United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

CODE 410

(no)

DEFINITION

A structure used to control the grade in natural or constructed channels.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce erosion
- Improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where channels require a structure to stabilize the grade or to control gully erosion.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct this practice to comply with all Federal, State, and local regulations.

Set the crest of the inlet at an elevation that will stabilize the channel and prevent upstream head cutting.

Design earthen embankments and auxiliary spillways to handle the total capacity flow indicated in tables 1 or 2 without overtopping any embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable earthen embankment for anticipated flow conditions.

Peak flow rates for upland watersheds may be obtained using procedures contained in National Engineering Handbook (NEH), Part 650, Chapter 2, "Estimating Runoff Volume and Peak Discharge" and the associated Texas NEH supplement, TX650, Chapter 2, "Estimating Runoff"; the WinTR-55 computer program and user guide; or the WinTR-20 computer program and user guide. Peak flow rates for flatland watersheds, i.e. average slopes less than .002 ft/ft and void of geologic terraces or benches, may be obtained from of Texas Engineering Technical Note No. 210-18-TX8, "Guide to Determine Instantaneous Peak Flow for Flatland Areas."

A stability analysis of the downstream channel shall be made. The structure shall be designed and installed so that anticipated downstream channel degradation will not affect the proper function of the structure.

Provide a minimum sediment storage capacity equal to the expected life of the structure, or provide for periodic cleanout.

Provide measures necessary to prevent serious injury or loss of life such as protective guardrails, warning signs, fences, or lifesaving equipment.

Seed or sod the exposed surfaces of earthen embankments, earth spillways, borrow areas, and other areas disturbed during construction in accordance with NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342). If climatic conditions preclude the use of seed or sod, use NRCS CPS Mulching (Code 484) to install inorganic cover material such as gravel.

Table 1. Design Criteria for Establishing Minimum Capacity of Full-flow Open Structures

Maximum drainage area for indicated rainfall in a 5-year frequency, 24-hour duration storm				Frequency of minimum design, 24-hour duration storm	
0–3 inches	3–5 inches	5+ inches	Vertical drop	Principal spillway capacity	Total capacity
acres			feet	year	year
1,200	450	250	0–5	5	10
2,200	900	500	0–10	10	25

Table 2. Design Criteria for Establishing Minimum Capacity of Side-inlet, Open-weir, or Pipe-drop Drainage Structure

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

Embankment dams

Low-hazard dams that have a product of storage times the effective height of the dam of 3,000 ac-ft^2 or more, those more than 35 feet in effective height, and all significant and high-hazard dams must meet or exceed the criteria specified in NRCS Engineering Technical Release (Title 210), 60, “Earth Dams and Reservoirs.”

Low-hazard dams that have a product of storage times the effective height of the dam of less than 3,000 ac-ft^2 and an effective height of 35 feet or less must meet or exceed the requirements specified in NRCS CPS Pond (Code 378).

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

Storage is the capacity of the reservoir in acre-feet below the elevation of the crest of the lowest auxiliary spillway or the elevation of the top of the dam if there is no open channel auxiliary spillway.

If peak discharge is reduced due to detention storage, dams shall be flood routed by using SITES, Water Resource Site Computer Analysis Computer Program. Either the average condition runoff curve number shown in Figure TX650-2.4 of the Texas NEH supplement, TX650, Chapter 2, “Estimating Runoff” or antecedent moisture condition (AMC) II may be used to determine the runoff curve number. Stream hydraulics (calculation of velocities assuming uniform or gradually varied flow conditions) is the preferred method for calculating time of concentration (Tc). If Tc is calculated from a published formula, the associated average velocity shall be checked for reasonableness.

Pond-sized dams

If mechanical spillways are required, the minimum capacity of the principal spillway must convey the peak flow expected from a 24-hour duration design storm of the frequency shown in table 3, less any reduction from detention storage. *Criteria contained in Table 3 are limited to conduit principal spillways.* For dams with effective height less than 20 feet, a stable auxiliary spillway with no overfalls, and good auxiliary spillway vegetation along its reentry into the downstream channel, the designer may reduce the principal spillway capacity to no less than 80 percent of the 2-year frequency, 24-hour duration storm. For dams with a storage capacity more than 50 acre-feet or criteria values exceeding those shown in table 3, use the 10-year frequency, 24-hour duration storm as the minimum design storm.

