

NATURAL RESOURCES CONSERVATION SERVICE  
MONTANA CONSERVATION PRACTICE STANDARD

## GRADE STABILIZATION STRUCTURE (NUMBER)

### CODE 410

#### DEFINITION

A structure used to control the grade and head cutting in natural or artificial channels.

#### SCOPE

This standard applies to all types of grade stabilization structures, including a combination of earth embankments and mechanical spillways and full-flow or detention-type structures. This standard also applies to channel side-inlet structures installed to lower the water from a field elevation, a surface drain, or a waterway to a deeper outlet channel. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels (587).

#### PURPOSE

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

#### CONDITIONS WHERE PRACTICE APPLIES

In areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion. Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

#### DESIGN CRITERIA

The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that will stabilize upstream head cutting.

**Embankment dams.** Class (a) dams that have a product of storage times the effective height of the dam of 3,000 or more, those more than 35 feet in effective height, and all class (b) and class (c) dams shall meet or exceed the requirements specified in Technical Release No. 60 (TR-60).

Class (a) dams that have a product of storage times the effective height of the dam of less than 3,000 and an effective height of 35 feet or less shall meet or exceed the requirements specified for ponds (378).

The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

**Pond size dams.** If mechanical spillways are required, the minimum capacity of the principal spillway shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in Table 1, less any reduction because of detention storage.

NRCS, MT  
February 2014

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard contact the Natural Resources Conservation Service.

**NOTE:** This type of font (AaBbCcDdEe 123..) indicates NRCS National Standards.  
This type of font (AaBbCcDdEe 123..) indicates Montana Supplement.

Table 1. Design criteria for establishing minimum capacity of the principal spillway for dams with storage capacity of less than 50 acre-feet.

Maximum drainage area for indicated rainfall <sup>1</sup>			Effective height of dam	Frequency of minimum design, 24-hour duration storm
0-3 in.	3 - 5 in.	5+ in.		
-----acres-----			<i>feet</i>	<i>year</i>
200	100	50	35 or less	2
400	200	100	20 or less	2
400	200	100	20 - 35	5
600	400	200	20 or less	5

<sup>1</sup> In a 5-year frequency, 24-hour duration storm

If the effective height of the dam is less than 20 feet and the emergency spillway has a stable grade throughout its length with no overfalls and has good vegetation along its re-entry into the downstream channel, the principal spillway capacity may be reduced but can be no less than 80 percent of the 2-year frequency, 24-hour duration storm.

If criteria values exceed those shown in Table 1 or the storage capacity is more than 50 acre-feet, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

Grade stabilization structures with a settled fill height of less than 15 feet and 10-year frequency, 24-hour storm runoff less than 10 acre-feet, shall be designed to control the 10-year frequency storm without overtopping. The mechanical spillway, regardless of size, may be considered in design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment can be designed to meet the requirements for water and sediment control basins (638) rather than the requirements for ponds (378).

**Full-flow open structures.** Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the Engineering Field Handbook, the National Engineering Handbook (NEH), **Structure for Water Control (Code 587)**, and other applicable NRCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction because of detention storage. If site conditions exceed those shown in Table 2, the minimum design 24-hour storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions

upstream or downstream. Provisions must be made to insure re-entry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 feet or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or as specified in Table 2 or 3, as applicable, less any reduction because of detention storage, whichever is greater. The drop box capacity (attached to a new or existing culvert) must equal or exceed the culvert capacity at design flow.

**All structures shall be designed to meet specific site conditions and functional requirements. Measures to prevent water piping through the soil foundation, abutments or structure shall be designed and installed where necessary. Structures shall be designed with adequate keyways into the channel banks and bottom.**

**Refer to NEH, Part 639, ASAE Paper 972062, "Design of Rock Chutes" for typical rock chute design information.**

Table 2. Design criteria for establishing minimum capacity of full-flow open structures.

Maximum drainage area for indicated rainfall*			Vertical drop	Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.		Principal spillway capacity	Total capacity
-----acres-----			<i>feet</i>	<i>year</i>	<i>year</i>
1,200	450	250	5 or less	5	10
2,200	900	500	10 or less	10	25

\* In a 5-year frequency, 24-hour duration storm.

Table 3. Design criteria for establishing minimum capacity of side-inlet, open weir, or pipe-drop-drainage structure.

Maximum drainage area for indicated rainfall*			Vertical drop	Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.		Receiving channel depth	Total capacity
-----acres-----			<i>feet</i>	<i>feet</i>	<i>year</i>
1,200	450	250	0 - 5	0 - 10	--
1,200	450	250	5 - 10	10 - 20	10
2,200	900	500	0 - 10	0 - 20	25

\* In a 5-year frequency, 24-hour duration storm.

**Island-type structures.** If the mechanical spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. For channels with very small drainage areas, the mechanical spillway should carry at least the 2-year, 24-hour storm or the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2 for total capacity without overtopping the headwall extensions of the mechanical spillway. Provision must be made for safe re-entry of bypassed flow as necessary.

**Side-inlet drainage structures.** The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in Table 3. The minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions. If site condition values exceed those shown in Table 3,

the 50-year frequency storm shall be used for minimum design of total capacity.

**General criteria.** Earth embankment and emergency spillways of structures for which criteria are not provided under the standard for ponds (378) or in TR-60 must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow indicated in Tables 2 or 3 without overtopping the dam. The foundation preparation, compaction, top width, and side slopes must ensure a stable dam for anticipated flow conditions. Discharge from the structure shall be sufficient that no crop damage results from flow detention.

Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout.

The earth embankment pond structures are potentially hazardous and precautions must be

taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

If the area is used for livestock, the structures, earthfill, vegetated spillways, and other areas should be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death to trespassers.

**Protection.** The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded or sodded as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, non-vegetative coverings such as gravel or other mulches may be used.

**Landscape resources.** In highly visible public areas and those associated with recreation,

careful considerations should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.