Grade Stabilization Structures

General

A grade stabilization structure lowers water from one elevation to another without erosion. It stabilizes the grade or controls head cutting in natural or artificial channels. Overfall structures may be designed using materials such as concrete, rock, masonry, steel, aluminum, or treated wood. Pipe drops of metal pipes with suitable inlet and outlet structures may also be used. Typical examples of grade control structures are shown in the sketches which follow.

Grade Stabilization Structures

Definition: A structure to stabilize the grade or to control head cutting in natural or artificial channels.

Purpose: Grade stabilization structures are installed to stabilize the grade and control erosion in natural or artificial channels, prevent the formation or advance of gullies, and reduce environmental and pollution hazards.
Conditions Where Practice Applies

These structures apply where the concentration and flow velocity of water are such that structures are required to stabilize the grade in channels or to control gully erosion. Special attention will be given to maintaining or improving habitat for fish and wildlife, where applicable.

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Planning Considerations

Water Quantity: Effects on volumes and rates of runoff, evaporation, deep percolation, and ground water recharges should be considered.

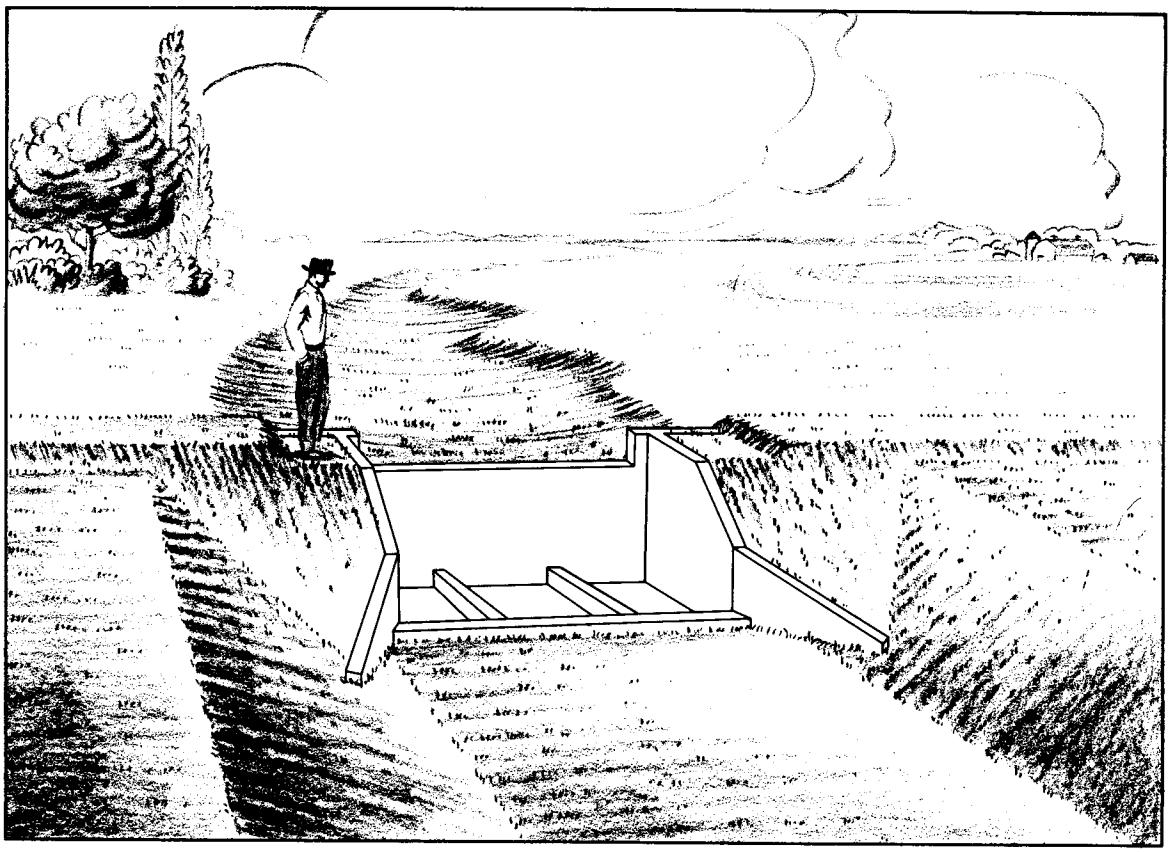
Water Quality: The following effects on water quality should be considered.

