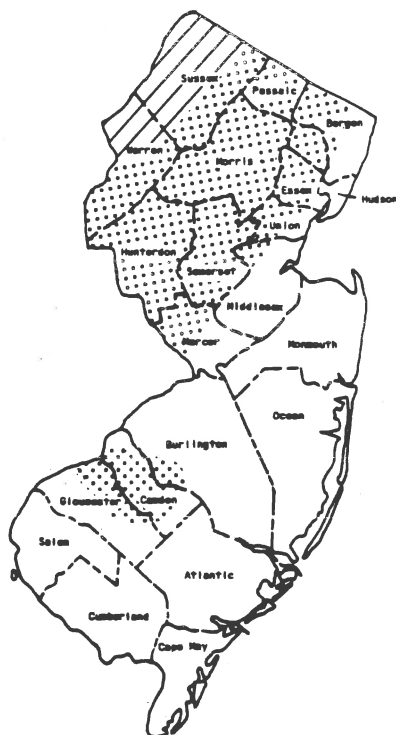
### SHEEP FESCUE

Ares

# Plant Hardiness Zones

AVERAGE ANNUAL MINIMUM TEMPERATURE (F)

## New Jersey



ZONE

5-



-20° to -10°

ZONE

6-



-10° to 0°

ZONE

7-



0° to 10°

USDA - SCS - NJ  
CLASSIFICATION OF NEW JERSEY SOIL SERIES  
INTO SITE CONDITIONS IMPORTANT TO SEEDING

A = Droughty  
B = Well and moderately well drained  
C = Somewhat poorly drained  
D = Poorly and very poorly drained

| <u>Series</u> | <u>Class</u> | <u>Series</u> | <u>Class</u> | <u>Series</u> | <u>Class</u> | <u>Series</u> | <u>Class</u> |
|---------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|
| Abbottstown   | C            | Coplay        | D            | Lamington     | C            | Pope          | B            |
| Adelphia      | B            | Cossayuna     | B            | Lansdale      | B            | Portsmouth    | D            |
| Adrian        | D            | Crestmore     | B            | Lansdowne     | B            | Preakness     | D            |
| Albia         | C            | Croton        | D            | Lawrenceville | B            | Quakertown    | B            |
| Amwell        | C            | Culvers       | C            | Legore        | B            | Raritan       | C            |
| Annandale     | B            | Donlonton     | C            | Lehigh        | C            | Raynham       | C            |
| Asbury        | B            | Downer        | B            | Lenoir        | C            | Readington    | B            |
| Atherton      | D            | Doylestown    | D            | Leon          | D            | Reaville      | C            |
| Athol         | B            | Dragston      | C            | Lincroft      | A            | Rhinebeck     | C            |
| Atsion        | D            | Duffield      | B            | Livingston    | D            | Ridgebury     | D            |
| Aura          | B            | Dunellen      | B            | Lyons         | D            | Riverhead     | B            |
| Barclay       | C            | Dutchess      | B            | Marksboro     | C            | Rockaway      | B            |
| Bartley       | B            | Edneyville    | B            | Marlton       | B            | Rockport      | B            |
| Bath          | B            | Elkton        | D            | Matapeake     | B            | Roe           | C            |
| Bayboro       | D            | Ellington     | B            | Matawan       | B            | Rowland       | B            |
| Beatty        | B            | Evesboro      | A            | Matlock       | D            | Royce         | B            |
| Bedlington    | B            | Fallsington   | D            | Mattapex      | B            | Rutlege       | D            |
| Berks         | B            | Fort Mott     | A            | Meckesville   | B            | St. Johns     | D            |
| Berryland     | D            | Fredon        | D            | Middlebury    | B            | Sassafras     | B            |
| Bertie        | C            | Freehold      | B            | Minoa         | C            | Scio          | C            |
| Bibb          | D            | Freneau       | D            | Monmouth      | B            | Shrewsbury    | D            |
| Bliddeford    | D            | Galestown     | A            | Mount Lucas   | B            | Sloan         | D            |
| Birdsboro     | B            | Hackettstown  | B            | Nassau        | A            | Stephensburg  | B            |
| Boonton       | B            | Haledon       | C            | Navesink      | B            | Swartswood    | B            |
| Bowmansville  | C            | Halsey        | D            | Neshaminy     | B            | Tinton        | A            |
| Boynton       | D            | Hammonton     | B            | Netcong       | B            | Tioga         | B            |
| Braceville    | B            | Hazen         | B            | Nixon         | B            | Townsbury     | B            |
| Bridgeville   | C            | Hazleton      | B            | Nixonton      | B            | Tunkhannock   | B            |
| Bucks         | B            | Hero          | B            | Norton        | B            | Turbotville   | C            |
| Burnham       | D            | Hibernia      | C            | Norwich       | D            | Unadilla      | B            |
| Califon       | B            | Holmdel       | B            | Oquaga        | B            | Valois        | B            |
| Carlisle      | D            | Holyoke       | A            | Oster         | D            | Wallkill      | D            |
| Cattaraugus   | B            | Hoosic        | A            | Othello       | D            | Washington    | B            |
| Chalfont      | C            | Howell        | B            | Otisville     | A            | Wassaic       | B            |
| Chatfield     | B            | Keansburg     | D            | Palmyra       | B            | Watchung      | D            |
| Chenango      | B            | Kendala       | D            | Parker        | A            | Wayland       | D            |
| Chillum       | B            | Keyport       | B            | Parsippany    | D            | Weeksville    | D            |
| Chippewa      | C            | Kistler       | B            | Pasquotank    | D            | Wellsboro     | C            |
| Cokesbury     | D            | Kleij         | A            | Pattenburg    | B            | Westphalia    | B            |
| Colden        | D            | Klinesville   | A            | Pemberton     | A            | Whippany      | C            |
| Colemanstown  | D            | Kresson       | C            | Penn          | B            | Whitman       | D            |
| Collington    | B            | Lackawanna    | B            | Phelps        | C            | Woodglen      | D            |
| Colonia       | A            | Lakehurst     | A            | Plummer       | D            | Woodmansie    | B            |
| Colts Neck    | B            | Lakeland      | A            | Pocomoke      | D            | Woodstown     | B            |
| Comly         | C            | Lakewood      | A            | Pompton       | C            | Wooster       | B            |
|               |              |               |              |               |              | Wurtsboro     | B            |



STANDARD  
FOR  
STABILIZATION WITH MULCH ONLY

Definition

Stabilizing exposed soils with non-vegetative materials.

Purpose

To protect exposed soil surfaces from erosion damage and to reduce offsite environmental damage.

Where Applicable

This practice is applicable to areas subject to erosion, where the season and other conditions may not be suitable for growing an erosion-resistant cover or where stabilization is needed for a short period until more suitable protection can be applied.

Methods and Materials

I. Site Preparation

- A. Grade, as needed and feasible, to permit the use of conventional equipment for applying and anchoring mulch. All grading should be done in accordance with Standard for Land Grading, p. 4.11.
- B. Employ needed erosion control practices such as diversions, grade stabilization structures, channel stabilization measures, sediment basins, and waterways. See Standards 4.2 through 4.16.

II. Protective Materials

- A. Unrotted small-grain straw, hay, or salt hay at 2.0 to 2.5 tons per acre is spread uniformly at 90 to 115 pounds per 1,000 square feet and anchored with a mulch anchoring tool, liquid mulch binders, or netting tiedown. Other suitable materials may be used if approved by the Soil Conservation District.
- B. Asphalt emulsion or cutback asphalt is recommended at the rate of 600 to 1,200 gallons per acre. This is suitable for a limited period of time where travel by people, animals, or machines is not a problem.
- C. Synthetic or organic soil stabilizers may be used -- under suitable conditions and in sufficient quantities.
- D. Wood-fiber or paper-fiber mulch at the rate of 1,500 pounds per acre may be applied by a hydroseeder or hydromulcher.
- E. Mulch netting, such as paper jute, excelsior, cotton, or plastic, may be used.
- F. Woodchips applied uniformly to a minimum depth of 2 inches may be used. Woodchips will not be used on areas where flowing water could wash them into an inlet and plug it.
- G. Gravel, crushed stone, or slag at the rate of 9 cubic yards per 1,000 sq. ft. applied uniformly to a minimum depth of 3 inches may be used. Size 2 or 3 (ASTM C-33) is recommended.

III. Mulch Anchoring - should be accomplished immediately after placement of hay or straw mulch to minimize loss by wind or water. This may be done by one of the following methods, depending upon the size of the area and steepness of slopes.

- A. Peg and Twine - Drive 8 to 10 inch wooden pegs to within 2 to 3 inches of the soil surface every 4 feet in all directions. Stakes may be driven before or after applying mulch. Secure mulch to soil surface by stretching twine between pegs in a criss-cross and a square pattern. Secure twine around each peg with two or more round turns.
- B. Mulch Nettings - Staple paper, cotton, or plastic nettings over hay or straw mulch. Use a degradable netting in areas to be mowed. Netting is usually available in rolls 4 feet wide and up to 300 feet long.



C. Mulch Anchoring Tool - A tractor-drawn implement especially designed to punch and anchor mulch into the soil surface. This practice affords maximum erosion control, but its use is limited to those slopes upon which the tractor can operate safely. Tool penetration should be done about 3 to 4 inches. On sloping land, the operation should be done on the contour.

D. Liquid Mulch-binders

1. Applications should be heavier at edges where wind catches the mulch, in valleys, and at crests of banks. Remainder of area should be uniform in appearance.

2. Use one of the following:

a. Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2).

Apply 0.04 gal./sq. yd. or 194 gal./acre on flat slopes and slopes less than 8 feet high. On slopes 8 feet or more high, use .075 gal./sq. yd. or 363 gal./acre.

b. Cutback asphalt - rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800).

Apply 0.04 gal./sq. yd. or 194 gal./acre on flat areas and on slopes less than 8 feet high. On slopes 8 feet or more high, use 0.075 gal./sq. yd. or 363 gal./acre.

c. Synthetic or Organic binders - binders such as Curasol, DCA-70, Petro-set, and Terra-Tack may be used at rates recommended by the manufacturer to anchor mulch materials.

Note: All names given above are registered trade names. This does not constitute a recommendation of these products to the exclusion of other products.

STANDARD  
FOR  
PERMANENT STABILIZATION WITH SOD

Definition

Establishing permanent vegetation using sod.

Purpose

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

Where Applicable

On exposed soils that have a potential for causing off-site environmental damage where a quick vegetative cover is desired. Moisture is required for success; access to irrigation is essential.

Methods and Materials

1. Cultivated sod is preferred over native or pasture sod. Specify "Certified Sod," or other high quality cultivated sod.
2. Sod should be free of weeds and undesirable coarse weedy grasses.
3. Sod should be of uniform thickness, approximately 5/8 inch, plus or minus 1/4 inch, at time of cutting. (Excludes top growth.)
4. Sod should be vigorous and dense and be able to retain its own shape and weight when suspended vertically with a firm grasp from the upper 10 percent of the strip. Broken pads or torn and uneven ends will not be acceptable.
5. For droughty sites, a sod of Kentucky 31 tall fescue and bluegrass is preferred over a straight bluegrass sod.
6. Only moist, fresh, unheated sod should be used. Sod should be harvested, delivered, and installed within a period of 36 hours.

I. Site Preparation

- A. Grade as needed and feasible to permit the use of conventional equipment for liming, fertilizing, and soil preparation. All grading should be done in accordance with Standard for Land Grading, page 4.11.
- B. Install needed erosion control practices and facilities, such as interceptor ditches, dikes and terraces, erosion stops, and desilting basins. See Standards 4.2 through 4.16.

II. Soil Preparation

- A. Apply limestone and fertilizer according to soil tests such as those offered by Rutgers University Soil Testing Laboratory. Soil sample mailers are available from the local Cooperative Extension Service office. If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 500 pounds per acre or 11 pounds per 1,000 square feet of 10-20-10 or equivalent. In addition, 300 pounds 38-0-0 per acre or equivalent of slow release nitrogen may be used in lieu of topdressing. Apply limestone (equivalent to 50 percent calcium plus magnesium oxides) as follows:

| SOIL TEXTURE                           | TONS/ACRE | LBS./1,000 SQ. FT. |
|----------------------------------------|-----------|--------------------|
| Clay, clay loam, and high organic soil | 4         | 180                |
| Sandy loam, loam, silt loam            | 3         | 135                |
| Loamy sand, sand                       | 2         | 90                 |

Pulverized dolomitic limestone is preferred for most soils south of the New Brunswick-Trenton line.

- B. Work lime and fertilizer into the soil as nearly as practical to a depth of 4 inches with a disc, springtooth harrow, or other suitable equipment. The final harrowing or disking operation should be on the general contour. Continue tillage until a reasonably uniform, fine seedbed is prepared.
- C. Remove from the surface all objects that would prevent good sod to soil contact and remove all other debris, such as wire, cable, tree roots, pieces of concrete, clods, lumps, or other unsuitable material.
- D. Inspect site just before seeding. If traffic has left the soil compacted, the area must be refilled and firmed as above.

### III. Sod Placement

- A. Sod strips should be laid on the contour, never up and down the slope, starting at the bottom of the slope and working up. On steep slopes, the use of ladders will facilitate the work and prevent damage to the sod. During periods of high temperature, lightly irrigate the soil immediately prior to laying the sod.
- B. Place sod strips with snug, even joints that are staggered. Open spaces invite erosion.
- C. Roll or tamp sod immediately following placement to insure solid contact of root mat and soil surface. Do not overlap sod. All joints should be butted tightly in order to prevent voids which would cause drying of the roots.
- D. On slopes greater than 3 to 1, secure sod to surface soil with wood pegs, wire staples, or split shingles (8 to 10 inches long by 3/4 inch wide).
- E. Surface water cannot always be diverted from flowing over the face of the slope, but a capping strip of heavy jute or plastic netting, properly secured, along the crown of the slope and edges will provide extra protection against lifting and undercutting of sod. The same technique can be used to anchor sod in water-carrying channels and other critical areas. Wire staples must be used to anchor netting in channel work.
- F. Immediately following installation, sod should be watered until moisture penetrates the soil layer beneath sod to a depth of 4 inches. Maintain optimum moisture for at least two weeks.

### IV. Topdressing - If slow release nitrogen (300 pounds 38-0-0 per acre or equivalent) is used in addition to suggested fertilizer, then a follow-up of topdressing is not mandatory.

- A. Spring installation of sod will require an application of fertilizer such as 10-20-10 or equivalent at 400 pounds per acre or 10 pounds per 1,000 square feet between September 1 and October 15.
- B. Fall installation of sod will require the above between March 15 and May 1.

STANDARD  
FOR  
TOPSOILING

Definition

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

Purpose

To improve the soil medium for plant establishment and maintenance.

Where Applicable

Topsoil should be used where soils are: sands, gravelly soils, clays, silty clays, very shallow, or where they are extremely acid (less than pH 4.0) or salty (conductivity greater than 1.0 millimhos per centimeter); or where topsoil is available on site and assurance of improved vegetative growth is desired.

Methods and Materials

I. Materials

Topsoil should be friable and loamy, free of debris, objectionable weeds and stones, and contain no toxic substance that may be harmful to plant growth. A pH range of 5.0-7.5 is acceptable. Soluble salts should not be excessive (conductivity less than 0.5 millimhos per centimeter). Topsoil hauled in from off site should have a minimum organic matter content of 2.75 percent. Organic matter content may be raised by additives.

II. Stripping and Stockpiling

- A. Field exploration should be made to determine whether quantity and or quality of surface soil justifies stripping.
- B. Stripping should be confined to the immediate construction area.
- C. Where feasible, lime may be applied before stripping at a rate determined by soil tests to bring the soil pH to 6.5. In lieu of soil tests, see lime rate guide in seedbed preparation for permanent vegetative cover, page 3.2.1.
- D. A 4-6 inch stripping depth is common, but may vary depending on the particular soil.
- E. Stockpiles of topsoil should be situated so as not to obstruct natural drainage or cause off-site environmental damage.
- F. Stockpiles should be vegetated in accordance with standards previously described herein; see 3.1 or 3.2. Weeds should not be allowed to grow on stockpiles.

III. Site Preparation

- A. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance. See page 4.1.
- B. Subsoil should be tested for lime requirement and limestone, if needed, should be applied to bring soil pH to 6.5 and incorporated into the soil as nearly as practical to a depth of 4 inches.
- C. Immediately prior to topsoil distribution, the surface should be scarified to provide a good bond with the topsoil.
- D. Employ needed erosion control practices such as diversions, grade stabilization structures, channel stabilization measures, sedimentation basins, and waterways. See Standards 4.2 through 4.16.

IV. Applying Topsoil

- A. Topsoil should be handled only when it is dry enough to work without damaging soil structure; i.e., less than field capacity (see glossary).
- B. A uniform application to a depth of 5 inches (unsettled) is recommended. Soils with a pH of 4.0 or less or containing iron sulfide shall be covered with a minimum depth of 12 inches of soil having a pH of 5.0 or more.



STANDARD  
FOR  
MAINTAINING VEGETATION

Definition

The perpetuation of vegetative cover.

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 make repairs after an extended period of neglect.

Where Applicable

On areas where existing vegetation protects or enhances the environment.

Methods and Materials

A preventive maintenance program anticipates requirements and accomplishes work when it can be done with least effort and 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 preventive maintenance depends upon the category of the vegetation and land; i.e., improved, semi-improved, and unimproved grounds.

- A. Mowing is a recurring practice and its intensity depends upon the function of the ground cover. On improved areas, such as lawns, certain recreation fields, and picnic areas, mowing will be frequent. On semi-improved areas, mowing will be infrequent. Unimproved areas may be left unmowed to permit natural succession.
- 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. Drainageways are subject to rapid infestation by weeds and woody plants. These should be controlled, since they often reduce drainageway efficiency. 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.



STANDARD  
FOR  
DUNE STABILIZATION

Definition

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

Purpose

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

Where Applicable

On seashore areas where blowing sands, tide, and storm waters may cause damage. Stay at least one hundred feet (horizontal distance) from mean high tide line (MHT).

Methods and Materials

A. Vegetative

1. Planting

- a. American beachgrass (*Ammophila breviflorata* ("Cape" variety) will be planted between February 15 and April 1 when sand is not frozen.
- b. Three to five culms, which may be joined, are placed in a hole. Planting depth will be at least 6 inches, but no deeper than 8 inches.
- c. It is recommended that planting stock be cut to approximately 15 inches long.
- d. Plants will be spaced 18 x 18 inches; where erosion is severe, 12 x 12 inches. Plants should be staggered in alternate rows.
- e. Fertilizer will be applied after 10 days, but within 30 days following the planting date. The rate will be 50 lbs. N, 50 lbs.  $P_2O_5$ , and 50 lbs.  $K_2O$  per acre. Mineral fertilizer will be applied as a top dressing. When a slow-release fertilizer is used, it will be placed in the hole with the plants.
- f. Compact the sand firmly around the transplant to eliminate air pockets.
- g. Plant above the storm tide elevation.
- h. To build dunes, plantings are made to form a continuous block and should consist of at least 10 rows paralleling the shoreline. Rows should be closer together at the center of the dune and wider apart at the edges.
- i. Site - Planting will be delayed on hydraulic fill until salt has been leached to a low level. Sand placed by earth moving equipment will be allowed to be compacted by rains prior to dune planting. Dunes built with aid of sand fence are planted when dune is near top of fence.
- j. Maintenance - A spring application of 50 lbs. of inorganic nitrogen fertilizer should be applied after regrowth commences. It is desirable to apply  $P_2O_5$  and  $K_2O$  at a rate of 25 lbs./acre in alternate years.

2. Alternate Planting

- a. "Sea Isle" Japanese sedge may be interplanted with "Cape." The sedge will be planted in alternate rows on the same spacing and planting date as Cape.
- b. Two vegetative parts (or rhizomes) of Sea Isle constitutes a planting unit and will be placed in each planting hole. If potted plants are available, these will be used. Cover the pot with 1" to 3" of sand. When bare root plants must be used, the top of the vegetative part will be planted 2" to 4" deep.
- c. The growing points on Japanese sedge are very fragile. The vegetative parts must be handled carefully to avoid damage. Do not compact the sand around the plant with the root, but carefully cover each plant by hand.



**B. Mechanical**

1. In frontal areas, dunes may be created by erection of sand fences, set in parallel rows spaced 20 to 30 feet apart, roughly parallel to the beach, and yet be somewhat at a right angle to the prevailing wind direction. Two to four rows of sand fence should be constructed so that the forward row of fence is not closer than 100 feet to the mean high water elevation. The center line of the rows of fence should correspond to the proposed center line of the future dune.
2. As the areas between the rows of fence fill with sand, additional rows of fence can be added between the existing fence rows. The ideal frontal dune should be about 120 feet wide at the base and 12 feet high.
3. New dunes should be vegetated as in "A" above.
4. Where foot or vehicular traffic is expected to be significant over these dunes, it is recommended a curvilinear path be constructed to direct such 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.

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

Definition

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

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 that which is commonly used throughout the State of New Jersey.

The services of a Landscape Architect or a Horticulturist should be utilized for the selection of plant material for specific sites where problems exist due to soil or other ecological conditions.

EVERGREEN TREES

Latin Name

Common Name

Abies concolor  
Ilex opaca  
Juniperus virginiana  
Picea abies  
Picea pungens  
Pinus nigra  
Pinus strobus  
Pinus thunbergi  
Pseudotsuga taxifolia

White Fir  
American Holly  
Eastern Red Cedar  
Norway Spruce  
Colorado Spruce  
Austrian Pine  
White Pine  
Japanese Black Pine  
Douglas Fir

DECIDUOUS TREES

Latin Name

Common Name

Acer platanoides and varieties  
Acer rubrum and varieties  
Acer saccharum  
Aesculus hippocastanum  
Carya ovata  
Celtis occidentalis  
Fagus grandifolia  
Fagus sylvatica and varieties

Norway Maple  
Red Maple or Swamp Maple  
Sugar Maple  
Horsechestnut  
Shagbark Hickory  
Common Hackberry  
American Beech  
European Beech

Populus maximowiczii  
Populus alba Boileana  
Quercus alba  
Quercus borealis  
Quercus coccinea  
Quercus palustris  
Quercus phellos  
Salix babylonica  
Tilia americana  
Tilia cordata and varieties  
Tilia tomentosa  
Zelkova serrata

London Plane Tree  
Japanese Poplar  
Boileana Poplar (Lombardy)  
White Oak  
Red Oak  
Scarlet Oak  
Pin Oak  
Willow Oak  
Babylon Weeping Willow  
American Linden  
Littleleaf Linden  
Silver Linden  
Japanese Zelkova

# SMALL DECIDUOUS TREES

## Latin Name

Acer campestre  
Acer ginnala  
Amelanchier canadensis  
Betula varieties  
Carpinus betulus  
Carpinus caroliniana  
Cornus Florida  
Cornus kousa  
Cornus mas  
Cotinus coggygria  
Crataegus crusgalli  
Crataegus phaenopyrum  
Elaeagnus angustifolia  
Hibiscus syriacus  
Magnolia virginiana  
Malus varieties  
Oxydendron arboreum  
Prunus varieties  
Pyrus calleryana  
Salix caprea

## Common Name

Hedge Maple  
Amur Maple  
Shadblow Serviceberry  
Birch  
European Hornbeam  
American Hornbeam  
Flowering Dogwood  
Japanese Dogwood  
Cornelian Cherry Dogwood  
Smokebush  
Cockspur Thorn  
Washington Hawthorn  
Russian Olive  
Shrub Althea  
Sweetbay Magnolia  
Crabapples  
Sorrel Tree or Sourwood  
Cherries  
Callery Pear  
Goat or Pussy Willow

## SHRUBS

## Latin Name

Aronia arbutifolia  
Aronia arbutifolia brilliantissima  
Berberis thunbergi  
Chaenomeles lagenaria  
Clethra alnifolia and varieties  
Cornus varieties  
Elaeagnus umbellata  
Euonymus alatus and varieties  
Forsythia intermedia and varieties  
Forsythia suspensa  
Hamamelis varieties  
Ilex glabra  
Ilex verticillata  
Kalmia latifolia  
Ligustrum varieties  
Lindera benzoin  
Myrica pennsylvanica  
Rhododendron maximum  
Rhus varieties  
Rosa varieties  
Syringa vulgaris  
Vaccinium corymbosum  
Viburnum varieties

## Common Name

Red Chokeberry  
Brilliant Chokeberry  
Japanese Barberry  
Flowering Quince  
Summersweet Clethra  
Siberian Dogwood  
Autumn Elaeagnus  
Winged Euonymus  
Border Forsythia  
Weeping Forsythia  
Witchhazel  
Inkberry  
Winterberry Holly  
Mountain Laurel  
Privet  
Spicebush  
Northern Bayberry  
Rosebay Rhododendron  
Sumac  
Rose  
Common Lilac  
Highbush Blueberry  
Viburnum

## GROUND COVERS AND VINES

## Latin Name

Campsis radicans  
Euonymus fortunei vegetus  
Hedera helix  
Juniperus conferta  
Juniperus horizontalis plumosa  
Loncera japonica halliana  
Parthenocissus quinquefolia  
Parthenocissus tricuspidata  
Rosa Max Graf  
Vitis sp.  
Wisteria floribunda  
Wisteria sinensis

## Common Name

Trumpet creeper  
Winter creeper Euonymus  
English Ivy  
Shore Juniper  
Andorra Juniper  
Hall's Japanese Honeysuckle  
Virginia Creeper  
Japanese Creeper  
Max Graf Rose  
Grapes sp.  
Japanese Wisteria  
Chinese Wisteria

STANDARD  
FOR  
TREE PROTECTION DURING CONSTRUCTION

Definition

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

Purpose

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

Where Applicable

On new development sites containing valuable trees.

Methods and Materials

1. The reconnaissance before land clearing begins can result in an aesthetically pleasing development with natural vegetation rather than the presence of dead or dying trees. Inventory the site and clearly mark the trees to be saved. Consider relocating streets, houses, or other structures if necessary and feasible. Once clearing begins and damage to the trees occurs, valuable specimens may be lost.

- a. Characteristics of trees to be protected and saved. The following lists characteristics that should be evaluated before deciding to remove or protect a tree.

(1) Tree Vigor

Vigor is the overall condition of the tree. A tree of low vigor is more susceptible to damage by environmental changes than healthy trees and is more susceptible to insect and disease attacks. Indications of poor vigor include the dying of the tips of the branches and entire limbs, small annual twig growth, stunted leaf size, sparse foliage, and poor foliage color. Avoid saving hollow or rotten trees, trees cracked, split, leaning or crooked, oozing sap, or with broken tops.

(2) Tree Age

Very old, picturesque trees may be more aesthetically valuable than smaller, young trees, but also require more extensive protection measures. If leaving a very old tree, be sure it is sound and healthy.

(3) Species

Many species of trees found in New Jersey woodlands are not suitable for shade tree uses around buildings. Avoid protecting trees that are short-lived, brittle, have soft wood, messy leaves, fruit, or are frequently attacked by insects and disease.

(4) Resistant to Insects and Diseases

Avoid leaving trees in highly visible areas or specimens that are frequent targets of insects and diseases. American Elm, for example, could be lost due to Dutch Elm Disease. Wild Cherry, another example, is a favorite host of the tent caterpillar, which causes defoliation of the trees in early summer.

(5) Tree Aesthetics

Choose trees that are aesthetically pleasing, exhibiting good shape and form. Avoid leaning, crooked, and misshapen trees. Occasionally, an odd-shaped tree or one of unusual form may add interest to the landscape if strategically located. Be sure the tree is structurally sound and vigorous.

(6) Spring and Autumn Coloration

Species differ in fall color. Some are bright red, others orange and yellow. Other species exhibit no autumn color, such as walnut, locust, and sycamore.

(7) Wildlife Benefits

Favor trees that are preferred by wildlife for food, cover, and nesting. A mixture of evergreens and hardwoods is beneficial. Evergreen trees are important for cover during the winter months. The hardwoods are more valuable for food.

(8) Air Pollution Susceptibility

Tree species vary greatly in this respect. Symptoms vary from browning on the edges of the leaves and needles, to stunting of growth, to death of the tree.

(9) Species Longevity

Favor trees whose life span is long, such as oak, beech, and tulip poplar. Short-lived trees should be avoided for use as shade, lawn, or specimen trees. Although some short-lived trees have an attractive form or pleasing coloration in the spring or fall, such trees may not live for a long time.

b. Criteria for protecting remaining trees:

(1) Mechanical damage - see Figure 3.9-1.

(2) Box trees within 25 feet of a building site to prevent mechanical injury. Fencing or other barrier should be installed at the drip line of the tree branches. See Figure 3.9-1.

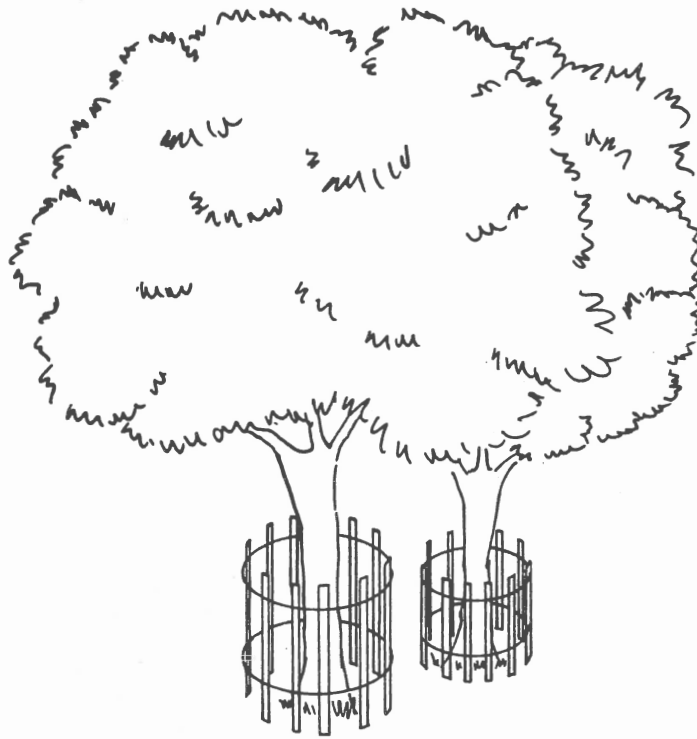
(3) Boards will not be nailed to trees during building operations.

(4) Feeder roots should not be cut in an area inside the drip line of the tree branches.

(5) Damaged trunks or exposed roots will be painted immediately with a good grade of "tree paint." Care for serious injury should be prescribed by a professional forester or licensed tree expert.

(6) Tree limb removal, where necessary, will be done flush to trunk or main branch and that area painted with a good grade of tree paint.

NOTE: For more specific data on certain tree characteristics, consult the tree shrub and vine standard in this handbook (pg. 3.8.1) or consult local professional experts. Your local soil conservation district or county agricultural agent can assist you in this.



Incorrect fencing for tree protection

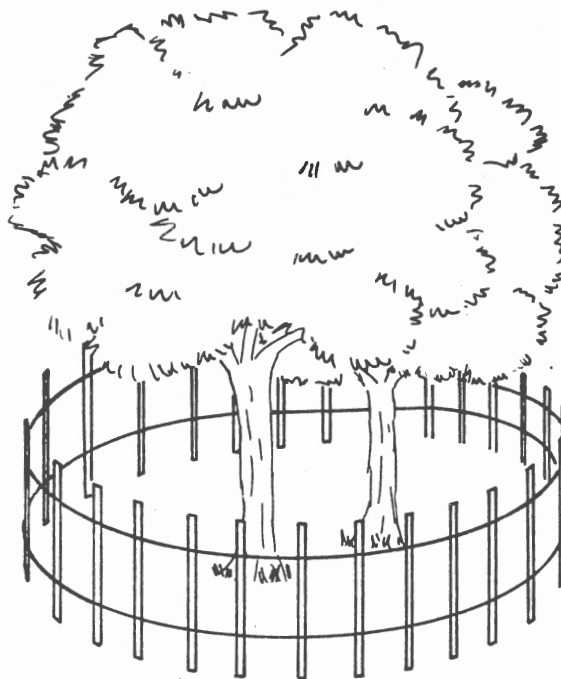
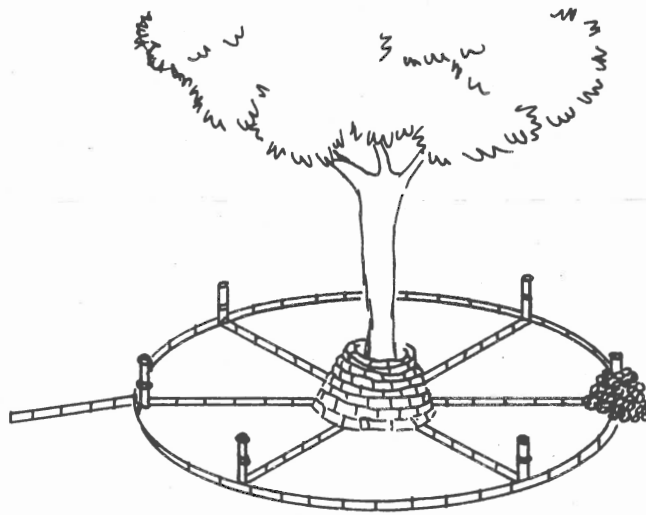
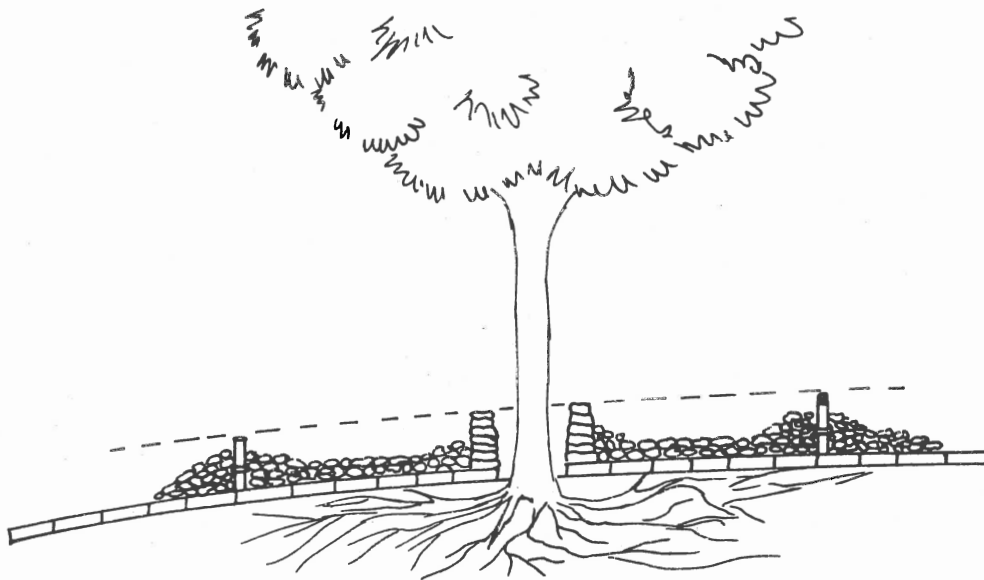


Figure 3.9-I Correct fencing for tree protection



Isometric



Section

Figure 3.9-II Tree protection - tile and gravel will allow air circulation to root zone under a fill

FIGURE 3.9 III

A retaining wall protects a tree from a lowered grade

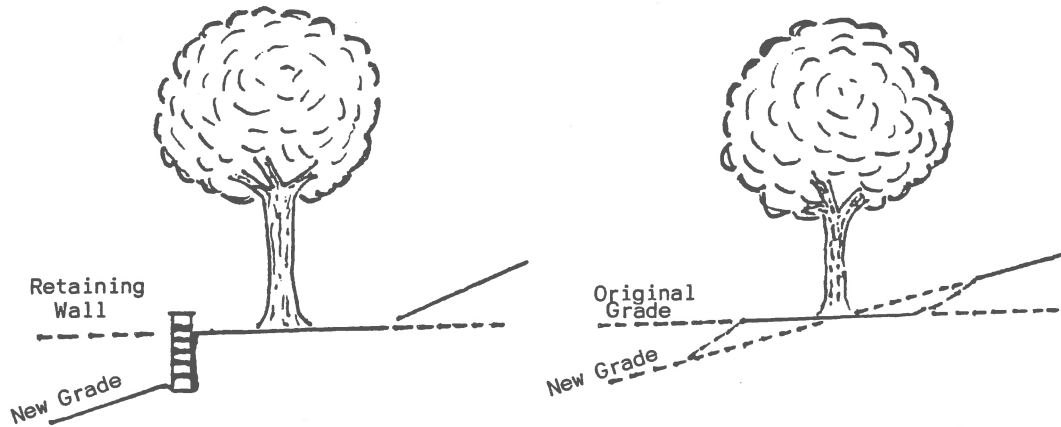
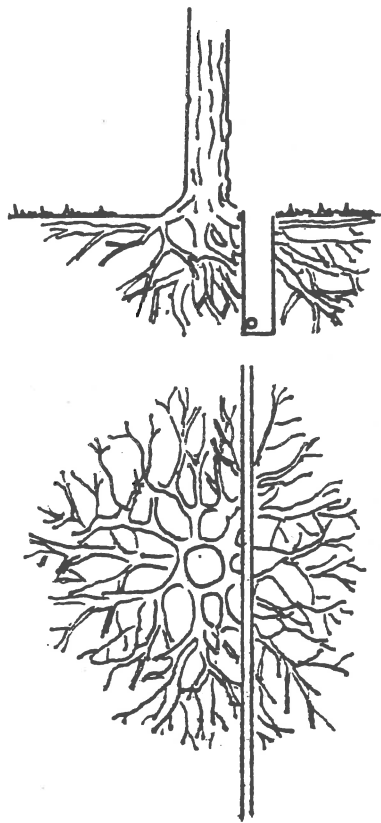
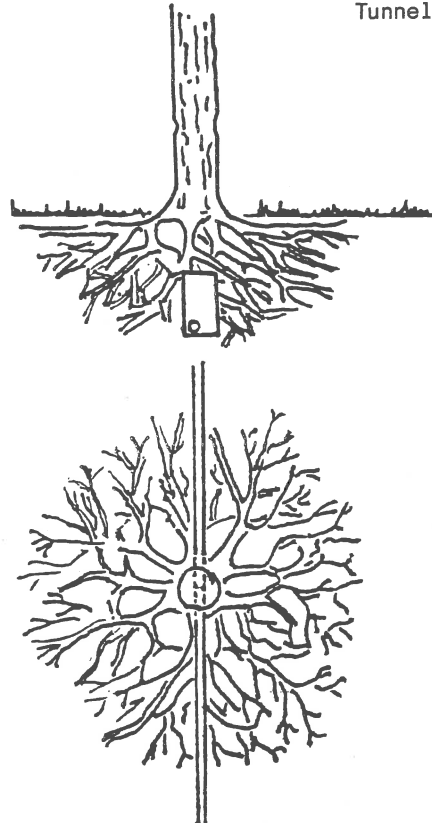


FIGURE 3.9 IV

Trenching



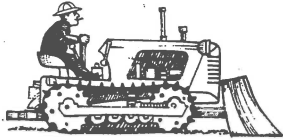
Tunneling - Preferred



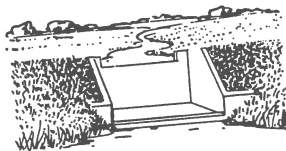
Utilities should be tunneled beneath tree roots. The drawings on the left show trenching that would probably kill the tree. The drawings on the right show how tunneling under the tree will preserve many of the important feeder roots.







# STRUCTURAL STANDARDS





STANDARD  
FOR  
LAND GRADING

Definition

Reshaping the ground surface by grading to planned grades which are determined by topographic survey and layout.

Purpose

The practice is for one or more of the following: Provide more suitable sites for land development; Improve surface draining; and control erosion.

Conditions Where Practice Applies

This practice is applicable where grading to planned elevations is practical and 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.

Planning Criteria

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

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

The development and establishment of the plan shall include the following:

1. 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.
2. The permanently exposed faces of earth cuts and fills shall be vegetated or otherwise protected from erosion.
3. Provisions shall be made to safely conduct surface water to storm drains or suitable water courses and to prevent surface runoff from damaging cut faces and full slopes.
4. Subsurface drainage is to 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 Standard for Subsurface Drainage (p. 4.8.1).
5. Adjoining property shall be protected from excavation and filling operations.
6. Fill shall not be placed adjacent to the bank of a stream or channel, unless provisions are made to protect the hydraulic, biological, esthetic, and other environmental functions of the stream.

Installation Requirements

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

Topsoil is to be stripped and stockpiled in amounts necessary to complete finish grading of all exposed areas requiring topsoil. See Standard for Topsoiling (p. 3.5.1).

Fill material is to 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 slippage, erosion, or excess saturation.

All disturbed areas shall be left with a neat and finished appearance and shall be protected from erosion. See Vegetative Standards (p. 3.1.1 to 3.7.1).

Trees to be retained shall be protected if necessary in accordance with the Standard for Tree Protection During Construction (p. 3.9.1).



STANDARD  
FOR  
DIVERSION

Definition

A channel with a supporting ridge on the lower side constructed across the slope.

Scope

This standard covers the installation of diversions with drainage areas up to 100 acres.

Temporary

Diversions 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

Diversions installed as an integral part of an overall water management and disposal system and to remain for protection of property.

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.

Conditions Where Practice Applies

This practice applies to sites where runoff is damaging: (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, and (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.

Design Criteria

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 Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, August 1984.
2. SCS Technical Release No. 55.

The minimum size shall be that required to confine the peak runoff from the design storm plus required freeboard. The design storm and freeboard shall comply with the following table:

| DIVERSION TYPE | TYPICAL AREA OF PROTECTION                              | DESIGN STORM FREQUENCY | FREEBOARD REQUIRED |
|----------------|---------------------------------------------------------|------------------------|--------------------|
| Temporary      | Construction Areas (structures, roads, pipelines, etc.) | 2 years                | 0.0                |
|                | Building Sites                                          | 5 years                | 0.0                |

| DIVERSION TYPE | TYPICAL AREA OF PROTECTION                                                    | DESIGN STORM FREQUENCY | FREEBOARD REQUIRED |
|----------------|-------------------------------------------------------------------------------|------------------------|--------------------|
| Permanent      | Agricultural Land                                                             | 25 years               | 0.3 ft.            |
|                | Urban Land Areas, Play Fields, Recreation Areas, Agricultural Buildings, etc. | 25 years               | 0.3 ft.            |
|                | Homes, schools, Industrial buildings, etc.                                    | 50 years               | 0.5 ft.            |

#### Small Diversions

1. Where the diversion channel grade is between 0.25% and 5%, a permanent vegetative cover is planned and the design flow is equal to or less than given below, the dimensions given below for a parabolic channel may be used instead of preparing an individual design for the diversion.

| CHANNEL DIMENSIONS |                    |                |
|--------------------|--------------------|----------------|
| Q<br>(cfs)         | TOP WIDTH<br>(ft.) | DEPTH<br>(ft.) |
| 5                  | 12                 | 1.9            |
| 10                 | 22                 | 1.9            |

The depth given above includes 0.3 ft. freeboard and 0.1 ft. settlement. Side slopes shall be 3:1 or flatter, and the ridge top width shall be 4 ft. or wider.

2. Where the diversion will be 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 spacings, and the size given above for 5 cfs may be used instead of preparing individual designs for each diversion.

| ROAD GRADE<br>(percent) | APPROXIMATE DISTANCE<br>BETWEEN DIVERSIONS (ft.) |
|-------------------------|--------------------------------------------------|
| 1                       | 400                                              |
| 2                       | 245                                              |
| 5                       | 125                                              |
| 10                      | 78                                               |
| 15                      | 58                                               |
| 20                      | 47                                               |
| 25                      | 40                                               |
| 30                      | 35                                               |

#### 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. The following table will be used in selecting maximum permissible velocities:

| SOIL TEXTURE                                      | MAXIMUM PERMISSIBLE†<br>VELOCITY (ft./sec.) |        |        |
|---------------------------------------------------|---------------------------------------------|--------|--------|
|                                                   | CHANNEL VEGETATION                          |        |        |
|                                                   | Non-Veg.*                                   | Veg.** | 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                  | 2.0                                         | 2.5    | 4.0    |
| Clay, clay loam, sandy clay, silty clay           | 2.5                                         | 3.0    | 5.0    |

†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 A6 for example and charts for use in design. Maximum permissible velocities for vegetated channels may be increased by 3 ft./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 to excessively drained soils, the use of most cool season sod types will not survive without continued irrigation. Placement of sod in such areas must be approved by the District.

| VEGETATIVE RETARDANCE FACTORS       |                                               |
|-------------------------------------|-----------------------------------------------|
| For Determining<br>Minimum Capacity | For Determining<br>Maximum Allowable Velocity |
| D                                   | E                                             |

Tables to select channel dimensions are available in Chapters 7 and 9, Ref. #1.

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 channel cross section shall be such that the diversion can be properly maintained with modern equipment. The channel may be parabolic, vee-shaped, or trapezoidal.

The side slopes for permanent diversions shall not be steeper than 3:1 for maintenance purposes, and preferably 4:1. Where frequent crossings are expected, slopes should be flatter. The back slope of the ridge is not to be steeper than 3:1 and preferably 4:1. The ridge shall include a settlement factor equal to 5 percent of the height. The minimum top width of the diversion ridge after settlement is to be 4.0 feet at the design water elevation.

In determining the cross section for temporary 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 1/2:1.

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

#### Location

Diversion location 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 water courses and putting additional flow into a water course.

#### 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 provided.

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



### Protection Against Sedimentation

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

1. Land treatment or structural measures shall be installed to stabilize the source of sediment or trap the sediment.
2. If it is not possible to stabilize or trap the sediment, a filter strip of close growing grass shall be maintained above the diversion channel. The filter strip width measured from the center of the channel shall be at least one-half the channel top width plus 15 feet.

#### 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 open channel.

The outlet, in all cases, must be stable and convey water to a disposal point where damage will not result. Constructed vegetative outlets must be established prior to diversion construction.

#### Temporary Stone Outlet Structure

A temporary stone outlet structure for a diversion may be used only where the contributing watershed is less than five acres. The minimum length, in feet, of the crest of the stone outlet structure shall be equal to six times the number of acres of the contributing drainage area. The crest of the stone outlet structure shall be level and at least six inches lower than the lowest elevation of the top of the diversion. The stone shall be crushed stone and be 4" to 8" in diameter except for a one-foot thick blanket of 2" 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 structure shall be embedded into the soil a minimum of four inches.

#### Permanent Cover and Erosion Protection

A permanent vegetative cover shall be established on all diversions in accordance with the Standards for Permanent Vegetative Cover for Soil Stabilization, p. 3.2.1 or Standards for Permanent Stabilization with Sod, p. 3.4.1. Where the season and other conditions may not be suitable for growing permanent erosion resistant cover, erosion protection will be provided in accordance with the Standards for Temporary Vegetative Cover for Soil Stabilization, p. 3.1.1 or Standards for Stabilization with Mulch Only, p. 3.3.1.

Diversions that are not designed to have a permanent vegetative cover shall be designed for bare channel velocities and with flat side slopes to prevent channel and side slope erosion. Diversions that are designed to have a permanent vegetative cover shall be seeded from the toe of the backslope to the upstream side of the designed channel width plus any required filter strip. Other areas disturbed by 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 diversion. All ditches or gullies which must be crossed will 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 diversion are to be removed.

Vegetation is to be removed and the base for the ridge thoroughly disked before placement of fill.

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

The top of the constructed ridge is 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 Standards for Permanent Vegetative Cover for Soil Stabilization, p. 3.2.1.

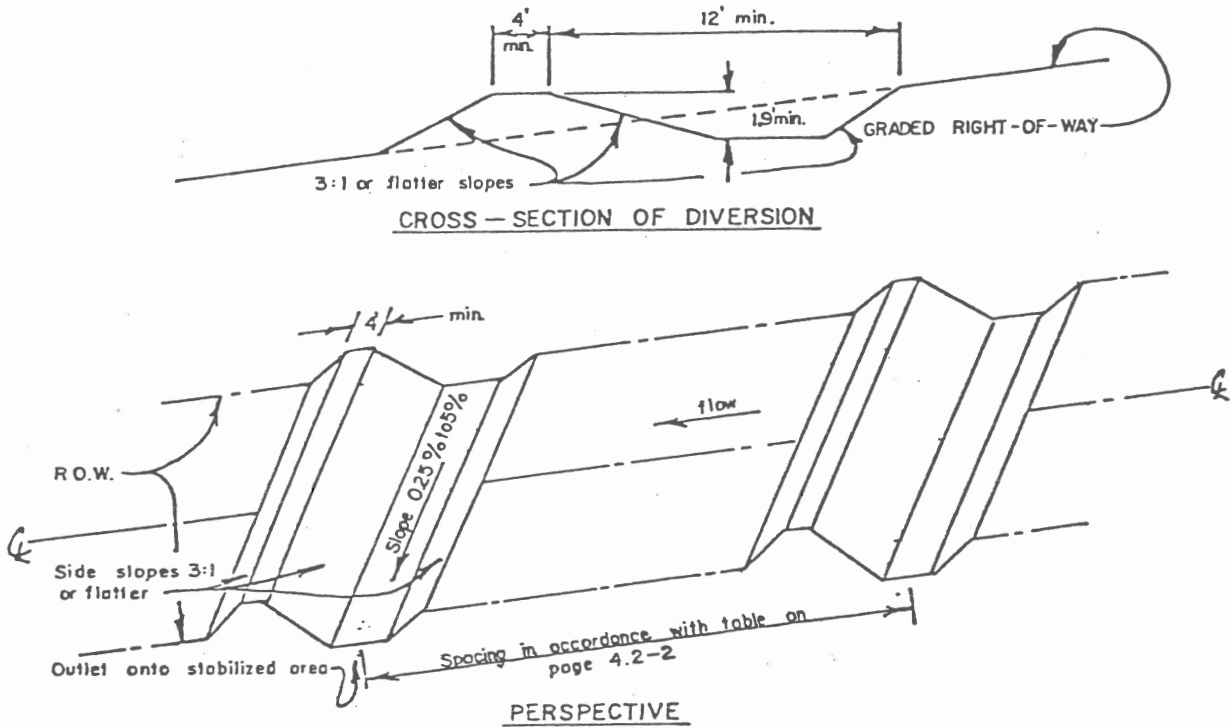
If there is no sediment protection provided on temporary diversions, it should be anticipated that periodic cleanout may be required.

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

FIGURE 4.2-1

SMALL DIVERSIONS FOR GRADED RIGHT-OF-WAY

For use on graded right-of-way, if the only drainage area is the right-of-way



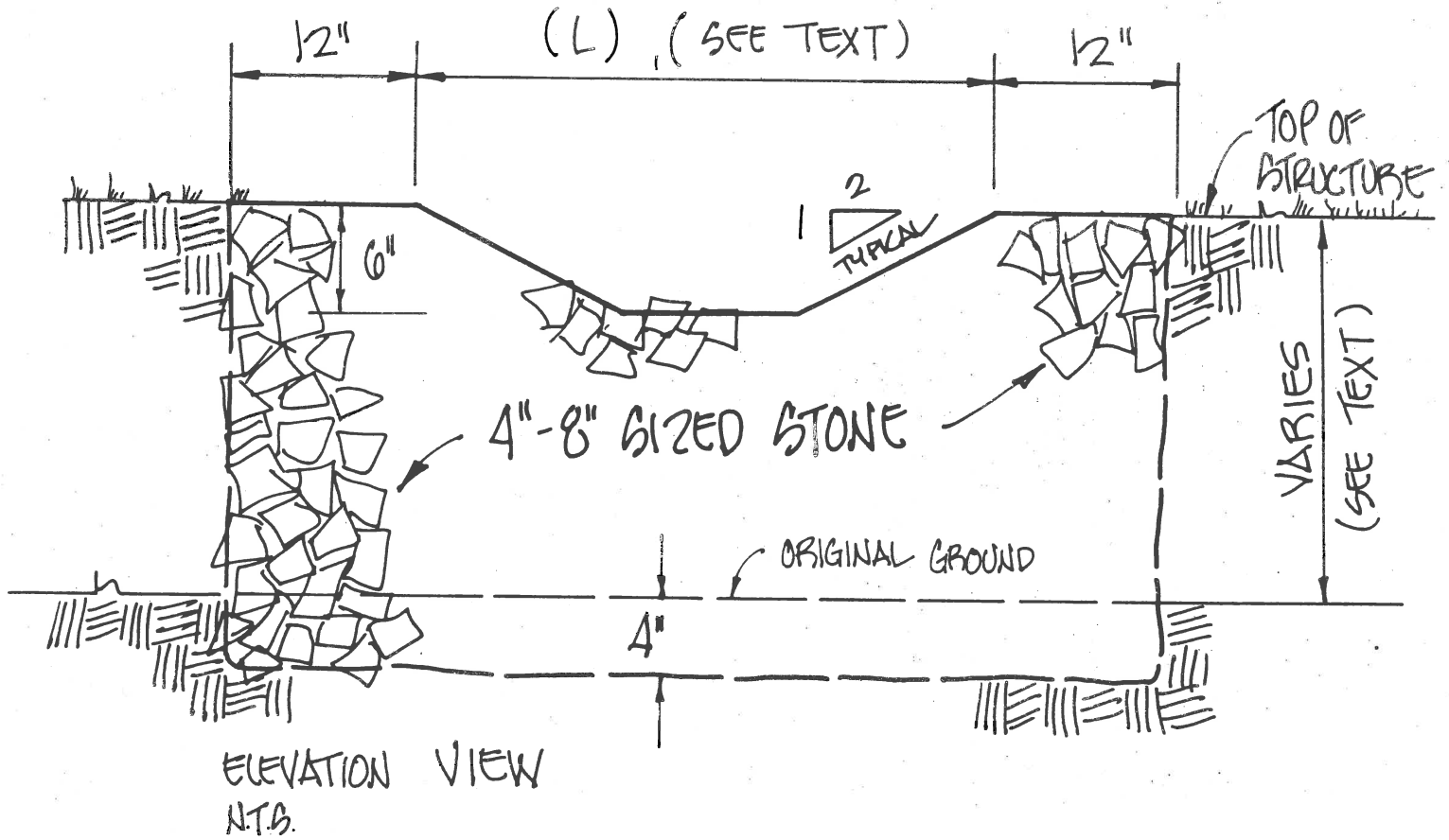
DESIGN CRITERIA

Top width - 4 ft. min.  
 Height - 1.9 ft. min. (height measured from the upslope toe to top of the dike).  
 Side slopes - 3:1 or flatter (flat enough to allow construction traffic to cross if desired.)  
 Grade - 0.25% to 5%.  
 Spacing - according to Table on page 4.2.2.

GENERAL NOTES

1. Top width may be wider and side slopes may be flatter, if desired.
2. Diverted runoff shall outlet onto an undisturbed stable area, or onto an area that has been stabilized.
3. Periodic inspection and required maintenance must be provided.

FIGURE 4.2.2

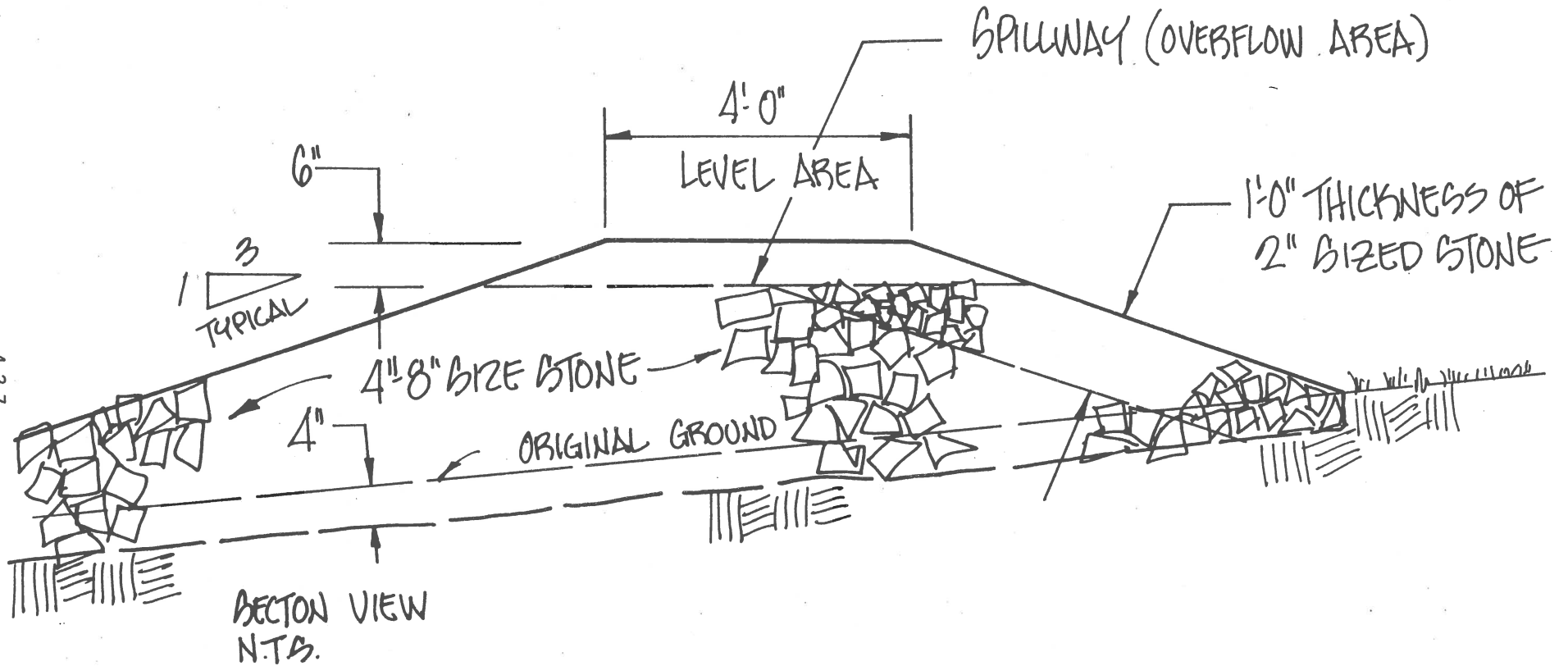


## TEMPORARY STONE OUTLET STRUCTURE

FIGURE 4.2.3

Diversion

4.2.7



## TEMPORARY STONE OUTLET STRUCTURE

Revised April 1987



STANDARD  
FOR  
GRASSED WATERWAY

Definition

A natural or constructed watercourse shaped or graded in earth materials and stabilized with suitable vegetation for the safe conveyance of runoff water.

Purpose

To provide for the conveyance of excess surface water without damage by erosion or flooding.

Conditions Where Practice Applies

This practice applies to sites with drainage areas less than 200 acres where concentrated runoff requires vegetative protection or stone center lining to control erosion. Slope of 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.

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. 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 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. The following table will be used in selecting the maximum permissible velocities:

| SOIL TEXTURE                                            | MAXIMUM PERMISSIBLE VELOCITY†<br>(ft./sec.) |       |
|---------------------------------------------------------|---------------------------------------------|-------|
|                                                         | CHANNEL VEGETATION                          |       |
|                                                         | Vegetated*                                  | Sod** |
| Sand, silt loam, sandy loam, loamy sand, loam, and muck | 2.0                                         | 3.0   |
| Silty clay loam, sandy clay loam                        | 2.5                                         | 4.0   |
| Clay, clay loam, sandy clay, silty clay                 | 3.0                                         | 5.0   |

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

\*Maximum permissible velocities for vegetated channels may be increased by 3 ft./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 to excessively drained soils, the use of most cool season sod types will not survive without continued irrigation. Placement of sod in such areas must be approved by the District.

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 A6 for example and charts for use in design.

| VEGETATIVE RETARDANCE FACTORS       |                                               |
|-------------------------------------|-----------------------------------------------|
| For Determining<br>Minimum Capacity | For Determining<br>Maximum Allowable Velocity |
| D                                   | E                                             |

Tables to select channel dimensions are available in Chapter 7, Ref. #1.

#### 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 will be 10 feet. The maximum design top width shall not exceed 50 feet.

The cross section may be parabolic, vee-shaped, 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 1/2 inch 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 one-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.

#### Vegetation

##### Permanent Cover

A permanent vegetative cover shall be established on all grassed waterways in accordance with the Standards for Permanent Vegetative Cover for Soil Stabilization, p. 3.2.1 or Standards for Permanent Stabilization with Sod, p. 3.4.1. Where the season and other conditions may not be suitable for growing permanent erosion resistant cover, erosion protection will be provided in accordance with the Standards for Temporary Vegetative Cover for Soil Stabilization, p. 3.1.1 or Standards for Stabilization for Mulch Only, p. 3.3.1. The seeding will 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.

##### Vegetative Lining

Waterways or outlets shall be protected against erosion by vegetative means as soon after construction as practical and before diversions or other channels are outletted into them. Consideration should be given to the use of jute matting, excelsior matting (see Appendix A5), or sodding channels to provide erosion protection as soon after construction as possible.

Seeding, fertilizing, mulching, and sodding shall be in accordance with the applicable standards.

STANDARD  
FOR  
SEDIMENT BASIN

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 or more.

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 or less.
4. The effective height of the dam is 20 feet or less. The effective height of the dam is defined as the difference in elevation in feet 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 60" (TR60) by the Soil Conservation Service, U.S. Department of Agriculture.

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 Water Resources, for the construction and inspection of dams or for stream encroachments, shall apply.

Purpose

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; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, and stone.

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 a sediment basin offers the most practical solution to the problem.

