STD & SPEC 3.13

# TEMPORARY SEDIMENT TRAP

ST

## Definition

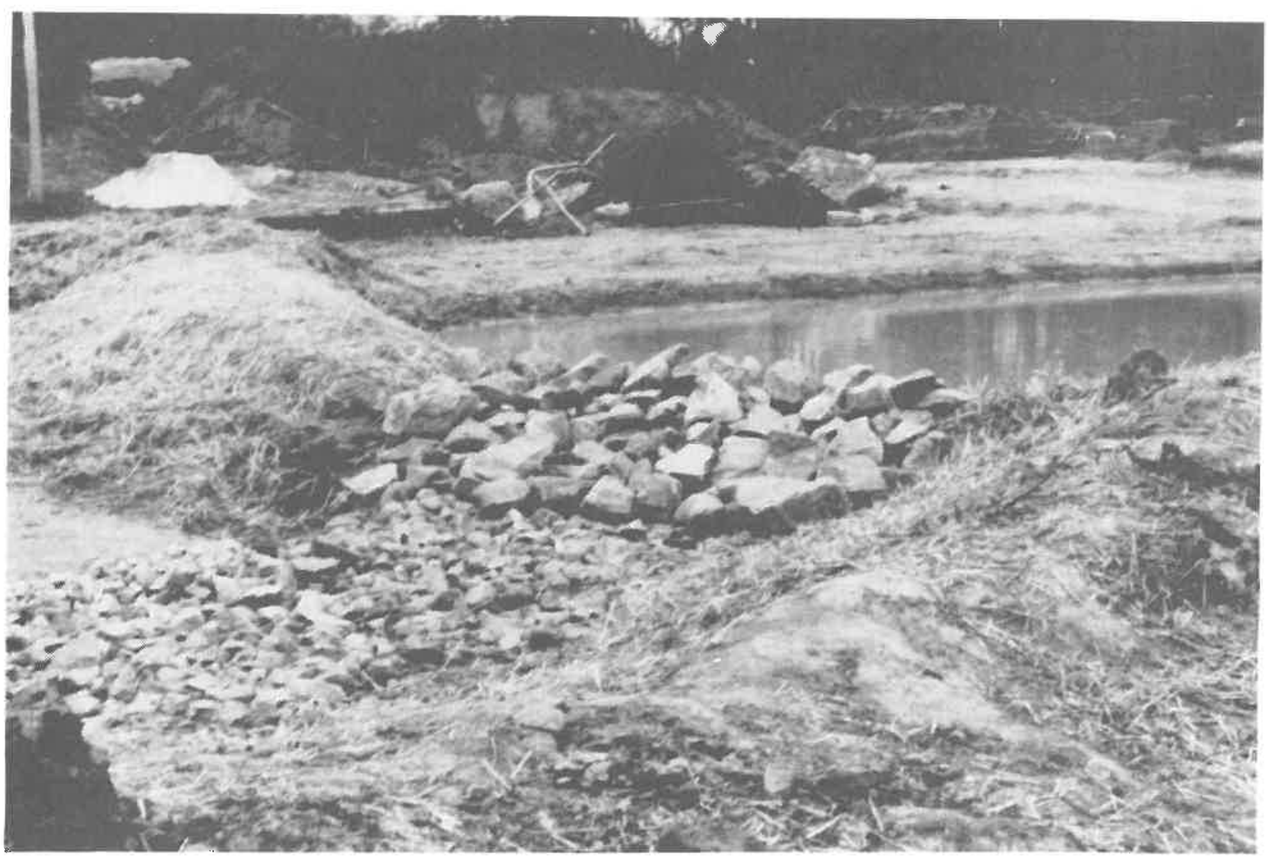
A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

## Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

## Conditions Where Practice Applies

1. Below disturbed areas where the total contributing drainage area is less than 3 acres.



2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).

3. The sediment trap may be constructed either independently or in conjunction with a TEMPORARY DIVERSION DIKE (Std. & Spec. 3.09).

## Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is 3 acres or greater, refer to SEDIMENT BASIN (Std. & Spec. 3.14).

Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Recent studies have been conducted on the performance of sediment traps (and basins) which were constructed using the design criteria found in previous editions of this handbook. The studies indicate that the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow. To achieve a more acceptable removal rate (60%), it was necessary to revise the design of these measures in this handbook. The total initial storage volume for both the sediment trap and the TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14) has been doubled. There are both a "wet" storage volume and a drawdown or "dry" storage volume which help to enhance sediment fall-out and prevent excessive sediment losses during large storm events which occur during the advanced stages of land disturbance (28).

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in this handbook, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

## Design Criteria

### Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \times A_1 \times D_1$$

where,

$V_1$ = the wet storage volume in cubic feet

$A_1$ = the surface area of the flooded area at the base of the stone outlet in square feet

$D_1$ = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet

The dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2} \times D_2$$

where,

$V_2$ = the dry storage volume in cubic feet

$A_1$ = the surface area of the flooded area at the base of the stone outlet in square feet

$A_2$ = the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square feet

$D_2$ = the depth in feet, measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

Note: Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

## Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 4 feet to facilitate clean-out and for site safety considerations.

## Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be VDOT #3, #357, or #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth which meets the physical requirements noted in Std. & Spec. 3.19, RIPRAP shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 6 feet times the number of acres comprising the total area draining to the trap. The crest of the stone outlet must be at least 1.0 foot below the top of the embankment to ensure that the flow will travel over the stone and not the embankment. The outlet shall be configured as noted in Plate 3.13-2.

## Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Plate 3.13-1. Side slopes of the embankment shall be 2:1 or flatter.

## Removal

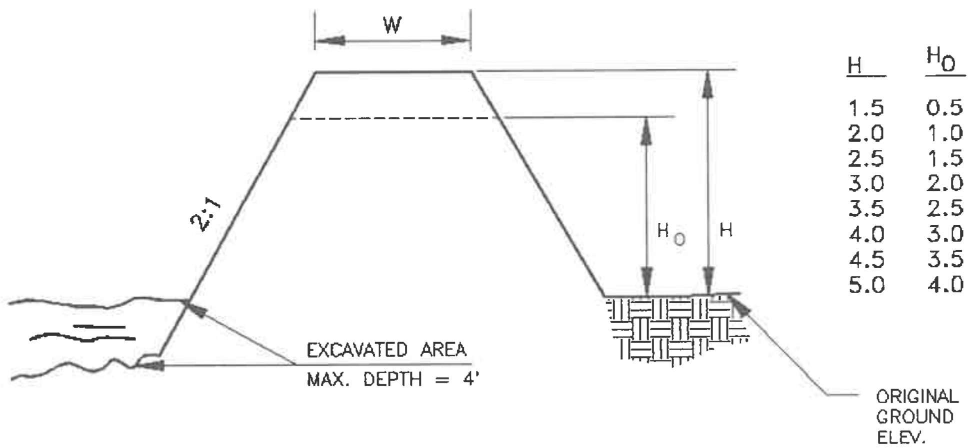
Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

## Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.

2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 6-inch layers by traversing with construction equipment.

## MINIMUM TOP WIDTH (W) REQUIRED FOR SEDIMENT TRAP EMBANKMENTS ACCORDING TO HEIGHT OF EMBANKMENT (FEET)




| H | $H_O$ | W |
|---|---|---|
| 1.5 | 0.5 | 2.0 |
| 2.0 | 1.0 | 2.0 |
| 2.5 | 1.5 | 2.5 |
| 3.0 | 2.0 | 2.5 |
| 3.5 | 2.5 | 3.0 |
| 4.0 | 3.0 | 3.0 |
| 4.5 | 3.5 | 4.0 |
| 5.0 | 4.0 | 4.5 |

Source: Va. DSWC

Plate 3.13-1

3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Std. & Spec.'s 3.31 and 3.32) immediately after installation.

4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.

5. The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.

6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

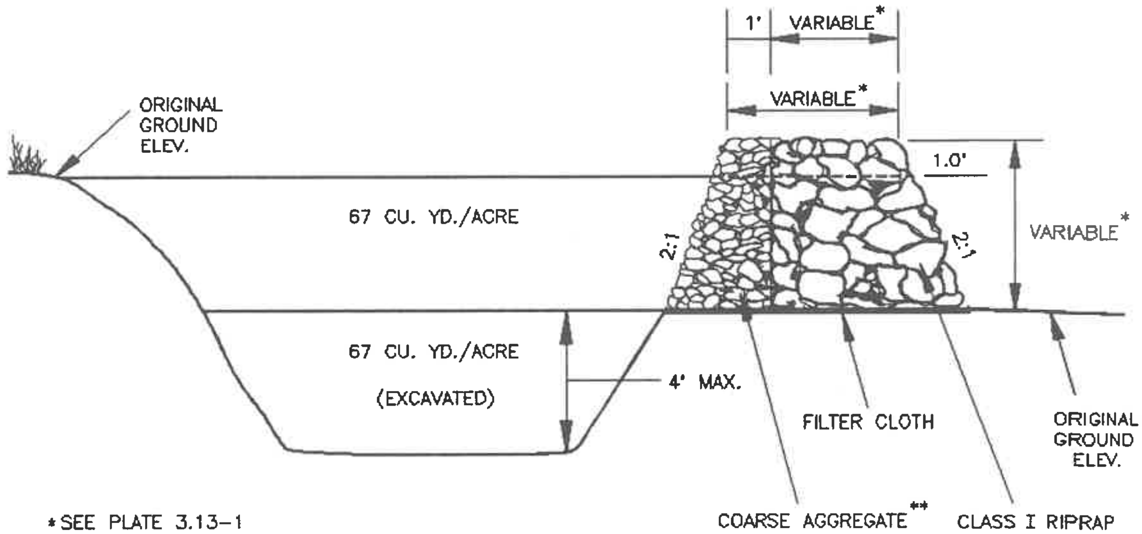
## Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

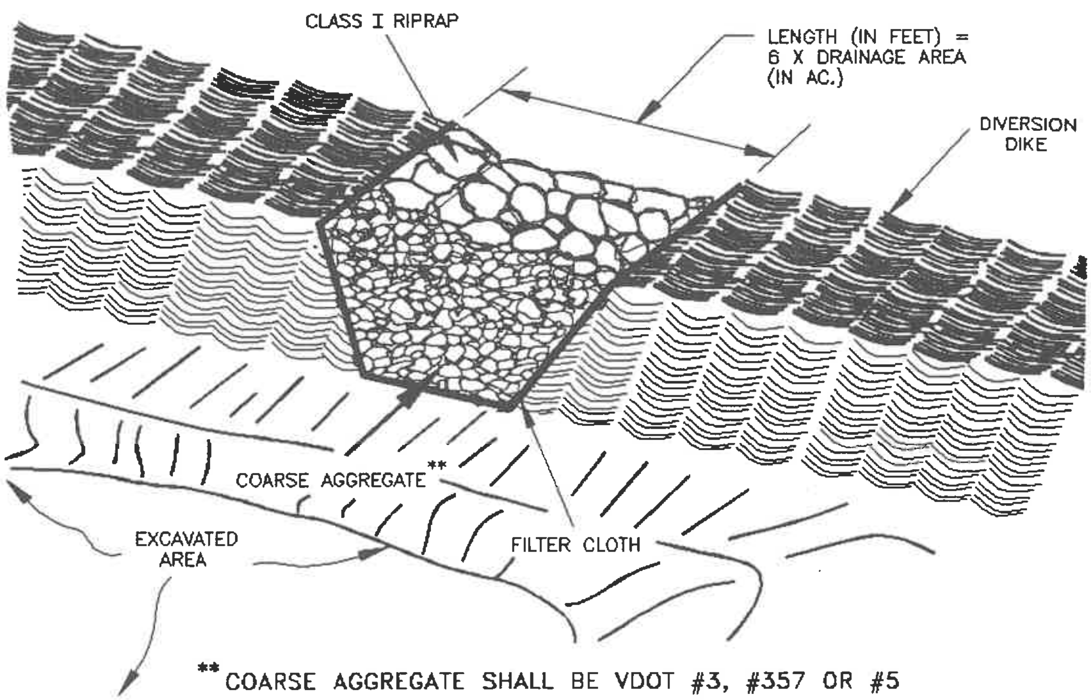
2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.

3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.

# TEMPORARY SEDIMENT TRAP




CROSS SECTION OF OUTLET




**COARSE AGGREGATE SHALL BE VDOT #3, #357 OR #5

OUTLET (PERSPECTIVE VIEW)

Source: Va. DSWC

Plate 3.13-2

## STD & SPEC 3.14

# TEMPORARY SEDIMENT BASIN

SB

### Definition

A temporary barrier or dam with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway.

### Purpose

To detain sediment-laden runoff from disturbed areas in "wet" and "dry" storage long enough for the majority of the sediment to settle out.

### Conditions Where Practice Applies

Below disturbed areas where the total contributing drainage area is equal to or greater than three (3) acres. There must be sufficient space and appropriate topography for the construction of a temporary impoundment. These structures are limited to a useful life of 18 months unless they are designed as permanent impoundments. It is recommended that these measures, by virtue of their potential to impound large volumes of water, be designed by a qualified professional.

## Planning Considerations

### Effectiveness

Sediment basins constructed as per this specification are, at best, 60% effective in trapping sediment which flows into them during large storm events (those which cause flow from the outfall pipe) or during periods of minimal vegetative cover at a construction site (28). Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc., to reduce the amount of sediment flowing into the basin.

The sediment removal efficiency problems noted for previous designs of the TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) are also applicable to the sediment basin. In order to contain the majority of sediment which flows to the structure, the basin should have a permanent pool, or wet storage area and a dry storage area which dewaters over time. The volume of the permanent pool (needed to protect against re-suspension of sediment and promote better settling conditions) must be 67 cubic yards per acre of drainage area and the volume of dry storage above the permanent pool (needed to prevent "short-circuiting" of basin during larger storm events) must be an additional 67 cubic yards per acre of drainage area. The total storage volume of the basin at the principal spillway riser crest will therefore be 134 cubic yards per acre of drainage area (28).

Sediment basins, along with other perimeter controls which are intended to trap sediment, shall be constructed as a first step in any land disturbing activity and shall be made functional before upslope land disturbance takes place (MS #4).

### Location

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

### Multiple Use

Sediment basins may remain in place after construction and final site stabilization are completed to serve as permanent stormwater management structures. Because the most practical location for a sediment basin is often the most practical location for a stormwater management basin, it is often desirable to utilize these structures for permanent stormwater management purposes. It should be noted, however, that in most cases, a typical structure's outfall system will vary during the construction and post-construction periods. Care must be taken to avoid constructing an outfall system which will achieve the desired post-construction quantity or quality control but will not provide the necessary medium for the containment and settling of sediment-laden construction runoff. Notably, the design for permanent ponds is beyond the scope of these standards and specifications.

## Design Criteria

### Maximum Drainage Area

The maximum allowable drainage area into a temporary sediment basin shall be 100 acres. It is recommended that when the drainage area to any one temporary basin exceeds 50 acres, an alternative design procedure which more accurately defines the specific hydrology and hydraulics of the site and the control measure be used. The design procedures in this standard and specification do not generate hydrographs, utilize storage volumes or provide a routing of the design storms; for a large drainage area, this may result in an excessively large diameter riser or an oversized basin. Notably, design considerations which are more accurate and project-specific than those in this specification are acceptable and encouraged with any size basin.

