NATURAL RESOURCES CONSERVATION SERVICE
VIRGINIA CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

(No.)
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. (Refer to Virginia NRCS Conservation Practice Standard *Structure for Water Control (Code 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 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 ft 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 ft or less shall meet or exceed the requirements specified for Virginia NRCS Conservation Practice Standard *Pond (Code 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.

If the effective height of the dam is less than 20 ft and the emergency spillway has a stable grade throughout its length with no overfalls and has good vegetation along its reentry 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-ft, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

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*			Effective height of dam	Frequency of minimum design, 24-hour duration storm
0-3 in.	3 - 5 in.	5+ in.		
----------*acres*----------			*ft*	*yr*
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

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

Grade stabilization structures with a settled fill height of less than 15 ft and 10-year frequency, 24-hour storm runoff less than 10 acre-ft, 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 Virginia NRCS Conservation Practice Standard *Water and Sediment Control Basin (Code 638)* rather than the requirements for *Pond (Code 378)*.

Full-flow open structures. Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the National Engineering Handbook, Part 650, Engineering Field Manual for Conservation Practices, 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 ensure reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 ft 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.

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 reentry 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 Virginia NRCS Conservation Practice Standard *Pond (Code 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

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

Maximum drainage area for indicated rainfall*				Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.	Vertical drop	Principal spillway capacity	Total capacity
----------*acres*----------			*ft*	*yr*	*yr*
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*				Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.	Vertical drop	Receiving channel depth	Total capacity
----------*acres*----------			*ft*	*ft*	*yr*
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.

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 treated in accordance with Virginia NRCS Conservation Practice Standard *Critical Area Planting (Code 342)*, as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, nonvegetative coverings such as gravel or other mulches may be used in accordance with Virginia NRCS Conservation Practice Standard *Mulching (Code 484)*.

CONSIDERATIONS

Quantity

1. Effects on volumes and rates of runoff, evaporation, deep percolation and ground water recharge.

2. Effects of the structure on soil water and resulting changes in plant growth and transpiration.

Quality

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 visual quality of downstream water resources.

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.

Record all required information in an engineer field book, on a plan sheet or design computation sheet, or in another appropriate location.

DESIGN DATA

1. Completed Environmental Evaluation and subsequent requirements.
2. Soils and geologic investigation reports, including suitability of soils for fill.
3. Survey and plot data: profile, cross-sections, topography, as needed.
4. Design computations including: purpose of practice, references used:
    a. breach analysis
    b. land use
    c. anticipated sediment storage.
5. Plan view of site with existing and planned features, including dimensions, distances, etc.
6. Cover Sheet.
7. Materials and quantities needed. Identify borrow material and/or spoil area, as needed.
8. Vegetation and/or ground cover requirements.
9. Identification of needed Erosion & Sediment Control measures.
10. Supplemental practices required including safety measures.
11. NEH, Part 642, Specifications for Construction Contracts or the Virginia 700 Series Construction Specifications.
12. Operation and Maintenance Plan.
13. Mitigation requirements, as applicable.

CHECK DATA

1. As-built survey.
2. As-built plans including dimensions, types and quantities of materials installed, and variations from design. Include justification for variations.
3. Adequacy of vegetation and/or ground cover.
4. Certification of completion.
5. Certification of components supplied by others.

OPERATION AND MAINTENANCE

Provisions shall be made as necessary for operation and maintenance requirements and

may include a formal plan for larger, more complex grade stabilization structures. The operation and maintenance plan should include an emergency action plan when required by local or state regulations, and for all high hazard class structures.

The structure should be inspected at least annually, and especially after heavy rains, to determine whether it is functioning properly or if repairs are needed.

Appurtenances such as trash racks, outlet structures and gates shall be kept free of trash and replaced when needed. Remove debris accumulation at the structure, and immediately upstream and downstream. Debris can reduce hydraulic capacity and cause structural damage or failure during a runoff event.

Immediately repair any vandalism, vehicular, livestock, or storm damage to earthfills, side slopes, spillways, outlets or other appurtenances. Erosion on the slopes of the structure and in the earth spillway shall be filled with suitable soil, compacted, and fertilized as needed.

If seepage through or under the structure occurs, proper corrective measures shall be taken immediately.

The vegetative cover of the structure and earth spillway shall be maintained by mowing and fertilizing when needed. Trees can cause leaks and safety hazards and should not be permitted on the embankment, in the auxiliary spillway, or within 25' of the embankment groin. Apply supplemental nutrients as needed to maintain the desired species composition and stand density. Control undesired weed species, especially state-listed noxious weeds.

Damage to the embankment from burrowing animals will be repaired and the animals shall be removed.

Avoid operating farm equipment too close to the structure.

Maintain fences needed to exclude livestock, human, and vehicular traffic.

Make sure all structure drains are functional and soil is not being transported through the drainage system. The screens and/or rodent guards shall also be kept in place.

Periodically replace and relocate any rock riprap either by machine or by hand. Repair or replace riprap rocks to the lines and grades of the original design.

REFERENCES

USDA-Natural Resources Conservation Service. National Engineering Handbook, Section 5, Hydraulics; Part 630, Hydrology; Part 642, Specifications for Construction Contracts; and Part 650, Engineering Field Handbook.

Virginia Impounding Structure Regulations. http://www.dcr.virginia.gov/documents/DamSafetyRegulations.pdf

USDA-Natural Resources Conservation Service, TR-210-60 - Earth Dams and Reservoirs (Revised July 2005) (7/2005).

USDA-Natural Resources Conservation Service. Electronic Field Office Technical Guide (eFOTG), Section IV [Online]. Available at http://www.nrcs.usda.gov/technical/eFOTG

USDA-Natural Resources Conservation Service. Virginia 700 Series Construction Specifications. [On-line]. Available at http://www.nrcs.usda.gov/technical/eFOTG