Design Criteria

Sediment Basin Location

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 benefit from the terrain.
- d. For ease of cleanout of the trapped sediment.
- e. To minimize interference with other construction activities and construction of utilities.



### Sediment Basin Volume

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

1. The volume necessary to obtain 70% trap efficiency at the start of the basin's useful life, or
2. a. The volume necessary to provide sediment storage capacity and provide for temporary storm-water runoff storage from a 2-year frequency, 24-hour duration, Type III storm, or  
b. Use the modified rational method up to 20 acres, as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater for a 2-year frequency storm.

### Principal Spillway Crest Elevation

The principal spillway crest elevation shall be the lower of one (1) foot 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 SCS "Engineering Field Manual," the approximate methods in the SCS "Urban Hydrology for Small Watersheds" (TR55), or other generally accepted methods of flood routing.

The modified rational method on a drainage basin up to 20 acres, 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 4.4-1 and with

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

I = average annual surface runoff from Figure 4.4-1 converted to units of acre feet.

For a normally dry sediment basin, the actual trap efficiency is reduced 10% where the incoming sediment is predominately silt, clay, or fine grained. Therefore, enter Curve 4.4-1 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 4.4-1 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 0.07 acre feet of sediment storage volume per acre of total drainage area per year of planned life.
2. Provide sediment storage based on the following formula and figures:

$$V = (DA)(A)(DR)(TE)\left(\frac{1}{3}\right)(2,000 \text{ lbs./tons})(1/43560 \text{ sq. ft./Ac.})$$

where:

V = the volume of sediment trapped in AC. ft./yr.

DA = the total drainage area in acres.

A = the average annual erosion in tons per acre per year using the values below for the listed land use

| LAND USE                                                                                     | AVERAGE ANNUAL EROSION |
|----------------------------------------------------------------------------------------------|------------------------|
| Wooded areas                                                                                 | 0.2 ton/ac/yr          |
| Developed urban areas, grassed areas, pastures, hay fields, abandoned fields with good cover | 1.0 ton/ac/yr          |
| Clean tilled cropland (corn, soybeans, etc.)                                                 | 10 ton/ac/yr           |
| Construction areas                                                                           | 50 ton/ac/yr           |

DR = the delivery ratio determined from Curve 4.4-2.

TE = the trap efficiency as determined above.

$\gamma$  = the estimated sediment density in the sediment basin in lbs./cu. ft.  
(See Table 4.4-1).

$\gamma_s$  = the submerged density in a wet sediment pool.

$\gamma_a$  = the aerated density in a normally dry sediment pool.

TABLE 4.4-1

| SOIL TEXTURE                             | $\gamma_s$<br>Submerged<br>(lbs./cu. ft.) | Aerated<br>(lbs./cu. ft.) |
|------------------------------------------|-------------------------------------------|---------------------------|
| Clay                                     | 40-60                                     | 60-80                     |
| Silt                                     | 55-75                                     | 75-85                     |
| Clay-silt mixtures<br>(equal parts)      | 40-65                                     | 65-85                     |
| Sand-silt mixtures<br>(equal parts)      | 75-95                                     | 95-100                    |
| Clay-silt-sand mixtures<br>(equal parts) | 50-80                                     | 80-100                    |
| Sand                                     | 85-100                                    | 85-100                    |
| Gravel                                   | 85-125                                    | 85-125                    |
| Poorly sorted sand and gravel            | 95-130                                    | 95-130                    |

3. Provide sediment storage based on the same procedure as 2. above except determine (A) using the Universal Soil Loss Equation (Appendix A1) 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 the installation of one or more baffles.

The minimum width shall be:

$$W = 10 \sqrt{Q_5}$$

where:

W = the width in ft.

$Q_5$  = peak discharge from a 5 year frequency storm in cfs.

The average depth shall be at least 4 feet.

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

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

where:

W = width in feet

Q<sub>25</sub> = peak discharge from a 25 year frequency storm in cfs.

The average depth shall be at least 4 feet.

#### 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. 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, 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 back-filling operations.

#### Seepage Control

Seepage control is to be included if seepage may create swamping downstream; 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 4.4-2. When the embankment top is to be used as a public road, the minimum width, guardrails, 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 4.4-2

| TOTAL HEIGHT<br>OF EMBANKMENT<br>(feet) | MINIMUM<br>TOP WIDTH<br>(feet) |
|-----------------------------------------|--------------------------------|
| <20                                     | 10                             |
| 20-24                                   | 12                             |

For dams which raise the water elevation five (5) feet 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 Water Resources, 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 five horizontal to one vertical (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 of Other than Earthfill

Sediment basins with effective heights of less than 5 feet 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 for corrugated or helical pipe and 6 inches 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. 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 inches or less in diameter to dewater the basin.
2. Dewatering 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 normal dry sediment basin.

If a normally dry or partially dry sediment basin is planned, the basin shall be dewatered by a 4 inch 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:

- a. 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.
- b. 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 dewatered by using a subsurface drain, it shall be in accordance with the Subsurface Drain Standard.

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 riprap, excavated plunge pools, or use of other generally accepted methods.

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:

Let  $V$  = projection of the antiseep collar in feet

$L$  = length in feet 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 intersects the conduit, whichever is shorter.

$n$  = number of antiseep collars.

The ratio of the length of the line of seepage ( $L + 2nV$ ) 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.

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 to it without overtopping the dam. A closed conduit principal spillway having a conduit with a cross-sectional area of 3 square feet or more, 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 to 1 or flatter and has existing vegetation or is immediately protected by sodding, rock riprap, 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 4.4-5 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 SCS Engineering Field Manual; the SCS Technical Release 55; the modified rational method up to 20 acres, 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 4.4-5

#### MINIMUM DESIGN STORM

| DRAINAGE AREA<br>(acres) | FREQUENCY<br>(years) | MINIMUM DURATION*<br>(hours) |
|--------------------------|----------------------|------------------------------|
| less than 20             | 10                   | 24                           |
| 21 - 49                  | 25                   | 24                           |
| over 49                  | 100                  | 24                           |

\*For use by SCS 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 ft. per second for vegetated channels in soils with a plasticity index of 10 or less and 6 ft. 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 to 1 or flatter. The bottom width shall be 10 feet 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.
  - (1) Inlet channel - the inlet channel shall be level and straight for at least 20 feet 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 top width minimum, and be high enough to contain the design flow plus one foot of freeboard.

#### Structural Spillways Other Than Pipe

Structural spillways other than pipe will 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 4.4-5.

#### 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, 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 or in or adjacent to a stream or floodplain.

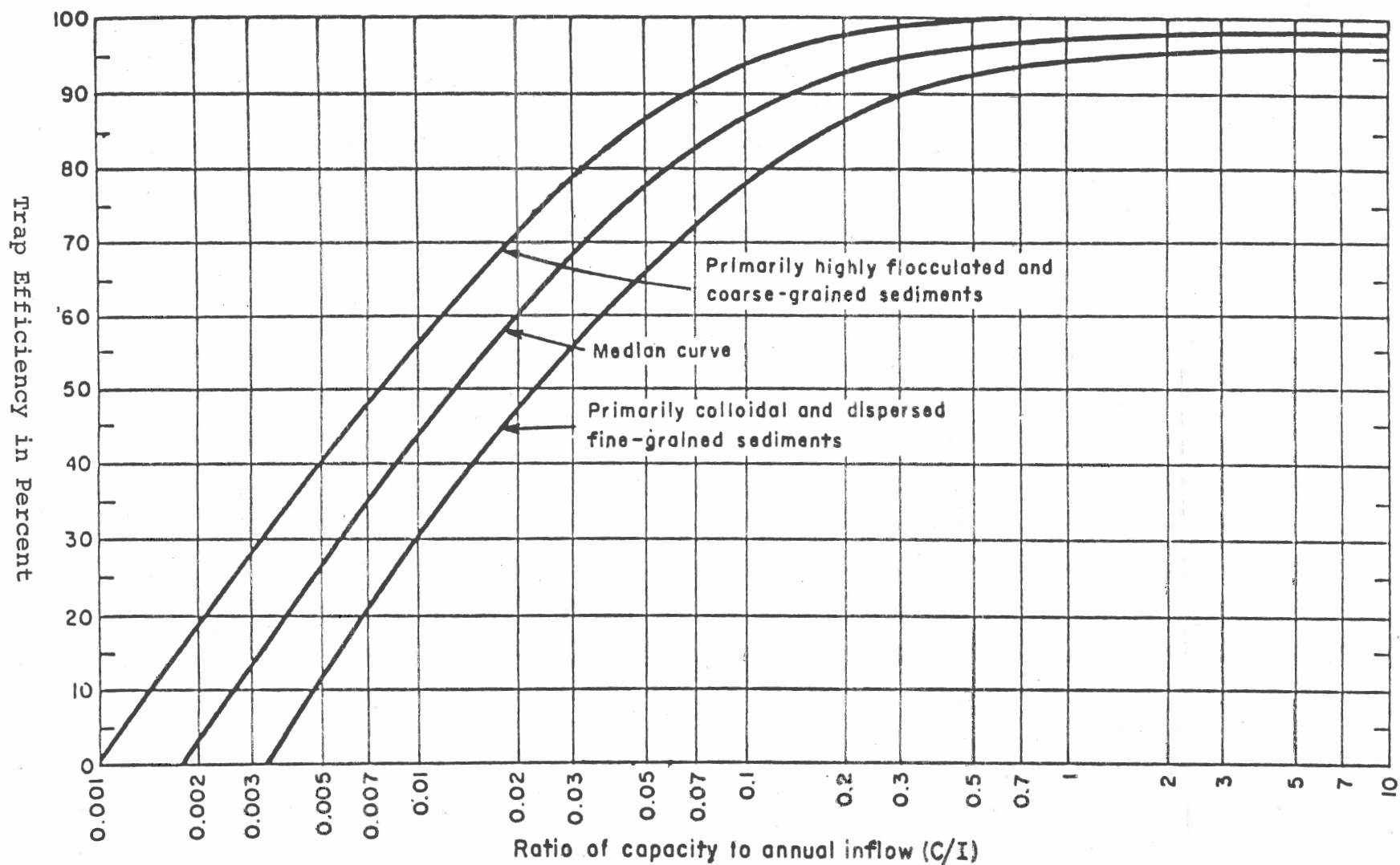
The plans shall also show the method of removal of the sediment basin after the drainage area is stabilized, and shall include the stabilizing of the sediment basin site. Water lying over the trapped sediment shall be removed from the basin by pumping, cutting the top of the riser, or other appropriate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

#### Safety

Sediment basins attract children and can be very dangerous. They should 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

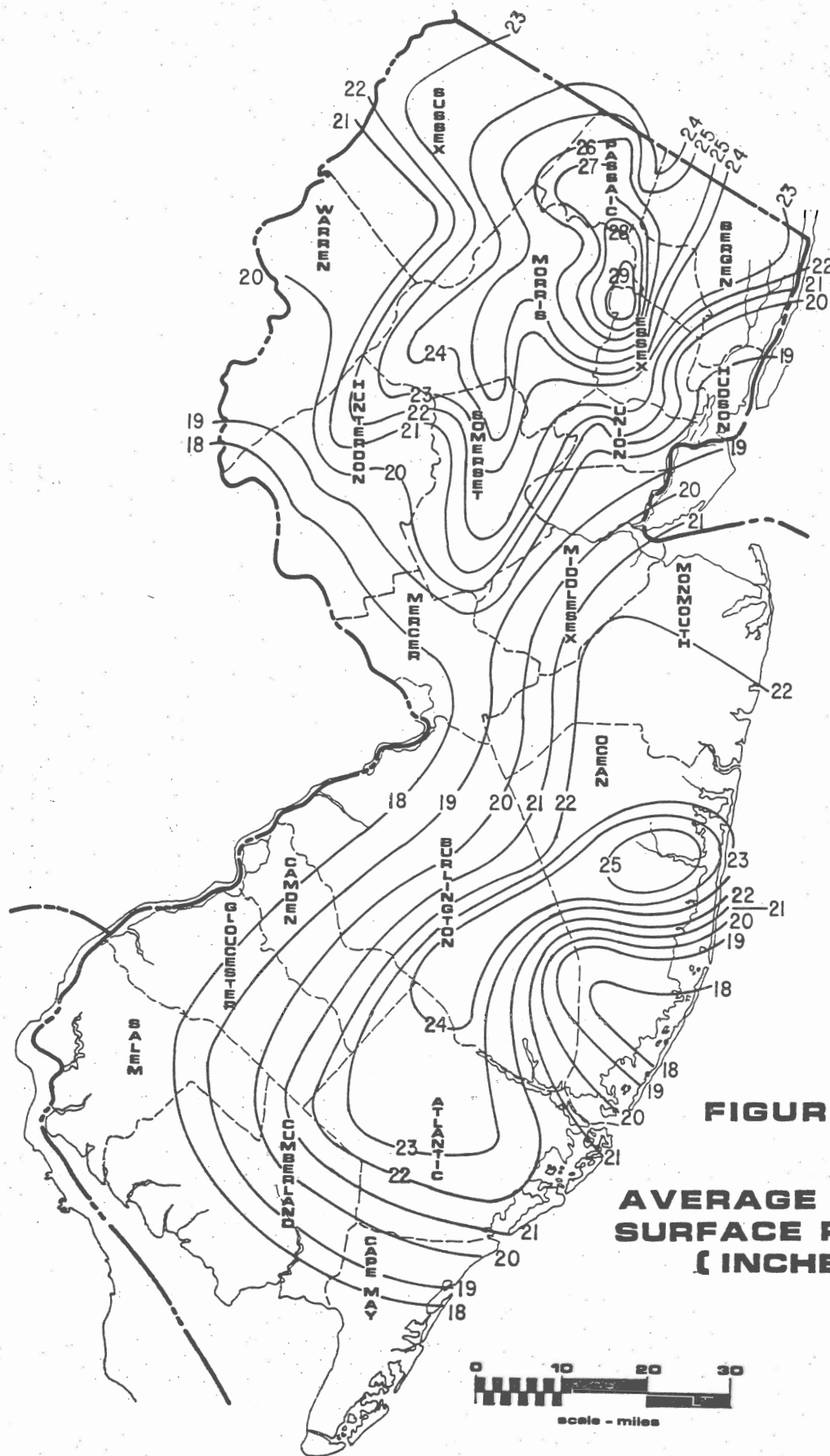
The plans shall indicate who is responsible for operation and maintenance during the life of the sediment basin.



CURVE 4.4-1

TRAP EFFICIENCY OF RESERVOIRS

Reference: Brune, Gunnar M., "Trap Efficiency of Reservoirs",  
Trans. AGU, Vol. 34, No.3, pp 407-418, June 1953.



**FIGURE 4.4-1**

**AVERAGE ANNUAL  
SURFACE RUNOFF  
( INCHES )**



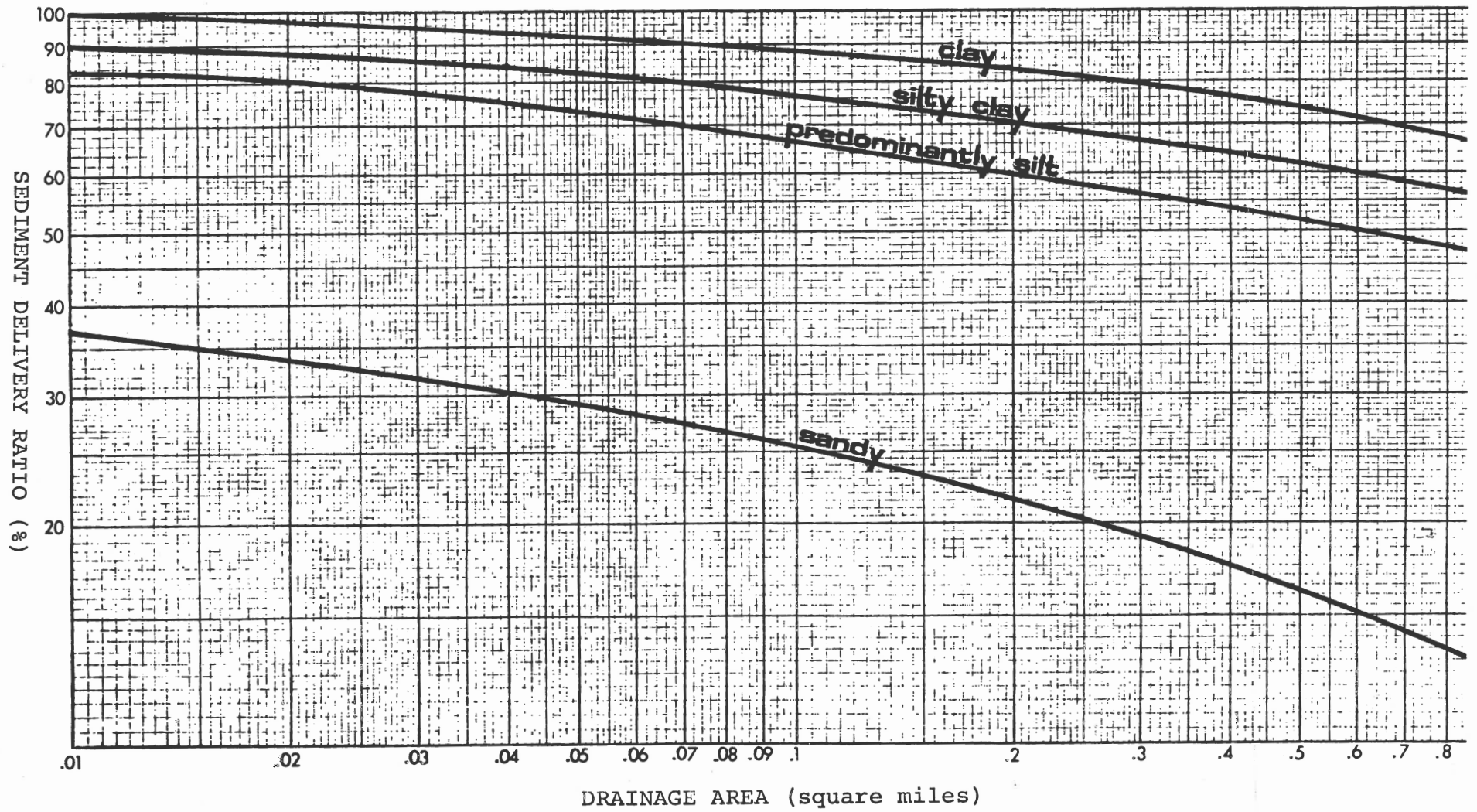


FIGURE 4.4-2  
SEDIMENT DELIVERY RATIO VS. DRAINAGE AREA

STANDARD  
FOR  
SLOPE PROTECTION STRUCTURES

Definition

Structures to safely conduct surface runoff from the top of a slope to the bottom of the slope.

Purpose

The purpose of this practice is to convey storm runoff safely down existing slopes and cut and fill slopes to minimize erosion.

Conditions Where Practice Applies

Slope protection structures are to be used where concentrated water will cause excessive 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.

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 4.5-1 and 4.5-2.

Protection against scour at the discharge end of the open flume shall be provided in the form of an energy dissipator or other measures such as an SAF, rock riprap revetment, or plunge pool.

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 4.5-1.
2. T - is the top width of parabolic flumes. The minimum top widths and maximum drainage areas shall conform to Table 4.5-2.
3. H - is the height of the dike at the entrance to the structure and shall be a minimum of 2.5 feet.
4. d - is the depth of the paved down slope section and shall be a minimum of 10 inches for trapezoidal or rectangular flumes. The depths of parabolic flumes shall be as shown in Table 4.5-2.
5. L - is the length of the inlet and outlet paved sections and each shall be a minimum of 6 feet.

The above dimensions are illustrated in Figure 4.5-1.

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 4.5-1 and 4.5-2 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 4.5-1 and 4.5-2 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 Pipe Drops of this Standard.

TABLE 4.5-1

## FLUMES WITH TRAPEZOIDAL AND RECTANGULAR SECTIONS

| BOTTOM WIDTHS AND DRAINAGE AREA<br>FOR TRAPEZOIDAL FLUMES WITH FLOW<br>DEPTHS EQUAL 10 INCHES |                          | BOTTOM WIDTHS AND DRAINAGE AREA<br>FOR RECTANGULAR FLUMES WITH FLOW<br>DEPTHS EQUAL 10 INCHES |                          |
|-----------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------|--------------------------|
| Bottom Width<br>(feet)                                                                        | Drainage Area<br>(acres) | Bottom Width<br>(feet)                                                                        | Drainage Area<br>(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                       |

Dikes to be 2.5 feet in height above flume entrance

TABLE 4.5-2

## FLUMES WITH PARABOLIC SECTIONS

| DEPTHS EQUAL 1 FOOT |                          | DEPTHS EQUAL 1.5 FEET |                          |
|---------------------|--------------------------|-----------------------|--------------------------|
| Top Width<br>(feet) | Drainage Area<br>(acres) | Top Width<br>(feet)   | Drainage Area<br>(acres) |
| 4                   | 3                        | 4                     | 4                        |
| 6                   | 4                        | 6                     | 5                        |
| 8                   | 5                        | 8                     | 5                        |
| 10                  | 6                        | 10                    | 7                        |
| 12                  | 7                        | 12                    | 8                        |
| 14                  | 8                        | 14                    | 10                       |
|                     |                          | 16                    | 11                       |

Dikes to be 2.5 feet in height above flume entrance

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:

- Rational Method - for peak discharge of uniform drainage areas up to one half of a square mile as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, August 1984.
- SCS Technical Release No. 55 - for drainage area less than five square miles.
- For areas greater than or equal to five square miles, use SCS Technical Release No. 20 or other officially approved methodology.

Pipe capacities may be determined from charts in Chapter 6, Ref. (1), or other accepted sources.

A hood inlet type entrance should be used as shown in Figure 4.5-11. The pipe drop inlet shall be protected by riprap or concrete.

Flexible Downdrain

A heavy duty fabric or other material may be used as a temporary or interim structure, as shown in Figure 4.5-11. Use of flexible down drains is not recommended during the winter months. Standard metal end sections shall be used.

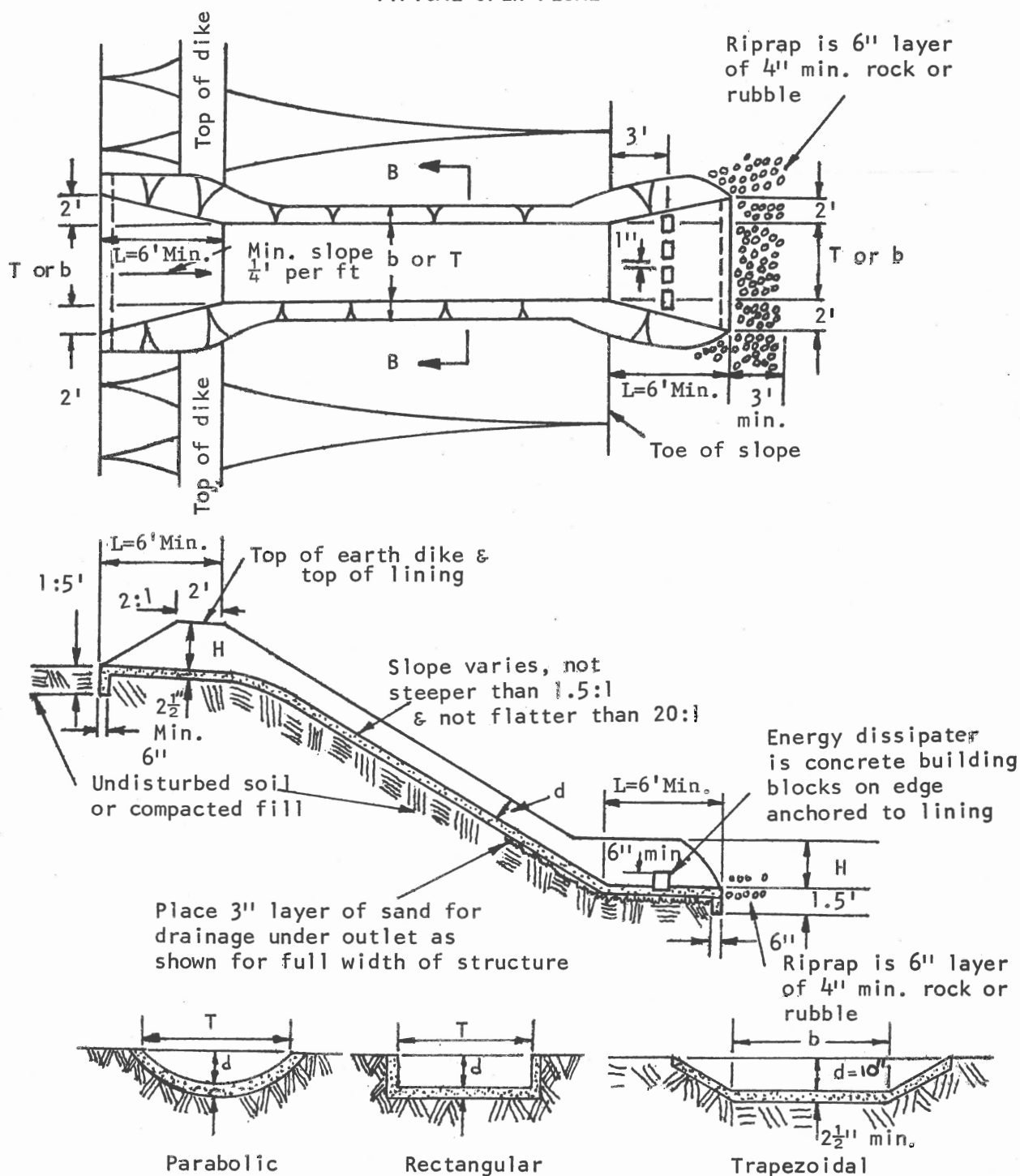
Outlet protection shall be provided by riprap or other means.

Diversion dikes or deep curb cuts shall be used in conjunction with pipe drops. 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 0.5 feet 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 vertical to 1.5 horizontal (1.5:1) 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 should 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 1/4 to 1/2 inch per foot.
5. Hood Inlet Pipe Drops
  - a. The pipe shall be imbedded in the embankment to a depth that will insure stability.
  - b. Protection measures of concrete or riprap shall be installed at the inlet and outlet as needed to protect against 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, p. 4.14.1.

FIGURE 4.5-I  
TYPICAL OPEN FLUME

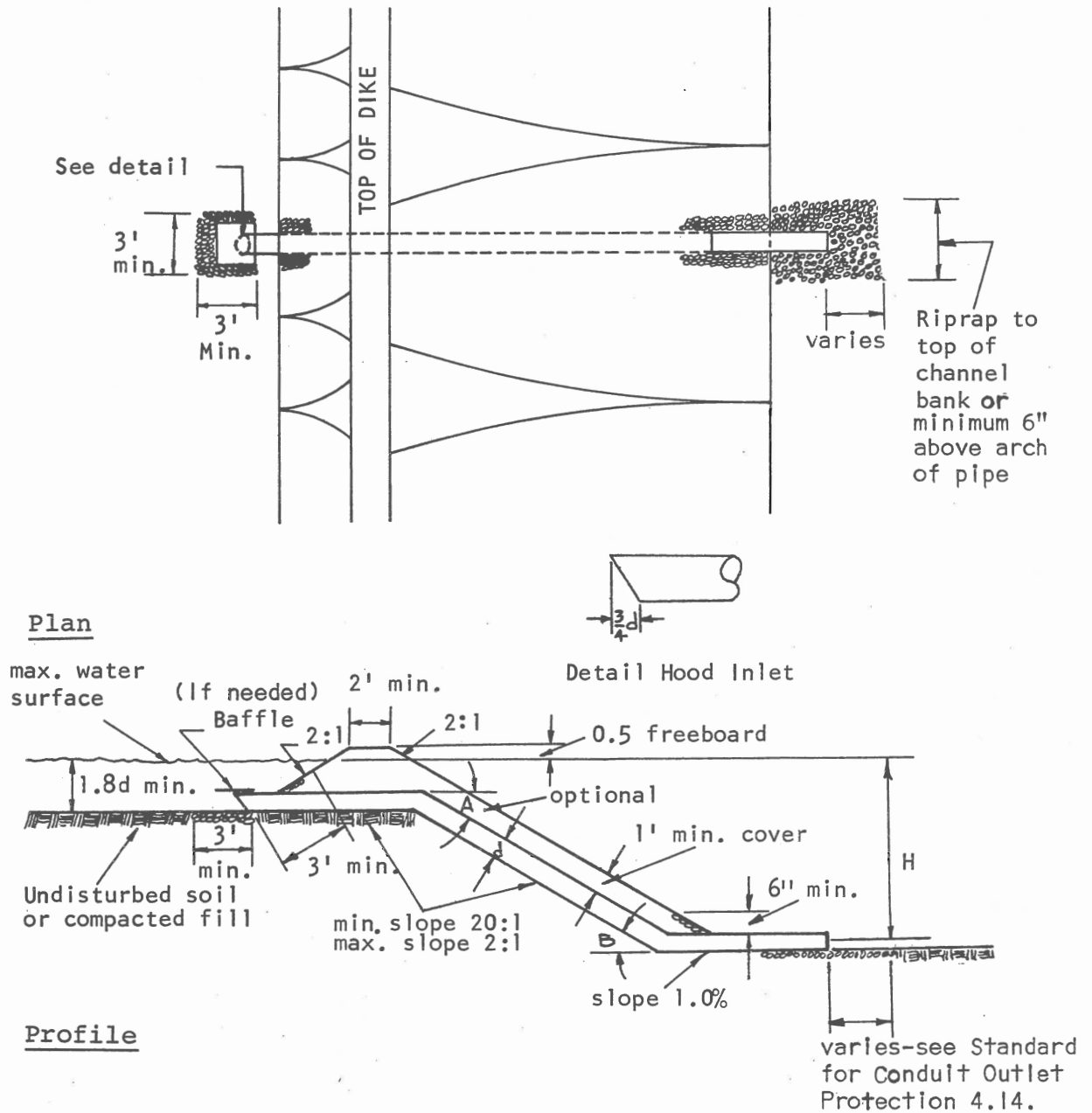


Alternate Sections B-B

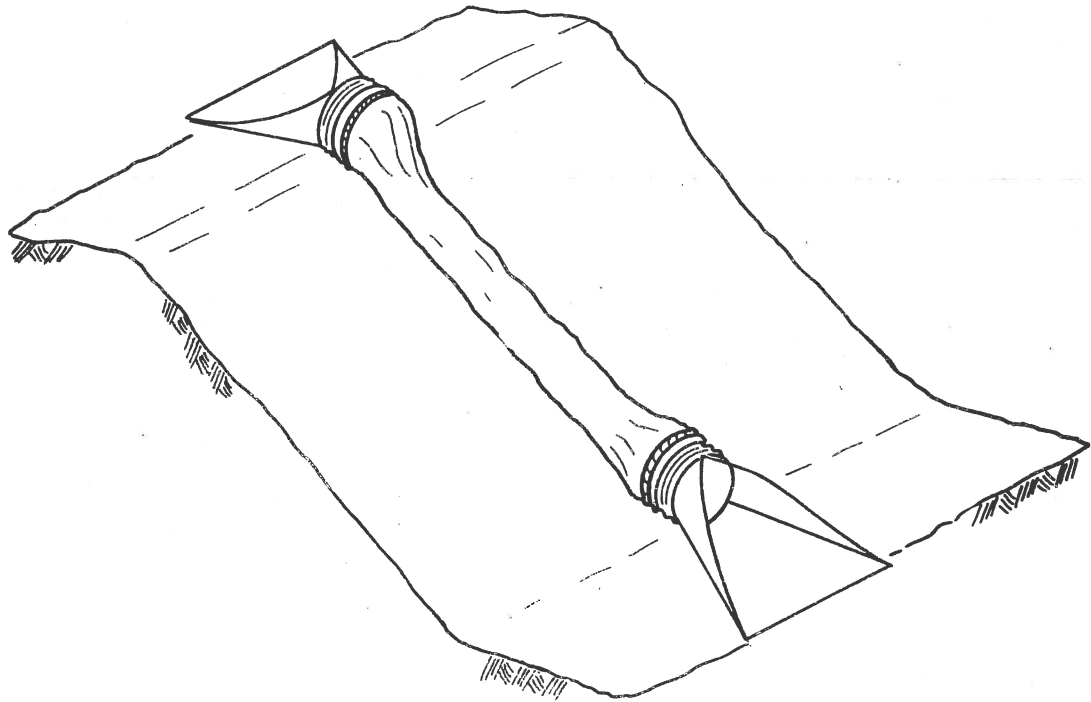
Notes:

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 4.14 shall also apply.

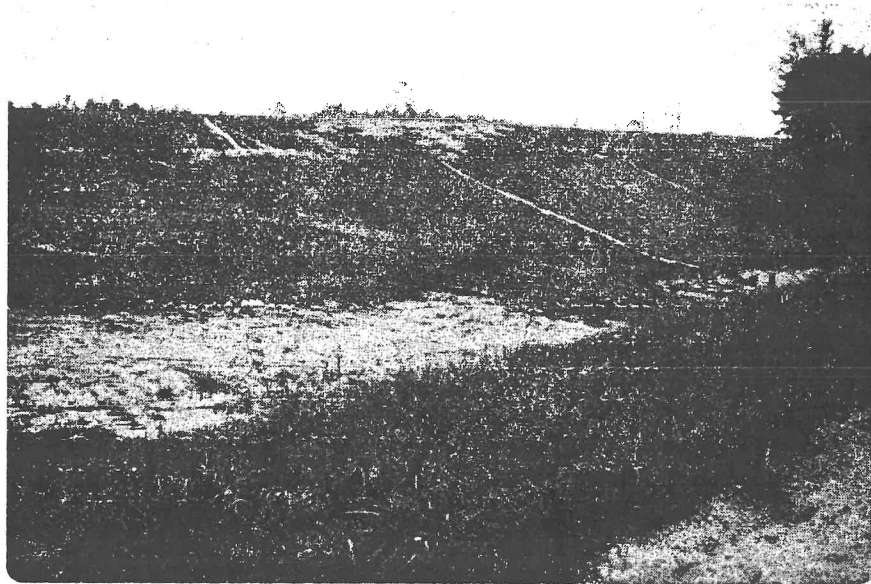
FIGURE 4.5-II  
BANK PROTECTION STRUCTURE  
(Hood Inlet Pipe)



No scale



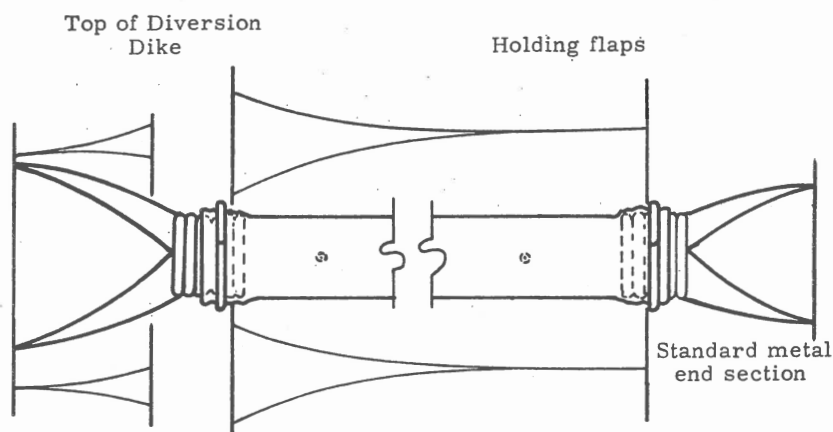
Flexible down drain - isometric



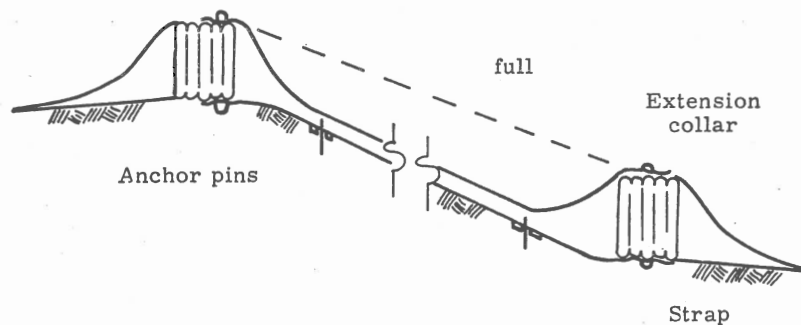
Flexible down drain - installed

## MAINTENANCE:

Inspect 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.



PLAN VIEW



Flexible down drain





STANDARD  
FOR  
CHANNEL STABILIZATION

Definition

Stabilizing a channel, either natural or artificial, in which water flows with a free surface.

Purpose

Open channels are constructed or stabilized to be nonerodible and provide adequate capacity for the conveyance of flood water, draining, other water management purposes, or any combination thereof.

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.

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 food or shelter 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 considering the requirements for construction, operation, and maintenance. See Standard for Tree Protection During Construction, p. 3.9.1.

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 of uniform drainage areas up to one half of a square mile as outlined in Technical Manual for Storm Encroachment, Trenton, N.J., Bureau of Flood Plain Management, August 1984.
2. SCS Technical Release No. 55 for drainage areas less than five square miles.
3. For areas greater than or equal to five square miles, use SCS Technical Release No. 20 or other officially approved methodology.

Hydraulic Requirements

Manning's formula shall be used to determine the velocities in the channels.

The "n" values for use in this formula shall be estimated using currently accepted guides along with knowledge and experience regarding the conditions.

Acceptable guides can be found in Refs. 6, 7, and Appendix A8.

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 or flatter unless the design, using the procedures in Appendix A8, shows that a steeper side slope is stable. Channel side slopes of materials other than earth shall be designed stable.

### 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 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 of one square mile 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 4.6-1. 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 4.6-1. The actual velocity is defined as the velocity developed during the 2-year frequency peak discharge.

TABLE 4.6-1

#### ALLOWABLE VELOCITY FOR VARIOUS SOIL TEXTURES

| SOIL TEXTURE                             | ALLOWABLE VELOCITY<br>ft./sec. |
|------------------------------------------|--------------------------------|
| Sand                                     | 1.75                           |
| Sandy loam                               | 2.5                            |
| Silt loam                                | 3.0                            |
| Sandy clay loam                          | 3.5                            |
| Clay loam                                | 4.0                            |
| Clay, fine gravel, graded loam to gravel | 5.0                            |
| Cobbles                                  | 5.5                            |
| Shale (nonweathered shale)               | 6.0                            |

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.

#### Channel Stability (drainage area greater than one square mile)

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 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 A8 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 or allowable velocity procedures given in Appendix A8. 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:

#### A. Tractive Stress - see Appendix A8

1. Coarse grained soils
2. Fine grained noncohesiveness soils ( $PI < 10$ )

#### B. Allowable Velocity - see Appendix A8

1. Coarse grained soils (tractive stress procedure recommended)
2. Fine grained cohesive soils ( $PI > 10$ )
3. Fine grained noncohesive soils ( $PI < 10$ ) (tractive stress procedure 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, p. 4.12.1.
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. See Standard for Grade Stabilization Structure, p. 4.17.1.

They may be constructed of concrete, rock, masonry, steel, gablons, aluminum, or treated timber.

The structures must be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions.

Chapter 6, 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.

Chapter 15, Ref. #6, provides design considerations for energy dissipation with the hydraulic jump.

#### 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 will be left standing, brush and stumps will not be removed, and channels will be excavated from one side, leaving vegetation on the opposite side.
3. Construction plans will specifically detail the location and handling of spoils.
4. Seeding, fertilizing, and mulching shall conform to the Standards for Permanent Vegetative Cover for Soil Stabilization, p. 3.2.1.
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 Standards for Stabilization with Mulch Only, p. 3.3.1.

STANDARD  
FOR  
DETENTION BASIN  
FOR CONTROL OF DOWNSTREAM EROSION

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 or more.

Scope

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

Purpose

Detention basins are an available option to reduce 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.

Conditions Where Practice Applies

This practice applies if there is a potential for increased downstream erosion due to construction at development sites, or from other land use changes, or if local ordinances require storm detention basins. The increased downstream 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, regulations promulgated by DEP pursuant to that Act shall 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.

Design Criteria

Structural aspects of detention basins shall be as stipulated by applicable municipal, county, and state requirements. In the absence of such criteria, Appendix A-10, Structural Guidelines for Detention Basins, may be used. In addition, it must be shown for the peak outflow, as determined by the Rational Method or TR55, that there will be no soil erosion and sedimentation problems off-site. 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 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 up to one half square mile.

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

If there is an overall storm water management plan for the watershed that considers erosion, downstream peak flow increases that are compatible with the overall plan may be allowed.

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 (4.14) 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, p. 3.2.1. 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 should 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 operation 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 New Jersey Department of Environmental Protection shall be met where applicable.

STANDARD  
FOR  
SUBSURFACE DRAINAGE

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.

Purpose

A drain may serve one or more of the following purposes:

1. Improve vegetation by lowering the water table.
2. Intercept and prevent water movement into a potentially wet area.
3. Relieve artesian pressures.
4. Reduce surface runoff.
5. Serve as an outlet for other drains.
6. Replace natural subsurface drainage patterns which are interrupted by construction operations.

Conditions Where Practice Applies

Drains are 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.

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.

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), the use of Table 4.8-1, or by other accepted methods.

TABLE 4.8-1  
INFLOW RATES FROM DIFFERENT SOIL TEXTURES 1/ 2/

| SOIL TEXTURE           | UNIFIED SOIL CLASSIFICATION | INFLOW RATE PER 1000 FT. OF LINE IN CFS |
|------------------------|-----------------------------|-----------------------------------------|
| Coarse sand and gravel | GP, GW, SP, SW              | 0.15 to 1.00                            |
| Sandy or gravelly loam | SM, SC, GM, GC              | 0.07 to 0.25                            |
| Silt loam              | CL, ML                      | 0.04 to 0.10                            |
| Clay and clay loam     | CL, CH, MH                  | 0.02 to 0.20                            |

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.



### Size of Drain

The size of drains shall be computed by applying Manning's formula, or by the method contained in Chapter 14, Ref. (1).

The minimum drain shall be equivalent to a 4-inch diameter pipe.

### Depth, Spacing, and Location

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 feet per second 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 4.8-2, 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 tar impregnated paper, burlap, or special filter material such as plastic or fiber glass fabrics.
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 two inches.
4. For continuous pipe or tubing with perforations, completely enclose the pipe with filter material of plastic, fiber glass, or properly graded sand and gravel as specified under filters and filter materials on page 4.8.3.
5. Install relief vents where changes in grade exceed 5 percent.

TABLE 4.8-2

#### MAXIMUM PERMISSIBLE VELOCITIES IN DRAINS WITHOUT PROTECTIVE MEASURES

| SOIL TEXTURE           | VELOCITY -<br>FEET PER SECOND |
|------------------------|-------------------------------|
| Sandy loam             | 2.5                           |
| Silt and silt loam     | 4.0                           |
| Silty clay loam        | 5.0                           |
| Clay and clay loam     | 6.0                           |
| Coarse sand and gravel | 8.0                           |

### 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 need for a filter shall be determined by the characteristics of the soil materials at drain depth and the velocity of flow in the conduit.

Not less than three inches of filter material shall be used for sand-gravel filters.<sup>1</sup> Filters of organic material such as salt hay, straw, or wood chips shall provide a six-inch thickness.

Where fiber glass material is used, it shall be manufactured from borosilicate type glass and the manufacturer of the material shall certify that it is suitable for underground use. The material shall cover all open joints and perforations.

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

### Installation Requirements

All drains shall be laid to line and grade and covered with not less than three inches 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 one-fourth inch for mineral soils or one-half inch for organic soils. Openings wider than these shall be covered with fiber glass 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 two inches from rock.

When 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.

<sup>1</sup>A recommended method of installation is to place filter material to a depth of three inches 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 sieve.



STANDARD  
FOR  
TRAFFIC CONTROL

Definition

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

Purpose

To minimize land disturbance.

Where Applicable

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

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.



STANDARD  
FOR  
DUST CONTROL

Definition

The control of dust on construction sites and roads.

Purpose

To prevent blowing and movement of dust from exposed soil surfaces, reduce on- and off-site damage and health hazards, and improve traffic safety.

Where Applicable

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

Planning Criteria

The following methods should be considered for controlling dust:

Mulches - See Standards for Stabilization with Mulches Only (p. 3.3.1).

Vegetative Cover - See Standards for: Temporary Vegetative Cover (p. 3.1.1), Permanent Vegetative Cover (p. 3.2.1), and Permanent Stabilization with Sod (p. 3.6.1).

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

|                          | WATER<br>DILUTION | TYPE OF NOZZLE | APPLY<br>GALLONS/ACRE |
|--------------------------|-------------------|----------------|-----------------------|
| Anionic asphalt emulsion | 7:1               | Coarse Spray   | 1,200                 |
| Latex emulsion           | 12.5:1            | Fine Spray     | 235                   |
| Resin in water           | 4:1               | Fine Spray     | 300                   |

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



STANDARD  
FOR  
LINED WATERWAY

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.

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.

Purpose

Waterways are lined to provide for safe disposal or runoff without damage by erosion or flooding, in situations where grassed waterways would be inadequate.

Conditions Where Practice Applies

This practice applies where the following conditions exist:

1. The water velocity is such that lining is required to control 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 preclude 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 (4.5.1) shall apply.

Design Criteria

Capacity

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 with a coefficient of roughness "n" as follows:

| LINING        | "n" VALUE                   |
|---------------|-----------------------------|
| Concrete      |                             |
| Trowel finish | 0.012 - 0.014               |
| Float finish  | 0.013 - 0.017               |
| Gunit         | 0.016 - 0.022               |
| Flagstone     | 0.020 - 0.025               |
| Gabion        | 0.025                       |
| Riprap        | see the Standard for Riprap |

Velocity

Maximum design velocity shall be as shown below. Except for short transition sections, slopes in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical will be restricted to straight reaches.



| DESIGN FLOW DEPTH | MAXIMUM VELOCITY |
|-------------------|------------------|
| 0 - 0.5'          | 25 fps           |
| 0.5 - 1.0'        | 15 fps           |
| > 1.0'            | 10 fps           |

Lined waterways with velocities exceeding critical shall discharge into an energy dissipator 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 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:

| LINING                                                                                                  | STEEPEST PERMISSIBLE<br>SIDE SLOPE |
|---------------------------------------------------------------------------------------------------------|------------------------------------|
| Non-Reinforced Concrete -<br>Hand-placed, formed concrete<br>Height of lining 1.5 feet or less          | vertical                           |
| Hand-placed, screeded concrete<br>or mortared in-place flagstone -<br>Height of lining less than 2 feet | 1 to 1                             |
| Height of lining more than 2 feet                                                                       | 2 to 1                             |
| Reinforced slip form concrete -<br>Height of lining less than 3 feet                                    | 1 to 1                             |
| Rock riprap                                                                                             | 2 to 1                             |

#### Lining Thickness

Minimum lining thickness shall be as follows:

Concrete - 4 inches

Rock riprap - as per Standard for Riprap

Flagstone - 4 inches including mortar bed

#### Related Structures

Side inlets, drop structures, and energy dissipators 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, prevent erosion, reduce uplift pressure, and collect water will be used and will be 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 will be provided as needed.

Concrete or Mortar

Concrete or mortar shall meet New Jersey Department of Transportation standards, Ref. #10, Appendix A9.

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.



STANDARD  
FOR  
RIPRAP

Definition

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

Purpose

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

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 ten percent.

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 discharges of uniform drainage areas up to one-half of a square mile, as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management, August 1984.
2. SCS Technical Release No. 55 - for drainage areas less than five square miles.
3. For areas greater than or equal to five square miles, use SCS Technical Release No. 20 or other officially 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 on 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. The only exemption to this would be if there is 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 gradation of riprap, etc., should be taken into consideration when determining the thickness of riprap lining. The thickness of riprap lining shall meet at least one of the following two criteria:

1. A thickness of at least three times the  $d_{50}$  size if a filter layer is not used.
2. A thickness of at least two times the  $d_{50}$  size if a filter layer is used.

The minimum thickness shall be 6 inches.

#### Filter

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. Leaching is reduced to a negligible rate by using a properly designed filter under the riprap or by making the riprap layer thick enough and with fine enough interstices to keep erosion currents away from underlying soil.

A filter is required unless the riprap lining has a thickness of at least 3 times the  $d_{50}$  size of the riprap. On steep slopes, highly erodible soils, loose sand, or with high water velocities, a filter should be used or riprap thickness increased beyond the minimums.

A filter can be of two general forms. One is a synthetic filter fabric manufactured for that express purpose. Another is a properly graded layer of sand, gravel, or stone.

A sand, gravel, or stone filter shall meet the following criteria:

$$\begin{array}{ll} \frac{d_{15} \text{ Riprap}}{d_{85} \text{ Filter}} < 5 & \frac{d_{15} \text{ Riprap}}{d_{15} \text{ Filter}} < 40 \\ \frac{d_{50} \text{ Riprap}}{d_{50} \text{ Filter}} < 40 \end{array}$$

Where  $d_{15}$ ,  $d_{50}$ , and  $d_{85}$  are the diameters of riprap and filter material of which 15, 50, and 85% are finer by weight. The base material may be used as the filter if it meets the above criteria. The minimum sand gravel or stone filter thickness shall be 6 inches or 3 times the  $d_{50}$  size of the filter, whichever is greater.

Synthetic filter fabric shall meet the following criteria:

- A. For filter fabric adjacent to granular materials containing 50% or less by weight of fines (Minus No. 200 material):

1.  $\frac{85\% \text{ size of material (mm)}}{\text{EOS* (mm)}} > 1$
2. Open area not to exceed 36%.

- B. For filter fabric adjacent to all other soils:

1. EOS\* no larger than the opening in the U.S. Standard Sieve No. 70.
2. Open area not to exceed 10%.

NOTE: No cloth specified should have an open area less than 4% or an EOS\* with openings smaller than the opening in a U.S. Standard Sieve Size No. 100. When possible, it is preferable to specify a cloth with openings as large as allowable by the criteria. It may not be possible to obtain a suitable cloth with the maximum allowable openings, which also meets the strength requirements, however, due to the limited number of cloths available.

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

Synthetic filter fabric shall meet the U.S. Army Corps of Engineers Guide Specifications, CW02215, November 1977, for strength. Riprap that is 12" and larger shall not be dumped directly onto synthetic filter cloth unless the manufacturer recommends such use for the cloth. Otherwise, a 4-inch minimum thickness blanket of gravel shall be placed over the filter cloth, or the riprap shall be placed directly on the filter cloth by hand or by the bucket of the equipment.

#### Quality

Stone for riprap shall consist of field stone or quarry stone of approximately 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 pounds per cubic foot, 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 satisfactory discharge 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 filter 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 movement of foundation soils is not anticipated.
4. Ice conditions are not severe.
5. A filter is used.
6. Slopes somewhat steeper than 2 to 1 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, filter, and quality criteria shall be as outlined below.
2. The design water velocity does not exceed that given below:

TABLE 4.12-1

| GABION THICKNESS<br>(ft.) | MAXIMUM VELOCITY<br>(ft./sec.) |
|---------------------------|--------------------------------|
| 1/2                       | 6                              |
| 3/4                       | 11                             |
| 1                         | 14                             |

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. All gabions or Reno mattresses placed against the bottom of a channel shall be underlain by filter fabric or a gravel filter designed according to the limits outlined in Table 4.12-2.
7. The rock used to fill the gabions shall be 4" to 7" angular, block-shaped rock.

TABLE 4.12-2

| SOIL TEXTURE                             | EROSIVE VELOCITY<br>VE | MAXIMUM ALLOWABLE<br>BOTTOM SLOPE USING<br>GEO TEXTILE FABRICS* |
|------------------------------------------|------------------------|-----------------------------------------------------------------|
| Sandy loam                               | 2.5 fps                | .029 ft/ft                                                      |
| Silt loam                                | 3.0 fps                | .041 ft/ft                                                      |
| Sandy clay loam                          | 3.5 fps                | .056 ft/ft                                                      |
| Clay loam                                | 4.0 fps                | .074 ft/ft                                                      |
| Clay, fine gravel, graded loam to gravel | 5.0 fps                | .115 ft/ft                                                      |
| Cobbles                                  | 5.5 fps                | .139 ft/ft                                                      |

\*For bottom slopes steeper than those shown, a properly designed gravel filter shall be placed under the gabions.

Synthetic filter fabric shall conform to the criteria on p. 4.12.3 from Table 4.6-1 of the Channel Stabilization Standard.

Sand, gravel, or stone filters placed under gabions or Reno mattresses shall meet the filter requirements.

#### Concrete Revetment Blocks

Concrete revetment blocks are precast 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 feet per second.
3. The Manning's "n" value used for concrete revetment blocks shall be 0.026, unless otherwise recommended by manufacturer's literature.
4. A filter 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.

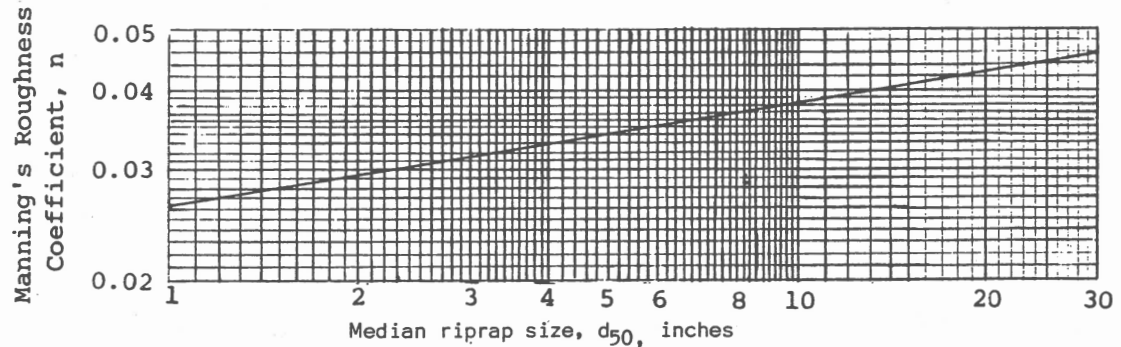
NOTE: This procedure is for uniform flow at normal depth in channels and is not to be used for design of riprap energy dissipation devices immediately downstream from such high velocity devices as pipes and culverts. See the Standard for Conduit Outlet Protection, p. 4.14.1.

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 riprapped channel from  $n = 0.0395 d_{50}^{1/6}$ , where  $d_{50}$  is in feet, or by using Curve 4.12-1, below, where  $d_{50}$  is in inches.

CURVE 4.12-1

MANNING'S "n" FOR RIPRAP-LINED CHANNELS



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 4.12-2 to find the  $P/R$  ratio.
2. Enter Curve 4.12-3 with  $S_b$ ,  $Q$ , and  $P/R$  to find median riprap diameter,  $d_{50}$ , for straight channels.
3. Enter Curve 4.12-1 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 4.12-4 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 4.12-5 to determine maximum stable side slope of riprap surface. In Curve 4.12-5, 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 4.12-5, 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 4.12-6 with the computed side slope to determine  $K$  for that side slope.
  - c. Enter Curve 4.12-6 with the desired side slope to determine  $K'$ .
  - d. Compute riprap size for desired slope by the formula:

$$d_{50}' = d_{50} \frac{K}{K'}$$

6. Maximum side slopes, 2:1.



### Triangular Channels

1. Enter Curve 4.12-3A with  $S_b$ ,  $Q$ , and  $Z$  and find the median riprap diameter,  $d_{50}$ , for straight channels.
2. Enter Curve 4.12-1 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.  
 $S = 0.01$  ft./ft.  
Side slopes = 2.5:1.  
Mean bend radius,  $R_o = 25'$ .  
 $n = 0.033$  (estimated, and used to design the channel to find that  $b = 6'$  and  $d = 1.8'$ ).  
Type of rock available is crushed stone.

Solution:

#### Straight channel reach

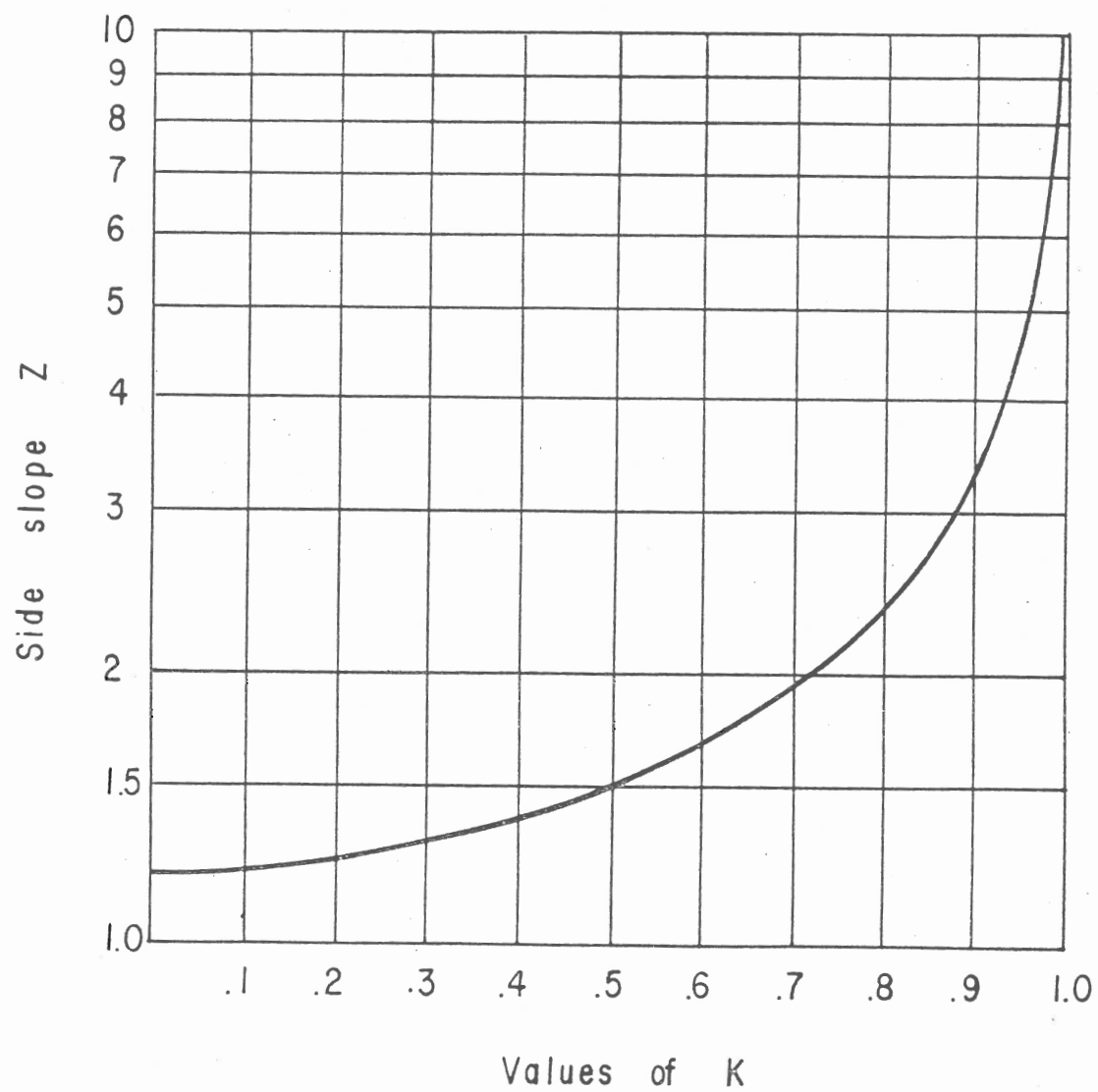
$b/d = 6/1.8 = 3.33$ .  
from Curve 4.12-2,  $P/R = 13.0$ .  
from Curve 4.12-3,  $d_{50} = 3.4"$ .  
from Curve 4.12-1,  $n$  (actual) = 0.032, which is reasonably close to the estimated  $n$  of 0.033.  
Use 5" as maximum riprap size and 8" as riprap layer thickness with a filter.

#### Channel bend

$B_s = b + 2zd = 6 + (2)(2.5)(1.8) = 15'$ .  
 $B_s/R_o = 15/25 = 0.60$ .  
from Curve 4.12-4,  $F_B = 1.33$ .  
 $F_B = 1.33 > 1.1$ , therefore, the bend factor must be used.  
Riprap size in bend,  $d_{50} = 3.4 \times 1.33 = 4.52"$ .