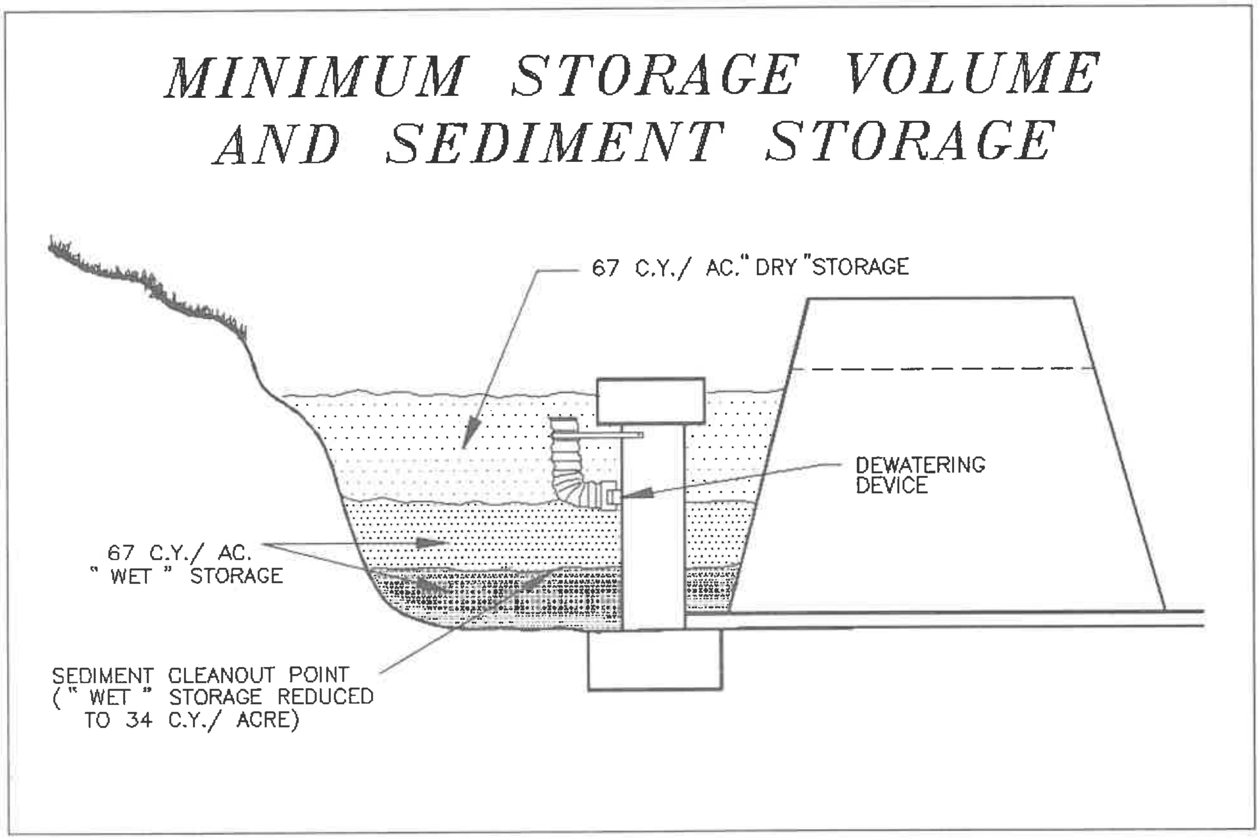
### Basin Capacity

The design storage capacity of the basin must be at least 134 cubic yards per acre of total contributing drainage area (see Plate 3.14-1). One half of the design volume (or 67 cubic yards) shall be in the form of a permanent pool, and the remaining half as drawdown volume. The volume of the permanent pool shall be measured from the low point of the basin to the elevation corresponding to one half the total storage volume. The volume of the drawdown area shall be measured from the elevation of the permanent pool to the crest of the principal spillway (riser pipe). Sediment should be removed from the basin when the volume of the permanent pool has been reduced by one half. In no case shall the sediment cleanout level be higher than one foot below the bottom of the dewatering device. The elevation of the sediment cleanout level should be calculated and clearly marked on the plans and riser (since this part of the riser normally will be under water, a mark should appear above the permanent pool a measured distance above the cleanout elevation).

While attempting to attain the desired storage capacities, efforts should be made to keep embankment heights to a minimum. This precaution takes on added significance when the basin will only serve as a temporary measure or will need substantial retrofitting prior to functioning as a permanent measure. When site topography permits, the designer should give strong consideration to the use of excavation to obtain the required capacity and to possibly reduce the height of the embankment. This excavation can be performed in a manner which creates a wet storage forebay area or which increases the storage capacity over the entire length of the basin.

### Basin Shape

To improve sediment trapping efficiency of the basin, the effective flow length must be twice the effective flow width. This basin shape may be attained by properly selecting the site of the basin, by excavation, or by the use of baffles. See Appendix 3.14-a for pertinent design details.




Source: Va. DSWC Plate 3.14-1

Embankment Cross-Section

For embankments of less than 10 feet, the embankment must have a minimum top width of 6 feet, and the side slopes must be 2:1 or flatter. In the case of an embankment 10 to 14 feet in height, the minimum top width shall be 8 feet and the side slopes shall be 2½:1 or flatter. For 15-foot embankments (maximum allowed under these specifications), the top width must be 10 feet with maximum 2½:1 side slopes.

Spillway Design

The outlets for the basin shall consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 25-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 25-year storm. However, an attempt to provide a separate emergency spillway should always be made (refer to "Emergency Spillway" later on in this section). Runoff computations shall be based upon the soil cover conditions which are expected to prevail during the life of the basin. Refer to Chapter 5 for calculation of the peak rate of runoff. Notably, the flow through the dewatering orifice cannot be utilized when calculating the 25-year storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

The spillways designed by the procedures contained in the standard and specification will not necessarily result in any reduction in the peak rate of runoff. If a reduction in peak runoff is desired, the appropriate hydrographs/storm routings should be generated to choose the basin and outlet sizes.

## Principal Spillway

For maximum effectiveness, the principal spillway should consist of a vertical pipe or box of corrugated metal or reinforced concrete, with a minimum diameter of 15 inches, joined by a watertight connection to a horizontal pipe (barrel) extending through the embankment and outletting beyond the downstream toe of the fill. If the principal spillway is used in conjunction with a separate emergency spillway, the principal spillway must be designed to pass at least the peak flow expected from of 2-year storm. If no emergency spillway is used, the principal spillway must be designed to pass the entire peak flow expected from a 25-year storm (see Appendix 3.14-a for design details).

### Design Elevations

The crest of the principal spillway shall be set at the elevation corresponding to the storage volume required (67 cubic yards/acre wet storage plus 67 cubic yards/acre dry storage = 134 cubic yards/acre). If the principal spillway is used in conjunction with an emergency spillway, this elevation shall be a minimum of 1.0 foot below the crest of the emergency spillway. In addition, a minimum freeboard of 1.0 foot shall be provided between the design high water (25-year) and the top of the embankment (see Plate 3.14-2). If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 feet below the top of the embankment; also, a minimum freeboard of 2.0 feet shall be provided between the design high water and the top of the embankment.

### Anti-Vortex Device and Trash Rack

An anti-vortex device and trash rack shall be attached to the top of the principal spillway to improve the flow characteristics of water into the spillway and prevent floating debris from blocking the principal spillway. The anti-vortex device shall be of the concentric type as shown in Plate 3.14-10. See Appendix 3.14-a for design procedures for the anti-vortex device and trash rack.

### Dewatering

Provisions shall be made to dewater the basin down to the permanent pool elevation. Recent studies by the Washington Metropolitan Council of Governments have shown that it is necessary to provide at least a 6-hour drawdown time in the dry storage area in order to achieve up to 60% removal of sediment (28).

Dewatering of the dry storage should be done in a manner which removes the "cleaner" water without removing the potentially sediment-laden water found in the wet storage area or any appreciable quantities of floating debris. An economical and efficient device for performing the drawdown is a section of perforated vertical tubing which is connected to the principal spillway at two locations. See Plate 3.14-15 which depicts the orientation of such a device. By virtue of the potential for the dewatering device or orifice becoming clogged, no credit is given for drawdown by the device in the calculation of the principal or emergency spillway locations. The method for sizing the dewatering orifice and the associated flexible conduit is located in Appendix 3.14-a.

Base

The base of the principal spillway must be firmly anchored to prevent its floating. If the riser of the spillway is greater than 10 feet in height, computations must be made to determine the anchoring requirements. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

For risers 10 feet or less in height, the anchoring may be done in one of the two following ways:

1. A concrete base 18 inches thick and twice the width of riser diameter shall be used and the riser embedded 6 inches into the concrete. See Plate 3.14-3 and Appendix 3.14-a for design details.

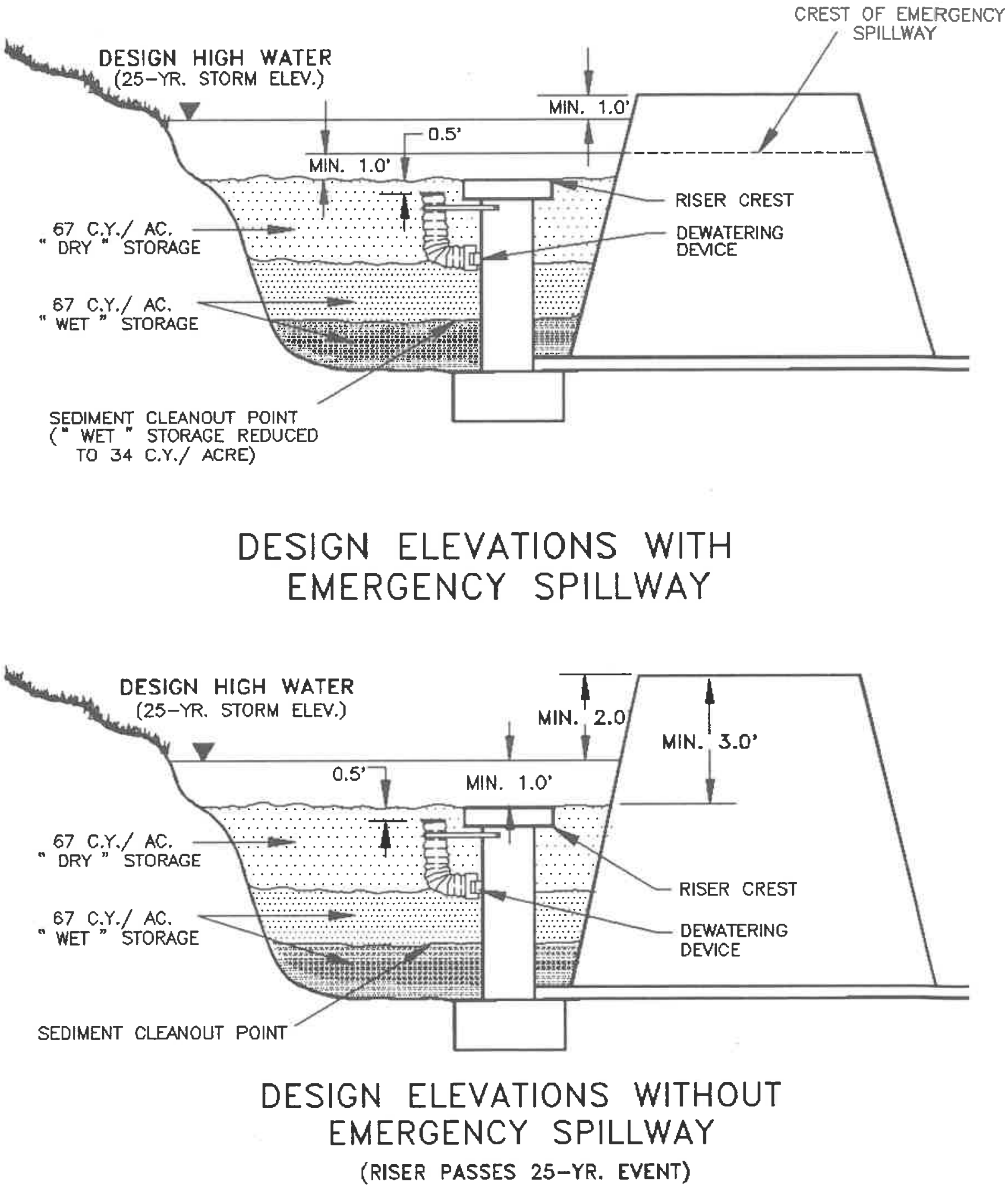
2. A square steel plate, a minimum of 1/4-inch thick and having a width equal to twice the diameter of the riser shall be used; it shall be covered with 2.5 feet of stone, gravel, or compacted soil to prevent flotation. See Plate 3.14-3 and Appendix 3.14-a for design details.

   Note: If the steel base is used, special attention should be given to compaction so that 95% compaction is achieved over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidently during removal of sediment from basin.

Barrel

The barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The connection between the riser and the barrel must be watertight. The outlet of the barrel must be protected to prevent erosion or scour of downstream area. See Appendix 3.14-a for design details.

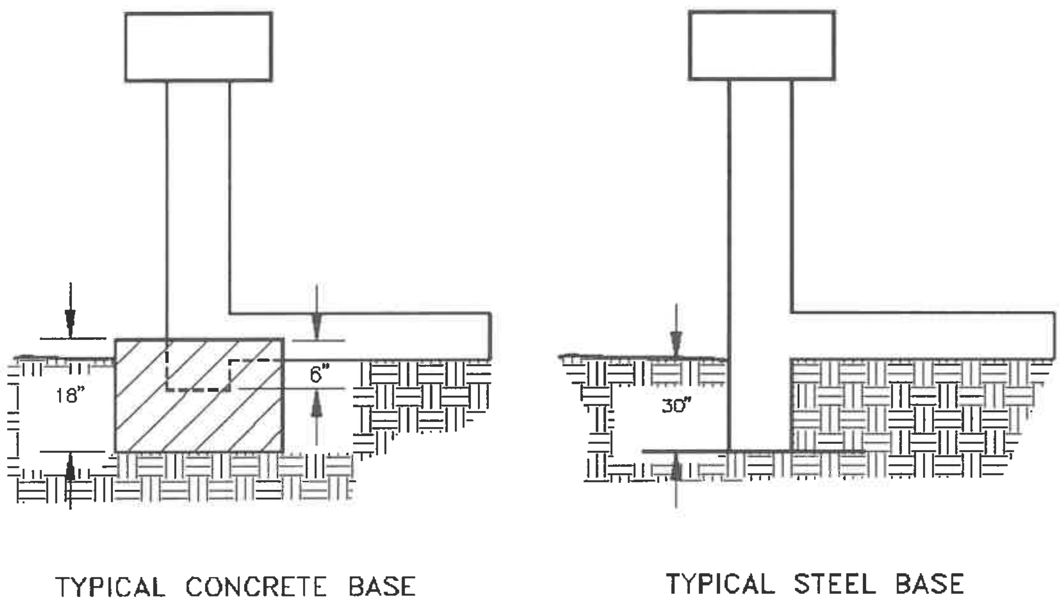
# SEDIMENT BASIN SCHEMATIC ELEVATIONS




Source: Va. DSWC

Plate 3.14-2

# RISER PIPE BASE CONDITIONS




Source: Va. DSWC

Plate 3.14-3

Anti-Seep Collars

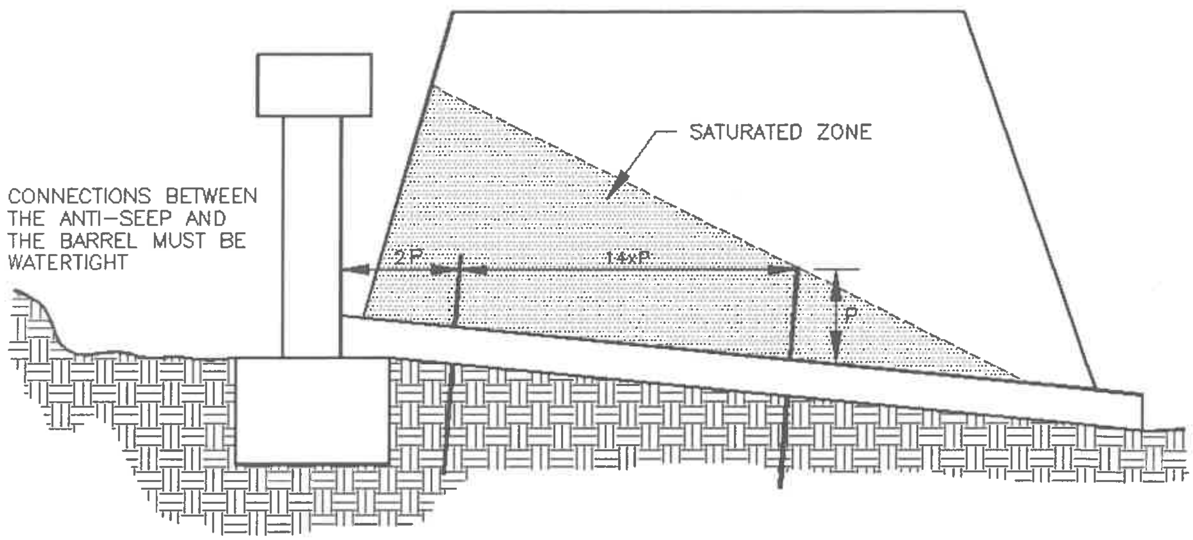
Anti-seep collars shall be used on the barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions is met:

1. The settled height of the embankment exceeds 10 feet.

2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM) and the barrel is greater than 10 inches in diameter.

