

**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.

Water Quality Enhancement

The primary benefit to water quality is through the prevention of steep slope erosion, by providing a means to safely convey stormwater runoff down to a stable area or condition. Total suspended solids discharged from the site, both during and after construction will be reduced.

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 25-1 and 25-2.

Protection against scour at the discharge end of the open flume shall be provided in the form of an energy dissipater or other measures such as 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 25-1.
2. T - is the top width of parabolic flumes. The minimum top widths and maximum drainage areas shall conform to Table 25-2.
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 25-2.
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 25-1.

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 25-1 and 25-2 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 25-1 and 25-2 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 25-1

## FLUMES WITH TRAPEZOIDAL AND RECTANGULAR SECTIONS

Bottom Widths And Drainage Area For Trapezoidal Flumes With Flow Depths Equal to 10 Inches	
Bottom Width (feet)	Drainage Area (acres)
2	7
4	10
6	13
8	16
10	19
12	24

Bottom Widths And Drainage Area For Rectangular Flumes With Flow Depths Equal to 10 Inches	
Bottom Width (feet)	Drainage Area (acres)
2	3
4	5
6	10
8	13
10	16
12	20

Dikes to be 2.5 feet in height above flume entrance.

TABLE 25-2

## FLUMES WITH PARABOLIC SECTIONS

Depths Equal to 1 Foot	
Top Width (feet)	Drainage Area (acres)
4	3
6	4
8	5
10	6
12	7
14	8

Depths Equal to 1.5 Feet	
Top Width (feet)	Drainage Area (acres)
4	4
6	5
8	5
10	7
12	8
14	10
16	11

Dikes to be 2.5 feet in height above flume entrance

Riprap Lined Chutes

Stable rock sizes and flow depths for riprap-lined channels having gradients between 2 percent and 40 percent may be determined using the following detailed design process from Design of Rock Chutes by Robinson, Rice, and Kadavy.

For channel slopes between 2% and 10%:

$$D_{50} = [q(S)^{1.5}/4.75(10)^{-3}]^{1/1.89}$$

For channel slopes between 10% and 40%:

$$D_{50} = [q(S)^{0.58}/3.93(10)^{-2}]^{1/1.89}$$

$$z = [n(q)/1.486(S)^{0.50}]^{3/5}$$

$$\text{where } n = 0.047(D_{50}S)^{0.147}$$

$D_{50}$  = Particle (stone) size for which 50% of  
the sample is finer, in.

$S$  = Bed slope, ft./ft.

$z$  = Flow depth, ft.

$q$  = Unit discharge, ft<sup>3</sup>/s/ft

(Total discharge÷Bottom width)

Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical velocity shall be restricted to straight reaches. Maximum channel side slope shall not exceed 2:1 for this method.

Pipe Drops

The design capacity shall be as required to pass peak runoff from a 10-year frequency storm.

Peak discharge values shall be determined by the following:

1. Rational Method - for peak discharge of uniform drainage areas as outlined in Technical Manual for Land Use Regulation Program, Bureau of Inland and Coastal Regulations Stream Encroachment Permits, Trenton, N.J. September 1997 or subsequent editions
2. USDA-NRCS Win TR-55 or Win TR-20
3. U.S. Army Corps of Engineers HEC HMS
4. Other methods which produce similar results to the models listed above.

Pipe capacities may be determined from charts in Appendix 11, Chapter 6, Ref. (1), or other accepted sources.

A hood inlet type entrance should be used as shown in Figure 25-2. The pipe drop inlet shall be protected by riprap or concrete.

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  $\frac{1}{4}$  to  $\frac{1}{2}$  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, pg. 12-1.

### Unconcentrated surface runoff from paved surfaces

A permanent vegetative cover shall be established through seeding or pegged (anchored) sod on all slopes receiving unconcentrated runoff from paved surfaces. Seeded slopes shall utilize a non-biodegradable turf reinforcement matting, installed in accordance with manufacturers instructions.

Slopes receiving unconcentrated surface flows shall not exceed those shown in the NJDEP Best Management Practices Manual, Chapter 9.10, Table 9.10-2 (reproduced below). An optional stone trench installed along the edge of pavement may be added to aid in the prevention of flow concentration. Maximum contributing drainage areas shall be as defined in Chapter 9.10 of the Manual.