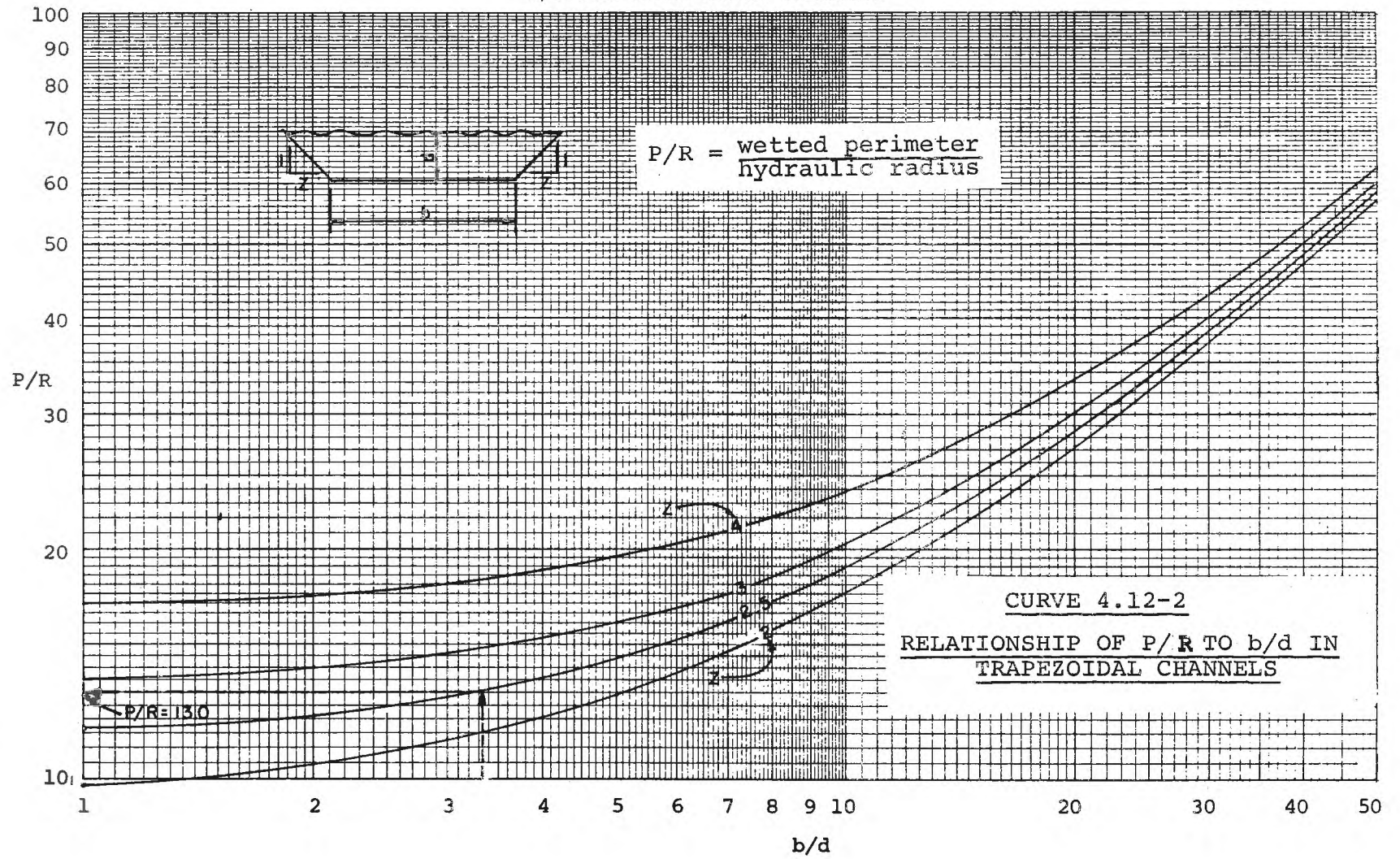
The heavier riprap for the bend shall extend upstream and downstream from the ends of the bend a distance of  $(5)(6) = 30$  feet.

From Curve 4.12-5, it can be found that the riprap for  $d_{50} = 3.4"$  and  $4.52"$  will both be stable on a 2.5:1 side slope.

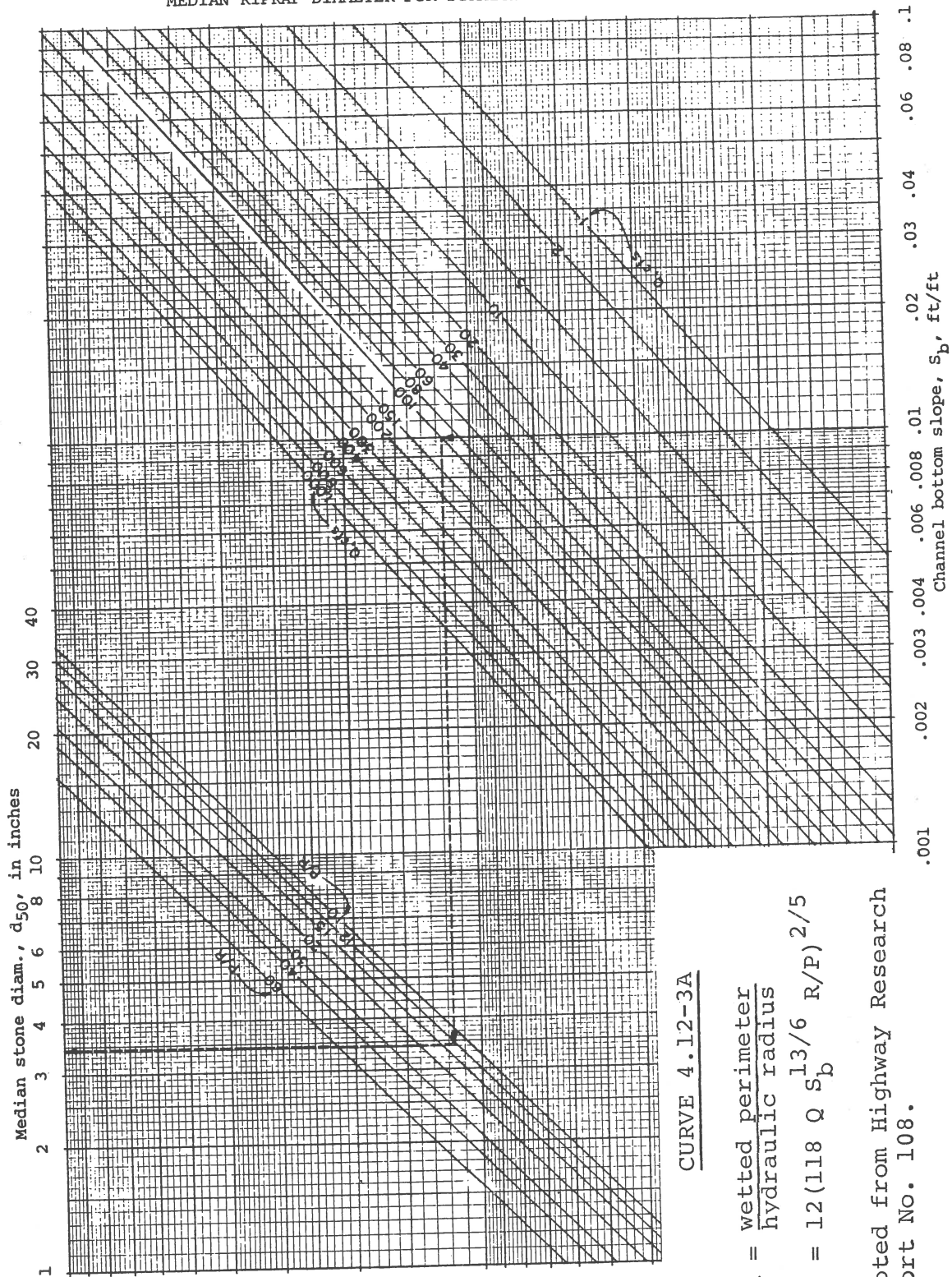


CURVE 4.12-6

# P/R FOR TRAPEZOIDAL CHANNELS



# MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRAPEZOIDAL CHANNELS



# ITS



Revised April 1987

# CURVE 4.12-4

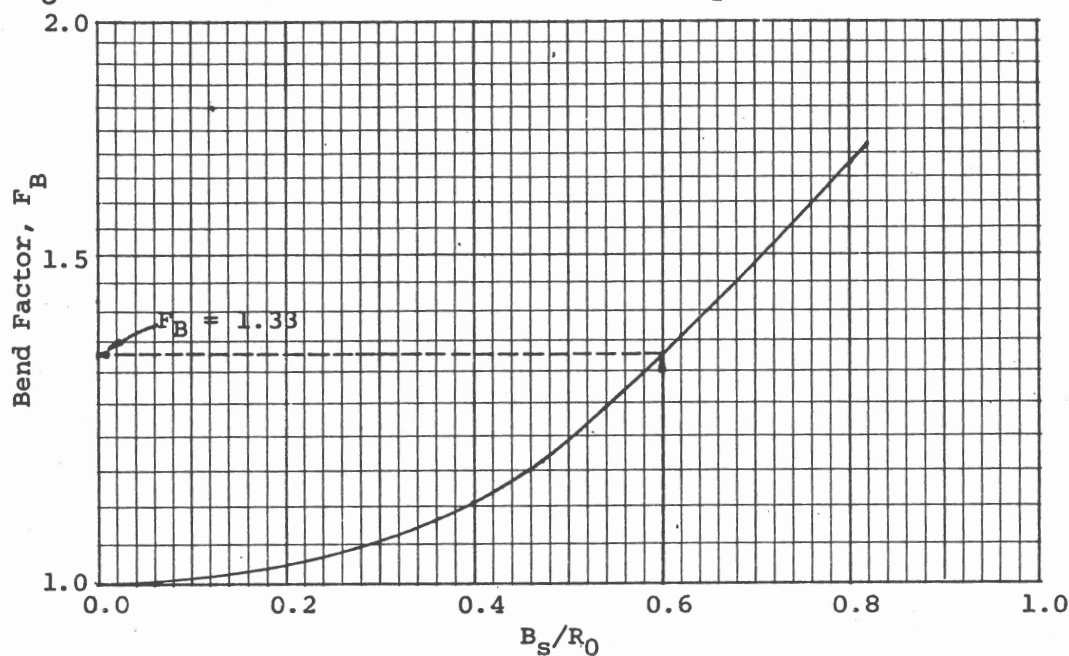
## RIPRAP SIZE CORRECTION FACTOR FOR FLOW IN CHANNEL BENDS

$$d_{50}(\text{for bend}) = d_{50}(\text{for straight}) \times F_B$$

$B_s$  = channel surface width

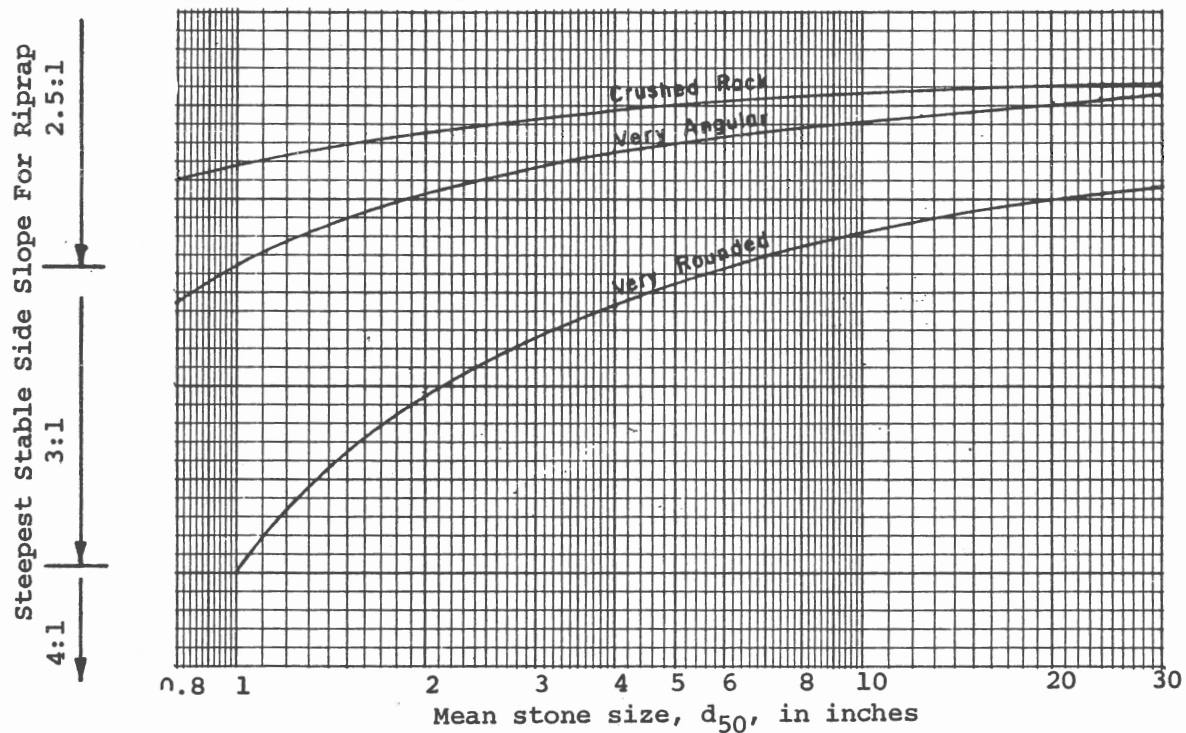
$R_0$  = mean radius of bend

Adapted from Highway Research  
Report No. 108.



# CURVE 4.12-5

## MAXIMUM RIPRAP SIDE SLOPE WITH RESPECT TO RIPRAP SIZE





STANDARD  
FOR  
SEDIMENT BARRIER

Definition

A temporary barrier installed across or at the toe of a slope.

Purpose

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

Conditions Where Practice Applies

The sediment barrier is used where:

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

Design Criteria

A. All types of sediment barriers:

1. Contributing drainage area is less than 1 acre and the length of slope above the barrier is less than 150 feet.
2. The slope of the contributing drainage area for at least 30 feet 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 (e.g., straw, hay, or other acceptable vegetative material):

1. All bales shall be securely tied and staked on the contour. See Figure 4.13-1 for details.
2. Bales shall be placed in a row with ends tightly abutting the adjacent bales.
3. Each bale shall be embedded in the soil a minimum of 4 inches.
4. Bales shall be securely anchored in place by two stakes or re-bars driven through each bale. The first stake in each bale shall be driven toward previously laid bale to force bales together.

C. Requirements for slit fence:

1. Fence posts shall be spaced 8 feet center-to-center or closer. They shall extend at least 2 feet into the ground. They shall extend at least 2 feet above ground.
2. A metal fence with 6 inch or smaller openings and at least 2 feet high may be utilized, fastened to the fence posts.
3. A filter fabric, recommended for such use by the manufacturer, shall be buried at least 6 inches deep in the ground. The filter fabric shall extend at least 2 feet above the ground. Filter fabric may be fastened in place by stake or other accepted means as specified by the district office.

D. Requirements for stone barrier:

1. The stone shall be piled to a natural angle of repose with a height of at least 2 feet.
2. The stone shall meet ASTM C-33 size No. 2 or 3.



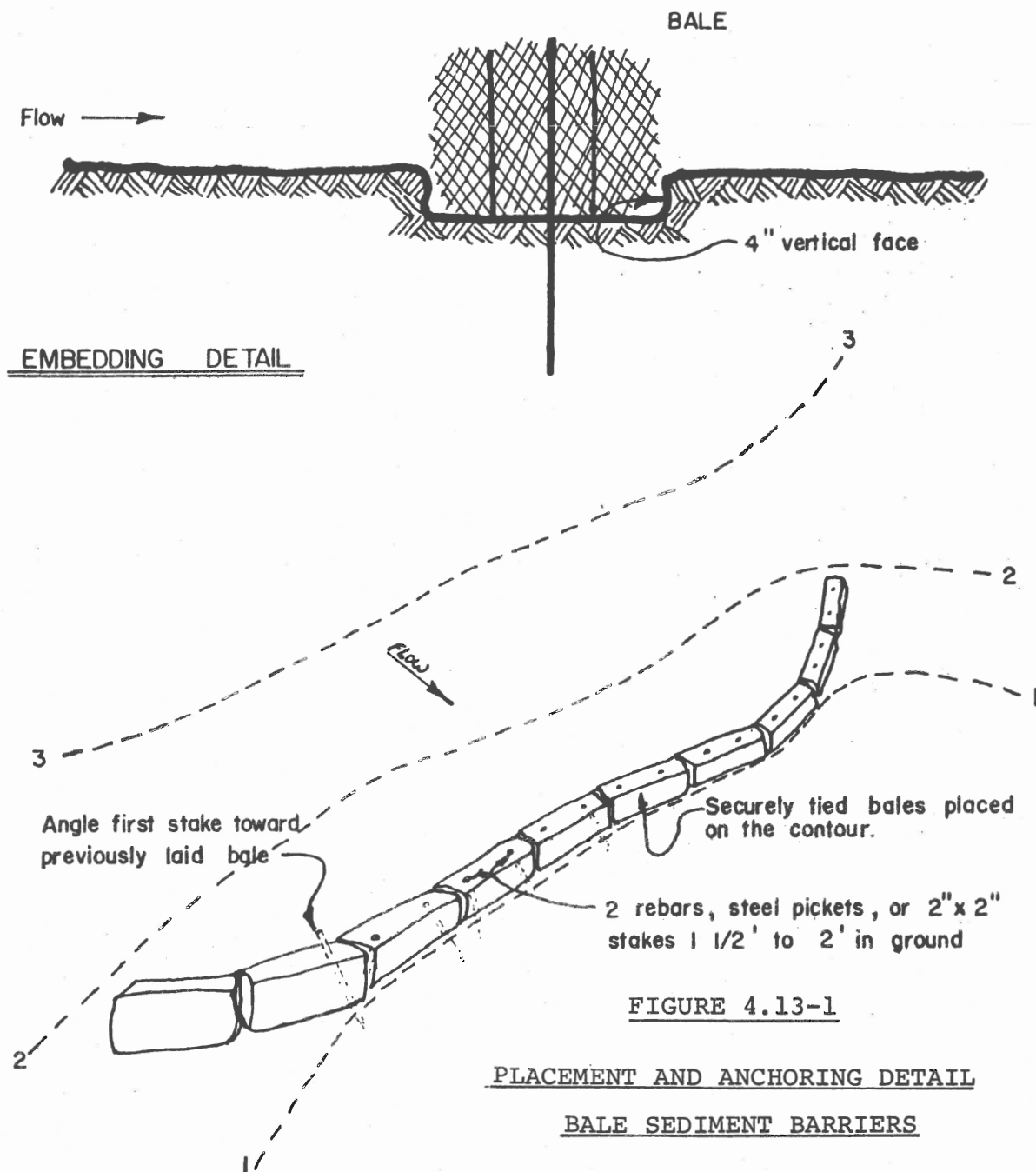
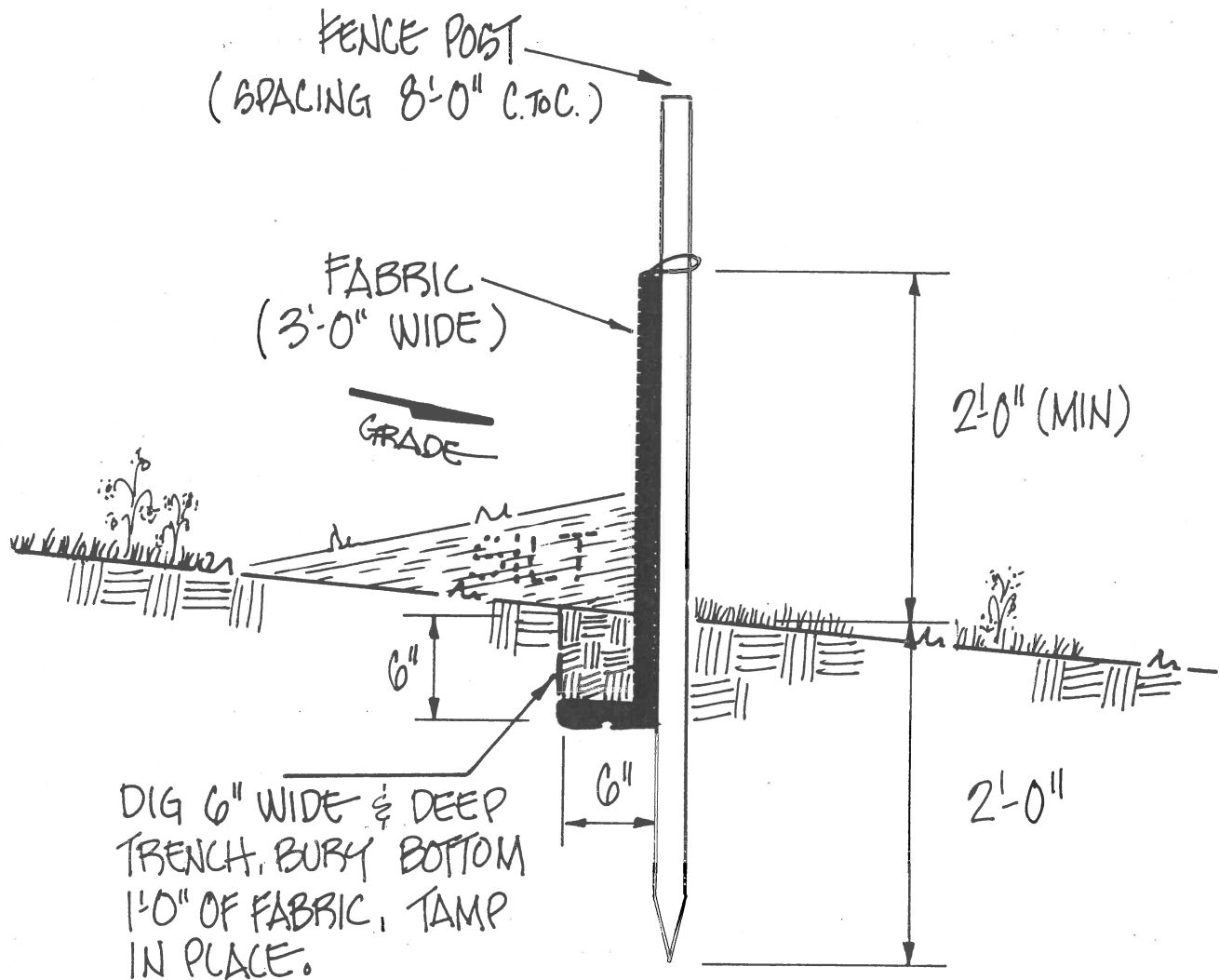


FIGURE 4.13-2



SILT FENCE DETAIL



STANDARD  
FOR  
CONDUIT OUTLET PROTECTION

Definition

Conduit Outlet Protection consists of an erosion resistant section between a conduit outlet and a stable downstream channel.

Purpose

To provide a stable area at the outlet of a conduit in which the exit velocity from the conduit is reduced to a velocity consistent with a stable condition in the downstream channel.

Conditions Where Practice Applies

This practice applies to all conduit outlets.

Design Criteria

Determination of Needs

The need for conduit outlet protection shall be determined by comparing the allowable velocity for the soil onto which the conduit is discharging to the velocity in the conduit. The allowable velocity for the soil shall be that given in Table 4.14-1. 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 will be used.

TABLE 4.14-1

ALLOWABLE VELOCITIES FOR VARIOUS SOILS

| SOIL TEXTURE                             | ALLOWABLE VELOCITY<br>(ft./sec.) |
|------------------------------------------|----------------------------------|
| Sand                                     | 1.75                             |
| Sandy loam                               | 2.5                              |
| Silt loam (also high lime clay)          | 3.0                              |
| Sandy clay loam                          | 3.5                              |
| Clay loam                                | 4.0                              |
| Clay, fine gravel, graded loam to gravel | 5.0                              |
| Cobbles                                  | 5.5                              |
| Shale (non-weathered)                    | 6.0                              |

A. Horizontal Riprap Apron

Apron Dimensions

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

$$L_a = \frac{1.8 Q}{D_o^{3/2}} + 7 D_o \quad TW < \frac{1}{2} D_o$$

$$L_a = \frac{3 Q}{D_o^{3/2}} \quad TW \geq \frac{1}{2} D_o$$

Where  $D_o$  is the maximum inside culvert width in feet,  $Q$  is the pipe discharge in cfs for the conduit design storm or the 25 year storm, whichever is greater.

2. Where there is no well-defined channel immediately downstream of apron, the width,  $W$ , of the outlet end of the apron shall be as follows:

For tailwater elevation greater than or equal to the elevation of the center of the pipe,  $W = 3 D_o + 0.4 L_a$ .

For tailwater elevation less than the elevation of the center of the pipe,  $W = 3 D_o + L_a$ .

Where  $L_a$  is the length of apron determined from the formula and  $D_o$  is the culvert width.

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 apron, the bottom width of the apron shall be at least equal to the bottom width of the channel; and the structural lining shall extend at least one foot above the tailwater elevation but no lower than two-thirds of the vertical conduit dimension above the conduit invert.
4. The side slopes shall be 2:1 or flatter.
5. The bottom grade shall be 0.0% (level).
6. There shall be no overfall at the end of the apron or at the end of the culvert.

#### B. Riprap

The median stone diameter,  $d_{50}$ , in feet, shall be determined from the formula:

$$\text{For Horizontal Apron: } d_{50} = \frac{0.02}{TW} \left( \frac{Q}{D_o} \right)^{4/3}$$

For areas where TW cannot be computed, use  $TW = 0.2 D_o$

Where  $Q$  and  $D_o$  are as defined under apron dimensions and TW is tailwater depth above the invert of culvert in feet.

#### Preformed Scour Hole

Preformed scour holes may be utilized, as depicted in Figure 14.14-4, where conditions dictate the impractical use of flat aprons. The median stone diameter,  $d_{50}$ , in feet, shall be determined from the following formulas:

$$d_{50} = \frac{0.0125}{TW} \left( \frac{Q}{D_o} \right)^{4/3} \quad \text{where } Y = 1/2 D_o$$

$$d_{50} = \frac{0.0082}{TW} \left( \frac{Q}{D_o} \right)^{4/3} \quad \text{where } Y = D_o$$

$Y$  = depth of scour hole below culvert invert

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.

#### Downstream Protection

The conduit discharge shall not cause 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

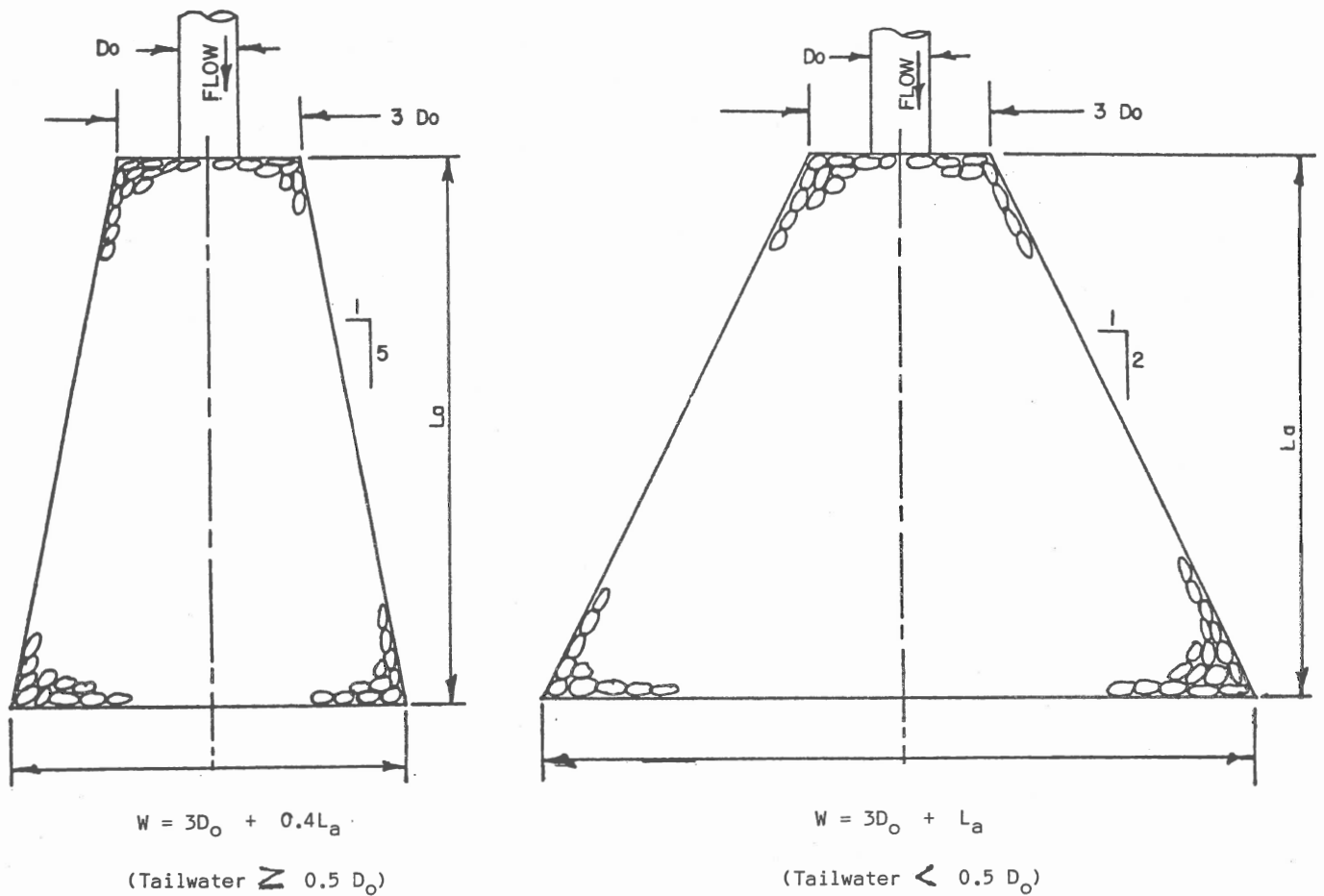
1. Fifty percent, by weight, of the riprap mixture shall be smaller than the median size stone designated as  $d_{50}$ . The largest stone size in the mixture shall be 1.5 times the  $d_{50}$  size. The riprap shall be reasonably well graded.
2. The thickness of riprap lining, filter, and quality shall meet the requirements in the riprap standard (pp. 4.12.2 - 4.12.3).
3. Properly designed concrete paving may be substituted for riprap.
4. Gabions or concrete revetment blocks may be substituted for riprap 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" angular shaped rock.

#### Installation Requirements

1. No bends or curves at the intersection of the conduit and apron or scour hole will be permitted.
2. There shall be no overfall from the end of the apron to the receiving channel.

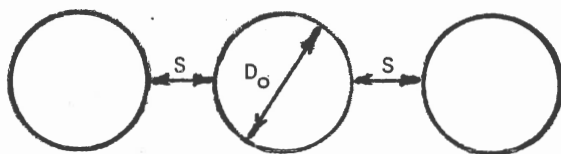
# References

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.



CONFIGURATION OF CONDUIT OUTLET PROTECTION

# GUIDANCE FOR MULTIPLE CULVERT OUTLETS



All Culverts  
Same Diameter  
Discharging Same Q

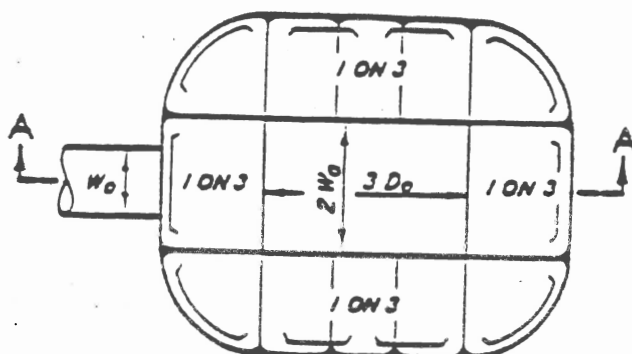
FOR  $S < \frac{1}{4}D_o$

Size Riprap & Length For 1 Pipe  
Width shall accommodate all culverts

FOR  $S \geq \frac{1}{4}D_o$

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  $\frac{1}{4}D_o$ . Width shall accommodate all culverts.



PLAN



SECTION A-A

PREFORMED SCOUR HOLE

# STANDARD FOR STABILIZED CONSTRUCTION ENTRANCE

## Definition

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

## Purpose

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

## 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.

## Design Criteria

Stone Size - Use ASTM C-33, size No. 2 or 3. Use crushed stone.

Thickness - not less than six (6) inches.

Width - not less than full width of points of ingress or egress.

Length - 50 feet minimum where the soils are sands or gravels or 100 feet minimum where soils are clays or silts, except where the traveled length is less than 50 or 100 feet respectively. These lengths may be increased where field conditions dictate.

At poorly drained locations, subsurface drainage gravel filter or filter fabric shall be installed before installing the stabilized construction entrance.

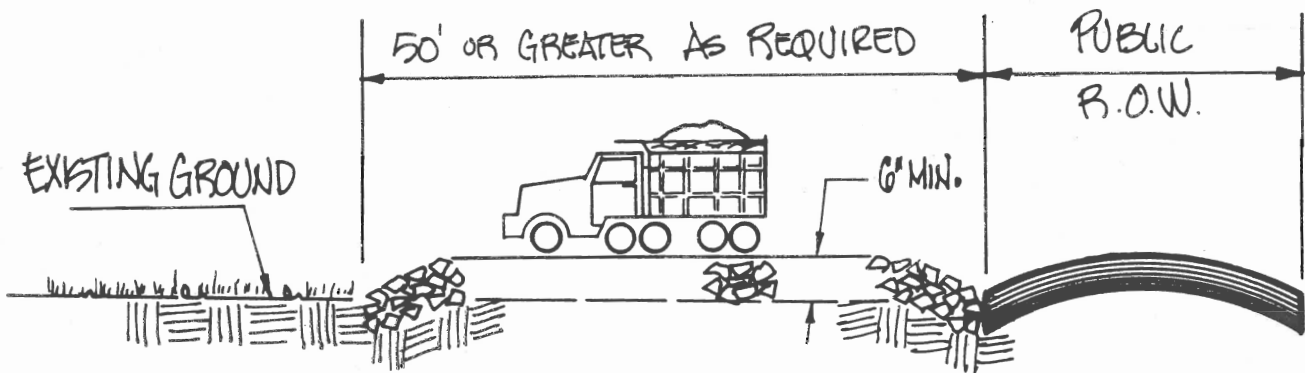
## Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone 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 rights-of-way must be removed immediately.

TABLE Grading Requirements for Coarse Aggregates

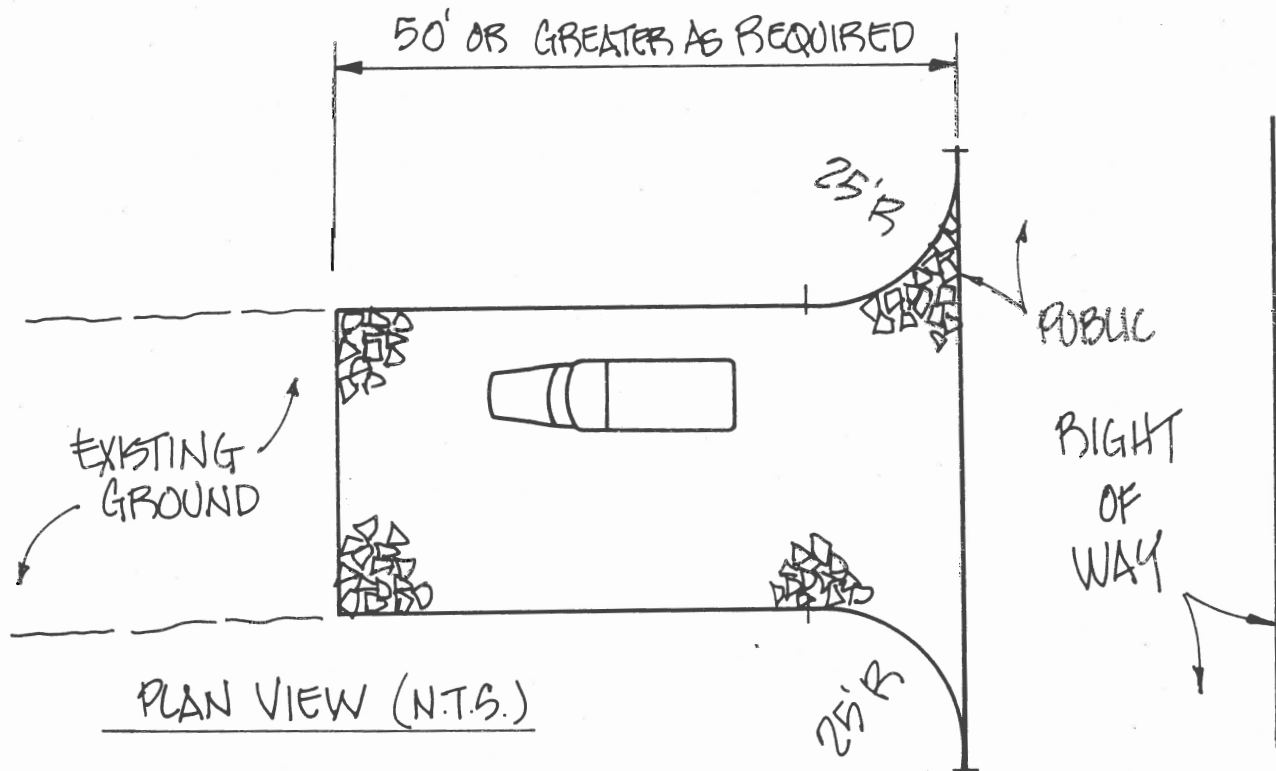
| Size Number | Nominal Size (Sieves with Square Openings) | Amounts Finer than Each Laboratory Sieve (Square-Openings), Weight Percent |                   |                  |                   |                  |                     |                    |                    |                    |                   |                    |                    |                     |
|-------------|--------------------------------------------|----------------------------------------------------------------------------|-------------------|------------------|-------------------|------------------|---------------------|--------------------|--------------------|--------------------|-------------------|--------------------|--------------------|---------------------|
|             |                                            | 100 mm<br>(4 in.)                                                          | 90 mm<br>(3½ in.) | 75 mm<br>(3 in.) | 63 mm<br>(2½ in.) | 50 mm<br>(2 in.) | 37.5 mm<br>(1½ in.) | 25.0 mm<br>(1 in.) | 19.0 mm<br>(¾ in.) | 12.5 mm<br>(½ in.) | 9.5 mm<br>(¾ in.) | 4.75 mm<br>(No. 4) | 2.36 mm<br>(No. 8) | 1.18 mm<br>(No. 16) |
| 2           | 63 to 37.5 mm<br>(2½ to 1½ in.)            | ...                                                                        | ...               | 100              | 90 to 100         | 35 to 70         | 0 to 15             | ...                | 0 to 5             | ...                | ...               | ...                | ...                | ...                 |
| 3           | 50 to 25.0 mm<br>(2 to 1 in.)              | ...                                                                        | ...               | ...              | 100               | 90 to 100        | 35 to 70            | 0 to 15            | ...                | 0 to 5             | ...               | ...                | ...                | ...                 |





PROFILE N.T.S.

- PROVIDE APPROPRIATE TRANSITION BETWEEN STABILIZED CONSTRUCTION ENTRANCE AND PUBLIC R.O.W.



PLAN VIEW (N.T.S.)

## STABILIZED CONSTRUCTION ENTRANCE

STANDARD  
FOR  
STORM SEWER INLET PROTECTION

Definition

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

Purpose

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

Conditions Where Practice Applies

1. Contributing drainage area is 3 acres or less.
2. A storm sewer or the outlet channel of a storm sewer needs protection from sediment.
3. Traffic will not destroy or cause constant maintenance of the storm sewer inlet protection.
4. A traffic hazard will not be created.

Design Criteria

A. General - All types of storm sewer inlet protection:

1. Must slow the storm water, provide the coarse sediment particles a chance to settle, and provide an area to retain the particles that have settled; or
2. Must prevent the storm water from entering the catch basin inlet.

The following sections provide three methods. Other methods that accomplish the purpose of storm sewer inlet protection may be used if approved by the Soil Conservation District.

Inspections shall be frequent. Maintenance, repair, and replacement shall be made promptly as needed.

The barrier shall be removed when the area draining toward the inlet has been stabilized.

B. Blocked Inlet - Catch basin inlets may be blocked, until the area draining toward the catch basin is permanently protected from erosion, when:

1. The material used to block the inlet is prevented from floating or being carried into the inlet; and
2. an erosion or a flooding problem is not caused by blocking the inlet.

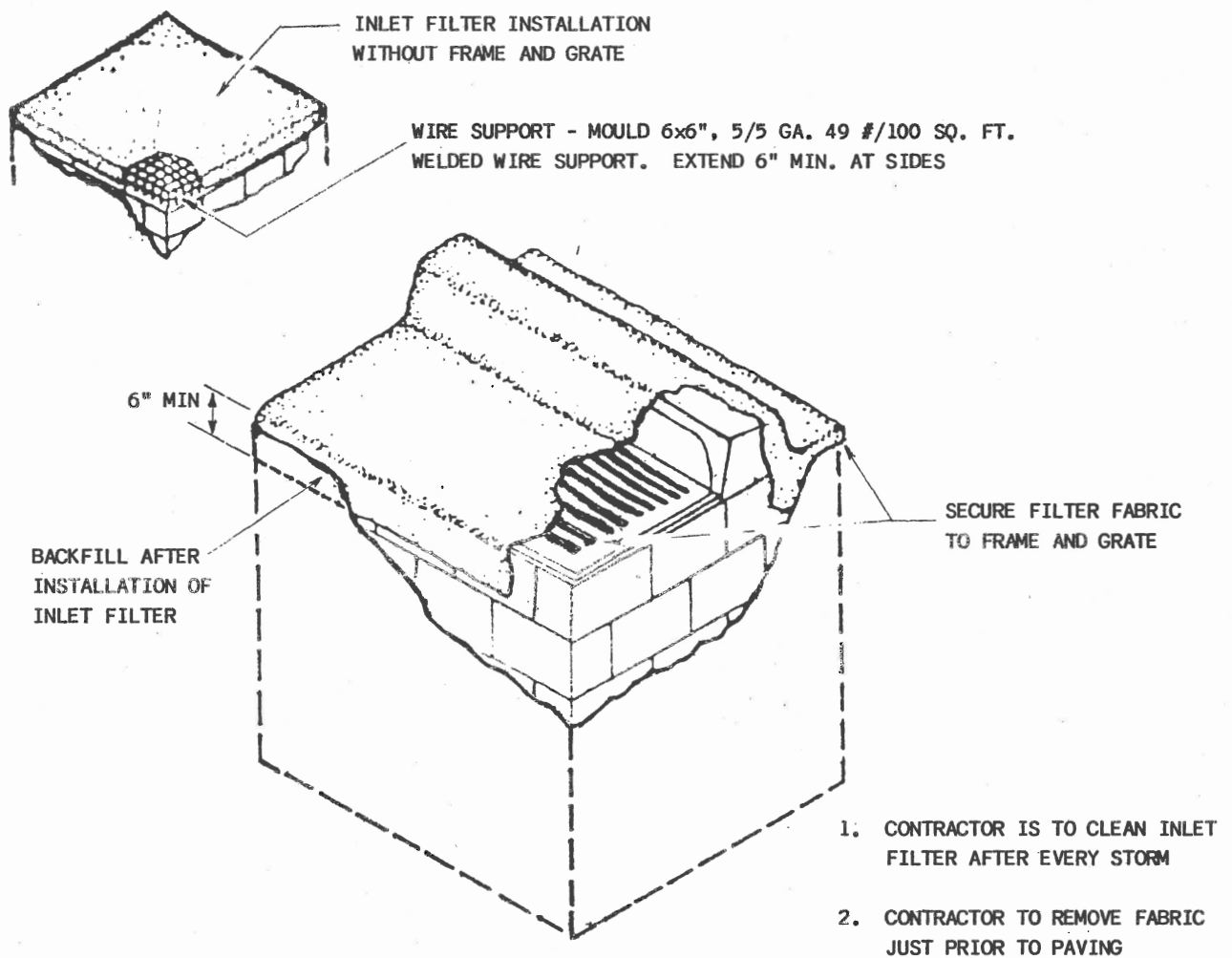
C. Protected Inlet:

1. The perimeter length of the barrier shall be at least four times the perimeter length of the storm sewer inlet. The top of the barrier shall be level and uniform for at least this length.
2. The barrier shall encircle the inlet.
3. If bales (straw, hay or other acceptable vegetative materials) are used for the barrier, they shall be staked down in accordance with the sediment barrier standard. Where staking is not practical, they shall be tied together to prevent movement or openings in the barrier.
4. If gravel is used for the barrier, it shall be piled at least 1 1/2 feet high to its natural angle of repose. The gravel shall meet size no. 2 or 3 in ASTM C-33.

D. Inlet with Sediment Trap:

1. A screen is placed completely over the inlet.
2. A sturdy protective frame is placed around the inlet and filled with ASTM C-33 size no. 2 or 3 stone.

3. A sediment trap is excavated behind the curb at the inlet. The basin shall be at least 12 to 14 inches in depth, approximately 36 inches in width, and approximately 7 to 10 feet in length parallel to the curb.
4. Storm water will reach the sediment trap via curb cuts adjacent to each side of the inlet structure. These openings shall be at least 12 inches in length. Storm water may also reach the basin via overland flow land area behind the curb. The curb cuts shall be repaired when the sediment trap is removed.

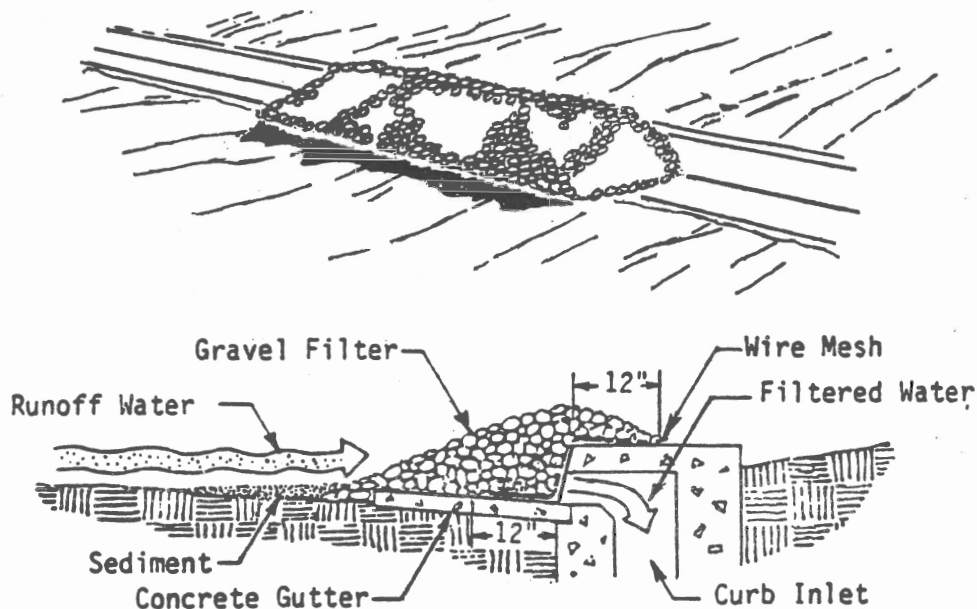


### INLET FILTER DETAIL

N.T.S.

### GRAVEL CURB INLET SEDIMENT FILTER

- A. Hardware cloth or comparable wire mesh with  $\frac{1}{2}$  openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the inlet cover and at least 12 inches of wire extends across the concrete gutter from the inlet opening, as illustrated.
- B. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely. Two (2) to three (3) inch coarse aggregate shall be used.
- C. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the inlet, cleaned and replaced.



### Specific Application

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

### GRAVEL CURB INLET SEDIMENT FILTER



STANDARD  
FOR  
GRADE STABILIZATION STRUCTURE

Definition

A structure (drop, chute, etc) to control the grade and head cutting in natural or artificial channels.

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 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.

Purpose

To stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to reduce environmental and pollution hazards.

Conditions Where Practice Applies

This standard applies to areas where the concentration and flow velocity of water require 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.

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:

| TOTAL HEIGHT OF EMBANKMENT<br>(feet) | TOP WIDTH<br>(feet) |
|--------------------------------------|---------------------|
| up to 20                             | 10                  |
| 20 - 24                              | 12                  |

Side slopes - The combined upstream and downstream side slopes of the settled embankment shall not be less than five horizontal to one vertical, with neither slope steeper than 2:1. 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 1.0 feet 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 on both sides of the structure.

### Structure Spillways

Chute and drop spillways shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices, The National Engineering Handbook, and other applicable 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 4.17-1 or 4.17-2, as applicable, less any reduction because of detention storage.

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 4.17-1

MINIMUM CAPACITY OF FULL-FLOW STRUCTURES

| DRAINAGE<br>AREA<br>(acre) | VERTICAL<br>DROP<br>(feet) | MINIMUM DESIGN STORM                               |                                       |                               |
|----------------------------|----------------------------|----------------------------------------------------|---------------------------------------|-------------------------------|
|                            |                            | STRUCTURE SPILLWAY<br>CAPACITY FREQUENCY<br>(year) | TOTAL<br>CAPACITY FREQUENCY<br>(year) | MINIMUM<br>DURATION<br>(hour) |
| 250 or less                | 5 or less                  | 5                                                  | 10                                    | 24                            |
| 500 or less                | 10 or less                 | 10                                                 | 25                                    | 24                            |
| all other                  | all other                  | 25                                                 | 100                                   | 24                            |

TABLE 4.17-2

MINIMUM CAPACITY OF ISLAND STRUCTURES

| DRAINAGE<br>AREA<br>(acre) | VERTICAL<br>DROP<br>(feet) | MINIMUM DESIGN STORM                                         |                                       |                               |
|----------------------------|----------------------------|--------------------------------------------------------------|---------------------------------------|-------------------------------|
|                            |                            | STRUCTURE SPILLWAY<br>CAPACITY*<br>(year)                    | TOTAL<br>CAPACITY FREQUENCY<br>(year) | MINIMUM<br>DURATION<br>(hour) |
| 250 or less                | 5 or less                  | 1                                                            | 10                                    | 24                            |
| 500 or less                | 10 or less                 | 1                                                            | 25                                    | 24                            |
| all other                  |                            | 1 year or channel<br>design capacity,<br>whichever is higher | 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 4.17-1 and 4.17-2, 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 reenter 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.

### Toe Wall Drop Structures

Toe wall drop structures may be used if the vertical drop is 4 feet 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 4.17-1 or 4.17-2 as applicable or as required by the responsible road authority, whichever is greater.

STANDARD  
FOR  
PARKING LOT STORAGE

Definition

The temporary storage of runoff on a parking lot.

Purpose

Parking lot storage is used to reduce erosion and downstream flooding by temporary storage of runoff.

Conditions Where Practice Applies

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

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 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 in areas where cars and light trucks are to be parked, or 10 inches 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. No increase in peak discharge from these two storms, 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.

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

1. the timing of peak flows from subwatersheds;
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 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. 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 the approximate methods in the Soil Conservation Service Engineering Field Manual, the Soil Conservation Technical Release 55 (TR55), modified rational method as described in Special Report 43 by the American Public Works Association, Practices in Detention of Urban Stormwater, or other generally accepted methods of flood routing.



### 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 to do 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.

STANDARD  
FOR  
ROOFTOP STORAGE

Definition

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

Purpose

Rooftop storage is used to reduce erosion and downstream flooding by temporary storage of runoff.

Conditions Where Practice Applies

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

Design Criteria

Structural Design

The roof shall be structurally sound and capable of holding detained storm water 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.

Design Storms

The peak discharge from the 2-year and 10-year frequency, storms shall be analyzed. No increase in peak discharge from these two storms, 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.

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

1. the timing of peak flows from subwatersheds;
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 erosion, downstream peak flow increases that are compatible with the overall flood plain management system may be allowed.

Detention Ring Design

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.



STANDARD  
FOR  
UNDERGROUND TANKS

Definition

The temporary storage of runoff in a buried structure.

Purpose

Underground tanks are used to reduce downstream erosion and flooding by temporary storage of runoff.

Conditions Where Practice Applies

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

Design Criteria

Structural Design

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. Structural design criteria must be based on sound and accepted engineering principles.

Design Storms

The peak discharge from the 2-year and 10-year frequency, storms shall be analyzed. No increase in peak discharge from these two storms, 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.

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

1. the timing of peak flows from subwatersheds;
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 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. The outlet and the temporary storage in the tank must handle the runoff from the design storms. Flood routing may be done using the approximate methods in the Soil Conservation Service Engineering Field Manual, the Soil Conservation Technical Release 55 (TR55), modified rational or other generally accepted methods of flood routing. The maximum time of storage shall not exceed 3 days.

General

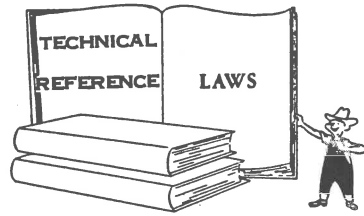
In acid or sulfidic soils, tank materials shall be nonreactive with the soil or measures shall be taken to protect the tank from the soil. Provisions shall be made to prevent debris from entering the tank. Debris collectors shall be placed so that the need for maintenance can be readily detected and 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

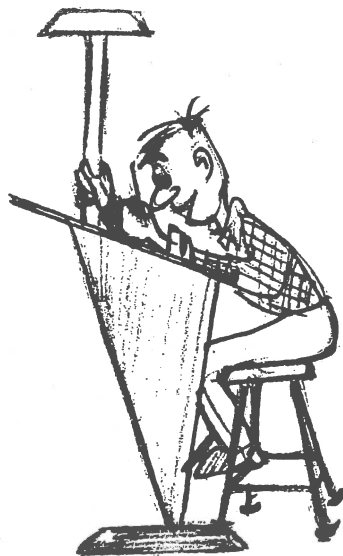
Ownership and responsibility for operation and maintenance of the underground tank, after the site is completed, must be determined during design. To be effective over a long period of time, the underground tank must be properly maintained. Tanks should normally be owned by a unit of government that 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.



## APPENDICES





## 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 interrill 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 interrill erosion.

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\*Page A1.1-A1.20 written by Dr Devah Borah and presented at Cook College, Rutgers University, Sediment and Erosion Control Short Course, Spring 1986.

Universal Soil Loss Equation

Revised April 1987



Rill erosion is much more noticeable than interrill 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 interrill 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.

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 stripcropping 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 end 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 from one segment to the next. For irregular slopes, therefore, 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 value 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.<br>(Top to Bottom) | Adjustment Factors for Given Number<br>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 for various nonseed 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 interrill 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 ration 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 4.4-2 gives delivery ratios for different soil texture and drainage areas. A general guide to sediment delivery ratios from conservation sites are 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 boundry of site)                                                                                              | .60                         |
| Damage area more than 1 mile downstream                                                                                                                                                                                         | .50 or less                 |
| \1 New Jersey Soil Conservation Service, "Sediment Pollution and Erosion Control Guide for Resource Conservation, "Technical Guide, 1971. The values are based on judgement 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.