The anti-seep collars shall be installed within the saturated zone. The maximum spacing between collars shall be 14 times the projection of the collars above the barrel. Collars shall not be closer than 2 feet to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure that 95% compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight. See Plate 3.14-4 and Appendix 3.14-a for details and design procedure.

## ANTI-SEEP COLLAR




Source: Va. DSWC Plate 3.14-4

Alternatives to Anti-Seep Collars

Anti-seep collars are designed to control seepage and piping along the barrel by increasing the flow length and thus making any flow along the barrel travel a longer distance. However, due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective or actually result in an increase in seepage and piping.

Alternative measures have been developed and are being incorporated into embankment designs. These measures include a structure known as a "filter diaphragm." A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. Typically, the structure is 4 to 5 inches in width, approximately one foot in height and is located at the barrel elevation at its intersection with the upper bounds of the seepage zone. The measure controls the transport of embankment fines, which is the major concern with piping and seepage. The diaphragm channels any undesirable flow through the fine-graded material, which traps any embankment material being transported. The flow is then conveyed out of the embankment through a perforated toe drain.

The critical design element of the filter diaphragm is the grain-size distribution of the filter material which is determined by the grain-size distribution of the embankment fill material. The use and design of these measures should be based on site-specific geotechnical information and should be supervised by a qualified professional.

## Emergency Spillway

The emergency spillway acts as a safety release for a sediment basin, or any impoundment-type structure, by conveying the larger, less frequent storms through the basin without damage to the embankment. The emergency spillway also acts as its name implies - in case of an emergency such as excessive sedimentation or damage to the riser which prevents flow through the principal spillway. The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material (not fill). Where conditions will not allow the construction of an emergency spillway on undisturbed material, a spillway may be constructed of a non-erodible material such as riprap. The spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the channel. See Plate 3.14-5 and Appendix 3.14-a for details and design procedure.

An evaluation of site and downstream conditions must be made to determine the feasibility and justification for the incorporation of an emergency spillway. In some cases, the site topography does not allow a spillway to be constructed in undisturbed material, and the temporary nature of the facility may not warrant the cost of disturbing more acreage to construct and armor a spillway. The principal spillway should then be sized to convey all the design storms. If the facility is designed as a permanent facility with downstream restrictions, the added expense of constructing and armoring an emergency spillway may be justified.

### Capacity

The emergency spillway shall be designed to carry the portion of the peak rate of runoff expected from a 25-year storm which is not carried by the principal spillway. See Appendix 3.14-a for design procedure and details.

### Design Elevations

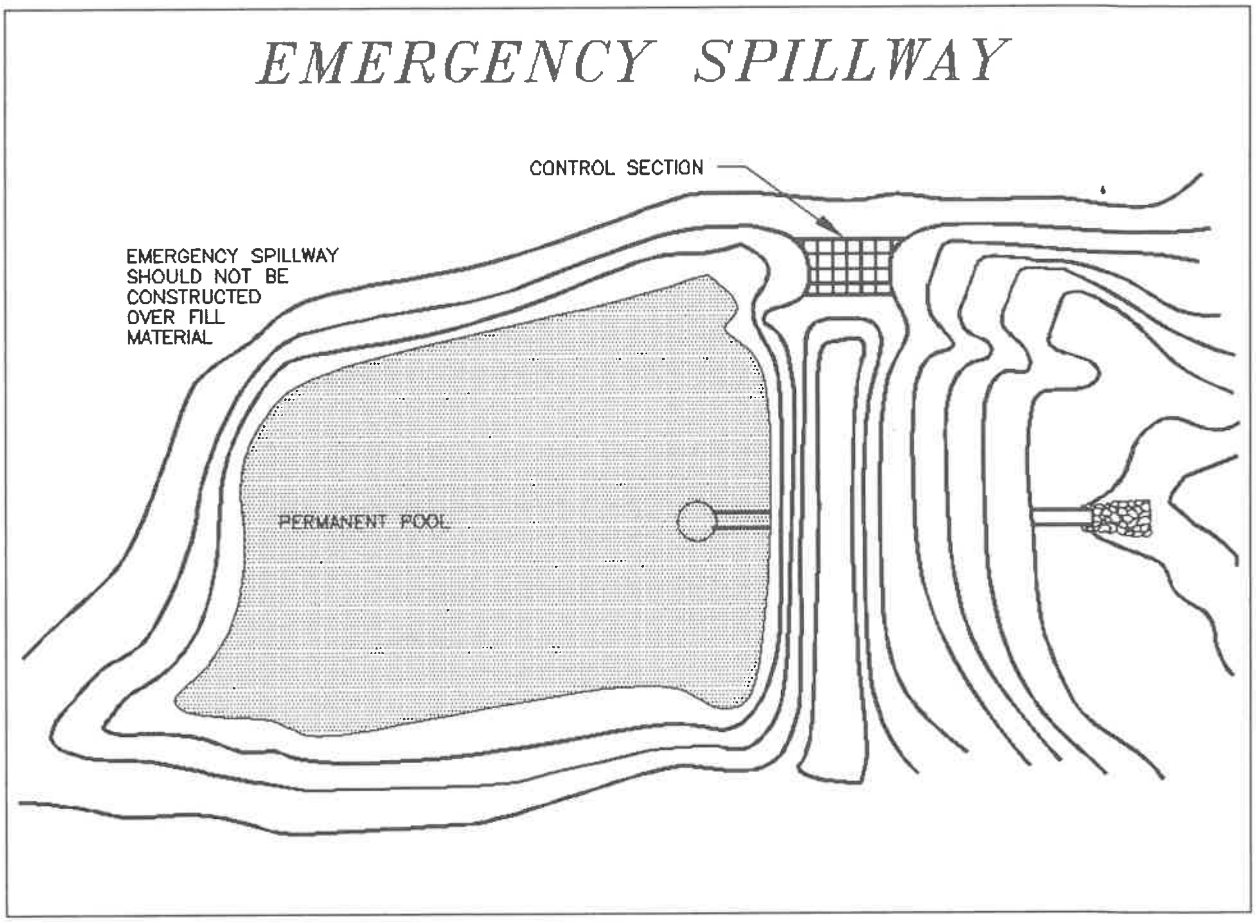
The 25-year storm elevation through the emergency spillway shall be at least 1.0 foot below the top of the embankment. The crest of the emergency spillway channel shall be at least 1.0 foot above the crest of the principal spillway.

### Location

The emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so as to avoid sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

### Maximum Velocities

The maximum allowable velocity in the emergency spillway channel will depend upon the type of lining used. For vegetated linings, allowable velocities are listed in Table 3.17-A (Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNELS). For non-erodible linings, such as concrete or riprap, design velocities may be increased. However, the emergency spillway channel shall return the flow to the receiving channel at a non-eroding velocity. See Appendix 3.14-a for design procedure and details.




Source: Va. DSWC Plate 3.14-5

Stabilization

The embankment of the sediment basin shall receive temporary or permanent seeding immediately after installation (see TEMPORARY SEEDING, Std. & Spec. 3.31 or PERMANENT SEEDING, Std. & Spec. 3.32). If excavation is required in the basin, side slopes should not be steeper than 1½:1.

Disposal

Sediment shall be removed from the basin when the sediment level is no higher than 1 foot below the bottom of the dewatering orifice, or one-half of the permanent pool volume, whichever is lower. Plans for the sediment basin shall indicate the methods for disposing of sediment removed from the basin. Possible alternatives are the use of the material in fill areas on-site or removal to an approved off-site location.

Sediment basin plans shall indicate the final disposition of the sediment basin after the upstream drainage area is stabilized. The plans shall include methods for the removal of excess water lying over the sediment, stabilization of the basin site, and the disposal of any excess material. Where the sediment basin has been designed as a permanent stormwater management basin, plans should also address the steps necessary for the conversion from sediment basin to a permanent detention or retention facility.

### Safety

Sediment basins can be attractive to children and can be dangerous. They should, therefore, be fenced or otherwise made inaccessible to persons or animals unless this is deemed unnecessary by the plan approving authority due to the remoteness of the site or other circumstances. Strategically placed signs around the impoundment reading "DANGER-QUICKSAND" should also be installed. In any case, local ordinances and regulations regarding health and safety must be adhered to (see Std. & Spec. 3.01, SAFETY FENCE).

## Construction Specifications

### Site Preparation

Areas under the embankment or any structural works related to the basin shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material. In order to facilitate cleanout and restoration, the area of most frequent inundation (measured from the top of the principal spillway) will be cleared of all brush and trees.

### Cutoff Trench

For earth-fill embankments, a cutoff trench shall be excavated along the centerline of the dam. The trench must extend at least 1 foot into a stable, impervious layer of soil and have a minimum depth of 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet, but also must be 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 drained during the backfilling/compacting operations.

### Embankment

The fill material shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other perishable or objectionable material. The material selected must have enough strength for the dam to remain stable and be tight enough, when properly compacted, to prevent excessive percolation of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportion is appropriate. Any embankment material should contain approximately 20% clay particles by weight. Using the Unified Soil Classification System, SC (clayey sand), GC (clayey gravel) and CL ("low liquid limit" clay) are among the preferred types of embankment soils. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain the proper amount of moisture to ensure that 95% compaction will be achieved. Fill material will be placed in 6-inch continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is transversed by at least one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary) to avoid damage and achieve desired compaction. The embankment shall be constructed to an elevation 10% higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to not less than 5%.

Principal Spillway

The riser of the principal spillway shall be securely attached to the barrel by a watertight connection. The barrel and riser shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent its floating. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary). Fill material shall be placed around the pipe in 4-inch layers and compacted until 95% compaction is achieved. A minimum of two feet of fill shall be hand-compacted over the barrel before crossing it with construction equipment.

Emergency Spillway

Vegetative emergency spillways shall not be constructed over fill material. Design elevations, widths, entrance and exit channel slopes are critical to the successful operation of the spillway and should be adhered to closely during construction.

Vegetative Stabilization

The embankment and emergency spillway of the sediment basin shall be stabilized with temporary or permanent vegetation immediately after installation of the basin (see TEMPORARY SEEDING, Std. & Spec. 3.31 or PERMANENT SEEDING, Std. & Spec. 3.32).

Erosion and Sediment Control

The construction of the sediment basin shall be carried out in a manner such that it does not result in sediment problems downstream.

Safety

All state and local requirements shall be met concerning fencing and signs warning the public of the hazards of soft, saturated sediment and flood waters (refer to Std. & Spec. 3.01, SAFETY FENCE).

## Maintenance

The basin embankment should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment.

The emergency spillway should be checked regularly to ensure that its lining is well established and erosion-resistant.

The basin should be checked after each runoff-producing rainfall for sediment cleanout. When the sediment reaches the clean-out level, it shall be removed and properly disposed of.

# APPENDIX 3.14-a

## Design Procedure for Temporary Sediment Basins

The following design procedure provides a step-by-step method for the design of a temporary sediment basin. The data sheet found in the back of this Appendix should be used in the erosion and sediment control plan to outline design values calculated.

I. Basin Volume

A. Determine the required basin volume. The design capacity of the basin must be at least 134 cubic yards per acre of total contributing drainage area, half of which shall be in the form of a permanent pool or wet storage, and the remaining half as a "drawdown" area or dry storage.

1. For a natural basin, the wet storage volume may be approximated as follows:

$$V_1 = 0.4 \times A_1 \times D_1$$

where,

$V_1$ = the wet storage volume in cubic feet

$A_1$ = the surface area of the flooded area at the invert of the dewatering outlet, in square feet

$D_1$ = the maximum depth in feet, measured from the low point in the basin to the invert of the dewatering outlet

2. For a natural basin, the dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2} \times D_2$$

where,

$V_2$ = the dry storage volume in cubic feet

$A_1$ = the surface area of the flooded area at the invert of the dewatering outlet, in square feet (see #1 above)

$A_2$ = the surface area of the flooded area at the crest of the principal spillway

$D_2$ = the depth, in feet, measured from the invert of the dewatering outlet to the crest of the principal spillway

Note 1: The volumes may be computed from more precise contour information or other suitable methods.

Note 2: Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

B. If the volume of the basin is inadequate or embankment height becomes excessive, pursue the use of excavation to obtain the required volume.

II. Basin Shape

A. The shape of the basin must be such that the length-to-width ratio is at least 2 to 1 according to the following equation:

$$\textit{Length-to-width Ratio} = \frac{L}{We}$$

where,

We = A/L = the effective width

A = the surface area of the normal pool

L = the length of the flow path from the inflow to the outflow. If there is more than one inflow point, any inflow which carries more than 30% of the peak rate of inflow must meet these criteria.

B. The correct basin shape can be obtained by proper site selection, excavation, or the use of baffles. Baffles increase the flow length by deflecting the flow. The baffles should be placed halfway between the inflow point and the outflow. Plate 3.14-6 shows the detail for baffle construction and three situations where baffles might be used.

III. Determine whether the basin will have a separate emergency spillway.

IV. Determine the elevation of the crest of the principal spillway for the required volume (dewatering orifice at 67 cubic yards per acre and crest of principal spillway 134 cubic yards per acre).

V. Estimate the elevation of the design high water and the required height of the dam.

A. If an emergency spillway is included, the crest of the principal spillway must be at least 1.0 foot below the crest of the emergency spillway.

B. If an emergency spillway is included, the elevation of the peak flow through the emergency spillway (which will be the design high water for the 25-year storm) must be at least 1.0 foot below the top of embankment.

C. If an emergency spillway is <u>not</u> included, the crest of the principal spillway must be at least 3 feet below the top of the embankment.

D. If an emergency spillway is <u>not</u> included, the elevation of the design high water for the 25-year storm must be 2.0 feet below the top of the embankment.