Table 3. 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 in a 5-year frequency, 24-hour duration storm			**Effective height of dam**	**Frequency of minimum design, 24-hour duration storm**
0–3 inches	**3–5 inches**	**5+ inches**		
acres			**feet**	**year**
200	100	50	0–35	2
400	200	100	0–20	2
400	200	100	20–*35*	5
600	400	200	0–20	5

Small pond-sized dams

For dams with an effective height of less than 15 feet and 10-year frequency, 24-hour storm runoff volume less than 10 acre-feet, the designer may use the requirements of NRCS CPS Water and Sediment Control Basin (Code 638). Design the grade control structure to control the peak flow from the 10-year frequency, 24-hour duration storm without overtopping. If the combination of storage and mechanical spillway discharge will handle the design storm, an auxiliary spillway is not required.

Full-flow open structures

Full-flow open structures consist of formless concrete chutes, gabion chutes drop spillway structures, aluminum toe walls, etc. installed in locations where tailwater does not affect the discharge capacity for the principal spillway design storm.

Design drop, chute, and box inlet drop spillways to the guidance in the NRCS National Engineering Handbook (Title 210), Part 650, “Engineering Field Handbook” and other applicable NRCS publications and reports. Provide a minimum capacity to pass the peak flow expected from a design storm of the frequency and duration shown in table 1, less any reduction from detention storage. If site conditions exceed those shown in table 1, design the minimum principal spillway capacity for the 25-year frequency (24-hour duration) storm and design the minimum total capacity for the 100-year frequency (24-hour duration) storm. Structures must not create unstable conditions upstream or downstream. Install provisions for reentry of bypassed storm flows.

The ratio of the capacity of drop boxes to road culverts must meet the requirements of the responsible road authority or as specified in table 1 or 2, as applicable, less any reduction from 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

Island Type Structures consist of full-flow open structures installed in locations where downstream tail water conditions limit the structure capacity prior to the passage of the principal spillway storm shown in Table 1.

Design the minimum capacity equal to the capacity of the downstream channel. Design the minimum auxiliary spillway capacity equal to that required to pass the peak flow expected from a 24-hour duration storm of the frequency shown in table 1 for total capacity without overtopping the headwall extensions of the mechanical spillway. Make provision for safe reentry of bypassed flow as necessary.

Downstream channel discharge shall be computed using Manning's formula. The minimum anticipated "n" value and the maximum anticipated hydraulic gradient slope shall be used to estimate downstream channel capacity. NRCS approved water surface profile computer programs may be used to evaluate downstream capacities.

Side-inlet, open weir, or pipe-drop drainage structures
Table 2 provides 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. Design the minimum principal spillway capacity equal to the design drainage curve runoff for all conditions. If site condition values exceed those shown in table 2, use the 50-year frequency, 24-hour duration storm for minimum design of total capacity.

Structures used strictly for water management applications such as rice water management, shall follow NRCS CPS Structure for Water Control (Code 587).

A pipe drop used as a side inlet drainage structure is generally a simple structure consisting of a straight, relatively short section of pipe which outlets into a drainage ditch or channel with a headwall or other provision at the inlet to direct flow into the pipe. It is adapted for low head discharge of small quantities of water and fill heights which are normally less than 4 feet above natural ground. The distance measured from the bottom of outlet end of pipe to bottom of outlet ditch or channel should not exceed 2 feet.

When a pipe drop is used to control a headcut or overfall at the end of a lateral drainage ditch, it shall be designed to discharge the design capacity of the lateral ditch plus 25 percent or more.

The size of pipe drops may be determined from drawing 4-L-6593 – Design of Culverts Flowing Full, tables 4-L-10,557 – Tables for Computing Culvert Discharge and Minimum Surcharge or other approved tools. Pipe drops may be designed and installed in accordance with standard drawing TX-EN-0459 Flashboard riser Water Control Structure, drawing 4-L-15072A – Corrugated Metal Pipe Drop Structure with Metal End Section, or other approved plans, except that the vertical drop at the outlet end should not exceed 2 feet.