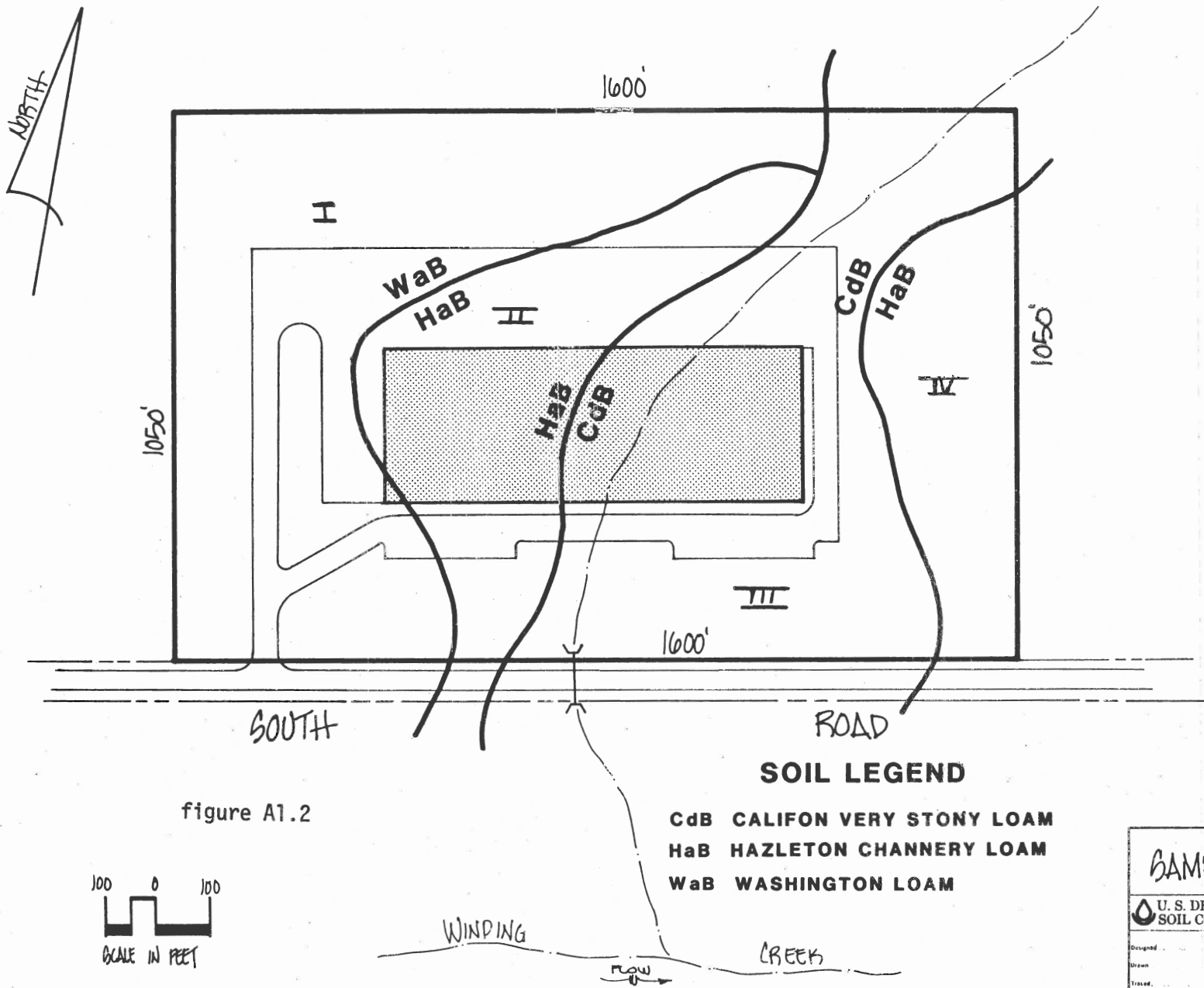


figure A1.2

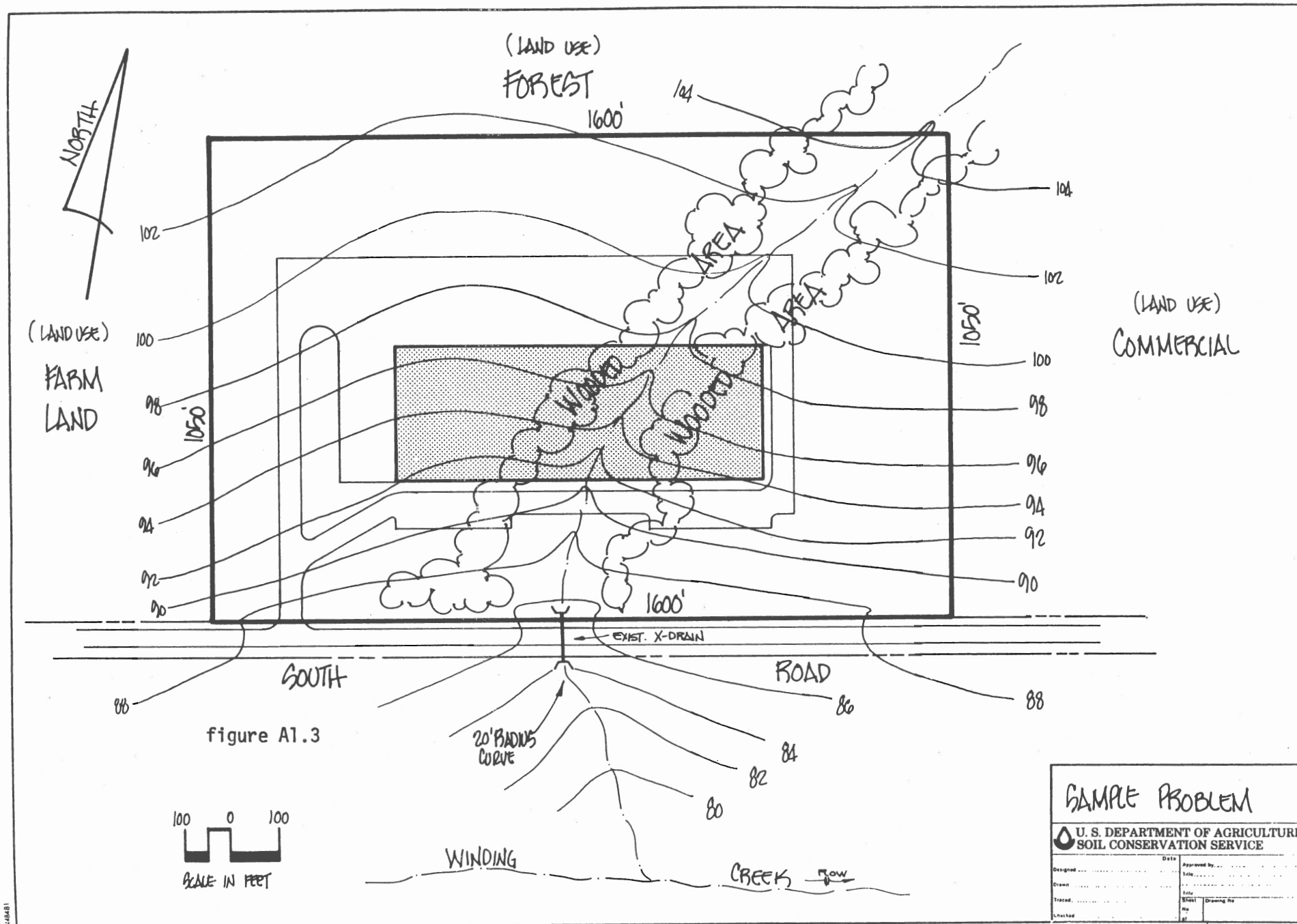
### SOIL LEGEND

**CdB** CALIFON VERY STONY LOAM  
**HaB** HAZLETON CHANNERY LOAM  
**WaB** WASHINGTON LOAM

**SAMPLE PROBLEM**

U. S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE

|          |       |             |
|----------|-------|-------------|
| Designed | Date  | Approved by |
| Drawn    | Title |             |
| Traced   | Sheet | Drawing No. |
| Checked  | No.   |             |





### 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 K in subarea $\frac{\sum ak}{A}$ (t/ac) | AK tons |
|----------|-------------|--------------------------|---------------|----------|--------------------------|--------------------------------------------------|---------|
| I        | WaB         | 0-9                      | 10.4          | 0.28     | 14.5                     | 0.29                                             | 4.2     |
|          |             | 9-52                     | 4.1           | 0.32     |                          |                                                  |         |
| II       | HaB         | 0-6                      | 1.7           | 0.17     | 6.8                      | 0.16                                             | 1.1     |
|          |             | 6-56                     | 5.1           | 0.15     |                          |                                                  |         |
| III      | CdB         | 0-10                     | 6.9           | 0.17     | 12.6                     | 0.23                                             | 2.9     |
|          |             | 10-50                    | 5.7           | 0.30 *2  |                          |                                                  |         |
| IV       | HaB         | 0-6                      | 4.7           | 0.17     | 4.7                      | 0.17                                             | 0.8     |
| Total    |             |                          |               |          | 38.6                     |                                                  | 9.0     |

$$\text{Weighted K} = \frac{\sum AK}{\sum A} = 9/38.6 = 0.23 \text{ t/ac (answer)}$$

### 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 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. \*1 Assumed that the building and parking area is levelled around 95-ft contour. \*2  $(0.32 + 0.28)/2 = 0.30$

MLRA(S): 144A, 14B  
 REV. MLM-WCK, 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<br>(IN.)                                | USDA TEXTURE                                                                                          | UNIFIED                        | AASHTO                       | PERCENT OF MATERIAL LESS<br>> 3 IN. THAN 3" PASSING SIEVE NO.<br>(PCT) |                          |                                    |                                                                              |                                                           | LIQUID<br>LIMIT            | PLAS-<br>TICITY               |                              |
| 0-10                                          | STO-L                                                                                                 | CL                             | A-4, A-6                     | 3-10                                                                   | 80-100                   | 60-95                              | 55-80                                                                        | 50-70                                                     | 20-30                      | 7-12                          |                              |
| 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                                                     | 23-40                      | 3-15                          |                              |
| 23-50                                         | L, CL, GR-SL                                                                                          | SM, ML, CL, SC                 | A-4, A-6, A-2                | 3-10                                                                   | 85-100                   | 65-95                              | 40-90                                                                        | 25-70                                                     | 23-40                      | 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<br>(IN.)                                | CLAY<br>(PCT)                                                                                         | MOISTURE<br>DENSITY<br>(G/CM3) | PERME-<br>ABILITY<br>(IN/HR) | AVAILABLE<br>WATER CAPACITY<br>(IN/IN)                                 | SOIL<br>REACTION<br>(PH) | SALINITY<br>(MMHOS/CM)             | SHRINK-<br>SWELL<br>POTENTIAL                                                | EROSION<br>FACTORS<br>K <sub>f</sub> Y <sub>f</sub> GROUP | ORGANIC<br>MATTER<br>(PCT) | CORROSIVITY<br>STEEL CONCRETE |                              |
| 0-10                                          |                                                                                                       | 0.6-2.0                        | 0.16-0.20                    | 4.5-5.5                                                                | -                        | -                                  | LOW                                                                          | .17                                                       | 3                          | -                             | 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                         | DEPTH<br>(FT)                | KIND                                                                   | MONTHS                   | DEPTH<br>(IN)                      | HARDNESS                                                                     | DEPTH<br>(IN)                                             | HARDNESS                   | INIT. TOTAL GRP<br>(IN)       | POTENTIAL<br>FROST<br>ACTION |
| NONE                                          |                                                                                                       |                                | 0.5-2.5                      | PERCHED                                                                | DEC-MAY                  | -                                  | -                                                                            | >60                                                       | -                          | -                             | C HIGH                       |
| SANITARY FACILITIES (B)                       |                                                                                                       |                                |                              |                                                                        |                          | CONSTRUCTION MATERIAL (B)          |                                                                              |                                                           |                            |                               |                              |
| SEPTIC TANK<br>ABSORPTION<br>FIELDS           | SEVERE-WETNESS, PERCS SLOWLY                                                                          |                                |                              |                                                                        |                          | ROADFILL                           | POOR-FROST ACTION                                                            |                                                           |                            |                               |                              |
| SEWAGE<br>LAGOON<br>AREAS                     | 0-2%: SLIGHT<br>2-7%: MODERATE-SLOPE<br>7+%: SEVERE-SLOPE                                             |                                |                              |                                                                        |                          | SAND                               | IMPROBABLE-EXCESS FINES                                                      |                                                           |                            |                               |                              |
| SANITARY<br>LANDFILL<br>(TRENCH)              | SEVERE-WETNESS                                                                                        |                                |                              |                                                                        |                          | GRAVEL                             | IMPROBABLE-EXCESS FINES                                                      |                                                           |                            |                               |                              |
| SANITARY<br>LANDFILL<br>(AREA)                | SEVERE-WETNESS                                                                                        |                                |                              |                                                                        |                          | TOPSOIL                            | POOR-LARGE STONES                                                            |                                                           |                            |                               |                              |
| DAILY<br>COVER FOR<br>LANDFILL                | 0-8%: FAIR-LARGE STONES, SMALL STONES<br>8-15%: FAIR-SLOPE, LARGE STONES, SMALL STONES                |                                |                              |                                                                        |                          | POND<br>RESERVOIR<br>AREA          | 0-3%: MODERATE-SEEPAGE<br>3-8%: MODERATE-SEEPAGE, SLOPE<br>8+%: SEVERE-SLOPE |                                                           |                            |                               |                              |
| BUILDING SITE DEVELOPMENT (B)                 |                                                                                                       |                                |                              |                                                                        |                          |                                    |                                                                              |                                                           |                            |                               |                              |
| SHALLOW<br>EXCAVATIONS                        | SEVERE-WETNESS                                                                                        |                                |                              |                                                                        |                          | EMBANKMENTS<br>DIKES AND<br>LEVEES | SEVERE-PIPING, WETNESS                                                       |                                                           |                            |                               |                              |
| DWELLINGS<br>WITHOUT<br>BASEMENTS             | SEVERE-WETNESS, FROST ACTION                                                                          |                                |                              |                                                                        |                          | EXCAVATED<br>PONDS<br>AQUIFER FED  | SEVERE-NO WATER                                                              |                                                           |                            |                               |                              |
| DWELLINGS<br>WITH<br>BASEMENTS                | SEVERE-WETNESS                                                                                        |                                |                              |                                                                        |                          | DRAINAGE                           | LARGE STONES, PERCS SLOWLY, WETNESS                                          |                                                           |                            |                               |                              |
| SMALL<br>COMMERCIAL<br>BUILDINGS              | 0-8%: SEVERE-WETNESS, FROST ACTION<br>8-15%: SEVERE-SLOPE, WETNESS, FROST ACTION                      |                                |                              |                                                                        |                          | IRRIGATION                         | LARGE STONES, PERCS SLOWLY, WETNESS                                          |                                                           |                            |                               |                              |
| LOCAL<br>ROADS AND<br>STREETS                 | SEVERE-FROST ACTION                                                                                   |                                |                              |                                                                        |                          | TERRACES<br>AND<br>DIVERSIONS      | LARGE STONES, PERCS SLOWLY, ROOTING DEPTH                                    |                                                           |                            |                               |                              |
| LANDS-<br>LANDSCAPING<br>AND GOLF<br>FAIRWAYS | 0-8%: MODERATE-LARGE STONES, SMALL STONES,<br>WETNESS<br>8-15%: MODERATE-SLOPE, LARGE STONES, WETNESS |                                |                              |                                                                        |                          | GRASSED<br>WATERWAYS               | LARGE STONES, PERCS SLOWLY, ROOTING DEPTH                                    |                                                           |                            |                               |                              |
| REGIONAL INTERPRETATIONS                      |                                                                                                       |                                |                              |                                                                        |                          |                                    |                                                                              |                                                           |                            |                               |                              |

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.  
C RATINGS BASED ON NORTHEAST REGIONAL CRITERIA, MARCH 1966.  
D RATINGS BASED ON SOILS MEMOS 69, OCT. 1968; 26, SEPT. 1967; OR 74, JAN. 1972.

MLBA(S): 144A  
REV. WCK, 9-79  
ULTIC HAPLUDALES, FINE-LOAMY, MIXED, MESIC

WASHINGTON SERIES  
STONY

THE WASHINGTON SERIES CONSISTS OF DEEP, WELL CFAINED 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             |                              | PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. |                                                                                        |                  |                      | LIQUID LIMIT | PLASTICITY INDEX |          |              |
| 0-9                                 | STO-L        | STO-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, SIL      | 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                                  | UMB          |                       |                      |                                  |                    |                              |                                                    |                                                                                        |                  |                      |              |                  |          |              |
| DEPTH (IN.)                         | CLAY (PCT)   | MOIST DENSITY (G/CM3) | PERMEABILITY (IN/HR) | AVAILABLE WATER CAPACITY (IN/IN) | SOIL REACTION (PH) | SALINITY (MMHOS/CM)          | SWELL POTENTIAL                                    | EROSION FACTORS                                                                        | WIND EROD. GROUP | ORGANIC MATTER (PCT) | CORROSION    | 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                | -                    | 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                            |              |                       | HIGH WATER TABLE     |                                  |                    | CEMENTED PAR.                |                                                    | BEDROCK                                                                                |                  | SUBSIDENCE           |              | TYPOTENTIAL      |          |              |
| FREQUENCY                           | DURATION     |                       | MONTHS               |                                  | DEPTH (FT)         | KIND                         | MONTHS                                             | DEPTH (IN)                                                                             | HARDNESS         | DEPTH (IN)           | HARDNESS     | INIT. TOTAL (IN) | GRP      | FROST ACTION |
| NONE                                |              |                       |                      |                                  | >6.0               |                              |                                                    | -                                                                                      |                  | >60                  |              | -                |          | B MODERATE   |
| SANITARY FACILITIES (B)             |              |                       |                      |                                  |                    | CONSTRUCTION MATERIAL (B)    |                                                    |                                                                                        |                  |                      |              |                  |          |              |
| SEPTIC TANK ABSORPTION FIELDS       |              |                       |                      |                                  |                    | ROADFILL                     |                                                    | 0-25%: POOR-LOW STRENGTH<br>25+X: POOR-SLOPE, LOW STRENGTH                             |                  |                      |              |                  |          |              |
| SEWAGE LAGOON AREAS                 |              |                       |                      |                                  |                    | SAND                         |                                                    | IMPROBABLE-EXCESS FINES                                                                |                  |                      |              |                  |          |              |
| SANITARY LANDFILL (TRENCH)          |              |                       |                      |                                  |                    | GRAVEL                       |                                                    | IMPROBABLE-EXCESS FINES                                                                |                  |                      |              |                  |          |              |
| SANITARY LANDFILL (AREA)            |              |                       |                      |                                  |                    | TOPSOIL                      |                                                    | 0-15%: POOR-LARGE STONES, SMALL STONES<br>15+X: POOR-SLOPE, LARGE STONES, SMALL STONES |                  |                      |              |                  |          |              |
| DAILY COVER FOR LANDFILL            |              |                       |                      |                                  |                    | POND RESERVOIR AREA          |                                                    | 0-3%: MODERATE-SEEPAGE<br>3-8%: MODERATE-SLOPE, SEEPAGE<br>8+X: SEVERE-SLOPE           |                  |                      |              |                  |          |              |
| BUILDING SITE DEVELOPMENT (B)       |              |                       |                      |                                  |                    | WATER MANAGEMENT (B)         |                                                    |                                                                                        |                  |                      |              |                  |          |              |
| SHALLOW EXCAVATIONS                 |              |                       |                      |                                  |                    | EMBANKMENTS DIKES AND LEVEES |                                                    | MODERATE-PIPING                                                                        |                  |                      |              |                  |          |              |
| DWELLINGS WITHOUT BASEMENTS         |              |                       |                      |                                  |                    | EXCAVATED PONDS AQUIFER FED  |                                                    | SEVERE-NO WATER                                                                        |                  |                      |              |                  |          |              |
| DWELLINGS WITH BASEMENTS            |              |                       |                      |                                  |                    | DRAINAGE                     |                                                    | 0-3%: FAVORABLE<br>3+X: SLOPE                                                          |                  |                      |              |                  |          |              |
| SMALL COMMERCIAL BUILDINGS          |              |                       |                      |                                  |                    | IRRIGATION                   |                                                    | 0-3%: FAVORABLE<br>3+X: SLOPE                                                          |                  |                      |              |                  |          |              |
| LOCAL ROADS AND STREETS             |              |                       |                      |                                  |                    | TERRACES AND DIVERSIONS      |                                                    | 0-8%: FAVORABLE<br>8+X: SLOPE                                                          |                  |                      |              |                  |          |              |
| LAWS, LANDSCAPING AND GOLF FAIRWAYS |              |                       |                      |                                  |                    | GRASSED WATERWAYS            |                                                    | 0-8%: FAVORABLE<br>8+X: SLOPE                                                          |                  |                      |              |                  |          |              |
| REGIONAL INTERPRETATIONS            |              |                       |                      |                                  |                    |                              |                                                    |                                                                                        |                  |                      |              |                  |          |              |
|                                     |              |                       |                      |                                  |                    |                              |                                                    |                                                                                        |                  |                      |              |                  |          |              |

| RECREATIONAL DEVELOPMENT |                                                                                                                            | (C)              |                                                                                                                              |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------|
| CAMP AREAS               | 0-8%: MODERATE-LARGE STONES, SMALL STONES, DUSTY<br>8-15%: MODERATE-SLOPE, LARGE STONES, SMALL STONES<br>15+: SEVERE-SLOPE | PLAYGROUNDS      | 0-6%: SEVERE-SMALL STONES, LARGE STONES<br>6+: SEVERE-SLOPE, LARGE STONES, SMALL STONES                                      |
| PICNIC AREAS             | 0-8%: MODERATE-SMALL STONES, LARGE STONES, DUSTY<br>8-15%: MODERATE-SLOPE, SMALL STONES, LARGE STONES<br>15+: SEVERE-SLOPE | PATHS AND TRAILS | 0-15%: MODERATE-LARGE STONES, SMALL STONES, DUSTY<br>15-25%: MODERATE-SLOPE, LARGE STONES, SMALL STONES<br>15+: SEVERE-SLOPE |

| CLASS-<br>DETERMINING<br>PHASE | CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT) |           |           |           |           |           |           |           |
|--------------------------------|-----------------------------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | CAPA-<br>BILITY                                                             |           |           |           |           |           |           |           |
| 0-3%                           | NINE TIER                                                                   | NINE TIER | NINE TIER | NINE TIER | NINE TIER | NINE TIER | NINE TIER | NINE TIER |
| 3-25%                          | SS                                                                          | -         | -         | -         | -         | -         | -         | -         |
| 25-35%                         | 6S                                                                          |           |           |           |           |           |           |           |
|                                | 6E                                                                          |           |           |           |           |           |           |           |

| CLASS-<br>DETERMINING<br>PHASE |  | ORD<br>SYM | MANAGEMENT PROBLEMS |                 |                     |                   | POTENTIAL PRODUCTIVITY | TREES TO PLANT   |               |                                                                  |
|--------------------------------|--|------------|---------------------|-----------------|---------------------|-------------------|------------------------|------------------|---------------|------------------------------------------------------------------|
|                                |  |            | EROSION<br>HAZARD   | EQUIP.<br>LIMIT | SEEDLING<br>MORT'Y. | WINDTH.<br>HAZARD | PLANT<br>COMPET.       | COMMON TREES     | SITE<br>INDEX |                                                                  |
| 0-15%                          |  | 1D         | SLIGHT              | SLIGHT          | SLIGHT              | SLIGHT            |                        | NORTHERN RED OAK | 85            | EASTERN WHITE PINE                                               |
| 15-35%                         |  | 1R         | SLIGHT              | Moderate        | SLIGHT              | SLIGHT            |                        | YELLOW-POPLAR    | 95            | EUROPEAN LARCH<br>BLACK WALNUT<br>YELLOW-POPLAR<br>NORWAY SPRUCE |

[illegible]

| CLASS<br>DETERMINING<br>PHASE | GRAIN & GRASS & LEGUME |            | POTENTIAL FOR HABITAT ELEMENTS |             |                |               |                 | POTENTIAL AS HABITAT FOR: |                  |                 |         |   |
|-------------------------------|------------------------|------------|--------------------------------|-------------|----------------|---------------|-----------------|---------------------------|------------------|-----------------|---------|---|
|                               | WILD SEED              | WILD HERB. | WILD TREES                     | WILD SHRUBS | WETLAND PLANTS | SHALLOO WATER | OPENED WILDLIFE | WOODL WILDLIFE            | WETLAND WILDLIFE | RANGEL WILDLIFE |         |   |
| 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 | - |

[illegible]

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.  
E EXCESSIVE PERMEABILITY RATE MAY ALLOW POLLUTION OF GROUND WATER.

MLRA(S): 147, 148, 126, 127, 124

REV. GHL, 9-83

TYPIC DYSTROCHREPTS, LOAMY-SKELETAL, MIXED, MESIC

HAZLETON SERIES

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 REDDISH-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                           |                    | PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. (PCT) |                                                                                                                        |                 |            |                      | LIQUID LIMIT | PLASTICITY INDEX |
| 0-6                                  | SC, L, ESL             |                                                                                                                                                                                              | ML                   | A-4                              |                    | 0-5                                                      | 90-100                                                                                                                 | 90-100          | 75-90      | 65-70                | -            | -                |
| 0-6                                  | CL, SL, CN-L           |                                                                                                                                                                                              | HL, GM, SM           | A-2, A-4                         |                    | 0-15                                                     | 60-85                                                                                                                  | 60-80           | 60-75      | 35-55                | -            | -                |
| 6-32                                 | CL, SL, L, CNV-L       |                                                                                                                                                                                              | GM, SM, ML, SC       | A-2, A-4, A-1                    |                    | 0-50                                                     | 60-85                                                                                                                  | 45-90           | 35-70      | 20-55                | <30          | NP-8             |
| 32-56                                | CL, SL, CNV-SL, CNV-LS |                                                                                                                                                                                              | GM, SM, SC, GC       | A-2, A-1, A-4                    |                    | 0-60                                                     | 55-80                                                                                                                  | 35-75           | 25-65      | 15-50                | <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 | WIND GROUP | ORGANIC MATTER (PCT) | CORROSION    | POTENTIAL        |
| 0-6                                  | 7-18                   | 1.20-1.40                                                                                                                                                                                    | 2.0-6.0              | 0.12-0.16                        | 3.6-5.5            | -                                                        | LOW                                                                                                                    | 17              | 3          | -                    | 2-4          | LOW              |
| 0-6                                  | 7-18                   | 1.20-1.40                                                                                                                                                                                    | 2.0-6.0              | 0.10-0.14                        | 3.6-5.5            | -                                                        | LOW                                                                                                                    | 17              | 3          | -                    | 2-4          | LOW              |
| 6-32                                 | 7-18                   | 1.20-1.40                                                                                                                                                                                    | 2.0-20               | 0.08-0.12                        | 3.6-5.5            | -                                                        | LOW                                                                                                                    | 15              | -          | -                    | 2-4          | LOW              |
| 32-56                                | 5-15                   | 1.20-1.40                                                                                                                                                                                    | 2.0-20               | 0.06-0.12                        | 3.6-5.5            | -                                                        | LOW                                                                                                                    | 15              | -          | -                    | 2-4          | LOW              |
| 56                                   |                        |                                                                                                                                                                                              |                      |                                  |                    |                                                          |                                                                                                                        |                 |            |                      |              |                  |
| FLOODING                             |                        |                                                                                                                                                                                              |                      | HIGH WATER TABLE                 |                    | CEMENTED PAV.                                            |                                                                                                                        | BEDROCK         |            | SUBSIDENCE           |              | HYDROLYTIC       |
| FREQUENCY                            | DURATION               | MONTHS                                                                                                                                                                                       | DEPTH (FT)           | KIND                             | MONTHS             | DEPTH (IN)                                               | HARDNESS                                                                                                               | DEPTH (IN)      | HARDNESS   | INIT. TOTAL          | GRP          | FROST ACTION     |
| NONE                                 |                        |                                                                                                                                                                                              | >6.0                 |                                  |                    |                                                          |                                                                                                                        | >40             | HARD       | -                    | -            | B MODERATE       |
| SANITARY FACILITIES (B)              |                        |                                                                                                                                                                                              |                      |                                  |                    | CONSTRUCTION MATERIAL (B)                                |                                                                                                                        |                 |            |                      |              |                  |
| SEPTIC TANK ABSORPTION FIELDS        |                        | 0-15%: SEVERE-POOR FILTER<br>15+%: SEVERE-POOR FILTER, SLOPE                                                                                                                                 |                      |                                  |                    | ROADFILL                                                 | 0-15%: FAIR-AREA RECLAIM, THIN LAYER, LARGE STONES<br>15-25%: FAIR-SLOPE, AREA RECLAIM, THIN LAYER<br>25+%: POOR-SLOPE |                 |            |                      |              |                  |
| SEWAGE LAGOON AREAS                  |                        | 0-7%: SEVERE-SEEPAGE<br>7+%: SEVERE-SLOPE, SEEPAGE                                                                                                                                           |                      |                                  |                    | SAND                                                     | IMPROBABLE-EXCESS FINES                                                                                                |                 |            |                      |              |                  |
| SANITARY LANDFILL (TRENCH)           |                        | 0-15%: SEVERE-SEEPAGE, DEPTH TO ROCK<br>15+%: SEVERE-SLOPE, SEEPAGE, DEPTH TO ROCK                                                                                                           |                      |                                  |                    | GRAVEL                                                   | IMPROBABLE-EXCESS FINES                                                                                                |                 |            |                      |              |                  |
| SANITARY LANDFILL (AREA)             |                        | 0-15%: SEVERE-SEEPAGE<br>15+%: SEVERE-SLOPE, SEEPAGE                                                                                                                                         |                      |                                  |                    | TOPSOIL                                                  | 0-15%: POOR-SMALL STONES<br>15+%: POOR-SLOPE, SMALL STONES                                                             |                 |            |                      |              |                  |
| DAILY COVER FOR LANDFILL             |                        | 0-15%: POOR-SMALL STONES<br>15+%: POOR-SLOPE, SMALL STONES                                                                                                                                   |                      |                                  |                    |                                                          | WATER MANAGEMENT (B)                                                                                                   |                 |            |                      |              |                  |
|                                      |                        |                                                                                                                                                                                              |                      |                                  |                    | POND RESERVOIR AREA                                      | 0-8%: SEVERE-SEEPAGE<br>8+%: SEVERE-SEEPAGE, SLOPE                                                                     |                 |            |                      |              |                  |
| BUILDING SITE DEVELOPMENT (B)        |                        |                                                                                                                                                                                              |                      |                                  |                    | SEVERE-SEEPAGE, LARGE STONES                             |                                                                                                                        |                 |            |                      |              |                  |
| SHALLOW EXCAVATIONS                  |                        | 0-8%: MODERATE-DEPTH TO ROCK, LARGE STONES<br>8-15%: MODERATE-DEPTH TO ROCK, SLOPE, LARGE STONES<br>15+%: SEVERE-SLOPE                                                                       |                      |                                  |                    | EMBANKMENTS DIKES AND LEVEES                             |                                                                                                                        |                 |            |                      |              |                  |
| DWELLINGS WITHOUT BASEMENTS          |                        | 0-8%: MODERATE-LARGE STONES<br>8-15%: MODERATE-SLOPE, LARGE STONES<br>15+%: SEVERE-SLOPE                                                                                                     |                      |                                  |                    | EXCAVATED PONDS AQUIFER FED                              | SEVERE-NO WATER                                                                                                        |                 |            |                      |              |                  |
| DWELLINGS WITH BASEMENTS             |                        | 0-8%: MODERATE-LARGE STONES, DEPTH TO ROCK<br>8-15%: MODERATE-SLOPE, LARGE STONES, DEPTH TO ROCK<br>15+%: SEVERE-SLOPE                                                                       |                      |                                  |                    | DRAINAGE                                                 | DEEP TO WATER                                                                                                          |                 |            |                      |              |                  |
| SMALL COMMERCIAL BUILDINGS           |                        | 0-8%: MODERATE-LARGE STONES<br>8-15%: MODERATE-SLOPE, LARGE STONES<br>15+%: SEVERE-SLOPE                                                                                                     |                      |                                  |                    | IRRIGATION                                               | 0-3%: LARGE STONES, DROUGHTY<br>3+%: LARGE STONES, DROUGHTY, SLOPE                                                     |                 |            |                      |              |                  |
| LOCAL ROADS AND STREETS              |                        | 0-8%: MODERATE-FROST ACTION, LARGE STONES<br>8-15%: MODERATE-SLOPE, FROST ACTION, LARGE STONES<br>15+%: SEVERE-SLOPE                                                                         |                      |                                  |                    | TERRACES AND DIVERSIONS                                  | 0-8%: LARGE STONES, TOO SANDY<br>8+%: SLOPE, LARGE STONES, TOO SANDY                                                   |                 |            |                      |              |                  |
| LAWNS, LANDSCAPING AND GOLF FAIRWAYS |                        | 0-8% SC, L, ESL: MODERATE-DROUGHTY<br>0-8% CN: MODERATE-SMALL STONES, DROUGHTY<br>8-15% SL, L, ESL: MODERATE-SLOPE, DROUGHTY<br>8-15% CN: MODERATE-SLOPE, SMALL STONES<br>15+%: SEVERE-SLOPE |                      |                                  |                    | GRASSED WATERWAYS                                        | 0-8%: LARGE STONES, DROUGHTY<br>8+%: LARGE STONES, SLOPE, DROUGHTY                                                     |                 |            |                      |              |                  |
| REGIONAL INTERPRETATIONS             |                        |                                                                                                                                                                                              |                      |                                  |                    |                                                          |                                                                                                                        |                 |            |                      |              |                  |

## RECREATIONAL DEVELOPMENT (B)

| CAMP AREAS                             |                                   | PLAYGROUNDS                            |                                   |
|----------------------------------------|-----------------------------------|----------------------------------------|-----------------------------------|
| 0-8% SL, L FSL: SLIGHT                 | 0-2% SL, L FSL: SLIGHT            | 0-8% SL, L FSL: SLIGHT                 | 0-2% SL, L FSL: SLIGHT            |
| 8-15% CN: MODERATE-SMALL STONES        | 2-6% SL, L FSL: MODERATE-SLOPE    | 8-15% CN: MODERATE-SMALL STONES        | 2-6% SL, L FSL: MODERATE-SLOPE    |
| 8-15% CN: MODERATE-SLOPE               | 6% SL, L FSL: SEVERE-SLOPE        | 8-15% CN: MODERATE-SLOPE               | 6% SL, L FSL: SEVERE-SLOPE        |
| 8-15% CN: MODERATE-SLOPE, SMALL STONES | 0-6% CN: SEVERE-SMALL STONES      | 8-15% CN: MODERATE-SLOPE, SMALL STONES | 0-6% CN: SEVERE-SMALL STONES      |
| 15%: SEVERE-SLOPE                      | 6% CN: SEVERE-SMALL STONES, SLOPE | 15%: SEVERE-SLOPE                      | 6% CN: SEVERE-SMALL STONES, SLOPE |

| 15-41 SEVERE SLIPS             |                                                                             |      |              |      |               |      |              |      |                          |      |                                |      |                  |      |                          |      |
|--------------------------------|-----------------------------------------------------------------------------|------|--------------|------|---------------|------|--------------|------|--------------------------|------|--------------------------------|------|------------------|------|--------------------------|------|
| CLASS-<br>DETERMINING<br>PHASE | CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT) |      |              |      |               |      |              |      |                          |      |                                |      |                  |      |                          |      |
|                                | CAPA-<br>BILITY                                                             |      | CORN<br>(BU) |      | WHEAT<br>(BU) |      | OATS<br>(BU) |      | ALFALFA<br>HAY<br>(TONS) |      | GRASS-<br>LEGUME HAY<br>(TONS) |      | PASTURE<br>(AUM) |      | CORN<br>SILAGE<br>(TONS) |      |
|                                | NIR                                                                         | IRR. | NIR          | IRR. | NIR           | IRR. | NIR          | IRR. | NIR                      | IRR. | NIR                            | IRR. | NIR              | IRR. | NIR                      | 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              |      |                          |      |
| 35-4%                          | 7E                                                                          |      | -            |      | -             |      | -            |      | -                        |      | -                              |      |                  |      |                          |      |

## -WOODLAND-SUITABILITY--(C)

[illegible]

## WINDBREAKERS

| CLASS-DETERMINING PHASE |                   | SPECIES |                      | SPECIES |                   | SPECIES |                    | SPECIES |   |
|-------------------------|-------------------|---------|----------------------|---------|-------------------|---------|--------------------|---------|---|
| ALL                     | SIBERIAN PEASHROB | 7       | TATARIAN HONEYSUCKLE | 8       | AMOR HONEYSUCKLE  | 9       | LILAC              | 10      | 1 |
|                         | AUTUMN-OLIVE      | 9       | WASHINGTON HAWTHORN  | 10      | RADIANT CRABAPPLE | 12      | EASTERN REDCEDAR   | 18      | 2 |
|                         | JACK PINE         | 16      | AUSTRIAN PINE        | 18      | RED PINE          | 18      | EASTERN WHITE PINE |         |   |

## WILDLIFE HABITAT SUITABILITY (C)

| CLASS-<br>DETERMINING<br>PHASE | POTENTIAL FOR HABITAT ELEMENTS |                   |               |                |                   |        | POTENTIAL AS HABITAT FOR |                  |                 |                |                  |                 |
|--------------------------------|--------------------------------|-------------------|---------------|----------------|-------------------|--------|--------------------------|------------------|-----------------|----------------|------------------|-----------------|
|                                | GRAIN<br>SEED                  | GRASS &<br>LEGUME | WILD<br>HERB. | HARDW<br>TREES | CONIFER<br>PLANTS | SHRUBS | WETLAND<br>PLANTS        | SALCOOT<br>WATER | OPENED<br>WILDL | WOODL<br>WILDL | WETLAND<br>WILDL | RANGEL<br>WILDL |
| 0-10%                          | GOOD                           | GOOD              | GOOD          | GOOD           | GOOD              | -      | POOR                     | V. POOR          | GOOD            | GOOD           | V. POOR          | -               |
| 10-15%                         | FAIR                           | GOOD              | GOOD          | GOOD           | GOOD              | -      | V. POOR                  | V. POOR          | GOOD            | GOOD           | V. POOR          | -               |
| 15-25%<br>SSN                  | POOR                           | FAIR              | GOOD          | GOOD           | GOOD              | -      | V. POOR                  | V. POOR          | FAIR            | FAIR           | V. POOR          | -               |
| 25-35%<br>SSN                  | V. POOR                        | FAIR              | GOOD          | GOOD           | GOOD              | -      | V. POOR                  | V. POOR          | FAIR            | FAIR           | V. POOR          | -               |
| 35-45%<br>N                    | 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.

2. Required: For this site, estimate the Topographic Factor "LS"

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         |

$$\text{Weighted LS} = [(0.29)(11.6) + (0.65)(27.0)]/38.6 = 0.54$$

(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  $E = R K L S C P$

R: from Figure A1-1, R value in Hunterdon County is 175

Universal Soil Loss Equation

Revised April 1987



1. (cont'd)

K: weighted K value previously calculated is 0.23 t/ac

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:

$$E = (175) (0.23) (0.54) (1.0) (1.0) \\ 22 \text{ tons/acre/year}$$

3. The erosion from the entire site (sediment yield)

$$22 \text{ tons/acre/year} \times 38.6 \text{ acres} = 849 \text{ tons/year}$$

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:

$$0.7 \times 849 \text{ tons/year} = 594 \text{ tons/year (answer)}$$

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  $1.7 \times 849 \text{ tons/year}$  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  $0.7 \times 849$  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

Universal Soil Loss Equation

Revised April 1987

Therefore the total soil loss is  $100 + 302 = 402$  tons/year.  
The percent reduction would therefore be  $(849-409)/849 \times 100 = 53$  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  $\leq 5$  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  $402 \text{ tons/year} \times 0.12 = 48 \text{ tons/year}$
  - c. Reduction of annual soil loss  $(849-48)/849 \times 100$  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 to the basin during the construction period is  $E_t = 849 \text{ tons/year} \times 1.80$  or 1528 tons

5. Using Table A1-7, the saturated sediment volume for which the sediment basin will be designed is:

$1528 \times .00077 = 1.18 \text{ acre-feet}$   
or  
 $1528 \times 1.24 = 1895 \text{ cu. yd.}$  (answer)

FIGURE A1-1

RAINFALL EROSION VALUES "R"  
NEW JERSEY MAP

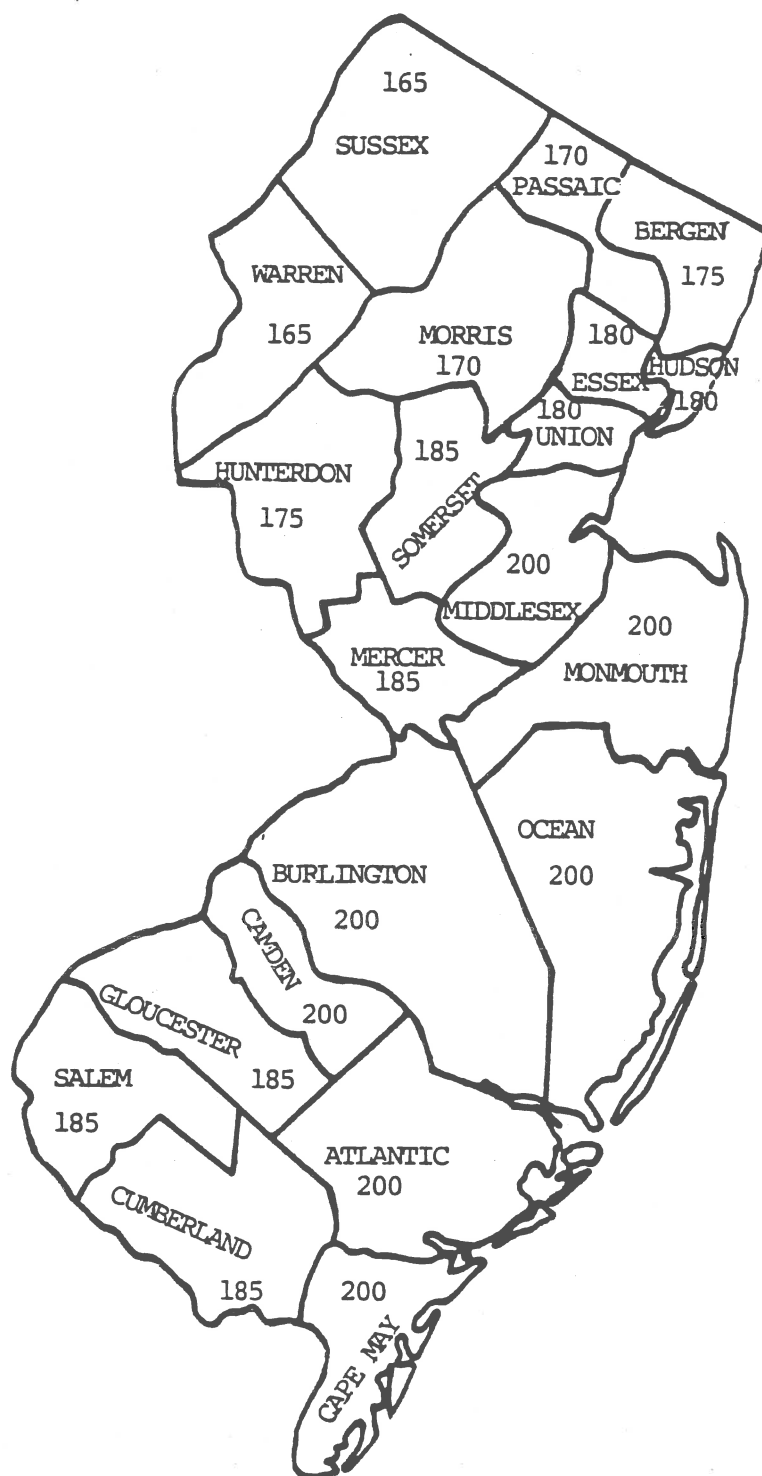


TABLE A1-1

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<br>(Alpha<br>Listing) | Local<br>Mapping <sup>1/</sup><br>No. | Typical<br>Profile<br>(inches) | USDA<br>Texture<br>Range | Unified<br>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            | 2/   | -  |
|                                   |                                       | 30-60                          | ls, gls, vgl             | 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,             | ML, CL            | 0.2  | 35 |
|                                   |                                       |                                | gfsl, gl, gsil           |                   |      |    |
|                                   |                                       | 30-45                          | fsl, sil, gfsl,          | ML, CL, SM, SC    | 0.2  | 35 |
|                                   |                                       |                                | gsil                     |                   |      |    |
|                                   |                                       | 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<br>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 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

2/ Alluvial soil, unassigned.

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R=175

| Soil Series<br>(Alpha<br>Listing) | Local <sup>1/</sup><br>Mapping<br>No. | Typical<br>Profile<br>(inches) | USDA<br>Texture<br>Range | Unified<br>System | K    | KR |
|-----------------------------------|---------------------------------------|--------------------------------|--------------------------|-------------------|------|----|
| Carlisle                          |                                       | 0-60                           | m                        | Pt                | -    | -  |
| Cattaraugus                       |                                       | 0-20                           | fs1                      | SM,ML,CL          | 0.24 | 42 |
|                                   |                                       |                                | gl                       | SM,ML,CL          | 0.17 | 30 |
|                                   |                                       | 20-60                          | fs1 (pan)                | SM,ML,CL          | 0.3  | 53 |
| Chatfield                         |                                       | 0-28                           | l                        | ML,CL             | 0.17 | 30 |
|                                   |                                       | 28+                            | gneiss bedrock           |                   |      |    |
| Chenango                          |                                       | 0-20                           | sl                       | SM                | 0.24 | 42 |
|                                   |                                       |                                | gfs1,ks1                 | GM                | 0.17 | 30 |
|                                   |                                       | 20-30                          | vgsl,gs1                 | SM,GM             | 0.2  | 35 |
|                                   |                                       | 30-60                          | g,s,gl                   | GP-GM,GM          | 0.2  | 35 |
| Chippewa                          |                                       | 0-13                           | sil                      | ML,CL             | 0.32 | 56 |
|                                   |                                       |                                | chsil,est1               | 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 |
|                                   |                                       | 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,vfs1                   | 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                          | gs1                      | SM,GM             | 0.2  | 35 |
| Crestmore                         |                                       | 0-30                           | l,sil                    | ML,CL             | 0.32 | 56 |
|                                   |                                       | 30+                            | bedrock                  |                   |      |    |
| Culvers                           |                                       | 0-16                           | fs1                      | 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,<br>shsil      | GM,SM             | 0.20 | 35 |
| Ellington                         |                                       | 0-15                           | l,fs1                    | ML,SM             | 0.24 | 42 |
|                                   |                                       |                                | gl,gs1                   | ML,SM             | 0.24 | 42 |
|                                   |                                       | 15-38                          | l,sl                     | ML,SM             | 0.3  | 53 |
|                                   |                                       |                                | gl,gs1                   | ML,SM             | 0.2  | 35 |
|                                   |                                       | 38-60                          | s,gs                     | SM,SP-SM,GM       | 0.2  | 35 |

<sup>1/</sup> Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R=175

| Soil Series<br>(Alpha<br>Listing) | Local <sup>1/</sup><br>Mapping<br>No. | Typical<br>Profile<br>(inches) | USDA<br>Texture<br>Range | Unified<br>System     | K    | KR |
|-----------------------------------|---------------------------------------|--------------------------------|--------------------------|-----------------------|------|----|
| Fredon                            |                                       | 0-7                            | 1                        | ML,CL,SM              | 0.24 | 42 |
|                                   |                                       | 7-30                           | sl,fsl                   | SM,ML,CL              | 0.3  | 53 |
|                                   |                                       |                                | 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,gsl                  | ML,CL                 | 0.32 | 56 |
|                                   |                                       | 10-46                          | sil,l,fsl,               | ML,CL                 | 0.3  | 53 |
|                                   |                                       |                                | gsil,gl,gfsl             |                       |      |    |
|                                   |                                       | 46-60                          | vfsl,sl,gvfsl            | SM,SC                 | 0.2  | 35 |
| Halsey                            |                                       |                                | gsl                      |                       |      |    |
|                                   |                                       | 0-24                           | 1                        | 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                           | 1                        | 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                           | 1                        | 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,vgs1                 | GM,SM,ML,CL           | 0.2  | 35 |
|                                   |                                       | 26-60                          | s & g                    | SW,GW,SM,GM,<br>SP,GP | 0.2  | 35 |
| Kendaia                           |                                       | 0-8                            | sil,l,fsl                | ML                    | 0.28 | 49 |
|                                   |                                       | 8-20                           | sil,l                    | ML,ML-CL              | 0.4  | 70 |
|                                   |                                       | 20-40                          | sil,l                    | ML-CL,ML,SM           | 0.4  | 70 |
|                                   |                                       |                                |                          | ML-CL,ML,SM<br>GM-GC  | 0.3  | 53 |
| Kistler                           |                                       | 0-14                           | shsil                    | ML,CL                 | 0.24 | 42 |
|                                   |                                       | 14-24                          | vshsil                   | ML,CL,GM              | 0.2  | 35 |
|                                   |                                       | 24+                            | slate bedrock            |                       |      |    |
| Lackawana                         |                                       | 0-26                           | 1                        | ML,CL                 | 0.24 | 42 |
|                                   |                                       |                                | chsil                    | ML,CL                 | 0.17 | 30 |
|                                   |                                       | 26-52                          | chl(pan)                 | ML,CL                 | 0.3  | 53 |

<sup>1/</sup> Mapping units may be inserted on the basis of the local county soil survey.



TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R-175

| Soil Series<br>(Alpha<br>Listing) | Local <sup>1/</sup><br>Mapping<br>No. | Typical<br>Profile<br>(inches) | USDA<br>Texture<br>Range | Unified<br>System     | K    | KR |
|-----------------------------------|---------------------------------------|--------------------------------|--------------------------|-----------------------|------|----|
| 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,<br>ML,CL | 0.4  | 70 |
|                                   |                                       | 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,ML              | 0.24 | 42 |
|                                   |                                       | 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,SM,GM       |                       | 0.20 | 35 |
|                                   |                                       |                                | vsil                     |                       |      |    |
|                                   |                                       | 7-16                           | chsil,vchsil             | SM,SC,GM,GC           | 0.2  | 35 |
|                                   |                                       |                                | shsil,vshsil             |                       |      |    |
|                                   |                                       | 16+                            | shale bedrock            |                       |      |    |
| Netcong                           |                                       | 0-60                           | gsl,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<br>GP-GM          | SM,SP-SM,GM,<br>GP-GM | 0.2  | 35 |
| 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 |

<sup>1/</sup> Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R=175

| Soil Series<br>(Alpha<br>Listing) | Local <sup>1/</sup><br>Mapping<br>No. | Typical<br>Profile<br>(inches) | USDA<br>Texture<br>Range    | Unified<br>System    | K    | KR |
|-----------------------------------|---------------------------------------|--------------------------------|-----------------------------|----------------------|------|----|
| 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 |
| 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 |
|                                   |                                       |                                | vstl,estl                   | 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<br>GM | 0.2  | 35 |
| Rockaway                          |                                       | 0-30                           | l                           | ML,SM,SC             | 0.24 | 42 |
|                                   |                                       |                                | gsl,gl,vstl,<br>vstsl,estsl | ML,SM,SC             | 0.17 | 30 |
|                                   |                                       | 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                           | l                           | ML,CL                | 0.24 | 42 |
|                                   |                                       | 10-36                          | l,sil                       | ML,CL                | 0.3  | 53 |
|                                   |                                       | 36-60                          | fs                          | SM                   | 0.2  | 35 |

<sup>1/</sup> Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R=175

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range | Unified<br>System     | K    | KR |
|-----------------------------------|-------------------------|--------------------------------------|--------------------------|-----------------------|------|----|
| 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 |
|                                   |                         | 26+                                  | shale bedrock            |                       |      |    |
| Swartswood                        |                         | 0-30                                 | gfsl,gl,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                                 | vfs1                     | ML,CL                 | 0.49 | 86 |
|                                   |                         | 10-60                                | sil,vfs1                 | ML,CL                 | 0.4  | 70 |
|                                   |                         | 60-70                                | g & s                    | SP-SM,GP-GM,<br>GW-GM | 0.3  | 53 |
| 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                                | muck & 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<br>sil & fsl  | ML,CL,SC,SM,GM,<br>GC | 0.4  | 70 |
| 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<br>(pan)      | SM,SC,ML,CL           | 0.3  | 53 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2a EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 144, R=175

| <u>Soil Series</u><br>(Alpha<br>Listing) | <u>Local</u><br><u>Mapping</u><br><u>No.</u> | <u>1/</u><br><u>Typical</u><br><u>Profile</u><br><u>(Inches)</u> | <u>USDA</u><br><u>Texture</u><br><u>Range</u> | <u>Unified</u><br><u>System</u> | <u>K</u>    | <u>KR</u> |
|------------------------------------------|----------------------------------------------|------------------------------------------------------------------|-----------------------------------------------|---------------------------------|-------------|-----------|
| Whippany                                 |                                              | 0-9                                                              | sil                                           | ML,CL                           | 0.43        | 75        |
|                                          |                                              | 9-60                                                             | sil,sicl,sic,<br>C                            | ML,CL,CH                        | 0.4         | 70        |
| Whitman                                  |                                              | 0-10                                                             | fsl,sl,lvfsl,<br>vstl,estsl                   | OL,SM,ML                        | 0.24        | 42        |
|                                          |                                              | 10-40                                                            | fsl,sl,l                                      | SM,ML-CL                        | 0.2         | 35        |
|                                          |                                              | 40-60                                                            | gsl                                           | SM                              | 0.2         | 35        |
|                                          |                                              |                                                                  |                                               |                                 |             |           |
| 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<br>gl,chl,gsil,<br>chsil,gcl,chcl    | ML,CL<br>ML,CL                  | 0.32<br>0.3 | 56<br>53  |
|                                          |                                              | 32-60                                                            | l,sil,chl,<br>chsil<br>gl,gsil                | ML,CL,SM,SC                     | 0.3         | 53        |
|                                          |                                              |                                                                  |                                               |                                 |             |           |
|                                          |                                              |                                                                  |                                               |                                 |             |           |
| 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        |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 148, R=175

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range     | Unified<br>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,<br>vgsil          | ML,CL,GC          | 0.3  | 53 |
| 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 |
| Bedington                         |                         | 0-9                                  | shsil                        | ML,CL             | 0.32 | 56 |
|                                   |                         | 9-35                                 | shsil,shl                    | ML,CL             | 0.2  | 35 |
|                                   |                         |                                      | 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<br>shale           |                   | 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 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 148, R = 175

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | <u>1/</u><br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range   | Unified<br>System | K    | KR  |
|-----------------------------------|-------------------------|---------------------------------------------|----------------------------|-------------------|------|-----|
| Bucks                             |                         | 0-21                                        | sil                        | ML,CL             | 0.32 | 56  |
|                                   |                         | 21-36                                       | sic1,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,gsc1                | 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  |
| Chalfont                          |                         |                                             | gs1                        | SM,GM             | 0.2  | 35  |
|                                   |                         | 0-18                                        | sil                        | ML,CL             | 0.43 | 75  |
|                                   |                         |                                             | vstsil                     | ML,CL             | 0.37 | 65  |
|                                   |                         | 18-50                                       | sil,sic1                   | ML,CL             | 0.6  | 105 |
|                                   |                         | 50-60                                       | shsil,shl                  | ML,GM             | 0.6  | 105 |
| Cokesbury                         |                         | 0-15                                        | l                          | ML,CL,SM          | 0.32 | 56  |
|                                   |                         |                                             | gl,vstl,estl               | SM,SC             | 0.24 | 42  |
|                                   |                         | 15-25                                       | cl,sic1                    | 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,sic1                   | ML,CL,CH          | 0.5  | 88  |
|                                   |                         | 36-48                                       | shsil,shsic1               | ML,CL,SMSC        | 0.4  | 70  |
|                                   |                         | 48+                                         | Shale bedrock              |                   |      |     |
| 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                                       | sic1                       | ML,CL,MH,CH       | 0.3  | 53  |
|                                   |                         | 36-60                                       | sic1                       | ML,CL             | 0.4  | 70  |
|                                   |                         |                                             | shsil                      | ML,CL             | 0.3  | 53  |
| Dunellen                          |                         | 0-15                                        | l,sl                       | ML,SM             | 0.24 | 42  |
|                                   |                         |                                             | gl,gs1                     | ML,SM             | 0.24 | 42  |
|                                   |                         | 15-38                                       | l,sl                       | ML,SM             | 0.3  | 53  |
|                                   |                         |                                             | gl,gs1                     | ML,SM             | 0.2  | 35  |
|                                   |                         | 38-60                                       | s,gs                       | SM,SP-SM,GM       | 0.2  | 35  |
| Edneyville                        |                         | 0-11                                        | estl,gl,stl,               | ML,SM             | 0.24 | 42  |
|                                   |                         |                                             | vstl                       |                   |      |     |
|                                   |                         | 11-39                                       | sl,l,scl                   | ML,SM,SC          | 0.4  | 70  |
|                                   |                         |                                             | gs1,gl,gsc1                | ML,SM,SC          | 0.3  | 53  |
| Hazleton                          |                         | 39-65                                       | gs1                        | SM,GM             | 0.2  | 35  |
|                                   |                         | 0-9                                         | chl,vstl                   | SM,GM             | 0.24 | 42  |
|                                   |                         | 9-40                                        | chl                        | SM,GM             | 0.20 | 35  |
|                                   |                         | 40-50                                       | vchl                       | GM                | 0.20 | 35  |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 148, R=175

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range   | Unified<br>System | K    | KR  |
|-----------------------------------|-------------------------|--------------------------------------|----------------------------|-------------------|------|-----|
| Klinesville                       |                         | 0-13                                 | shsil,shl,<br>shsil,vshsil | GM,SM,SC,ML       | 0.20 | 35  |
|                                   |                         | 13-18                                | vshsil,vshsl               | GM,GP             | 0.2  | 35  |
|                                   |                         | 18+                                  | Shale, Bedrock             |                   |      |     |
| 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  |
|                                   |                         | 45-60                                | 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  |
|                                   |                         | 14-30                                | chsicl                     | ML,CL             | 0.4  | 70  |
|                                   |                         | 30-41                                | chsicl,vchsil              | ML,CL,GM          | 0.3  | 53  |
|                                   |                         | 41+                                  | Shale Bedrock              |                   |      |     |
| Meckesville                       |                         | 0-10                                 | gl                         | ML,CL             | 0.28 | 49  |
|                                   |                         | 10-31                                | cl,l,scl,<br>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                                | sicl,cl                    | ML,CL             | 0.3  | 53  |
|                                   |                         |                                      | scl,sl                     | SM,SC             | 0.3  | 53  |
|                                   |                         | 54+                                  | Diabase Bedrock            |                   |      |     |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 148, R=175

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | <u>1/</u><br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range          | Unified<br>System      | K    | KR |
|-----------------------------------|-------------------------|---------------------------------------------|-----------------------------------|------------------------|------|----|
| 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,vgs1,gs1,<br>kl               | SM,GM,GP               | 0.17 | 30 |
|                                   |                         | 40-60                                       | estsp<br>vst1,vstls,<br>stsl,stls | GM                     | 0.20 | 35 |
| Parsippany                        |                         | 0-9                                         | l,sicl,sil                        | ML                     | 0.43 | 75 |
|                                   |                         | 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,gs1,<br>vgs1               | 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 Bedrock                     |                        |      |    |
| Pope                              |                         | 0-12                                        | fsl                               | SM                     | -    | -  |
|                                   |                         | 12-46                                       | fsl,l                             | SM,SC                  | -    | -  |
|                                   |                         | 46-60                                       | s,sl,gs,gs1,<br>vgs,vgs1          | SP-SM,SM,GP-GM,-<br>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 |

1/ Mapping units may be inserted on the basis of the local county soil survey



TABLE A1-2b EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 148, R=175

| <u>Soil Series</u><br>(Alpha Listing) | <u>Local 1/</u><br><u>Mapping</u><br><u>No.</u> | <u>Typical</u><br><u>Profile</u><br>(Inches) | <u>USDA</u><br><u>Texture</u><br><u>Range</u> | <u>Unified</u><br><u>System</u> | <u>K</u> | <u>KR</u> |
|---------------------------------------|-------------------------------------------------|----------------------------------------------|-----------------------------------------------|---------------------------------|----------|-----------|
| 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 Bedrock                                 |                                 |          |           |
| 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<br>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        |
|                                       |                                                 |                                              |                                               | GM                              |          |           |
| 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                                        | vgl                                           | 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        |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 149, R =200

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | <u>1/</u><br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range | Unified<br>System | K    | KR |
|-----------------------------------|-------------------------|---------------------------------------------|--------------------------|-------------------|------|----|
| Adelphia                          |                         | 0-14                                        | sl, fsl, l               | ML, CL, SM, SC    | 0.32 | 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         | 0.17 | 34 |
|                                   |                         | 16-60                                       | s, ls                    | SP, SP-SM         | 0.2  | 40 |
| Aura                              |                         | 0-13                                        | sl, l                    | SM, ML, CL        | 0.43 | 86 |
|                                   |                         |                                             | gl, gsl                  | SM, SC            | 0.32 | 60 |
|                                   |                         |                                             | ls                       | SP-SM, SM         | 0.28 | 40 |
|                                   |                         | 13-59                                       | scl                      | SM, SC            | 0.4  | 80 |
|                                   |                         |                                             | gsc1, 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                | 0.49 | 98 |
|                                   |                         | 14-40                                       | vfs1, fsl                | SM                | 0.4  | 80 |
|                                   |                         | 40-60                                       | fs, lfs                  | SM, SP-SM         | 0.3  | 60 |
| Bayboro                           |                         | 0-14                                        | sl, l, sil               | ML                | 0.37 | 74 |
|                                   |                         | 14-64                                       | c, cl, sic               | CH, CL, MH        | 0.2  | 40 |
| Berryland                         |                         | 0-12                                        | s, fs                    | SP, SP-SM         | 0.17 | 34 |
|                                   |                         | 12-72                                       | s, ls, sl                | SP, SP-SM         | 0.2  | 40 |
| Bertie                            |                         | 0-14                                        | sil, l                   | ML, CL            | 0.37 | 74 |
|                                   |                         | 14-40                                       | sil, sic1, l             | ML, CL            | 0.4  | 80 |
|                                   |                         | 40-60                                       | stratified               | SM, SC, ML        | 0.3  | 60 |
|                                   |                         |                                             | sl, l, ls                |                   |      |    |
|                                   |                         |                                             | gsl                      | SM                | 0.2  | 40 |
| Bibb                              |                         | 0-28                                        | sl to sic1               | ML, CL, SM        | 0.32 | 64 |
|                                   |                         | 28-60                                       | highly variable          | SM, GM, CL        | 0.20 | 40 |
| Chillum                           |                         | 0-28                                        | sil                      | ML, CL            | 0.32 | 64 |
|                                   |                         | 28-60                                       | gsc1, gl                 | SM, SC            | 0.3  | 60 |
|                                   |                         |                                             | gsl                      | GM                | 0.2  | 40 |
| Colemantown                       |                         | 0-14                                        | l                        | ML, CL, SM        | 0.43 | 86 |
|                                   |                         | 14-30                                       | sc, scl                  | CL, CH, MI        | 0.4  | 80 |
|                                   |                         | 30-60                                       | sl, cl, scl              | SC, ML, CL        | 0.4  | 80 |
| Collington                        |                         | 0-13                                        | sl, fsl                  | SM, SC, ML        | 0.28 | 56 |
|                                   |                         |                                             | ls                       | SM                | 0.20 | 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                | 0.28 | 56 |
|                                   |                         |                                             | ls                       | SM                | 0.20 | 40 |
|                                   |                         | 14-34                                       | scl, sl, l               | SM, SC            | 0.4  | 80 |
|                                   |                         | 34-60                                       | sl                       | SM                | 0.3  | 60 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 149, R=200

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range | Unified<br>System | K    | KR |
|-----------------------------------|-------------------------|--------------------------------------|--------------------------|-------------------|------|----|
| Donlonton                         |                         | 0-12                                 | fsl                      | ML,CL,SM,SC       | 0.43 | 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          | 0.28 | 56 |
|                                   |                         |                                      | ls                       | SM                | 0.20 | 40 |
|                                   |                         | 16-30                                | sl                       | SM                | 0.3  | 60 |
|                                   |                         | 30-60                                | s,ls                     | SP,SP-SM          | 0.2  | 40 |
| Dragston                          |                         | 0-14                                 | fsl,sl,lfs               | SM,SC,ML          | 0.28 | 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          | 0.43 | 86 |
|                                   |                         | 10-36                                | sic,c                    | CH,CL,MH          | 0.4  | 80 |
|                                   |                         | 36-60                                | sic,sicl,scl,csc         | SM,CL,CH,MH       | 0.4  | 80 |
| Evesboro                          |                         | 0-60                                 | ls,s,fs                  | SM,SP             | 0.17 | 34 |
| Fallsington                       |                         | 0-14                                 | sl,fsl,l                 | SM,SC,ML          | 0.28 | 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          | 0.20 | 40 |
|                                   |                         | 24-40                                | sl                       | SM                | 0.3  | 60 |
|                                   |                         | 40-60                                | s                        | SP-SM,SM          | 0.2  | 40 |
| Freehold                          |                         | 0-14                                 | fsl,sl,l                 | SM,ML             | 0.28 | 56 |
|                                   |                         |                                      | ls,lfs                   | SM                | 0.20 | 40 |
|                                   |                         | 14-32                                | sl,scl                   | SM,SC             | 0.4  | 80 |
|                                   |                         | 32-60                                | stratified<br>ls,fsl     | SM                | 0.2  | 40 |
| Freneau                           |                         | 0-60                                 | sl,l                     | SM,ML             | 0.28 | 56 |
| Galestown                         |                         | 0-60                                 | ls,s                     | SM,SP             | 0.17 | 34 |
| Hammonton                         |                         | 0-18                                 | sl                       | SM                | 0.28 | 56 |
|                                   |                         |                                      | ls                       | SP-SM,SM          | 0.20 | 40 |
|                                   |                         | 18-36                                | sl                       | SM                | 0.3  | 60 |
|                                   |                         | 36-60                                | s,ls,gs,gl               | SP-SM,SM          | 0.2  | 40 |
| Holmdel                           |                         | 0-14                                 | fsl,sl,l,lfs             | SM,ML             | 0.28 | 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          | 0.43 | 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          | 0.28 | 56 |
|                                   |                         | 30-60                                | sl,l                     | SM                | 0.3  | 60 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 149, R=200

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range | Unified<br>System | K    | KR    |
|-----------------------------------|-------------------------|--------------------------------------|--------------------------|-------------------|------|-------|
| Keyport                           |                         | 0-10                                 | sil,l,fsl,sl             | SM,ML             | 0.43 | 86    |
|                                   |                         | 10-44                                | c,sic,cl                 | CL,CH,MH          | 0.4  | 80    |
|                                   |                         | 44-72                                | sicl,sic                 | CL,ML,MH          | 0.4  | 80    |
| Sandy Substratum                  |                         | 44-72                                | scl,sl                   | SM,SC,ML,CL       | 0.3  | 60 2/ |
| Klej                              |                         | 0-40                                 | ls,fs                    | SM,SP-SM,SP       | 0.17 | 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-SM    | 0.43 | 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          | 0.17 | 34    |
| Lakeland                          |                         | 0-60                                 | ls,lfs,s                 | SM,SP             | 0.17 | 34    |
| Lakewood                          |                         | 0-60                                 | s,fs                     | SP,SP-SM          | 0.17 | 34    |
| Lenoir                            |                         | 0-10                                 | sil,l,fsl                | SM,ML             | 0.43 | 86    |
|                                   |                         | 10-60                                | sicl,c,sic,cl            | CL,CH,ML,MH       | 0.4  | 80    |
| Sandy Substratum                  |                         | 40-72                                | scl,sl                   | SM,SC,ML,CL       | 0.3  | 60 2/ |
| Leon                              |                         | 0-16                                 | s                        | SP,SP-SM          | 0.17 | 34    |
|                                   |                         | 16-60                                | s,ls                     | SP,SP-SM          | 0.2  | 40    |
| Lenoir                            |                         | 0-10                                 | l,sil                    | ML,CL             | 0.43 | 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          | 0.17 | 34    |
| Marlton                           |                         | 0-14                                 | sl,fsl                   | SM,SC             | 0.43 | 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          | 0.32 | 64    |
|                                   |                         | 16-34                                | sil,sicl                 | ML,CL             | 0.4  | 80    |
|                                   |                         | 34-60                                | s,ls,sl,l                | SM,SC,CL,ML       | 0.3  | 60    |
|                                   |                         |                                      | gs                       |                   |      |       |
| Matawan                           |                         | 0-20                                 | sl,ls,fsl                | SM,SC             | 0.32 | 64    |
|                                   |                         | 20-60                                | cl,scl,sc,sl             | CL,SC,SM          | 0.4  | 80    |
| Mattapex                          |                         | 0-14                                 | sil,l                    | ML,CL             | 0.37 | 74    |
|                                   |                         | 14-40                                | sicl,sil,cl              | ML,CL             | 0.4  | 80    |
|                                   |                         | 40-60                                | sl,ls,s,l                | SM,SC,CL,ML       | 0.2  | 40    |
|                                   |                         |                                      | gs                       |                   |      |       |
| Matlock                           |                         | 0-10                                 | l                        | ML,CL             | 0.43 | 86    |
|                                   |                         | 10-35                                | sc,scl                   | ML,CL,MH,CH       | 0.4  | 80    |
|                                   |                         | 35-60                                | sl,l                     | SM,SC,ML          | 0.3  | 60    |

1/ Mapping units may be inserted on the basis of the local county soil survey.