VI. Using Chapter 5 of this handbook, determine the peak rate of runoff expected from the drainage area of the basin for a 25-year storm. The "C" factor or "CN" value used in the runoff calculations should be derived from analysis of the contributing drainage area at the peak of land disturbance (condition which will create greatest peak runoff).

VII. Principal Spillway Design

A. If an emergency spillway is included, the principal spillway must at least pass the peak rate of runoff from the basin drainage area for a 2-year storm.

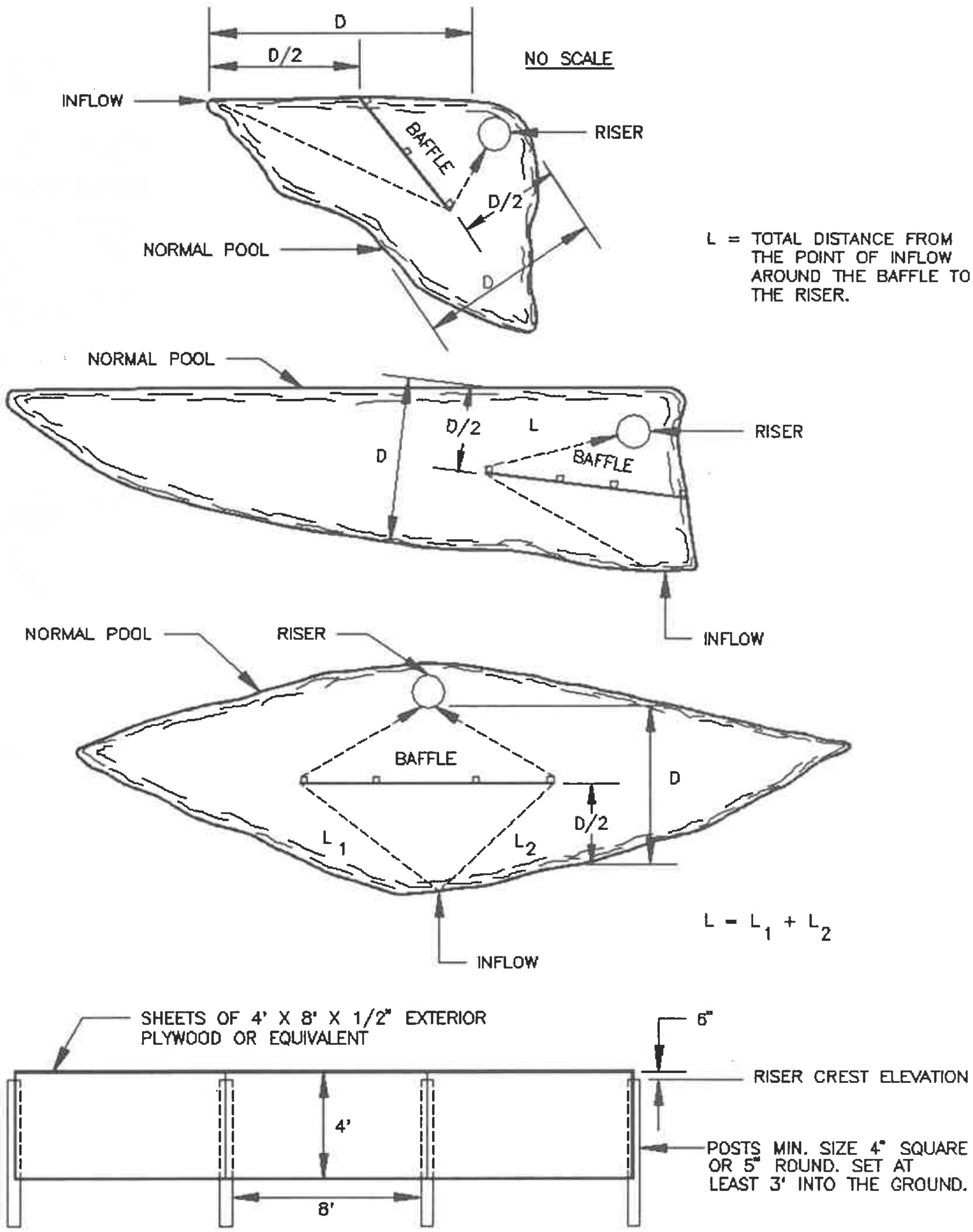
1. $Q_p$ = the 2-year peak rate of runoff.

B. If an emergency spillway is <u>not</u> included, the principal spillway must pass the peak rate of runoff from the basin drainage area for a 25-year storm.

1. Therefore,

$$Q_p = \text{the 25-year peak rate of runoff.}$$

# EXAMPLE PLAN VIEWS OF BAFFLE LOCATIONS IN SEDIMENT BASINS




Source: USDA-SCS

Plate 3.14-6

C. Refer to Plate 3.14-7, where h is the difference between the elevation of the crest of the principal spillway and the elevation of the crest of the emergency spillway.

D. Enter Plate 3.14-8 with $Q_p$. Choose the smallest riser which will pass the required flow with the available head, h.

E. Refer to Plate 3.14-7, where H is the difference in elevation of the centerline of the outlet of the barrel and the crest of the emergency spillway. L is the length of the barrel through the embankment.

F. Enter Table 3.14-A or Table 3.14-B with H. Choose the smallest size barrel which will pass the flow provided by the riser. If L is other than 70 feet, make the necessary correction.

## VIII. Emergency Spillway Design

A. The emergency spillway must pass the remainder of the 25-year peak rate of runoff not carried by the principal spillway.

B. Compute, $Q_e = Q_{25} - Q_p$

C. Refer to Plate 3.14-9 and Table 3.14-C.

D. Determine approximate permissible values for b, the bottom width; s, the slope of the exit channel; and X, minimum length of the exit channel.

E. Enter Table 3.14-C and choose an exit channel cross-section which passes the required flow and meets the other constraints of the site.

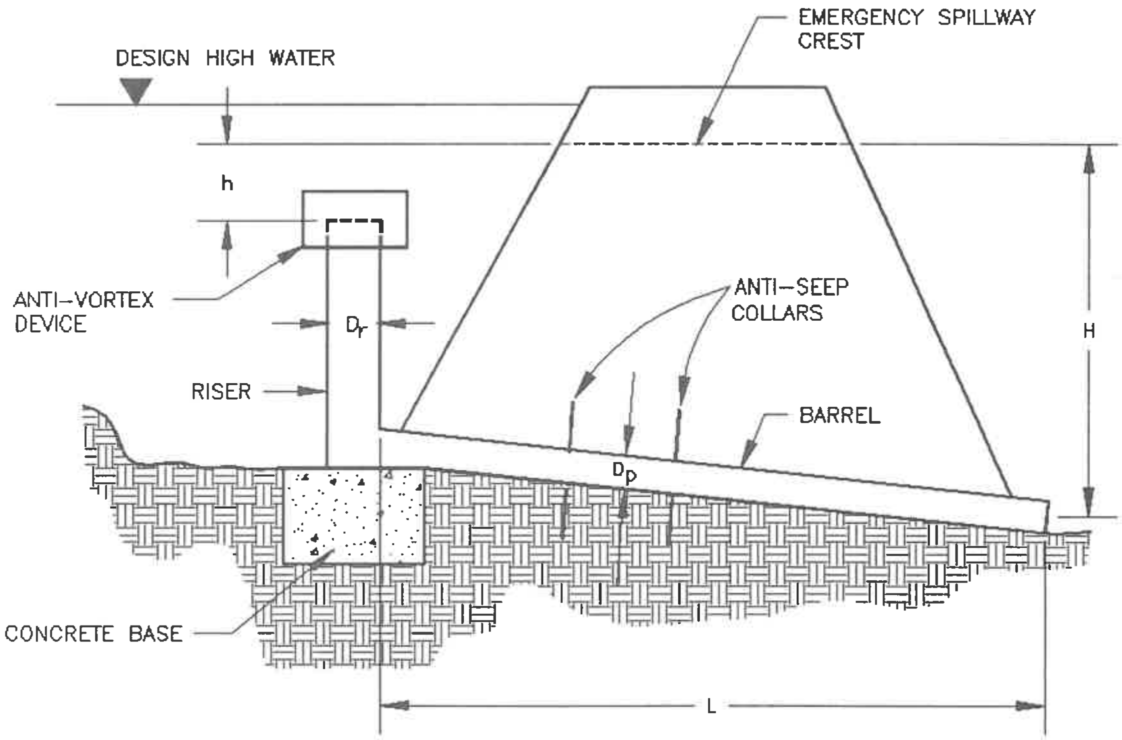
F. Note:

1. The maximum permissible velocity for vegetated waterways must be considered when designing an exit channel.

2. For a given Hp, a decrease in the exit slope from S as given in the table decreases spillway discharge, but increasing the exit slope from S does not increase discharge. If an exit slope (Se) steeper than S is used, then design procedures found in "Open Channel Flow" in Chapter 5 should be used to verify the adequacy of the exit channel.

3. Data to the right of heavy vertical lines should be used with caution, as the resulting sections will be either poorly proportioned or have excessive velocities.

# *PRINCIPAL SPILLWAY DESIGN*




H = HEAD ON PIPE THROUGH EMBANKMENT

h = HEAD OVER RISER CREST

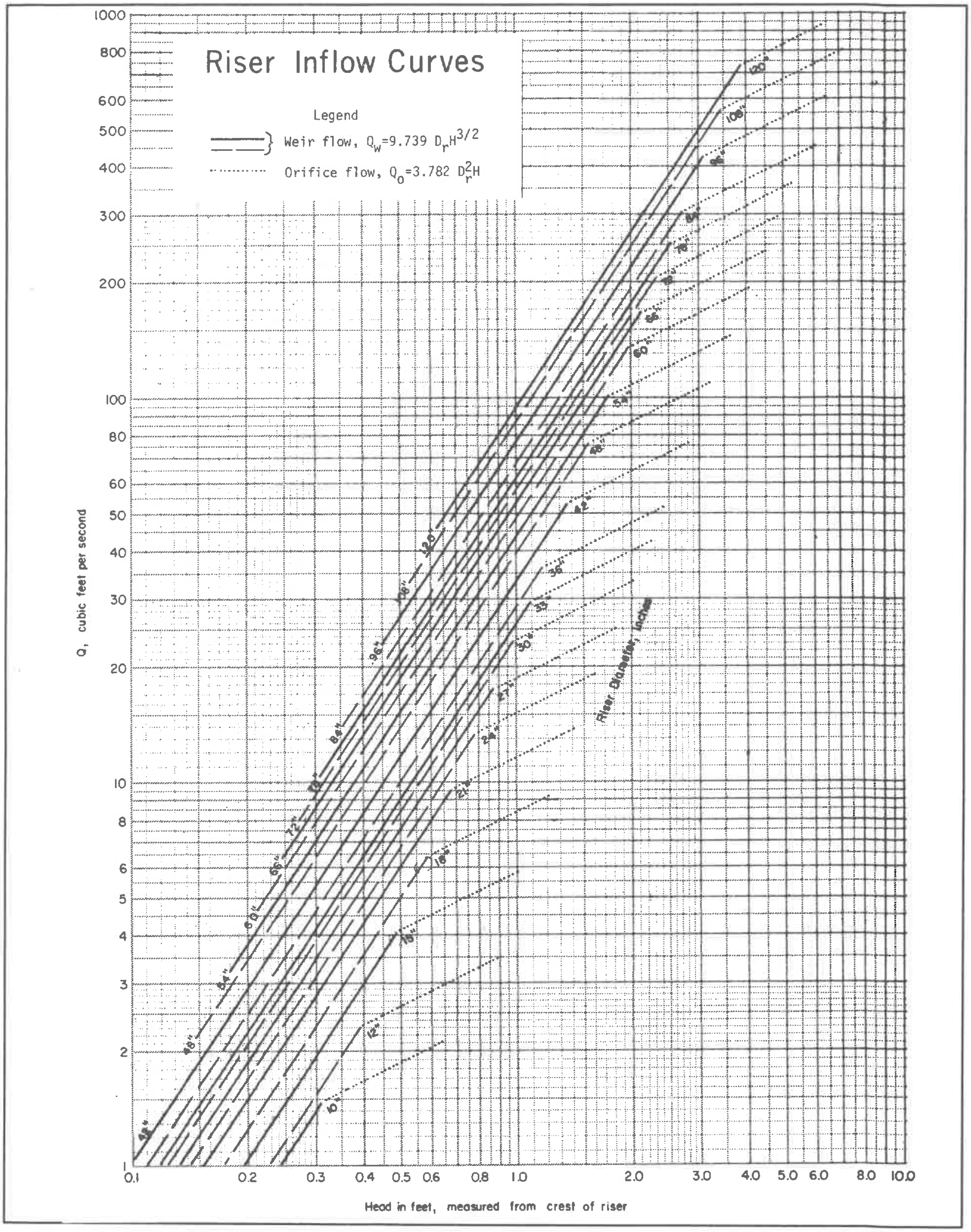
L = LENGTH OF PIPE THROUGH EMBANKMENT

$D_p$ = DIAMETER OF PIPE THROUGH EMBANKMENT

$D_r$ = DIAMETER OF RISER

Source: Va. DSWC

Plate 3.14-7




Source: USDA-SCS

Plate 3.14-8

# TABLE 3.14-A
# PIPE FLOW CHART, n = 0.025

FOR CORRUGATED METAL PIPE INLET $K_m = K_e + K_b = 1.0$ AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (full flow assumed)
Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