Pipe drop auxiliary spillway floor(s) shall be at or above the pipe design water surface at the pipe entrance.

For pipe drops in flatland areas, the settled fill shall be a minimum of 0.5 ft above the elevation of the auxiliary spillway(s) in areas where almost unlimited area is available for auxiliary spillway flow and overland flow occurs with high rainfall. The auxiliary spillway(s) shall carry at least three times the required capacity of the structure under these conditions. In areas where these conditions do not exist, the settled fill height should be increased to that for pipe drops in non-flatland areas.

For pipe drops in non-flatland areas, the settled fill shall have 1.0 ft minimum freeboard above the designed depth of flow in the auxiliary spillway(s) and have a minimum of 1.5 ft above the design water surface at the pipe entrance. The auxiliary spillway(s) shall have twice the design capacity of the ditch or channel above the structure.

Uncoated galvanized corrugated steel pipe may be used without cathodic protection where it or special coatings are not needed to attain normal life expectancy. An anti-vortex device is normally not required with this type of structure. Requirements for debris guards, pipe material, and couplers listed under Pond 378 shall apply to pipe drops.

The requirements for anti-seep collars on pipe drop structures shall be the same as for pipe drop inlets except for the following conditions. The requirements for anti-seep collars on pipe drops are waived when all the following conditions exist:

1. *Embankment consists of CH soil or CL soil with plasticity index greater than 15, and the foundation soil extends to a depth greater than the outlet channel.*
2. *Normal annual precipitation is greater than 36 inches and relatively high moisture contents are maintained near the ground surface the year around.*
3. *Pipe trench is excavated in natural or undisturbed soils and backfilled with moist CL or CH soil, which can be compacted to form a good bond with the pipe and trench walls.*
4. *Pipe grades are 15 percent or less.*
5. *Total vertical drop along the pipe from upper end to outlet end does not exceed 7 feet.*

CONSIDERATIONS

National Engineering Handbook (NEH), Part 650, Chapter 6, "Structures" and Texas Engineering Technical Note No. 210-15-TX1, "Erosion Control Practices" include general guidance for several types of grade stabilization structures.

Provide sufficient discharge to minimize crop-damaging water detention.

In highly visible public areas and those associated with recreation, give careful consideration to landscape resources. Landforms, structural materials, water elements, and plant materials should complement their surroundings visually and functionally. Consider using a diverse mix of native vegetation that is adapted to the site to provide enhanced ecological, habitat, and pollinator benefits. Shape excavated material and cut slopes to blend with the natural topography. Shape shorelines and create islands to add visual interest and wildlife habitat. Form and finish exposed concrete surfaces to add texture, reduce reflection, and to alter color contrast. Select sites to reduce adverse impacts or create desirable focal points.

Consider the effect of the grade control structure on aquatic habitat. For channels supporting fish, consider the effect of the structure on fish passage.

In natural channels, consider the effect of the grade control structure on fluvial geomorphic conditions.

Provide fences to protect structures, earth embankments, and vegetated spillways from livestock. Near urban areas, provide fencing as appropriate to control access and exclude traffic.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for installing grade stabilization structures that describe the requirements for applying the practice according to this standard. As a minimum, include—

- A plan view of the layout of the grade stabilization structure and appurtenant features.
- Typical profiles and cross sections of the grade stabilization structure and appurtenant features as needed.
- Structural drawings, as needed.
- Seeding requirements, as needed.
- Safety features.
- Site-specific construction requirements.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. As a minimum, include—

- Periodic inspections of all structures, earthen embankments, spillways, and other significant

appurtenances.
- Prompt repair or replacement of damaged components.
- Prompt removal of sediment when it reaches predetermined storage elevations.
- Periodic removal of trees, brush, and invasive species.
- Periodic inspection of safety components and immediate repair if necessary.

Require maintenance of vegetative protection and immediate seeding of bare areas as needed.

REFERENCES

USDA NRCS. 2019. Engineering Technical Release (Title 210), 60, Earth Dams and Reservoirs. Washington, D.C. https://directives.sc.egov.usda.gov

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