2/ Data for sandy substratum.

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 149, R=200

| Soil Series<br>(Alpha<br>Listing) | Local<br>Mapping<br>No. | 1/<br>Typical<br>Profile<br>(Inches) | USDA<br>Texture<br>Range | Unified<br>System | K    | KR |
|-----------------------------------|-------------------------|--------------------------------------|--------------------------|-------------------|------|----|
| Monmouth                          |                         | 0-11                                 | fs1,l,lfs                | SM,SC,ML,CL       | 0.43 | 86 |
|                                   |                         | 11-40                                | sc,scl                   | CL,SC             | 0.4  | 80 |
|                                   |                         | 40-60                                | sl,scl,sc                | SM,SC             | 0.3  | 60 |
| Nixonton                          |                         | 0-14                                 | fs1,lfs                  | SM                | 0.49 | 98 |
|                                   |                         | 14-40                                | vfs1,fs1                 | SM                | 0.4  | 80 |
|                                   |                         | 40-60                                | lfs,ls                   | SM,SP-SM          | 0.2  | 40 |
| Osier                             |                         | 0-60                                 | s,fs,ls,lfs              | SM,SP-SM          | 0.17 | 34 |
| Othello                           |                         | 0-14                                 | sil,l,fs1,sic1           | ML,CL             | 0.37 | 74 |
|                                   |                         | 14-34                                | sic1,sil                 | ML,CL             | 0.4  | 80 |
|                                   |                         | 34-60                                | sl,ls,scl                | SM,SC,CL          | 0.3  | 60 |
| Pasquotank                        |                         | 0-30                                 | vfs1,fs1                 | ML,SM             | 0.49 | 98 |
|                                   |                         | 30-60                                | vfs1,sl,ls               | ML,SM             | 0.2  | 40 |
| Pemberton                         |                         | 0-24                                 | s,ls                     | SM,SP-SM          | 0.20 | 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          | 0.17 | 34 |
|                                   |                         | 46-60                                | sl,scl                   | SM,SC             | 0.30 | 60 |
| Pocomoke                          |                         | 0-28                                 | sl,l,fs1,ls,<br>lfs      | SM,ML             | 0.28 | 56 |
|                                   |                         | 28-60                                | ls,s                     | SM,SP-SM          | 0.2  | 40 |
| Portsmouth                        |                         | 0-26                                 | sil                      | ML,CL             | 0.28 | 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          | 0.17 | 34 |
|                                   |                         | 12-72                                | s,ls,sl,gs               | SP,SP-SM          | 0.2  | 40 |
| Sassafras                         |                         | 0-14                                 | fs1,l,sl                 | SM,ML             | 0.28 | 56 |
|                                   |                         |                                      | ls,lfs                   | SM                | 0.20 | 40 |
|                                   |                         |                                      | gsl                      | SM,SP             | 0.24 | 48 |
|                                   |                         | 14-36                                | scl,sl,l                 | SM,SC,CL,ML       | 0.3  | 60 |
|                                   |                         | 36-60                                | sl,ls,fs1                | SM                | 0.2  | 40 |
|                                   |                         |                                      | gsl,gls                  | SM,SP,SP-SM       | -    | -  |
| Shrewsbury                        |                         | 0-14                                 | sl,fs1,l                 | SM,ML             | 0.28 | 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          | 0.20 | 40 |
|                                   |                         | 24-60                                | s,ls                     | SM,SC,SP-SM       | 0.20 | 40 |
| Weeksville                        |                         | 0-14                                 | fs1                      | ML,SM             | 0.49 | 98 |
|                                   |                         | 14-44                                | sil,fs1                  | ML,SM             | 0.4  | 80 |
|                                   |                         | 44-60                                | vfs1,fs1,scl             | ML,CL,SM          | 0.4  | 80 |

1/ Mapping units may be inserted on the basis of the local county soil survey.

TABLE A1-2c EROSION PROPERTIES OF SOILS IN NEW JERSEY  
LAND RESOURCE AREA 149, R=200

| <u>Soil Series</u><br>(Alpha<br>Listing) | <u>Local</u><br><u>Mapping</u><br><u>No.</u> | <u>1/</u><br><u>Typical</u><br><u>Profile</u><br><u>(Inches)</u> | <u>USDA</u><br><u>Texture</u><br><u>Range</u> | <u>Unified</u><br><u>System</u> | <u>K</u> | <u>KR</u> |
|------------------------------------------|----------------------------------------------|------------------------------------------------------------------|-----------------------------------------------|---------------------------------|----------|-----------|
| Westphalia                               |                                              | 0-14                                                             | fsl,lfs                                       | SM,ML                           | 0.49     | 98        |
|                                          |                                              | 14-28                                                            | fsl,lfs,<br>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                        | 0.20     | 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                        | 0.28     | 56        |
|                                          |                                              |                                                                  | ls                                            | SM                              | 0.20     | 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,gl                                        | SM,SP-SM                        |          |           |

1/ Mapping units may be inserted on the basis of the local county soil survey.

**TABLE A1-3**  
**VALUES OF THE TOPOGRAPHIC FACTOR "LS"**

| Length<br>of<br>Slope<br>Ft. (L) | 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  | 6.0  | 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

| <u>Type</u>                           | <u>T/ac</u> | <u>Slope %</u> | <u>C Value</u> | <u>Max<br/>Length</u> |
|---------------------------------------|-------------|----------------|----------------|-----------------------|
| 1. No Mulch<br>or Seeding             | -           | All            | 1.0            | -                     |
| 2. Straw or<br>Hay tied               | 1.0         | $\leq 5$       | .20            | 200                   |
|                                       |             | 6-10           | .20            | 100                   |
|                                       | 1.5         | $\leq 5$       | .12            | 300                   |
|                                       |             | 6-10           | .12            | 150                   |
|                                       | 2.0         | $\leq 5$       | .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                    |
|                                       | 135         | $\leq 15$      | .05            | 200                   |
|                                       |             | 16-20          | .05            | 150                   |
|                                       |             | 21-33          | .05            | 100                   |
|                                       |             | 34-50          | .05            | 75                    |
|                                       |             |                |                |                       |
| 3. Crushed<br>Stone (1/4"-<br>1 1/2") | 240         | $\leq 20$      | .02            | 300                   |
|                                       |             | 21-33          | .02            | 200                   |
|                                       |             | 34-50          | .02            | 150                   |
|                                       | 7           | $\leq 15$      | .08            | 75                    |
|                                       |             | 16-20          | .08            | 50                    |
|                                       |             |                |                |                       |
|                                       | 12          | $\leq 15$      | .05            | 150                   |
|                                       |             | 16-20          | .05            | 100                   |
|                                       |             | 21-33          | .05            | 75                    |
|                                       |             |                |                |                       |
| 4. Woodchips                          | 25          | $\leq 15$      | .02            | 200                   |
|                                       |             | 16-20          | .02            | 150                   |
|                                       |             | 21-33          | .02            | 100                   |
|                                       |             | 34-50          | .02            | 75                    |
|                                       |             |                |                |                       |

Universal Soil Loss Equation

Revised April 1987



Table A1-4

## C Values and Slope-Length Limits for Various Mulches \1

| Type                                                | T/ac           | C Value                             |                            |
|-----------------------------------------------------|----------------|-------------------------------------|----------------------------|
|                                                     |                | Through First 6<br>Weeks of Growing | After 6 Weeks<br>of Growth |
| 5. Temporary<br>(grain or<br>fast growing<br>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<br>Seeding, 2nd<br>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  $P_C$  OR SURFACE CONDITION FOR CONSTRUCTION SITES

| SURFACE CONDITION WITH NO COVER                                        | FACTOR $P_C$ * |
|------------------------------------------------------------------------|----------------|
| 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 Al-6

ADJUSTMENT FACTOR M FOR ESTIMATING MONTHLY AND PORTIONS OF ANNUAL SOIL LOSS  
FOR NEW JERSEY

| Starting<br>Months | ENDING 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?

$E_t = 70 \times 1.2 = 84.0$  tons per acre per year.

$E_t$  for July =  $84 \times 0.2 = 17$  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 September =  $84 \times 0.66 = 55$  tons per acre.

TABLE A1-7

APPROXIMATE WEIGHTS OF SOILS IN LBS. PER CUBIC FT. AND CONVERSION FACTORS

| <u>Soils</u>                  | <u>Volume Wt.</u><br><u>lb./cu. ft.</u> | <u>Conversion Factors</u> |                | <u>Tons to</u><br><u>Cu. Yds.</u> |
|-------------------------------|-----------------------------------------|---------------------------|----------------|-----------------------------------|
|                               |                                         | <u>Ac. Inches</u>         | <u>Ac. Ft.</u> |                                   |
| 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<br>and clay | 70                                      | 0.0079                    | 0.00066        | 1.06                              |
| <hr/>                         |                                         |                           |                |                                   |
| 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)

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<br>Year<br>In | Factor | Exceeded<br>Once In<br>(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:  $100 \times 1.25 = 125$  tons per acre, or one year in 20 the loss could be:  $100 \times 1.7 = 170$  tons per acre.

A single storm that may take place once in 10 years could cause a soil loss of  $100 \times 0.5 = 50$  tons per acre. If the single storm is one that occurs once in 2 years, the loss might be:  $100 \times 0.3 = 30$  tons per acre.

REQUIREMENTS, GUIDELINES AND PROCEDURES FOR  
PREPARING AND IMPLEMENTING "STANDARDS FOR SOIL EROSION AND  
SEDIMENT CONTROL IN NEW JERSEY"

PART 1 - Information needed by the local Soil Conservation District. A complete Application for Soil Erosion and Sediment Control Plan Certification, see Figure A2-1, includes the following items:

An application for certification of a soil erosion and sediment control plan shall include the following items:

1. One copy of:
  - a. Complete subdivision or site plan application, including key map, as submitted to the municipality. (Architectural drawings and building plans and specifications not required.)
  - b. Location of present and proposed drains and culverts with their discharge capacities and velocities and supporting computations, and identification of conditions below outlets.
  - c. Delineation of any area subject to flooding from the 100-year storm in compliance with the Flood Plains Act (NJSA 58:16A) or applicable municipal zoning.
  - d. Delineation of streams and other significant natural features within the project area.
  - e. Soils and other natural resource information used. (Delineation of the project's site on soil maps is desirable.)
  - f. Land cover and use of area adjacent to the land disturbance.
2. Four\* copies of the soil erosion and sediment control plan, at the same scale\* as the municipal site plan, to include the following (this information shall be detailed on the plat):
  - a. Proposed sequence of development including duration of each phase in the sequence.
  - b. Site grading plan showing delineation of land areas to be disturbed including proposed cut and fill areas together with existing and proposed profiles of these.
  - c. Contours at a two\* foot interval, showing present and proposed ground elevation.
  - d. Locations of all streams and existing and proposed drains and culverts.
  - e. Location and detail of all proposed erosion and sediment control structures including profiles, cross sections, appropriate notes, and supporting computations.
  - f. Location and detail of all proposed nonstructural methods of soil stabilization including rates and types of lime, fertilizer, seed, and mulch to be applied.
  - g. Control measures for non-growing season stabilization of exposed areas, where the establishment of vegetation is planned as the final control measure.
  - h. For residential development - control measures to apply to dwelling construction on individual lots and notation that such control measures shall apply to subsequent owners if title is conveyed. This notation shall be shown on the final plat.
  - i. Plans for maintenance of permanent soil erosion and sediment control measures and facilities during and after construction, also indicating who shall have responsibility for such maintenance.
3. Appropriate fees: (As adopted by the individual district.)
4. Additional items as may be required.

\*(Individual districts may require modifications in the above list.)

## PART II - Review Procedure

1. Check plans against soils and other applicable resource data for the following.
  - a. Flood plains
  - b. Erosion and sediment problems
  - c. Wetness or high water table
  - d. Slope hazards or stability
  - e. Bedrock
  - f. Off-site problems
  - g. Vegetative establishment and maintenance problems
  - h. Structural establishment and maintenance problems
  - i. Storm water management needs
  - j. Compatability with the surrounding environment
2. Field check apparent trouble spots as needed but not necessarily the whole plan.
3. Identify any needed changes in proposed vegetative or engineering practices.
4. Make notes of changes on the plat itself (preferred) or on an attached sheet.
5. If practices are added, attach or reference these to the applicable sections of "Standards for Soil Erosion and Sediment Control in New Jersey".
6. Review proposed schedule and sequence of implementation and comment.
7. Review off site effects and comment.
8. Review compatability of the development with surrounding environment and comment.
9. Write general notes (how to do it) if they will help clarify recommendations; stick to facts, not opinions.
10. Review maintenance notes and comment.
11. Suggest other reviews that may be required by agencies such as Environmental Protection, Health, Planning, Transportation and others.

## PART III - Follow up by reviewing agency

1. Return set of plans and the review summary to the sender.
2. Perform sufficient on site follow-up to determine if review detail is adequate.
3. Determine if training of developers, inspectors or others is required and assist with such training.
4. Enforce implementation of Soil Erosion and Sediment Control Plan on construction site, if necessary.



For District Use Only

Application Number

Disposition

**APPLICATION FOR SOIL EROSION AND SEDIMENT CONTROL PLAN CERTIFICATION**

The enclosed soil erosion and sediment control plan and supporting information are submitted for certification pursuant to the Soil Erosion and Sediment Control Act, Chapter 251, P.L. 1975 as amended (NJSA 4:24-39 et seq.). An application for certification of a soil erosion and sediment control plan shall include the items listed on the reverse side of this form.

|                          |                                    |                                |               |
|--------------------------|------------------------------------|--------------------------------|---------------|
| Project Owner(s) Name    |                                    | Phone                          |               |
| Project Owner(s) Address |                                    | City                           | State and Zip |
| Name of Project          |                                    | Project Location: Municipality |               |
| Project Street Address   |                                    | Block                          | Lot           |
| Total Area of Project    | Total Area of Land to be Disturbed | No. Dwelling or other Units    | Fee           |
|                          |                                    |                                | \$            |
| Plans Prepared by*       |                                    |                                |               |

|         |       |
|---------|-------|
| Address | Phone |
|---------|-------|

\*(Engineering related items of the Soil Erosion and Sediment Control Plan MUST be prepared by or under the direction of and be sealed by a Professional Engineer or Architect licensed in the State of New Jersey, in accordance with NJAC 13:27-6.1 et seq.)

|                   |  |                |  |
|-------------------|--|----------------|--|
| Agent Responsible |  | Job Supervisor |  |
| Address           |  | Address        |  |
| Phone             |  | Phone          |  |

The applicant hereby certifies that all soil erosion and sediment control measures are designed in accordance with current Standards for Soil Erosion and Sediment Control in New Jersey and will be installed in accordance with those Standards and the plan as approved by the Soil Conservation District and agrees as follows:

1. To notify the District in writing at least 48 hours in advance of any land disturbance activity. Failure to provide such notification may result in additional inspection fees.
2. To notify the District upon completion of the Project. (Note: No certificate of occupancy can be granted until a report of compliance is issued by the District.)
3. To maintain a copy of the certified plan on the project site during construction.
4. To allow District agents to go upon project lands for inspection.
5. That any conveyance of this project prior to its completion will transfer full responsibility for compliance with the certified plan to any subsequent owners.

The applicant hereby acknowledges that Engineering features contained in the Soil Erosion and Sediment Control Plan are reviewed for adequacy to reduce offsite soil erosion and sedimentation and not for adequacy of structural design. The applicant shall retain full responsibility for any damages which may result from any construction activity notwithstanding district certification of the subject soil erosion and sediment control plan. It is understood that approval of the plan submitted with this application shall be valid only for the duration of the initial project approval granted by the municipality. All municipal renewals of this project will require resubmission and approval by the district. In no case shall this approval extend beyond three and one half years.

|                        |                          |      |
|------------------------|--------------------------|------|
| Signature of Applicant | Applicant's Name (Print) | Date |
|------------------------|--------------------------|------|

Receipt of application, fee, plan and supporting documents is hereby acknowledged:

|                                |       |      |                            |
|--------------------------------|-------|------|----------------------------|
| Signature of District Official | Title | Date | Soil Conservation District |
|--------------------------------|-------|------|----------------------------|

The Soil Erosion and Sediment Control Plan submitted herewith is hereby determined to be complete:

|                                |       |      |                            |
|--------------------------------|-------|------|----------------------------|
| Signature of District Official | Title | Date | Soil Conservation District |
|--------------------------------|-------|------|----------------------------|





## APPENDIX A3

### GUIDE FOR CONSTRUCTION SPECIFICATIONS

The following are examples of requirements that may be used for preparing construction specifications. Incorporation of such requirements will help assure protection of disturbed areas especially where critical soil erosion problems may exist.

The contractor shall perform all work, furnish all materials and install all measures required to reasonably control soil erosion resulting from construction operations and minimize loss of sediment from the construction site. The contractor shall adhere to the certified soil erosion and sediment control plan showing the methods to be used for controlling erosion during construction which includes sequence of construction operations. When no work will be performed on critical areas for more than 60 days, they shall be protected by temporary seeding, mulching, or sodding, or the slope lengths shall be reduced by the installation of diversions or other means.

The contractor shall install erosion controls on all disturbed critical areas or disturbances adjacent to critical areas.

Critical areas are any area subject to excessive erosion due to highly erodible soils, slope length, steepness, water concentration or other factors. Areas may become critical when the vegetation or other soil surface protection is removed.

The permanent vegetative cover such as seeding or sodding on all areas shall be accomplished within 10 days after final grading operations have been completed. Time extensions beyond the 10 day requirement may be requested in writing and are subject to written approval.

Exposed soil having a pH value of less than 4 shall be covered with a minimum of 12 inches of soil material no coarser than a sandy loam or SM and that can be corrected to a minimum pH of 6.5.

Excavated soil material shall not be placed adjacent to rivers, streams or bodies of water in a manner that will cause it to be washed away by high water or runoff. Excess borrow material removed from the construction site shall be stabilized at the site of placement.

The contractor shall comply with applicable State and local regulations for prevention and abatement of pollution.



## APPENDIX A4

### MAINTENANCE OF STRUCTURAL MEASURES

Maintenance is the work required to keep practices in, or 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.

#### 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 of those who will accept such responsibility. All structures should be inspected at least semiannually 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; plugging of weep holes; operation of automatic drainage gates; condition of safety fences; 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 fills 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.



## APPENDIX A5

### GUIDE FOR INSTALLING SOIL STABILIZATION MATTING

Soil 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.

#### Materials

Jute mat shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn, 48 inches in width plus or minus 1 inch and weighing an average of 1.2 pounds per linear yard of cloth with a tolerance of plus or minus 5 percent, with approximately 78 warp ends per width of cloth and 41 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 and shall not vary in thickness by more than one half of its normal diameter.

Excelsior mat shall be wood excelsior, 48 inches in width plus or minus 1 inch and weighing 0.8 pounds per square yard plus or minus 10 percent. The excelsior material shall be covered with a netting to facilitate handling and to increase strength.

Staples - Staples for anchoring soil stabilization matting shall be made of 12 -to- 20 inch lengths of No. 8 plain iron wire.

#### Installation Requirements

Site Preparation: Shape and grade the waterway, channel or area to be protected as required by job plans and specifications.

Remove rocks, clods over 1½ inches in diameter, sticks and other material that will prevent contact of the matting with the soil surface.

Seeding: Lime, fertilizer and seed in accordance with the applicable seeding standard except that for jute matting one half of the seed may be applied prior to laying the matting and the remaining seed applied after laying the matting.

Do not cultipack.

Laying the Matting: (If instructions have been followed, the matting will be laid on loose soil. See Figure A5-1.)

Start laying the matting from the top of the channel or slope and unroll downhill so that one edge of the strip coincides with the channel center. Lay a second strip parallel to the first on the other side of the channel and allow at least a 2-inch overlap for jute matting. Excelsior matting may be butted. If one roll of matting does not extend the length of the channel, continue downhill with additional rolls.

Securing the Matting: Bury the top end of jute strips in a trench 4 inches or more deep. Tamp the trench full of soil. Reinforce with a row of staples driven through the jute about 4 inches downhill from the trench. These staples should be about 10 inches apart. Then staple the overlap in the channel center. These staples should be 3 to 4 feet apart. The outside edges may be stapled similarly at any time after the center has been stapled. Closer stapling along the sides is required where concentrated water may flow into the channel. The edges of excelsior matting should be stapled on 12 to 24 inch centers.

Succeeding strips of matting, farther down the channel or slope, are secured in a similar manner.

Where one roll of jute matting ends and another roll begins, the end of the top strip overlaps the trench where the upper end of the lower strip is buried. Make the overlap at least 4 inches and staple securely. Rolls of excelsior matting may be butted at the ends and securely stapled.

Erosion Stops: At any point, jute matting may be folded for burying in slit trenches and secured as were the upper ends. This checks water flow and erosion that may begin under the matting. It also gives improved tie-down. The procedure is recommended on the steeper slopes of sandy soil and gentler slopes subject to seepage. Spacings vary from 25 to 100 feet.

Diversions: Where diversions outlet into the waterway, the outlet should be protected with matting used in the same manner as in the main channel. The matting for the outlet is laid first so that matting in the main channel will overlap the outlet strip.

Matting Soil Contact: Get contact between matting and soil by rolling after laying, stapling and seeding are complete. Perfect contact is vital to keep water flow over - not under - the matting.

Inspection: After job completion, make sure the matting is in contact with the soil at all places and that critical areas are securely stapled down.

FIGURE A5-1

DETAIL FOR STABILIZING WATERWAYS WITH JUTE THATCHING

A. Bury the top end of the jute strips in a trench 4 inches or more in depth.

B. Tamp the trench full of soil.  
Secure with row of staples,  
10 inch spacing, 4 inches  
down from the trench

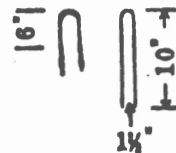
C. Overlap--Bury upper end of lower  
strip as in 'A' and 'B'. Overlap  
end of top strip 4 inches and staple.

D. Erosion stop--Fold of jute  
buried in slit trench and  
tamped, double row of  
staples.

2 inch  
overlap of  
jute strips  
where two or  
more strip  
widths are  
required.  
Staples on  
3' to 4'  
centers.

Place staples  
4 to 10 feet  
apart.

TYPICAL STAPLES  
#8 Gauge Wire







## APPENDIX A6

### 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 page 4.22. 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 page 4.23 for a clay loam soil with vegetation in the channel is 3.0 feet per second. 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 in table 4.23.

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  $Q/V = 20/3 = 6.7$  sq. ft. Enter Figure A6-6 with  $A = 6.7$  and  $R = 0.53$ , find bottom width equal 5 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  $V = 2$   
 $Q = VA = (2)(9) = 18$  cfs  
required 20 cfs capacity is larger.

#### Trial #2

Try  $d = 1.2$  feet, repeat steps in 1st trial  
find  $R = 0.76$   
 $A = 13$   
 $V = 2.8$   
 $Q = 36.4$  cfs is larger than required.

### Trial #3

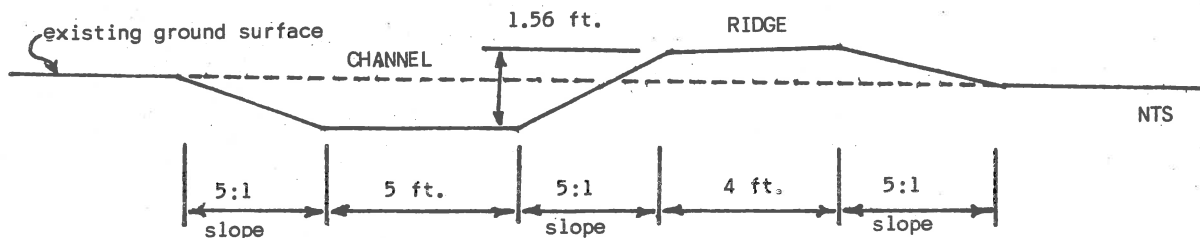
Try  $d=0.96$  feet,  
find  $R = 0.64$   
 $A = 9.4$   
 $V = 2.13$   
 $Q = 20$  cfs

#### Design Flow Dimensions:

- Grade = 1%
- Side slopes = 5:1
- Bottom width = 5 feet
- Depth = 1.1 feet (required flow depth)

#### Constructed Diversion Dimensions:

- Grade = 1%
- Side slopes of channel is 5:1 both sides, back slope of ridge is 5:1 and for maintenance reasons, ridge top width is 4 feet from the standard.
- Bottom width of the channel is 5 feet
- 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 cfs.

### Waterway Example Problem Solution:

The maximum permissible velocity from page 4.31 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 traverse 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 A6-15 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.

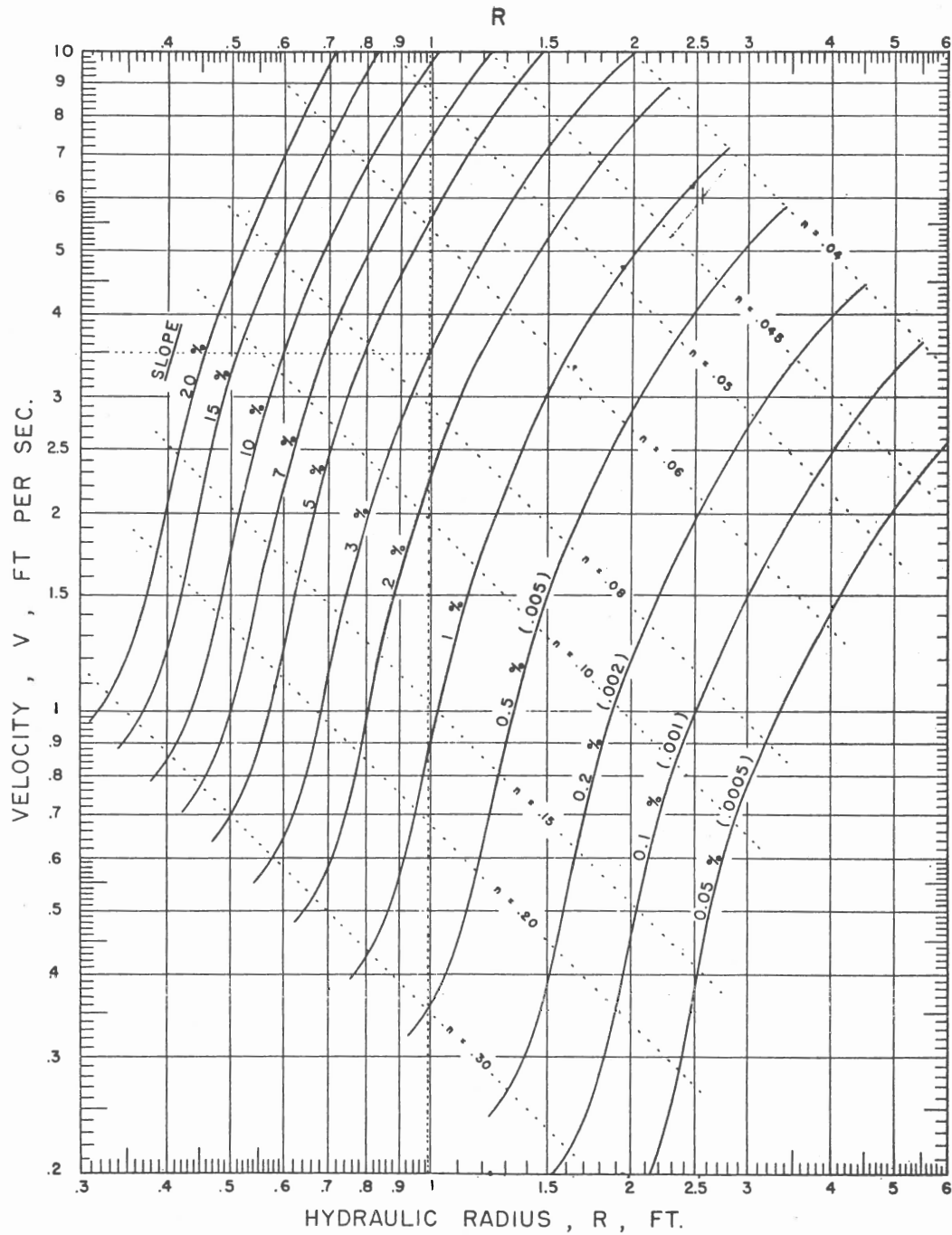


FIGURE A6-1

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE B (HIGH VEGETAL RETARDANCE)

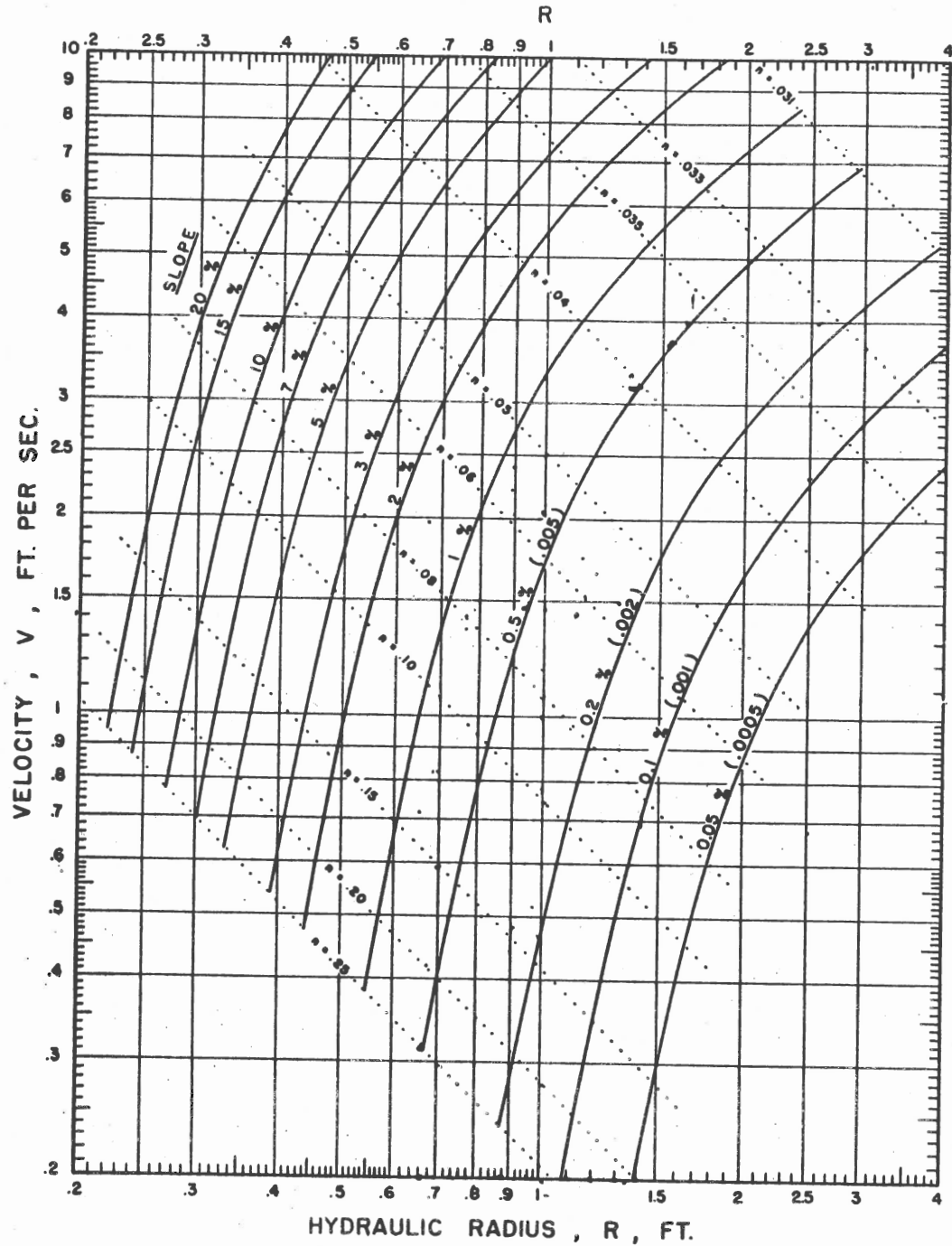


FIGURE A6-2

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE C (MODERATE VEGETAL RETARDANCE)

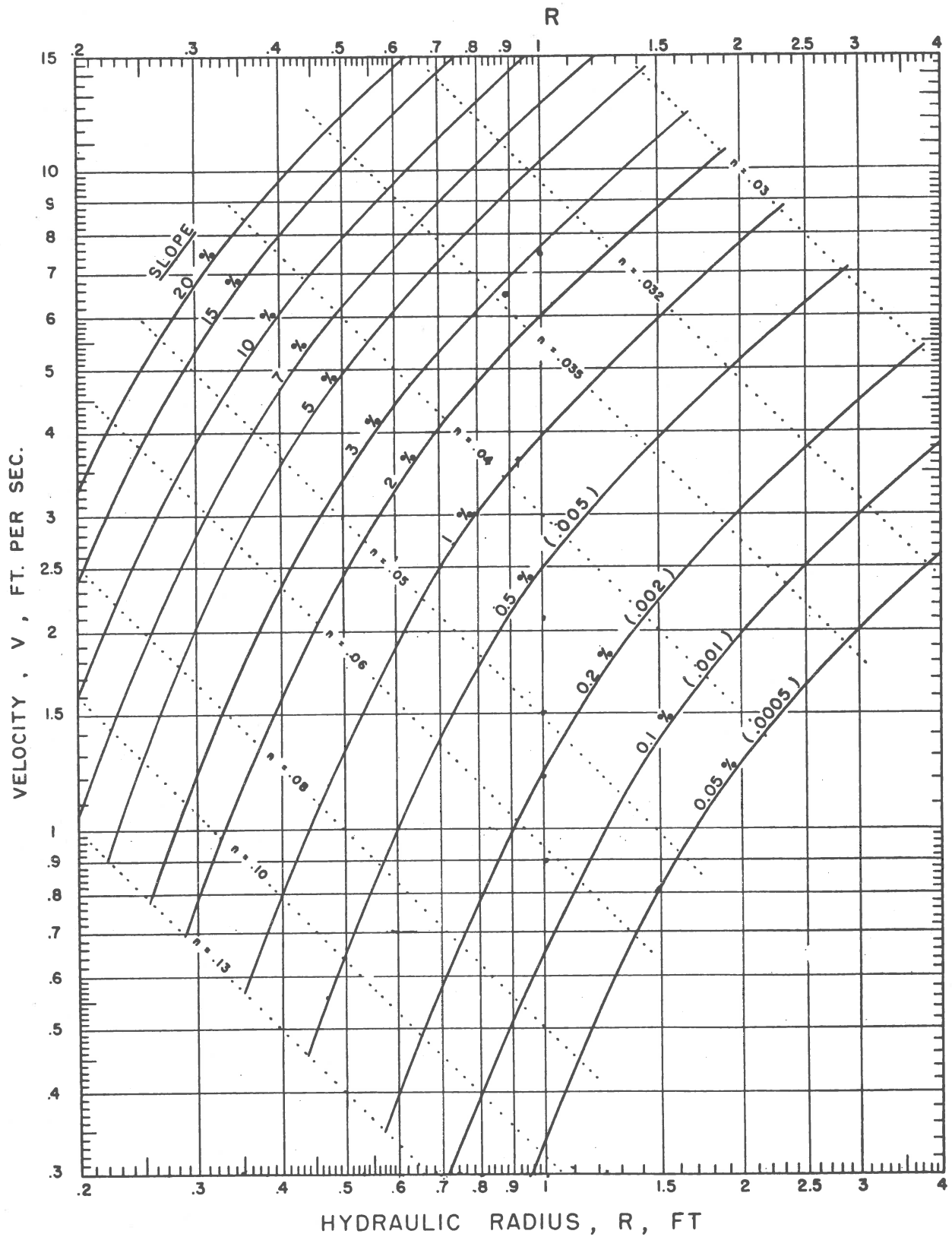


FIGURE A6-3

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE  $D$  (LOW VEGETAL RETARDANCE)



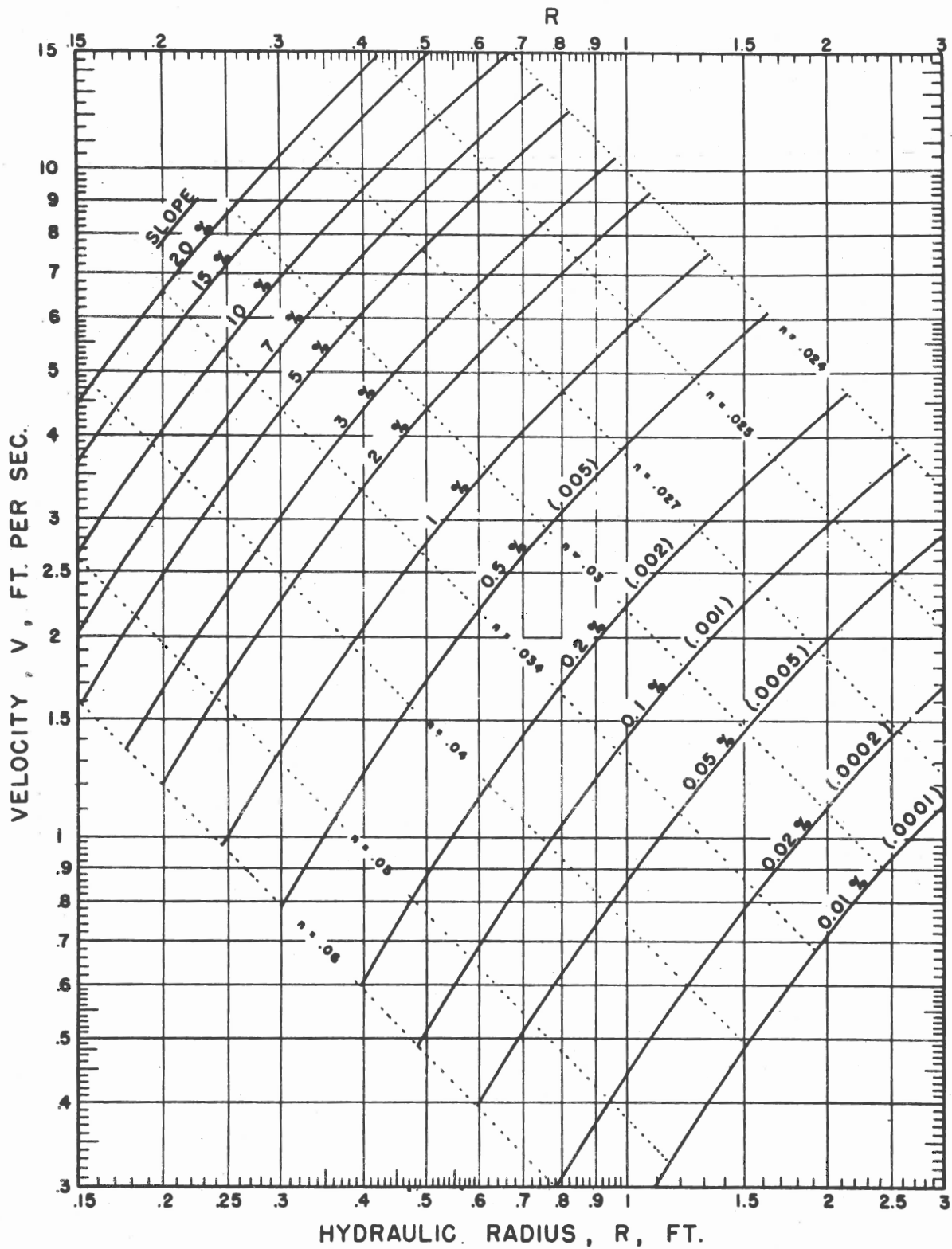


FIGURE A6-4

SOLUTION OF THE MANNING FORMULA FOR RETARDANCE E (VERY LOW VEGETAL RETARDANCE)

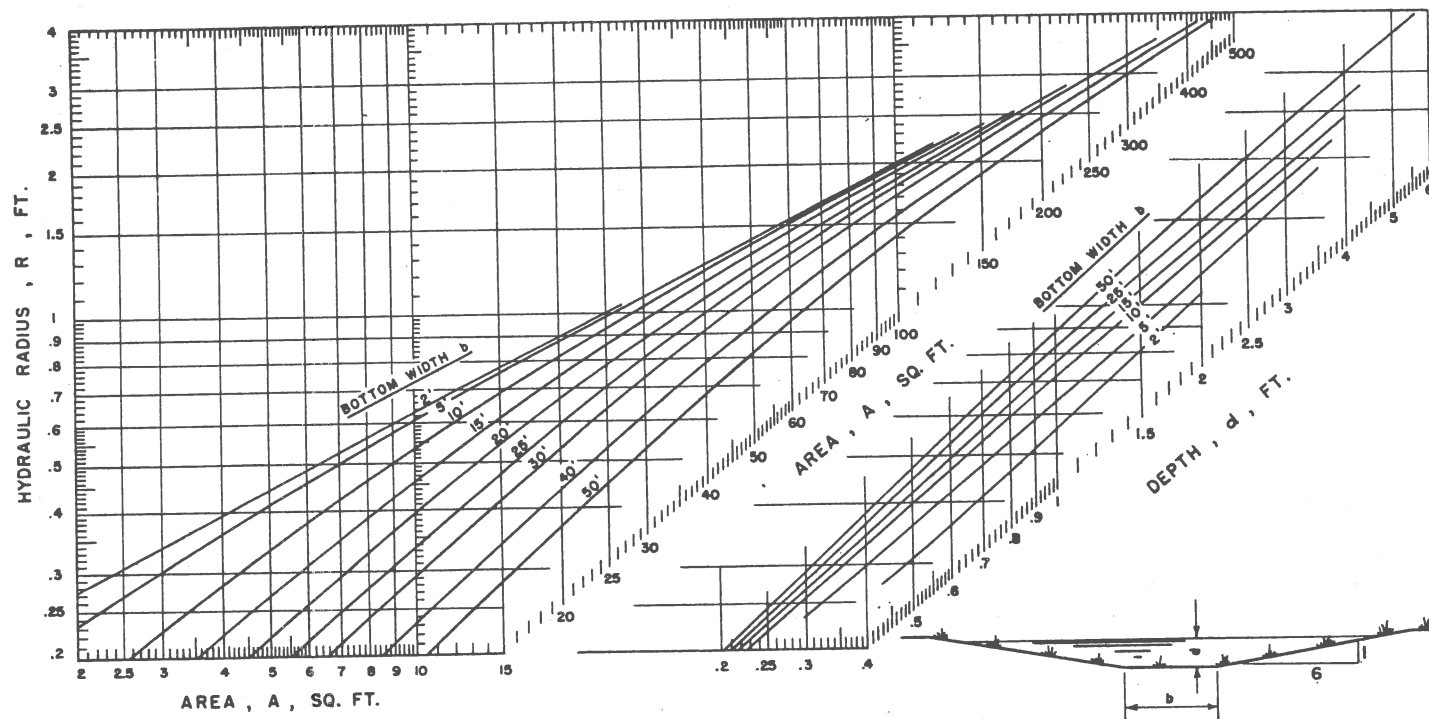


FIGURE A6-5

DIMENSIONS OF TRAPEZIODAL CHANNELS WITH 6 TO 1 SIDE SLOPES

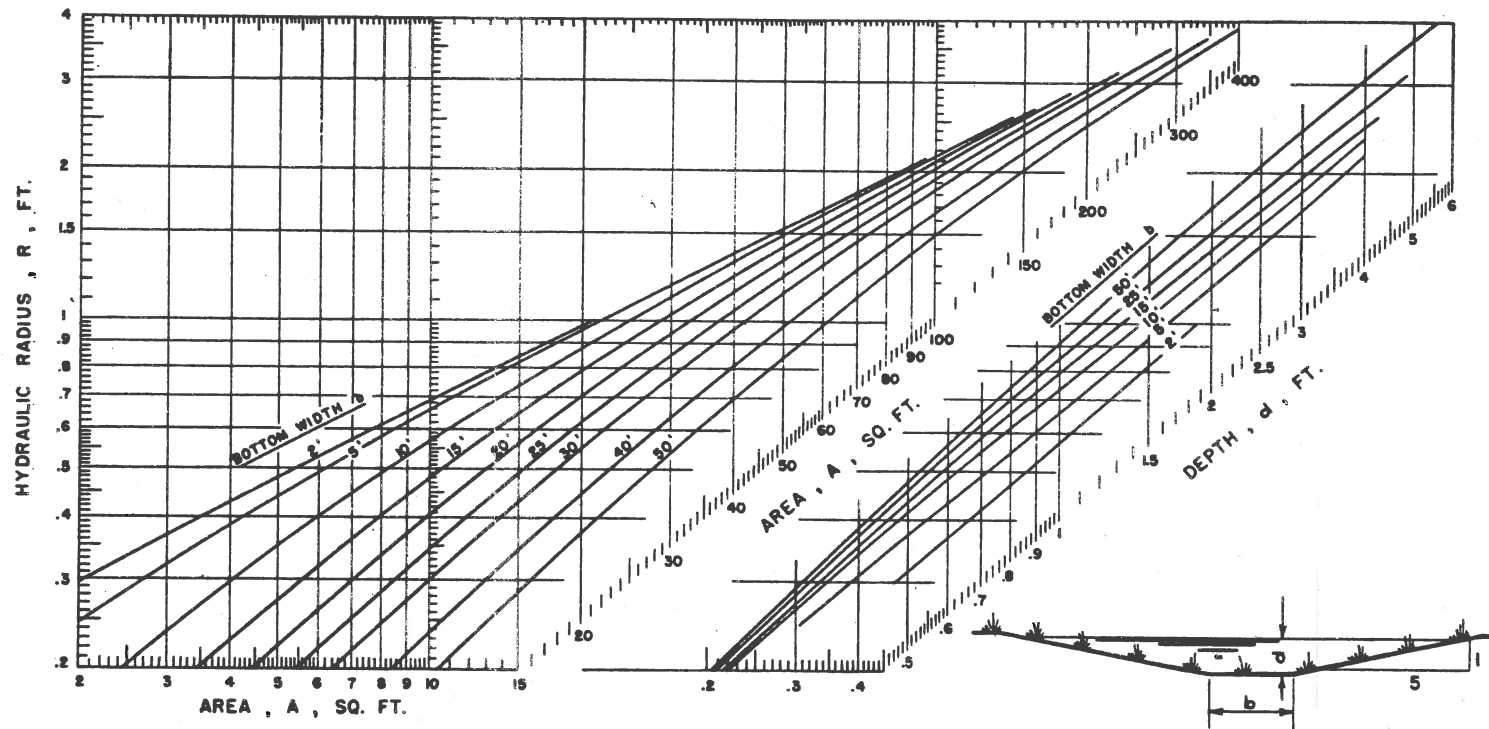


FIGURE A6-6

DIMENSIONS OF TRAPEZIODAL CHANNELS WITH 5 TO 1 SIDE SLOPES

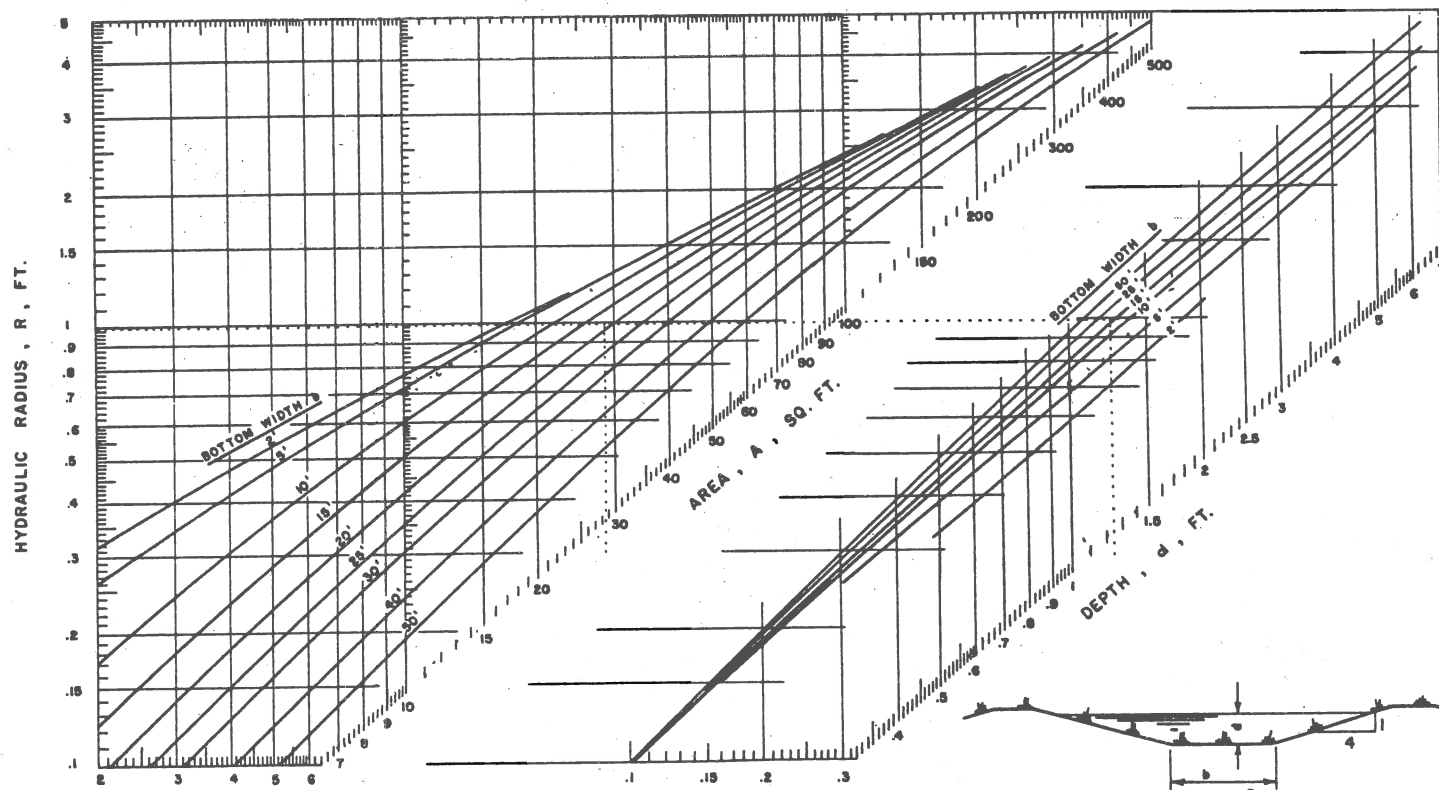


FIGURE A6-7

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 4 TO 1 SIDE SLOPES

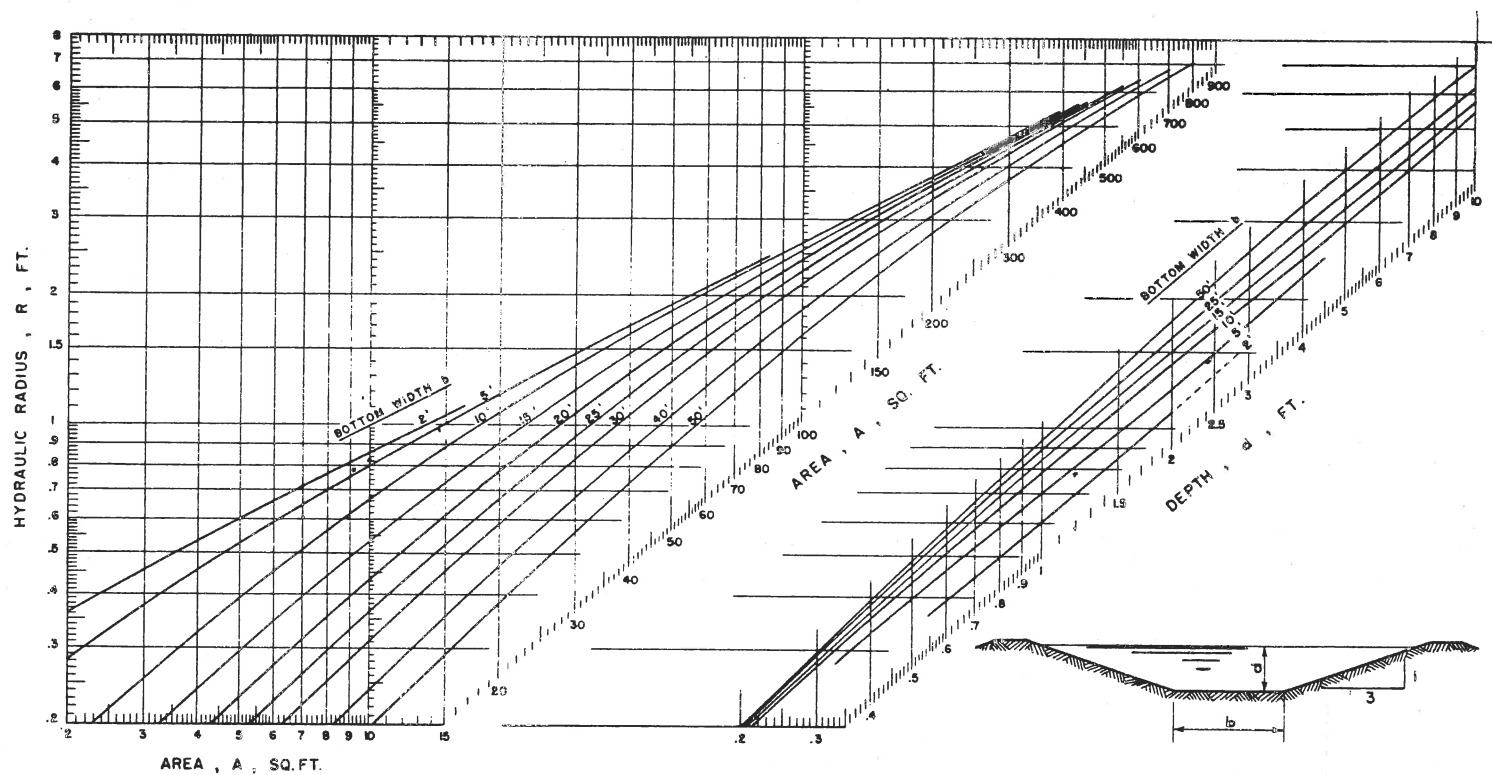


FIGURE A6-8

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 3 TO 1 SIDE SLOPES

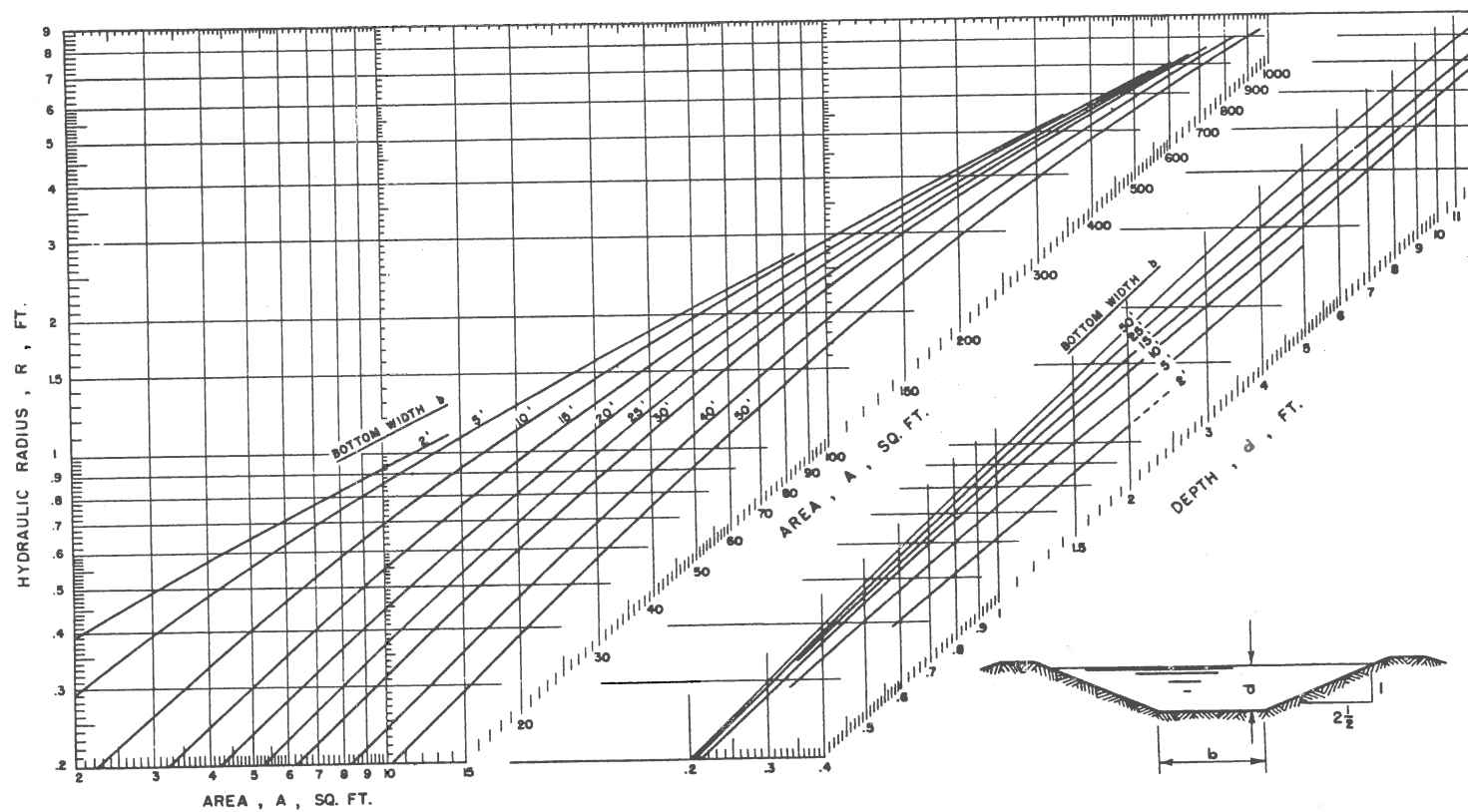


FIGURE A6-9

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 2-1/2 TO 1 SIDE SLOPES

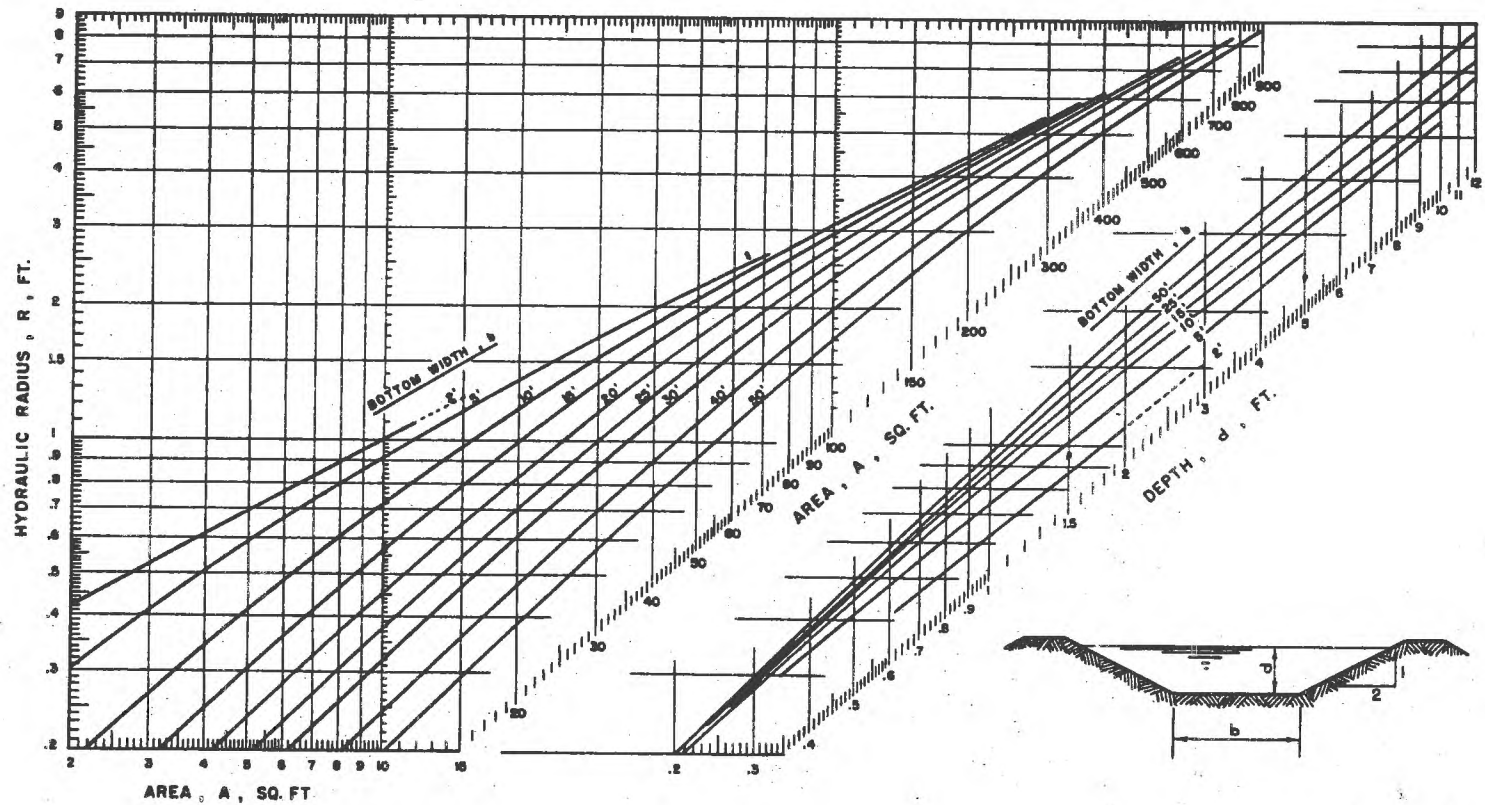


FIGURE A6-10

DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 2 TO 1 SIDE SLOPES

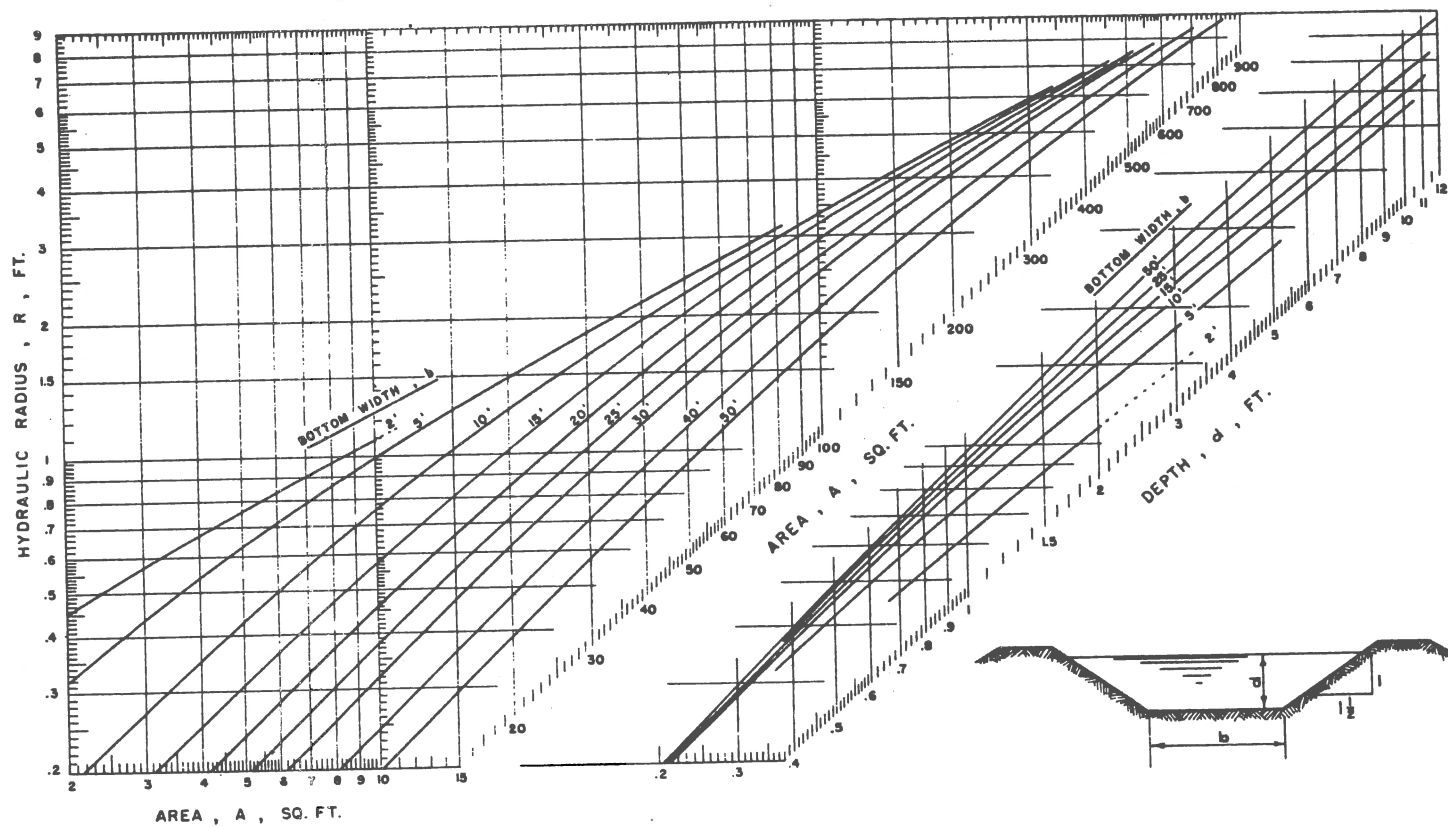
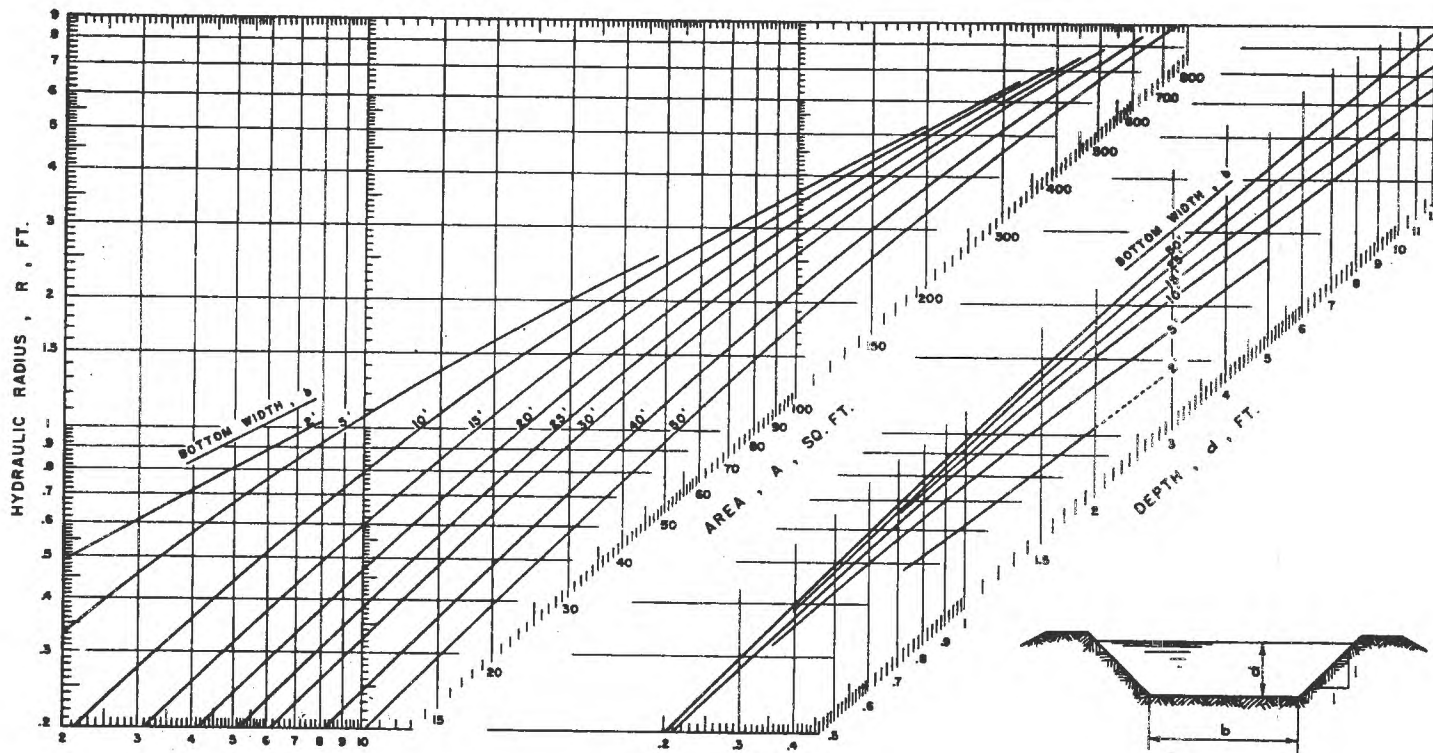