| H, in feet | 6" | 8" | 10" | 12" | 15" | 18" | 21" | 24" | 30" | 36" | 42" | 48" | 54" | 60" | 66" | 72" | 78" | 84" | 90" | 96" | 102" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.33 | 0.70 | 1.25 | 1.98 | 3.48 | 5.47 | 7.99 | 11.0 | 18.8 | 28.8 | 41.1 | 55.7 | 72.6 | 91.8 | 113 | 137 | 163 | 191 | 222 | 255 | 290 |
| 2 | 0.47 | 0.99 | 1.76 | 2.80 | 4.92 | 7.74 | 11.3 | 15.6 | 26.6 | 40.8 | 58.2 | 78.8 | 103 | 130 | 160 | 194 | 231 | 271 | 314 | 360 | 410 |
| 3 | 0.58 | 1.22 | 2.16 | 3.43 | 6.02 | 9.48 | 13.8 | 19.1 | 32.6 | 49.9 | 71.2 | 96.5 | 126 | 159 | 196 | 237 | 282 | 331 | 384 | 441 | 502 |
| 4 | 0.67 | 1.40 | 2.49 | 3.97 | 6.96 | 10.9 | 16.0 | 22.1 | 37.6 | 57.7 | 82.3 | 111 | 145 | 184 | 226 | 274 | 326 | 383 | 444 | 510 | 580 |
| 5 | 0.74 | 1.57 | 2.79 | 4.43 | 7.78 | 12.2 | 17.9 | 24.7 | 42.1 | 64.5 | 92.0 | 125 | 162 | 205 | 253 | 306 | 365 | 428 | 496 | 570 | 648 |
| 6 | 0.82 | 1.72 | 3.05 | 4.86 | 8.52 | 13.4 | 19.6 | 27.0 | 46.1 | 70.6 | 101 | 136 | 178 | 225 | 277 | 336 | 399 | 469 | 544 | 624 | 710 |
| 7 | 0.88 | 1.86 | 3.30 | 5.25 | 9.20 | 14.5 | 21.1 | 29.2 | 49.8 | 76.3 | 109 | 147 | 192 | 243 | 300 | 362 | 431 | 506 | 587 | 674 | 767 |
| 8 | 0.94 | 1.99 | 3.53 | 5.61 | 9.84 | 15.5 | 22.6 | 31.2 | 53.2 | 81.5 | 116 | 158 | 205 | 260 | 320 | 388 | 461 | 541 | 628 | 721 | 820 |
| 9 | 1.00 | 2.11 | 3.74 | 5.95 | 10.4 | 16.4 | 24.0 | 33.1 | 56.4 | 86.5 | 123 | 167 | 218 | 275 | 340 | 411 | 489 | 574 | 666 | 764 | 870 |
| 10 | 1.05 | 2.22 | 3.94 | 6.27 | 11.0 | 17.3 | 25.3 | 34.9 | 59.5 | 91.2 | 130 | 176 | 230 | 290 | 358 | 433 | 516 | 605 | 702 | 806 | 917 |
| 11 | 1.10 | 2.33 | 4.13 | 6.58 | 11.5 | 18.2 | 26.5 | 36.6 | 62.4 | 95.6 | 136 | 185 | 241 | 304 | 376 | 454 | 541 | 635 | 736 | 845 | 962 |
| 12 | 1.15 | 2.43 | 4.32 | 6.87 | 12.1 | 19.0 | 27.7 | 38.2 | 65.2 | 99.9 | 142 | 193 | 252 | 318 | 392 | 475 | 565 | 663 | 769 | 883 | 1004 |
| 13 | 1.20 | 2.53 | 4.49 | 7.15 | 12.6 | 19.7 | 28.8 | 39.8 | 67.8 | 104 | 148 | 201 | 262 | 331 | 408 | 494 | 588 | 690 | 800 | 919 | 1045 |
| 14 | 1.25 | 2.63 | 4.66 | 7.42 | 13.0 | 20.5 | 29.9 | 41.3 | 70.4 | 108 | 154 | 208 | 272 | 343 | 424 | 513 | 610 | 716 | 830 | 953 | 1085 |
| 15 | 1.29 | 2.72 | 4.83 | 7.68 | 13.5 | 21.2 | 30.9 | 42.8 | 72.8 | 112 | 159 | 216 | 281 | 355 | 439 | 531 | 631 | 741 | 860 | 987 | 1123 |
| 16 | 1.33 | 2.81 | 4.99 | 7.93 | 13.9 | 21.9 | 32.0 | 44.2 | 75.2 | 115 | 165 | 223 | 290 | 367 | 453 | 548 | 652 | 765 | 888 | 1019 | 1160 |
| 17 | 1.37 | 2.90 | 5.14 | 8.18 | 14.3 | 22.6 | 32.9 | 45.5 | 77.5 | 119 | 170 | 230 | 229 | 378 | 467 | 565 | 672 | 789 | 915 | 1051 | 1195 |
| 18 | 1.41 | 2.98 | 5.29 | 8.41 | 14.8 | 23.2 | 33.9 | 46.8 | 79.8 | 120 | 174 | 236 | 308 | 389 | 480 | 581 | 692 | 812 | 942 | 1081 | 1230 |
| 19 | 1.45 | 3.06 | 5.43 | 8.64 | 15.2 | 23.9 | 34.8 | 48.1 | 82.0 | 126 | 179 | 243 | 316 | 400 | 494 | 597 | 711 | 834 | 967 | 1111 | 1264 |
| 20 | 1.49 | 3.14 | 5.57 | 8.87 | 15.6 | 24.5 | 35.7 | 49.4 | 84.1 | 129 | 184 | 249 | 325 | 410 | 506 | 613 | 729 | 856 | 993 | 1139 | 1297 |
| 21 | 1.53 | 3.22 | 5.71 | 9.09 | 15.9 | 25.1 | 36.6 | 50.6 | 86.2 | 132 | 188 | 255 | 333 | 421 | 519 | 628 | 747 | 877 | 1017 | 1168 | 1329 |
| 22 | 1.56 | 3.29 | 5.85 | 9.30 | 16.3 | 25.7 | 37.5 | 51.8 | 88.2 | 135 | 193 | 261 | 341 | 430 | 531 | 643 | 765 | 898 | 1041 | 1195 | 1360 |
| 23 | 1.60 | 3.37 | 5.98 | 9.51 | 16.7 | 26.2 | 38.3 | 53.0 | 90.2 | 138 | 197 | 267 | 348 | 440 | 543 | 657 | 782 | 918 | 1064 | 1222 | 1390 |
| 24 | 1.63 | 3.44 | 6.11 | 9.72 | 17.0 | 26.8 | 39.1 | 54.1 | 92.1 | 141 | 201 | 273 | 356 | 450 | 555 | 671 | 799 | 937 | 1087 | 1248 | 1420 |
| 25 | 1.66 | 3.51 | 6.23 | 9.92 | 17.4 | 27.4 | 39.9 | 55.2 | 94.0 | 144 | 206 | 279 | 363 | 459 | 566 | 685 | 815 | 957 | 1110 | 1274 | 1450 |
| 26 | 1.70 | 3.58 | 6.36 | 10.1 | 17.7 | 27.9 | 40.7 | 56.3 | 95.9 | 147 | 210 | 284 | 370 | 468 | 577 | 699 | 831 | 976 | 1132 | 1299 | 1478 |
| 27 | 1.73 | 3.65 | 6.48 | 10.3 | 18.1 | 28.4 | 41.5 | 57.4 | 97.7 | 150 | 214 | 290 | 377 | 477 | 588 | 712 | 847 | 994 | 1153 | 1324 | 1507 |
| 28 | 1.76 | 3.72 | 6.60 | 10.5 | 18.4 | 29.0 | 42.3 | 58.4 | 99.5 | 153 | 218 | 295 | 384 | 486 | 599 | 725 | 863 | 1013 | 1174 | 1348 | 1534 |
| 29 | 1.79 | 3.78 | 6.71 | 10.7 | 18.7 | 29.5 | 43.0 | 59.5 | 101 | 155 | 221 | 300 | 391 | 494 | 610 | 738 | 878 | 1030 | 1195 | 1372 | 1561 |
| 30 | 1.82 | 3.85 | 6.83 | 10.9 | 19.1 | 30.0 | 43.7 | 60.5 | 103 | 158 | 225 | 305 | 398 | 503 | 620 | 750 | 893 | 1048 | 1216 | 1396 | 1588 |
| L, in feet | Correction Factors For Other Pipe Lengths | | | | | | | | | | | | | | | | | | | | |
| 20 | 1.69 | 1.63 | 1.58 | 1.53 | 1.47 | 1.42 | 1.37 | 1.34 | 1.28 | 1.24 | 1.20 | 1.18 | 1.16 | 1.14 | 1.13 | 1.11 | 1.10 | 1.10 | 1.09 | 1.08 | 1.08 |
| 30 | 1.44 | 1.41 | 1.39 | 1.36 | 1.32 | 1.29 | 1.27 | 1.24 | 1.21 | 1.18 | 1.15 | 1.13 | 1.12 | 1.11 | 1.10 | 1.09 | 1.08 | 1.07 | 1.07 | 1.06 | 1.06 |
| 40 | 1.28 | 1.27 | 1.25 | 1.23 | 1.21 | 1.20 | 1.18 | 1.17 | 1.14 | 1.12 | 1.11 | 1.10 | 1.09 | 1.08 | 1.07 | 1.06 | 1.06 | 1.05 | 1.05 | 1.05 | 1.04 |
| 50 | 1.16 | 1.16 | 1.15 | 1.14 | 1.13 | 1.12 | 1.11 | 1.10 | 1.09 | 1.08 | 1.07 | 1.06 | 1.06 | 1.05 | 1.05 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 |
| 60 | 1.07 | 1.07 | 1.07 | 1.06 | 1.06 | 1.05 | 1.05 | 1.05 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.01 |
| 70 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 80 | .94 | .94 | .95 | .95 | .95 | .95 | .96 | .96 | .96 | .97 | .97 | .97 | .98 | .98 | .98 | .98 | .98 | .98 | .99 | .99 | .99 |
| 90 | .89 | .89 | .90 | .90 | .91 | .91 | .92 | .92 | .93 | .94 | .94 | .95 | .95 | .96 | .96 | .96 | .97 | .97 | .97 | .97 | .94 |
| 100 | .85 | .85 | .86 | .86 | .87 | .88 | .89 | .89 | .90 | .91 | .92 | .93 | .93 | .94 | .94 | .95 | .95 | .95 | .96 | .96 | .94 |
| 120 | .78 | .79 | .79 | .90 | .81 | .82 | .83 | .83 | .85 | .86 | .87 | .89 | .89 | .90 | .91 | .89 | .92 | .93 | .93 | .94 | .92 |
| 140 | .72 | .73 | .74 | .75 | .76 | .77 | .78 | .79 | .81 | .82 | .84 | .85 | .86 | .87 | .88 | .86 | .89 | .90 | .91 | .91 | .90 |
| 160 | .68 | .69 | .69 | .70 | .71 | .73 | .74 | .75 | .77 | .79 | .80 | .82 | .83 | .84 | .85 | .92 | .87 | .88 | .89 | .89 | |

Source: USDA-SCS

# TABLE 3.14-B
# PIPE FLOW CHART, n = 0.013

FOR REINFORCED CONCRETE PIPE INLET $K_m = K_e + K_b = 0.65$ AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT (full flow assumed)
Note correction factors for pipe lengths other than 70 feet
diameter of pipe in inches

| H, in feet | 12" | 15" | 18" | 21" | 24" | 30" | 36" | 42" | 48" | 54" | 60" | 66" | 72" | 78" | 84" | 90" | 96" | 102" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.22 | 5.44 | 8.29 | 11.8 | 15.9 | 26.0 | 38.6 | 53.8 | 71.4 | 91.5 | 114 | 139 | 167 | 197 | 229 | 264 | 302 | 342 |
| 2 | 4.55 | 7.69 | 11.7 | 16.7 | 22.5 | 36.8 | 54.6 | 76.0 | 101 | 129 | 161 | 197 | 236 | 278 | 324 | 374 | 427 | 483 |
| 3 | 5.57 | 9.42 | 14.4 | 20.4 | 27.5 | 45.0 | 66.9 | 93.1 | 124 | 159 | 198 | 241 | 289 | 341 | 397 | 458 | 523 | 592 |
| 4 | 6.43 | 10.9 | 16.6 | 23.5 | 31.8 | 52.0 | 77.3 | 108 | 143 | 183 | 228 | 278 | 334 | 394 | 459 | 529 | 604 | 683 |
| 5 | 7.19 | 12.2 | 18.5 | 26.3 | 35.5 | 58.1 | 86.4 | 120 | 160 | 205 | 255 | 311 | 373 | 440 | 513 | 591 | 675 | 764 |
| 6 | 7.88 | 13.3 | 20.3 | 28.8 | 38.9 | 63.7 | 94.6 | 132 | 175 | 224 | 280 | 341 | 409 | 482 | 562 | 647 | 739 | 837 |
| 7 | 8.51 | 14.4 | 21.9 | 31.1 | 42.0 | 68.8 | 102 | 142 | 189 | 242 | 302 | 368 | 441 | 521 | 607 | 699 | 798 | 904 |
| 8 | 9.10 | 15.4 | 23.5 | 33.3 | 44.9 | 73.5 | 109 | 152 | 202 | 259 | 323 | 394 | 472 | 557 | 685 | 748 | 854 | 966 |
| 9 | 9.65 | 16.3 | 24.9 | 35.3 | 47.7 | 78.0 | 116 | 161 | 214 | 275 | 342 | 418 | 500 | 590 | 688 | 793 | 905 | 1025 |
| 10 | 10.2 | 17.2 | 26.2 | 37.2 | 50.2 | 82.2 | 122 | 170 | 226 | 289 | 361 | 440 | 527 | 622 | 725 | 836 | 954 | 1080 |
| 11 | 10.7 | 18.0 | 27.5 | 39.0 | 52.7 | 86.2 | 128 | 178 | 237 | 304 | 379 | 462 | 553 | 653 | 761 | 877 | 1001 | 1133 |
| 12 | 11.1 | 18.9 | 28.7 | 40.8 | 55.0 | 90.1 | 134 | 186 | 247 | 317 | 395 | 482 | 578 | 682 | 794 | 916 | 1045 | 1184 |
| 13 | 11.6 | 19.6 | 29.9 | 42.4 | 57.3 | 93.7 | 139 | 194 | 257 | 330 | 411 | 502 | 601 | 710 | 827 | 953 | 1088 | 1232 |
| 14 | 12.0 | 20.4 | 31.0 | 44.1 | 59.4 | 97.3 | 145 | 201 | 267 | 342 | 427 | 521 | 624 | 736 | 858 | 989 | 1129 | 1278 |
| 15 | 12.5 | 21.1 | 32.1 | 45.6 | 61.5 | 101 | 150 | 208 | 277 | 354 | 442 | 539 | 646 | 762 | 888 | 1024 | 1169 | 1323 |
| 16 | 12.9 | 21.8 | 33.2 | 47.1 | 63.5 | 104 | 155 | 215 | 286 | 366 | 457 | 557 | 667 | 787 | 917 | 1057 | 1207 | 1367 |
| 17 | 13.3 | 22.4 | 34.2 | 48.5 | 65.5 | 107 | 159 | 222 | 294 | 377 | 471 | 574 | 688 | 812 | 946 | 1090 | 1244 | 1409 |
| 18 | 13.7 | 23.1 | 35.2 | 49.9 | 67.4 | 110 | 164 | 228 | 303 | 388 | 484 | 591 | 708 | 835 | 973 | 1121 | 1280 | 1450 |
| 19 | 14.0 | 23.7 | 36.1 | 51.3 | 69.2 | 113 | 168 | 234 | 311 | 399 | 497 | 607 | 727 | 858 | 1000 | 1152 | 1315 | 1489 |
| 20 | 14.4 | 24.3 | 37.1 | 52.6 | 71.0 | 116 | 173 | 240 | 319 | 409 | 510 | 623 | 746 | 880 | 1026 | 1182 | 1350 | 1528 |
| 21 | 14.7 | 24.9 | 38.0 | 53.9 | 72.8 | 119 | 177 | 246 | 327 | 419 | 523 | 638 | 764 | 902 | 1051 | 1211 | 1383 | 1566 |
| 22 | 15.1 | 25.5 | 38.9 | 55.2 | 74.5 | 122 | 181 | 252 | 335 | 429 | 535 | 653 | 782 | 923 | 1076 | 1240 | 1415 | 1603 |
| 23 | 15.4 | 26.1 | 39.8 | 56.5 | 76.2 | 125 | 186 | 258 | 342 | 439 | 547 | 668 | 800 | 944 | 1100 | 1268 | 1447 | 1639 |
| 24 | 15.8 | 26.7 | 40.6 | 57.7 | 77.8 | 127 | 189 | 263 | 350 | 448 | 559 | 682 | 817 | 964 | 1123 | 1295 | 1478 | 1674 |
| 25 | 16.1 | 27.2 | 41.5 | 58.9 | 79.4 | 130 | 193 | 269 | 357 | 458 | 571 | 696 | 834 | 984 | 1147 | 1322 | 1509 | 1708 |
| 26 | 16.4 | 27.7 | 42.3 | 60.0 | 81.0 | 133 | 197 | 274 | 364 | 467 | 582 | 710 | 850 | 1004 | 1169 | 1348 | 1539 | 1742 |
| 27 | 16.7 | 28.3 | 43.1 | 61.2 | 82.5 | 135 | 201 | 279 | 371 | 476 | 593 | 723 | 867 | 1023 | 1192 | 1373 | 1568 | 1775 |
| 28 | 17.0 | 28.8 | 43.9 | 62.3 | 84.1 | 138 | 204 | 285 | 378 | 484 | 604 | 737 | 883 | 1041 | 1214 | 1399 | 1597 | 1808 |
| 29 | 17.3 | 29.3 | 44.7 | 63.4 | 85.5 | 140 | 208 | 290 | 384 | 493 | 615 | 750 | 898 | 1060 | 1235 | 1423 | 1625 | 1840 |
| 30 | 17.6 | 29.8 | 45.4 | 64.5 | 87.0 | 142 | 212 | 294 | 391 | 501 | 625 | 763 | 913 | 1078 | 1256 | 1448 | 1653 | 1871 |
| L, in feet | Correction Factors For Other Pipe Lengths | | | | | | | | | | | | | | | | | |
| 20 | 1.30 | 1.24 | 1.21 | 1.18 | 1.15 | 1.12 | 1.10 | 1.08 | 1.07 | 1.06 | 1.05 | 1.05 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.03 |
| 30 | 1.22 | 1.18 | 1.15 | 1.13 | 1.12 | 1.09 | 1.08 | 1.06 | 1.05 | 1.05 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 |
| 40 | 1.15 | 1.13 | 1.11 | 1.10 | 1.08 | 1.07 | 1.05 | 1.05 | 1.04 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 |
| 50 | 1.09 | 1.08 | 1.07 | 1.06 | 1.05 | 1.04 | 1.04 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 60 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 70 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 80 | .96 | .97 | .97 | .97 | .98 | .98 | .98 | .99 | .99 | .99 | .99 | .99 | .99 | .99 | .99 | .99 | .99 | .99 |
| 90 | .93 | .94 | .94 | .95 | .95 | .96 | .97 | .97 | .98 | .98 | .98 | .98 | .98 | .99 | .99 | .99 | .99 | .99 |
| 100 | .90 | .91 | .92 | .93 | .93 | .95 | .95 | .96 | .97 | .97 | .97 | .98 | .98 | .98 | .98 | .98 | .98 | .99 |
| 120 | .84 | .86 | .87 | .89 | .90 | .91 | .93 | .94 | .94 | .95 | .96 | .96 | .96 | .97 | .97 | .97 | .97 | .98 |
| 140 | .80 | .82 | .83 | .85 | .86 | .88 | .90 | .91 | .92 | .93 | .94 | .94 | .95 | .95 | .96 | .96 | .96 | .97 |
| 160 | .76 | .78 | .80 | .82 | .83 | .86 | .88 | .89 | .90 | .91 | .92 | .93 | .94 | .94 | .95 | .95 | .95 | .96 |