1. Ability of structure to trap sediment and sediment attached substances carried by runoff.

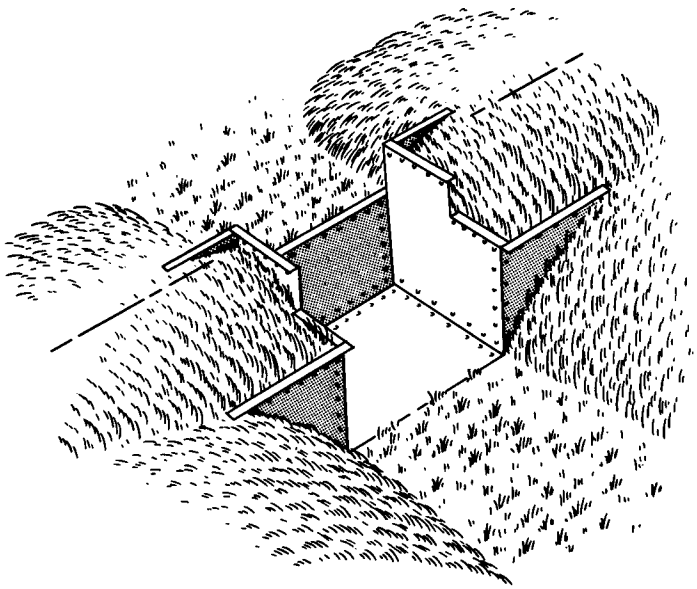
2. Effect of structure on the susceptibility of downstream stream banks and stream beds to erosion.

3. Effects of the proposed structure on the movement of dissolved substances to ground water.

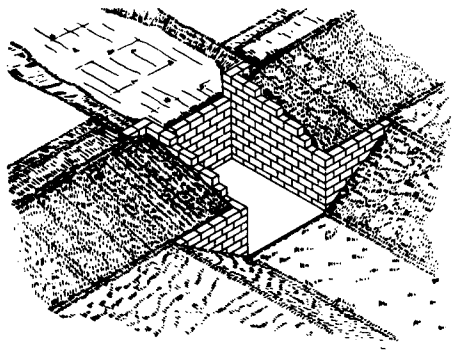
4. Effects on the visual quality of downstream water resources.



Reinforced concrete



Prefabricated metal



Concrete block

Figure 18 — Straight Drop Spillways

Design Criteria

Design and specifications should be prepared for each structure on an individual job basis, depending on its purpose and site conditions.

Capacity: Spillway capacity shall be adequate to pass, without damage to the structure, the overflow expected from a design storm commensurate with the purpose of the structure. Where a grade stabilization structure is part of an improved water conveyance system, the design storm shall be equal to or greater than that used for the channel improvement, i.e., channel modification, field ditch, grassed waterway, etc.

Peak runoff values used in determining the capacity requirements may be determined as outlined in Appendix B or by other accepted methods.

Design velocities and capacities shall be determined by using Manning's formula for open channel flow or other appropriate and accepted procedures. Design velocity computations will be based upon a roughness coefficient (n) commensurate with the type of channel lining to be used. Design velocities will be in the safe range for the type of channel linings used.

Structures which involve the retarding of floodwater or the impoundment of water shall be designed using the criteria set forth in the standard for sediment basins.

Where practical, a chute or drop may be used in conjunction with a vegetated spillway. In this case, the structure capacity without freeboard will be that portion of the total discharge that is not carried by the vegetated spillway with the upstream water surface just at the point of overtopping the earth dam embankment.

Freeboard: The freeboard capacity of the spillway will be the discharge through the spillway when the water surface is just at the point of overtopping the structure. The minimum freeboard peak flow shall be determined by increasing the design peak flow by 20 percent.

Design Aids

The following formulas are accepted for calculating the discharge from straight drop spillways:

1. $Q = 3.33\ (L - 0.2d)d^{3/2}$

   where Q = discharge in cfs
   L = length of weir in feet
   d = design depth of weir (freeboard is not included)

2. $Q = CL\left[H + \frac{Va^2}{2g}\right]^{3/2} = \frac{3.1\ L\ h^{3/2}}{(1.10+0.01F)}$

   where Q = discharge in cfs
   L = length of weir in feet
   H = head of weir in feet
   h = total depth of weir in feet (includes freeboard)
   Va = mean velocity of approach in fps
   g = acceleration of gravity in feet per second^2
   C = discharge coefficient
   F = overfall or drop over weir crest in feet

Table 10 gives discharge values for formula number 1.

With high tailwater, the weir will become submerged and free discharge must be modified accordingly. Figures 19 and 20 give the information that is needed to determine the effect of submergence of a weir in accordance with the following formula:

$$Qs = RQf$$

where Qs = submerged discharge in cfs
Qf = free discharge in cfs
R = ratio Qs / Qf

Specifications

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

The foundation for structures shall be cleared of all trees, brush, stumps, and other objectionable materials prior to the installation of the structures.

Structures shall be installed according to lines and grades shown on the plan. Materials used in construction shall be of a permanency commensurate with the design frequency and life expectancy of the practice.

Earth fill, when used as a part of the structure, shall be placed according to the construction specifications for sediment control basins.