FIGURE A6-11  
DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 1-1/2 TO 1 SIDE SLOPES





**FIGURE A6-12**  
DIMENSIONS OF TRAPEZOIDAL CHANNELS WITH 1 TO 1 SIDE SLOPES

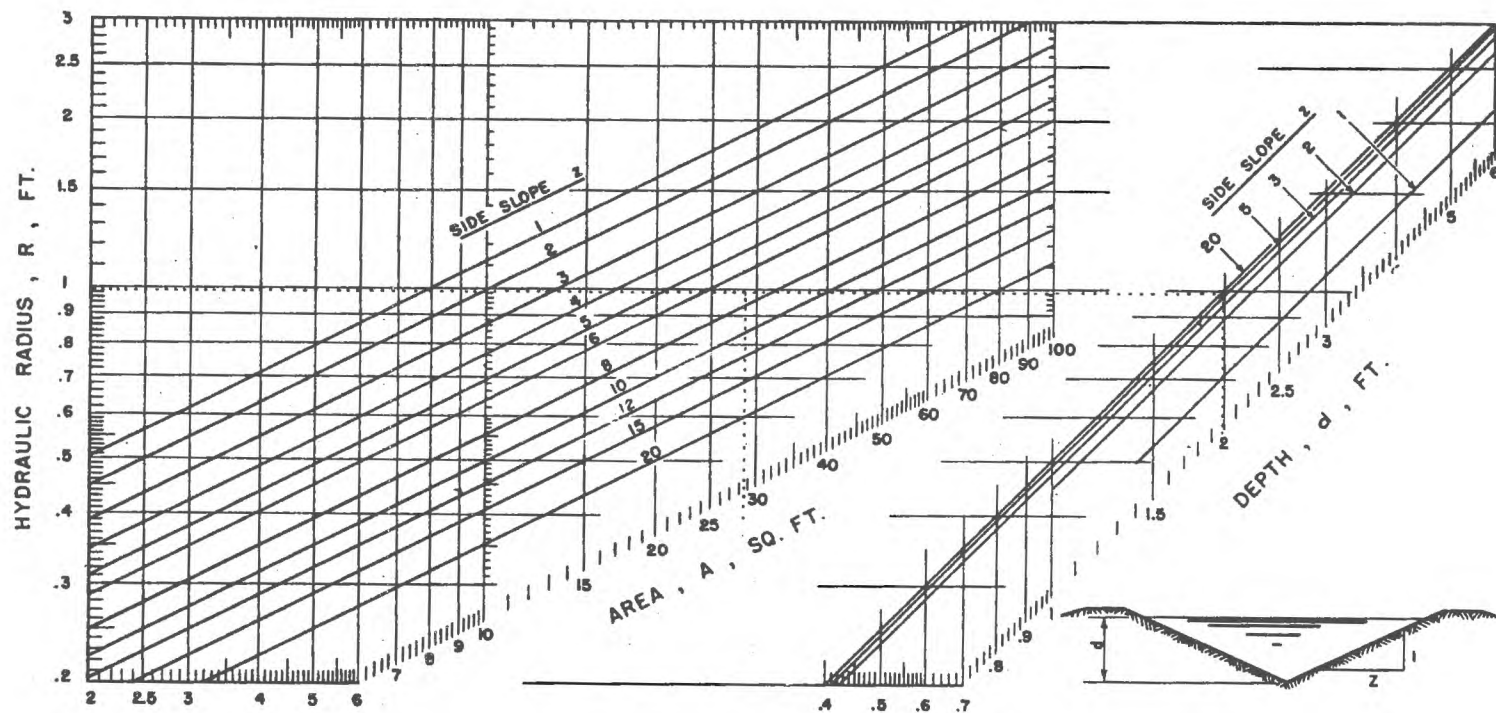
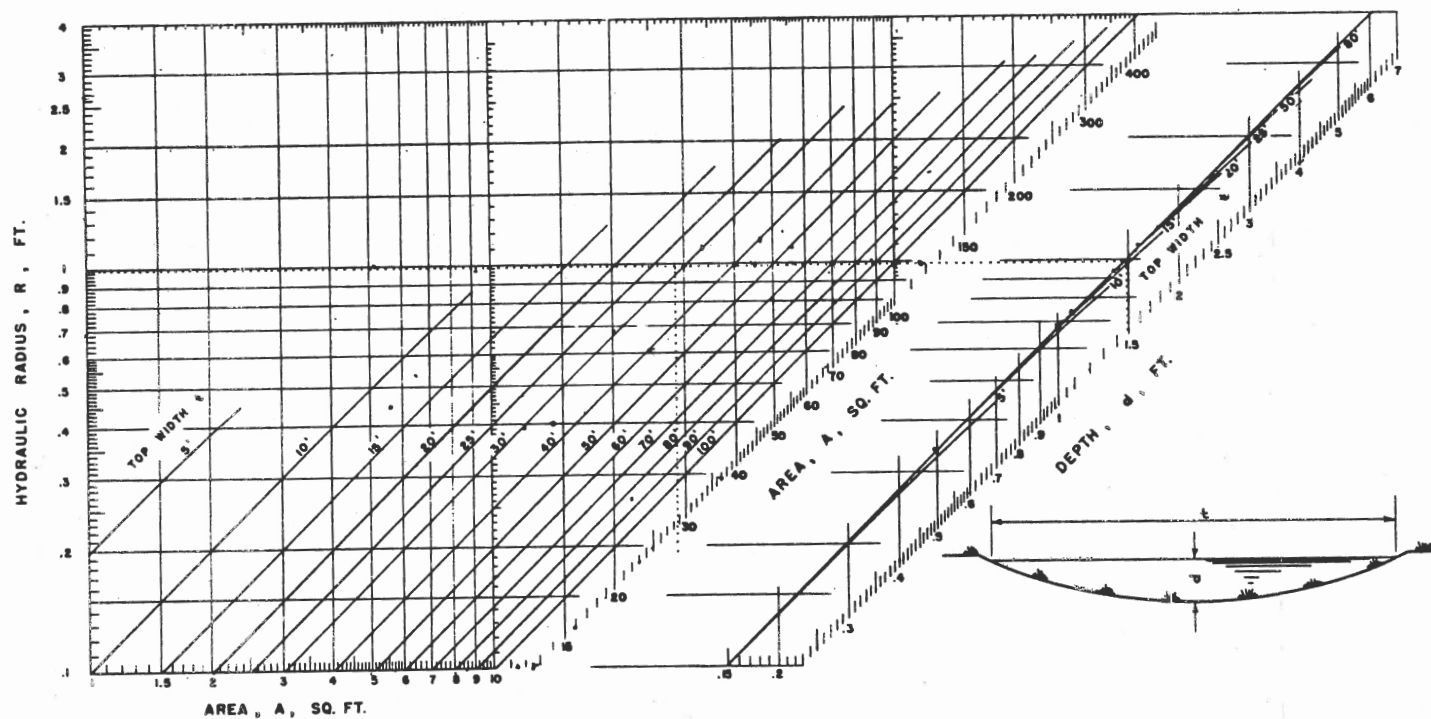
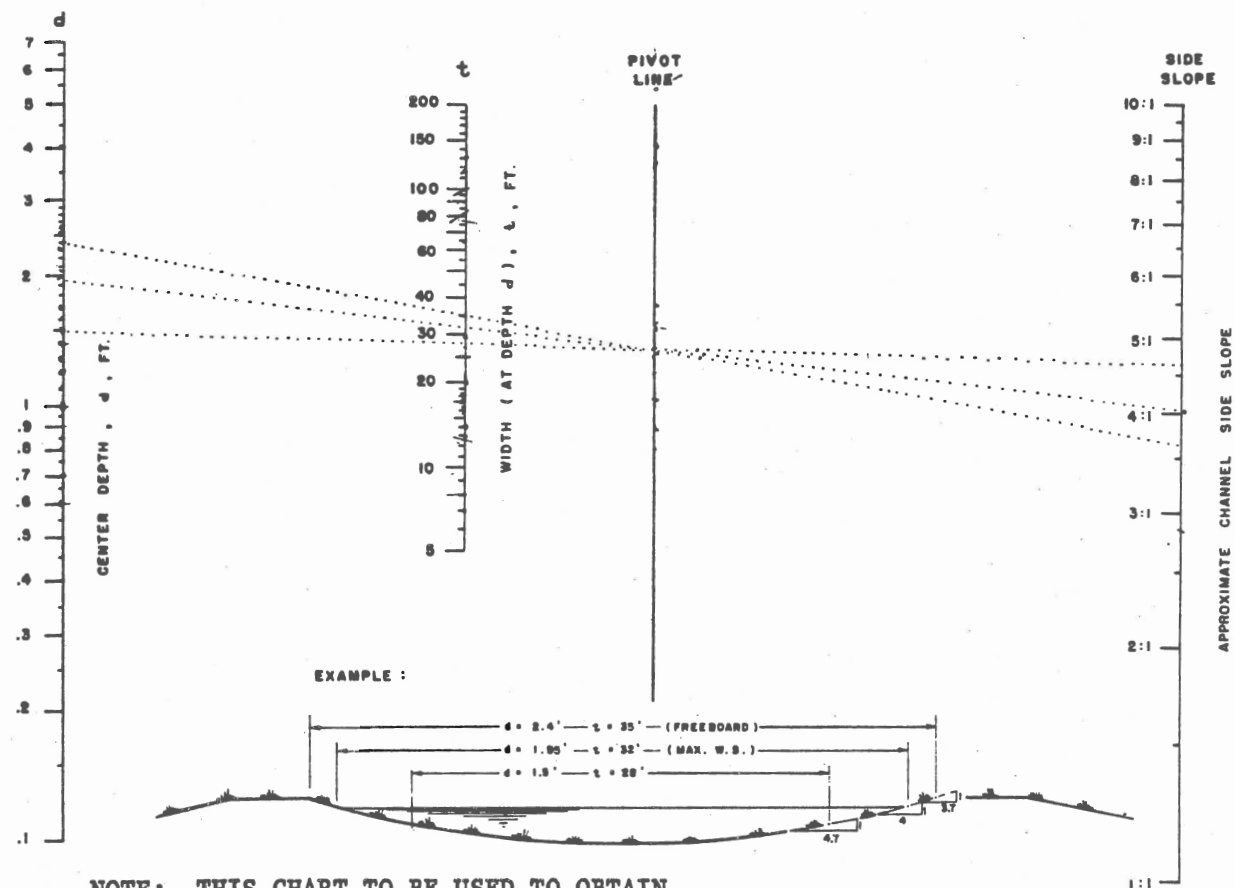


FIGURE A6-13  
DIMENSIONS OF TRIANGULAR CHANNELS



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**



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. 10 acres are to be cleared and developed into houses. 90 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;  $I = (25 \text{ in}) (1 \text{ ft}/12 \text{ in}) (100 \text{ ac})$   
 $I = 208.3 \text{ Ac ft}$

$$C = (208.3 \text{ ac. ft.}) (0.025)$$

$C = 5.21 \text{ ac. ft.} =$  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

1st year

Woods

$$(DA) (A) = 90 \text{ ac} \times 0.2 \text{ tons/ac/yr} = 18 \text{ tons/yr}$$

Construction Area

$$(DA) (A) = 10 \text{ ac} \times 60 \text{ tons} = 600 \text{ tons/yr}$$

$$(DA) (A) = 618 \text{ tons for the 1st year.}$$

2nd year

$$\text{Woods}(DA) (A) = 90 \text{ ac} \times 0.2 \text{ tons/ac/yr} = 18 \text{ tons/yr}$$

Urban Area

$$(DA) (A) = 10 \text{ ac} \times 1.0 \text{ tons/ac/yr} = 10 \text{ tons/yr}$$

$$(DA) (A) = (18 + 10) (1/2) = 14 \text{ tons for 2nd year}$$

for six month life.

$$(DA) (A) = 618 + 14 = 632 \text{ tons for the life of the basin.}$$

- b. Determine DR, delivery ratio

$$100/640 = 0.16 \text{ sq mi from Curve 4.4-2 for a sandy soil,}$$
$$\text{DR} = 24\%$$

- c. Determine  $\gamma$ , density of the sediment. From Table 4.4-1 the density of aerated sand is 85-100 lbs/ cu ft., Use  $\gamma = 90 \text{ lbs/cu ft.}$

- d. Determine minimum volume for sediment storage for the planned life of the structure.

$$V = (DA)(A)(DR)(TE) (1/\gamma) (2,000 \text{ lbs/ton})$$
$$(1/43,560 \text{ sq. ft./ac.})$$

$$V = (632)(0.24)(0.70)(1/90)(2,000)(1/43,560)$$

$$V = 0.054 \text{ Ac. ft.}$$

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 Hyrdology for Small Watersheds. The runoff curve number is 58. The runoff is 0.45 watershed inches from a 2 yr 24 hr 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" CMP riser with a 12" 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 yr 24 hr 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 cost 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 of 70% 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,  $I = 23\text{-}1/2$  inches for Morristown.  
 $I = (23\text{-}1/2 \text{ in}) (1 \text{ ft}/12 \text{ in}) (100 \text{ ac}) = 196 \text{ ac. ft.}$   
 $C = 23.5 \text{ ac. ft.} = \text{minimum volume for 70\% trap efficiency.}$
- 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 Curve 4.4-2 used the curve for silty clay with 0.16 sq. mi. drainage area, DR = 72%.
    - c. Determine,  $\gamma$ , density of sediment.  $\gamma = 80 \text{ lbs/cu ft}$ , 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 structure.  
 $V = (DA) (A) (DR) (TE) (1/\gamma) (2,000 \text{ lbs./ton})$   
 $(1/43,560 \text{ sq.ft./Ac.})$   
 $V = (618 + 14) (0.72) (0.70) (1/80) (2,000) (1/43,560)$   
 $V = 0.18 \text{ ac ft}$
  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 yr 24 hr 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" cmp riser with a 12" 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 yr 24 hr 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.
3. The minimum basin volume to meet the requirement for sediment storage capacity and temporary floodwater storage is 0.18 ac. ft. + 7.5 ac. ft. = 7.68 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

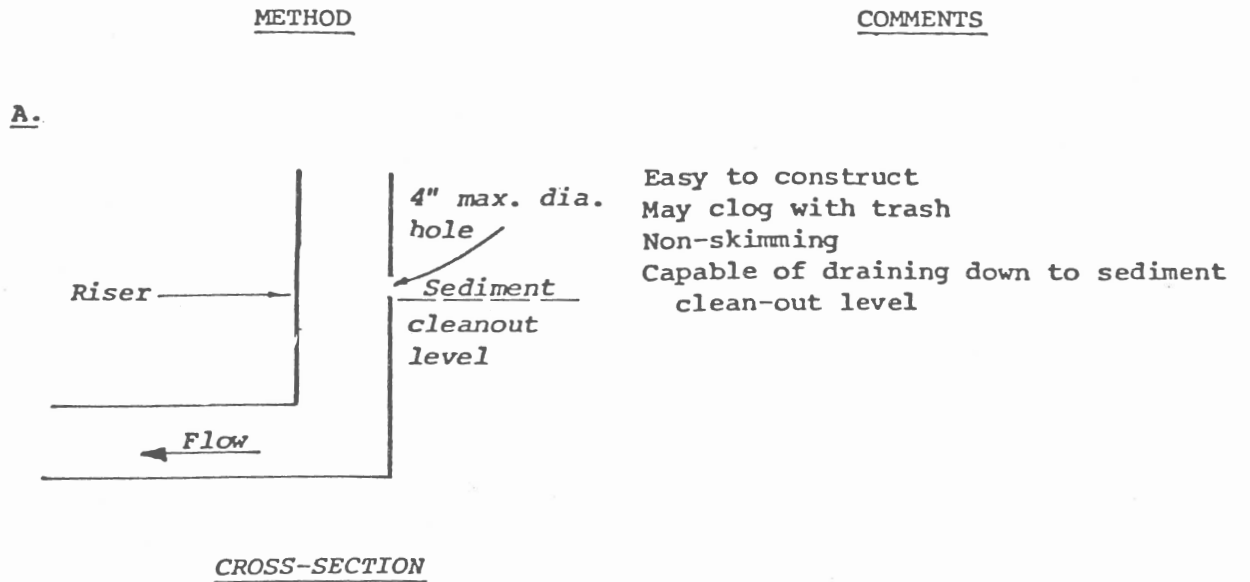
To have a reasonable size sediment basin that is effective, two factors are critical. The total drainage area must be small and the sediment must be coarse textured, or the basin becomes excessively large.

The effect of sediment size is shown by the difference in basin size from sample problem #1 to #2 when changing from a sand typical of South Jersey to a silt-clay typical of North Jersey the minimum basin volume goes from 5.21 ac. ft. to 23.5 ac. ft.

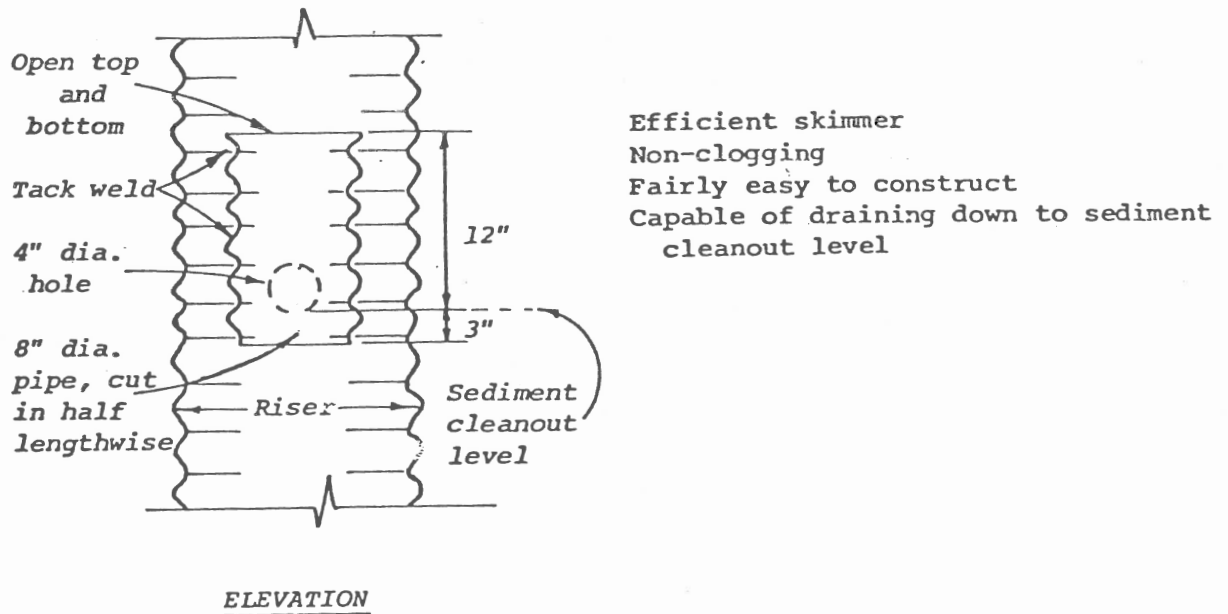
If the soils were silt and clay and the basin was located so the only drainage area was the 10 disturbed acres, the minimum basin volume would be 2.3 ac. ft. With sand sediments and a 10 ac. drainage area, the minimum basin volume would be 0.5 ac. ft.

## METHODS OF DEWATERING SEDIMENT BASINS

The dewatering methods shown here are inexpensive and operate automatically.



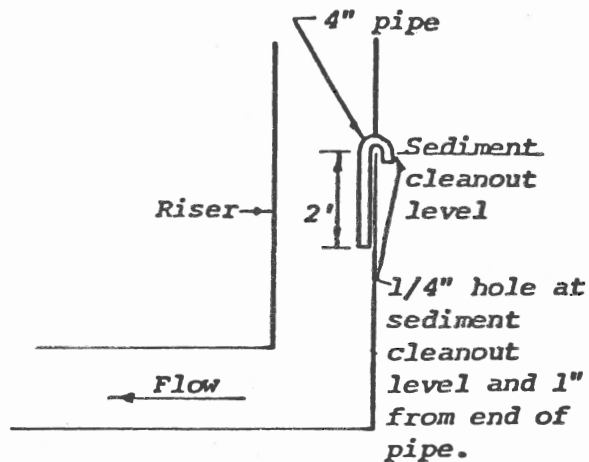
B. Same as "A" except for skimming device, detailed below:



METHOD

COMMENTS

C.

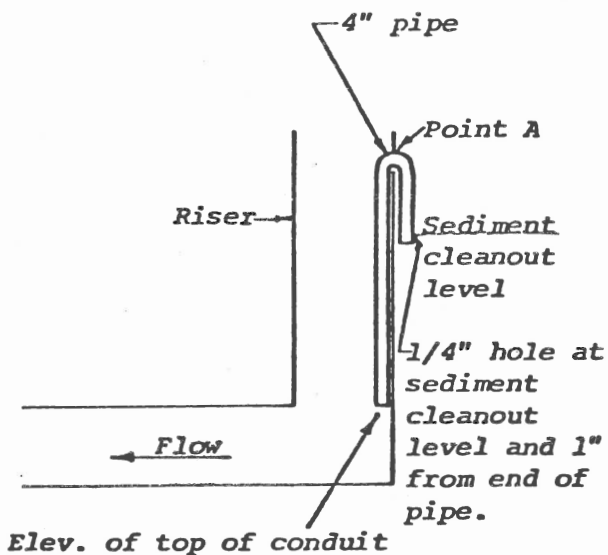


CROSS-SECTION

Efficient skimmer  
Capable of always draining down to sediment cleanout level and below

Higher discharge rate than "A" or "B".

D.

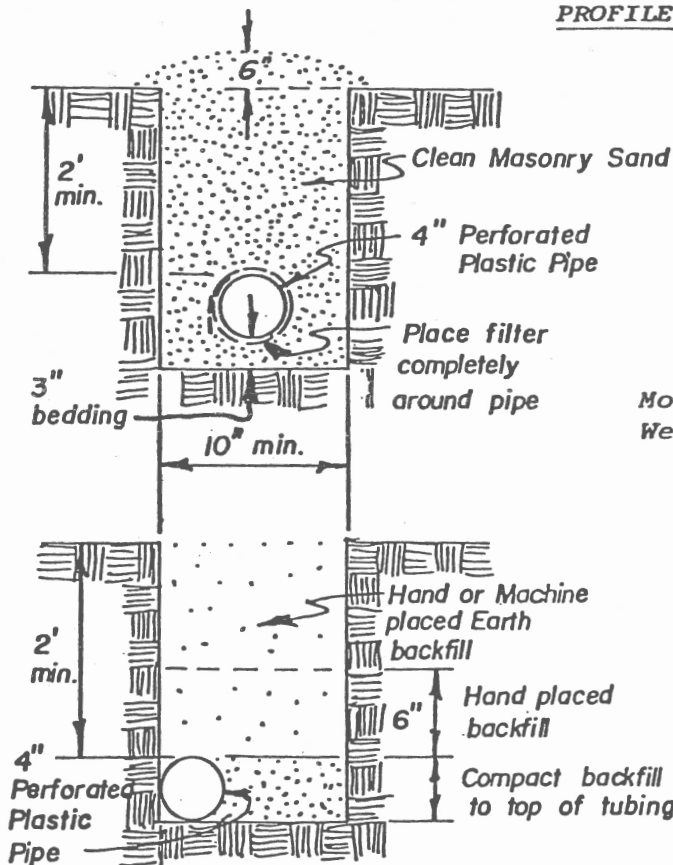
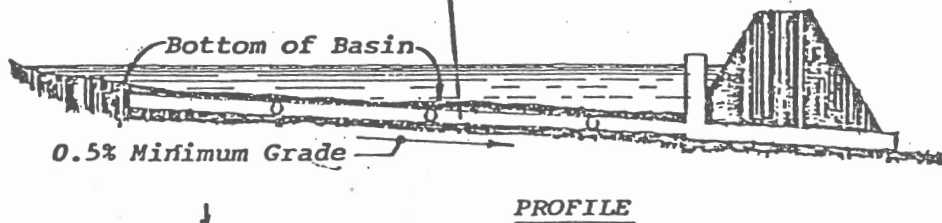
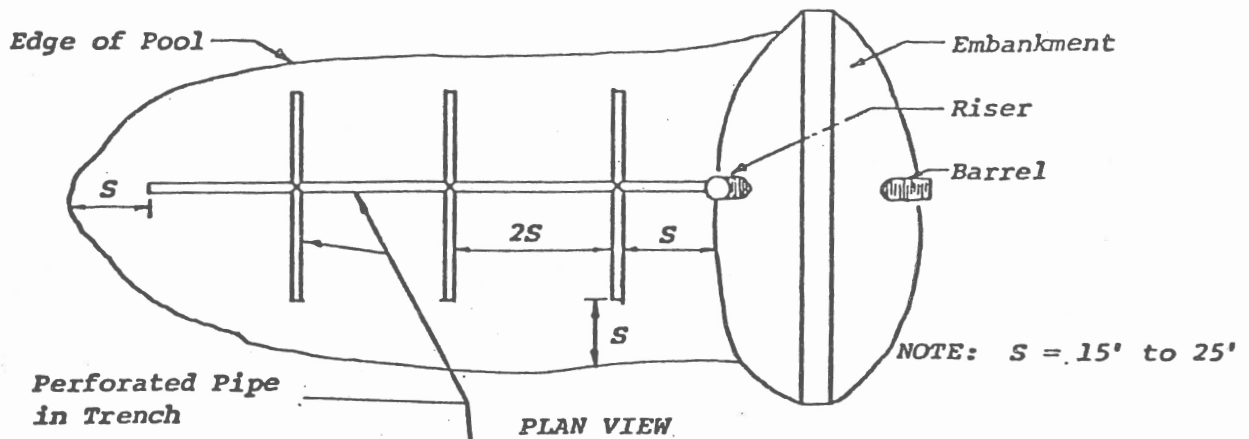


CROSS-SECTION

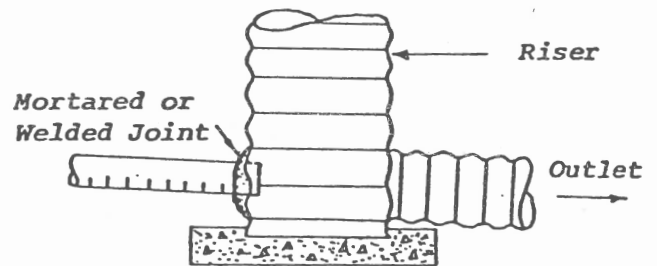
Efficient skimmer  
Water must inundate point A to prime siphon. Therefore, small storms will not prime siphon and drain pool down to sediment cleanout level.

Higher discharge rate than "C"

# DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN



CROSS SECTIONS  
DRAIN PIPE IN TRENCH



RISER CONNECTION

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.



APPENDIX A8  
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, see page A8.24.

Allowable Velocity Approach

General

This method of testing the erosion resistance of earth channels is based on data collected by several investigators.

Figure A8-1 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.

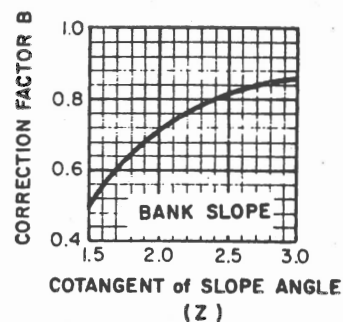
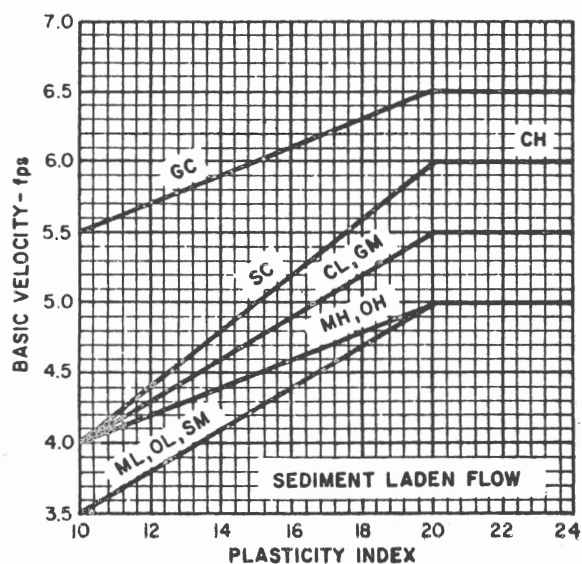
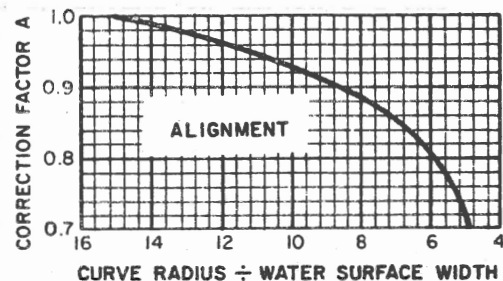
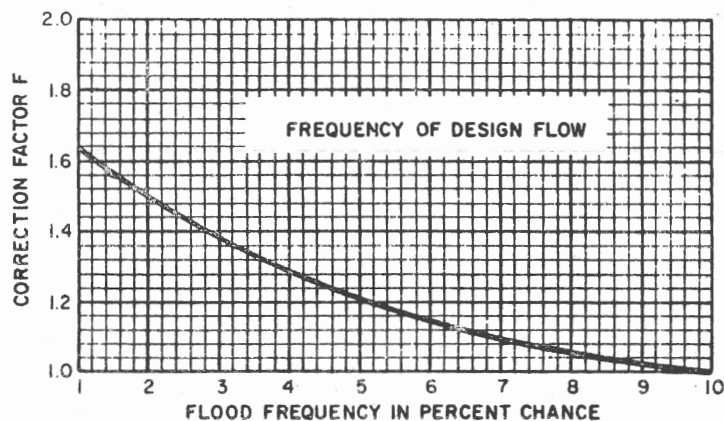
Stability is influenced by the concentration of fine material carried by the flow in suspension. There are two distinct types of flow depending on concentration of material in suspension.

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.

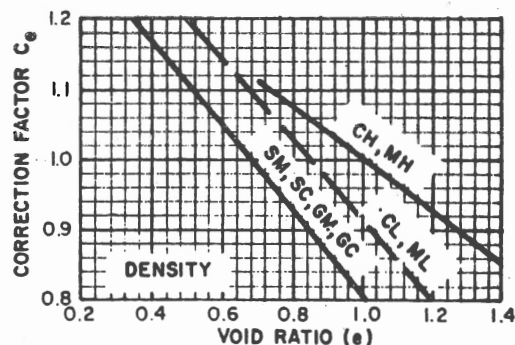
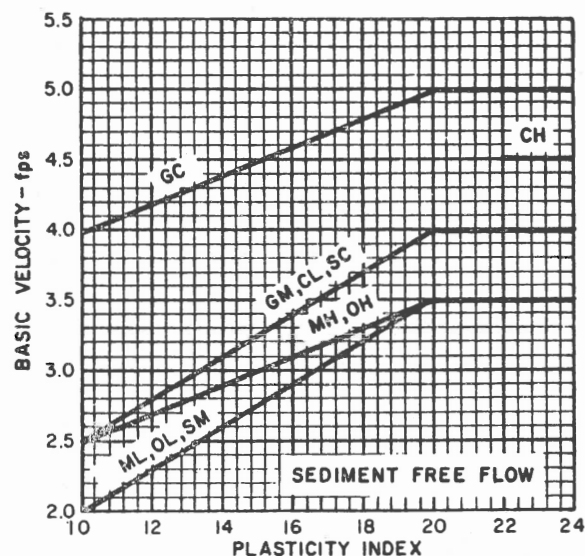
Sediment transport rates are usually expressed in tons per day. To convert them into concentration use the equation:

$$C = 370 \frac{Q_s}{Q} \quad (\text{Eq. A8-1})$$

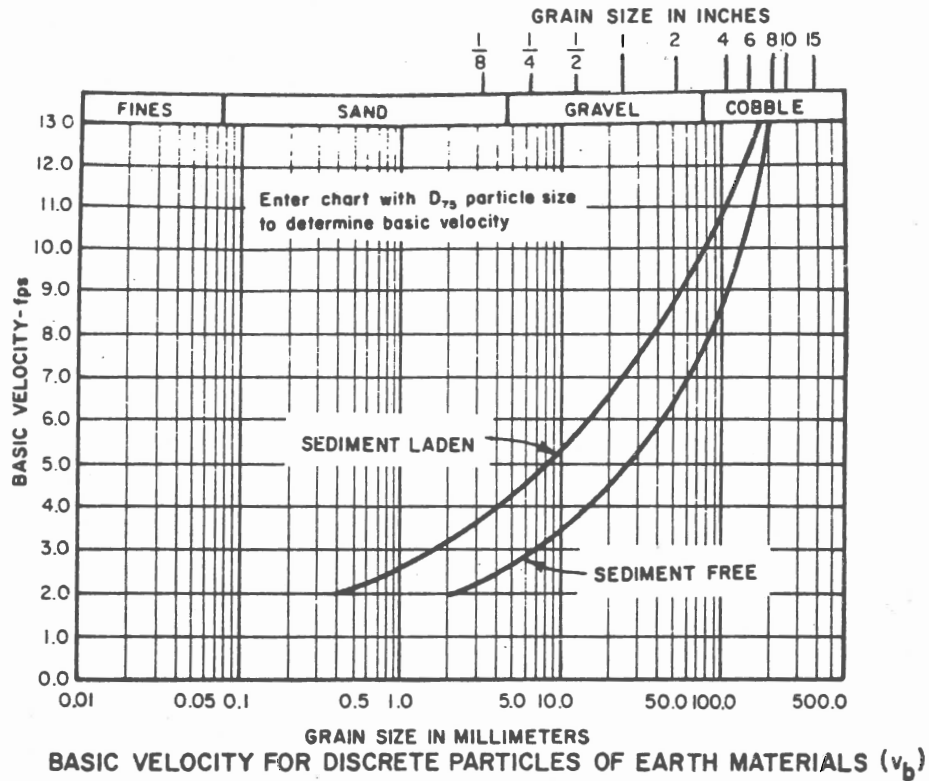
Depending on the type of soil, the effect of concentration of fine sediment (material smaller than 0.074 mm) in suspension on the allowable velocity is obtained from the curves on Figure A8-1.



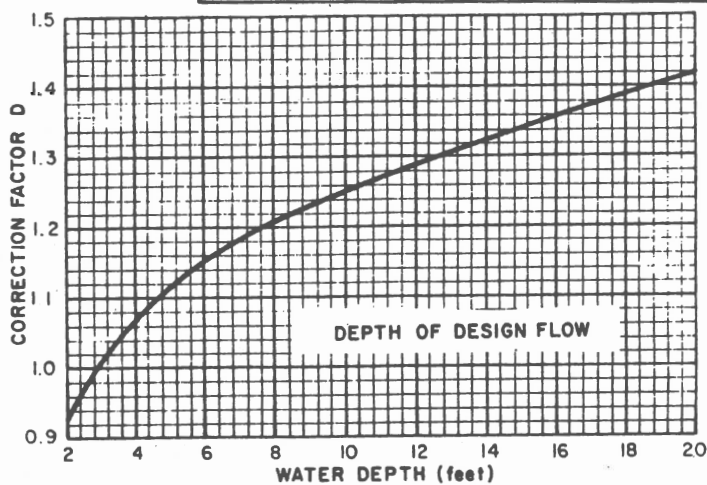
**BASIC VELOCITIES FOR COHERENT EARTH MATERIALS ( $v_b$ )**



**BASIC VELOCITIES FOR COHERENT EARTH MATERIALS ( $v_b$ )**



| ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS |                                                                    |
|-----------------------------------------------------|--------------------------------------------------------------------|
| CHANNEL BOUNDARY MATERIALS                          | ALLOWABLE VELOCITY                                                 |
| DISCRETE PARTICLES                                  |                                                                    |
| Sediment Laden Flow                                 |                                                                    |
| $D_{75} > 0.4 \text{ mm}$                           | Basic velocity chart value $\times D \times A \times B$            |
| $D_{75} < 0.4 \text{ mm}$                           | 2.0 fps                                                            |
| Sediment Free Flow                                  |                                                                    |
| $D_{75} > 2.0 \text{ mm}$                           | Basic velocity chart value $\times D \times A \times B$            |
| $D_{75} < 2.0 \text{ mm}$                           | 2.0 fps                                                            |
| COHERENT EARTH MATERIALS                            |                                                                    |
| $PI > 10$                                           | Basic velocity chart value $\times D \times A \times F \times C_e$ |
| $PI < 10$                                           | 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**



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 curve 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,  $C_e$ , 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 A8-1 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 a 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 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 1.0mm 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.

$$V_b = 6.7 \text{ fps.}$$

$$\text{Depth correction factor, } D = 1.22 \text{ (from Figure A8-1).}$$

$$\text{Bank slope correction, } B = 0.72 \text{ (from Figure A8-1).}$$

$$\text{Alignment correction } A,$$

$$\frac{\text{curve radius}}{\text{water surface width}} = \frac{600}{74.8} = 8.02$$

$$A = 0.89 \text{ (from Figure A8-1).}$$

$$\text{Density correction, } C_e, \text{ does not apply.}$$

$$\text{Frequency correction, } F, \text{ does not apply.}$$

$$V_a \text{ (straight reaches)} = V_b DB = (6.7)(1.22)(0.72) = 5.88 \text{ fps}$$

$$V_a \text{ (curved reaches)} = V_b DBA = (6.7)(1.22)(0.72)(0.89) = 5.24 \text{ fps}$$

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

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. The channel is to be excavated into a silty clay (CL) soil with a Plasticity Index of 18, a dry density of 92 pcf, 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.

$$V_b = 3.7 \text{ fps (from Figure A8-1)}$$

for the 2 percent chance flood.

Depth correction,  $D = 1.22$  (from Figure A8-1).

Density correction, compute  $e$ ;

$$e = G \frac{\gamma_w}{\gamma_d} - 1 = \frac{(2.71)(62.4)}{92} - 1 = 0.83$$

$$C_e = 1.0 \text{ (from Figure A8-1).}$$

Frequency correction,  $F = 1.5$  (from Figure A8-1).

Alignment correction  $A$ ,

$$\frac{\text{Curve radius}}{\text{water surface width}} = \frac{600}{74.8} = 8.02$$

$$A = 0.89 \text{ (from Figure A8-1).}$$

$$V_a \text{ (Straight reach)} = V_b D C_e F = (3.7)(1.22)(1.0)(1.5) = 6.77 \text{ fps.}$$

$$V_a \text{ (Curved reach)} = V_b D C_e F A = (3.7)(1.22)(1.0)(1.5)(0.89) = 6.03 \text{ fps.}$$

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.

$$V_a \text{ (Straight reaches)} = V_b D C_e = (3.7)(1.19)(1.0) = 4.40 \text{ fps.}$$

$$V_a \text{ (Curved reaches)} = V_b D C_e A = (3.7)(1.19)(1.0)(0.90) = 3.96 \text{ fps.}$$

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<sub>75</sub> 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<sub>75</sub> - 1/4 inch.

### Coarse-grained Discrete Particle Soils - D<sub>75</sub> > 1/4 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<sub>75</sub>, size between 0.25" (6.35 mm) and 5.0" (127mm) the value of Manning's coefficient n resulting from the roughness of the soil particles is determined by:

$$n_t = \frac{D_{75}^{1/6}}{39} \quad \text{with } D_{75} \text{ expressed in inches (Eq. A8-2)}$$

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  $s_t$ , the friction gradient associated with the particular boundary material being considered.

$$s_t = \left( \frac{n_t}{n} \right)^2 s_e \quad (\text{Eq. A8-3})$$

The tractive stress acting on the soil grains in an infinitely wide channel is found by:

$$\tau_\infty = \gamma_w d s_t \quad (\text{Eq. A8-4})$$

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 corners 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.

Figure 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,  $\tau_{Lb}$ , composed of soil particles with discrete, single grain behavior with a given  $D_{75}$  is:

$$\tau_{Lb} = 0.4 D_{75}$$

$$\text{When } 0.25 \text{ in.} < D_{75} < 5.0 \text{ in.} \quad (\text{Eq. A8-5})$$

The allowable tractive stress for channel sides,  $\tau_{Ls}$  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  $\phi_R$  with the horizontal is

$$\tau_{Ls} = 0.4 K D_{75} \quad . . . . 0.25 \text{ in.} < D_{75} < 5.0 \text{ in.} \quad (\text{Eq. A8-6})$$

$$\text{Where:} \quad K = \sqrt{\frac{z^2 - \cot^2 \phi_R}{1 + z^2}} \quad . . . \quad (\text{Eq. A8-7})$$

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  $\gamma_s$  of the constituents of the material having a grain size larger than the  $D_{75}$  size is significantly different than  $160 \text{ lb/ft}^3$ , the limiting tractive stress  $\tau_{Lb}$  and  $\tau_{Ls}$  as given by Equations (A8-5) and (A8-6) should be multiplied by the factor.

$$T = \frac{\gamma_s - \gamma_w}{97.6} \quad (\text{Eq. A8-8})$$

### Fine Grained Soils - $D_{75} < 1/4$ inch

#### A. Determination of Actual Tractive Stress

##### 1. Reference tractive stress -

The expression for reference tractive stress is:

$$\tau = \gamma_w R_t s_e \quad (\text{Eq. A8-9})$$

REFERENCE:  
Bureau of Reclamation "Progress Report  
on Results of Studies on Design of Stable  
Channels" Hyd-352

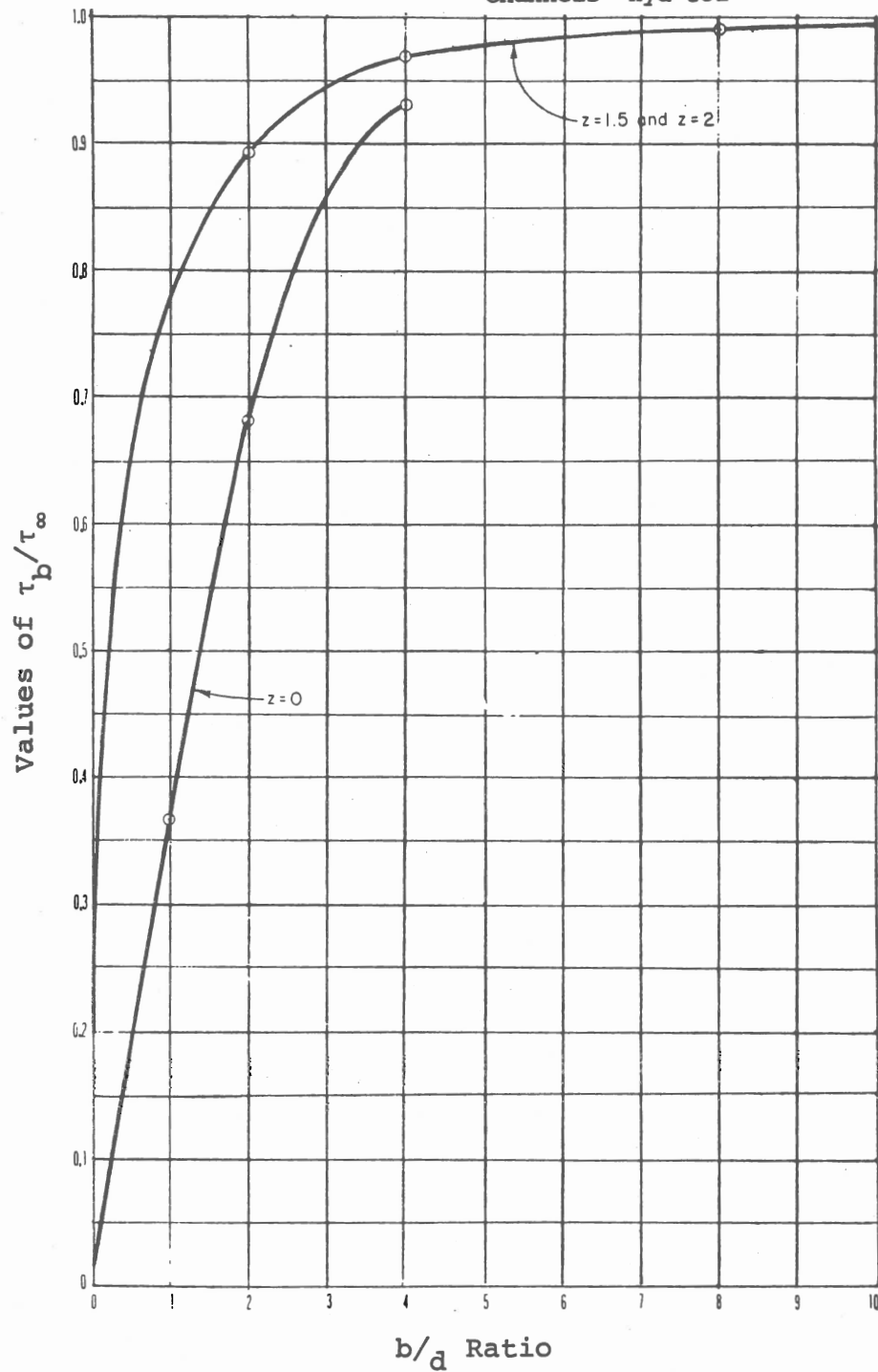


FIGURE A8-2

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS,  $\tau_b$ , ON BED OF  
STRAIGHT TRAPEZOIDAL CHANNELS

REFERENCE

Bureau of Reclamation "Progress Report  
of Results of Studies on Design of  
Stable Channels" Hyd-352

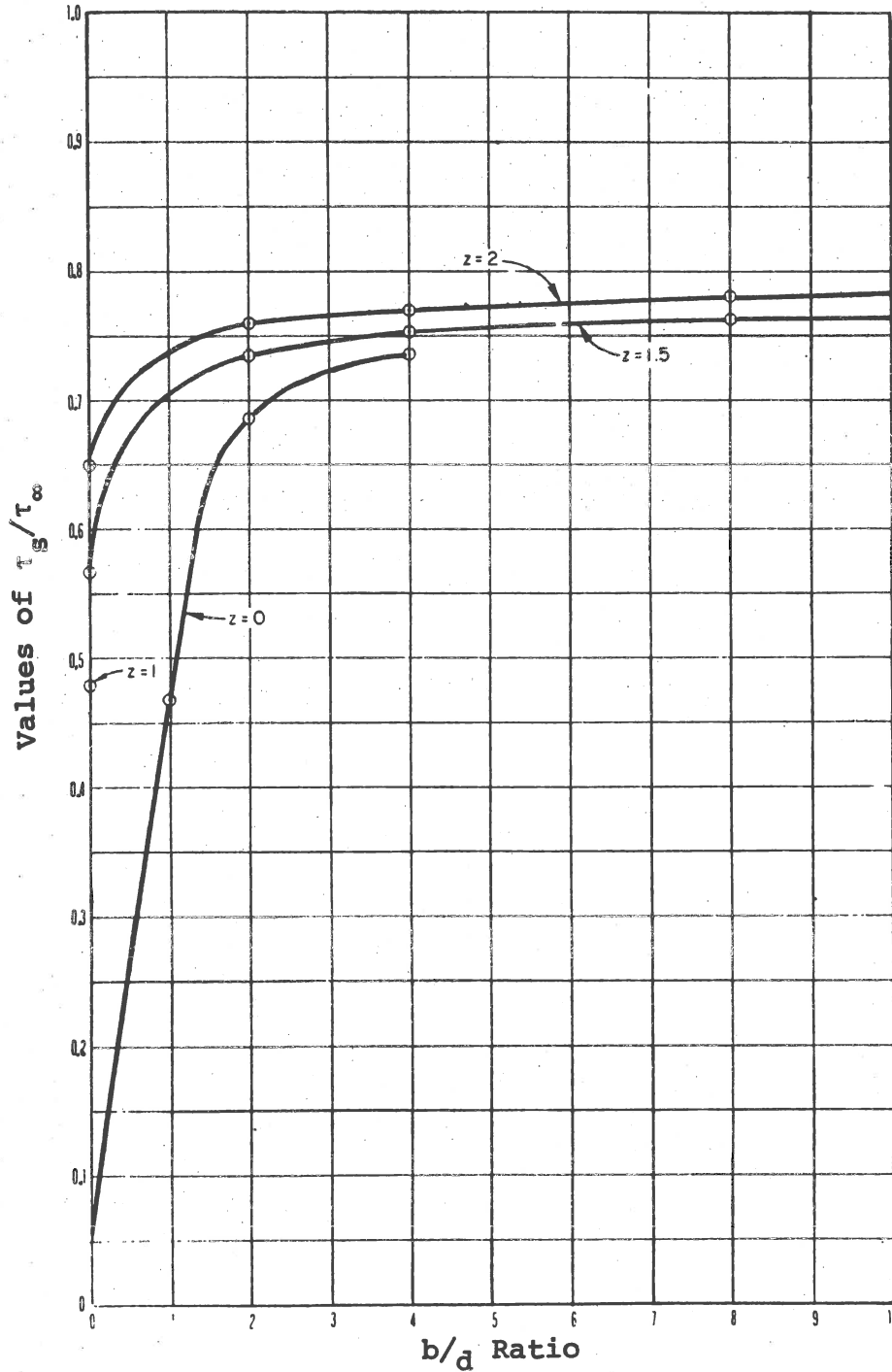


FIGURE A8-3

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS,  $\tau_s$ , ON SIDES  
OF STRAIGHT TRAPEZOIDAL CHANNELS

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

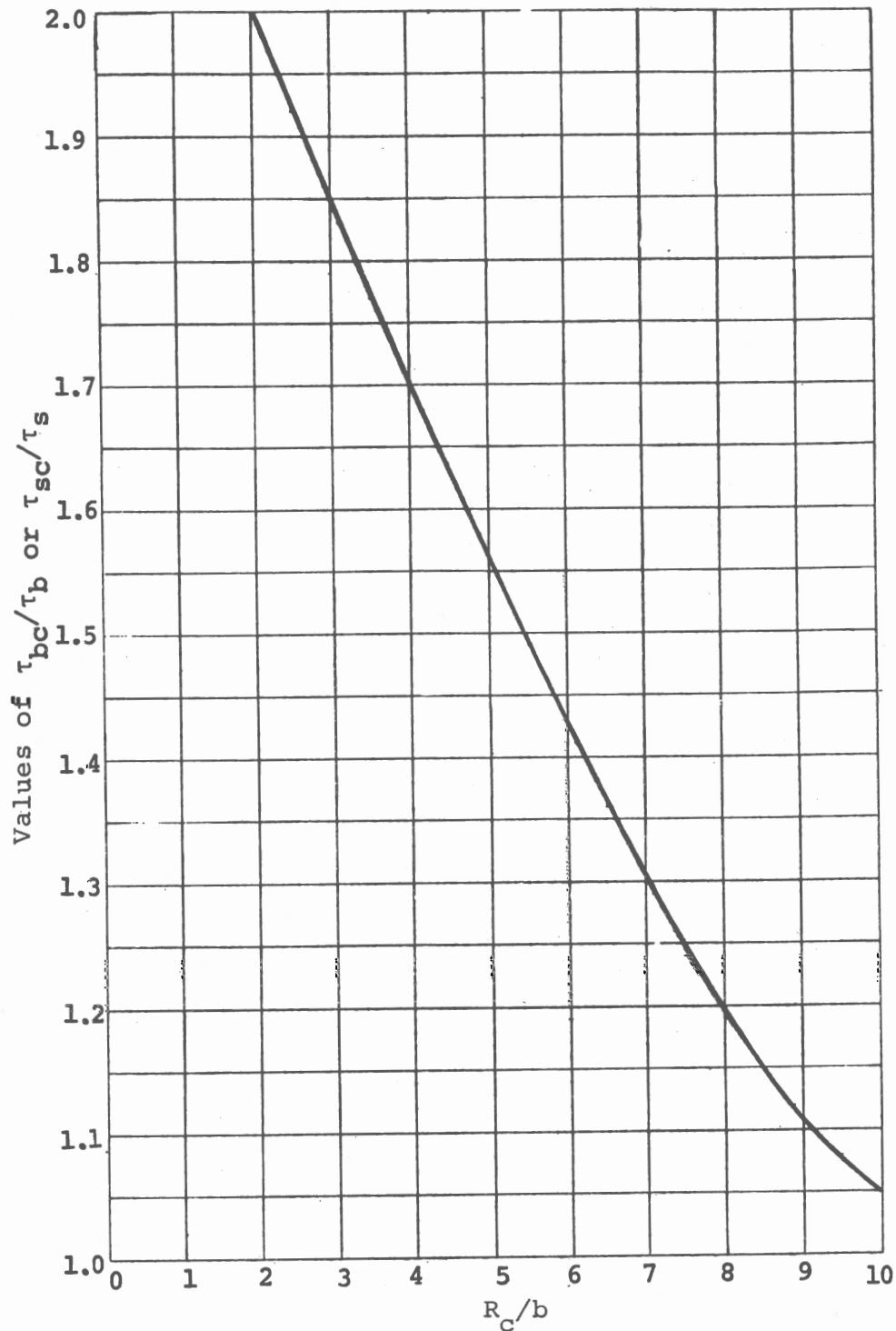


FIGURE A8-4

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESS,  $\tau_{bc}$  AND  $\tau_{sc}$ ,  
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