Source: USDA-SCS

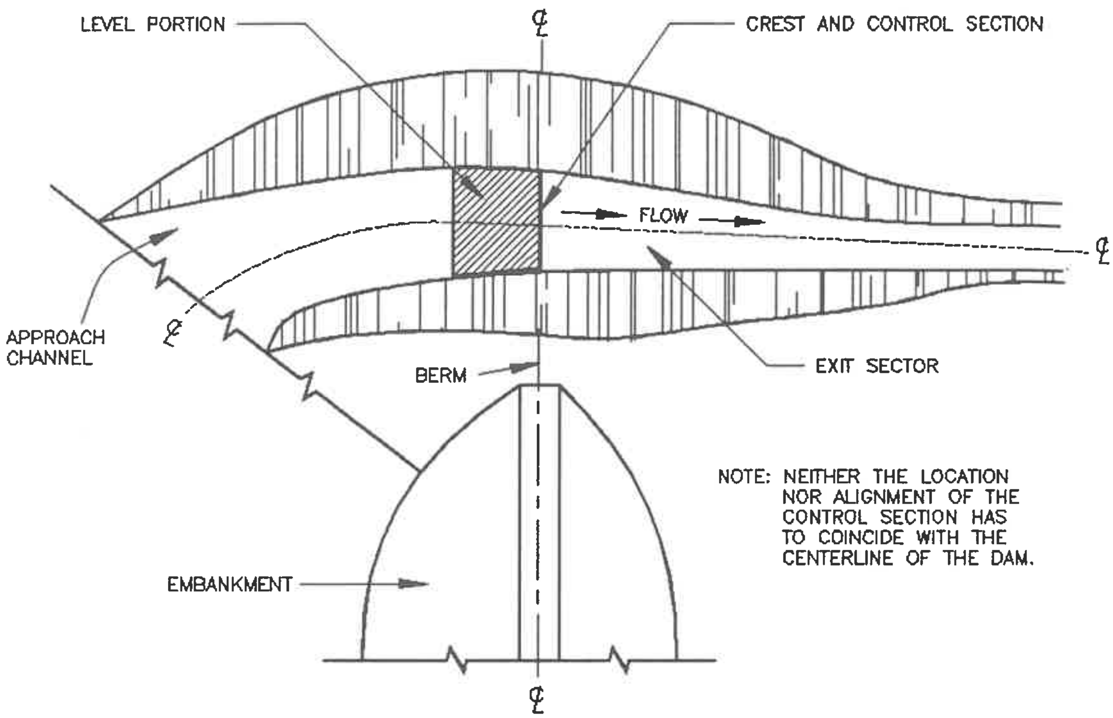
## TABLE 3.14-C

## DESIGN DATA FOR EARTH SPILLWAYS

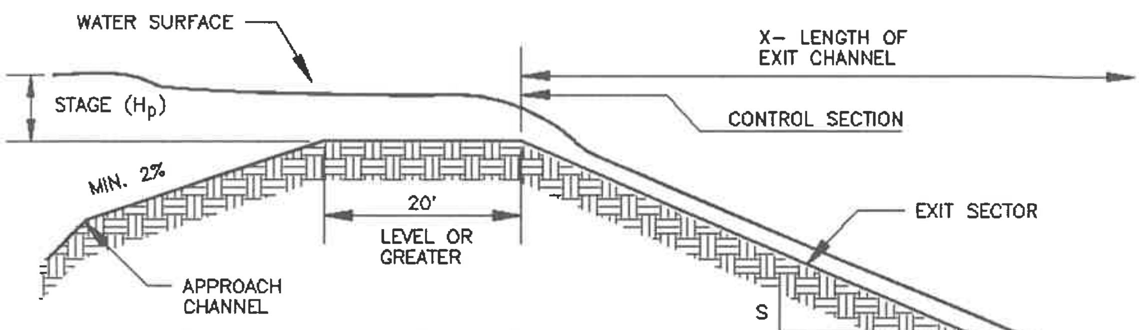
| STAGE (Hp) IN FEET | SPILLWAY VARIABLES | BOTTOM WIDTH (b) IN FEET | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| 0.5 | Q | 6 | 7 | 8 | 10 | 11 | 13 | 14 | 15 | 17 | 18 | 20 | 21 | 22 | 24 | 25 | 27 | 28 |
| | V | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| | S | 3.9 | 3.9 | 3.9 | 3.9 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| | X | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| 0.6 | Q | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 35 | 37 | 39 |
| | V | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | S | 3.7 | 3.7 | 3.7 | 3.7 | 3.6 | 3.7 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| | X | 36 | 36 | 36 | 36 | 36 | 36 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| 0.7 | Q | 11 | 13 | 16 | 18 | 20 | 23 | 25 | 28 | 30 | 33 | 35 | 38 | 41 | 43 | 44 | 46 | 48 |
| | V | 3.2 | 3.2 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| | S | 3.5 | 3.5 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 |
| | X | 39 | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| 0.8 | Q | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 35 | 38 | 42 | 45 | 46 | 48 | 51 | 54 | 57 | 60 |
| | V | 3.5 | 3.5 | 3.5 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| | S | 3.3 | 3.3 | 3.3 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| | X | 44 | 44 | 44 | 44 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| 0.9 | Q | 17 | 20 | 24 | 28 | 32 | 35 | 39 | 43 | 47 | 51 | 53 | 57 | 60 | 64 | 68 | 71 | 75 |
| | V | 3.7 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| | S | 3.2 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 |
| | X | 47 | 47 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| 1.0 | Q | 20 | 24 | 29 | 33 | 38 | 42 | 47 | 51 | 56 | 61 | 63 | 68 | 72 | 77 | 81 | 86 | 90 |
| | V | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | S | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | X | 51 | 51 | 51 | 51 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| 1.1 | Q | 23 | 28 | 34 | 39 | 44 | 49 | 54 | 60 | 65 | 70 | 74 | 79 | 84 | 89 | 95 | 100 | 105 |
| | V | 4.2 | 4.2 | 4.2 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 |
| | S | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| | X | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| 1.2 | Q | 28 | 33 | 40 | 45 | 51 | 58 | 64 | 69 | 76 | 80 | 86 | 92 | 98 | 104 | 110 | 116 | 122 |
| | V | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | S | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| | X | 58 | 58 | 59 | 59 | 59 | 59 | 59 | 59 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 1.3 | Q | 32 | 38 | 46 | 53 | 58 | 65 | 73 | 80 | 86 | 91 | 99 | 106 | 112 | 119 | 125 | 133 | 140 |
| | V | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| | S | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| | X | 62 | 62 | 62 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 64 | 64 | 64 | 64 | 64 | 64 |
| 1.4 | Q | 37 | 44 | 51 | 59 | 66 | 74 | 82 | 90 | 96 | 103 | 111 | 119 | 127 | 134 | 142 | 150 | 158 |
| | V | 4.7 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | S | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| | X | 65 | 66 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 68 | 68 | 69 |
| 1.5 | Q | 41 | 50 | 58 | 66 | 75 | 85 | 92 | 101 | 108 | 116 | 125 | 133 | 142 | 150 | 160 | 169 | 178 |
| | V | 4.8 | 4.9 | 4.9 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.1 | 5.1 | 5.1 |
| | S | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 |
| | X | 69 | 69 | 70 | 70 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 72 | 72 | 72 | 72 | 72 | 72 |
| 1.6 | Q | 46 | 56 | 65 | 75 | 84 | 94 | 104 | 112 | 122 | 132 | 142 | 149 | 158 | 168 | 178 | 187 | 197 |
| | V | 5.0 | 5.1 | 5.1 | 5.1 | 5.1 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 |
| | S | 2.6 | 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | X | 72 | 74 | 74 | 75 | 75 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 |
| 1.7 | Q | 52 | 62 | 72 | 83 | 94 | 105 | 115 | 126 | 135 | 145 | 156 | 167 | 175 | 187 | 196 | 206 | 217 |
| | V | 5.2 | 5.2 | 5.2 | 5.3 | 5.3 | 5.3 | 5.3 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| | S | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | X | 76 | 78 | 79 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| 1.8 | Q | 58 | 69 | 81 | 93 | 104 | 116 | 127 | 138 | 150 | 160 | 171 | 182 | 194 | 204 | 214 | 226 | 233 |
| | V | 5.3 | 5.4 | 5.4 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 |
| | S | 2.5 | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| | X | 80 | 82 | 83 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 |
| 1.9 | Q | 64 | 76 | 88 | 102 | 114 | 127 | 140 | 152 | 164 | 175 | 188 | 201 | 213 | 225 | 235 | 248 | 260 |
| | V | 5.5 | 5.5 | 5.5 | 5.6 | 5.6 | 5.6 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 |
| | S | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| | X | 84 | 85 | 86 | 87 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 |
| 2.0 | Q | 71 | 83 | 97 | 111 | 125 | 138 | 153 | 164 | 178 | 193 | 204 | 218 | 232 | 245 | 256 | 269 | 283 |
| | V | 5.6 | 5.7 | 5.7 | 5.7 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 |
| | S | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 88 | 90 | 91 | 91 | 91 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| 2.1 | Q | 77 | 91 | 107 | 122 | 135 | 149 | 162 | 177 | 192 | 207 | 220 | 234 | 250 | 267 | 276 | 291 | 305 |
| | V | 5.7 | 5.8 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | S | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 92 | 93 | 95 | 95 | 95 | 95 | 95 | 95 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 96 |
| 2.2 | Q | 84 | 100 | 116 | 131 | 146 | 163 | 177 | 194 | 210 | 224 | 238 | 253 | 269 | 288 | 301 | 314 | 330 |
| | V | 5.9 | 5.9 | 6.0 | 6.0 | 6.0 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.2 | 6.2 | 6.2 | 6.2 |
| | S | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 96 | 98 | 99 | 99 | 99 | 99 | 99 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 2.3 | Q | 90 | 108 | 124 | 140 | 158 | 175 | 193 | 208 | 226 | 243 | 258 | 275 | 292 | 306 | 323 | 341 | 354 |
| | V | 6.0 | 6.1 | 6.1 | 6.1 | 6.2 | 6.2 | 6.2 | 6.2 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 |
| | S | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | X | 100 | 102 | 102 | 103 | 103 | 103 | 104 | 104 | 104 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |
| 2.4 | Q | 99 | 116 | 136 | 152 | 170 | 189 | 206 | 224 | 241 | 260 | 275 | 294 | 312 | 327 | 346 | 364 | 378 |
| | V | 6.1 | 6.2 | 6.2 | 6.3 | 6.3 | 6.3 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 |
| | S | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | X | 105 | 105 | 106 | 107 | 107 | 108 | 108 | 108 | 108 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |

Source: USDA-SCS

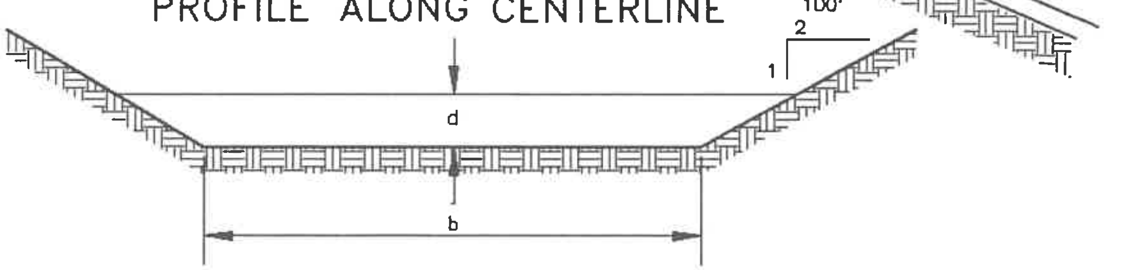
# EXCAVATED EARTH SPILLWAY




PLAN VIEW




PROFILE ALONG CENTERLINE




CROSS–SECTION AT CONTROL SECTION

Source: USDA-SCS

Plate 3.14-9

IX. Re-estimate the elevation of the design high water and the top of the dam based upon the design of the principal spillway and the emergency spillway.

X. Anti-Vortex Device and Trash Rack

A. This design procedure for the anti-vortex device and trash rack refers only to riser pipes of corrugated metal. There are numerous ways to provide protection for concrete pipe; these include various hoods and grates and rebar configurations which should be a part of project-specific design and will frequently be a part of a permanent structure.

B. Refer to Plate 3.14-10 and Table 3.14-D. Choose cylinder size, support bars, and top requirements from Table 3.14-D based on the diameter of the riser pipe.