For receiving **slopes that exceed** the thresholds designated in Table 9.10-2 of the BMP Manual, a properly designed slope protection structure must be provided in accordance with this Standard.

For receiving slopes with **contributing drainage areas that exceed** the thresholds defined in Chapter 9.10 of the BMP Manual, a properly designed slope protection structure must be provided in accordance with this Standard

If flows are to be directed and controlled via curb cuts, scuppers or other methods which will result in the concentration of flows., then a properly designed slope protection structure must be provided in accordance with this Standard.

#### Maximum slopes for unconcentrated flows from paved surfaces (reproduced from NJDEP BMP Manual Table 9.10-2)

Soil type	Maximum Slope (percent)
Sand	7
Sandy Loam	8
Loam, Silt Loam	8
Sandy Clay Loam	8
Clay Loam, Silty Clay, Clay	8

Figure 25-1

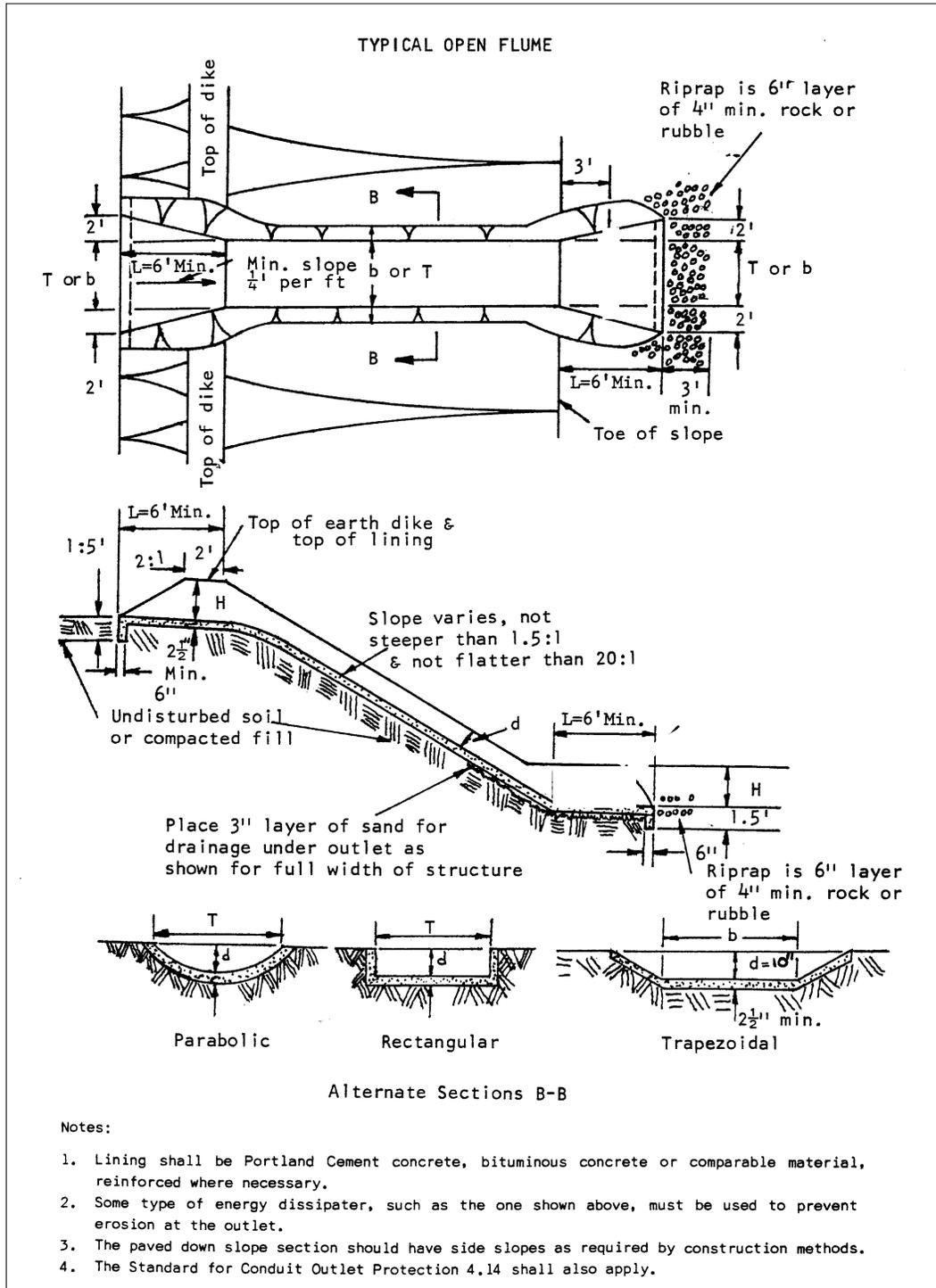


FIGURE 25-2

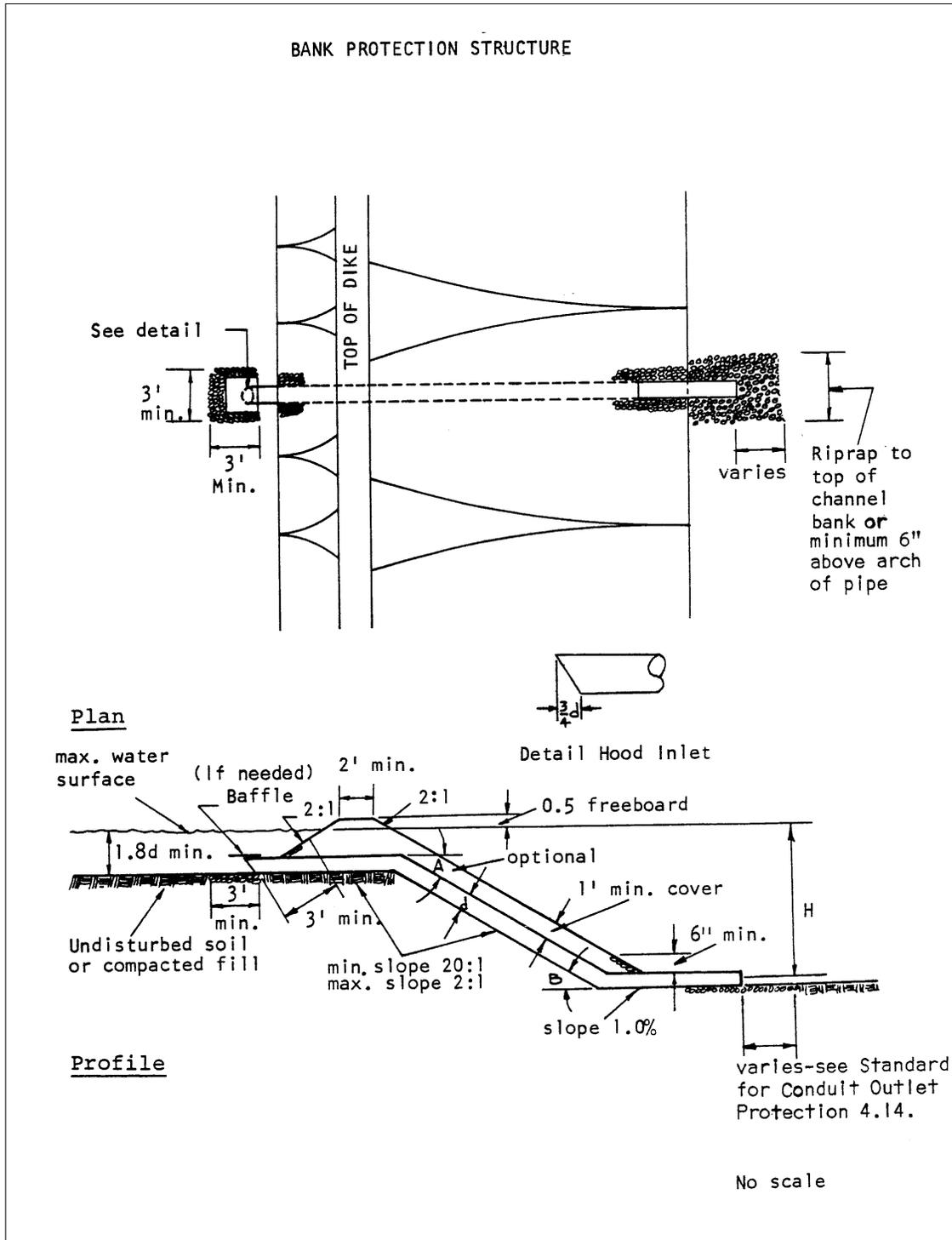


Figure 25-3: Pipe Slope Drain