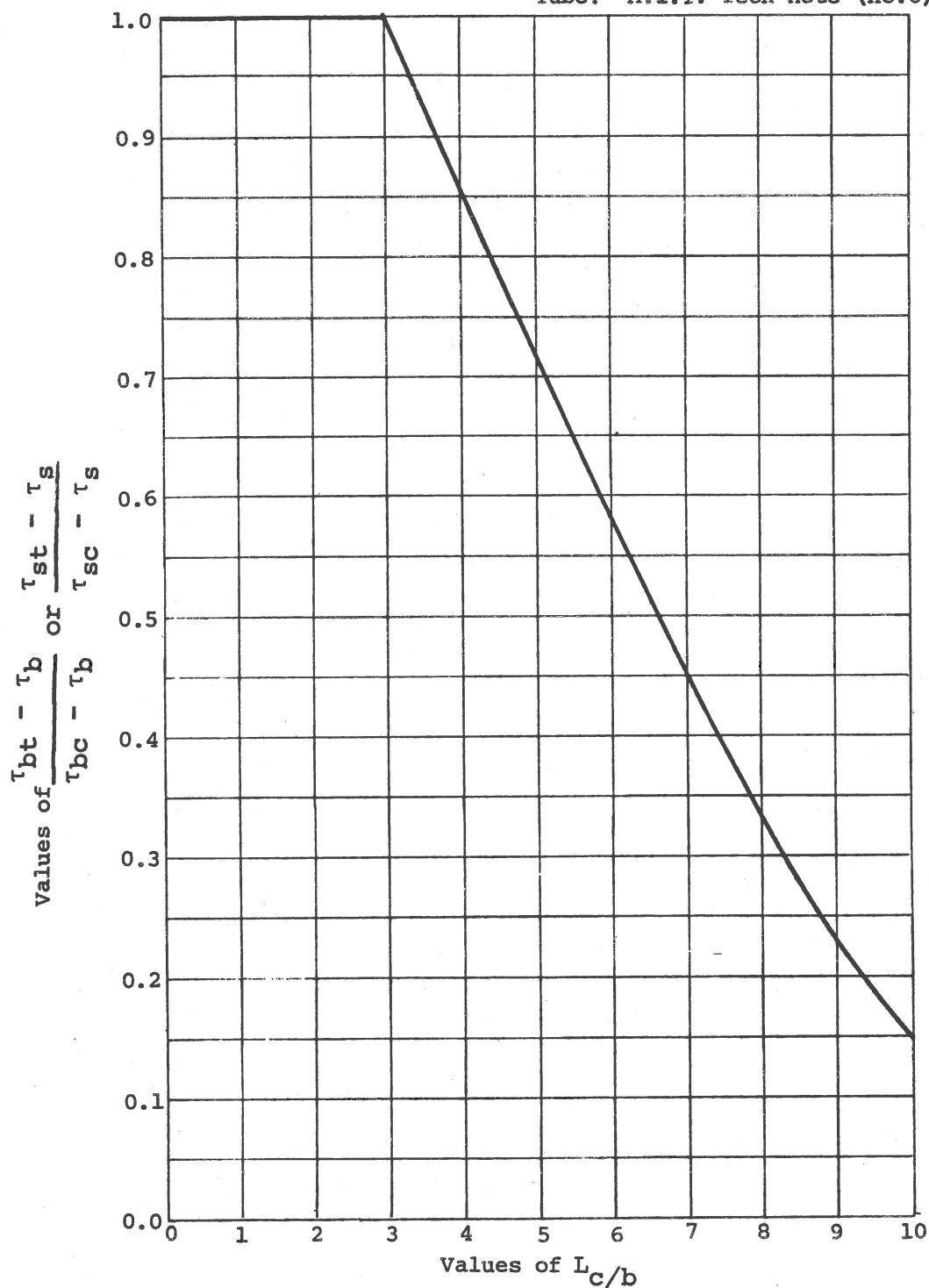


FIGURE A8-5

CHANNEL STABILITY; ACTUAL MAXIMUM TRACTIVE STRESSES  $\tau_{bt}$  AND  $\tau_{st}$ ,  
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

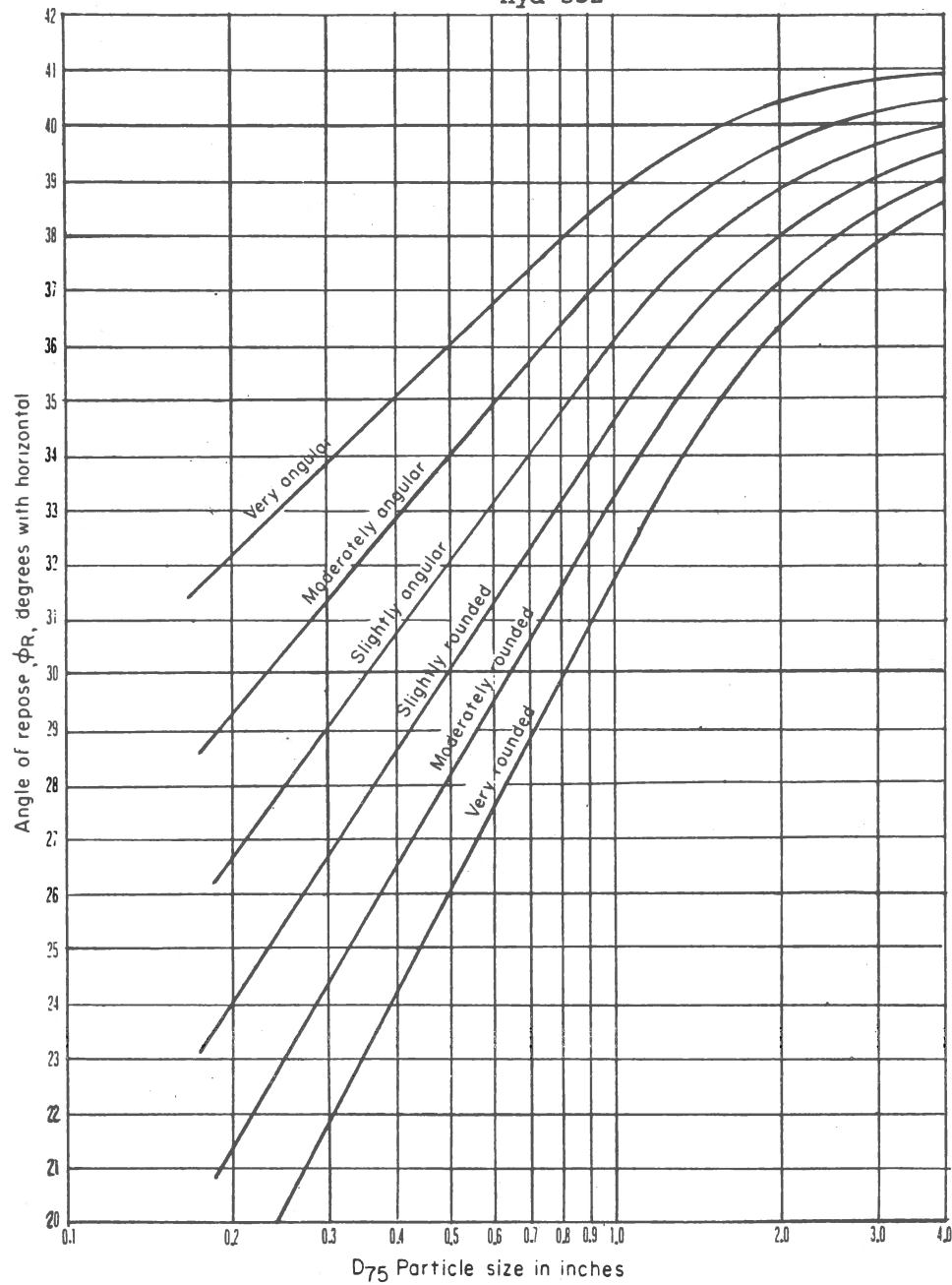


FIGURE A8-6

CHANNEL STABILITY; ANGLE OF RESPOSE,  $\phi_R$ , FOR NON-COHESIVE MATERIALS

REFERENCE:

Bureau of Reclamation "Progress Report  
on Results of Studies on Design of  
Stable Channels"  
Hyd-352

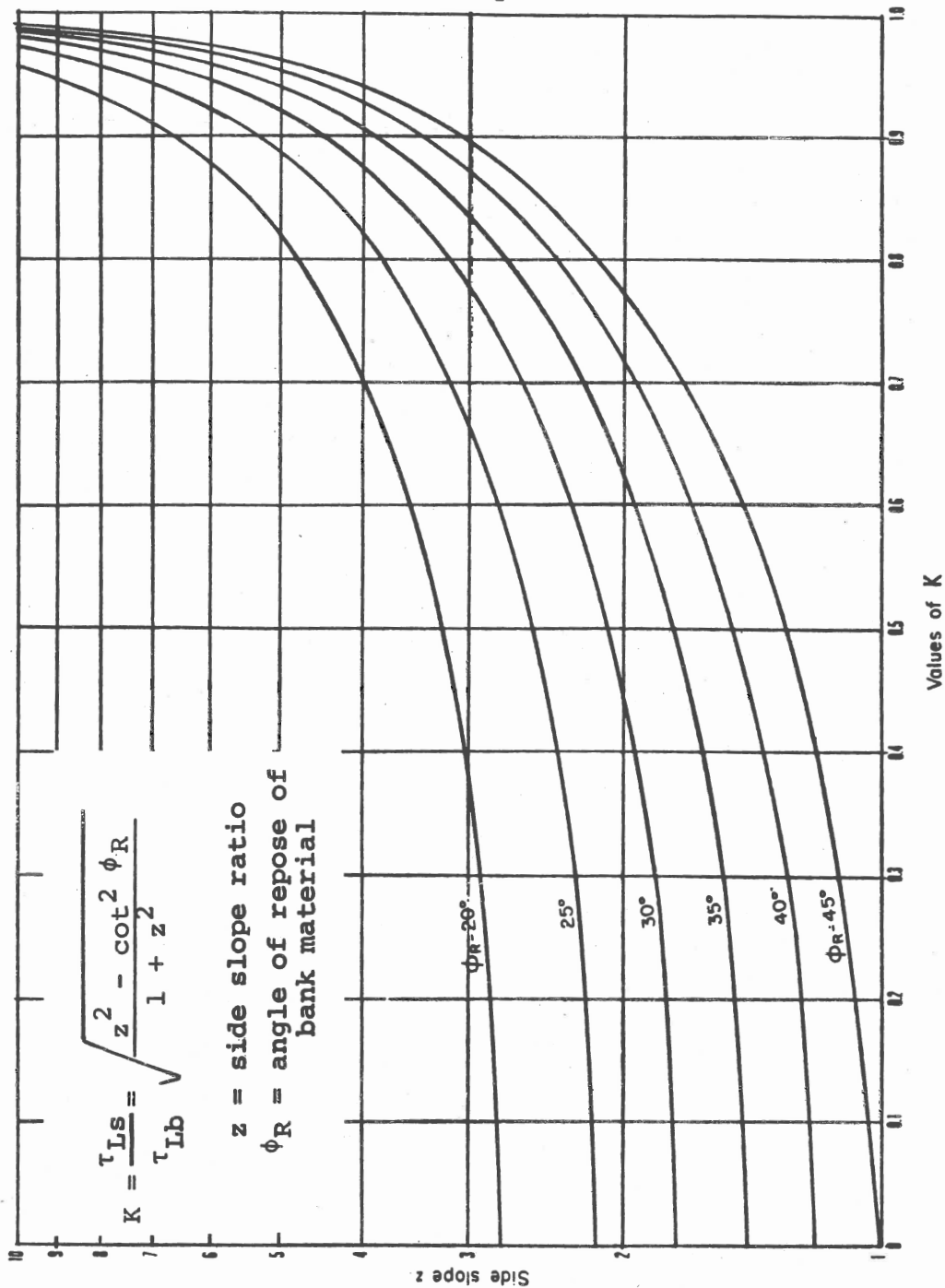


FIGURE A8-7

CHANNEL STABILITY; LIMITING TRACTIVE STRESS  $\tau_{Ls}$  FOR SIDES OF  
TRAPEZOIDAL CHANNELS HAVING NON-COHESIVE MATERIALS

In a given situation  $\gamma$  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.

$$\frac{V}{\sqrt{g R_t s_e}} = 5.75 \log \left( 12.27 \frac{R_t x}{k_s} \right) \quad (\text{Eq. A8-10})$$

where:  $K_s$  is the  $D_{65}$  size in ft.

The factor  $x$  in Equation A8-10 describes the effect on the frictional resistance of the ratio of the characteristic roughness length  $k_s$  to the thickness of the laminar sublayer  $\delta$ . This thickness is determined from the equation

$$\delta = \frac{11.6 \nu}{\sqrt{g R_t s_e}} \quad (\text{Eq. A8-11})$$

A relationship between  $x$  and  $k_s/\delta$  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 iterative procedure which is rather involved. A simpler graphical solution has been developed by Vanoni and Brooks a5 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  $\rho$  and kinematic viscosity of the water  $\nu$  can be obtained.

The computation of reference tractive stress ( $\tau$ ) 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 corners 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  $\tau$ , the reference tractive stress, to obtain values 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.

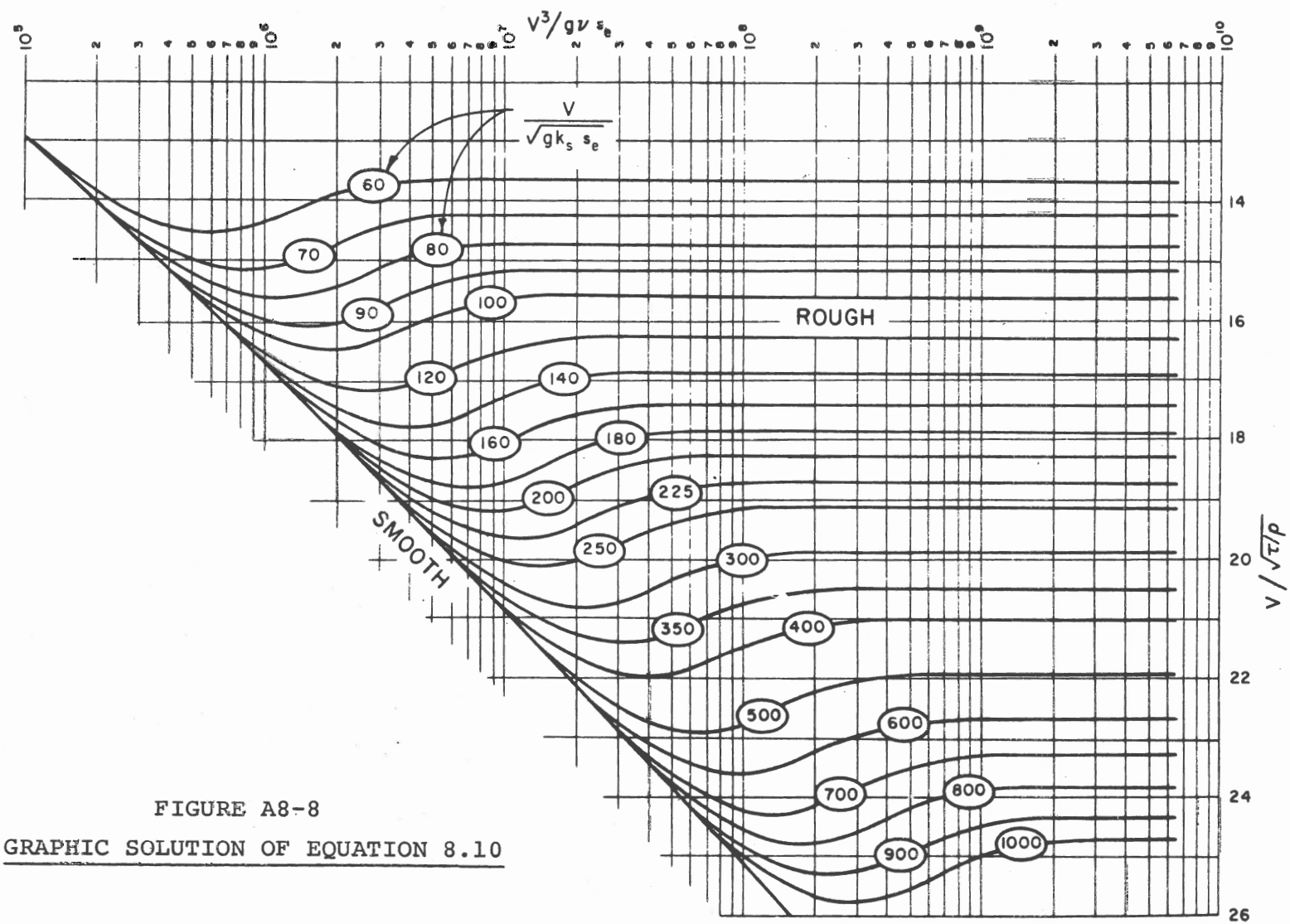


FIGURE A8-8  
GRAPHIC SOLUTION OF EQUATION 8.10

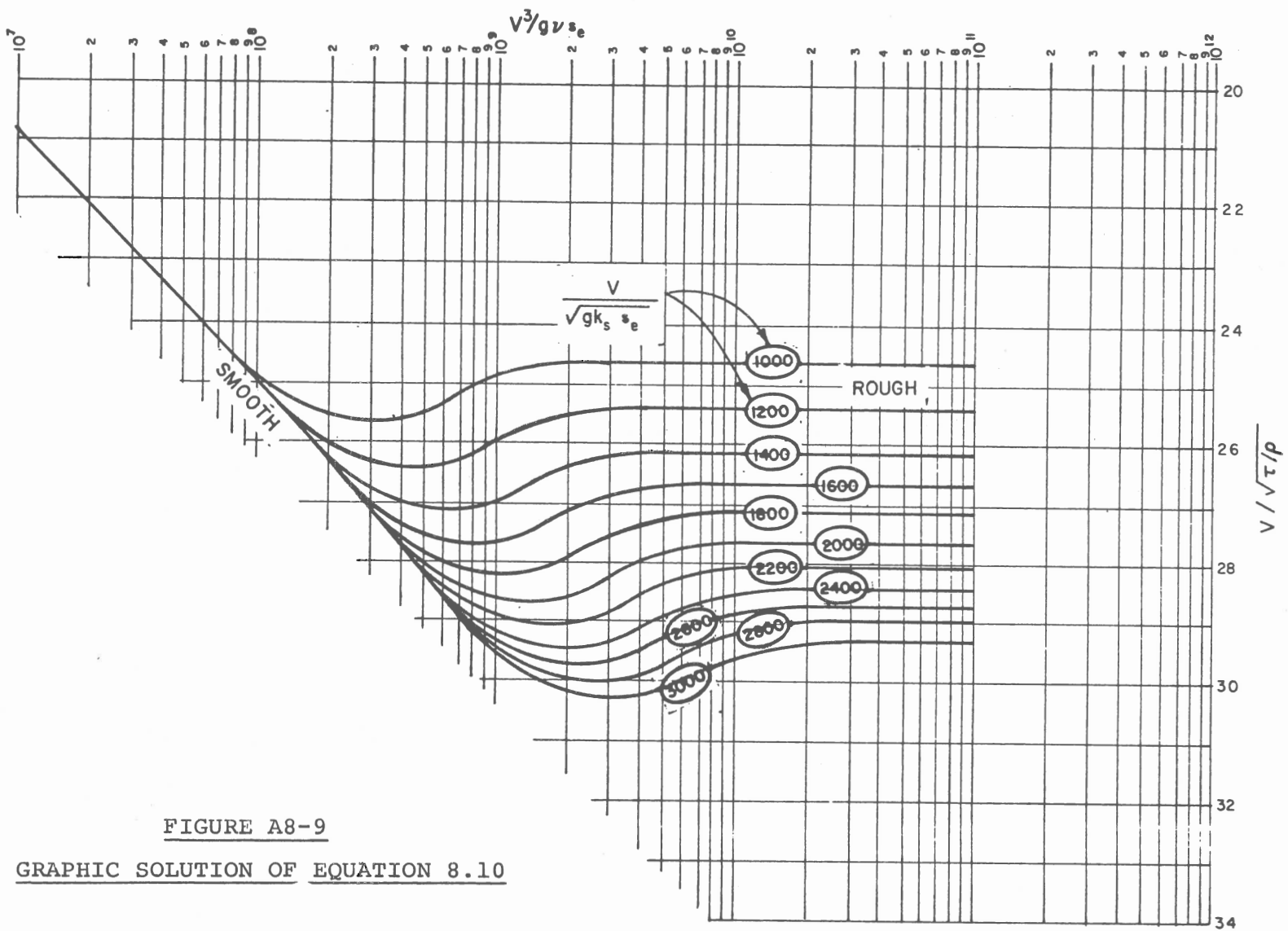


FIGURE A8-9

GRAPHIC SOLUTION OF EQUATION 8.10

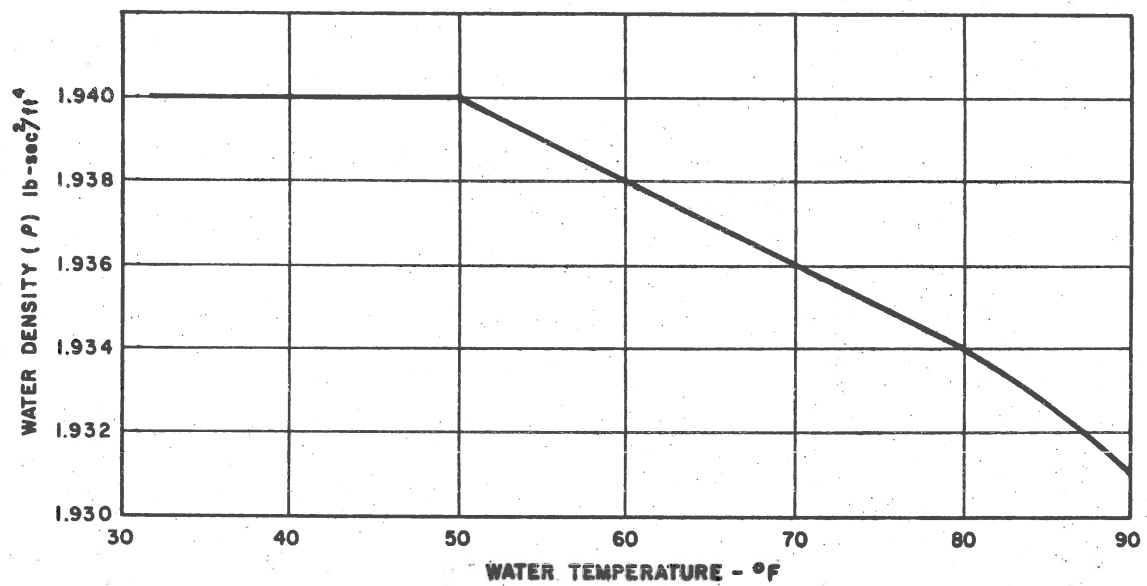
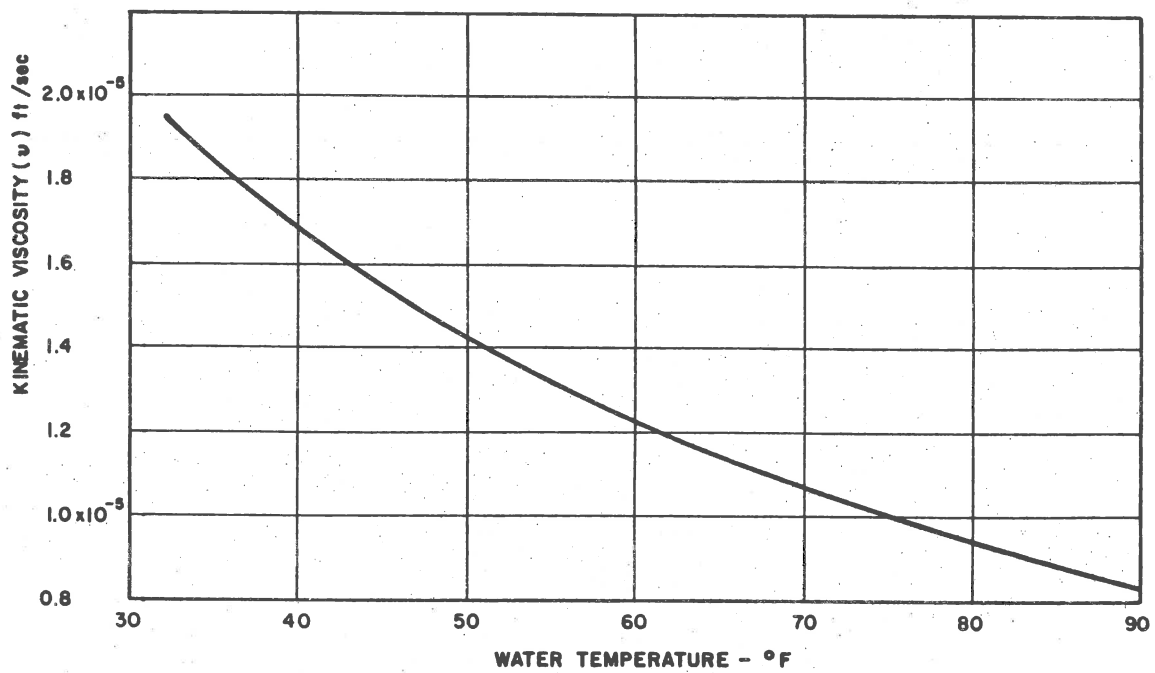


FIGURE A8-10  
VALUES OF  $\rho$  AND  $\nu$  FOR VARIOUS WATER TEMPERATURES

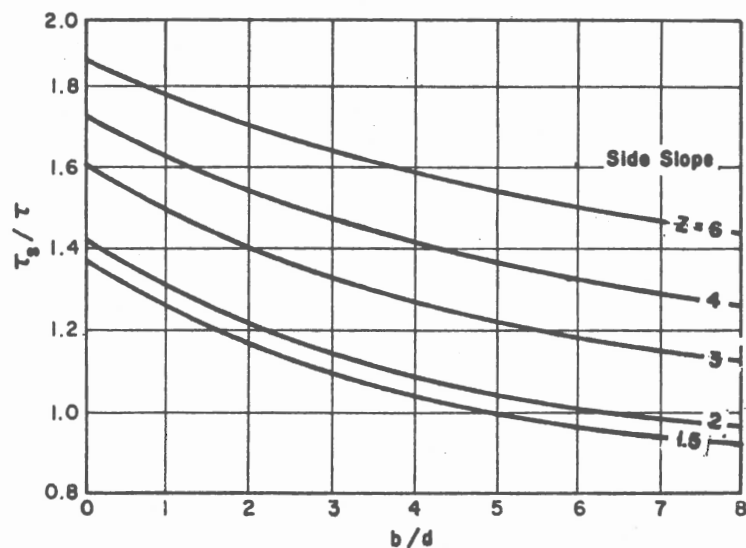


FIGURE A8-11  
APPLIED MAXIMUM TRACTIVE STRESS,  $\tau_s$ ,  
ON SIDES OF STRAIGHT TRAPEZOIDAL CHANNELS

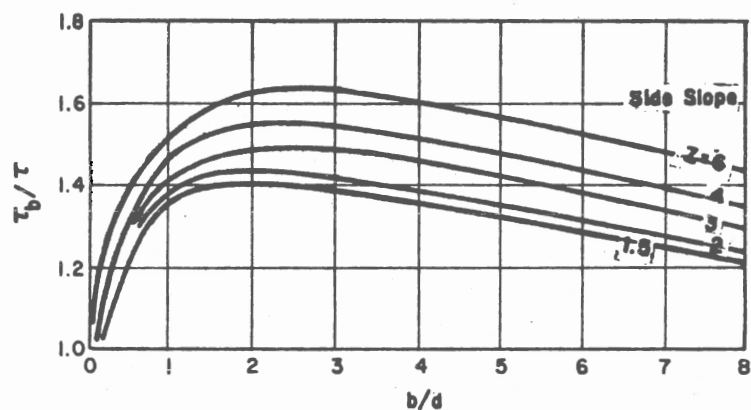


FIGURE A8-12  
APPLIED MAXIMUM TRACTIVE STRESS,  $\tau_b$ ,  
ON BED OF STRAIGHT TRAPEZOIDAL CHANNELS

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 5mm.

For values of  $D_{50}$  less than those shown on the chart (0.1mm) 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.

### Procedure - Tractive Stress Approach

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  $\rho$  and the kinematic viscosity of the water  $\nu$ .
3. Compute  $\frac{v^3}{g\nu s_e}$ .
4. Compute  $\frac{v}{\sqrt{gk_s s_e}}$ .
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  $\frac{v}{\sqrt{\tau/\rho}}$ .

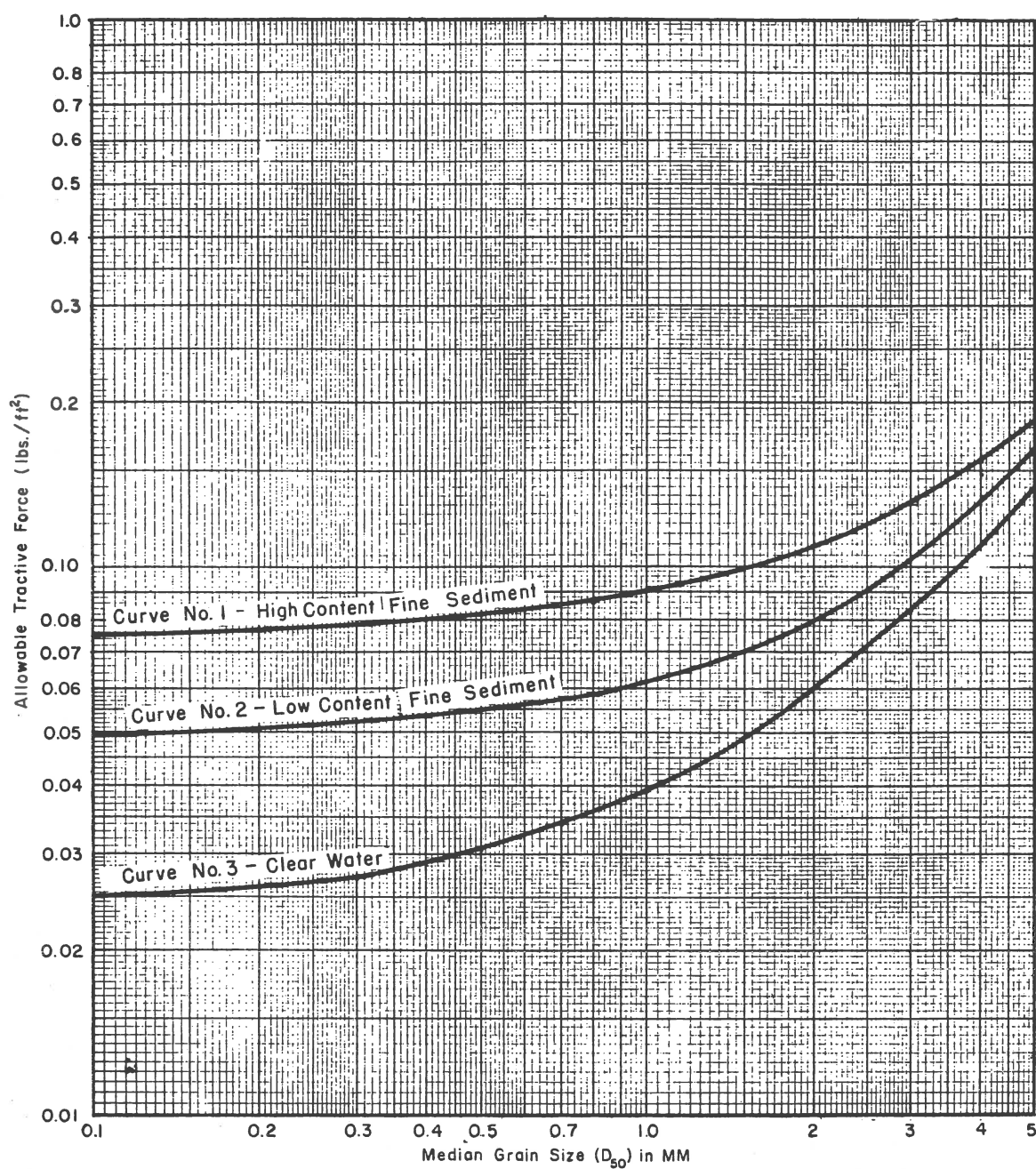


FIGURE A8-13

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

6. Compute  $\tau$  from  $\frac{V}{\sqrt{\tau/\rho}}$ ,  $V$  and  $\rho$

$$\tau = \frac{V^2 \rho}{(V/\sqrt{\tau/\rho})^2}$$

where the terms are defined in the glossary

#### Examples - Tractive Stress Approach

##### Example 3

Given: The bottom width of the trapezoidal channel is 18 feet with side slopes of 1 1/2:1. 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  $D_{75} > 1/4$  inch use the Lane method.

$$n_t = (0.90)^{1/6}/39 = 0.0252 \quad (\text{Eq. A8-1}).$$

$$\text{From Equation A8-3: } s_t - (n_t/n)^2 s_e = (0.025/0.045)^2 0.0026 = 0.00082.$$

$$\text{actual } \tau_\infty = V_w d s_t = (62.4) (3.5) (0.00082) = 0.179 \text{ psf.}$$

$$b/d \text{ (ratio of bottom width to depth)} = 18/3.5 = 5.14.$$

$$\text{from Figure A8-2 and A8-3 } \tau_s/\tau_\infty = 0.76; \tau_b/\tau_\infty = 0.98.$$

$$R_c/b \text{ (radius of curve/bottom width)} = 150/18 = 8.33.$$

$$\tau_{bc}/\tau_b = \tau_{sc}/\tau_s = 1.17 \text{ (Figure A8-4).}$$

$$\text{Actual } \tau_b = (0.179) (0.98) = 0.175 \text{ psf;}$$

$$\text{actual } \tau_s = (0.179) (0.76) = 0.136 \text{ psf}$$

$$\text{Actual } \tau_{bc} = (0.175) (1.17) = 0.205 \text{ psf;}$$

$$\text{actual } \tau_{sc} = (0.136) (1.17) = 0.159 \text{ psf}$$

Solving for allowable tractive stress -

$$\phi_R = 38.4^\circ \text{ (Figure A8-6). } K = 0.45 \text{ (Figure A8-7).}$$

$$\text{allowable: } \tau_{Lb} = (0.4) (D_{75}) = (0.4) (0.90) = 0.36$$

$$\text{allowable: } \tau_{Ls} = 0.4 K D_{75} = (0.4) (0.45) (0.90) = 0.162$$

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 1-1/2:1. 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.

$$\nu = 1.42 \times 10^{-5} \text{ ft}^2/\text{sec.}, \rho = 1.940 \text{ lb sec}^2/\text{ft}^4 \quad (\text{Figure A8-10}).$$

$$V^3/g\nu s_e = 3.23^3 / (32.2) (1.42 \times 10^{-5}) (0.0026) = 2.83 \times 10^7.$$

$$V/\sqrt{gk_s s_e} = 3.23 / \sqrt{(32.2) (0.01075/12) (0.0026)} = 373$$

$$V/\sqrt{\tau/\rho} = 21.6 \quad (\text{From Figure A8.8}).$$

$$\tau = V^2 \rho / (V/\sqrt{\tau/\rho})^2 = (3.23^2) 1.94 / (21.6)^2 = 0.0434 \text{ psf.}$$

$$b/d \text{ (ratio of bottom width to depth)} = 18/3.5 = 5.14$$

$$\tau_s/\tau = 1.0; \tau_b/\tau = 1.31 \quad (\text{from Figure A8-11 and A8-12}).$$

Actual Tractive Stresses:

$$\tau_s = (0.0434) (1.0) = 0.0434 \text{ psf}; \tau_b = (0.0434) (1.31) = 0.0569 \text{ psf}$$

Allowable Tractive Stresses:

$D_{50} = 0.127 \text{ mm}$ ; from Figure A8-13 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<sup>2</sup>)
- b - bottom width of a channel (feet).
- b<sub>T</sub> - 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<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, C<sub>5</sub> - coefficients used to determine channel proportions and slope when using the modified regime equations.
- C<sub>e</sub> - Density factor to adjust the basic velocity because of variations in the density of soil materials in the channel boundary.
- c<sub>m</sub> - cohesion intercept at natural moisture (psf).
- d - depth of flow (feet).
- d<sub>c</sub> - critical depth of flow (feet).
- d<sub>m</sub> - mean depth of flow (feet).
- D - depth factor to adjust basic velocity because of the effects of the depth flow.
- D<sub>s</sub> - the particle diameter of which 8% 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 (fps<sup>2</sup>).
- G - specific gravity.
- H<sub>C</sub> - depth of tension crack (feet).
- k<sub>s</sub> - characteristic length of roughness element, for granular material;  
k<sub>s</sub> = D<sub>65</sub> size in feet.
- K - coefficient modifying tractive force for gravitational forces on coarse, noncohesive materials on channel sides.
- n - Manning's coefficient.
- n<sub>t</sub> - Manning's coefficient for roughness of soil grains.
- P - wetted perimeter.
- PI - 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 - ft.  
 $x$  - 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 pcf.  
 $\gamma$  - unit weight of water (pcf).  
 $\gamma_d$  - dry unit weight (pcf).  
 $\gamma_m$  - moist unit weight (pcf).  
 $\gamma_s$  - unit weight of particles larger than 0.25" (pcf).  
 $\gamma_w$  - unit weight of water (62.4 pcf).  
 $\delta$  - thickness of laminar sublayer =  $\frac{11.6v}{\sqrt{gR_t s_e}}$   
 $\phi$  - angle of shearing resistance.  
 $\phi_m$  - angle of shearing resistance at natural moisture content.  
 $\phi_r$  - angle of repose of coarse noncohesive materials.  
 $\nu$  - kinematic viscosity of water (ft<sup>2</sup>/sec).

- $\rho$  - water density ( $\text{lb-sec}^2/\text{ft}^4$ ).
- $\tau$  - reference tractive stress (psf).
- $\tau_{\infty}$  - tractive stress in an infinitely wide channel (psf).
- $\tau_b$  - maximum tractive stress on the channel bed (psf).
- $\tau_s$  - maximum tractive stress on the channel sides (psf).
- $\tau_{bc}$  - maximum tractive stress on the bed in a curved reach (psf).
- $\tau_{sc}$  - maximum tractive stress on the sides in a curved reach (psf).
- $\tau_{Lb}$  - allowable tractive stress along the bed. (psf)
- $\tau_{Ls}$  - 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, floodways 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; 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 5 primary factors it is important that each factor be examined and considered independently. In considering each factor, it should be kept in mind that  $n$  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.

1st step. Selection of basic  $n$  value. This step requires the selection of 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 indicate 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  $n$ .



| <u>CHARACTER OF CHANNEL</u> | <u>BASIC n</u> |
|-----------------------------|----------------|
| Channels in earth           | 0.02           |
| Channels cut into rock      | 0.025          |
| Channels in fine gravel     | 0.024          |
| Channels in coarse gravel   | 0.028          |

2nd 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.

| <u>DEGREE OF IRREGULARITY</u> | <u>SURFACES COMPARABLE TO</u>                                                                                                                                                   | <u>MODIFYING VALUE</u> |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Smooth                        | The best obtainable for the materials involved.                                                                                                                                 | 0.000                  |
| Minor                         | Good dredged 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 excavated in rock. | 0.020                  |

3rd 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 OF 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<br>0.015 |

4th 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, 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.

| <u>RELATIVE EFFECT OF OBSTRUCTIONS</u> | <u>MODIFYING VALUE</u> |
|----------------------------------------|------------------------|
| Negligible                             | 0.000                  |
| Minor                                  | 0.010 to 0.015         |
| Appreciable                            | 0.020 to 0.030         |
| Severe                                 | 0.040 to 0.060         |

5th 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:

| <u>VEGETATION AND FLOW CONDITIONS<br/>COMPARABLE TO:</u>                                                                                                                 | <u>DEGREE OF<br/>EFFECT ON n</u> | <u>RANGE IN MODIFYING<br/>VALUE</u> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-------------------------------------|
| Dense growths of flexible turfgrasses or weeds, of which Bermuda and bluegrasses are examples, where the average depth of flow is 2 to 3 times the height of vegetation. | Low                              | 0.005 to 0.010                      |
| 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.                     |                                  |                                     |

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. High 0.025 to 0.050

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.

---

Turf grasses where the average depth of flow is less than one half the height of vegetation.

Growing season, bushy willows about 1 year old, intergrown with weeds in full foliage along side slopes; dense growth of cattails along channel bottom; any value of hydraulic radius up to 10 or 15 feet. Very high 0.050 to 0.100

Growing season; trees intergrown with weeds and brush, all in full foliage; any value of hydraulic radius up to 10 or 15 feet.

---

6th step. 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  $l_s$  = the straight length of the reach under consideration.

$l_m$  = the meander length of the channel in the reach.

Compute modifying value for meandering in accordance with the following table:

| <u>Ratio (<math>l_m/l_s</math>)</u> | <u>Degree of meandering</u> | <u>Modifying value</u> |
|-------------------------------------|-----------------------------|------------------------|
| 1.0 to 1.2                          | Minor                       | 0.000                  |
| 1.2 to 1.5                          | Appreciable                 | 0.15 $n_s$             |
| 1.5 and greater                     | Severe                      | 0.30 $n_s$             |

Where lengths for computing the approximate value of  $l_m/l_s$  are not readily obtainable the degree of meandering can usually be judged reasonably well.

7th step. 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.

Example 1. Estimation of  $n$  for a reach.

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.

| <u>STEP</u>         | <u>REMARKS</u>                                        | <u>MODIFYING VALUES</u> |
|---------------------|-------------------------------------------------------|-------------------------|
| 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.                          | <u>0.00</u>             |
| Total estimated $n$ |                                                       | 0.11                    |

USDA Technical Bulletin No. 129, Table 9, page 96, gives the following determined values for  $n$  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, 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. A uniform rainfall intensity for the entire rainfall period is assumed here. This is highly unlikely.

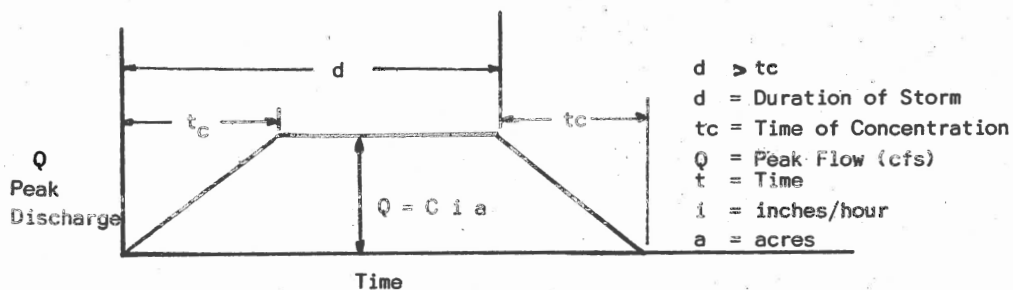
The MRM recommends that a coefficient be used in order to account for the antecedent moisture conditions of storms greater than those with a twenty-five (25) year recurrence interval ( $Q=ca \times c \times i \times a$ ). This attempts to predict a more realistic runoff volume which is characteristic of higher frequency storms. The maximum product of  $ca \times c$  cannot be greater than one.

#### Recommended Antecedent Precipitation Factors for the Rational Method

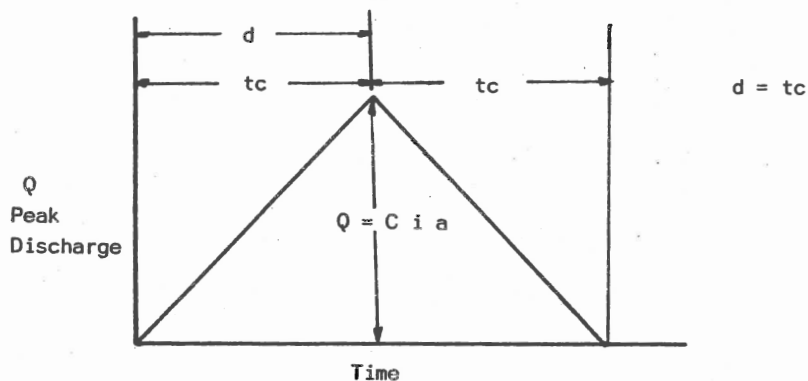
| <u>Recurrence<br/>Interval<br/>(years)</u> | <u>ca</u> |
|--------------------------------------------|-----------|
| 2 to 10                                    | 1.0       |
| 25                                         | 1.1       |
| 50                                         | 1.2       |
| 100                                        | 1.25      |

The time of concentration ( $t_c$ ) 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  $t_c$ , then the approximate hydrograph is a trapezoid.



**SECOND CASE** If the rainfall duration is equal to the time of concentration (assuming the  $t_c$  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 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 of 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, a 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:

#### Southern Portion

| Storm<br>(years) | Predeveloped<br>Condition |      |      |     |     | Postdeveloped<br>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 storm water 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 (4.14), Slope Protection (4.5), and Channel Stabilization (4.6) 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 a 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.

$$\begin{aligned}t_c &= 10 \text{ minutes} \\C &= 0.18 \text{ for the predeveloped drainage area} \\&\quad \text{at that point of future discharge} \\a &= 0.93 \text{ acres (not 8.07 acres)} \\i &= 5.5 \text{ inches per hour (10 year frequency)} \\Q &= C \times i \times a \\&= 0.18 \times 5.5 \times 0.93 \\&= 0.92 \text{ cfs predevelopment peak at the} \\&\quad \text{point of discharge which is the} \\&\quad \text{allowable release rate.}\end{aligned}$$

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 29.8 hours. To reach zero outflow 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 a duration equal to the time of concentration.

Table A9.2

Storage-Duration Values

| Duration<br>of<br>Storm<br>(hr)<br>(1) | Intensity<br>i<br>(in/hr)<br>(2) | Peak<br>Flow<br>Q<br>(cfs)<br>(3) | Volume<br>of<br>Runoff<br>(cuft)<br>(4) | Release<br>Flow<br>Volume<br>(cuft)<br>(5) | Required<br>Storage<br>Volume<br>(cuft)<br>(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                                         |

Column (3) Peak Flow =  $Q = c i a$   
 example :  $0.7 \times 4.8 \times 11.88 = 39.9 \text{ cfs}$

Column (4) Runoff Volume =  $Q \text{ (col 3)} \times \text{Duration of Storm (col 1)} \times 3600$   
 example :  $39.9 \text{ cfs} \times 0.25 \text{ hrs} \times 3600 = 35,925 \text{ cuft}$

Column (5) Release Volume =  $0.92 \text{ cfs} \times \text{Duration of Storm (col 1)} \times 3600$   
 example :  $0.92 \times 0.25 \times 3600 = 828 \text{ cuft}$

Column (6) Required Storage =  $\text{Runoff Volume (col 4)} - \text{Release Volume (col 5)}$   
 example :  $35,925 - 828 = 35,097$

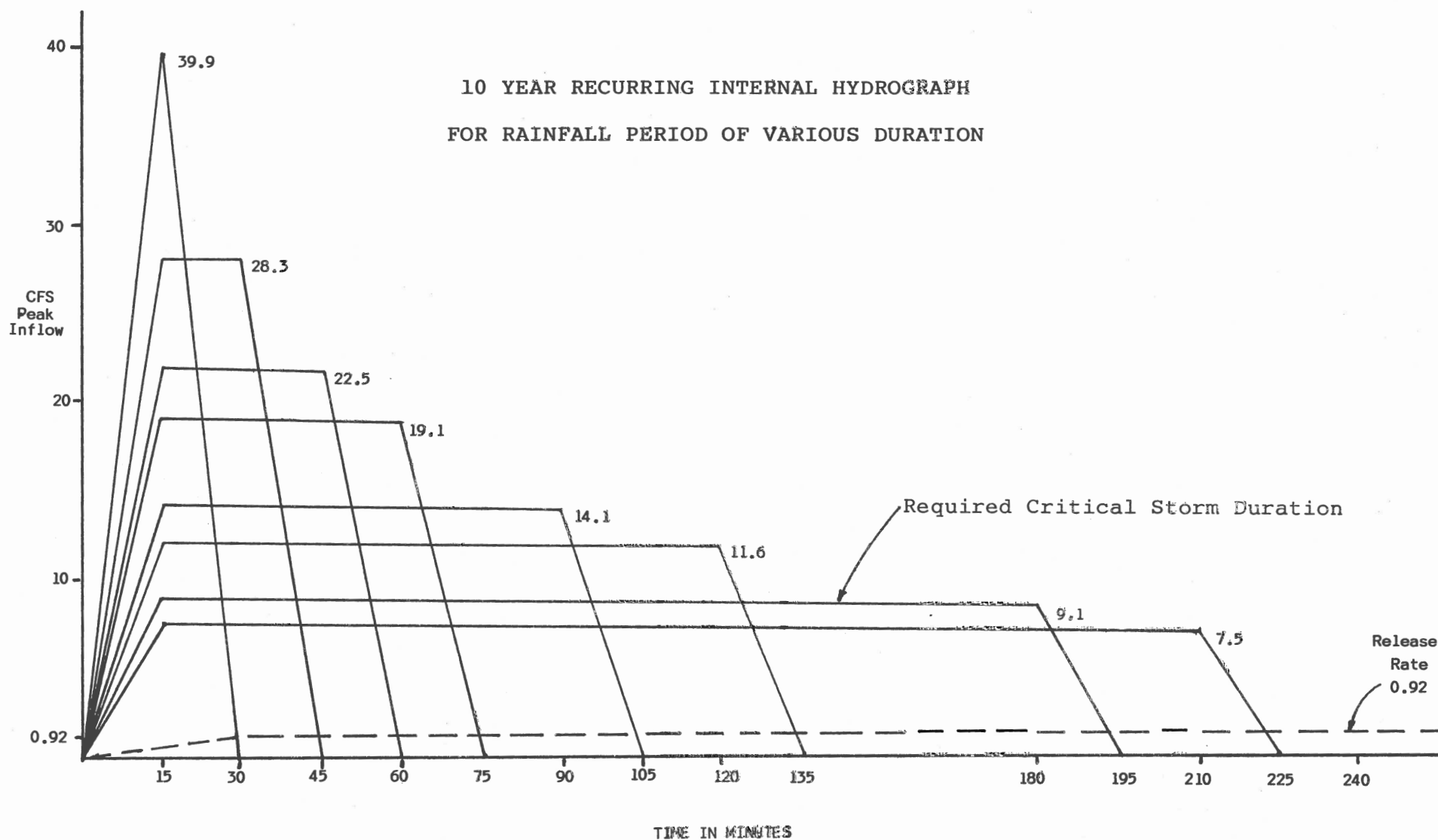


Figure A9.1

## Appendix A10

### Structural Guidelines for Detention Basin Soil Conservation Service Pond Standard No. 378

#### Definition

A water impoundment made by constructing a dam or embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 feet or more.

#### Purpose

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses, and to maintain or improve water quality.

#### Scope

This standard establishes the minimum acceptable quality for the design and construction of ponds if:

1. Failure of the dam will not result in the loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruptions of the use or service of public utilities.

2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is the difference in elevation, in feet, 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 is the upper limit.

3. The effective height of the dam is 35 feet or less and the dam is hazard class "a" (low hazard).

#### Conditions Where Practice Applies

Site Conditions. Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed emergency spillway, (2) a combination

of a principal spillway and the emergency spillway or (3) a principal spillway.

Drainage Area. The drainage area above the pond must be protected against erosion to the extent that expected sediment will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and ground water flow will maintain an adequate supply of water in the pond. The quality shall be suitable for the water's intended use.

Ratios of drainage area to normal pond area greater than 1000 to 1 will normally have excessive sedimentation, unless the drainage area is flat or has good cover.

If the surface water is the only source of water the ratio of drainage area to normal pond area shall be at least 10 to 1.

Ponds shall be protected from the contamination from the barnyards, septic tanks, storm and sanitary sewers or other sources.

Reservoir Area. The topography and soils of the site shall permit storage of water at a depth and volume that ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

#### Design Criteria For Embankment Ponds

Foundation cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up to abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

The cutoff shall extend up to the normal water line. The minimum depth shall be at least 3 feet.

Seepage control. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage creates swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment drains; (2) reservoir blanketing; or (3) a combination of these measures.

Earth embankment. The minimum top width for a dam is shown in table A10.1. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic

and 26 feet for two-way traffic. Guardrails or other safety measures shall meet the requirements of the responsible road authority.

Table A10.1 Minimum Top Width for Dams

| Total Height of<br>Embankment<br>(feet) | Top Width<br>(feet) |
|-----------------------------------------|---------------------|
| 10 or less                              | 6                   |
| 10-15                                   | 8                   |
| 15-20                                   | 10                  |
| 20-25                                   | 12                  |
| 25-35                                   | 14                  |
| 35 or more                              | 15                  |

The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical, and neither slope shall be steeper than two horizontal to one vertical. All slopes must be designed to be stable, even if flatter side slopes are required.

If needed to protect the slopes of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (USDA Soil Conservation Service, Technical Release Nos. 56 and 69).

The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the emergency spillway flowing at the design depth. The minimum difference in elevation between the crest of the emergency spillway and the settled top width of the dam shall be 2 feet for all dams having more than a 20 acre drainage area or more than 20 feet in effective height.

The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. This increase shall not be less than 5 percent except where detailed soil testing and laboratory analysis shows that a lesser amount is adequate.

Principal Spillway. A pipe conduit, with needed appurtenances, shall be placed under or through the dam, except where rock, concrete, or other types of mechanical spillways are used, or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

The crest elevation shall be no less than 0.5 feet below the crest of the emergency spillway for dams having a drainage area of 20 acres or less, and no less than 1 foot for those having a drainage area of more than 20 acres.

When the design discharge of the principal spillway is considered in calculating peak outflow through the emergency spillway, the crest elevation of the inlet shall be such that

the full flow will be generated in the conduit before there is discharge through the emergency spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the emergency spillways. The pipe diameter shall be no less than 4 inches. If the pipe conduit diameter is larger than 10 inches, its design discharge may be considered when calculating the peak outflow rate through the emergency spillway.

Pipe conduits under or through the dam shall meet the following requirements. The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Flexible pipe strength shall not be less than that necessary to support the design load with the maximum of 5 percent deflection. The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe joints shall be made watertight by the use of couplings, gaskets, caulking, or by welding.

For dams 20 feet or less in effective height, acceptable pipe materials are cast-iron, steel, corrugated steel or aluminum, concrete, plastic, vitrified clay with rubber gaskets, and and cast-in-place reinforced concrete. Concrete and vitrified clay pipe shall be laid in a concrete bedding. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding, or provisions for replacement should be made as necessary. Connections of plastic pipe to less flexible pipe or structure must be designed to avoid stress concentrations that could rupture the plastic.

For dams more than 20 feet in effective height, conduits shall be plastic, reinforced concrete, corrugated steel or aluminum, or welded steel pipe. The maximum height of fill over any principal spillway steel or aluminum pipe must not exceed 25 feet. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation. Concrete pipe shall have concrete bedding or a concrete cradle if required. Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as a Saint Anthony Falls stilling basin or an impact basin may be used to provide a safe outlet. Protective coatings of asphalt coated, or vinyl coating on galvanized corrugated metal pipe, or coal tar enamel on welded steel pipe should be provided in areas that have a history of pipe corrosion, or where the saturated soil resistivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

Specifications in tables A10.2 and A10.3 are to be

followed for polyvinyl chloride (PVC), steel, and aluminum pipe.

Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of joint-bridging straps should be considered on pipes that have protective coatings. Cathodic protection should be added later if mounting indicates the need.

Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exists:

1. The effective height of the dam is greater than 15 feet.
2. The conduit is of smooth pipe larger than 8 inches in diameter.
3. The conduit is of corrugated pipe larger than 12 inches in diameter.

Table A10.2

ACCEPTABLE PVC PIPE FOR USE IN EARTH DAMS /1

| Nominal Pipe Size<br>(inches) | Schedule for Standard<br>dimension ratio (SDR) | Maximum depth of<br>fill over pipe<br>(feet) |
|-------------------------------|------------------------------------------------|----------------------------------------------|
| 4 or smaller                  | Schedule 40                                    | 15                                           |
|                               | Schedule 80                                    | 20                                           |
|                               | SDR 26                                         | 10                                           |
| 6, 8, 10, 12                  | Schedule 40                                    | 10                                           |
|                               | Schedule 80                                    | 15                                           |
|                               | SDR 26                                         | 10                                           |

/1 Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM-1785 or ASTM-D-2241.



Table A10.3

**MINIMUM GAUGE FOR CORRUGATED METAL PIPE  
(2-2/3-IN X 1/2-IN CORRUGATIONS) /1**

| Fill<br>height<br>(ft) | Minimum gauge for<br>steel pipe with<br>diameter (in) of- |    |    |    |    |    | Minimum thickness (in)<br>of aluminum pipe /2<br>with diameter (in) of- |      |       |       |
|------------------------|-----------------------------------------------------------|----|----|----|----|----|-------------------------------------------------------------------------|------|-------|-------|
|                        | 21 and<br>less                                            | 24 | 30 | 36 | 42 | 48 | 21 and<br>less                                                          | 24   | 30    | 36    |
| 1-15                   | 16                                                        | 16 | 16 | 14 | 12 | 10 | 0.06                                                                    | 0.06 | 0.075 | 0.075 |
| 15-20                  | 16                                                        | 16 | 16 | 14 | 12 | 10 | .06                                                                     | .075 | .105  | .105  |
| 20-25                  | 16                                                        | 16 | 14 | 12 | 10 | 10 | .06                                                                     | .105 | .135  | /3    |

/1 Pipe with 6-, 8-, and 10-diameter has 1-1/2-in x 1/4-in corrugations.

/2 Riveted or helical fabrication.

/3 Not permitted

Seepage along pipes extending through the embankment shall be controlled by the use of a filter and drainage diaphragm, unless it is determined that antiseep collars will adequately serve the purpose.

The drain is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

The drain shall be minimum of 2 feet thick and extend vertically upward and horizontally at least three times the pipe diameter, and vertically downward at least 18 inches beneath the conduit invert. The drain diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

The drain shall be outletted at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exists in the embankment. Protecting drain fill from the surface erosion will be necessary.

When antiseep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe. Collar material shall be compatible with the pipe materials. The antiseep collar(s) shall increase by 15% the seepage path along the pipe.

Closed conduit spillways designed for pressure flow must have adequate antivortex devices.

To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by state law. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function.

Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1-1/4 inches.

The minimum diameter principal spillway pipe for a dam which raises the water height by more than 5 feet measured from the downstream toe of the dam to the emergency spillway crest is 18 inches. A principal spillway shall be used except where:

1. The drainage area is 10 acres or less, there is no spring or seep flow and the emergency spillway exit channel is on stable grade all the way back to the existing channel.
2. The drainage area is 10 acres or less, there is spring or seep flow and the emergency spillway exit channel is on a stable grade all the way back to the existing channel. For this condition a trickle tube shall be used in accordance with pages 11-13 and 11-16 of USDA, Soil Conservation Service, Engineering Field Manual.

Design Storm. Storage and effective height are defined under Scope.

1. Table A10.4 defines minimum design storm for the principal spillway.
2. Table A10.5 defines minimum design storm for the emergency spillway.

#### Pipe Conduit

1. Corrugated Steel Pipe - The pipe may be helical or riveted fabrication. Riveted pipe shall be closed riveted. Riveted pipe 36 inches or larger shall be doubled riveted. Pipe strength is not to be less than that indicated in table A10.7.

If corrugated metal pipes are used on embankments which raise the water height by more than 5 feet, the fill height over the pipe may not exceed 15 feet, and cathodic protection must be provided.

2. Corrugated Aluminum Pipe - The maximum effective fill height, as defined under Scope, shall be 20 feet or less. The pipe may be helical or riveted fabrication. Riveted pipe shall be closed riveted. Riveted pipe 36 inches or larger shall be double riveted

Pipe strength is not to be less than that indicated in table A10.8.

Fittings for aluminum pipe materials other than aluminum or aluminized steel must be separated from the aluminum pipe at all points by at least two layers of plastic having a total thickness of at least 24 mils, or by other permanent insulating material that effectively prevents galvanic corrosion.

Bolts used to join aluminum and steel must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion.

Bolts used to join aluminum, other than aluminum alloy bolts, must be galvanized, plastic coated, or otherwise protected to prevent galvanic action.

3. Plastic Pipe - PVC becomes brittle after years of exposure to sun and is susceptible to damage from impact, especially during periods of low temperature. Provisions should be made for protection from impact where necessary. Thicker walled pipe has greater resistance to damage from the ultraviolet rays of the sun. PVC pipe exposed to the sun should be protected by paint or by shielding to screen the ultraviolet rays. Use a good grade of water based paint. Paints with other based material might have an adverse effect on the plastic pipe. Repainting should be required as needed to retain the integrity of this ultraviolet protection.

Numerous other plastic materials are available but deterioration from sunlight, damage from impact, or susceptibility to fire make these less desirable for applications involving these exposures.

4. Smooth Steel - The maximum fill over the pipe shall not exceed 25 feet. The minimum wall thickness shall be 3/16 inch. The maximum size principal spillway barrel shall be 48 inches. Pipe joints shall be threaded or welded.