XI. Anti-Seep Collars

A. Anti-seep collars must be used under the conditions specified in the Design Criteria.

B. Anti-seep collars are used to increase the seepage length along the barrel by 10%.

C. Determine the length of the barrel within the saturated zone. This may be done graphically as in Plate 3.14-11 or by solving the following equation:

$$Ls = Y(Z + 4)\left(1 + \frac{S}{0.25 - S}\right)$$

where:

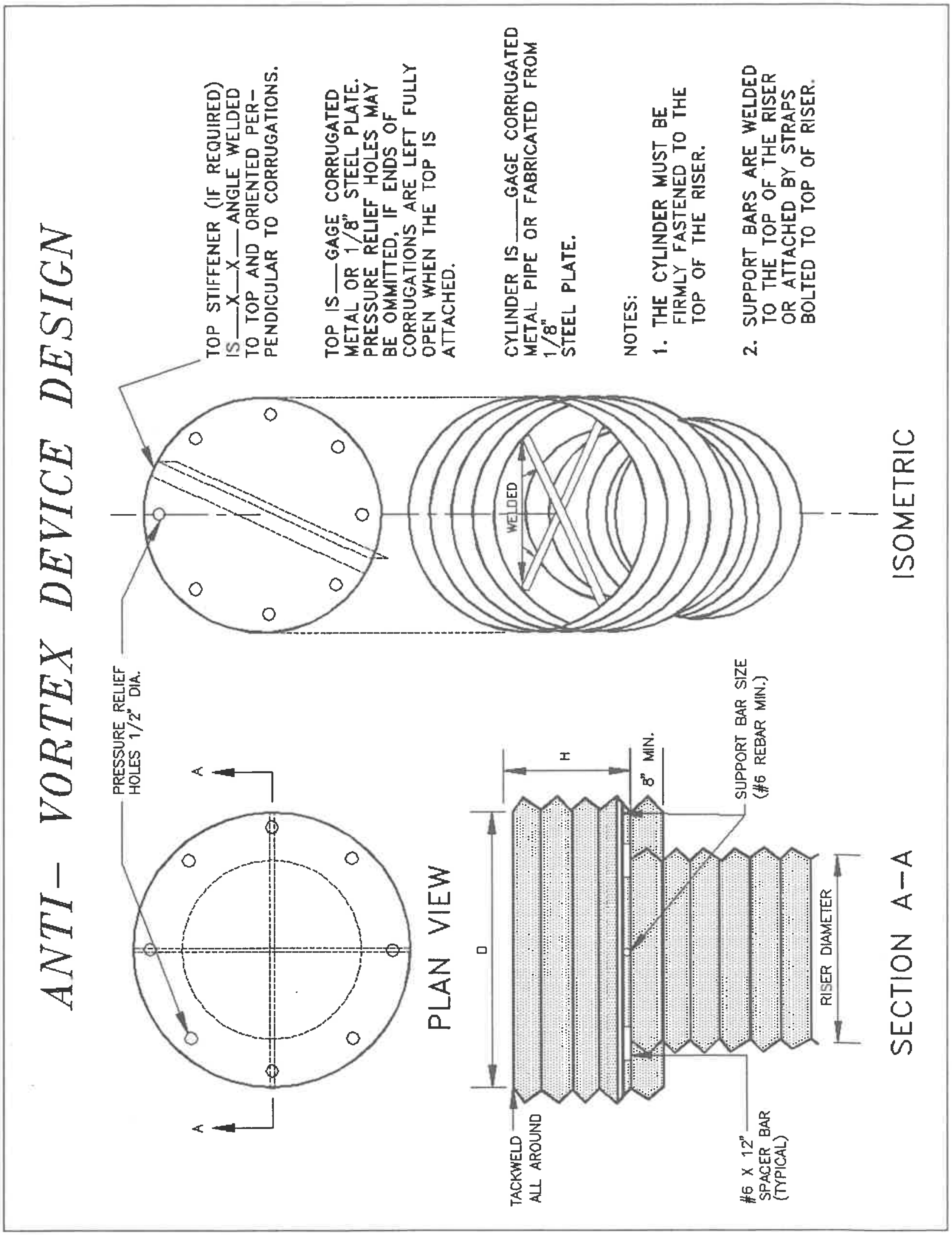
Ls = length of barrel in the saturated zone, feet

Y = the depth of water at the principal spillway crest, feet

Z = slope of the upstream face of embankment in Z feet horizontal to one vertical

S = slope of the barrel in feet per foot

D. Enter Plate 3.14-12 with Ls. Move horizontally right until one of the lines is intersected. Move vertically until the correct line for barrel diameter is intersected. Move horizontally right to read P, the size of the anti-seep collar.




Source: USDA-SCS Plate 3.14-10

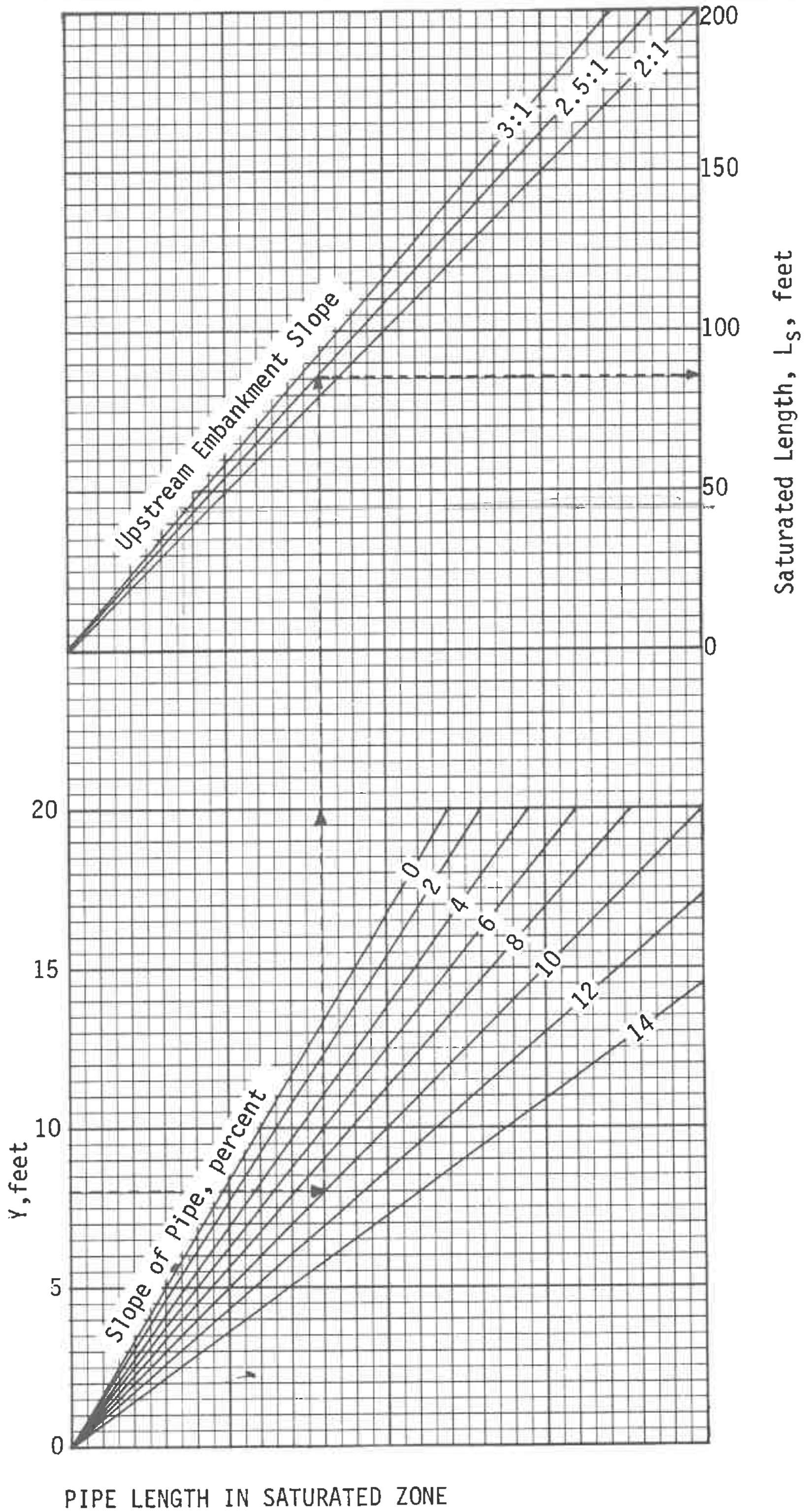
**TABLE 3.14-D**

**CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE DESIGN TABLE**

| Riser Diam., in. | Cylinder | | Height, inches | Minimum Size Support Bar | Minimum Top | |
|---|---|---|---|---|---|---|
| | Diameter, inches | Thickness, gage | | | Thickness | Stiffener |
| 12 | 18 | 16 | 6 | #6 Rebar or 1½ x 1½ x 3/16 angle | 16 ga. (F&C) | - |
| 15 | 21 | 16 | 7 | " " | " " | - |
| 18 | 27 | 16 | 8 | " " | " " | - |
| 21 | 30 | 16 | 11 | " " | 16 ga.(C), 14 ga.(F) | - |
| 24 | 36 | 16 | 13 | " " | " " | - |
| 27 | 42 | 16 | 15 | " " | " " | - |
| 36 | 54 | 14 | 17 | #8 Rebar | 14 ga.(C), 12 ga.(F) | - |
| 42 | 60 | 16 | 19 | " " | " " | - |
| 48 | 72 | 16 | 21 | 1¼" pipe or 1¼ x 1¼ x ¼ angle | 14 ga.(C), 10 ga.(F) | - |
| 54 | 78 | 16 | 25 | " " | " " | - |
| 60 | 90 | 14 | 29 | 1½" pipe or 1½ x 1½ x ¼ angle | 12 ga.(C), 8 ga.(F) | - |
| 66 | 96 | 14 | 33 | 2" pipe or 2 x 2 x 3/16 angle | 12 ga.(C), 8 ga.(F) w/stiffener | 2 x 2 x ¼ angle |
| 72 | 102 | 14 | 36 | " " | " " | 2½ x 2½ x ¼ angle |
| 78 | 114 | 14 | 39 | 2½" pipe or 2 x 2 x ¼ angle | " " | " " |
| 84 | 120 | 12 | 42 | 2½" pipe or 2½ x 2½ x ¼ angle | " " | 2½ x 2½ x 5/16 angle |

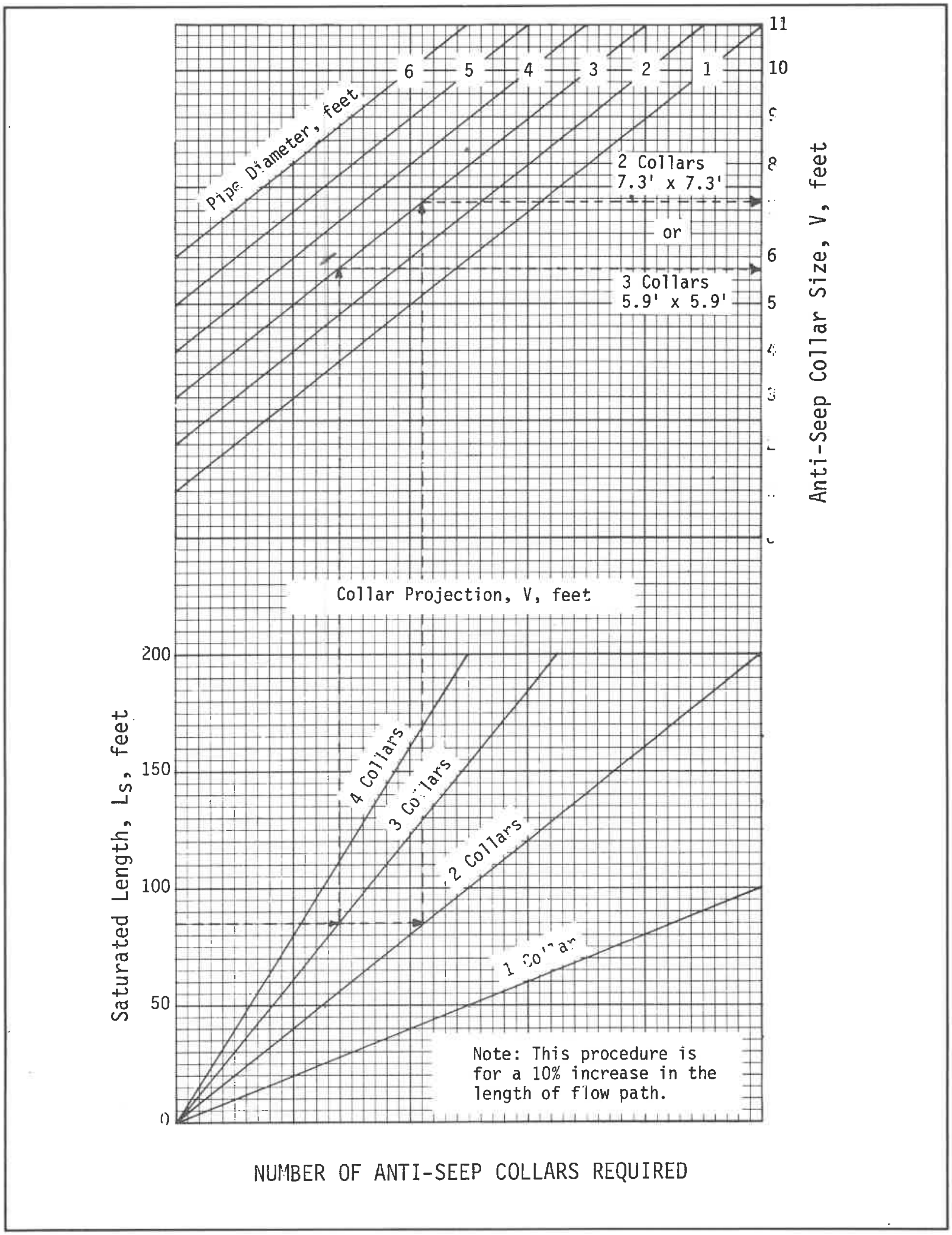
$\text{Note}_1$: The criterion for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.
$\text{Note}_2$: Corrugation for 12"-36" pipe measures 2⅔" x ½"; for 42" -84" the corrugation measures 5" x 1" or 8" x 1".
$\text{Note}_3$: C = corrugated; F = flat.

Source: Adapted from USDA-SCS and Carl M. Henshaw Drainage Products Information.




Source: USDA-SCS

Plate 3.14-11




Source: USDA-SCS

Plate 3.14-12

E. If more than one collar is used, the spacing between collars should be 14 times the projection of the collar above the barrel.

F. Collars should not be located closer than 2 feet to a pipe joint.

G. See Plate 3.14-13 for details of the anti-seep collar.

XII. Anchoring the Principal Spillway

A. The principal spillway must be firmly anchored to prevent its floating.

B. If the riser is over 10 feet high, the forces acting on the spillway must be calculated. A method of anchoring the spillway which provides a safety factor of 1.25 must be used (downward forces = 1.25 x upward forces).

C. If the riser is 10 feet or less in height, choose one of the two methods in Plate 3.14-14 to anchor the principal spillway.

XIII. Dewatering

A. Refer to Plate 3.14-15 for details and orientation.

B. Calculation of the diameter of the dewatering orifice:

Use a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice.