All disturbed areas shall be stabilized to prevent erosion. Sodding, seeding, fertilizing, and mulching shall conform to the recommendations in the standard and specifications for seeding and planting.

Table 10 — Chart Showing Capacity of Weirs (cfs)

Head "d"	Length of Weir Opening "L" in Feet											
	4	6	8	10	12	14	16	18	20	22	24	26
1'—6"	23	35	47	59	72	84	96	108	121	133	145	157
2'—0"	34	53	72	90	109	128	147	166	185	203	222	241
2'—6"	46	72	99	125	151	178	204	230	257	283	309	336
3'—0"	59	93	128	163	197	232	266	301	336	370	405	439
3'—6"	72	116	159	203	246	290	334	377	421	464	508	552
4'—0"	85	139	192	245	298	352	405	458	511	565	618	671
4'—6"	99	162	226	289	353	416	480	544	607	671	734	798
5'—0"	112	186	261	335	410	484	558	633	707	782	856	931
5'—6"	125	210	296	382	468	554	640	726	812	898	984	1070

Capacity of Weirs — $Q = 3.33 (L - 0.2d)d^{3/2}$

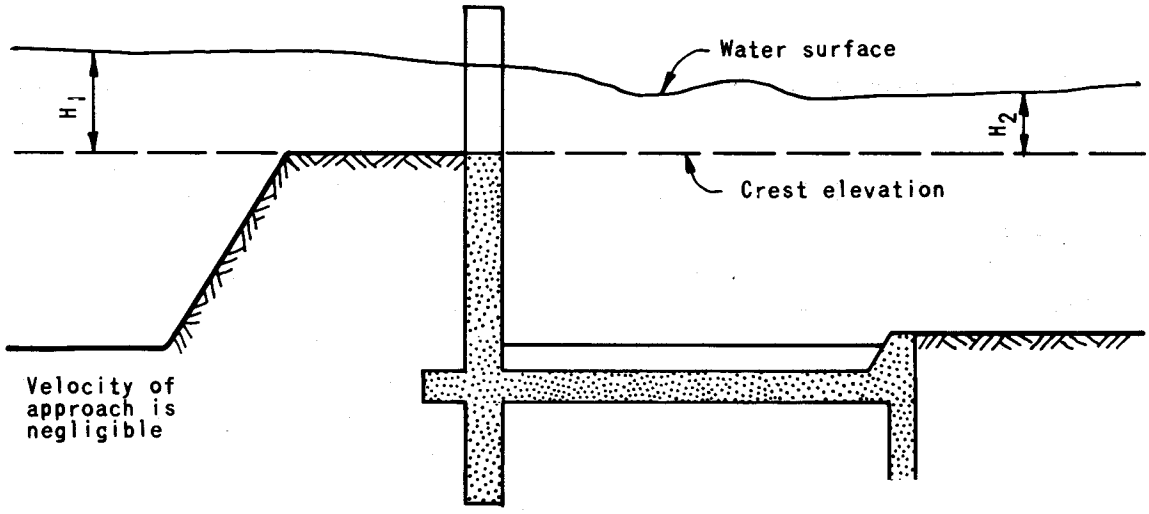


Figure 19 — Submerged Drop Spillway

H_2 = submergence = difference in elevation between tailwater and crest of weir in feet.

H_1 = upstream head on weir with negligible velocity of approach.