5. Vitrified Clay Pipe - The maximum effective fill height as defined under Scope, shall be 20 feet or less. The maximum principal spillway barrel size shall be 36 inches.

6. Concrete and Cast in Place Reinforced Concrete - The principal spillway shall meet the requirements of USDA, SCS Technical Release 60, Earth Dams and Reservoirs.

#### Inlet for Pipe Conduit

The inlet shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent flotation.

1. Hood Inlet - If the pipe is designed for pressure flow, the stage in the pond below the emergency spillway elevation

shall be adequate to prime the pipe. For smooth wall pipe this is 1.4D. For corrugated pipe this is 1.8D. D is the inside diameter of the pipe.

2. Drop Inlet - If the pipe is designed for pressure flow:

- a. The weir length shall be adequate to prime the emergency spillway elevation. See USDA, Soil Conservation Service, Engineering Field Manual for conservation practices page 6-43.

3. Outlet for Pipe Conduit - Conduits larger than 18 inch shall have one of the following types of outlets:

1. SAF stilling basin
2. Impact Basin
3. Cantilever outlet with the stilling basin. The invert of the cantilever outlet shall be above the water surface of the downstream channel when the principal spillway is flowing at the design capacity.

The cantilever outlet will be supported on a bent or pier and will extend a minimum of 8 feet beyond the bent or pier. The bent or pier will extend below the lowest elevation anticipated in the scour hole or to unweathered, sound rock. Guidance on the design of stilling basins is in USDA's SCS Design Note No. 6, Armored Scour Hole for Cantilever Outlet.

4. Conduit Outlet Protection - In accordance with the "Standards for Soil Erosion and Sedimentation Control in New Jersey".

#### Antiseep Collars

When antiseep collars are used in lieu of a drainage diaphragm, the following criteria are to be used to determine the size and number of antiseep collars.

Let V = vertical projection and minimum horizontal projection of the antiseep collar in feet.

Let L = length in feet of the conduit within the zone of saturation, measured from the downstream side of the riser to the toe drain or point where phreatic line intercepts the conduit, whichever is shorter.

Let n = number of antiseep collars.

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

### Emergency Spillways.

Emergency spillways convey large flood flows safely past earth embankments.

An emergency spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of closed conduit principal spillway without an emergency spillway:

A conduit with a cross-sectional area of 3 square feet or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table A10.6, less than reduction creditable to conduit discharge and detention storage.

Table A10.6

#### Minimum Spillway Capacity

| Drainage<br>area<br>(acre) | Effective height<br>of dam /1<br>(feet) | Storage<br>(acre-ft) | Minimum design<br>storm /2 |                               |
|----------------------------|-----------------------------------------|----------------------|----------------------------|-------------------------------|
|                            |                                         |                      | Frequency<br>(year)        | Minimum<br>duration<br>(hour) |
| 20 or less                 | 20 or less                              | Less than 50         | 10                         | 24                            |
| 20 or less                 | More than 20                            | Less than 50         | 25                         | 24                            |
| More than 20               | 20 or less                              | Less than 50         | 25                         | 24                            |
| All others                 |                                         |                      | 50                         | 24                            |

/1 As defined under "Scope".

/2 Select rain distribution based on climatological region

The emergency spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall either start with water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days drawdown, whichever is higher. The 10 day drawdown shall be computed from the crest of the emergency spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Emergency spillway shall provide for passing the design flow at safe velocity to a point downstream where the

dam will not be endangered.

Constructed emergency spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed. For dams having an effective height exceeding 20 feet, the emergency spillway shall have a bottom width of not less than 10 feet.

Upstream from the control section, the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography. The grade of the exit channel of a constructed emergency spillway shall fall within the range established by discharge requirements and permissible velocities.

When design discharge of the principal spillway is considered in calculating peak outflow through the emergency spillway, the crest elevation through the inlet shall be such that full flow will be generated in the conduit before there is discharge through the emergency spillway.

Emergency spillways shall 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 per second where only sparse vegetative cover can be expected and maintained, and 6 feet per second where excellent vegetative cover, a vigorous sod, can be expected and maintained.

Cross-section side slopes shall be 2 to 1 or flatter. Component parts of the emergency spillway are as follows;

1. Inlet Channel - The inlet channel shall be level for at least 20 feet upstream of the control section.
2. Exit Channel - The design flow should be contained in the exit channel without the use of dikes. If a dike is necessary it shall have at least 2:1 side slopes, 8 feet top width and be high enough to contain the design flow.

The exit channel shall be straight for at least 50 feet downstream of the control section.

Structural Emergency Spillways. If chutes or drops are used for the principal spillways or principal emergency or emergency spillways, they shall be designed according to the principles set forth in USDA, Soils Conservation Service Engineering Field Manual for Conservation Practices and the National Engineering Handbook - Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table A10.6, less any

reduction creditable to conduit discharge and detention storage.

Visual Resource Design. The visual resource design of ponds shall be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

Components for Visual Design Ponds are as follows:

Drains - All ponds which raise the water height more than five feet must be provided with a device to permit draining of the reservoir. All pipe conduits used as drains must meet the same requirements as the pipe conduit for the principal spillway.

Vegetation - The dam, emergency spillway, spoil and borrow areas, and other disturbed areas above normal water level shall be planted in accordance with the standard for critical area (see also SSCC Standard for Temporary (3.1) and Permanent (3.2) Vegetative Cover. A grass strip or other suitable protection shall be provided around the pond to protect against sedimentation and erosion.

Construction Inspection - Embankments which raise the water height (measured at the emergency spillway crest) more than five feet must have constant inspection during construction by a licensed professional engineer. A monthly written report of construction shall be prepared and submitted to the New Jersey Department of Environmental Protection Dam Safety Section.

Fencing - The embankment, spillway, and pond shall be fenced where necessary to protect the vegetation or for safety.

Dam Inspections - Dams which raise the water height by more than five feet shall have regular inspections performed every two years and a formal inspection performed every six years. An informal inspection shall be performed on the off year from the regular inspections. In the year of the formal inspection, regular and informal inspections need not be performed.

"Formal Inspection" means the inspection by a New Jersey licensed professional engineer to re-evaluate the safety and integrity of the dam and appurtenant structures to determine if the structure meets current design criteria, including a field inspection and a review of the records on project design, construction, and performance.

"Regular Inspection" means the visual inspection of a dam by a New Jersey licensed professional engineer to detect any signs of deterioration in material, developing weaknesses or unsafe hydraulic or structural behavior.

"Informal Inspection" means the visual inspection of the dam by the dam owner or operator to detect apparent signs of deterioration or other deficiencies of the dam structure or function.

Operation and Maintenance - An operation and maintenance manual will be developed for each pond which raises the water height by more than five feet.

The purpose of the manual is to provide guidance and instruction for the proper operation and maintenance of the pond and dam. The manual shall be composed of two parts. Part One must include the introduction, project description, project authorizations, project history, and list of project contracts. Part Two must contain the operation and maintenance instructions for major project facilities and equipment.

Ponds which raise the water height by five feet or less shall have an operation and maintenance schedule included in the design and made part of the farm plan. A yearly inspection shall include but not be limited to the following items plus any item unique to the particular pond:

- a. Plugged and deteriorating trash rack, riser, and water control gates.
- b. Damage to water pipe, valve, and watering facilities.
- c. Damage to pipe outlets and animal guards.
- d. Unstable wet areas below earthfills.
- e. Damaged or deteriorating fences.
- f. Wave damage to shoreline.
- g. Muskrat damage to the embankment or shoreline.
- h. Keep vegetation healthy and trim on the dam and earth spillway by liming, fertilizing, and mowing periodically. This also helps control undesirable brush and vegetative growth.
- i. Do not permit trees to grow on the dam.

#### Design Criteria for Excavated Ponds

Runoff. Runoff flow pattern shall be considered when locating the pond and placing the spoil.



Provisions shall be made where needed for a principal spillway, emergency spillway, and embankment in accordance with the embankment criteria (see table A10.6).

Side Slopes. Side slopes of the excavated ponds shall be stable and shall not be steeper than two horizontal to one vertical above the normal water level and 1 1/2 horizontal to one vertical below the normal water level. If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 5 horizontal to one vertical. The watering ramp shall have a gravel or paved surface.

Perimeter Form. If the structures are to be used for recreation or are highly visible to the public, the perimeter or edge should be curvilinear.

Inlet Protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Excavated Material. The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and so that it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to height that does not exceed 3 feet with the top grade to a continuous slope away from the pond.
2. Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 feet from the edge of the pond.
3. Shaped to a designed form that blends visually with the landscape.
4. Used for low embankment and leveling.
5. Hauled away.

The side slopes, spoiled material, and other disturbed areas above normal water level shall be planted in accordance with the critical area planting standard (see also SSCC Standard for Temporary (3.1) and Permanent (3.2) Vegetative Cover).

Plans and Specifications. Plans and specifications for installing ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Table A10.4  
Principal Spillway  
Minimum Design Storms /4

| Type /1     | Raised /2<br>Water<br>Height (ft) | Product of the<br>Storage times<br>the Effective<br>Height of<br>the Dam /3 | Drainage<br>Area<br>(acres) | Principal<br>Design<br>Storm |
|-------------|-----------------------------------|-----------------------------------------------------------------------------|-----------------------------|------------------------------|
| All         | ≤ 5                               | ≤ 300                                                                       | < 320                       | 1 yr 24 hr                   |
| Agriculture | >5                                | ≤ 300                                                                       | < 320                       | 1 yr 24 hr                   |
| Non-        |                                   |                                                                             |                             |                              |
| Agriculture | >5                                | ≤ 300                                                                       | < 320                       | 25yr 24 hr                   |
| All         | ≤5                                | 301 - 3000                                                                  | < 320                       | 2 yr 24 hr                   |
| Agriculture | >5                                | 301 - 3000                                                                  | < 320                       | 2 yr 24 hr                   |
| Non-        |                                   |                                                                             |                             |                              |
| Agriculture | >5                                | 301 - 3000                                                                  | < 320                       | 25yr 24 hr                   |
| All         | <5                                | < 300                                                                       | > 320                       | 1 yr 24 hr                   |
| All         | >5                                | > 300                                                                       | ≥ 320                       | 25yr 24 hr                   |
| All         | ≤5                                | 301 - 3000                                                                  | ≥ 320                       | 2 yr 24 hr                   |
| All         | >5                                | 301 - 3000                                                                  | ≥ 320                       | 25yr 24 hr                   |

/1 Agriculture is defined as being used in connection with the production of crops or livestock.

/2 Measured from the usual, mean low water height to the water surface during the emergency spillway design storm.

/3 As defined under "Scope"

/4 Spillway Storm is Type III

Table A10.5  
Emergency Spillway  
Minimum Design Storms /5

| Type/1      | Raised /2<br>Water<br>Height<br>(feet) | Total<br>Storage<br>/3 | Drainage<br>Area<br>(acres) | Emergency<br>Spillway<br>Design<br>Storm /4 |
|-------------|----------------------------------------|------------------------|-----------------------------|---------------------------------------------|
| All         | < 5                                    | < 50                   | ≤ 20                        | 10 yr 24 hr                                 |
| Agriculture | 5.1-20                                 | < 50                   | ≤ 20                        | 10 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | 5.1-20                                 | < 50                   | ≤ 20                        | 100 yr 24 hr                                |
| Agriculture | > 20                                   | < 50                   | ≤ 20                        | 25 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | > 20                                   | < 50                   | ≤ 20                        | 100 yr 24 hr                                |
| All         | ≤ 5                                    | ≥ 50                   | ≤ 20                        | 50 yr 24 hr                                 |
| Agriculture | 5.1-20                                 | ≥ 50                   | ≤ 20                        | 50 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | 5.1-20                                 | ≥ 50                   | ≤ 20                        | 100 yr 24 hr                                |
| Agriculture | > 20                                   | ≥ 50                   | ≤ 20                        | 50 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | > 20                                   | ≥ 50                   | ≥ 20                        | 100 yr 24 hr                                |
| All         | ≤ 5                                    | < 50                   | 21-320                      | 25 yr 24 hr                                 |
| Agriculture | 5.1-20                                 | < 50                   | 21-320                      | 25 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | 5.1-20                                 | < 50                   | 21-320                      | 100 yr 24 hr                                |
| Agriculture | > 20                                   | < 50                   | 21-320                      | 50 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | < 20                                   | < 50                   | 21-320                      | 100 yr 24 hr                                |
| All         | ≤ 5                                    | ≥ 50                   | 21-320                      | 50 yr 24 hr                                 |
| Agriculture | 5.1-20                                 | ≥ 50                   | 21-320                      | 50 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | 5.1-20                                 | ≥ 50                   | 21-320                      | 100 yr 24 hr                                |
| Agriculture | > 20                                   | ≥ 50                   | 21-320                      | 50 yr 24 hr                                 |
| Non-        |                                        |                        |                             |                                             |
| Agriculture | > 20                                   | ≥ 50                   | 21-320                      | 100 yr 24 hr                                |
| All         | ≤ 5                                    | all                    | > 320                       | 50 yr 24 hr                                 |
| All         | > 5                                    | all                    | > 320                       | 100 yr 24 hr                                |

/1 Agriculture use is defined as being used in connection with the production of crops or livestock.

/2 Measured from the usual, mean low water height to the water surface during the emergency spillway design storm.

/3 Measured below the crest of the emergency spillway.

/4 Any pond for which a state stream encroachment permit is required must use a minimum design storm of 100 yr 24 hr type III for the emergency spillway.

/5 Design storm is the type III

Table A10.7  
Minimum Gage for Corrugated Metal Pipe Risers  
2 2/3 - inch x 1/2 inch Corrugations  
Steel - Minimum Gage

| Fill Height Above Pipe<br>(feet) | Risers Only |    |    |
|----------------------------------|-------------|----|----|
|                                  | 54          | 60 | 66 |
| 1 - 15                           |             |    |    |
| 15 - 20                          | 10          | 8  | 8  |
| 20 - 25                          | 8           | 8  | 8  |

Table A10.8  
Aluminum Minimum Gage (inches)

| Risers Only |          |          |          |
|-------------|----------|----------|----------|
|             | 42       | 48       | 54       |
|             | 12(.105) | 10(.135) | 10(.135) |
| Risers Only | 12(.105) | 10(.135) | 10(.135) |
| 10(.135)    | 10(.135) | 10(.135) | 10(.135) |

## Construction Specifications For Embankment Ponds

### Foundation Preparation

The foundation area shall be cleared of trees, logs, stumps, roots, brush, boulders, sod and rubbish. If needed to establish vegetation, the topsoil and sod shall be stockpiled and spread on the completed dam and spillways. Foundation surfaces shall be sloped no steeper than a ratio of one horizontal to one vertical. The foundation area shall be thoroughly scarified before placement of the fill material. The surface shall have moisture added, or it shall be compacted if necessary so that the first layer of fill material can be compacted and bonded to the foundation.

The cutoff trench and any other required excavation shall be dug to the lines and grades shown on the plans or as staked in the field. If they are suitable, excavated materials may be used in the permanent fill. Existing stream channels in the foundation area shall be sloped no steeper than a ratio of one horizontal to one vertical. They shall be deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots, and other objectionable material and to accomodate compaction equipment.

Foundation areas shall be kept free of standing water when fill is placed on them.

### Fill Placement

The material placed in the fill shall be free of detrimental amounts of sod, roots, frozen soil, stones more than 6 inches in diameter (except rock fills) and other objectionable material.

Drainfill shall be kept from being contaminated by adjacent soil materials during placement by either placing it in a cleanly excavated trench or by keeping the drain at least one foot above the adjacent earthfill.

Selected drainfill and backfill material shall be placed around structures, pipe conduits, and antiseep collars at about the same rate on all sides to prevent damage from unequal loading.

Fill material shall be placed and spread beginning at the lowest point in the foundation and then bringing it up in horizontal layers thick enough that the required compaction can be obtained. The fill shall be constructed in continuous horizontal layers. If openings or sectionalized fills are required, the slope of the bonding surfaces between the embankment in place and the embankment to be placed shall not be steeper than the ratio of three horizontal to one vertical. The bonding surface shall be treated the same as that specified for the foundation to insure a good bond with the new fill.

The distribution and gradation of materials shall be

such that no lenses, pockets, streaks, or layers of material shall differ substantially in texture or gradation from the surrounding material. If it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the center and upstream parts of the fill. If zoned fills of substantially differing materials are specified, the zones shall be placed according to lines and grades shown on the drawings. The complete work shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

#### Moisture Control

The moisture content of the fill material shall be adequate for obtaining the required compaction. Material that is too wet shall be dried to meet this requirement, and material that is too dry shall be wetted and mixed until the requirement is met.

#### Compaction

Construction equipment shall be operated over each layer of fill to insure that the required compaction is obtained. Special equipment shall be used if needed to obtain the required compaction.

If a minimum required density is specified, each layer of fill shall be compacted as necessary to obtain that density.

Fill adjacent to structures, pipe conduits, and drainfill or antiseep collars shall be compacted to a density equivalent of that of the surrounding fill by hand tamping or by using manually directed power tampers or plate vibrators. Fill adjacent to concrete structures shall not be compacted until the concrete has had time to gain enough strength to support the load.

#### Protection

A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow area if soil and climatic conditions permit. If soil and climatic conditions preclude the use of vegetation and protection is needed, non-vegetated cover such as mulches or gravel may be used. In some places, temporary vegetation may be used until permanent vegetation can be established. The embankment and spillway shall be fenced if necessary to protect the vegetation.

Preparing the seedbed, seeding, fertilizing, and mulching shall comply with instructions in technical guidelines.

#### Principal Spillway

Corrugated metal pipe shall conform to the requirements of Federal Specifications WW-P-402 or WW-P-405, as

appropriate. Other pipe materials shall conform to the appropriate specifications. Antiseep collars shall be made of materials compatible with that of the pipe and shall be installed so that they are watertight. The pipe shall be installed according to the manufacturer's instructions. It may be firmly and uniformly bedded throughout its length and shall be installed to the line and grade shown on the drawings.

#### Concrete

The mix design and testing of concrete shall be consistent with the size requirements of the job. Mix requirements or necessary strength shall be specified. The type of cement, air entrainment, slump, aggregate, or other properties shall be specified as necessary. All concrete is to consist of a workable mix that can be placed and finished in an acceptable manner. Necessary curing shall be specified. Reinforcing steel shall be placed as indicated on the plans and shall be held securely in place during concrete placement. Subgrades and forms shall be installed to line and grade, and the forms shall be mortar tight and unyielding as the concrete is placed.

#### Foundation and Embankment Drains

Foundation and embankment drains, if required, shall be placed to the line and grade shown on the drawings. Detailed requirements for drain material and any required pipe shall be shown in the drawing and specifications for the job.

#### Excavated Ponds

The compacted excavation shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

#### Embankment and Excavated Ponds

Construction operations shall be carried out so that erosion and air and water pollution are minimized and held within legal limits. All work shall be conducted in a skillful manner. The completed job shall present a workman like appearance.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Fencing and cover to control erosion shall be established as needed. Appropriate safety measures, such as warning signs, rescue facilities, and fencing shall be provided as needed.

## APPENDIX A11

### REFERENCES

The following references are cited in the standards:

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6. Chow, Ven T., Open Channel Hydraulics, New York, N. Y., McGraw-Hill, 1959.
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- O'Knefski, R. C., C. R. Funk, R. E. Engel and R. W. Duell, "Lawn Grasses for New Jersey," Rutgers Turf Grass Proceedings, New Brunswick, N. J., Soils and Crops Offset Series No. 6, 1975, pp. 89-94.
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- Simons, Daryl B., Chen, Ung H., Swenson, Lawrence J., Hydraulic Test to Develop Criteria for the Use of Reno Matters, Civil Engineering Department, Engineering and Research Center, Colorado State University, Fort Collins, Colorado, March 1984.
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The following references are cited in the Appendices:

- a1. Fortier, S. F. and Scobey, F. C. - Permissible Canal Velocities, American Society of Civil Engineering Transactions, Vol. 89, pp. 940-956.
- a2. Lane, E. W. - Progress Report on Results of Studies on Design of Stable Channels, Hydraulic Laboratory Report No. Hyd-352, U. S. Bureau of Reclamation, June 1952.
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- a4. Einstein, H. A., The Bedload Function for Sediment Transportation in Open Channel Flow, USDA Technical Bulletin No. 1026, September 1950.
- a5. Vanoni, V. A. and Brooks, N. H., Laboratory Studies of the Roughness and Suspended Load of Alluvial Streams, U. S. Army Corps of Engineers, Missouri River Division Sediment Series No. 11, December 1957.

APPENDIX B

EXAMPLE FOR SEED SPECIFICATIONS

- A. The seed mixtures and specifications shall meet the minimum requirements as specified below.
1. Furnish the kinds and amounts of seed as indicated below to be seeded in all areas designated by the engineer, landscape architect, etc.  
  
(List mixtures and amounts of each species here)
  2. The minimum requirements for grass and legume seed used in the vegetative work are as follows:
    - a. All seed shall be labeled to show that it meets the requirements of the New Jersey State Seed Law.
    - b. Accumulated bag tags of seed used shall be submitted with the final pay estimate.
    - c. All seed shall have been tested within the 6 months immediately preceding the date of sowing such material on this job.
    - d. Inoculant - The inoculant for treating legume seed in the seed mixtures shall be a pure culture of nitrogen-fixing bacteria prepared for the species seeded. Inoculants shall not be used later than the date indicated on the container. Twice the supplier's recommended rate of inoculant will be used when seed is broadcasted; four times the recommended rate if hydroseeded.
    - e. The quality of the seed used shall conform to the guidelines shown on the following page.
- B. Grass seed mixtures checked by the Chief of the Bureau of Seed Certification, New Jersey Department of Agriculture, Trenton, New Jersey, will assure the purchaser that the mixture obtained is the mixture ordered.

TABLE B1-1  
QUALITY OF SEED\*

| <u>LEGUMES</u>                        | <u>Minimum**<br/>Seed Purity(%)</u> | <u>Minimum***<br/>Germination (%)</u> |
|---------------------------------------|-------------------------------------|---------------------------------------|
| Crownvetch                            | 95                                  | 68                                    |
| Lespedeza, Korean                     | 97                                  | 85                                    |
| Lespedeza, sericea                    | 98                                  | 85                                    |
| <u>GRASSES</u>                        |                                     |                                       |
| Bluegrass, Kentucky                   | 80                                  | 85                                    |
| Fescue, red (chewing and<br>creeping) | 97                                  | 80                                    |
| Fescue, tall (KY-31)                  | 97                                  | 85                                    |
| Redtop                                | 90                                  | 85                                    |
| Reed canarygrass                      | 96                                  | 80                                    |
| Ryegrass, annual or common            | 98                                  | 85                                    |
| Ryegrass, Perennial                   | 98                                  | 85                                    |
| Weeping lovegrass                     | 95                                  | 87                                    |
| <u>ANNUALS</u>                        |                                     |                                       |
| Barley                                | 98                                  | 90                                    |
| Millet                                | 99                                  | 80                                    |
| Oats                                  | 98                                  | 80                                    |
| Rye                                   | 98                                  | 85                                    |
| Sudangrass                            | 98                                  | 80                                    |

\*Seed containing prohibited or restricted noxious weeds will not be accepted.  
Prohibited noxious weeds - Bindweed, Canada thistle, quackgrass, hedge bind-  
weed, and horse nettle.  
Restricted noxious weeds - Wild garlic, bermudagrass, cheat, wild onion,  
corn cockle, dodder and wild onion, Johnsongrass, perennial sweet sudangrass,  
sorghum alnum and other perennial sorghum hybrids.

\*\*Seed should not contain in excess of 2.5 percent weed seed.

\*\*\*Lower germination is allowed if seeding rates are raised to compensate.

## APPENDIX B

TABLE B 2-1 GRASS AND LEGUME PLANTING GUIDE

| Common Name             | Botanical Name                                 | 1/<br>Germ.<br>Time<br>Days | Growth<br>Habit 2/<br>A | Season |      | Drainage Class         |              |                      |                            |                |        | Annual<br>Cover |             | pH<br>Range | Flooding<br>Tolerance | Erodible<br>Areas | Waterways &<br>Channels | Shade Tolerance | Foot Traffic | Playgrounds, Lawns<br>Athletic Fields | Beautification | Levels of 3/<br>Maintenance |     |  |
|-------------------------|------------------------------------------------|-----------------------------|-------------------------|--------|------|------------------------|--------------|----------------------|----------------------------|----------------|--------|-----------------|-------------|-------------|-----------------------|-------------------|-------------------------|-----------------|--------------|---------------------------------------|----------------|-----------------------------|-----|--|
|                         |                                                |                             |                         | Cool   | Warm | Dry, (Not<br>Droughty) | Well Drained | Mod. Well<br>Drained | Somewhat<br>Poorly Drained | Poorly Drained | Winter | Summer          | High        |             |                       |                   |                         |                 |              |                                       |                | Medium                      | Low |  |
|                         |                                                |                             |                         |        |      |                        |              |                      |                            |                |        |                 |             |             |                       |                   |                         |                 |              |                                       |                |                             |     |  |
| Barley<br>winter        | <u>Hordeum<br/>vulgare</u>                     | 7                           | A                       | X      | -    | -                      | X            | X                    | -                          | -              | X      | -               | 5.5<br>-7.8 | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | X                           | -   |  |
| Bermudagrass            | <u>Cynodon<br/>dactylon</u>                    | Plant<br>Veg.               | PL<br>RS                | -      | X    | X                      | X            | X                    | X                          | -              | -      | -               | 4.5<br>-7.5 | X           | X                     | X                 | -                       | X               | X            | X                                     | X              | X                           | X   |  |
| Bluegrass,<br>Kentucky  | <u>Poa<br/>pratensis</u>                       | 21-28                       | PL<br>R                 | X      | -    | -                      | X            | X                    | X                          | -              | -      | -               | 5.5<br>-7.0 | X           | X                     | X                 | -                       | X               | X            | X                                     | X              | X                           | X   |  |
| Canarygrass,<br>Reed    | <u>Phalaria<br/>arundinacea</u>                | 21                          | PL<br>R                 | X      | -    | X                      | X            | X                    | X                          | X              | -      | -               | 5.0<br>7.5  | X           | X                     | X                 | -                       | -               | -            | -                                     | X              | X                           | X   |  |
| Fescue,<br>creeping red | <u>Festuca<br/>rubra</u>                       | 21-28                       | PL<br>R                 | X      | -    | X                      | X            | X                    | X                          | -              | -      | -               | 4.5<br>-7.5 |             | X                     | X                 | X                       | X               | X            | X                                     | X              | X                           | X   |  |
| Fescue,<br>Chewings red | <u>Festuca<br/>comutata</u>                    | 21-28                       | PL                      | X      | -    | X                      | X            | X                    | X                          | -              | -      | -               | 4.5<br>-7.5 | X           | X                     | X                 | X                       | X               | X            | X                                     | X              | X                           | X   |  |
| Fescue,<br>tall (KY-31) | <u>Festuca<br/>arundinacea</u>                 | 14                          | PL<br>BR                | X      | -    | -                      | X            | X                    | X                          | -              | -      | -               | 5.0<br>-8.0 | X           | X                     | X                 | X                       | X               | X            | X                                     | X              | X                           | -   |  |
| Lovegrass,<br>weeping   | <u>Fragrostis<br/>curvula</u>                  | 5-14                        | Ps<br>B                 | -      | X    | X                      | X            | X                    | X                          | -              | -      | -               | 4.5<br>-8.0 | -           | X                     | -                 | -                       | -               | -            | -                                     | X              | X                           | X   |  |
| Millet                  | <u>Setaria<br/>&amp; Pennise-<br/>tum spp.</u> | 7-14                        | A                       | -      | X    | X                      | X            | X                    | X                          | -              | -      | X               | 4.5<br>-7.0 | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | -                           | X   |  |
| Oats                    | <u>Avena<br/>sativa</u>                        | 10                          | A                       | X      | -    | -                      | X            | X                    | -                          | -              | X      | -               | 5.5<br>-7   | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | X                           | -   |  |

- Notes: 1/ Germination time Days - No. of days required for majority of seeds to germinate and emerge under favorable conditions.
- 2/ Growth Habit: A - Annual; Bi - biennial; P - perennial; L - long-lived; s - short-lived; R - rhizomatous or spreads by rootstocks; S - stoloniferous; B - bunch
- 3/ Amount of fertilization and mowing tolerated.

TABLE B 2-1 GRASS AND LEGUME PLANTING GUIDE (cont'd)

| Common Name            | Botanical                   | 1/<br>Germ.<br>Time<br>Days | Growth<br>Habit 2/<br>Ps<br>A<br>PL<br>R<br>Bi | Season |      | Drainage Class         |              |                      |                            |                |        | Annual Cover |             | pH<br>Range | Flooding<br>Tolerance | Erodible<br>Areas | Waterways &<br>Channels | Shade Tolerance | Foot Traffic | Playgrounds, Lawns<br>Athletic Fields | Beautification | Levels of 3/<br>Maintenance |     |  |
|------------------------|-----------------------------|-----------------------------|------------------------------------------------|--------|------|------------------------|--------------|----------------------|----------------------------|----------------|--------|--------------|-------------|-------------|-----------------------|-------------------|-------------------------|-----------------|--------------|---------------------------------------|----------------|-----------------------------|-----|--|
|                        |                             |                             |                                                | Cool   | Warm | Dry, (Not<br>Droughty) | Well Drained | Mod. Well<br>Drained | Somewhat<br>Poorly Drained | Poorly Drained | Winter | Summer       | High        |             |                       |                   |                         |                 |              |                                       |                | Medium                      | Low |  |
| Redtop                 | <u>Agrostis alba</u>        | 10                          | Ps<br>B                                        | X      | -    | X                      | X            | X                    | X                          | X              | -      | -            | 4.0-<br>7.5 | X           | X                     | X                 | -                       | X               | X            | -                                     | -              | X                           | X   |  |
| Rye,<br>winter         | <u>Secale cereale</u>       | 7                           | A                                              | X      | -    | X                      | X            | X                    | -                          | -              | X      | -            | 5.5-<br>7   | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | X                           | X   |  |
| Ryegrass,<br>annual    | <u>Lolium multiflorum</u>   | 14                          | A                                              | X      | -    | -                      | X            | X                    | X                          | -              | X      | -            | 5.5-<br>7.5 | X           | X                     | -                 | X                       | -               | -            | -                                     | -              | X                           | X   |  |
| Ryegrass,<br>perennial | <u>Lolium perenne</u>       | 14                          | Ps<br>B                                        | X      | -    | -                      | X            | X                    | X                          | -              | -      | -            | 5.5-<br>7.5 | X           | X                     | -                 | X                       | X               | X            | X                                     | X              | X                           | -   |  |
| Sudangrass             | <u>Sorghum sudanense</u>    | 10                          | A                                              | -      | X    | X                      | X            | X                    | X                          | -              | -      | X            | 4.5-<br>7.5 | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | X                           | X   |  |
| Clover,<br>Alsike      | <u>Trifolium hybridum</u>   | 7                           | Ps<br>B                                        | X      | -    | -                      | X            | X                    | X                          | X              | -      | -            | 5.0-<br>7.5 | -           | -                     | -                 | -                       | -               | -            | X                                     | -              | X                           | X   |  |
| Crownvetch             | <u>Coronilla varia</u>      | 14-21                       | PL<br>R                                        | X      | X    | X                      | X            | X                    | -                          | -              | -      | -            | 5.5-<br>7.5 | -           | X                     | -                 | X                       | -               | -            | X                                     | -              | X                           | X   |  |
| Lespedeza,<br>Korean   | <u>Lespedeza stipulacea</u> | 7-14                        | A                                              | -      | X    | X                      | X            | X                    | X                          | -              | -      | X            | 5.5-<br>7.0 | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | -                           | X   |  |
| Lespedeza,<br>sericea  | <u>Lespedeza cuneata</u>    | 7-28                        | PL<br>B                                        | -      | X    | X                      | X            | X                    | X                          | -              | -      | -            | 5.5-<br>7.0 | -           | X                     | -                 | -                       | -               | -            | -                                     | -              | X                           | X   |  |
| Trefoil,<br>birdsfoot  | <u>Lotus corniculatus</u>   | 10                          | PL                                             | X      | -    | X                      | X            | X                    | X                          | -              | -      | -            | 5.0-<br>7.5 | X           | X                     | -                 | -                       | -               | -            | X                                     | -              | X                           | X   |  |
| Vetch, hairy           | <u>Vicia villosa</u>        | 10-14                       | A<br>Bi                                        | X      | -    | X                      | X            | X                    | -                          | -              | X      | -            | 5.0-<br>7.5 | -           | X                     | -                 | -                       | -               | -            | X                                     | X              | X                           | X   |  |

Notes: 1/ Germination time Days - No. of days required for majority of seeds to germinate and emerge under favorable conditions.

2/ Growth Habit: A - annual; Bi - biennial; P - perennial; L - long-lived; s - short-lived  
R - rhizomatous or spreads by rootstocks; S - stoloniferous; B - bunch

3/ Amount of fertilization and mowing tolerated.

# STATE OF NEW JERSEY

## SOIL EROSION AND SEDIMENT CONTROL ACT

CHAPTER 251, P.L. 1975\*

### 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. Jan. 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 act, (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.<sup>2</sup>

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.

e. "Erosion" means the detachment and movement of soil or rock fragments by water, wind, ice and gravity.

\* as amended by C. 264, P.L. 77 and C. 459, P.L. 79

f. "Plan" means a scheme which indicates land treatment measures, including a schedule of the timing for their installation, to minimize soil erosion and sedimentation.

g. "Project" means any disturbance of more than 5,000 square feet of the surface area of land (1) for the accomodation 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.

h. "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.

l. "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, § 3 eff. 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. 1. Section 4:24-45, 2. Section 4:24-1 et. seq.

#### 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 be pursuant to soil erosion control standards developed jointly by the Department of Transportation the Department of Environmental 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. Jan. 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, until such time as the local district determines that the municipality is not enforcing said ordinance.

L. 1975, C. 251, § 10 eff. Jan. 1, 1976, 1. Sections 4:24-43 to 4:24-4

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. 1, 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 a penalty of not less than \$25.00 nor more than \$3,000 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 NJSA 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.

##### 4:24-17.6 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.



# STATE OF NEW JERSEY

## SOIL EROSION AND SEDIMENT CONTROL ACT

RULES AND REGULATIONS  
pursuant to  
Chapter 251, P.L. 1975

Chapter 90  
NEW JERSEY ADMINISTRATIVE CODE  
Title 2  
Department of Agriculture  
Subtitle 1 State Soil Conservation Committee

### General Provisions

Authority  
N.J.S.A. 4:24-3 and 4:24-42

#### 2:90-1.1 PURPOSE

These rules and regulations are to implement P.L. 1975, Chapter 251, N.J.S.A. 4:29-39 et seq., hereinafter referred to as the act, to secure timely decisions by the soil conservation districts on application for development as defined therein, to assure adequate public notice of procedures thereunder and to continue effective administration of the law.

#### 2:90-1.2 DEFINITIONS

All definitions in Chapter 251, Laws of 1975, are incorporated in these regulations. The following words and terms, when used in this subchapter, shall have the following meanings, unless the context clearly indicates otherwise.

"Appeal" means a request for a review of district function.

"Hearing body" means the State Soil Conservation Committee.

#### 2:90-1.3 STANDARDS

(a) The State Soil Conservation Committee adopts and hereby incorporates into these rules by reference as standards for soil erosion and sediment control those standards published in the "Standards for Soil Erosion and Sediment Control in New Jersey", and identified as adopted or revised September 9, 1974, September 1979 and April 6, 1987 as the technical basis for local soil conservation district certification of soil erosion and sediment control plans. Specifically, these standards include the following.

|                                                   |        |
|---------------------------------------------------|--------|
| 1. Vegetative Standards:                          |        |
| Temporary Vegetative Cover for Soil Stabilization | 3.1.1  |
| Revised April 6, 1987                             |        |
| Permanent Vegetative Cover for Soil Stabilization | 3.2.1  |
| Revised April 6, 1987                             |        |
| Stabilization with Mulch Only                     | 3.3.1  |
| Revised September 1979                            |        |
| Permanent Stabilization with Sod                  | 3.4.1  |
| Revised September 1979                            |        |
| Topsoiling                                        | 3.5.1  |
| Revised September 1979                            |        |
| Maintaining Vegetation                            | 3.6.1  |
| Adopted September 1974                            |        |
| Dune Stabilization                                | 3.7.1  |
| Revised April 6, 1987                             |        |
| Trees, Shrubs and Vines                           | 3.8.1  |
| Adopted June 1974                                 |        |
| Protecting Trees During Construction              | 3.9.1  |
| Revised April 6, 1987                             |        |
| 2. Structural Standards:                          |        |
| Land Grading                                      | 4.1.1  |
| Revised April 6, 1987                             |        |
| Diversions                                        | 4.2.1  |
| Revised April 6, 1987                             |        |
| Grassed Waterway                                  | 4.3.1  |
| Revised April 6, 1987                             |        |
| Sediment Basin                                    | 4.4.1  |
| Revised April 6, 1987                             |        |
| Slope Protection Structures                       | 4.5.1  |
| Revised April 6, 1987                             |        |
| Channel Stabilization                             | 4.6.1  |
| Revised April 6, 1987                             |        |
| Detention Basin                                   | 4.7.1  |
| Revised April 6, 1987                             |        |
| Subsurface Drainage                               | 4.8.1  |
| Revised April 6, 1987                             |        |
| Traffic Control                                   | 4.9.1  |
| Revised April 6, 1987                             |        |
| Dust Control                                      | 4.10.1 |
| Revised April 6, 1987                             |        |
| Lined Waterway                                    | 4.11.1 |
| Revised April 6, 1987                             |        |
| Riprap                                            | 4.12.1 |
| Revised April 6, 1987                             |        |
| Sediment Barrier                                  | 4.13.1 |
| Revised April 6, 1987                             |        |
| Conduit Outlet Protection                         | 4.14.1 |
| Revised April 6, 1987                             |        |
| Stabilized Construction Entrance                  | 4.15.1 |
| Revised April 6, 1987                             |        |
| Storm Sewer Inlet Protection                      | 4.16.1 |
| Revised April 6, 1987                             |        |
| Grade Stabilization Structure                     | 4.17.1 |
| Adopted April 6, 1987                             |        |

|                       |        |
|-----------------------|--------|
| Parking Lot Storage   | 4.18.1 |
| Adopted April 6, 1987 |        |
| Rooftop Storage       | 4.19.1 |
| Adopted April 6, 1987 |        |
| Underground Tanks     | 4.20.1 |
| Adopted April 6, 1987 |        |

3. Copies of the Standards may be obtained by contacting the State Soil Conservation Committee or any of the soil conservation districts as follows:

- i. Bergen County Soil Conservation District;
- ii. Burlington County Soil Conservation District;
- iii. Camden County Soil Conservation District;
- iv. Cape-Atlantic Soil Conservation District (Cape May and Atlantic Counties);
- v. Cumberland County Soil Conservation District;
- vi. Freehold Soil Conservation District (Middlesex and Monmouth Counties);
- vii. Gloucester County Soil Conservation District;
- viii. Hudson, Essex and Passaic Soil Conservation District (Hudson, Essex and Passaic Counties);
- ix. Hunterdon County Soil Conservation District;
- x. Mercer County Soil Conservation District;
- xi. Morris County Soil Conservation District;
- xii. Ocean County Soil Conservation District;
- xiii. Salem County Soil Conservation District;
- xiv. Somerset-Union Soil Conservation District (Somerset and Union Counties);
- xv. Sussex County Soil Conservation District;
- xvi. Warren County Soil Conservation District.

(b) Where it can be satisfactorily demonstrated by the applicant that unique or innovative control measures or procedures not specified in this chapter may be applicable to specific sites, such measures may be proposed for consideration and utilized subject to approval by the soil conservation district and the State Soil Conservation Committee. Such approval may be granted only where it is determined that strict application of the standards as herein specified will not result in the most practical and effective control of soil erosion, sedimentation and storm-water damages.

(c) The location address, and telephone number of the local soil conservation districts may be obtained from the State Soil Conservation Committee, CN 330, Trenton, N.J. 08625, 609-292-5540.

## 2:90-1.4 APPLICATION

Applicants shall submit their plans to the district accompanied by an application form as prescribed by the committee. Such application shall indicate the information required to make a decision on certification of plans. Application forms are available at locations listed in section 3 of this subchapter.

(a) The district shall carry out the provisions of section 5 through 7 of the act.

(b) No project shall be undertaken by any person, partnership, or corporation, or other private or public agency unless the applicant has submitted to the district with local jurisdiction a plan for soil erosion and sediment control for such project, and the plan has been certified by the district as conforming to the standards promulgated by the New Jersey State Soil Conservation Committee. The plan shall provide for the control of soil erosion and sedimentation and utilize the standards for soil erosion and sediment control adopted by the New Jersey State Soil Conservation Committee.

(c) Approval by a municipal officer or agency for an application for development for any project shall be conditioned upon certification by the district for a plan for soil erosion and sediment control.

(d) The district shall review all soil erosion and sediment control plans submitted with a complete application and provide the applicant with a written notice indicating that:

- (1) The plan was certified;
- (2) The plan was certified subject to the attached conditions; or
- (3) The plan was denied certification with the reasons for the denial stated.

(e) The district shall include in the notice of certification or on the certified plan the following clause: "This certification is limited to the controls specified in this plan. It is not authorization to engage in the proposed land use unless such use has been previously approved by the municipality or other controlling agency."

(f) The district shall furnish the municipal planning board a copy of the certification or denial including all conditions and statements.

(g) The district shall grant or deny certification within 30 days from submission of a complete application. The district may be granted an additional 30 day review period through mutual written agreement with the applicant. Failure of the district to grant or deny certification within such period or such extension thereof shall constitute certification.

(h) The district shall require a new submission of the plan and application when a major revision is made.

#### 2:90-1.6 APPEAL PROCESS

(a) The State Soil Conservation Committee may, on its own motion or at the request of any person aggrieved of any action by the district, review the decision of any soil conservation district and make whatever determinations it deems appropriate in the matter. Any person aggrieved of any decision of a soil conservation district shall have ten days to appeal to the State Soil Conservation Committee which shall schedule a hearing and make a determination within 45 days of the petition for review. Any person against whom a stop-construction order is issued by any district shall also have the right to appeal to the State Soil Conservation Committee. Requests for appeal shall be addressed to:

Secretary, State Soil Conservation Committee  
CN 330  
Trenton, New Jersey 08625

(b) The committee shall appoint and utilize the hearing office procedures of the Department of Agriculture for fact-finding and recommendations to the committee.

(c) The committee shall send a written notice to the appellant of hearing, stating:

- (1) The application number;
- (2) Details of how decisions aggrieve appellant;
- (3) Date, time and place of hearing.

## 2.90-1.7 MUNICIPAL ORDINANCES

(a) Municipalities may adopt soil erosion and sediment control ordinances conforming to the standards promulgated by the committee. Adoption by the municipality of such ordinances must be completed by May 31, 1978, in order to qualify for an exemption from sections 5 through 9 of the act.

(b) Such ordinances adopted by municipalities may provide for the review and certification of plans by the district in accordance with these rules and regulations. In all such cases, there shall be written contracts with the municipalities requesting review and certification and fees shall be charged in accordance with the established district fee schedule.

(c) Municipalities shall obtain the approval of such ordinances by the committee before being exempt from the provisions of this act. The committee may continue after May 31, 1978, to review municipal ordinances enacted before May 31, 1978, and, if it so determines, grant approval to such ordinances.

(d) The committee shall secure review and comment by the district on municipal ordinances submitted to it. The district may recommend approval or disapproval to the committee. Written notification of approval or disapproval shall be sent to the district and municipality by the committee within 60 days.

(e) Municipalities having a soil erosion and sediment control ordinance presently in effect who wish to be exempt from sections 5 through 9 of this Act shall submit such ordinances to the committee for approval before May 31, 1978. Upon written notification of approval, which may be given after May 31, 1978, the municipality shall be exempt from sections 5 through 9 of this act.

(f) Districts shall annually review for compliance all soil erosion and sediment control ordinances enacted by municipalities within the district. The district shall inform the committee in writing of the results of this review by February 15 of each year. If at any time during the year, the district determines and so notifies the committee that any municipality is not enforcing its soil erosion and sediment control ordinance, the committee shall give written notice to the municipality that it is not longer exempt from section 5 through 9 of the act.

(g) Any proposed changes to a municipal ordinance which has received the approval of the committee, and is therefore exempt from sections 5 through 9 of the act, must be submitted to the committee for review and approval prior to enactment of the revised ordinance. For the municipality's exempt status to continue, all such changes must be found to be in accordance with the act and approved as such by the committee. Failure of the municipality to secure written notification of approval will result in discontinuance of municipal exemption from section 5 through 9 of the act.



## 2:90-1.8 FEES

Reasonable fees shall be set by the soil conservation districts based on cost. The fee schedule proposed by each district shall be approved by the committee before it is adopted by the district. Any person aggrieved of the set fee may appeal to the State Soil Conservation Committee as outlined in section 6 of this subchapter.

## 2:90-1.9 ENFORCEMENT

(a) Inspection of projects to determine execution in accordance with the certified plan shall be carried out by the district in close coordination with the municipal engineer and building inspector.

(b) The district shall determine whether or not the provisions of the certified plan are being followed by the applicant.

(c) The district shall inform the applicant in writing of observed deviation from the certified plan and request immediate compliance with the plan.

(d) The district or the municipality may issue a stop-construction order if the applicant takes no action to comply with the provisions of the certified plan.

(e) When a stop-construction order is issued, no further construction activity may take place until the applicant is in compliance with all provisions of the certified plan.

(f) The municipality shall not issue a certificate of occupancy for a project unless there has been compliance with the provisions of the certified plan for permanent measures. The district shall provide the municipality with a report of compliance upon completion of the project.

## 2:90-1.10 CHANGES

Changes in the certified plan must be submitted to the district for reevaluation and approval.

## 2:90-1.11 REPORTS

The districts shall submit quarterly reports to the committee giving number of applications, number of certifications, denials and number of reviews.

## 2:90-1.12 MUNICIPAL ORDINANCES FOR SOIL EROSION AND SEDIMENTATION CONTROL

(a) In order to protect the public interest and welfare and to enable the orderly continuance of municipal government in this State, the New Jersey State Soil Conservation Committee gave temporary approval to all municipal ordinances for soil erosion and sediment control adopted before January 1, 1976.

(b) Such temporary approval will be terminated on May 31, 1978.

## 2:90-1.13 MINING AND QUARRYING ACTIVITIES

Certification of a soil erosion and sediment control plan shall be required for the operation of all mining or quarrying activities regardless of proposed or actual related agricultural or horticultural use. Mining or quarrying activities shall include the extraction and removal of soils and/or sediment, as defined in N.J.S.A. 4:24-41, from the proposed site.

## 2:90-1.14 MINOR SUBDIVISION

An application for minor subdivision, where the subdivider certifies in writing that no land disturbance is proposed, shall not be deemed a project for the purposes of the Soil Erosion and Sediment Control Act of 1975, as amended, N.J.S.A. 4:24-39 et seq. Municipal approval of subsequent applications for construction permits on lots derived from such subdivisions shall be conditioned upon district certification of a plan for soil erosion and sediment control where more than 5,000 square feet of the surface area of land will be disturbed by the applicant for the concurrent construction of two or more single family dwelling units or other structures. Concurrent construction, with respect to this policy, means any activity where land is disturbed in two or more lots at the same time by the same applicant in the same subdivision.



## APPENDIX C3

### CHRONOLOGY OF

#### STANDARDS FOR SOIL EROSION AND SEDIMENT CONTROL IN NEW JERSEY

##### TITLE

FOREWORD AND ACKNOWLEDGEMENT: Published November 1982, Revised April 1987

PREFACE: Published June 1972, Deleted November 1982

INTRODUCTION: Published June 1972, Revised November, 1982, April 1987

GENERAL GUIDELINES: Published June 1972, Revised April 1987

##### VEGETATIVE STANDARDS

TEMPORARY VEGETATIVE COVER FOR SOIL STABILIZATION: Adopted June 1972, Revised January 1974, September 1979, April 1987

PERMANENT VEGETATIVE COVER FOR SOIL STABILIZATION: Adopted June 1972, Revised January 1974, September 1979, April 1987

STABILIZATION WITH MULCH ONLY: Adopted June 1972, Revised January 1974, September 1979

PERMANENT STABILIZATION WITH SOD: Adopted June 1972, Revised January 1974, September 1979

TOPSOILING: Adopted June 1972, Revised September 1979

MAINTAINING VEGETATION: Adopted June 1972

DUNE STABILIZATION: Adopted June 1972, Revised January 1974, September 1979, April 1987

TREES, SHRUBS AND VINES: Adopted January 1974

PROTECTING TREES DURING CONSTRUCTION: Adopted January 1974, Revised April 1987

##### STRUCTURAL STANDARDS

LAND GRADING: Adopted June 1972, Revised January 1974, April 1987

DIVERSIONS: Adopted June 1972, Revised September 1979, April 1987

GRASSED WATERWAY: Adopted June 1972, Revised September 1979, April 1987

SEDIMENT BASIN: Adopted June 1972, Revised January 1974, September 1979, April 1987

SLOPE PROTECTION STRUCTURES: Adopted June 1972, Revised January 1974, April 1987

CHANNEL STABILIZATION: Adopted June 1972, Revised January 1974, September 1979, April 1987

FLOODWATER RETARDING STRUCTURES: Adopted June 1972, Revised January 1974.

Changed to Detention Basin and Revised April 1987

DETENTION BASIN: Formerly Floodwater Retarding Structure. Revised April 1987

TRAFFIC CONTROL: Adopted January 1974, Revised April 1987

DUST CONTROL: Adopted January 1974, Revised September 1979, April 1987

LINED WATERWAY: Adopted September 1979, Revised April 1987

RIPRAP: Adopted September 1979, Revised April 1987

SEDIMENT BARRIER: Adopted September 1979, Revised April 1987

CONDUIT OUTLET PROTECTION: Adopted September 1979, Correction November 1980, Revised April 1987

STABILIZED CONSTRUCTION ENTRANCE: Adopted September 1979, Revised April 1987

STORM SEWER INLET PROTECTION: Adopted September 1979, Revised April 1987

GRADE STABILIZATION STRUCTURE: Adopted April 1987

PARKING LOT STORAGE: Adopted April 1987

ROOFTOP STORAGE: Adopted April 1987

UNDERGROUND TANKS: Adopted April 1987

#### APPENDIX A

THE UNIVERSAL SOIL LOSS EQUATION: Published June 1972, Revised September 1979, April 1987  
REQUIREMENTS FOR A SOIL EROSION AND SEDIMENT CONTROL PLAN: Published June 1972,  
Revised 1976, November 1982, April 1987  
GUIDE FOR CONSTRUCTION SPECIFICATIONS: Published June 1972, Revised July 1980,  
November 1982, April 1987  
MAINTENANCE OF STRUCTURAL MEASURES: Published June 1972, Revised April 1987  
GUIDE FOR INSTALLING SOIL STABILIZATION MATTING: Published June 1972  
DIVERSION AND GRASSED WATERWAY DESIGN PROCEDURE: Published July 1980, Revised April 1987  
SEDIMENT BASIN DESIGN PROCEDURE: Published July 1980  
CHANNEL STABILITY ANALYSIS PROCEDURE: Published July 1980, Revised April 1987  
MODIFIED RATIONAL METHOD: Published April 1987  
STRUCTURAL GUIDELINES FOR DETENTION BASIN: Published April 1987

REFERENCES: Published June 1972, Revised January 1974, July 19676, July 1980, April 1987

#### APPENDIX B

EXAMPLE FOR SEED SPECIFICATION: Published June 1972  
GRASS AND LEGUME PLANTING GUIDE: Published June 1972

#### APPENDIX C

SOIL EROSION AND SEDIMENT CONTROL ACT: Effective January 1, 1976, Amended October 18, 1977,  
February 27, 1980  
NEW JERSEY ADMINISTRATIVE CODE 2:90-1.1 et seq: Effective January 1, 1976,  
Amended January 5, 1978, July 3, 1980, Readopted June 24, 1985, Amended April 6, 1987  
CHRONOLOGY OF STANDARDS FOR SOIL EROSION AND SEDIMENT CONTROL IN NEW JERSEY:  
Published July 1980, Revised November 1982, April 1987

#### APPENDIX D

GLOSSARY: Published June 1972, Revised July 1980, April 1987

#### APPENDIX E

DIRECTORY SOIL CONSERVATION DISTRICTS IN NEW JERSEY: Published June 1972,  
Revised January 1974, July 1976, July 1980, November 1982, April 1987

APPENDIX D1

G L O S S A R Y

Acre-feet - An engineering term used to denote a volume 1 acre in area and 1 foot in depth.

Aggrade - The alteration of a channel caused by the deposition of sediment.

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.

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.

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.

Cutoff Trench - A long, narrow excavation constructed along the center line 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 Highwater - 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 on the lower side constructed across or at the bottom of a slope for the purpose of intercepting surface runoff.

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 overdry 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 long, narrow vegetative planting used to retard or collect sediment for the protection of diversions, drainage basins, or other structures.

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.

Flood Plain - The relatively flat area adjoining the channel of a natural stream which has been or may be hereafter covered by flood water.

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 highwater and the top of the dam, dike, levee or diversion ridge.

Grade Stabilization Structure - A structure for the purpose of stabilizing the grade of a watercourse, thereby preventing further headcutting or lowering of the channel grade.

Grading - Any stripping, cutting, filling, stockpiling, or any combination there-of and 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, used to conduct surface water.

Hood Inlet - A pipe entrance wherein the top edge of the pipe is extended  $\frac{3}{4}$  of the diameter beyond the bottom invert cut on an angle.

Hydrograph - A graph showing for a given point on a stream or for a given point in any drainage system, the discharge, stage, velocity, or other property of water with respect to time.

Inoculant - A peat carrier impregnated with bacteria which form a symbiotic relationship enabling legumes to utilize atmospheric nitrogen. Most of our 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, drainageways 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.

Mannings Formula - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

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.

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.

pH - A measure of acidity or basicity with pH 7 being neutral and pH 6.5 being a desirable degree of soil acidity. Basicity above pH 7 is rare in eastern U.S. soils.

Pipe Drop - A circular conduit used to convey water down steep grades.

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 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.

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.

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 earthen 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 controls 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 Horizon - A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

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.

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.

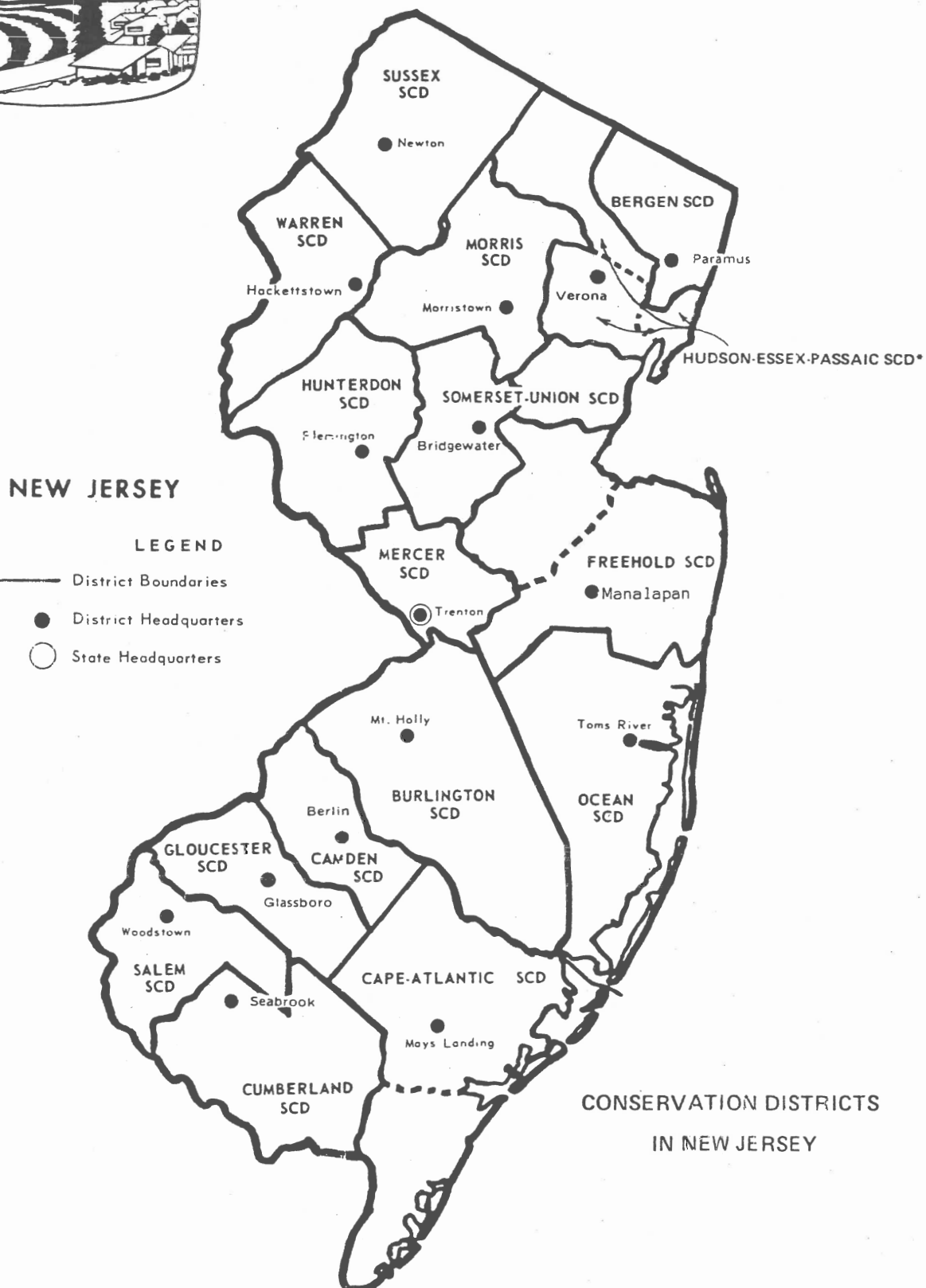
Vegetative Protection - Stabilization of erosive or sediment producing areas by covering the soil with:

- a. Permanent seeding, producing long-term vegetative cover,
- b. Short-term seeding, producing temporary vegetative cover, or
- c. Sodding, producing areas covered with a turf of perennial sod-forming grass.

Velocity - The rate of flow measured in feet per second.

Waterway - A natural course or constructed channel for the flow of water. See grassed waterway.





\* HEP Headquarters in Verona



SOIL CONSERVATION DISTRICTS IN NEW JERSEY

| NAME                                   | ADDRESS                                                                                | TELEPHONE NUMBER            |
|----------------------------------------|----------------------------------------------------------------------------------------|-----------------------------|
| BERGEN                                 | 327 Ridgewood Avenue<br>Paramus 07652                                                  | 201-261-4407<br>or 538-1552 |
| BURLINGTON                             | Cramer Building, Route 38<br>Mount Holly 08060                                         | 609-267-7410<br>or 267-0811 |
| CAMDEN                                 | Municipal Building<br>59 South White Horse Pike<br>Berlin 08009                        | 609-767-6299<br>or 767-3977 |
| CAPE-ATLANTIC                          | Atlantic County Office Building<br>1200 West Harding Highway<br>Mays Landing 08330     | 609-625-3144<br>or 625-9400 |
| CUMBERLAND                             | P. O. Box 5148, Route 77<br>Seabrook 08302                                             | 609-451-2422<br>or 451-2144 |
| FREEHOLD<br>(Monmouth & Middlesex Co.) | 211 Freehold Road<br>Manalapan, 07726                                                  | 201-446-2300<br>or 462-1079 |
| GLOUCESTER                             | Jamesway Plaza<br>North Delsea Drive, Box 507<br>Glassboro 08028                       | 609-881-8323<br>or 582-9027 |
| HUDSON, ESSEX & PASSAIC                | 571 Bloomfield Avenue<br>Verona 07044                                                  | 201-239-1886<br>or 239-1939 |
| HUNTERDON                              | Extension Center Building<br>4 Gauntt Place<br>Flemington 08822                        | 201-782-3915<br>or 788-1397 |
| MERCER                                 | 930 Spruce Street<br>Trenton 08648                                                     | 609-989-6847<br>or 695-5415 |
| MORRIS                                 | Court House<br>Morristown 07960<br>(Location - W. Hanover Avenue)<br>(Morris Township) | 201-829-8699<br>or 538-1552 |
| OCEAN                                  | 6 Mott Place, CN 2191<br>Toms River 08753                                              | 201-244-7048<br>or 349-1007 |
| SALEM                                  | 1000 East, Route 40, Box 47<br>Woodstown 08098                                         | 609-769-1124                |
| SOMERSET-UNION                         | Somerset County 4-H Building<br>308 Milltown Road<br>Bridgewater 08807                 | 201-526-2701<br>or 725-3848 |
| SUSSEX                                 | R.D. #7, Box 13<br>Route 206 South<br>Newton 07860                                     | 201-383-7315<br>or 383-3800 |
| WARREN                                 | Stiger Street<br>Hackettstown 07840                                                    | 201-852-2579<br>or 852-5450 |

STATE SOIL CONSERVATION COMMITTEE  
CN 330, TRENTON, NJ 08625  
TEL: 609-292-5540



*Standards for*  
***Soil Erosion and  
Sediment Control***  
*in New Jersey*

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