Naming the variables:

A = flow area of orifice, in square feet

d = diameter of circular orifice, in feet

h = average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in feet

Q = volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic feet per second

S = total storage available in dry storage area, cubic feet

Q = S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A = \frac{Q}{\left(64.32 \ x \ h\right)^{\frac{1}{2}} (0.6)}$$

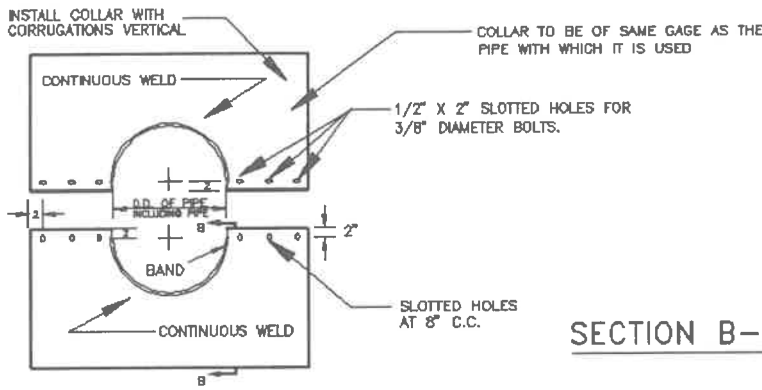
Then, substitute in calculated A and find d:

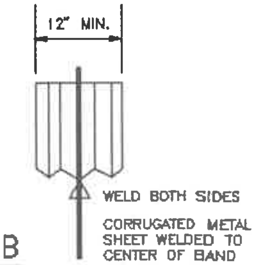
$$d* = 2 \ x \left(\frac{A}{3.14}\right)^{\frac{1}{2}}$$

* Diameter of dewatering orifice should never be less than 3 inches in order to help prevent clogging by soil or debris.

<u>Note</u>: Flexible tubing used should be at least 2 inches larger in diameter than the calculated orifice to promote improved flow characteristics.

# DETAILS OF CORRUGATED METAL ANTI-SEEP COLLAR




SECTION B–B

ELEVATION OF UNASSEMBLED COLLAR

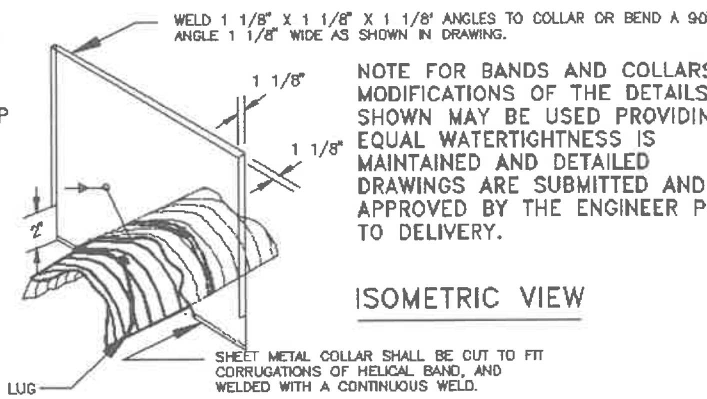
NOTES FOR COLLARS:

1. ALL MATERIALS TO BE IN ACCORDANCE WITH CONSTRUCTION AND CONSTRUCTION MATERIAL SPECIFICATIONS.
2. WHEN SPECIFIED ON THE PLANS, COATING OF COLLARS SHALL BE IN ACCORDANCE WITH CONSTRUCTION AND CONSTRUCTION MATERIAL SPECIFICATIONS.
3. UNASSEMBLED COLLARS SHALL BE MARKED BY PAINTING OR TAGGING TO IDENTIFY MATCHING PAIRS.
4. THE LAP BETWEEN THE TWO HALF SECTIONS AND BETWEEN THE PIPE AND CONNECTING BAND SHALL BE CAULKED WITH ASPHALT MASTIC AT TIME OF INSTALLATION.
5. EACH COLLAR SHALL BE FURNISHED WITH TWO 1/2" DIAMETER RODS WITH STANDARD TANK LUGS FOR CONNECTING COLLARS TO PIPE.

# DETAIL OF HELICAL PIPE ANTI-SEEP COLLAR

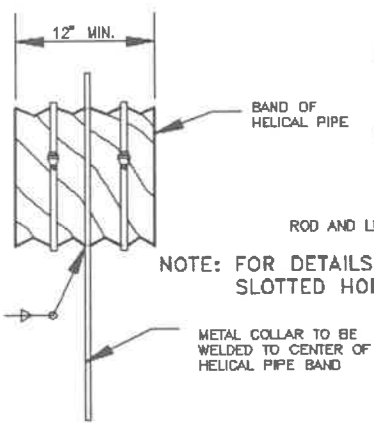
SIZE AND SPACING OF SLOTTED OPENINGS SHALL BE THE SAME AS SHOWN FOR CM COLLAR.

USE RODS AND LUGS TO CLAMP BANDS SECURELY TO PIPE.




NOTE FOR BANDS AND COLLARS: MODIFICATIONS OF THE DETAILS SHOWN MAY BE USED PROVIDING EQUAL WATERTIGHTNESS IS MAINTAINED AND DETAILED DRAWINGS ARE SUBMITTED AND APPROVED BY THE ENGINEER PRIOR TO DELIVERY.

ISOMETRIC VIEW




PARTIAL ELEVATION

NOTE: FOR DETAILS OF FABRICATION DIMENSIONS, MINIMUM GAGES, SLOTTED HOLES, AND NOTES, SEE DETAIL ABOVE.

NOTE: TWO OTHER TYPES OF ANTI-SEEP COLLARS ARE:

1. CORRUGATED METAL, SIMILAR TO UPPER, EXCEPT SHOP WELDED TO A SHORT (4FT.) SECTION OF THE PIPE AND CONNECTED WITH CONNECTING BANDS TO THE PIPE.
2. CONCRETE, SIX INCHES THICK FORMED AROUND THE PIPE WITH #3 REBAR SPACED 15" HORIZONTALLY AND VERTICALLY.

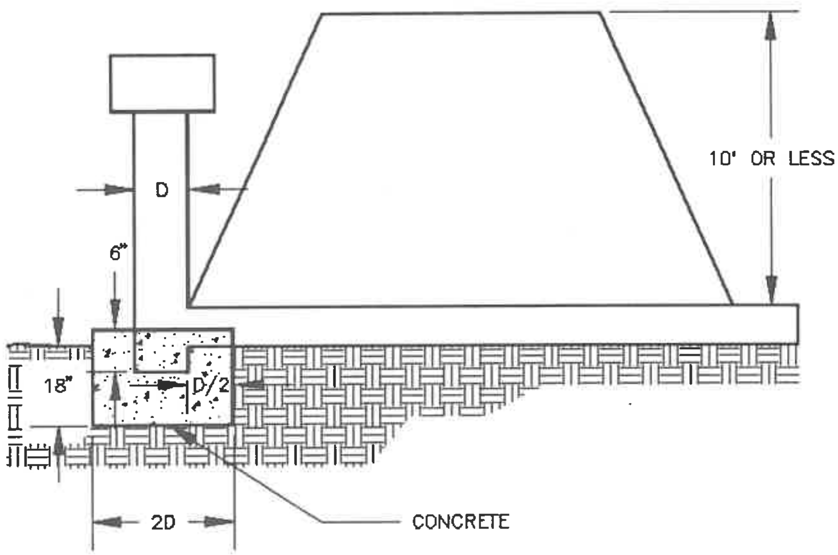
REF: ENGR. FIELD MANUAL

Source: USDA-SCS

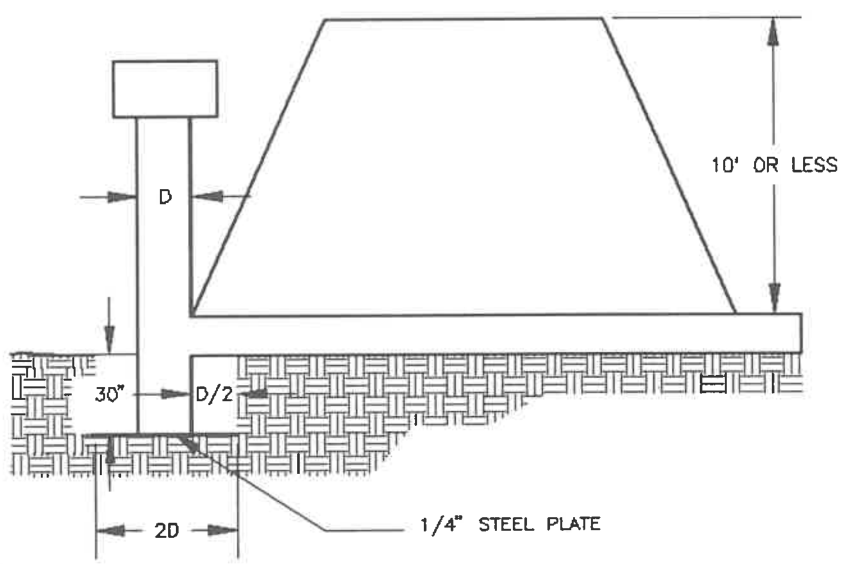
Plate 3.14-13

# *RISER PIPE BASE CONDITIONS FOR EMBANKMENTS LESS THAN 10' HIGH*

CONCRETE BASE FOR EMBANKMENT 10' OR LESS IN HEIGHT



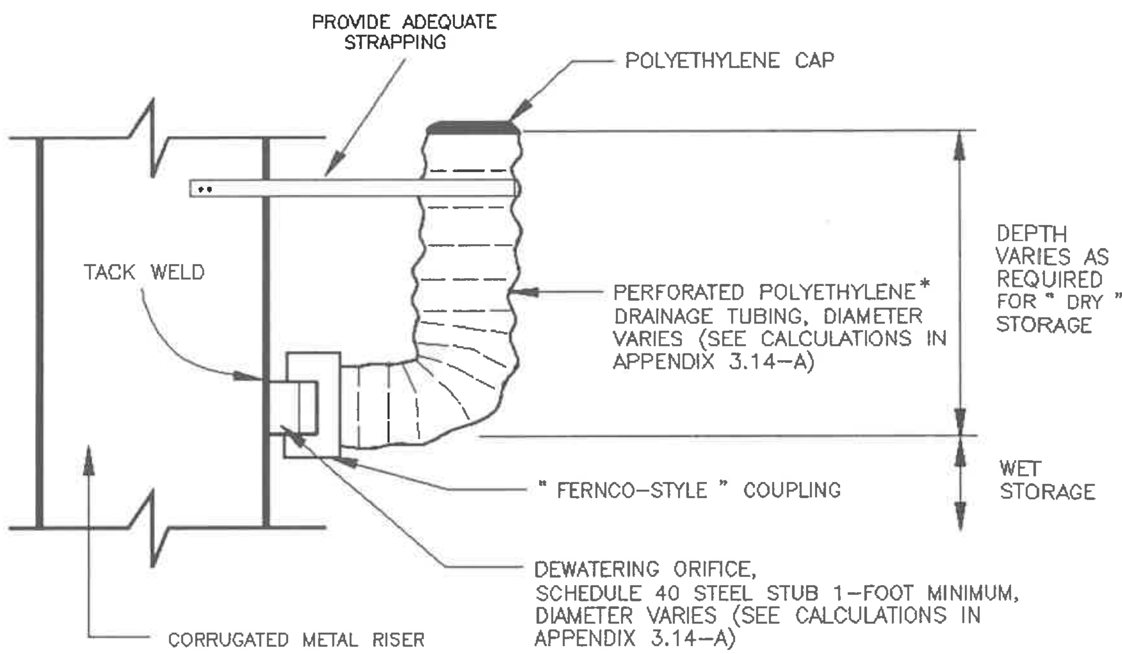

STEEL BASE FOR EMBANKMENT 10' OR LESS IN HEIGHT




Source: Va. DSWC

Plate 3.14-14

# RECOMMENDED DEWATERING SYSTEM FOR SEDIMENT BASINS




NOTE: WITH CONCRETE RISER, USE PVC SCHEDULE 40 STUB FOR DEWATERING ORIFICE

*DRAINAGE TUBING SHALL COMPLY WITH ASTM F667 AND AASHTO M294

Source: Va. DSWC

Plate 3.14-15

## TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

(with or without an emergency spillway)

Project ______________________________________________

Basin # ________________ Location _______________________

Total area draining to basin: _______ acres.

Basin Volume Design

**Wet Storage:**

1. Minimum required volume = 67 cu. yds. x Total Drainage Area (acres).

   67 cu. yds. x ______ acres = ______ cu. yds.

2. Available basin volume = _______ cu. yds. at elevation _______. (From storage - elevation curve)

3. Excavate ______ cu. yds. to obtain required volume*.

   * Elevation corresponding to required volume = invert of the dewatering orifice.

4. Available volume before cleanout required.

   33 cu. yds. x _____ acres = _____ cu. yds.

5. Elevation corresponding to cleanout level = _________.

   (From Storage - Elevation Curve)

6. Distance from invert of the dewatering orifice to cleanout level = _____ ft. (Min. = 1.0 ft.)

**Dry Storage:**

7. Minimum required volume = 67 cu. yds. x Total Drainage Area (acres).

   67 cu. yds. x ______ acres = ______ cu. yds.

8. Total available basin volume at crest of riser* = _______ cu. yds. at elevation _______. (From Storage - Elevation Curve)

* Minimum = 134 cu. yds./acre of total drainage area.

9. Diameter of dewatering orifice = ______________in.

10. Diameter of flexible tubing = ___________in. (diameter of dewatering orifice plus 2 inches).

Preliminary Design Elevations

11. Crest of Riser = ____________

Top of Dam = ____________

Design High Water = ____________

Upstream Toe of Dam = ____________

Basin Shape

12. $\frac{\text{Length of Flow}}{\text{Effective Width}} \quad \frac{L}{We} =$ ________

If > 2, baffles are not required ______________

If < 2, baffles are required ______________

Runoff

13. $Q_2$ = ________ cfs (From Chapter 5)

14. $Q_{25}$ = ________ cfs (From Chapter 5)

Principal Spillway Design

15. With emergency spillway, required spillway capacity $Q_p = Q_2 =$ ______ cfs. (riser and barrel)

Without emergency spillway, required spillway capacity $Q_p = Q_{25} =$ _____ cfs. (riser and barrel)

16. With emergency spillway:

Assumed available head (h) = ___________ ft. (Using $Q_2$)

h = Crest of Emergency Spillway Elevation - Crest of Riser Elevation

Without emergency spillway:

Assumed available head (h) = ___________ ft. (Using $Q_{25}$)

h = Design High Water Elevation - Crest of Riser Elevation

17. Riser diameter ($D_r$) = ______ in. Actual head (h) = _____ ft.

(From Plate 3.14-8.)

Note: Avoid orifice flow conditions.

18. Barrel length (l) = _______ ft.

Head (H) on barrel through embankment = _______ft.

(From Plate 3.14-7).

19. Barrel diameter = _________ in.

(From Plate 3.14-B [concrete pipe] or Plate 3.14-A [corrugated pipe]).

20. Trash rack and anti-vortex device

Diameter = _______ inches.

Height = ______ inches.

(From Table 3.14-D).

## Emergency Spillway Design

21. Required spillway capacity $Q_e$ = $Q_{25}$ - $Q_p$ = ___________cfs.

22. Bottom width (b) = ________ ft.; the slope of the exit channel (s) = ________ ft./foot; and the minimum length of the exit channel (x) = ________ ft.
(From Table 3.14-C).

Anti-Seep Collar Design

23. Depth of water at principal spillway crest (Y) = ____ ft.

Slope of upstream face of embankment (Z) = ________:1.

Slope of principal spillway barrel ($S_b$) = __________%

Length of barrel in saturated zone ($L_s$) = _________ ft.

24. Number of collars required = _______ dimensions = __________

(from Plate 3.14-12).

Final Design Elevations

25. Top of Dam = _________

Design High Water = _________

Emergency Spillway Crest = _________

Principal Spillway Crest = _________

Dewatering Orifice Invert = _________

Cleanout Elevation = _________

Elevation of Upstream Toe of Dam
or Excavated Bottom of "Wet Storage
Area" (if excavation was performed) = _________