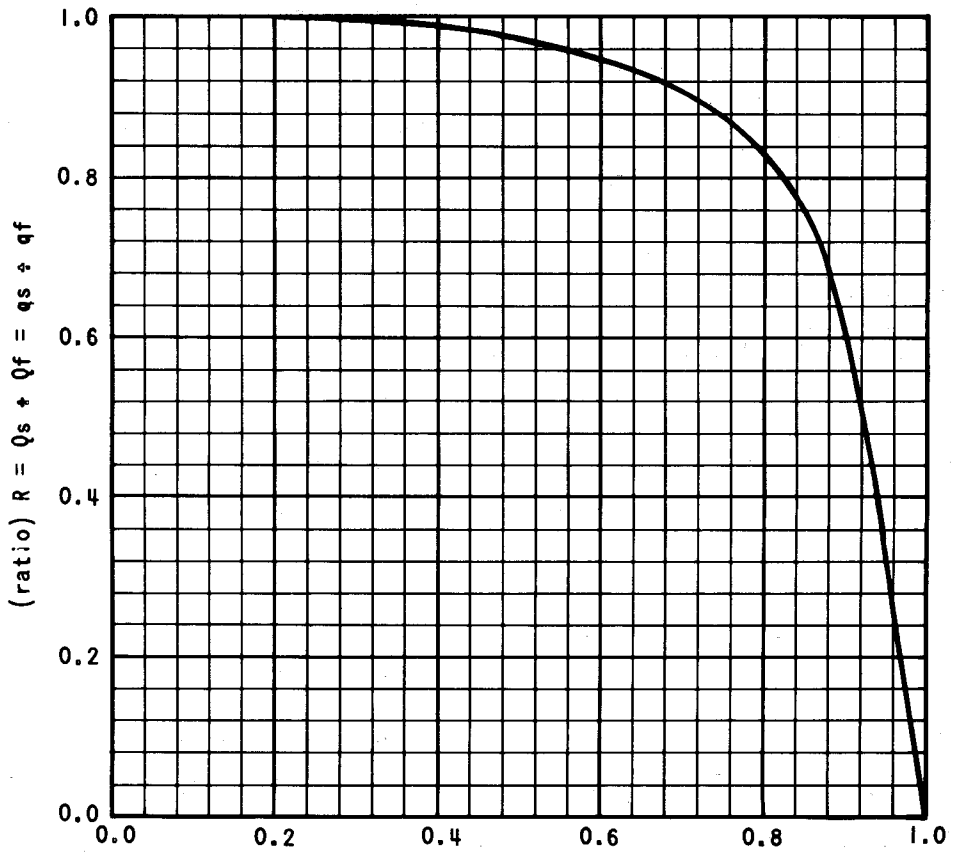
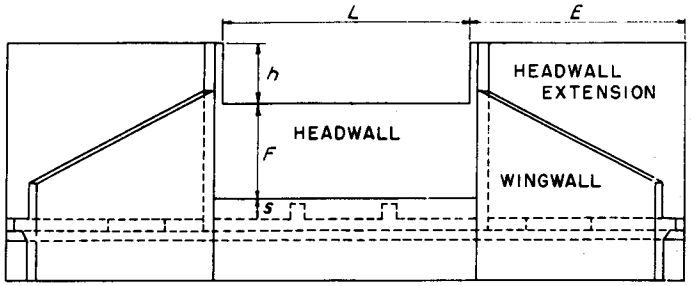
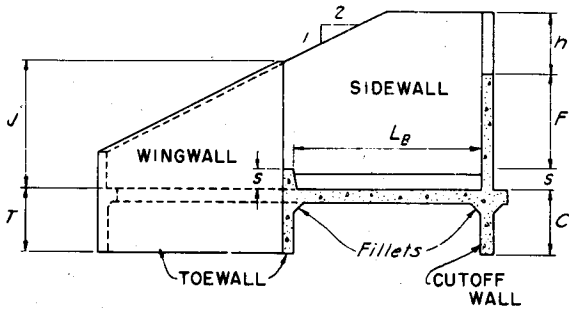


Figure 20 — Submergence Ratio H_2/H_1

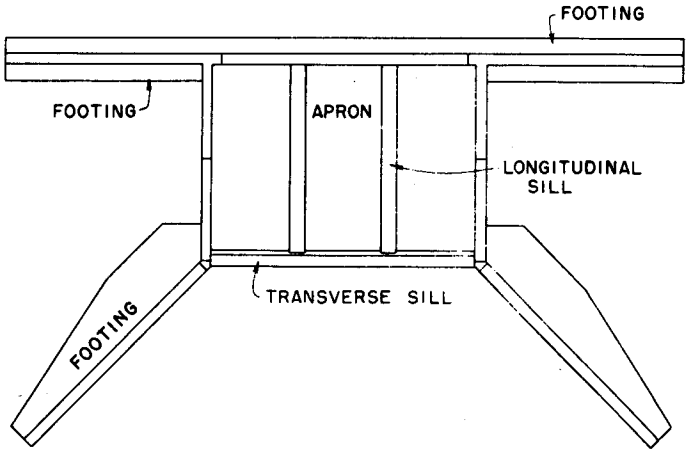
DROP SPILLWAYS: NOMENCLATURE AND SYMBOLS OF DROP SPILLWAY



DOWNSTREAM ELEVATION



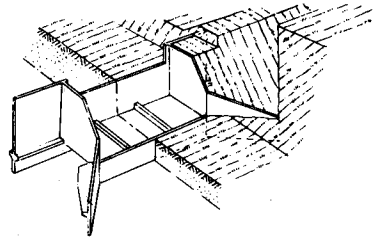
SECTION ON CENTER LINE



PLAN

SYMBOLS

- L = Length of weir.
- h = Depth of weir.
- F = Drop through spillway from crest of weir to top of transverse sill.
- s = Height of transverse sill.
- L_B = Length of apron.
- T = Depth of toewall below top of apron.
- C = Depth of cutoff wall below top of apron.
- d_c = Critical depth of weir.
- E = Length of headwall extension.
- J = Height of wingwall and sidewall at junction.



PERSPECTIVE VIEW

REFERENCE

Rev. 12-14-53

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SOIL CONSERVATION SERVICE
ENGINEERING STANDARDS UNIT

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SHEET 1 OF 1
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